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Management of Insect and Mite Pests of Chili using Botanical and Synthetic Chemicals

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ABSTRACT

Background: The spice crop chili is cultivated all over Bangladesh but the yield is very low due to the infestation of insect and mite pests. This study investigated the efficacy of some botanical and synthetic chemicals for management of mite, whitefly and thrips attacking chili plants.

Methods: The chili variety BARI Morich 2 was cultivated in Gazipur, Bangladesh and the chemicals, namely Neem oil @ 1.5 ml/L water, Omite 57 EC @ 2.0 ml/L water, Vertimec 018 EC @ 1.25 ml/L water, Liquor 1.8 EC @ 2.0 ml/L water and Confidor 20% SL @ 1.5 ml/L water were applied on the plants to manage mite, whitefly and thrips. The efficacy of the botanical and synthetic pesticides was compared to control treatment (untreated).

Result: The applied chemicals significantly reduced the abundance of mite, thrips and whiteflies, resulting in the lower level of leaf curl index of plants compared to control. All the treatments revealed a significantly higher yield and benefit-cost ratio than that of control. Omite showed the lowest abundance of mite and Confidor showed the lowest leaf curl index with a lower abundance of whiteflies and thrips. Confidor treated plots gave the highest yield and benefit-cost ratio.

Key words: Benefit-cost ratio, Botanical, Efficacy, Synthetic pesticides, Yield.

INTRODUCTION

Chili, *Capsicum frutescence* (Solanaceae), is a widely grown vegetable and commercial spice crop in most tropical and sub-tropical countries. Besides the traditional use of chilies as vegetables, spices, sauces and pickles, the green chili fruits are a good source of vitamin A and C (Singh *et al.*, 2007; Mondal and Mondal, 2012).

Many factors are responsible for the low productivity of chili. Among these, damage due to insect infestation is an important one. Insect-pests continuously change their trend and become a barrier to the growth and cultivation of chili. Over 35 species of arthropods attack chili plants and the most significant pests are mite, thrips, aphids and whitefly (Pradeep and Korat, 2018).

Thrips, whitefly and mites suck sap from the plants with their piercing-sucking mouthparts, causing leaf curling, leaf and fruit dropping and withering to the infested plants. Thrips and whitefly help in transmitting virus diseases (Jones 2003). The mite-infested leaves of chili plants become bronzed with downward curled margins, flowers are distorted, shoots grow twisted and fruits may be misshapen and become russet (Kumar *et al.,* 2018). In a severe infestation of sucking insects, the tender leaves and buds of chili plants get brittle, resulting in complete defoliation and total crop loss (Sathua *et al.,* 2017). An infestation of yellow mite, *Polyphagotarsonemus latus* Banks and thrips, *Scirtothrips dorsalis* Hood, results in severe leaf curl of chili plants and causes yield loss of 30%-55% (Rai *et al.*, 2007).

Currently, the situation is distressing and economic yield is not possible without the use of pesticides. Now a days, a large number of newer insecticides and acaricides are available in the market. Some new insecticides, such as thiacloprid, acetamiprid and flonicamid were effective against thrips population reduction up to 70.8-74.8%, whereas flonicamid was very effective against the whitefly population reduction upto 72.2% over control (Swathi *et al.*, 2018). Imidacloprid was highly effective against thrips infesting the bean (Cermeli *et al.*, 2002) and was also reported to be effective against whitefly and thrips population on mothbeans (Naga *et al.*, 2015). That's why these types of insecticides were used to control the sucking pests of chili in current study.

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Farmers use chemical pesticides for rapid action for controlling pests, thereby creating problems like pesticide resistance, pest resurgence, environmental pollution and destruction of natural enemies of the pest (Jeyarani *et al*., 2010). In this regard, it is always advisable to use insecticides from different classes in rotation to impede insecticide resistance development. Therefore, the present study was conducted to evaluate the efficacy of botanical and some synthetic chemical pesticides for the management of mite, whitefly and thrips attacking chili and to determine the benefit-cost ratios after applying the treatments.

MATERIALS AND METHODS

Study site and condition

The study was conducted during three consecutive seasons from March 2019 to August 2019, September 2019 to March 2020 and August 2020 to January 2021 in research field of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. The study site is located in the middle of Bangladesh (25°25′ N and 89°5′ E). Annual mean maximum and minimum temperatures, relative humidity and rainfall are 36.0°C, 12.7°C, 65.8% and 237.6 cm, respectively (Amin *et al.,* 2015).

Cultivation of chili varieties

The study was carried out with chili variety BARI Morich 2. Seeds were collected from the Spices Research Centre, Bangladesh Agricultural Research Institute, Bogura. The collected seeds were sown on different polyethylene bags for the first, second and third seasons, on March 1st 2019, September 10th 2019 and August 1st 2020, respectively to raise seedlings. Seedlings were transplanted in the field on 15th April 2019 for the first season, 24th October 2019 for the second season and 15th September 2020 for the third season. The experimental field was laid out in a randomized complete block design with three replications. The plot size was 2.5 m × 2.5 m and the space between the two plots was 50 cm. Each plot contained five rows and each row had five plants 50 cm apart from each other. Manures and fertilizers were applied according to the Fertilizer Recommendation Guide (FRG 2012). Intercultural operations were done based on necessity.

Application of treatments and data collection

The botanical and synthetic chemical treatments, namely Neem oil @ 1.5 ml/L water, Omite (Propergite) 57 EC @ 2.0 ml/L water, Vertimec (Abamectin) 018 EC @ 1.25 ml/L water, Liquor (Abamectin) 1.8 EC @ 2.0 ml/L water and Confidor (Imidacloprid) 20% SL @ 1.5 ml/L water were applied to manage mites, thrips and whitefly attacking the chili plants. The control plots were kept free from insect pest management. The insecticides were sprayed three times at 15 days interval after observing the pest infestation. Five plants were randomly selected to collect data on the abundance of mites and one young shoot (apical three leaves) from each of the selected plants was plucked. All samples were kept fresh in polyethylene bags and brought to the laboratory at 24, 48 and 72 hours after insecticide spraying in each season. The number of mites per three leaves was observed under a stereomicroscope. The number of whiteflies and thrips on three leaves from each of five selected plants was visually counted using a hand lens at 24, 48 and 72 hours after insecticide spraying. For the efficacy evaluation, the reduction in the abundance of the mites, thrips and whiteflies over control was calculated using the following formulae:

% Reduction of abundance over control =

$$\frac{\text{Abundance in control plot} - \text{Abundance in treated plot}}{\text{Abundance in control plot}} \times 100$$

Observation of leaf curl index and yield contributing characteristics

Leaf curl index (LCI) of virus infection was determined for each one of three seasons after the first harvest. In the case of infestation by whitefly, 25 plants were randomly selected and graded based on a disease scoring scale of 0-9 (0 = normal leaf; 1 = very mild curling of 1%-10% leaves; 3 = curling of 11%-25% leaves; 5 = curling of 26%-50% leaves; 7 = stunting of the plants and curling of 50%-75% leaves; 9 = stunting and bushy appearance of plant and curling of >75% leaves) (Bhutia *et al*. 2015). In case of infestation by mites and thrips, 25 plants were graded according to Latha and Hunumanthraya (2018) into five indices of 0, 1, 2, 3 and 4 (0 = normal leaf; 1 = 1%-25% curl; 2 = 26%-50% curl; 3 = 51%-75% curl and 4 = >75% curl). For the evaluation of the efficacy of different pesticides, LCI (%), the number of fruits per plant and the weight of fruits over control were calculated using the following formulae:

$$\text{LCI \%} = \frac{\sum \text{Numerical ratings}}{\text{Highest grade of rating} \times \text{Total number of plants examined}} \times 100$$

% Increase fruits over control =

$$\frac{\text{Fruits of treated plot - Fruits of untreated plot}}{\text{Fruits of untreated plot}} \times 100$$

% Increase weight over control =

$$\frac{\text{Weight of treated plot - Weight of untreated plot}}{\text{Weight of untreated plot}} \times 100$$

Calculation of yield and benefit-cost ratio

At every harvest, the plucked fruits of each treatment were separated into marketable and infested categories and their weights were measured. The yield of each plot was converted into ton/ha. The economic analysis and benefit-cost ratio (BCR) were calculated based on the total expenditure for each treatment and the total return per hectare. The total expenditure for treatment indicates the costs for labor and inputs. The gross return of treatment is the total price obtained from the total yield of the treatment. The net return was calculated by subtracting the expenditure of treatment from its gross return. The adjusted net return of each treatment was calculated by subtracting the net return of the control from the net return of the treatments. The BCR is calculated by using the following formula:

$$\text{Benefit-Cost Ratio} = \frac{\text{Adjusted net return}}{\text{Total cost}}$$

The per cent increase in yield over control in various treatments was calculated by using the following formula:

$$\text{\% Yield increases over control} = \frac{\text{Yield of treated plot - Yield of untreated plot}}{\text{Yield of untreated plot}} \times 100$$

Data analysis

Data on the efficacy of botanical and chemical pesticides on the abundance of mites, thrips, whiteflies, leaf curl index, yield contributing characteristics and effect of different treatments on yield of chili were analyzed using a one-way analysis of variance (ANOVA). Mean values were separated according to Tukey HSD posthoc statistics at 5% level of significance. All the analyses were performed using IBM SPSS 20.0.

RESULTS AND DISCUSSION

Efficacy of the botanical and chemical pesticides against mite

The abundance of mites among the treatments in the first, second and third seasons at 24, 48 and 72 hours after spray ranged from 1.5-5.8, 1.9-5.9 and 1.8-5.7 per three leaves, respectively and the results differed significantly (Table 1). All the insecticides showed a statistically lower number of mites than that of control. Omite showed the lowest (1.9 mites/3 leaves) mean mite abundance among the botanical and chemical pesticide treatments. The efficacy of the botanical and chemical insecticides against mites showed that Omite and Vertimec gave the best reduction over control (66.1% and 53.6%, respectively). Kumar *et al.* (2005) reported that propargite (0.228%) had 90.66, 94.88, 68.77 and 50.55% of *P. latus* mortality after one, two, seven and 14 days of spraying, respectively. Singh and Singh (2013) reported that the maximum percent reduction of yellow mite in chili occurred when the plants were treated with abamectin and propargite (77.28% and 72.66%, respectively).

Efficacy of the botanical and chemical pesticides against whitefly

The whitefly abundance among treatments in the first, second and third seasons at 24, 48 and 72 hours after spray ranged from 1.8-6.2, 1.7-5.9 and 1.9-6.0 per three leaves, respectively, with a statistically significant difference (Table 2). All the pesticides had statistically lower whitefly abundances than control. Confidor showed the lowest mean whitefly abundance (2.1 whitefly/3 leaves) and the highest reduction in its population (64.4%) over control. The results display

Table 1: The efficacy of the botanical and chemical pesticides on the abundance of mite attacking chili plants.

Treatment	Abundance (Number of mite/ three leaves)									Mean abundance	Reduction over control (%)
	First season			Second season			Third season				
	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT		
Neem oil	3.3±0.7ab	3.2±0.7b	3.4±0.6b	4.1±0.7ab	4.0±0.5ab	3.9±0.5b	4.5±0.6ab	4.3±0.5ab	4.2±0.5ab	3.9	30.4
Omite	1.9±0.6b	1.8±0.6b	1.5±0.3c	2.0±0.5b	1.9±0.5b	2.0±0.4c	2.4±0.5b	2.2±0.7b	1.8±0.3c	1.9	66.1
Vertimec	2.6±0.5b	2.4±0.5b	2.2±0.4bc	3.1±0.4ab	2.9±0.5bc	2.6±0.4bc	2.7±0.6ab	2.4±0.5b	2.3±0.4c	2.6	53.6
Liquor	2.8±0.9b	2.7±0.5b	2.3±0.4bc	3.3±0.8ab	3.1±0.4bc	2.9±0.4bc	3.2±0.9ab	3.0±0.5b	2.5±0.5bc	2.9	48.2
Confidor	2.7±0.6b	2.5±0.5b	2.4±0.4bc	3.6±0.5ab	3.5±0.3bc	3.2±0.5bc	3.8±0.9ab	3.6±0.5ab	3.5±0.4bc	3.2	42.9
Control	5.5±0.5a	5.7±0.5a	5.8±0.3a	5.5±0.5a	5.6±0.6a	5.9±0.6a	5.4±0.5a	5.6±0.6a	5.7±0.6a	5.6	-

HAT= Hour after treatment; Data expressed as mean ±SE. Means within a column followed by the same letter (s) are not significantly different according to Tukey HSD *posthoc* statistic at <0.05.

Table 2: The efficacy of the botanical and chemical pesticides on the abundance of whitefly attacking chili plants.

Treatment	Abundance (Number of whitefly/ three leaves)									Mean abundance	Reduction over control (%)
	First season			Second season			Third season				
	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT		
Neem oil	4.4±0.5ab	4.3±0.4ab	4.2±0.4ab	4.3±0.5ab	4.2±0.5ab	4.1±0.4ab	4.6±0.6ab	4.5±0.3ab	4.5±0.6ab	4.3	27.1
Omite	3.1±0.7b	3.0±0.7bc	2.9±0.6bc	3.5±0.7ab	3.4±0.6ab	3.2±0.5bc	3.2±0.7ab	3.0±0.7bc	3.0±0.6bc	3.1	47.5
Vertimec	3.1±0.6b	2.8±0.4bc	2.6±0.5bc	2.8±0.7b	2.7±0.5b	2.7±0.5bc	2.9±0.5b	2.8±0.4bc	2.6±0.5bc	2.8	52.5
Liquor	4.0±0.4ab	3.8±0.6bc	3.6±0.5bc	3.9±0.6ab	3.7±0.7ab	3.5±0.6bc	3.7±0.4ab	3.6±0.5bc	3.5±0.6bc	3.7	37.3
Confidor	2.2±0.6b	2.0±0.4c	1.8±0.4c	2.3±0.5b	2.1±0.5b	1.7±0.5c	2.2±0.5b	2.1±0.4c	1.9±0.4c	2.1	64.4
Control	5.9±0.7a	6.0±0.5a	6.2±0.6a	5.6±0.7a	5.7±0.6a	5.9±0.5a	5.7±0.8a	5.7±0.4a	6.0±0.5a	5.9	-

HAT= Hour after treatment; Data expressed as mean ± SE. Means within a column followed by the same letter (s) are not significantly different according to Tukey HSD *posthoc* statistic at <0.05.

close conformity with the results obtained by Pradeep and Korat (2018), who reported that imidacloprid gave 69.12% mean whitefly population reduction over control. Rashid *et al.*, (2012) reported that 2% neem oil and 3% neem seed extract significantly reduced the whitefly and thrips population up to twelve days than untreated control on cotton.

Efficacy of the botanical and chemical pesticides against thrips

The thrips abundance among treatments in the first, second and third seasons at 24, 48 and 72 hours after insecticide spraying was statistically different, ranging from 1.4-5.4, 1.5-5.9 and 1.6-5.5 per three leaves, respectively (Table 3). Confidor showed the lowest (1.6 thrips/3 leaves) mean thrips abundance among the botanical and chemical pesticide treatments. Confidor gave the best performance to reduce the thrips population (70.9%) compared to control. Pradeep and Korat (2018) also reported that imidacloprid showed the maximum mean thrips population reduction during the first, second and third spray (61.48, 60.29 and 73.45%, respectively).

Efficacy of the botanical and chemical pesticides on leaf curl index and yield contributing characteristics

The efficacy of botanical and chemical pesticides on LCI, number of fruits and fruit weight of chili in the first season, second season and third season differed significantly (Table 4). The findings of this study showed that Confidor reached the highest results among all the treatments, causing an increase in fruit number and weight (38.4% and 35.3%, respectively) compared to the control. We also observed that, among all pesticides, the Neem oil had the lowest increase in fruit number and weight of 15.5% and 11.8%, respectively.

Effect of the botanical and chemical pesticides on the average yield of chili plants

The effect of botanical and chemical pesticide treatments on the average yield of chili in the first season, second season and third season ranged from 11.5±0.3 to 16.2±0.3, 10.4±0.2 to 16.7±0.2 and 10.8±0.2 to 16.5±0.2 ton/ha, respectively and results differed significantly (Table 5). All the pesticides resulted in a higher yield than that of control. The highest mean yield of chili was found in the Confidor (16.5 ton/ha) treated plot, followed by Vertimec (15.6 ton/ha), Omite (15.1 ton/ha) and Liquor (14.1 ton/ha). Among the treatments, Confidor and Neem oil treated plot gave the highest and lowest results (51.4% and 21.1%, respectively) in the increase of yield over control.

The benefit-cost ratio

The BCR analyses of botanical and synthetic chemical treatments against major sucking pests are presented in Table 6. The gross and net return among the treatments varied from US$ 10,900-16,500 and US$ 4,426.8-13,840.7, respectively. All the pesticides showed a higher amount of gross and net returns compared to the control. The highest

Table 3: The efficacy of the botanical and chemical pesticides on the abundance of thrips attacking chili plants.

Treatment	Abundance (Number of thrips/ three leaves)									Mean abundance	Reduction over control (%)
	First season			Second season			Third season				
	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT		
Neem oil	3.4±0.6ab	3.3±0.4ab	3.2±0.5ab	4.2±0.5ab	4.0±0.6ab	4.0±0.9ab	3.8±0.5ab	3.6±0.5ab	3.5±0.6ab	3.7	32.7
Omite	2.4±0.6b	2.3±0.5b	2.1±0.4b	2.6±0.6bc	2.7±0.5bc	2.5±0.6b	3.0±0.5b	2.8±0.4b	2.6±0.5b	2.6	52.7
Vertimec	3.0±0.3ab	2.8±0.4b	2.5±0.5b	2.9±0.3bc	2.8±0.4bc	2.6±0.4b	3.4±0.2b	3.2±0.6ab	2.9±0.6b	2.9	47.3
Liquor	2.7±0.5b	2.7±0.5b	2.6±0.6b	3.1±0.6bc	2.8±0.5bc	2.7±0.7b	3.8±0.5ab	3.8±0.7ab	3.7±0.7ab	3.1	43.6
Confidor	1.8±0.5b	1.5±0.5b	1.4±0.3b	1.7±0.4c	1.6±0.6c	1.5±0.4b	2.0±0.4b	1.7±0.4b	1.6±0.5b	1.6	70.9
Control	5.1±0.8a	5.2±0.5a	5.4±0.5a	5.6±0.8a	5.7±0.7a	5.9±0.6a	5.3±0.5a	5.4±0.7a	5.5±0.4a	5.5	-

HAT= Hour after treatment; Data expressed as mean ± SE. Means within a column followed by the same letter (s) are not significantly different according to Tukey HSD *posthoc* statistic at <0.05.

Table 4: The efficacy of the botanical and chemical pesticides on leaf curl index and yield contributing characteristics of the chili plants.

Treatment	Leaf curl index			Number of fruits/plant					Weight of fruits (g)				
	First season	Second season	Third season	First season	Second season	Third season	Mean number	Increase fruit over control (%)	First season	Second season	Third season	Mean weight	Increase weight over control (%)
Neem oil	1.2±0.1ab	1.4±0.1ab	1.3±0.1ab	104.1±3.2bc	105.0±3.4bc	106.9±3.1bc	105.3	15.5	1.9±0.0bc	1.8±0.1cd	1.9±0.0cd	1.9	11.8
Omite	1.0±0.1ab	1.3±0.1ab	1.2±0.1ab	109.3±6.9ac	109.2±5.2ab	110.5±4.8bc	109.7	20.3	2.0±0.1b	2.0±0.1bd	2.1±0.1ac	2.0	17.6
Vertimec	1.0±0.1ab	1.3±0.1ab	1.3±0.1ab	114.2±4.8ab	112.2±4.6ab	115.2±4.6ab	113.9	24.9	2.1±0.1ab	2.1±0.1b	2.2±0.1ab	2.1	23.5
Liquor	1.2±0.1ab	1.4±0.1ab	1.2±0.2ab	107.2±3.8ac	109.2±3.8ab	108.7±3.5bc	108.4	18.9	2.0±0.1bc	2.1±0.1bc	2.0±0.1bd	2.0	17.6
Confidor	1.0±0.1b	1.1±0.1b	0.9±0.1b	125.6±5.0a	123.6±4.1a	129.3±3.8a	126.2	38.4	2.3±0.1a	2.4±0.0a	2.3±0.1a	2.3	35.3
Control	1.3±0.1a	1.7±0.2a	1.5±0.2a	91.3±5.0c	89.0±4.4c	93.4±4.9c	91.2	-	1.7±0.0c	1.8±0.1d	1.7±0.1d	1.7	-

Data expressed as mean ± SE. Means within a column followed by the same letter (s) are not significantly different according to Tukey HSD *posthoc* statistic at <0.05.

Table 5: The effect of the botanical and chemical pesticides on the yield of chili plants.

Treatments	Yield (ton/ha)				Yield increases over control (%)
	First season	Second season	Third season	Mean yield	
Neem oil	13.3±0.2c	12.8±0.2d	13.5±0.2d	13.2	21.1
Omite	15.1±0.3ab	14.9±0.3bc	15.3±0.2bc	15.1	38.5
Vertimec	15.5±0.2a	15.4±0.2b	15.8±0.2ab	15.6	43.1
Liquor	14.1±0.3bc	14.0±0.3c	14.3±0.3cd	14.1	29.4
Confidor	16.2±0.3a	16.7±0.2a	16.5±0.2a	16.5	51.4
Control	11.5±0.3d	10.4±0.2e	10.8±0.2e	10.9	-

Data expressed as mean ± SE. Means within a column followed by the same letter (s) are not significantly different according to Tukey HSD *posthoc* statistic at <0.05.

Table 6: The benefit-cost ratio analyses of the botanical and chemical pesticides against insect and mite pests of chili plants.

Treatment	Total cost (US dollar)	Yield (ton/ha)	Gross return (US dollar)	Net return (US dollar)	Adjusted net return (US dollar)	BCR
Neem oil	2498.1	13.2	13200	10701.9	6275.1	2.5
Omite	2664.3	15.1	15100	12435.7	8008.9	3.0
Vertimec	2719.6	15.6	15600	12880.4	8453.6	3.1
Liquor	2540.7	14.1	14100	11559.3	7132.5	2.8
Confidor	2659.3	16.5	16500	13840.7	9413.8	3.5
Control	6473.2	10.9	10900	4426.8	-	-

gross and net returns were obtained in the plants treated with Confidor. The highest and the lowest adjusted net returns were found in Confidor and Neem oil (US$ 9413.8 and US$ 6275.1, respectively). Both Confidor and Neem oil treated plots revealed the highest and lowest BCR, respectively (3.5 and 2.5, respectively).

CONCLUSION

This experiment revealed that all the pesticides had an effective performance against mites, whiteflies and thrips populations in consecutive three chili growing seasons. The Omite pesticide performed better in reducing both mite and whitefly populations whereas, the reduction of thrips population was the highest in plots treated with Confidor.

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REFERENCES

Amin, M.R., Namni, S., Miah, M.R.U., Miah, M.G., Zakaria, M., Suh, S.J. and Kwon, Y.J. (2015). Insect inventories in a mango based agroforestry area in Bangladesh: Foraging behavior and performance of pollinators on fruit set. Entomological Research. 45(4): 217-224.

Bhutia, N.D., Seth, T., Shende, V.D., Dutta, S. and Chattopadhyay, A. (2015). Estimation of heterosis, dominance effect and genetic control of fresh fruit yield, quality and leaf curl disease severity traits of chili pepper (*Capsicum annuum* L.). Scientia Horticulturae. 182: 47-55.

Cermeli, M., Morales, P., Godoy, F., Romero, R. and Cárdenas, O. (2002). Presencia de la cochinilla rosada de la cayena *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae) en Venezuela. Entomotropica. 17(1): 103-105.

FRG. (2012). Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council, Farmgate, Dhaka.

Jeyarani, S., Bhaskaran, E.V. and Kamaraju, K. (2010). Monitoring of Acaricide Resistance in Field Collected Population of *Tetranychus urticae* Koch (Acari: Tetranychidae) on Okra. In: Proceedings of the International Symposium-cum-Workshop in Acarology, BCKV, Kalyani, Kolkata. p. 75.

Jones, D.R. (2003). Plant viruses transmitted by whiteflies. European Journal of Plant Pathology. 109(3): 195-219.

Kumar, A., Sharma, A., Vishwakarma, N. and Singh, M. (2018). Study of cost economics of management of chili mites through Abamectin 1.8 EC. International Journal of Current Microbiological and Applied Science. 7(9): 1659-1663.

Kumar, S., Mani, C. and Singh, R.N. (2005). Field evaluation of omite and some other acaricides against broad mite, *Polyphagotarsonemus latus* (Banks.) on chili under Varanasi condition of eastern Uttar Pradesh. Pestology. 29(11): 61-63.

Latha, S. and Hunumanthraya, L. (2018). Screening of chili genotypes against chili thrips (*Scirtothrips dorsalis* Hood) and yellow mite (*Polyphagotarsonemus latus* Banks). Journal of Entomology and Zoology Studies. 6: 2739-2744.

Mondal, B. and Mondal, P. (2012). Eco-friendly pest management practices for leaf curl complex of chili (*Capsicum annuum* L.). Journal of Biopesticides. 5: 115-118.

Naga, K.L., Naqvi, A.R., Naga, B.L., Singh, A.K., Meena, B.M. and Meena, A. (2015). Bioefficacy of newer insecticides against major sap sucking insect pests of mothbean [*Vigna aconitifolia* (Jacq.) Marechal] and their impact on yield parameters. Journal of Experimental Zoology, India. 18(2): 1011-1015.

Pradeep, M.S. and Korat, D.M. (2018). Impact of pesticidal sprays in reducing sucking pests population on chili. International Journal of Current Microbiology and Applied Science. 6: 478-486.

Rai, A.B., Satpathy, S., Gracy, R.G., Swamy, T.M.S. and Rai, M. (2007). Yellow mite (*Polyphagotarsonemus latus* Banks) menace in chili crop. Vegetable Science. 34(1): 1-13.

Rashid, M.M., Khattak, M.K. and Abdullah, K. (2012). Evaluation of botanical and synthetic insecticides for the management of cotton pest insects. Pakistan Journal of Zoology. 44: 1317-1324.

Sathua, S.K., Reddy, M.S., Sulagitti, A. and Singh, R.N. (2017). Bio-efficacy of various insecticides and botanicals against chili thrips (*S. dorsalis* Hood) and their comparative cost: Benefit analysis in chili crop. Journal of Entomology and Zoology Studies. 5(2): 130-134.

Singh, A.P. and Singh, R.N. (2013). Management of yellow mite, *Polyphagotarsonemus latus* (Acari: Tarsonemidae) in chili. Indian Journal of Agricultural Sciences. 11: 1250-1252.

Singh, S., Gamlath, S. and Wakeling, L. (2007). Nutritional aspects of food extrusion: A review. International Journal of Food Science and Technology. 42(8): 916-929.

Swathi, K., Seetharamu, P., Dhurua, S. and Suresh, M. (2018). Efficacy of newer insecticides against sucking pests of rice fallow blackgram. Indian Journal of Agricultural Research. 52(6): 700-703.