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Integrated management of thrips-mite and borer complex attacking chilli

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Abstract
Thrips, mite and borer complex are the most serious insect pests which reduce chilli yield remarkably in many chilli growing areas. This study exposed that sustainable bio-rational based management packages including different mechanical approaches and bio-pesticides were effective against Thrips, mite and borer pests in chilli. The results indicated that, spraying of Sodium lauryl ether sulphate (Fizimite) and Matrine (Biotrin) along with blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* was most effective against Thrips, mites and borer pests. The lowest number of Thrips and fruit borer infestation was observed from spraying of Sodium lauryl ether sulphate (Fizimite) and Matrine (Biotrin) along with blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* treated plots. The highest yield (20.93 t/ha) and net income (145525 Tk/ha) were also obtained from spraying of Sodium lauryl ether sulphate (Fizimite) and Matrine (Biotrin) along with blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* treated plots. Only application of chemical insecticides is not effective against the insect pest's population in a long-term. In contrast, mechanical approaches such as sticky trap, pheromone trap as well as different bio-pesticides are environmental, economical, dependable and that facilitate the Integrated Pest Management (IPM) concept.

Keywords: Chilli, thrips, mite, borer complex, management

Introduction
Chilli is a well-known versatile crops. It is used as vegetable, spice, condiment, sauce, pickles and medicine. Chilli is widely cultivated in all parts of Bangladesh. Area under both summer and winter chilli is about 96900 hectares with an annual production of dry chilli 157607 tons during 2019-20 in Bangladesh [1]. Among the numerous causes liable for low production of chilli, the insect pests are of major threat, which largely affect the yield. Chilli crop is infested with Thrips and mite starting from seedling stage in nursery to harvesting of crop in field. In addition to these, pod borers including *Helicoverpa armigera* and *Spodoptera litura* also cause serious destruction to the crop during different cropping stages. Thrips, mite and borer complex cause severe damage in chilli crop and reduce its yield. Thrips, mite and borer complex are responsible to crop loss about 30-50%, 30-70% and 30-40% respectively [2]. For controlling insect pests, farmers frequently apply large quantities of toxic chemical insecticides which cause health hazard to non-target animals, resurgence and pest resistance [3].
Chilli growers used to spray more than six times of toxic chemical pesticide apply for controlling insect pests, the frequency of sprays have been increased day by day and because of that, production cost has also been increased massively creating the production of chilli extremely hazardous and non-profitable. The residual effect of chemical pesticide in chilli is also a great concern from the point of exports and domestic consumption as well. The extensive and indiscriminate use of toxic chemical pesticide is a continuous risk to the human health and environment [4]. The non- judicial application of chemical pesticides leads to increase the residues in the soil. It also serves as a powerful selection pressure for altering the genetic makeup of a pest population, leading to the development of resistance [4]. Resistance to different specific insecticides including pyrethroids, organophosphorus and carbamate groups in common cutworm created sporadic out breaks and significantly catastrophe of the crop [5, 9]. It is also creating a great risk to cultivate the tomato, cabbage, aroids, cauliflower, jute, chilli,

Etc. As poisonous pesticides have harmful effects for controlling insect pests, it becomes imperative to search for alternative methods that are sustainable, dependable, ecologically sound and economical as well.

IPM technologies included bio-pesticides and other mechanical approaches can be the alternative of chemical pesticides for controlling insect pests. Bio-pesticides such as sodium lauryl ether sulphate and Bt + Abamectin suggested for a sustainable management option for controlling sucking insect pests of the betel vine [10]. However, bio-pesticides Matrine can effectively control Thrips and different Lepidopteran borer insect pests [11, 13]. The combination of different IPM components can control insect pests of chilli through eco-friendly, efficiently and economically. Presently our farmers have no suitable and effective IPM management options against Thrips, mite and borer pests.

In this study, IPM technology has been developed to enhance the supply of nontoxic chilli for both abroad and national market. Here we have showed that the IPM approaches through bio-pesticides, other mechanical and cultural practices were effective against Thrips, mite and borer pests such as *Spodoptera litura* and *Helicoverpa armigera* in chilli.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Burirhat, Rangpur during the rabi season of 2020-21 for determining suitable management approach for controlling the Thrips, mite and borer complex in chilli. There were five treatments *viz*. T_1 = Blue sticky trap @ 40 Nos./ha + Spraying of Sodium lauryl ether sulphate (Fizimite) @ 1 ml/L of water thrice starting from the first appearance of Thrips or mite infestation at 10 days interval + Pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* @ 40 Nos./ha + Matrine (Biotrin) @ 1.5 ml/L of water thrice during visible borer infestation at 10 days interval, T_2 = Spraying of Matrine and plant oil (K-mite) @ 1 ml/L of water and application of soil recharge @ 5 gm/L of water thrice starting from the first appearance of Thrips or mite infestation at 10 days interval + Pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* @ 40 Nos./ha + Application of HNPV @ 0.1 g/L of water and SNPV @ 0.2 g/L of water thrice during visible borer infestation at 10 days interval, T_3 = Spraying of Abamectin (Ecomec 1.8 EC) @ 1 ml/L of water thrice starting from the first appearance of Thrips or mite infestation at 10 days interval + Pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* @ 40 Nos./ha + Application of HNPV @ 0.1 g/L of water and SNPV @ 0.2 g/L of water thrice during visible borer infestation at 10 days interval, T_4 = Alternative spraying of Chlorfenapyr (Intrepid 10 SC) @ 1.2 ml/L of water and Abamectin (Ecomec 1.8 EC) @ 1 ml/L of water thrice starting from the first appearance of Thrips or mite infestation at 10 days interval and T_5 = Untreated control. The experiment was laid out in a randomized complete block (RCB) design with 3 replications. The chilli variety was BARI Morich-3. The seeds were sown in the seed bed and they were transplanted in the experiment field after 40 days. The unit plot size was 3m x 3m with a plant to plant spacing of 50cm apart maintaining a row to row distance of 50cm. Sticky and pheromone traps were placed starting from two weeks after transplanting. At least 500m distance were maintained between without sex pheromone and sex pheromone plots. Data on number of Thrips were recorded from 15 cm upper twig per plant from randomly selected 5 plants per plot. A piece of white paper was placed below the 15 cm twig and five equal pressures put on the twig with finger then fallen number of Thrips were recorded. For mite population, three leaves (From top, middle and bottom) were carefully selected from each plant and five plants were recorded from each experimental plot. The collected leaves were carried to the laboratory for further recording underneath bright field compound microscope (40X) (Olympus-CX21). Number of Thrips and mite were recorded a before spraying and at an interval of 3 and 7 days after spraying. Three sprays were done at 15 days interval in the study. The number and weight of healthy and borers infested fruits were counted and recorded during each harvest. Data were analyzed through IBM SPSS and subjected to one way ANOVA. Means were separated using the Tukey test. The gross economic return was calculated on the basis of prevailing market price of the commodities. According to Henderson and Tilton [14], the percentage reduction in Thrips and mite population were measured.

Results

In many cases the increasing and indiscriminate use of synthetic insecticides have totally failed to control the pests as the pest populations are growing resistant to the used pesticides and causing non-profitable crop production system. In this perspective, the effectiveness of different treatments including sustainable management options with bio-rational management were carefully considered and confirmed in contrast with untreated control are given here.

Effectiveness of various management options against chilli Thrips

Effectiveness of various management options against chilli Thrips is demonstrated in Table 1. The average Thrips population per 15 cm twig before treatment application ranged between 2. 93-4. 45. From the results it was shown that mean number of Thrips was the lowest (1.02 Thrips/15 cm twig) in T_1 (Blue sticky trap + Fizimite + Pheromone mass trapping + Biotrin) treated plots with population reduction of 69.26% on the third day after treatment application (DATA) and it was followed by T_3 (Abamectin + Pheromone mass trapping + HNPV+ SNPV) treated plots with population reduction of 57.97% and T_4 (Chlorfenapyr + Abamectin) treated plots with population reduction of 57.82%. The untreated control exhibited significantly highest Thrips per 15 cm twig (5.04 Thrips/15 cm twig). After 7th days of treatment application, mean number of Thrips was the lowest (1.25 Thrips/15 cm twig) in T_1 (Blue sticky trap + Fizimite + Pheromone trapping + Biotrin) treated plots with population reduction of 67.67% and it was followed by T_4 (Chlorfenapyr + Abamectin) treated plots with population reduction of 59.95% and T_3 (Abamectin + Pheromone trapping + HNPV+ SNPV) treated plots with population reduction of 57.60%. The untreated control treatment showed significantly highest Thrips per 15 cm twig 5.04 and 5.87 at third and seventh day after treatment respectively.

Table 1: Effectiveness of different management options against Thrips on chilli at RARS, Burirhat, Rangpur during 2020-21 cropping season

Treatments	Pretreatment count (Thrips/15 cm twig)	Mean no. of Thrips population/15 cm twig		Overall mean no. of Thrips/ 15 cm twig	Reduction of Thrips population over control (%)		Overall reduction of Thrips (%)
		3 Data	7 Data		3 data	7 Data	
Blue sticky trap + Fizimite + Pheromone trapping + Biotrin	2.93±0.04 b	1.02±0.06c	1.25±0.12c	1.14	69.26	67.67	68.47
K-mite + Soil recharge + heromone trapping + HNPV+ SNPV	4.09±0.50ab	2.07±0.08b	2.55±0.10b	2.31	55.31	52.73	54.02
Abamectin + Pheromone trapping + HNPV+ SNPV	3.97±0.25ab	1.89± .19b	2.22±0.10b	2.96	57.97	57.60	57.79
Chlorfenapyr + Abamectin	3.16±0.12b	1.51± .23bc	1.67±0.04c	1.59	57.82	59.95	58.89
Untreated Control	4.45±0.14a	5.04±0.15a	5.87±0.12a		-	-	-

Data = Days after treatment application± Corresponds to standard error

Effectiveness of various management options against chilli mite

Effectiveness of various management options against chilli mite is demonstrated in Table 2. The average mite population per leaf before treatment application ranged between 0.34-0.59. It was shown that on the third day after treatment application, mean mite population was the lowest (0.09 mite/leaf) in T_2 (K-mite + Soil recharge + Pheromone mass trapping + HNPV+ SNPV) treated plots with population reduction of 80.77%, followed by T_1 (Blue sticky trap + Fizimite + Pheromone mass trapping + Biotrin) treated plots with population reduction of 73.33% and T_3 (Abamectin + Pheromone mass trapping + HNPV+ SNPV) treated plots with population reduction of 62.86%. The untreated control demonstrated significantly highest mite per leaf (0.77 mite/leaf). After 7th days of treatment application almost similar trend of results were also observed.

Table 2: Effectiveness of different management options against mite on chilli at RARS, Burirhat, Rangpur during 2020-21 cropping season

Treatments	Pretreatment count (mite/leaf)	Mean no. of mite population/leaf		Overall mean no. of mite/leaf	Reduction of mite population over control (%)		Overall reduction of mite (%)
		3 Data	7 Data		3 Data	7 Data	
Blue sticky trap + Fizimite + Pheromone trapping + Biotrin	0.39±0.02b	0.13±0.01bc	0.21±0.02b	0.17	73.33	68.42	70.88
K-mite + Soil recharge + Pheromone trapping + HNPV+ SNPV	0.34±0.04b	0.09±0.01c	0.14±0.02b	0.12	80.77	75.76	78.27
Abamectin + Pheromone trapping + HNPV+ SNPV	0.45±0.02ab	0.22±0.01bc	0.28±0.02b	0.25	62.86	61.36	62.11
Chlorfenapyr + Abamectin	0.47±0.04ab	0.24±0.03b	0.32±0.02b	0.28	61.11	58.70	59.91
Untreated Control	0.59±0.06a	0.77±0.05a	0.97±0.08a		-	-	-

Data = Days after treatment application± Corresponds to standard error

Effectiveness of various management options on borer insect pests of chilli and yield

The lowest fruit borer infestation by number (1.82%) and weight (1.66%) were obtained from T_1 (Blue sticky trap + Biotrin + Pheromone mass trapping + Fizimite), followed by T_2 (K-mite + Soil recharge + Pheromone mass trapping + HNPV+ SNPV) and T_3 (Abamectin + Pheromone mass trapping + HNPV+ SNPV). The highest yield (20.93 t/ha) was obtained from T_1 (Blue sticky trap + Biotrin + Pheromone mass trapping + Fizimite) (Table 3).

Economic returns under different treatments are demonstrated in Table 4. Economic returns under different treatments was varied depending on market price of the commodities. The highest net income (145525 Tk/ha) and marginal benefit cost ratio (4.62) were obtained from T_1 (Blue sticky trap + Biotrin + Pheromone mass trapping + Fizimite).

Table 3: Effectiveness of different management options against borer pests on chilli at RARS, Burirhat, Rangpur during 2020-21 cropping season

Treatments	% Fruit infestation (By no.)	% Fruit infestation (By wt.)	Yield (t/ha)
Blue sticky trap + Fizimite + Pheromone trapping + Biotrin	1.82 ± 0.24d	1.66 ± 0.14d	20.93 ± 0.81a
K-mite + Soil recharge + Pheromone trapping + HNPV+ SNPV	2.46 ± 0.31cd	2.37 ± 0.16d	19.33 ± 0.67ab
Abamectin + Pheromone trapping + HNPV+ SNPV	4.21 ± 0.01c	3.95 ± 0.07c	16.53 ± 0.58b
Chlorfenapyr + Abamectin	6.81 ± 0.67b	6.36 ± 0.60b	15.73 ± 0.71bc
Untreated Control	9.43 ± 0.35a	8.65 ± 0.40a	12.08 ± 1.09c

± Corresponds to standard error

Table 4: Cost and return analysis of different treatments assigned for the management of different insect pests of chilli at RARS, Burirhat, Rangpur during 2020-21 cropping season

Treatments	Yield (t/ha)	Addl. yield over control (t/ha)	Addl. income over control (Tk/ha)	Cost of insecticide appl.(Tk/ha)	Net income (Tk/ha)	Mbcr
Blue sticky trap + Fizimite + Pheromone trapping + Biotrin	20.93	8.85	177000	31475	145525	4.62
K-mite + Soil recharge + Pheromone trapping + HNPV+ SNPV	19.33	7.25	145000	50650	94350	1.86
Abamectin + Pheromone trapping + HNPV+ SNPV	16.53	4.45	89000	34900	54100	1.55
Chlorfenapyr + Abamectin	15.73	3.65	73000	13080	59920	4.58
Untreated Control	12.08	-	-	-	-	-

MBCR = Marginal benefit cost ratio Cost relevant materials or activities:

Farm gate price of chilli = Tk. 20/Kg, Sex pheromone = Tk. 30/lure, Cost of trap and soap water = Tk. 100/trap, Blue sticky trap= Tk. 40/trap, Trap management = 12 labour/ha, Fizimite = Tk. 400/100ml, K-mite = Tk. 4500/L, Ecomec = Tk. 200/100ml, Soil recharge = Tk. 1600/kg, SNPV = Tk. 34000/Kg, HNPV = Tk. 38000/Kg, Biotrin = Tk. 3500/L, Intrepid 10 SC = Tk. 130/50ml, 2 Labour required for per ha spray, Labour wage = Tk. 450/day/laborer (8 hours day), Spray volume required = 500L/ha

4. Discussion

Thrips, mite and borer pests in chilli were effectively controlled through integrated pest management approaches including bio-pesticides and other mechanical practices such as sticky trap [15, 17]. In this study, our results demonstrated that the lowermost Thrips population was documented from the blue sticky trap and pheromone mass trapping along with spraying of Fizimite and Biotrin treated plots (Table 1). Up to date, a small number of reports have been available on bio-rational based management of chilli Thrips. Hossain *et al*. [10] have reported that alternate application of Antario and Fizimite were found effective against betel leaf sucking insect pest. Celiz *et al*. [11] have stated that Thrips were successfully controlled by bio-pesticide called Matrine. Mannan, *et al*. [17] showed that spraying of bio-pesticides along with the sticky traps were effectively controlled Thrips in chilli, in agreement with our results. Our results showed that the lowest mite population was recorded from the treatment spraying of K-mite, Soil recharge, HNPV and SNPV along with pheromone mass trapping which was statistically similar with the spraying of Fizimite and Biotrin along with the blue sticky trap and pheromone mass trapping (Table 2). Biopesticide such as Fizimite was found effective for managing sucking pest like red mite [10].

After fruit setting, borer insect pests such as *Helicoverpa armigera* and *Spodoptera litura* infest chilli fruits. It was found that the lowest percentage of infested fruits by number and weight as well as highest yield were found from the blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* along with application of Fizimite and Biotrin treated plots which was statistically similar with the treatment spraying of K-mite, Soil recharge, HNPV and SNPV along with pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura*. The highest net income and marginal benefit cost ratio were obtained from the treatment spraying of Fizimite and Biotrin along with the blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura*. Matrine is an effective biological insecticide which can effectively control different Lepidopteran borer insect pests [12, 13]. Borer insect pests of chilli are successfully managed through spraying of HNPV and SNPV along with pheromone trapping of *Spodoptera litura* and weekly release of a larval parasitoid, *Bracon hebetor* [18]. Pheromone mass trapping was reported to control a wide range of insect pest such as Dipteran, Lepidopteran, Homopteran and Coleopteran [19, 20]. In the same way, target insect pests population was declined by long-term use of pheromone based management option [21, 22]. In our study, it has been revealed that application of different bio-pesticides along with mass trapping of insect pests was found an effective sustainable management package against chilli insect pests which was supported by the above authors.

Conclusion

Our results showed that spraying of Sodium lauryl ether sulphate (Fizimite) and Matrine (Biotrin) along with blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* was most effective against Thrips and borer complex of chilli. Whereas, spraying of Matrine and plant oil (K-mite), soil recharge, HNPV and SNPV along with pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* was more effective against mite but statistically similar with spraying of Sodium lauryl ether sulphate (Fizimite) and Matrine (Biotrin) along with blue sticky trap and pheromone mass trapping *Helicoverpa armigera* and *Spodoptera litura* treated plots. The higher yield and net income were obtained from spraying of Sodium lauryl ether sulphate (Fizimite) and Matrine (Biotrin) along with blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* treated plots. From the above results it may be concluded that thrice sprayed of Sodium lauryl ether sulphate (Fizimite) @ 1 ml/L of water starting from the first appearance of Thrips or mite infestation at 10 days interval and thrice sprayed of Matrine (Biotrin 0.5%) @ 1.5 ml/L of water during visible borer infestation at 10 days interval along with blue sticky trap and pheromone mass trapping of *Helicoverpa armigera* and *Spodoptera litura* were most effective against Thrips, mite and borer complex of chilli in respect of reducing major insect pests infestation with higher yield and economic returns. From the above viewpoint, we hope this study will be very useful for developing sustainable management tactics for different insect pests of chilli using different bio-pesticides, pheromone trap and sticky trap.

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