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Leaf Miner (*Phytomyza* spp.) Infestation on Som Plant *(Machilus bombycina* King) and Plant based Formulation for their Sustainable Management

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ABSTRACT

Muga silk worm (*Antheraea assama* West wood) is reared on leaves of som plant *(Machilus bombycina* King) because of their high nutritional value. Rearing becomes difficult due to attack of large number of insect-pests on som plant. Leaf miner (*Phytomyza spp.*) (Diptera: Agromyzidae) is a major pest and very harmful to som plant leaves. From observation it is found that leaf miner was found active throughout the year on som plant leaves. Higher population level was maintained during 27th standard week to 34th standard week that is during 1st week of July to last week of August with highest population (20.42 larvae/5 leaves) recorded on 32nd standard week that is on the 2nd week of August. Leaf miner population had a significant positive correlation with temperature and relative humidity. A mixed formulation of imidacloprid with azadiraction was found to be the most effective against leaf miner showing 79.24% mortality with imidacloprid 76.25% and in the mixed formulation imidacloprid+polygonum 73.74 %. It is concluded that lower dose of imidacloprid mixing with azadiractin/polygonam/spilanthes extracts will be environmentally sound and eco-friendly and is recommended for leaf miner control to promote organic farming.

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Authors' Contribution
SKG conceived and designed the study. He also supervised the work and prepared the manuscript. TM executed the experimental work and analyzed the data.

Key words
Muga rearing, Silk production, Bio-pesticides, Eco-friendly, Organic farming

INTRODUCTION

Muga silk worm (*Antheraea assama* West wood) is reared on som plant *(Machilus bombycina* King) which is an important medium sized tree cultivated as agro forestry. Nutritional value of leaves of som plant plays an important role in the larval growth and silk production. Benchamin and Giridhar (2005) reported that yellow golden muga silk (*Antherea assama* West wood) is cultivated and produced only in India. Its cultivation is restricted to the north-eastern India mainly at Bhrambhaputra valley of Assam state. Terai region of West Bengal, India mainly Coochbehar, Alipurdwar and Jalpaiguri districts have immense possibility of its cultivation for agro-climatic similarity with lower Assam (Ghosh *et al*., 2016).

Rearing becomes difficult due to attack of large number of insect-pests on som plant (Singh *et al*., 2000). Insect pests are known to interfere considerably with all the phases of host plant propagation and cultivation (Thangavelu and Singh, 1994). From nursery to mature plants, stem borer, hairy caterpillar, leaf miner, gall insect, termites and aphid are major pests of food plants. Different species of leaf miner (*Phytomyza* spp.) (Diptera: Agromyzidae) are major and very harmful pest of som plant leaves. The adult female leaf miners produce characteristic feeding marks on leaves and lay eggs into some of these marks. The larva feeds in the leaf 'mines'. In severe cases the leaf area is reduced enough which affect the feeding activity of muga silk worm. The larva of muga silkworm does not prefer infested leaves and thus muga cultivation is badly affected and lowered the production of silk.

As uses of chemical pesticides are harmful, searching of alternatives is urgent. Plant based formulations may fulfil this requirement. Neem, pongamia, chrysanthemum, zinger, turmeric, ocimum, garlic, tobacco, custard apple etc are reported as most common pescicidal plants used for pest control in sericulture (Mandal *et al*., 2016). It acts in various ways *viz* insect growth regulators (IGR), feeding deterrents, confusants and repellents (Schmutterer, 1990). The neem/azadiractin products act as antifeedant, growth regulator, insect repellent, chemosterilant and toxicant; any pest escaping one effect may be killed by other (Vijayalakashmi *et al*., 1995). The most abundant neem constituent, azadirachtin is considered an excellent phyto-pesticide due to its biodegradability, demonstrated low toxicity to vertebrates, safety to non-target organisms and environmental safety (Jacobson, 1989). Azadirachtrn and extracts of *Polygonum* plant gave moderate to higher

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flea beetle control, recording more than 50% mortality (Ghosh, 2014). *Polygonum* is a notorious weed found in terai region of West Bengal, India locally known as "Biskanthali" (Sarkar and Mukherjee, 2005). Ghosh *et al*. (2009) reported that *Polygonum* plant extracts provided 59.77% aphid suppression in ladysfinger field. Nicotine, an alkaloid obtained from *Nicotiana tabacum,* is well-established botanical pesticide (Ujvary, 1999). Use of mixture of synthetic and tobacco/neem/spilanthes was more economically beneficial than using synthetics alone (Ghosh, 2017). A rapid degradation of persistency was observed in imidacloprid which has a great importance (Ghosh *et al*., 2012). Imidacloprid provided the best suppression of white fly populations (77.00 %) (Ghosh, 2012). The main objective of this study was to formulate eco-friendly management of insect pests of som plant by application of safe pesticide particularly plant product and thus promote better muga silk worm rearing with a quality production for silk industry.

MATERIAL AND METHODS

Experiment location and period

Studies were conducted in the farm and entomology laboratory of UBKV-Agriculture University at Coochbehar, India for two years (2010-11). The study area is located in the foothill area of Himalaya in India. This zone is situated between 25°57' and 27° N latitude and 88°25' and 89°54' E longitude (Subba and Ghosh, 2016). The soil of the land is sandy to loam with slightly acetic in nature. The climate is subtropical humid with a winter spell during November to February (Ghosh, 1999).

Incidence of leaf miner on som plant

Som plants were planted and cultivated under recommended fertilizer doses with standard cultural practices to study the infestation and population dynamics of leaf miner and influence of climatic condition. The plants were fertilized once a year (95 g Urea+145 g SSP+35 g MOP/ plant). Plots size was as 3 m X 3 m in 5 m X 5 m containing 5 plants without taking plant protection measures. Five replications were taken in a Randomized Block Design (RBD). The total leaf miner larvae population / 5 leaves from bottom, middle and top from five randomly selected plants per replication was recorded at seven days (Standard Meteorological Week) interval throughout the year. The recording of larval population on som plant leaves was taken from starting of January to end of December for both the years. Data recorded for the two years, 2010 and 2011 were presented graphically with climatic parameters *viz.* temperature, relative humidity, total rainfall etc. Correlation co-efficient (r) between population dynamics of leaf miner larvae and important climatic parameters were worked out to find out influence of climate on population incidence.

*Evaluation of plant based pesticides against leaf miner (*Phytomyza *spp.) on som plant*

Som plants were grown under standard cultivation practices with recommended fertilizer doses. The fertilizers were applied to the plants once a year (95 g Urea+145 g SSP+35 g MOP/ plant). Spacing was as 3 m X 3 m in 5 m X 5 m sized plots containing five plants with five replications. Under this experiment eleven pesticide treatments and one untreated control were taken and three sprays at 10 day intervals were made. Generally, March-April and August-September are the suitable period for controlling insect pests on som plant when the plants remain vacant from rearing of muga silk worm. Hence, under the present study, spraying had been done during August-September when incidence of leaf miner was at its highest level. Treatments details are as follows: flower parts of *Polygonum hydropiper* (T1), 50.00 ml/L (5%); leaves of *Pongamia pinnata* (T2), 50.00 ml/L (5%); Azadirachtin (Nimarin 1500 ppm) (T3), 2.5 ml/L; Garlic bulb (*Allium sativum*) (T4), 50.00 ml/L (5%); Imidacloprid (Confidor 17.8 SL) (T5), 1 ml/3 L (0.05%); Tobacco (*Nicotiana tabacum)* (T6) leaves, 50.00 ml/L (5%); flower parts of *Spilanthes paniculata* (T7), 50.00 ml/L (5%); Imidacloprid (Confidor 17.8 SL)+Azadiractin (T8), 0.5 ml/ 3L+2.5ml/L; Imidacloprid (Confidor 17.8 SL) + Polygonum (T9), 0.5ml/3L + 50.00 ml/L; Azadiractin+Polygonum (T10), 2.5ml/L + 50.00 ml/L; Azadiractin+Spilanthes (T11), 2.5ml/L + 50.00 ml/L; untreated control (T12).

Plant based extracts and data reading

For the plant extracts standard extraction methodology developed by Ghosh (2019) was followed. At 10 day intervals three sprays were done during August-September with the initiation of heavy infestation of the pest. Leaf miner population were recorded 3, 6, and 9 days after each spraying. The total leaf miner larvae /5 leaves from bottom, middle and top leaves from five randomly selected plants per replication were taken. The results were expressed as leaf miner larvae population controlled (%) compared to population recorded on the control plot. Percent reduction of leaf miner larvae over control treatment was calculated according to Abbott's formula (Abbott, 1925). Software data were analyzed by using INDO-STAT. For analysis of variance following RBD treatment means were separated by applying CD Test (critical difference) at 5 % level of significance.

RESULTS

Incidence of leaf miner on som plant

Leaf miner (*Phytomyza* sp.) (Diptera: Agromyzidae), an important pest of som plant, appeared in both the years (2010 and 2011). Larvae of leaf miner were found inside the mined leaves of som plant. In 2010, its incidence was witnessed at the very beginning of the year and higher level of larvae population was recorded during 27th meteorological standard week to 34th meteorological standard week that is during 1st week of July to last week of August when average temperature, average relative humidity and weekly total rainfall were 28.55°C-31.09°C, 77.56%-90.56% and 19.10mm-134.50mm, respectively. Highest population (23.17larvae/5 leaves) was recorded on 32nd meteorological standard week that is on 2nd week of August when average temperature, relative humidity and weekly average rainfall were 30.98°C, 77.64% and 54.60mm, respectively. Lower population level was observed during 1st meteorological standard week to 10th meteorological standard week that is during 1st week of January to 2nd week of March when average temperature, relative humidity and weekly average rainfall were 18.01°C-29.29°C, 53.85%-86.99% and 0.00mm-0.60mm, respectively. In 2011, higher population level was recorded during 25th meteorological standard week to 34th meteorological standard week that is during 4th week of June to Last week of August when average temperature, average relative humidity and weekly total rainfall were 27.21°C-29.85°C, 79.99%- 92.50% and 31.40mm- 291.40mm, respectively. Highest population (18.33larvae /5 leaves) of leaf miner was recorded on 29th meteorological standard week that is on 3rd week of July when average temperature, average relative humidity and weekly total rainfall were 28.92°C, 85.78% and 165.20mm, respectively. Lower population level was observed during 1st meteorological standard week to 6th meteorological standard week that is during 1st week of January to 2nd week of February when average temperature, average relative humidity and weekly total rainfall were 15.57°C-19.92°C, 67.14%-89.99% and 0.00mm-0.90mm, respectively.

The pooled data of 2010 and 2011 on leaf miner larvae population incidence for the two years (2010 and 2011), showed that leaf miner was active year round (Fig. 1). Lower population level was recorded during 1st meteorological standard week to 6th meteorological standard week that is during 1st week of January to 2nd week of February and higher population level was maintained during 27th meteorological standard week to 34th meteorological standard week that is during 1st week of July to last week of August. Highest population (20.42 larvae/5 leaves) was recorded on 32nd meteorological standard week that is on the 2nd week of August.

Correlation studies (Supplementary Table I) between leaf miner larvae population and environmental parameters revealed that leaf miner population had a significant positive correlation with temperature (maximum, minimum and average) and relative humidity (maximum, minimum and average) while significant negative correlation with temperature difference. This indicates that activity of leaf miner population increase with the rise of temperature and relative humidity.

Evaluation of plant based pesticides against leaf miner on som plant

Under the present investigation the treatments and their persistence at different days after spraying varied significantly in their control of leaf miner larvae populations (Table I). Among the twelve treatments including one untreated control a mixed formulation of imidacloprid, a chemical insecticide at low dose with azadiraction, a plant based insecticide was found most effective against leaf miner recording highest control (79.24 % control), closely followed by recommended dose of imidacloprid (76.25% control) and mixed formulation imidacloprid+polygonum (73.74 % control). From over all observation it was found that mixed formulation Azadiractin+ polygonum, mixed formulation azadiractin+spilanthes and azadiractin provided moderate results recording 60.92 %, 54.83 % and 52.33 % control, respectively.

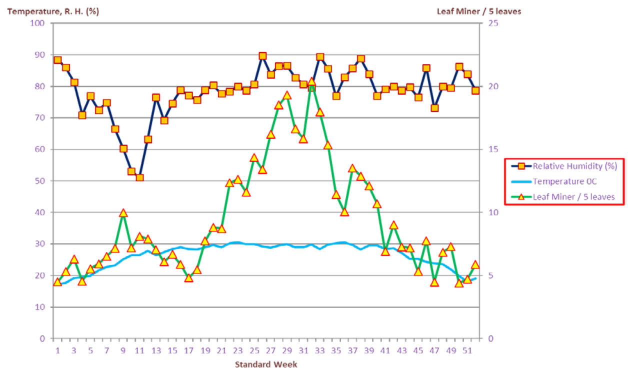

Fig. 1. Seasonal incidence of leaf miner (*Phytomyza* spp.) population (Average) as influenced by temperature and relative humidity.

Three days after treatment (Table I), imidacloprid+ azadiractin was found most effectively against leaf miner recording 81.27 % control, closely followed by imidacloprid treatment recording 75.76 % control and imidacloprid+Polygonum (75.19% control). There were no significant differences among these three treatments. Six days after treatment, imidacloprid+azadiractin was found most effective treatment against leaf miner

Table I. Overall efficacy of plant extracts against leaf miner (*Phytomyza* sp.) on som plant (grand mean of 2010 and 2011).

Treatments	Dose ml / Litre (%)	Over all efficacy (% reduction or increase)				
		Pre-treatment obs. larva of leaf miner / 5 leaf	3 DAT	6 DAT	9 DAT	Mean
Polygonum (T1)	50.00 ml/L(5%)	10.77	46.62(42.95)	41.72(39.94)	36.32(37.02)	41.55(39.97)
Pongamia (T2)	50.00 ml/L(5%)	12.78	34.95(36.24)	30.63(33.53)	25.85(30.55)	30.48(33.44)
Azadirachtin (Nimarin 1500 ppm) (T3)	2.5 ml/L	10.87	55.51(48.23)	54.86(47.79)	46.62(42.95)	52.33(46.32)
Garlic (T4)	50.00 ml/L(5%)	11.57	27.08(31.22)	26.79(30.89)	22.68(28.32)	25.52(30.14)
Imidacloprid (Confidor 17.8 SL) (T5)	1 ml/3 L	11.89	75.76(60.65)	76.98(61.34)	76.01(60.83)	76.25(60.94)
Tobacco (T6)	50.00 ml/L(5%)	12.45	35.14(36.21)	36.91(36.77)	31.11(33.25)	34.39(35.41)
Spilanthes (T7)	50.00 ml/L(5%)	11.02	42.71(40.53)	36.02(36.55)	32.86(34.92)	37.20(37.33)
Imidacloprid+Azadiractin (T8)	0.5ml/3L+ 2.5ml/L	10.86	81.27(67.98)	81.27(67.98)	75.19(60.14)	79.24(65.37)
Imidacloprid+Polygonum (T9)	0.5ml/3L+50.00ml/L	12.25	75.19(60.14)	73.52(59.03)	72.52(58.39)	73.74(59.19)
Azadiractin+Polygonum (T10)	2.5ml/L+ 50.00ml/L	12.78	65.56(54.07)	63.35 (54.08)	53.84 (51.63)	60.92 (53.26)
Azadiractin+Spilanthes (T11)	2.5ml/L + 50.00ml/L	10.98	61.60 (51.75)	54.93 (47.78)	47.95(43.69)	54.83 (47.74)
Untreated Control (T12)	---------	12.44	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)
S Em (±)	---------	--------	2.27	2.11	2.39	----
CD at 5%	----------	NS	6.89	6.47	7.03	----

Figure in the parenthesis are angular transformed values; DAT, days after treatment; NS, not significant.

recording 81.27 % control, closely followed by imidacloprid treatment recording 76.98% control. There were no significant differences between these two treatments. Nine days after treatment, imidacloprid was found to be most effective (76.01% control) against leaf miner, closely followed by Imidacloprid+azadiractin (75.19% control) and imidacloprid+Polygonum (72.52% control). There were no significant differences among these three treatments.

DISCUSSION

Larvae of leaf miner were found inside the mined leaves of som plant and found year round infesting the som plant leaves. So it is difficult to control the pest. From correlation study it is found that activity of leaf miner population increase with the rise of temperature and relative humidity. Singh and Sarvanan (2008) reported that leaf miner population increased with the rise of maximum temperature, morning relative humidity which supported the present study. The study was also supported by Yadav *et al*. (2010) where they reported that incidence of *Phytomyza* spp. was positively correlated with minimum and maximum temperatures in all genotypes under protected and unprotected treatments during both years. They also reported that all genotypes under protected and unprotected treatments were found positively correlated with relative humidity and rainfall during both years. As muga silk worm is rearing on som plants so it is not possible to spray on som plant leaves year round. Higher population level is found during July- August – September, when the temperature and relative humidity remain high. So under this study spray has been done during August-September. It is also noted that during August-September the plant remain vacant from rearing of muga silk worm.

Chemical synthetic insecticides should not be used for pest control on som plant as because the muga silk worm is rearing on som plants and there is every possibility of killing of muga silk worm. Though Singh and Sarvanan (2008) reported that imidacloprid gave 100% control of leaf miner after five days of spraying but this should not be allowed in som plant for leaf miner control. Microbial pesticides also should not be used as they cause different diseases to muga silk worm and immediately kill it. So plant based products are suitable and safe for controlling insect pest on som plants. Rahardjo *et al*. (2020) reported that the application of plant extract that has an insecticidal effect is considered as one promising alternative in reducing the negative effects of synthetic pesticides. They also reported that the respected treatments of Chinese mahogany leaf extract, pyrethrum petal, chinaberry leaf and commercial botanical insecticide Neem Plus also supressed more than 62% leaf miner attacks and induced the increase of marketable produce. Plant based products when used singly they did not record higher control of leaf miner on som plant. Plant based insecticide azadiractin provided moderate control (52.33 % control) when used alone. Plant extracts like polygonum, tobacco, pongamia and garlic when used alone provided lower killing, 41.55, 34.39, 30.48 and 25.52, respectively. When these plant extracts are used mixing with small amount (50 % lower of the recommended doses) of chemical insecticide, imidacloprid provided higher killing of the leaf miner. Plant based insecticide, azadiractin when used mixing with small amount (50 % lower of the recommended doses) of chemical insecticide, imidacloprid provided highest killing of leaf miner (79.24 % control). Plant based insecticide azadiractin when applied mixing with plant based extracts provided higher killing of leaf miner. Most important three treatments for controlling leaf miner are imidacloprid+azadiractin, imidacloprid+polygonum and azadiractin+polygonum providing 79.24 %, 73.74 % and 60.92 % leaf miner control respectively. They contain plant based formulation with small amount of chemical formulation and provided higher control measure. Extracts of *Polygonum* plant provided better aphids control, providing about 60% control (Ghosh *et al*., 2009) and they also reported that polygonum plant extracts provided 59.77% control in ladyfinger. But Imidacloprid or other chemical synthetic pesticides being highly toxic, should not be used in pest control on som plant. There is every possibility to contaminate som plat leaf and the muga silk worm may be damages with the toxic chemicals. So use of highly toxic insecticides should be avoided. Ghosh *et al*. (2013) reported that a rapid degradation of persistency was observed in imidacloprid and neem oil than other pesticides tested. So imidacloprid as small amount may be recommended mixing with plant based insecticides for general use of the farmers for its higher efficacy and rapid degradation. We should use plant based pesticides mixing with plant based extracts like azadiractin with polygonum. Plant based insecticides or plant extract cannot give higher control when it is used individually but when it is mixed with other formulations it provides higher control. We should also use plant based pesticides/extracts like azadiractin/polygonam/spilanthes mixing with small dose of synthetic chemical pesticide like imidacloprid which will be environmentally sound and eco-friendly.

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Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20200503080502

Statement of conflict of interest

The authors have declared no conflict of interest.

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Supplementary Material

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Supplementary Table I. Correlation co-efficient between leaf miner (*Phytomyza sp*.) and environmental parameters.

Environmental parameter		Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Temperature ^{0}C	Maximum	0.498**	0.247	Y= 0.75x - 13.82
	Minimum	0.693**	0.479	Y= 0.574x - 2.940
	Difference	-0.709**	0.502	Y= -0.993x + 18.85
	Average	0.643**	0.413	Y= 0.710x - 9.238
Relative Humidity (%)	Maximum	0.241*	0.058	Y= 0.151x - 3.093
	Minimum	0.389**	0.151	Y= 0.165x - 2.665
	Average	0.353**	0.124	Y= 0.191x - 5.488

*, Significant at 5% level of significance; **, Significant at 1% level of significance.

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