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Divya S
ICAR-Krishi Vigyan Kendra, Hans Roever Campus, Valikandapuram, Perambalur Dt., Tamil Nadu, India

J Kathiravan
ICAR-Krishi Vigyan Kendra, Hans Roever Campus, Valikandapuram, Perambalur Dt., Tamil Nadu, India

VE Nethaji Mariappan
ICAR-Krishi Vigyan Kendra, Hans Roever Campus, Valikandapuram, Perambalur Dt., Tamil Nadu, India

Correspondence
Divya S
ICAR-Krishi Vigyan Kendra, Hans Roever Campus, Valikandapuram, Perambalur Dt., Tamil Nadu, India

Evaluation of AESA based integrated pest management techniques for management of shoot and fruit borer, *Leucinodes orbonalis* Guenee in Brinjal

Divya S, J Kathiravan and VE Nethaji Mariappan

Abstract
Field experiments were carried out during the season Rabi 2016/17 at village Seetharamapuram, Perambalur, Tamil Nadu, India to evaluate the efficacy of Agro–Ecosystem Analysis (AESA) based Integrated Pest Management (IPM) practices with the farmer practice of spraying different insecticides against *L. orbonalis* on brinjal. The findings revealed that minimum brinjal shoot and fruit borer 8.9 per cent with highest abundance of parasitoids (5.82 nos.) in terms of different species occurred with least population of aphid and whitefly 2.16 and 1.19 numbers per three leaves whereas in farmers practices 25 percent incidence of brinjal shoot and fruit borer with minimum parasitoid recorded 1.15 nos and maximum population of aphid and whitefly (16.5, 14.58) respectively. The AESA based IPM practices that consisted of cultural and mechanical components itself proved to be an ideal management strategy against brinjal shoot and fruit borer along with a benefit: cost ratio of 3.03 whereas 2.19 in farmers practices.

Keywords: Brinjal shoot and fruit borer, sunflower inter crop, bhendi boder crop, light trap, pheromone traps, *Trichogramma chilonis*

1. Introduction

Brinjal (*Solanum melongena* Linnaeus) belongs to the crop family Solanaceae (Nightshade) is native to Indian Subcontinent [1, 2]. Brinjal is being cultivated since remote antiquity in Southeast Asia and as its nature that vulnerability to various weather factors becomes an important crop of tropical and subtropical countries of the world [3]. Brinjal is a major vegetable in India, Out of several factors to cause low productivity, the insect pest attack to the crop is one of the vital constraints. The brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen is the most destructive pest of brinjal. In severe infestation it causes up to 70 per cent yield loss of fruit in south and southeast Asia [4]. Damage of the pest belongs to all parts of the plants like inflorescence, fruits and shoots. Larvae bore into fruits and shoots and in younger plants, caterpillars drill into midrib of large leaves. At the time of maturity, damage of the insect on fruits causes a serious loss in yield [5].

In Perambalur district, Seetharamapuram village has the sizeable area under brinjal cultivation but the productivity level is very low due to fruit borer infestation. The magnitude of problem has been wide spread over the past years due to the monophagus pest in monoculture area. The farmers rely on using number of chemical insecticides for the management and leads to more cost of cultivation, environmental pollution, pesticide residue and reduced yield. Keeping the above point in view, the present study were under taken to evaluate the AESA based Integrated Pest Management technologies for the management against Brinjal shoot and fruit borer under real farm situation over the locally cultivated Rabi brinjal crop. Some relevant studies Islam (2017) [6] performed a research on an economic study on practicing IPM technology for producing bitter gourd in selected areas of Comilla district and the study revealed that IPM farmers gained more profit than non-IPM farmers on bitter gourd production. The average per hectare total cost of bitter gourd production was 368335 kg/q and 444508 kg/q for IPM and non-IPM farmers respectively in the study areas.

L. orbonalis is being active throughout the year and the abundance and distribution of this pest is highly influenced by meteorological parameters [7]. The management of this pest is too difficult because the larvae lie inside the fruit or shoot and the pesticide do not reach the pest directly [8]. However, farmers rely exclusively on the application of pesticides to control *L. orbonalis*, produce blemish-free brinjal fruit and get maximum yield. In the meantime, the insect is becoming tolerant to the chemicals, making it more difficult to control [9]. Apart from this the frequent uses of insecticides leave toxic residues, cause environmental pollution and health hazards. And also the indiscriminate use of toxic, broad-spectrum pesticides threatens the health of farmers and consumers, through environmental contamination, bioaccumulation and biomagnification of toxic residues, and disturbance in ecological balance [10]. Therefore, there is need to explore some environmentally safe measures for the control of this notorious pest.

2. Materials and Methods

2.1 Experimental layout

The field experiments were carried out to evaluate the efficacy of AESA based IPM technologies against *L.orbonalis* on brinjal at Seetharamapuram village, Perambalur District, Tamil Nadu, India, during the seasons *Rabi* 2016/17(November 2016 to April 2017). The experiments were conducted in ten farmers field.

T1. AESA based IPM module components

1. Cultivated bhendi plants as border crop
2. sunflower as intercrop
3. Application of neem cake @ 100 kg/acre at the time of transplanting
4. Soil test based fertilizer application,
5. The light trap, pheromone trap and yellow sticky traps installed in the field just after flowering at the height of one feet from the crop canopy for monitoring of BS&FB
6. Release of *Trichogramma chilonis* @ 3 cc/acre for 4 times at weekly interval

T2. Farmers practice component

Applied insecticides at least three times a week (*i.e.*,Repeated use of different insecticides *viz*., Chlorantraniliprole 18.5% SC, Flubendiamide 20 WG, Spinosad 2.5% SC, Chlorpyrifos 20% EC against *L. orbonalis* on brinjal)

2.2 Observations recorded

Since the date of installation of pheromone traps and light trap the observation of the trap catches were recorded every fortnight interval. The number of natural enemies prevailed and sucking pest in treated plot and farmers practice were counted at harvesting stage. The shoot damage was recorded on monthly basis from transplanting to harvest. The fruit damage was recorded at the time of each harvesting. In the farmers practice pre-treatment observations on the infestation of *L. orbonalis* were taken before spraying and all infested shoots and fruits were removed manually while pre and post treatment observations were made in weekly interval. Ten plants were randomly selected from each plot and tagged for the periodical observations on fruit damage and yield starting with the first picking/harvesting. The percentage fruit damage was estimated throughout the cropping period by using the following formula:

$$\text{Percentage of infested fruits} = \frac{\text{Sum of infested fruits in each picking}}{\text{Total no. of fruits harvested in each picking}} \times 100$$

Total yield was calculated by summing the weights of each harvest including the infested fruits, as the infested (with holes) fruits were also marketed at lower price. To justify the economic viability of the management against *L. orbonalis*, the benefit: cost (B:C) ratio was calculated from the marketable yield, regarding cost of treatments incurred in the management.

2.3 Data analysis

The homogeneity of the data was tested through paired T-test

3. Results and Discussions

Field trail was laid out in large plot area in 10 famers field during Rabi 2016-17 to evaluate the AESA based IPM module in compared with farmers practice against *L. arbonalis.*

3.1 Efficiency of *L. arbonalis* moth catches in pheromone trap and light trap

In AESA based IPM field the Pheromone trap installed @ 12/ha and light trap 1 / acre at flowering stage and the observation on moth catches recorded on every fortnight for 2 months. The moth catches in pheromone trap was recorded as (12.4, 11.7, 29.75, 5.8) respectively and moth catches in light trap was recorded as (24.5, 23.7, 11.8 and 7.8) respectively on 15, 30, 45 and 60 DAT (Table 1). Since the male moths were trapped continuously in pheromone trap after flowering it caused appropriate mating disruption resulting into reduction in shoot damage during growth period. There was highly significant positive correlation between male moth catches and shoot damage in AESA based IPM field.

Table 1: Efficiency of traps in catching fruit and shoot borer, *Leucinodes orbonalis* moths

Treatments	Traps	Average number of fruit and shoot borer moths/trap				
		15 DAT	30 DAT	45 DAT	60 DAT	Total
AESA based IPM field	Pheromone trap counts	12.4	11.7	29.75	5.8	59.65
	Shoot and fruit borer in Light trap	24.5	23.7	11.8	7.8	67.8
Farmer practice	Pheromone trap counts	-	-	-	-	-
	Shoot and fruit borer in Light trap					

3.2 Impact of natural enemy population in AESA based IPM field

The results regarding the natural enemy was higher population were observed in AESA based IPM plot than farmers practice (Table 2). The presence of lady bird beetle, green lace wing bug, bigeyed bug, preying mantids, chalcid was recorded with a mean population of 10.5, 11.01, 5.99, 4.1, 2.2 respectively during 4th week of march, 2017 in randomly selected twenty plants in AESA field and whereas in control field it where recorded as 5.8, 1.96, 1.36, 0.66, 0.6 respectively.

Table 2: Number of natural enemies in AESA based IPM field and farmers practices

SI. No	Natural enemies recorded	Population of natural enemies/plant (nos)	
		AESA based IPM field	Farmers practice
1	Coccinellids	10.5	5.58
2	Green lace wing bug	11.01	1.96
3	Big eyed bug	5.99	1.36
4	Preying mantids	4.11	0.66
5	Chalcid wasp	2.2	0.6
	Mean	5.82	1.15
	Variance	14.34	0.41
	t Stat	2.95	

3.3 Effectiveness of treatments on shoot damage

The comparative effectiveness of treatments on percent shoot infestation caused by BSFB is presented in Table 3. The percent shoot infestation was the lowest (8.5%) in AESA based IPM plots at harvesting stage and highest in farmers practice (25.00%)

Table 3: Effect of AESA based IPM on the brinjal shoot damage during Rabi 2016-17

Treatments	Shoot damage Per cent								
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	Mean	Variance	t Stat
AESA based IPM field	8.30	9.41	8.50	9.91	8.2	8.5	8.90	0.52	2.78
Farmers practice	24.20	22.60	28.80	27.50	23.72	22.40	25.00	8.71	

3.4 Impact of sucking pest Population in AESA based IPM field

A significantly large build up of natural enemies in AESA based IPM field kept low population of sucking pest like aphids and whiteflies. In the present study the average population of aphid was (2.16) and whitefly (1.19) per three leaves per plant in treatment field and high population of sucking pest aphid (16.5) and whitefly (14.56) per three leaves / plant was observed in farmers practice presented in table 4.

Table 4: Effect of intercrops and border crops on incidence of the sucking pest Aphid, *Myzus persicae* (Sulzer) and whitefly *Bemisia tabaci*.

Sucking pest	(Mean number of insect population /3 leaves/ plant) 90 DAT	
	AESA based IPM	Control
Aphid	2.16	16.5
Whitefly	1.19	14.58

3.5 Efficacy of the treatments on yield and economics

In the present study the effect of IPM treatments have directly influence on yield of brinjal, which was evaluated in terms of total yield and damaged fruit yield presented in Table 5. It is revealed that the healthy fruit yield was the highest (32.83 t ha^{-1}) whereas (23.46 t ha^{-1}) in farmers field. The lowest infested fruit yield (0.61 t ha^{-1}) was observed in treatment field and 3.56 t ha^{-1} in farmers practice (Fig.1). As the farmers practice depends heavily on the usage of insecticides for the management of shoot and fruit borer the cost of cultivation in the farmers practice is higher than the AESA based IPM module. The cost of cultivation and net return per hectare in treatment field were Rs. 330905 and Rs.657445 whereas Rs.369959 and Rs. 440791 in farmers practice (Fig.2) and favorable cost benefit ratio of 3.03 and 2.19 were recorded in treatment field and farmers practices respectively.

Table 5: Economics of AESA based IPM on shoot and fruit borer of brinjal during rabi season (2016 -17)

Treatments	Total Yield (t/ha)	Damaged fruit (t/ha)	Total cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C
AESA based IPM field	33.44	0.61	330905	1003350	657445	3.03
Farmers practice	27.02	3.56	369959	810750	440791	2.19

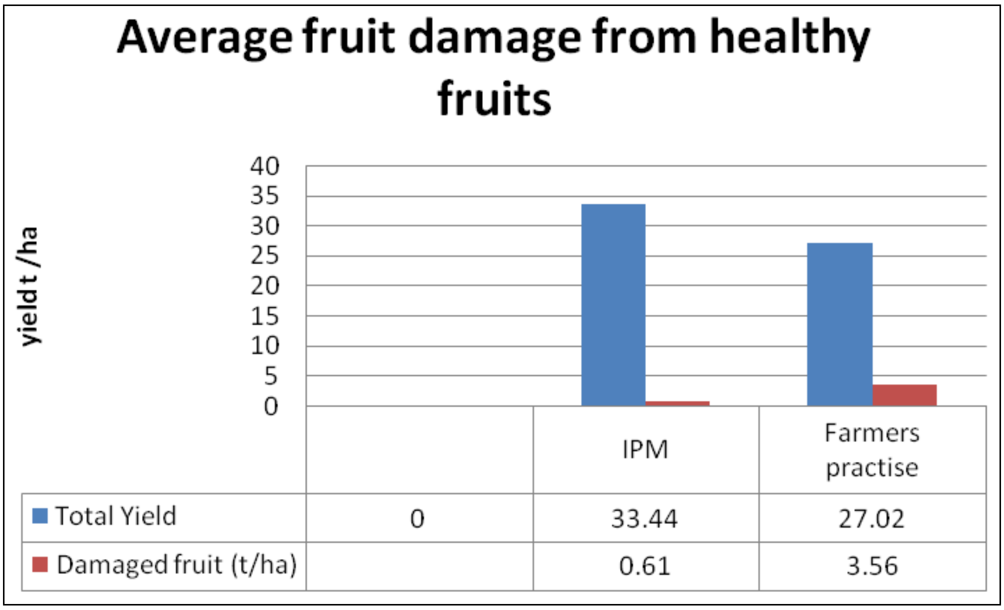

Fig 1: Damaged fruit estimation in AESA based IPM and farmers practice

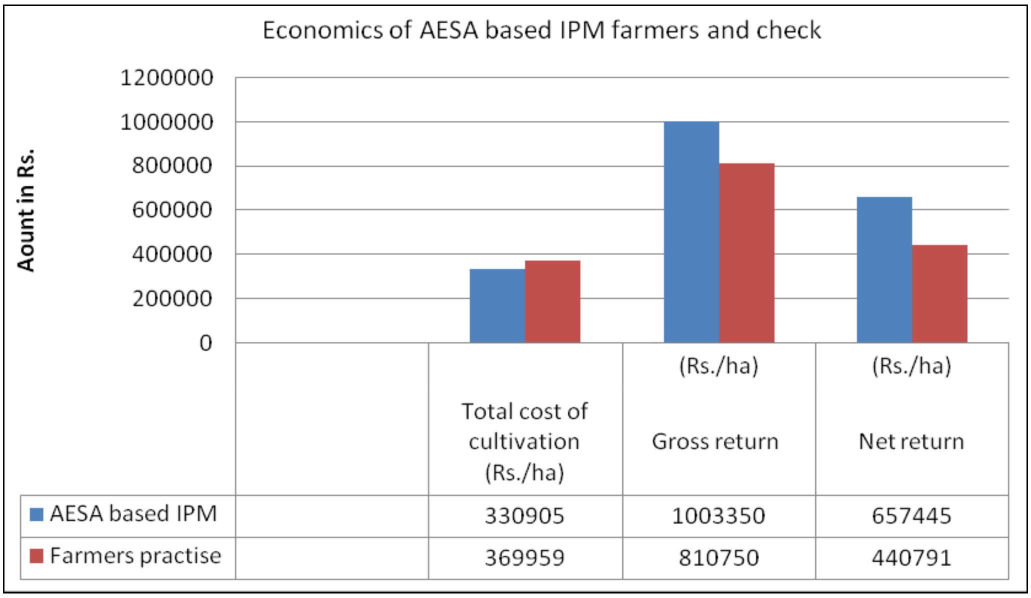

Fig 2: Economics of AESA based IPM on shoot and fruit borer with farmers practice

Almost similar findings were reported by some researchers supporting the results of the present study were as follows the IPM module plot comprises of spraying of Neem oil 3 % @ 2.5 ml/lit, placing of *L. arbonalis* pheromone trap @ 4 nos/acre from 30 DAT, release of egg parasitoid *Trichogramma chilonis* @ 1.25 lakh/ ha at weekly interval from 30 DAP, spraying of *Bacillus thuringiensis* @ 2 g/lit when egg and neonate larvae of *L. arbonalis* where observed and spraying of Flubendiamide 20 WG @ 375 g/750 lit when fruit damage exceeds 5% [11]. The biointensive approach comprises of seedling treatment with immidachloprid 200 SL, soil incorporation of neem cake, placing of yellow sticky trap, spraying of neem soap, collection and destruction of infested shoots and fruits, placing of sex pheromone traps and release of *Trichogramma chilonis* along with need based application of bio pesticide Bt or emamectin benzoate or Chlorantraniliprole 18.5 SC reduced the shoot and fruit borer damage of 9.06 and 16.53 % in kharif and 9.41 and 15.06 in Rabi season respectively with favorable benefit cost ratio of 9.14 and 9.10 during kharif and rabi season respectively [12].

The installation of pheromone trap 65 number per hectare, starting from 15 days after transplanting till final harvest and changing the lure at monthly interval gave quite substantial protection in shoot damage (58.39%), fruit damage (38.17%) and increase in yield (49.71%) over control in brinjal field [13]. In a field experiment that a predators re-colonization in the botanical-sprayed plots, while it was not so in the chemical treatment [14]. The coccinellids are the most important predators and prey upon large numbers of sucking pests like aphids, jassid, white flies and lepidopteran eggs and neonate larvae [15]. The *T. chilonis* reduced the fruit borer damage when inundatively released at the rate of 2.5-10 lakh adults ha^{-1} [16-18]. The borer damage was 19% when egg parasitoid was released @ 2.5 lakh adults ha^{-1} [19].

Fruit damage percentage was higher and percent prevention against *L. orbonalis* was lower under a continuous series of pesticide applications, i.e., farmers' practice. This might be due to a reduction of the population of natural enemies of *L. orbonalis* and the development of resistance in *L. orbonalis* against different groups of insecticides. The result revealed that the AESA based IPM practices provided a better level of control than the farmers' practice.

4. Conclusion
It is concluded that the AESA based Integrated Pest Management techniques is sufficient enough to replace the farmer's regular practice of pesticide application for reduction of shoot and fruit damage as well as yield increase.

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