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Sustainable management approach for sucking pests control in betel leaf of Bangladesh

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Abstract

Background: Betel leaf is the oldest and now highly paid farmer's crop, but the most vulnerable to insect pests, leading to massive yield drops in Bangladesh. For this reason, the experiment was carried out at the Spices Research Centre, Bangladesh, during the period of January 2018 to December 2018 and to assess the effectiveness of the different bio-rational approach against the betel leaf sucking pests. In this study, BARI Paan-3 was used as a test crop. Studies were important that sucking insect pests to include red mite population (black fly, white fly, red mite and mealy bug) has been found actively around the year in Bangladesh.

Results: Studies have shown that sucking insect population (black fly, white fly, red mite and mealy bug) has been found actively year round, whereas the maximum (22.7, 17.2, 16.1, and 14 adult/vine) and minimum (3.2, 2.8, 2.6, and 1.5 adult/vine) were recorded during the month of October and January, respectively. The results explored that the significant variations and the R^2 value suggested that biotic factor contributes 57.9, 50.9, 51.3, and 53.7% variations in black fly, white fly, red spider mite, and mealy bug population. Among approaches, the highest mortality rate (80.56, 84.73, 82.44, and 90.96%) of black fly, white fly, red mite, and mealy bug over untreated control with maximum vine yield (18.61 t/ha) is recorded from sanitation + three alternate spraying of fizimite and antario.

Conclusions: It had concluded that sanitation of betel leaf garden along with three alternate spraying of fizimite (sodium lauryl ether) at 1 ml/l and antario WP (Bt + abamectin 0.1%) at 0.5 g/l recommended for an effective management of the betel vine sucking pest complex.

Keywords: Betel leaf, Bio-rational, Strategy, Sucking pest

Introduction

Betel vine (*Piper betle* L.) is a perennial evergreen shade loving creeper belonging to the family *Piperaceae*. It is a highly remunerative crop to the farmers of Bangladesh. Betel vine is commercially cultivated in the moist, tropical, and sub-tropical regions of Bangladesh, India, and Sri Lanka and to a limited extent in some other Asian countries (Maiti and Saikia 2002). It plays a vital role in agriculture as well as in the economy of Bangladesh. It is highly labor-intensive and one-hectare betel vine that can generate 5000 working days in a year (Acharjee et al. 1988). The vine cultivated traditionally over the years without any improved package of practices (Guha 2006). It is known that the extract of betel leaves has antioxidant property due to the presence of chevibetol (CHV), allylpyrocatechol (APC), (Choudhary and Kale 2002; Rathee et al. 2006), anti-carcinogenic properties due to the presence of hydroxyl-chavicol (Amonkar et al. 1986; Bhide et al. 1991) and also has hypolipidemic activity (Gramza and Korczak 2005) and antibacterial activity (Nalina and Rahim 2007; Bissa et al. 2007; Ramji et al. 2002). Researches in the recent past explore the

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scientific basis of the traditional uses of this plant as well as discovering new molecules in betel vine, which can be used as medicine. The crop is subjected to attack by large no. of insect pests causing huge loss in leaf yield (Nikam et al. 1958). The white and black fly, red mite, and mealy bug have been identified as the significant constraints in increasing the leaf yield of betel vine (Giri 1995; Jana 2006). To get rid of their infestation, farmers used to apply a minimum of 5 to 6 times of pesticide sprays, and the number of sprays are increasing over the years, and hence, the cost of cultivation has increased enormously making cultivation of betel leaf highly risky and non-profitable. This results in abatement in the biodiversity of natural enemies' vis-a-vis outbreak of secondary pests. In the recent past, the development of resistance to pesticides, pesticide-induced resurgence, and contamination of food and eco-system are problems incurred due to pesticide management. Pesticide residues in betel leaf are also of great concern from the point of domestic consumption and exports as well. Chemical insecticide results in the destruction of beneficial organisms, flora, and fauna. Cost-effective crop production requires a combination of optimum use of chemical and non-chemical techniques of pest management. Bio-rational management approach in recent years has gained importance in overcoming these problems. However, there are no studies done in Bangladesh on population buildup and management of sucking insects through the bio-rational approach. This study is therefore undertaken to study the population buildup of sucking insects as influenced by climatic factors and to evaluate the efficacy of different bio-rational-based management approaches against sucking insect pest complex of betel leaf.

Materials and method

The field study was conducted in 7 years old standing betel vine boroj at Spices Research Centre, BARI, Shibganj, Bogura, Bangladesh (geographic coordinates 25.0167°N, 89.3167°E), during January 2018–December 2018 to study the population buildup of sucking insect pests as influenced by climatic factors and to evaluate the efficacy of different bio-rational-based management approaches against sucking insect pests complex of betel leaf. The experimental plot was prepared with five ploughings and cross ploughings followed by laddering to break the clods as well as to level the soil. The weeds and stubbles of previous crops were collected and removed from the soil. The unit plot size was 6 m × 5 m, and the spacing was 50 cm × 25 cm. BARI Paan-3 was used as a test crop for this trial. The treatments were:

T_1 = sanitation + alternate spraying of spinosad (Success 2.5 SC) at 1.2 ml/l and abamectin (Biomax 1.8 EC) at 1 ml/l

T_2 = sanitation + alternate spraying of azadirachtin (Bioneem plus1EC) at 1 ml/l and antario WP (Bt + abamectin 0.1%) at 0.5 g/l

T_3 = sanitation + alternate spraying of abamectin (Biomax 1.8 EC) at 1 ml/l and fytoclean (potassium salt of fatty acid) at 5 ml/l

T_4 = sanitation + alternate spraying of fizimite (sodium lauryl ether) at 1 ml/l and antario wp (Bt + abamectin 0.1%) at 0.5 g/l

T_5 = farmers practice: spraying of imidacloprid (Admire 200SL) at 0.25 ml/l

T_6 = untreated control.

Treatments were assigned in a randomized complete block design with three replications. Recommended doses of fertilizers (MOC 6 t/ha, urea 180 kg, TSP 150 kg, MoP 36 kg, Zypsum 50 kg, and zinc sulphate 15 kg per hectare) were applied. To control anthracnose of betel leaf, the crop was sprayed with Tilt 250EC at 0.5 ml/L of water at 15 days interval starting from the month of March to May. For the control of leaf rot or vine rot disease, three alternate sprays of Ridomil MZ 72 WP (0.2%), Secure (0.1%), and Score (0.1%) were done at 10 days interval. For counting the population of black fly, white fly, red mite, and mealy bug, ten rows from the middle of the boroj were chosen. Two vines were taken randomly from each row, totaling 20 vines from ten rows. Adult white and black flies, red mite, and mealy bug populations were recorded at monthly intervals during January 2018–December 2018 for seasonal incidence of those sucking pests. Three sprays were given at 15 days interval during the Month of March–April and August–September. In each plot, ten betel vines were visually checked to count pest populations and to measure the number of pest per vine. The yield of fresh betel vine from different plucking was revealed from each treated plots and computed as t ha$-^{1}$. The recorded data were analyzed, and mean values were adjusted and separated by Duncan's Multiple Range Test (DMRT) according to Gomez and Gomez (1984). Percent of black fly, white fly, red mite, and mealy bug population reduction over untreated control was calculated using the following formula of Dutta et al. (2014).

$$\text{Insect population reduction } (\%) = \frac{\text{Mean value of control} - \text{Mean value of treatments}}{\text{Mean value of controls}} \times 100$$

Results

Incidence of betel vine insect pests with weather parameters is presented in Table 1, and monthly distribution of meteorological parameters and insect population buildup in betel leaf is presented in Fig. 1.

White fly inhabitants ranged from 2.8 to 17.2 and reached its peak of 16.8/vine during May and 17.2

Table 1 Monthly distribution of meteorological parameters and insect population buildup in betel leaf during January to December 2018

Observation Month	Average temperature (°C)	Relative humidity (%)	Average rainfall (mm)	Mean no. of insect population/vine			
				Black fly	White fly	Red mite	Mealy bug
January 2018	18.1	81.5	9	3.2	2.8	2.6	1.5
February 2018	22.5	78.7	0	5.6	4.8	4.6	3.5
March 2018	26.6	76.3	0	8.3	7.4	7.1	6.0
April 2018	30.4	75.9	0	15.8	12.9	11.9	10.7
May 2018	31.2	74.5	127	20.5	16.8	15.8	13.7
June 2018	29.8	85.5	430	15.2	11.7	10.7	9.6
July 2018	29.6	85.1	550	12.2	6.6	6.4	5.3
August 2018	29.3	87.9	292	10.5	2.5	2.3	1.2
September 2018	28.8	84.3	208	12.2	9.3	8.3	7.2
October 2018	28.1	81.4	198	22.7	17.2	16.1	14
November 2018	25.6	81.6	0	18.2	14.3	13.3	11.2
December 2018	19.9	83.2	0	4.6	3.6	3.4	2.3

Source: Meteorological station, Bogra

during October. Red mite population ranged from 2.6 to 16.1 and reached its peak 15.8/vine during May and 16.1 during October. Present results were in concurrence with the findings of Roopa and Nandihalli (2009) and Nandini et al. (2010). The incidence of mealy bug was started from the first week of January and continued till to the complete growing period of betel vine plant. Population ranged from 1.5 to 14.0 and reached its peak 13.6/vine during May and 14.0 during October. Multiple linear regression models, along with coefficients of determination (R^2) regarding the impact of weather parameters on the seasonal abundance of different insect pest of betel leaf, are presented in Table 2.

It was evident from Table 2 that temperature individually contributed 54.7% abundance of black fly population buildup, and its effect was significant. The combined effect of temperature and relative humidity was significant and exerted 57% abundance. The average monthly rainfall along with temperature and relative humidity contributed 57.9% abundance of black

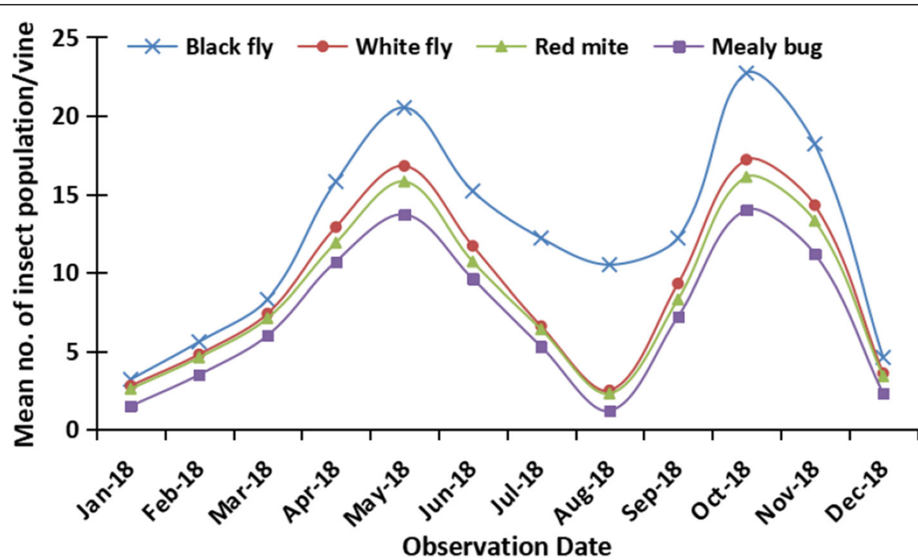

Fig. 1 Mean number of insect population per vine observed at different date in Betel leaf. It was evident from the study that black fly population incidence was started from the month of January (3.2 adult/vine) and continued until the entire growing period of the crop. Population ranged from 3.2 to 22.7 and reached its peak 20.5/vine and 22.7/vine during the month of May and October, respectively

Table 2 Multiple linear regression models along with coefficients of determination (R^2) regarding the impact of weather parameters on the seasonal abundance of different insect pests of betel leaf

Name of the insect	Regression equation	R^2	$100R^2$	% Role of individual factor	F statistic
Black fly	$Y = -16.438 + 1.082X_1$	0.547	54.7	54.7	$F_{1,10} = 12.09$, $P < 0.01$
	$Y = 2.190 + 1.075X_1 - 0.227X_2$	0.570	57.0	3.7	$F_{2,9} = 5.97$, $P < 0.05$
	$Y = -14.675 + 1.222X_1 - 0.057X_2 - 0.006X_3$	0.579	57.9	0.9	$F_{3,8} = 3.67$, $P < 0.10$
White fly	$Y = -12.201 + 0.726X_1$	0.343	34.3	34.3	$F_{1,10} = 5.21$, $P < 0.05$
	$Y = 31.610 + 0.710X_1 - 0.509X_2$	0.503	50.3	16.0	$F_{2,9} = 4.56$, $P < 0.05$
	$Y = 20.288 + 0.809X_1 - 0.395X_2 - 0.004X_3$	0.509	50.9	0.6	$F_{3,8} = 2.76$, $P < 0.10$
Red spider mite	$Y = -9.342 + 0.671X_1$	0.339	33.9	33.9	$F_{1,10} = 5.12$, $P < 0.05$
	$Y = 30.813 + 0.655X_1 - 0.489X_2$	0.510	51.0	17.1	$F_{2,9} = 4.69$, $P < 0.05$
	$Y = 2.843 + 0.725X_1 - 0.408X_2 - 0.003X_3$	0.513	51.3	0.3	$F_{3,8} = 2.82$, $P < 0.10$
Mealy bug	$Y = -10.008 + 0.645X_1$	0.363	36.3	36.3	$F_{1,10} = 5.70$, $P < 0.05$
	$Y = 27.265 + 0.630X_1 - 0.454X_2$	0.535	53.5	17.2	$F_{2,9} = 5.18$, $P < 0.05$
	$Y = 1.223 + 0.683X_1 - 0.393X_2 - 0.002X_3$	0.537	53.7	0.2	$F_{3,8} = 3.10$, $P = 0.089$

Y = insect population/vine; X_1 = average temperature (°C); X_2 = relative humidity (%); X_3 = average rainfall (mm)

fly population which was statistically significant. The individual effect of relative humidity and rainfall on black fly population abundance was 3.7% and 0.9%, respectively. However, in the case of white fly abundance, temperature individually contributed 34.3% abundance, and its effect was significant. The combined effect of temperature and relative humidity was significant and exerted 50.3% abundance. The average monthly rainfall along with temperature and relative humidity contributed 50.9% abundance of white fly population which was statistically significant. The individual effect of relative humidity and rainfall on white fly population abundance was 16% and 0.6%, respectively. In the case of red spider mite abundance, temperature individually contributed 33.9% abundance and its effect was significant. The combined effect of temperature and relative humidity was significant and exerted 51% abundance. The average monthly rainfall along with temperature and relative humidity contributed 51.3% abundance of red mite population that was statistically significant. The individual effect of relative humidity and rainfall on red mite population abundance was 17.1% and 0.3%, respectively. The combined effect of temperature and relative humidity was significant and exerted 53.5% abundance. The average monthly rainfall along with temperature and relative humidity contributed 53.7% abundance of mealy bug population. The individual effect of relative humidity and rainfall on mealy bug population abundance was 17.2% and 0.3%, respectively. The multiple linear regression analysis showed that all the weather parameters together contributed 53.7% population abundance of mealy bug, and the equation was not significant.

Efficacy of different treatments against sucking pests of betel leaf

Efficacy of different treatments against sucking pests of betel leaf is presented in Table 3.

Table 3 Efficacy of different treatments against sucking pests of betel leaf (mean of three sprayings)

Treatments	No. of black fly/vine	% reduction over control	No. of white fly/vine	% reduction over control	No. of red mite /vine	% reduction over control	No. of mealy bug /vine	% reduction over control
Sanitation + spinosad + abamectin	3.51d	78.06	2.23de	74.40	1.92 cd	73.66	0.91d	87.15
Sanitation + azadirachtin + antario	7.55c	52.81	3.60c	58.67	3.11c	57.34	3.92b	44.63
Sanitation + abamectin + fytoclean	11.43b	28.56	4.92b	43.51	5.14b	29.49	1.75 cd	75.28
Sanitation + fizimite + antario	3.11d	80.56	1.33e	84.73	1.28d	82.44	0.64d	90.96
Farmers practice	6.86c	57.13	2.95 cd	66.13	2.97 cd	59.26	2.60c	63.28
Untreated control	16.00a	–	8.71a	–	7.29a	–	7.08a	–
Level of sigf.	**	–	**	–	**	–	**	–
CV (%)	6.95		10.10	–	17.63	–	16.43	–

Data represent mean of three observations. Mean followed by the same letter(s) in the same column did not differ significantly from each other at 1% level by DMRT

Among the different treatments tested, black fly population was ranged from 3.11 to 16 adult/vine. The treatment sanitation with three alternate spraying of fizimite and antario recorded significantly the lowest number of black fly (3.11adult/vine) population which was statistically similar with sanitation with three alternate spraying of spinosad and abamectin treated plot with black fly population of 3.51 adults/vine. The maximum number of black fly (16.00) was recorded from untreated control. However, the highest (80.56%) reduction of black fly population over untreated control was calculated from sanitation with three alternate spraying of fizimite and antario-treated plot followed by sanitation with three alternate spraying of spinosad and abamectin and farmers practice with population reduction of 78.06% and 57.13%, respectively. Among the different treatments, significantly, the lowest number of white fly (2.44 adult/vine) was recorded in sanitation with three alternate spraying of fizimite and antario-treated plot which was statistically similar with sanitation with three alternate spraying of spinosad and abamectin with white fly population of 2.23 adults/vine. However, the maximum (84.73%) reduction of white fly population over untreated control was recorded from sanitation with three alternate spraying of fizimite and antario-treated plot followed by sanitation with three alternate spraying of spinosad and abamectin and farmers practice with population reduction of 74.40% and 66.13%, respectively. Similarly, the treatment sanitation with three alternate spraying of fizimite and antario recorded significantly the lowest number of red mite (1.28/vine) population which was statistically similar with sanitation with three alternate spraying of spinosad and abamectin-treated plot with mite population of 1.92/vine. The maximum number of black fly (7.29/vine) was recorded from untreated control. However, the highest (82.44%) reduction of black fly population over untreated control was calculated from sanitation with three alternate spraying of fizimite and antario-treated plot followed by sanitation with three alternate spraying of spinosad and abamectin and farmers practice with population reduction of 73.66% and 59.26%, respectively. The maximum number of mealy bug population (7.08 adult/vine) was recorded from untreated control. Effect of different treatments on fresh vine yield of betel leaf is presented in Fig. 2.

The highest vine yield (18.61 t/ha) was also obtained from sanitation + alternate spraying of fizimite and antario followed by sanitation + alternate spraying of spinosad and abamectin (16.67 t/ha) that indicated better control of sucking insect pest compared to other treatments. The lowest yield (9.11 t/ha) was recorded from the untreated control plot.

Discussion

The crop has been cultivated traditionally over the years without any improved package of practices leading to diminishing returns (Guha 2006). The crop was raised under covered structure creating a microclimatic condition that not only favors crop growth but also influences pest incidence. Jana (2006) reported two-peak population of black fly on betel vine once from May to August and other from September to November, which confirms the findings of the present study. However, white fly incidence was started from the first week of January and

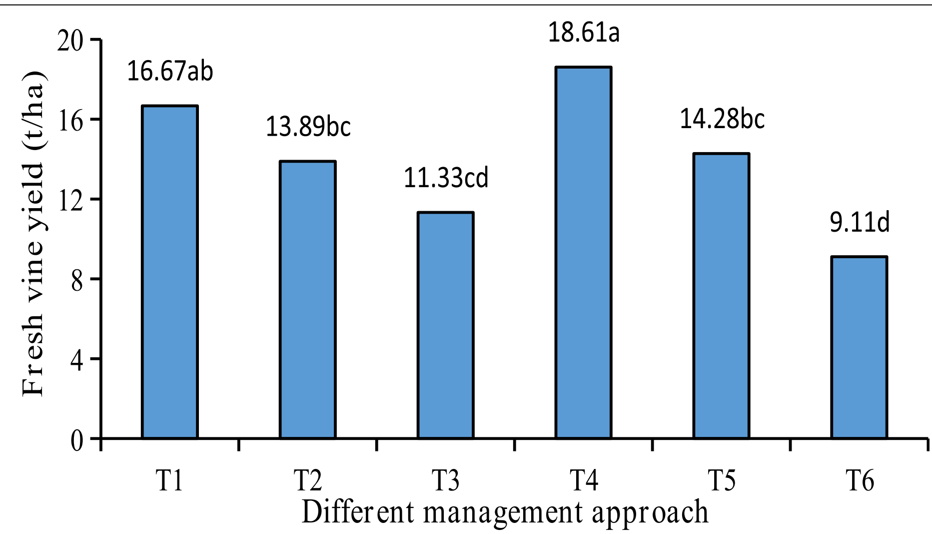

Fig. 2 Effect of different treatments on fresh vine yield of betel leaf. *T1* = sanitation + spinosad + abamectin, *T2* = sanitation + azadirachtin + antario, *T3* = ,anitation + abamectin + fytoclean, *T4* = sanitation + fizimite + antario, *T5* = farmers practice, and T6 = untreated control (water spray)

continued till to the entire growing period of a betel vine plant. Giri (1995) observed that the highest population of white fly was found from October to November, which confirms the results under the present investigation. In the case of red mite, the incidence was started from January and continued until the entire growing period of betel vine plant. All the treatments except untreated control recorded a significantly lower number of sucker insect pest populations. However, different sucking pest treatment sanitation with three alternate spraying of fizimite and antario recorded significantly the lowest number (0.64/vine) of adult mealy bug population which was statistically similar with sanitation with three alternate spraying of spinosad and abamectin-treated plot with mite population of 0.91/vine. However, the highest (90.96%) reduction of mealy bug population over untreated control was calculated from sanitation with three alternate spraying of fizimite and antario followed by sanitation with three alternate spraying of spinosad and abamectin and sanitation with three alternate spraying of abamectin and fytoclean with a population reduction of 87.15% and 75.28%, respectively. The multiple linear regression analysis showed that all the weather parameters together contributed 50.9% white fly, 51.3% red mite, 36.3% mealy bug, and 57.9% black fly population abundance, and the equation was significant. Mandal et al. (2008) reported 16.91 to 27.07% increase in yield of cotton over control due to the use of biopesticides. Cost-effective crop production requires a combination of optimum use of chemicals and non-chemical techniques of pest management specially for sucking types of insect pest.

Conclusion

From the study, it had been concluded that sanitation + alternate spraying with fizimite (1 ml/L of water) and antario (0.5 g/L of water) three times at 10 days interval from the first appearance of insect infestation was recommended for the management of sucking insect pest complex of betel leaf with higher yield. Furthermore, management strategy add with farmer's attitude focuses for betel leaf cultivation.

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Authors' contributions

Conceptualization, methodology and investigation: [Md. Motaher Hossain]; Writing—original draft preparation: [Md. Motaher Hossain]; Formal analysis: [Md. Motaher Hossain, Ashutus Singha, and Md. Abu Sayem Jiku,], Writing—review and editing: [Md. Motaher Hossain, Md Abu Sayem Jiku, Md. Akhtaruzzaman Sarkar, Ashutus Singha, Debasish Sarker, Md Ashraful Alam, and Shata Rupa Sinha]; Funding acquisition: [Md. Motaher Hossain, Md. Akhtaruzzaman Sarkar, and Debasish Sarker]; Supervision: [Debasish Sarker]. All authors revised, read, and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analyzed during the current study are included in this study.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable.

Competing interests

The authors declare that the research was conducted in the absence of any commercial or financial relations that could be constructed as a potential conflict of interest.

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