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Study of some rational IPM modules to manage tomato fruit borer (*Helicoverpa armigera* Hub.) during rabi season under red and Lateritic zone of West Bengal

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Abstract
Effectiveness of selected IPM modules was evaluated against *H. armigera* on tomato under field conditions at the farmer's field at Binuria village near the Sriniketan of Birbhum District of West Bengal, for a year 2015-16 on tomato. The test variety was selected for the study was *Patharkuchi*, were transplanted in field in randomized complete block design. Nine modules with a non IPM module were evaluated over control and cost benefit ratio of these modules was also estimated. Seven modules were tested with integration of three control strategies i.e., use of Neem seed cake, Bird parching and use of *Beauveria bassiana* as biocontrol agent except in non IPM and control one. Seven modules included with pesticide of different mode of action, i.e. bio pesticides like *B. bassiana*, *B. thuringiensis* and HaNPV and chemical pesticide like Emmamectin benzoate, Spinosad, Flubendiamide, Rynaxypyr respectively. The Non IPM modules contains only chemical component, Cypermethrin. Results revealed that all IPM modules were effective than control in reducing fruit damage by *H. armigera.* However, maximum tomato yield (22.55 t ha-1) was obtained in M4 (use of Emmamectin benzoate was integrated with other control strategies) with highest incremental cost benefit ratio (2.35). It was concluded that integration of different control measures along with judicial use of pesticide in IPM program not only reduced fruit losses but also increased yield and net return.

Keywords: *H. armigera*, Neem seed cake, Bird parching, *Beauveria bassiana*, new generation chemical pesticides

Introduction
Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular and widely grown vegetable crops in the world. Tomato production has been intensified over the years, however, yields continue to be low due to several production constraints such as pests, diseases and environmental factors [1]. Tomato fruit borer (*Helicoverpa armigera* Hub.) is the major pest that causes significant yield losses in tomato [3]. *H. armigera* feeds on both tomato foliage as well as fruit thereby affecting fruit quality both from human consumption and marketing point of view [2]. The tomato fruit borer, *Helicoverpa armigera (*Hubner) is a key pest as it attacks the cashable part of the plant i.e. fruits and makes them unfit for human consumption causing considerable crop loss leading up to 55 per cent [4]. It has been estimated that the crops worth Rs.1000 crore are lost annually by this pest [5].

The management of fruit borer through non chemical strategy has been undertaken by the many researchers throughout the world is limited. Hence, the use of chemical insecticides is regarded to be the most useful measure to combat this pest. The only common method for controlling tomato fruit borer in India is the application of chemical insecticide which is now indispensable in vegetable crop protection due to its rapid effect, ease of application and availability. But the excessive use of synthetic pesticide not only causes various environmental and health problems [6] but also result in the development of pesticide resistance in pests [7]. Surprisingly, most of the vegetable growers apply almost 10-12 sprays in a season. Thus, the fruits, which are harvested at the short intervals, are likely to retain unavoidably high level of pesticide residues which may be highly hazardous causing serious problems including pest resistance, pest outbreak, pest resurgence and environmental pollution [9].

The concept of Integrated Pest Management (IPM) is becoming a practicable and acceptable approach over the world. The idea is to maintain the pest population below economic threshold rather than eradicate it.

The best insect pest management in terms of economics & maintenance of pest population below threshold level can be achieved by studying the fluctuation of pest population in relation to weather factors as well as physiological stages of crop and integrating different pest control tactics to hit upon on life cycle of the pests in right time. In IPM all the available control measures are usually focused for pest suppression in such a way that pesticide becomes the last option. In IPM, use of pesticide is at least minimized, if cannot be avoided altogether [8]. In the present study, various control measures (Neem seed cake, Bird parching, use of *Beauveria bassiana* as biocontrol agent and use different group pesticide) were combined together for the management of *H. armigera* on tomato crop, in order to minimize the use of pesticide. Therefore, the present study was designed to evaluate different IPM modules for the management of pest problem with least or no pesticide usage.

Materials and methods

The field experiment was laid out at the farmers' field at Binuria village near Sriniketan of Birbhum District of West Bengal, for a year 2015-2016 on tomato. The test variety was selected for the study was *Patharkuchi*, a promising, locally accepted tomato variety with fruits of medium sized, was sown in a Randomized Block Design with nine treatments including control and three replications in the seasons. Seeds were collected from the local sources and these were sown separately on raised seedbeds of 1m x 2m area in lines with a gap of about one foot to avoid any hazards of mix up of the main experimental field. The crop has been raised following standard agronomic practices.

IPM modules

Table 1: Different pest management modules used for sustainable pr oduction of tomato

IPM Module	Application of neem seed cake @ 6 q/ha during transplanting	Bird parching @ 75/ha	Spraying of insecticides	
			1st spray at 45DAT	2nd, 3rd and 4th sprays at 15 days interval from 60 DAT
M1	Yes	Yes	*B.bassiana*@1 ml/l	*B.bassiana*@ 1 ml/l
M2	Yes	Yes	*B.bassiana*@1 ml/l	*B.thuringiensis*@ 1 ml/l
M3	Yes	Yes	*B.bassiana*@1 ml/l	HaNPV@2ml/l
M4	Yes	Yes	*B.bassiana*@1 ml/l	Emamectin benzoate @ 0.5 gm/l
M5	Yes	Yes	*B.bassiana*@1 ml/l	Spinosad @ 0.3 ml/l
M6	Yes	Yes	*B.bassiana*@1 ml/l	Flubendiamide@ 0.2 gm/l
M7	Yes	Yes	*B.bassiana*@1 ml/l	Rynaxypyr@ 0.3 ml/l
M8 (Non-IPM)	No	No	Cypermethrin@1 ml/l	Cypermethrin@ 1 ml/l
M9 (Control)	No	No	No	No

Sampling of fruit borer for IPM modules experiment

To study bio-efficacy of different insecticides against the fruit borer was studied and observations on population of pests were recorded one day before each spraying as pre-treatment count as well as 3, 7 and 14 days after spraying. Second spraying of insecticides was done at 60 DAT when uniform insect population was observed in all the treatments. Third and fourth spraying were done at 15 days interval. For recording the pest population, five plants were selected randomly from inner rows and tagged in each plot. The data on larval population were examined carefully in each tagged plant and averaged to get number of larvae/plant/plot. These bioassay data were subjected to analysis of variance after making necessary transformation for comparison of treatment means while fruit damage were recorded though counting of total number of fruits and number of damaged fruits and statistically analysed with arc sine values obtained from the conversion of percentage of infestation (Gomez and Gomez, 1984). Reduction of borer population in different treatments over control was computed from the formula as described by (Flemming & Retnakaran, 1985).

$$\text{Population reduction over control (\%)} = \left(1 - \frac{\text{Post-treatment population in treatment}}{\text{Pre-treatment population in treatment}} \times \frac{\text{Pre-treatment population in untreated control}}{\text{Post-treatment population in untreated control}}\right) \times 100$$

Observations on yield of tomato

First plucking of fruits was made at 60 DAT and successive plucking was done at regular interval. Fruit yield of each plot was taken from whole population separately and total yield of each treatment was calculated by cumulating the successive picking from respective plots. Thereafter, yield per plot was computed to ton per hectare. To compare the yield performance of tomato in different treatments, analysis of variance was carried out in randomized block design. The per cent increase of yield in treatment over control was calculated from the following formula (Vanisree *et al.*, 2013).

$$\text{Percentage increase of yield in treatment over control} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

Analysis of incremental benefit-cost ratios (ICBR) was carried out to find out the cost effective treatment. The analysis was done by estimating different cost of cultivation and return from fruit yield in each treatment after converting them to one hectare of land and the ratio was calculated using following formula:

$$\text{ICBR} = \frac{\text{Net gain in treatment}}{\text{Total cost in treatment}}$$

Where, Net gain in treatment = Realization over control – Total cost in treatment

Realization over control = Total gain in treatment – (Total gain in control- Total cost in control)

Results and Discussion

Efficacy study of different modules

Nine modules consisting of 7 IPM modules and one non-IPM module including control were evaluated against *H. armigera*. First spraying was applied as a prophylactic measure. After which, three more sprays with different insecticides were resorted to manage the population of noxious pest.

Pre-treatment count revealed that before 2nd spraying larval population of *H. armigera* was significantly lower in all the pest management modules as compared to control plots. Insecticidal intervention resulted in further reduction of fruit borer population.

Table 2 depicted almost similar trends during subsequent spraying. The fruit borer population was significantly lower in different modules as compared to control and all pest management modules supported better protection against *H. armigera* during the entire observational period. Module M4 proved best effective among all modules followed by module M7, M6 and M5. Besides, the modules containing microbial insecticides gave reasonable protection against the fruit borer population but proved slightly less efficacious as compared to non-IPM module. The percent protection offered by different modules was in order of M4 (86.01%)> M7 (74.63%)> M8 (69.56%) > M6 (67.67%)> M5 (63.72%)>M2 (56.03%)>M3 (53.35%)> M1 (53.12%). The present findings were in agreement with Eckel *et al*. (1996) who recorded emamectin benzoate 0.16 EC most effective when applied @ 0.01 Ib a.i/ac against tomato fruit worm, *H. zea* at Florida.

Table 2: Efficacy of different modules against larval population development and their corresponding fruit damage.

Modules	No of larvae /plant			Mean larval population	% reduction over control after final spraying
	2nd spray	3rd spray	4th spray		
M1	1.01	0.70	0.38	0.70	53.12
M2	0.87	0.54	0.24	0.55	56.03
M3	0.95	0.61	0.29	0.62	53.35
M4	0.56	0.15	0.02	0.24	86.01
M5	0.79	0.31	0.11	0.40	63.72
M6	0.69	0.27	0.08	0.35	67.67
M7	0.65	0.22	0.05	0.31	74.63
M8 (Non-IPM)	0.81	0.35	0.12	0.43	69.56
M9 (Control)	3.67	3.45	2.17	3.10	-

Economics of different pest management modules and fruit yield of tomato

Fruit yield of corresponding to different modules were statistically analysed and presented in Table 16 and Fig.5. All the modules produced significantly higher yield than the untreated control. The highest yield was obtained in M4 (22.55t/ha) which was statistically significant with almost all the modules except the module M7 (21.47t/ha). The results indicated that the M4 was reasonably effective against the sucking pest and highly effective against the fruit borer which proved highly destructive to tomato crop. Analysis of incremental cost-benefit ratio revealed the superiority of M4 module over other Modules. The Incremental cost benefit ratio was in order of M4 (2.35) > M7 (2.14) > M8 (2.12) > M6 (2.04) > M5 (1.96) > M2(1.58) > M3(1.36) and M1(1.32). The present finding was in corroboration with Walgenbach and Estes (1992) who reported that insecticides vizendosulfan, fenvalerate and methomyl found more profitable than carbaryl and *B. thuringiensis.*

Table 3: Fruit yield and economics of tomato cultivation in different modules during 2015-2016

Modules	Production cost (Rs/ha)	Plant protection cost (Rs/ha)	Total cost (Rs/ha)	Yield (t/ha)	% Yield increase over control	Gross realization (Rs/ha) @ Rs. 18000/t	Net realization over control (Rs/ha)	Net gain (Rs/ha)	ICBR
M1	70000	14440	84440	16.27	84.09	244102.5	196017.5	111577.5	1.32
M2	70000	14345	84345	17.73	100.53	265905	217725	133380	1.58
M3	70000	15510	85510	16.59	87.64	248805	201790	116280	1.36
M4	70000	17615	87615	22.55	155.12	338295	293385	205770	2.35
M5	70000	18750	88750	20.41	130.84	306090	262315	173565	1.96
M6	70000	16520	86520	20.59	132.88	308797.5	262792.5	176272.5	2.04
M7	70000	18435	88435	21.47	142.87	322050	277960	189525	2.14
M8 (Non-IPM)	70000	3400	73400	19.22	117.40	288277.5	229152.5	155752.5	2.12
M9 (Control)	70000	-	70000	8.84	-	132525	-	-	-
SEm (±)				0.403					
CD (p=0.05)				1.21					
CV (%)				13.34					

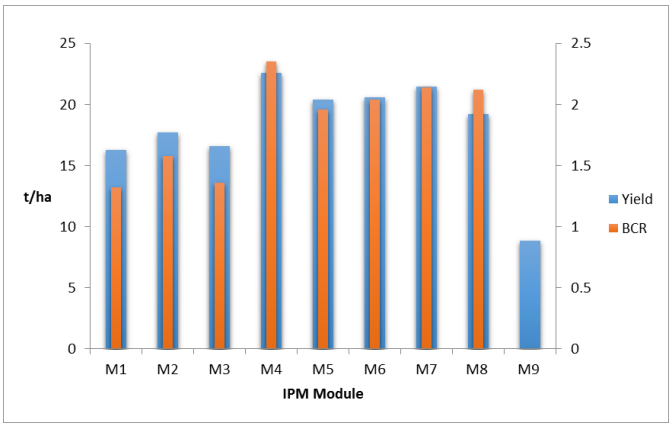

Fig 1: Fruit yield of tomato and Incremental cost-benefit ratio in different IPM module

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