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BIOINTENSIVE MANAGEMENT OF BRINJAL SHOOT AND FRUIT BORER *LEUCINODES ORBONALIS* GUENEE

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ABSTRACT

Biointensive integrated pest management (BIPM), insecticidal management, state recommended practices and farmers' practices were evaluated for their efficacy against brinjal shoot and fruit borer (BSFB) during 2016 and 2017. BIPM module recorded the lowest (8.4%) shoot damage while a maximum of 12.1% was observed with insecticidal management. Fruit damage was less (20.7%) in farmers' practices over insecticidal management (34.0%). Yield of marketable fruits was more (464.9 q/ha) in farmers' practices, at par with BIPM (442.0 q/ha). Yield (377.8 q/ha) of marketable fruits in insecticidal management was statistically on par with state recommended practices (383.1 q/ha). Despite the higher net returns (Rs. 4,77,865), B:C ratio was lower (3.9) in farmers' practices because of the higher cost of production. BIPM produced net returns of Rs. 4,64,201 with a high B:C ratio of 4.4. Thus, BIPM proved to be the best management option for economic production of brinjal.

Keywords: Biointensive IPM, brinjal, *Leucinodes orbonalis*, shoot and fruit damage, marketable fruit yield, farmers' practices, cost benefits

Brinjal, *Solanum melongena* L., is an important solanaceous vegetable crop cultivated in India(Anonymous, 2017a), and it is grown throughout the year (Kolhe, 2017), with increased cultivation and production (Anonymous, 2018). However, productivity of brinjal in India (18.5 t/ha) is low (FAOSTAT, 2016).Various insect pests attack the crop at different phenological stages that reduce the productivity and quality. Nearly 140 species of insect pests had been reported (Biswas et al., 1992; Dwivedi et al., 2014). Of these, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee is most important. It had been reported from all brinjal growing areas with damage as high as 95% (ISAAA, 2008; Yadav et al., 2015). Sporadic as well as regular outbreaks had been reported in India (Chakraborti and Sarkar, 2011).Internal feeding habit of BSFB is the main constraint in its management (Mathur et al., 2012). Prasad et al.(2017) estimated avoidable loss to an extent of48.5%. Farmersrely on chemicals with 25-80 sprays (Dhandapani et al., 2003). Insecticides belonging to different groups such as biorationals, biopesticides, botanicals, chitin synthesis inhibitors etc. had been evaluated (Rahman et al., 2009; Singh et al., 2016a; Tripura et al., 2017). However, very few studies focus on integration of different tactics, and an IPM regime is essential. Present study is to develop and evaluate biointensive IPM (BIPM) in comparison with other packages for management of*L. orbonalis* under Punjab conditions.

MATERIALS AND METHODS

Field experiments were conducted on summer brinjal during 2016 and 2017 at the Entomological Research Farm, Department of Entomology, Punjab Agricultural University, Ludhiana. The experiment was laid in randomized block design (RBD) with a plot size of 50 m^2(each plot separated by a gap of 1 m) with four modules tested in four replications in addition to untreated control. The hybrid BH-3 was raised as per recommended agronomic practices as per the PAU Package of Practices (state). Spray application was done during evening hours with a knapsack sprayer. Details of the components of management modules are given below:

M_1: Biointensive Integrated Pest Management (BIPM) consisting of- Deep ploughing 15 days before preparation of field for transplanting; Soil application of Farm Yard Manure @ 10 tonnes/ha; Neemcake @ 500 kg/ha as basal application; Weekly clipping of infested shoots from onset of BSFB; Removal of alternate hosts; 4-5 releases of *Trichogramma chilonis* Ishii @ 1.5 lakh/ha from flowering stage at weekly intervals; Spray of azadirachtin (Neeemazal 1%) @ 1000 ml/ha at 40 and 70 days after transplanting (DAT); Spray of Bt formulation (Delfin WG) @ 750 g/ha 50 and 80 DAT; and Spray of *Beauveria bassiana* (Mycojaal) @ 1000 ml/ha at 60 and 90 DAT

M$_2$: Insecticidal management consisting of: Spray of triazophos 40 EC @ 1.25 l/ha at 40 DAT; Spray of chlorantriniliprole 18.5 SC @ 100 ml/ha at 50 DAT; Spray of lambda-cyhalothrin 4.9 CS @ 125 ml/l at 65 DAT; and Spray of emamectin benzoate 25 WG @ 100 g/ha at 75 DAT.

M$_3$: State recommended practices of- Regular picking and destruction of infested fruits by deep burying in soil; Spray of fenvalerate 20 EC @ 250 ml/ha at 40 DAT; Spray of triazophos 40 EC @ 1.25 l/ha at 55 DAT; Spray of cypermethrin 10 EC @ 500 ml/ha at 70 DAT; and Spray of ekalux 25 EC @ 2.0 l/ha at 85 DAT

M$_4$: Farmer's practices of - Soil application of phorate 10 G @ 1 g/seedling 15 DAT; Spray of spray of flubendiamide 20 WG @ 150 ml/ha; Spray of spinosad 45 SC @ 150 ml/ha; Spray of indoxacarb 14.5 SC @ 500 ml/ha; and Spray of ekalux @ 2.0 l/ha. Here each of the insecticidal spray was used as per above sequence at weekly intervals and repeated four times in the same sequence during the cropping season.

The observations on shoot damage were recorded from 20 randomly selected and tagged plants in each plot at weekly intervals. Data on shoot and fruit damage was recorded starting from 30 days after transplanting (DAT) and 45 DAT till final picking. The number of healthy and infested fruits along with their weight/ plot was recorded at different pickings and % shoot and fruit damage was worked out. The % increase/ decrease in yield over control were also calculated. Cumulative fruit yield was worked out by adding the yield of different pickings. The yield of healthy and infested fruits was converted into marketable yield (t/ha). Economics of each module was worked out as per Economics of Vegetable Crops in Punjab, published by Department of Economics and Sociology, PAU, Ludhiana (Anonymous 2017b). Benefit cost ratio (BCR) was calculated on basis of net returns and total cost of production.

RESULTS AND DISCUSSION

Efficacy of modules in reducing shoot infestation by *L. orbonalis* was studied at weekly intervals starting from 30 days after transplanting (DAT) to 107 DAT (Table 1). Data over two seasons demonstrate that BIPM reduced shoot damage to 2.6-12.3%. The incidence ranged from 4.4-18.8% in insecticidal management, 4.9-17.4% in state recommended practices and 5.9-16.1% in farmers' practices. Cumulative damage of twelve weeks revealed that BIPM led to significant reduction. Significantly less infestation was in BIPM module (8.4%). Other three chemical based treatments were at par with each other. Regular clipping of infested shoot in case of BIPM played a critical role as compared to sole application of insecticides. Clipping and burying of infested shoots reduces the pest load and prevents the survival.

Regular clipping of infested shoots reducing shoot infestation significantly has been corroborated by several workers (Rahman et al., 2002; Alam et al., 2003; FAO, 2003; Anonymous 2015; Javed et al., 2017). Bhushan et al. (2011) reported results similar to the present study, where 9.32% infestation was recorded when clipping of infested shoots was a component. Shoot damage ranging from 9.1-9.5% during *kharif* and *rabi* season under BIPM, followed by farmers practice and bio-rational pest management reported by

Table 1. Effect of management modules on shoot damage in summer brinjal crop (pooled, 2016 & 2017)

Modules	Days after transplanting												
	30	37	44	51	58	65	72	79	86	93	100	107	Mean
BIPM	10.9 (3.4)	12.2 (3.6)	12.3 (3.6)	10.2 (3.3)	11.4 (3.5)	10.8 (3.4)	8.7 (3.1)	7.2 (2.9)	5.6 (2.6)	4.6 (2.4)	4.4 (2.3)	2.6 (1.9)	8.4 (3.1)
Insecticidal management	13.5 (3.8)	15.0 (4.0)	16.8 (4.2)	18.8 (4.4)	16.8 (4.2)	16.4 (4.2)	13.7 (3.8)	10.3 (3.4)	7.9 (3.0)	6.5 (2.7)	5.4 (2.5)	4.4 (2.3)	12.1 (3.6)
State package of practices	15.7 (4.1)	17.4 (4.3)	15.6 (4.1)	15.3 (4.0)	16.4 (4.2)	14.7 (4.0)	11.9 (3.6)	9.6 (3.3)	8.0 (3.0)	6.3 (2.7)	6.0 (2.6)	4.9 (2.4)	11.8 (3.6)
Farmer's practices	15.9 (4.1)	14.8 (4.0)	16.1 (4.1)	14.8 (4.0)	14.1 (3.9)	15.4 (4.0)	12.8 (3.7)	10.4 (3.4)	8.4 (3.1)	6.6 (2.8)	5.9 (2.6)	5.9 (2.6)	11.8 (3.6)
Untreated control	20.2 (4.6)	24.2 (5.0)	23.8 (5.0)	25.4 (5.1)	25.1 (5.1)	20.2 (4.6)	15.8 (4.1)	12.3 (3.6)	9.8 (3.3)	9.3 (3.2)	8.3 (3.1)	7.8 (3.0)	16.8 (4.2)
LSD (p= 0.05)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.1)	(0.2)

Figures are mean of four replications; figures in parentheses are square root transformations

Shanmugam et al. (2015) was similar to the results of present study. Das (2015) however reported lower shoot damage of 4.9 and 6.3% in two different IPM modules and 4.5% in farmers practice. Pandey et al. (2016) recorded least shoot damage of 20.46% when infested shoots were clipped followed by application of neem seed kernel extract (NSKE), while maximum shoot damage was recorded in farmers practice (31.5-32.1%). On the other hand, Yadav et al. (2017) compared six BIPM and farmers practice against untreated control and found that shoot infestation in the initial weeks was non-significant in all the treatments, while in the later stages farmers practice recorded lower shoot damage.

The mean fruit damage in BIPM, insecticidal management, state package of practices and farmers' practices ranged from 25.6-35.8, 28.5-43.1, 19.7-36.8 and 18.0-27.3%, respectively (Table 2). Overall, fruit damage was lowest in farmers' practice with value of 20.7%, and it was significantly lowest among all modules. This was followed by damage of 27.0 and 29.4% under state package of practices and BIPM, respectively which were statistically similar and highest fruit damage was recorded in insecticidal management (34.0%). Extensive spray schedule till the final picking in case of farmers' practice lead to reduced infestation followed by BIPM. However, schedule of sprays in case of insecticidal management and state package of practices limited to a narrow period resulted in higher fruit damage.

Shanmugam et al. (2015) reported low fruit damage (11.5%) in farmers practice while fruit damage in biorational module was higher (18.0%). Singh et al. (2016b) reported that combination of various management options resulted in 19.8% fruit damage which was in accordance with present study. On the other hand, Nayak et al. (2014) reported shoot damage varying from 6.5-18.3% in different IPM and BIPM modules against 25.9% shoot infestation in farmers practice. Results by Yadav et al. (2017) agree with the present study where fruit damage in farmers practice was lower than some of the BIPM. Javed et al. (2017) reported lowest fruit infestation (6.9-13.1%) in modules where infested shoot were clipped.

Yield parameters presented in Table 3 reveal that BIPM had the lowest yield (35.2 q/ha) of infested fruits with, and it was par with farmers' practice (34.7 q/ha) and state package of practices (37.6 q/ha). Insecticidal management had significantly higher yield as compared to the above said treatments with 43.4 q/ha infested fruits. Yield of marketable fruits, was found to be higher infarmers' practices (464.9 q/ha) followed by BIPM (442.0 q/ha). Yield across insecticidal management and state package of practices were 377.8 and 383.1 q/ha and was statistically at par. Highest net returns were gained from farmers' practices (Rs. 4,77,865), followed by BIPM (Rs. 4,64,201). Net returns were very similar in insecticidal management (Rs. 4,04,524) and state package of practices (Rs. 4,04,862).

Table 2. Effect of different management modules on per cent fruit damage (number basis) in summer brinjal crop (2016 and 2017)

Modules	Days after transplanting										
	45	52	59	66	73	80	87	94	101	108	Mean
BIPM	28.5	26.4	30.1	27.8	25.6	29.4	30.8	28.5	31.1	35.8	29.4
	(32.2)	(30.8)	(33.2)	(31.7)	(30.3)	(32.7)	(33.6)	(32.2)	(33.8)	(36.7)	(32.8)
Insecticidal management	28.9	31.3	32.7	36.1	32.1	28.5	33.5	36.6	37.4	43.1	34.0
	(32.5)	(34.0)	(34.8)	(36.8)	(34.5)	(32.2)	(35.3)	(37.2)	(37.7)	(41.0)	(35.6)
State package of practices	19.7	25.8	24.2	27.3	22.5	27.6	23.9	28.9	33.1	36.8	27.0
	(26.3)	(30.4)	(29.4)	(31.4)	(28.3)	(31.6)	(29.2)	(32.5)	(35.1)	(37.3)	(31.2)
Farmer's practices	18.6	19.9	20.3	19.5	18.0	20.7	21.5	18.5	22.6	27.3	20.7
	(25.5)	(26.4)	(26.8)	(26.2)	(25.1)	(27.0)	(27.6)	(25.4)	(28.3)	(31.4)	(27.0)
Untreated control	41.7	44.1	44.5	46.7	47.6	45.1	47.3	49.8	53.5	55.1	47.5
	(40.2)	(41.6)	(41.8)	(43.1)	(43.6)	(42.1)	(43.4)	(44.8)	(47.0)	(47.9)	(43.6)
LSD (p= 0.05)	(2.6)	(2.7)	(2.7)	(2.8)	(2.7)	(2.8)	(2.8)	(3.0)	(3.2)	(3.4)	(2.9)

Figures mean of four replications; Figures in parentheses arc sine transformations

Table 3. Yield and cost economics of different management modules in summer brinjal crop (2016 and 2017)

Modules	Yield of infested fruits (q/ ha)	% decrease over control	Yield of marketable fruits (q/ ha)	% increase over control	Total cost (Rs.)	Gross returns (Rs.)	Net returns	B:C ratio
BIPM	35.2	38.0	442.0	31.3	1,06,797	5,70,998	4,64,201	4.4
Insecticidal management	43.4	23.6	377.8	19.6	83,444	4,87,967	4,04,524	4.9
State package of practices	37.6	33.8	383.1	20.7	89,981	4,94,843	4,04,862	4.5
Farmer's practices	34.7	38.9	464.9	34.7	1,22,730	6,00,595	4,77,865	3.9
Untreated control	56.8	-	303.8	-	80,034	3,92,490	3,12,457	3.9
LSD (p= 0.05)	4.5	-	40.8	-	-	-	-	-

Yield mean of eight pickings

Among different treatments B:C ratio was highest in insecticidal management (4.9), followed by 4.5 in state recommended practices, 4.4 in BIPM, 3.9 in farmers' practices and 3.9 in untreated control. Details on the cost of different inputs in the five modules are given in the Table 4. Despite the highest returns, farmers' practice lagged behind in B:C ratio because of the higher cost of sprays and labour involved in the management of BSFB. Insecticidal management and state package of practices had high B:C ratio due to less sprays and labor cost involved. BIPM is labour intensive and had lower B:C ratio than insecticidal management and state package of practices. But on the basis of net returns, BIPM proves to be a viable alternative against the insecticide driven methods of pest management in brinjal.

Management regime following the integration of various crop protection tactics was found to be superior over the other regimes by several workers (Sardana et al. 2004, Jhala et al. 2005, Dutta et al. 2011,Yadav et al. 2017). Bhushan et al. (2011) also recorded highest returns and B:C ratio (1:8.4) from IPM while the lowest returns and B:C ratio of 1:0.6 was recorded in case of farmers practice. Shanmugam et al. (2015) reported highest yield and B:C ratio from BIPM, however these parameters were higher in case of farmers practice when compared with bio-rational module. Das (2015) recorded higher B: C ratio in two IPM modules (3.7 and 4.2) with higher net returns, while farmers practice had B:C ratio of 3.3. Pandey et al. (2016) also reported lowest net returns and B:C ratio in case of farmers practice, while 22.9-23.3% increase in yield from IPM module over the weekly application of insecticides.

Table 4. Economic parameters of different management modules in summer brinjal crop (2016 and 2017)

Agricultural operations	BIPM	Insecticidal management	State package of practices	Farmers' practices	Untreated control
Seed and seed treatment	15,003.19	15,003.19	15,003.19	15,003.19	15,003.19
Fertilizers	7,017.50	4,892.50	4,892.50	4,892.50	4,892.50
Hoeing	20,850.00	20,850.00	20,850.00	20,850.00	20,850.00
Irrigation	3,287.50	3,287.50	3,287.50	3,287.50	3,287.50
Labour	28,500.00	28,200.00	28,200.00	29,700.00	27,600.00
Tractor	9,607.50	8,400.00	8,400.00	8,400.00	8,400.00
Insecticides	19,025.00	2,810.00	2,947.25	35,583.59	-
Trichocards	1,875.00	-	-	-	-
Clipping of infested shoots/ infested fruits	19,200.00	-	1,600.00	-	-
Total cost	1,24,365.69	83,443.19	85,180.44	1,17,716.78	80,033.19

Figures in Rupees

Results of the present study clearly indicate that production in BIPM is similar to the farmer's practice without use of insecticides. In the present era where consumers are highly aware of the environmental and health implications of insecticide sprays, BIPM is an excellent alternative to the use of chemicals in economical vegetable production. Education and training of farmers for decision making and understanding the concept of IPM are necessary. Also BIPM needs to be popularized among farmers through field demonstrations over larger landscapes. The demonstrations on efficacy of BIPM will provide farmers an impetus to follow integrated and non-chemical approaches for crop protection.

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