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RESEARCH ARTICLE

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Chemical Management of *Spilosoma obliqua* Walker in Greengram

A. Ghosal, M. Sehgal[1], N.K. Adhikary[2], N.C. Sahu

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ABSTRACT

Background: Greengram the most important pulse crops in India suffers a lot due to infestation of many lepidopteran caterpillars mainly at its reproductive stage. *Spilosoma obliqua* Walk. Arctiidae, Lepidoptera commonly called Bihar hairy caterpillar (BHC) is categorized as the most devastating.

Methods: Field efficacy of nine new generation popular insecticides were tested in coastal saline zone of West Bengal against BHC in greengram (IPM 2-3) during 2021-2022. Leaf dip bioassay study of those selected insecticides were also conducted to compute the LC_{50} value against the field collected as well as laboratory reared F_2 generation 3rd instar larvae of BHC.

Result: All the test insecticides showed lethal effect towards BHC but the magnitude of protection over control was significantly higher in spinosad (70.92%) followed by flubendiamide (70.35%). Pyriproxifen+fenpropathrin (29.92%) was proved to be the least effective treatment followed by pyriproxyfen+bifenthrin (31.91%). As per LC_{50} value (ppm) flubendiamide showed the highest toxicity against BHC in respect of laboratory reared caterpillar and field collected caterpillar (4.49 and 6.71 respectively), while pyriproxifen+fenpropathrin the lowest (624 and 637 ppm). BHC was recorded as potent defoliator which was reflected in yield, while pod damage is not so pronounced.

Key words: Bihar hairy caterpillar, Flubendiamide, Greengram, Insecticides, LC_{50}.

INTRODUCTION

Greengram (*Vigna radiata*) is a member of Fabaceae family (Kumar and Baojun, 2018) widely grown throughout Asia (South East-Asia, India and East Asia), Southern USA and Southern Europe as important pulse crop (Heuze *et al.* 2015). Being a legume greengram has wide acceptance over the farming community as a component of crop rotation and green manuring for its biomass (7.16 t ha^{-1}), nitrogen fixing ability in soil (30-251 kg ha^{-1}). The seeds are invariably a good sources of vegetative protein (Heuze *et al.* 2015). India is the largest producer (3.2 million metric tons in 2022) and consumer of mung bean (> 50% of production). Like other pulses, insect pests are the one of the important limiting factors at all stages from sowing to harvest. Out of several insect attack one Diptera, two Orthoptera, two Hemiptera, four Coleoptera and six Lepidoptera members were so important (Islam *et al.* 1984). *Spilosoma obliqua* Walk. commonly called as jute hairy caterpillar or Bihar hairy caterpillar (BHC) is the most devastating (Lal, 2008; Mobarak *et al.* 2020). On an average 32.97 per cent yield loss was reported on different cultivars of green gram (Duraimurugan *et al.* 2014). Insecticidal management is the most potent option adopted by the farmer because of its quick knock down effect. Toxic effects of any chemical on a biological system depends on various factors such as, permeability of membrane barrier to the chemical and its arrival at that target site, sensitivity of the target site to the chemical, metabolism of the chemical, physiological condition *etc.* Physiological approaches to insecticides selectivity is now gaining important role for their minimal impact over the environment. The development of resistance of insects creates a major problem throughout the world resistance which is a dynamic phenomenon. The present attempt was made to assay the impact of some potent insecticides for the management of BHC in greengram in changing climate.

Sasya Shyamala Krishi Vigyan Kendra, Ramakrishna Mission Vivekananda Educational and Research Institute, Kolkata-700 103, West Bengal, India.

[1]ICAR-National Research Centre for Integrated Pest Management, Pusa-110012, New Delhi, India.

[2]ICAR-All India Coordinated Research Projects on Vegetable, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema-797 106 Nagaland, India.

Corresponding Author: A. Ghosal, Sasya Shyamala Krishi Vigyan Kendra, Ramakrishna Mission Vivekananda Educational and Research Institute, Kolkata-700 103, West Bengal, India.
Email: ghosalabhijit87@gmail.com

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MATERIALS AND METHODS

The experiment was carried out in randomized block design (RBD) with nine insecticides including a *Bacillus thuringiensis* (Bt) *i.e.* spinosad 45% SC @ 0.32 ml lit^{-1}, emamection benzoate 5% SG @ 0.5 g lit^{-1}, B.t. @ 2 ml lit^{-1}, pyriproxyfen 10%+bifenthrin 10% EC @ 2 ml lit^{-1}, novaluron 10% EC @ 2 ml lit^{-1}, indoxacarb 14.5% SC @ 0.8 ml lit^{-1}, lamda cyhalothrin 5% EC @ 0.6 ml lit^{-1}, flubendiamide 39.35% SC @ 0.25 ml lit^{-1}, profenofos 40%+cypermethrin 4% EC @ 2 ml lit^{-1}, pyriproxifen5% EC+fenpropathrin 15% EC@ 1 ml lit^{-1}along with a control (no spray) at village Narayantala, Basanti, South 24 Parganas, West Bengal. IPM 2-3 variety released by IIPR-Kanpur was taken as test plant, which was sowed at the first fortnight of February 2021 and 2022. The crop was raised through broad casting with a seed rate of 30 kg ha^{-1} maintaining the plant population of 55 plants per sq. meter unit area done by thinning at 20 DAS with 16 kg P_2O_5 per acre during final land preparation, 2% DAP and boron was sprayed at 30 and 45 DAS respectively. Spraying the crop was initiated after gregarious feeding (10% leaf feeding) or 10 nos. of 2nd instar larvae noted per leaf from 1 sq. m area randomly selected from five locations. The crop was sprayed twice at a gap of 15 days. Population was recorded before the spray and seven days after each spray. The laboratory experiment was carried out at Plant Health Clinic Laboratory, Sasya Shyamala Krishi Vigyan Kendra, RKMVERI, Arapanch, West Bengal. Third instar larvae of BHC were collected from field for bioassay test as well as larvae were collected from experimental field, reared in glass jar with leaves of greengram and they were allowed for becoming adult. After transformation from larvae to pupae, the pupae were placed in a petridish which was filled with sand. Then the petridish with the pupae was kept inside a large glass jar and a cotton swab soaked in 15% honey solution was also kept inside the jar. Then the jar was covered with a cloth. When the adults emerged from the pupae they mated and laid the eggs on the inner surface of the cloth cover and also on cotton swab. The eggs were carefully collected with the help of brush and allowed for hatching and feeding on the fresh leaves for getting the desired stage of caterpillar.

Leaf dip bioassay method was followed as suggested by IRAC (Anonymous, 1990). The tender succulent green leaves of greengram were dipped into the test solution of insecticide (six concentrations for each insecticide replicating three time) for 10 seconds with gentle agitation. Leaf surface was allowed to dry and then the leaves were placed in each petridish. Ten numbers of larvae collected (starved over 5 hours) were released in each petridish. For untreated control, the leaf was dipped in plain water.

In the laboratory, relative toxicity of the insecticides was worked out. The mortality rate of larvae recorded after 24 h were converted to percentage of mortality by using the following formula:

$$\text{Percentage of mortality} = \frac{\text{Number of dead insects}}{\text{Number of treated insects}} \times 100$$

Generally moribund insects were considered as dead. The data were subjected to probit analysis after correcting the mortality in the untreated check by Abbott's formula (Abbott, 1925).

$$P = \frac{P_1 - C}{100 - C} \times 100$$

Where,

P= Per cent corrected mortality.

P_1= Per cent observed mortality.

C= Per cent control mortality.

The probit analysis was done by a method modified by D.J. Finney (1971) for the mathematical estimation of the median lethal concentration (LC_{50}) and probit regression line (Finney, 1964; Finney, 1971). The order of relative toxicity of different insecticides was then determined by comparison of LC_{50} values by taking the insecticide possessing the highest LC_{50} value as unity.

The differential response of different population of BHC to different insecticides in terms of LC_{50} values was attributed to the development of resistance as compared to the most susceptible population. Resistance index was computed according to the formula suggested by FAO (1979) as follows:-

$$\text{Resistance index} = \frac{LC_{50} \text{ of resistant strain}}{LC_{50} \text{ of susceptible strain}}$$

Dosage mortality response on the basis of laboratory reared insect larvae of F_2 generation and field population and computed to resistance index formula to find out their variation of toxicity.

RESULT AND DISCUSSION

Effect of different insecticides against BHC infestation on greengram

As the result indicated in Table 1 that the pretreatment count of BHC larval population, varied from 16.67 to 18.67 numbers of larvae per plants. The highest mean reduction of BHC population was recorded in novaluron (92.38%) treated plots followed by flubendiamide (92.05%), spinosad (91.90%) and chlorfenapyr (84.13%). All the chemicals showed significant reduction of larval population of BHC but in untreated plot the population increased up to 39.33 per cent after the period of the second and final round spray.

The mean percentage of pod damage after first spray was only 3 per cent in spinosad treated plots followed by novaluron (3.10%), flubendiamide (3.25%), mixed formulation of profenofos+cypermethrin (4.72%) and chlorfenapyr (6.40%). Similar trend of mean pod damage was also recorded after the second spray with the lowest reduction of pod damage in spinosad (0.70%) followed by flubendiamide (0.75%) and novaluron (1%). The rest of the other insecticides also performed well in reducing the pod damage. The overall mean percentage of pod damage as well as percent of reduction over control were the lowest and the highest in spinosad (1.85% and 88.78% respectively) followed by other chemicals ranging from 2 to 5.78 per cent pod damage and 64.95 to 87.87 per cent reduction over control. In untreated control plot, the mean percentage of pod damage increased up to 16.49 per cent. The highest yield was recorded in spinosad (12.05 q ha^{-1}) treated plot followed by flubendiamide (12.01 q ha^{-1}),

Table 1: Efficacy of different insecticides against *Spilosoma obliqua* infestation on greengram.

Treatments	Mean no. of defoliators/plant before spray	Mean % reduction or increase (+) after		Overall mean % reduction. increase (+)	Mean % of pod damage after spray		Overall mean % pod damage	Percent protection over control	Yield q/ha **	Yield increase over control (%)
		1st spray**	2nd spray**		1st spray**	2nd spray**				
Flubendiamide	17.35	85.60 (67.70)	98.5 (82.97)	92.05	3.25 (10.47)	0.75 (5.13)	2.00	87.87	12.01	70.35
Chlorfenapyr	18.67	81.75 (64.75)	86.5 (68.44)	84.13	6.40 (14.65)	3.55 (10.94)	4.98	69.80	10.39	47.37
Spinosad	16.67	85.30 (67.46)	98.5 (82.97)	91.90	3.00 (9.97)	0.70 (4.80)	1.85	88.78	12.05	70.92
Emamectin benzoate	17.00	76.60 (61.07)	88.4 (70.09)	82.50	6.65 (15.00)	3.25 (10.47)	4.95	69.98	10.75	52.48
B.t	18.00	78.75 (62.58)	81.3 (64.38)	80.03	6.70 (15.00)	4.35 (12.11)	5.53	66.46	9.55	35.46
Novaluron	18.33	87.30 (69.12)	97.45 (80.90)	92.38	3.10 (10.14)	1.00 (5.74)	2.05	87.57	11.85	68.08
Pyriproxyfen+Bifenthrin	17.67	76.40 (60.94)	79.55 (63.15)	77.98	7.25 (15.68)	4.18 (11.83)	5.72	65.31	9.30	31.91
Pyriproxifen+Fenpropathrin	16.67	71.66 (57.86)	83.25 (65.88)	77.46	7.50 (15.89)	4.05 (11.68)	5.78	64.95	9.16	29.92
Profenofos+Cypermethrin	18.67	84.30 (66.66)	78.75 (62.58)	81.53	4.72 (12.52)	4.68 (12.52)	4.70	71.50	10.08	42.97
Untreated	17.33	(+) 27.67 (0.00)	(+) 39.33 (0.00)	33.50	14.62 (22.46)	18.35 (25.40)	16.49		7.05	
SE. m ±		2.48	3.63		2.13	1.27			0.12	
CD (0.05)		4.21	6.17		3.62	2.16			0.25	
CD (0.01)		6.09	8.93		5.24	3.13			0 .54	

* = Significant at 5 per cent level , ** = Significant at 1 per cent level in the parenthesis are angular transformed values.

novaluron (11.85q ha^{-1}), emamection benzoate (10.75q ha^{-1}), chlorfenapyr (10.39q ha^{-1}) and profenofos +cypermethrin (10.08q ha^{-1}). The rest of the chemicals also showed good yield with respect to untreated control plot.

Dose-mortality responses and LC_{50} values of insecticides against BHC

The nine test insecticides were evaluated to determine the LC_{50} value against the BHC caterpillar through leaf dip assay. The data from the Table 2 and 3 showed that the acute toxicity of flubendiamide is higher than other insecticides. The LC_{50} values of flubendiamide was 4.49 and 6.71 (laboratory and field strain) ppm followed by emamectin benzoate (4.87 and 7.2 ppm) and spinosad (6.54 and 8.7 ppm). Novaluron, pyriproxyfen+bifenthrin and pyriproxifen +fenpropathrin exhibited lower levels of toxicity with higher LC_{50} values. B.t also showed lower toxicity with higher LC_{50} values (150 and 177 ppm). Variation of relative toxicity in laboratory rearing and field collected larvae indicates the lower sensitivity of field population than laboratory cultured insects. Table 4 shows that the level of tolerance is higher in field collected larvae; whereas susceptibility is more in laboratory condition except in the case of novaluron and pyriproxifen+bifenthrin. Profenofos+cypermethrin had the greatest variation (1.65), followed by flubendiamide (1.49).

BHC is one of the most potential defoliator of greengram. High fecundity and dispersal of the crawlers creates heavy loss of seed yield of pulses. It is pertinent from the present observation that insecticide plays an important role in minimizing the infestation of insect pests. The test insecticides proved to reduce the seed yield damage to the tune of 70.92 per cent over untreated. The range of protection over untreated plot was 29.92 to 70.92 per cent. Thus selection of insecticides is critical to reduce the yield loss. In the present investigation, the order efficacy is novaluron followed by flubendiamide, spinosad, emamectin benzoate, chlorfenapyr. The insecticides selected to assay have novel modes of action. Profenofos+cypermethrin and pyriproxifen+bifenthrin can protect the crop from a variety of insect pests. A similar findings was also reported by Ghosal *et al.* (2018). The novel IGR based benzoylphenyl urea based insecticide novaluron was found to be the best chemical in our present study because of its ability to inhibit a common stimulatory effect on the reproductive stage of adult females, in spite of the time of larval treatment (Hamadah *et al.* 2015). The efficacy of emamectin benzoate and novaluron against BHC was also supported by Meena *et al.* (2020). As reported by Sasmal and Kumar (2016), spinosad a derivative of soil actinomycetes, *Saccharopolyspora spinosa*, containing spinosyn A and spinosyn D readily affect the acetyl choline receptor and disrupt GABA was proved highly effective insecticides against BHC in greengram, In our present experiment the flubendiamide, benzenedicarboxamides or phthalic acid diamides member showed high toxicity against the larval population of BHC, which is comparable with the findings of Tatagar *et al.*(2009). The uniqueness of the structure of flubendiamide results from three parts with novel substituents; a heptafluoroisopropyl group in the anilide moiety, a sulfonylalkyl group in the aliphatic amide moiety and an iodine atom at the 3-position of the phthalic acid moiety. The compound shows extremely strong insecticidal activity, especially against lepidopterous pests, including resistant strains. Flubendiamide would have a novel mode of action because the insecticidal symptoms accompanied by a discriminative contraction of the larval body are distinguished from those of commercial insecticides. It is also very safe for non-target organisms (Tohnishi *et al.* 2005).

Efficacy of biorational pesticides with novel chemistry like spinosad, emamectin benzoate, chlorfenapyr and flubendiamide upon lepidopteran caterpillar was also proved by Ghosal *et al.* (2012; 2013). Mishra *et al.* (2017) also reported similar observation. Toxicity of flubendiamide, emamectin benzoate, profenophos was also measured by Selvaraj *et al.* (2014); who also suggested that synergistic effect of profenophos in combination with λ-cyhalothrin (3:1) will boost the effect of profenophos. As an insect growth regulator pyriproxifen act on eggs and immature larva preferably young instar thus in field condition to protect against diverse instars, combination with bifenthrin showed

Table 2: Dosage Mortality response and LC_{50} values of different insecticides for the laboratory rearing larvae of *Spilosoma obliqua* (leaf dip-bioassay and 24 hrs exposure).

Insecticide	Heterogeneity χ^2 (5)	Regression equation (y=)	LC_{50} (ppm)	Fiducial limits	Relative toxicity
Flubendiamide	2.96	1.09x+2.39	4.49	2.26-6.7	138.98
Chlorfenapyr	3.37	2.86x-0.25	19.5	11.7-24.5	32
Spinosad	1.32	2.14x+1.81	6.54	2.81-8.62	95.41
Emamectin benzoate	4.08	4.27x +2.52	4.87	2.72-6.92	128.13
B.t	1.16	1.92x-1.71	150	121-337	4.16
Novaluron	5.81	3.82x+2.16	371	117-534	1.68
Pyriproxyfen+Bifenthrin	2.23	4.06x-1.76	416	278-696	1.5
Pyriproxifen+Fenpropathrin	4.22	227x+0.84	624	326-792	1
Profenofos +Cypermethrin	3.21	2.73x+1.02	42.3	23.3-67.5	14.75

Table 3: Dosage Mortality response and LC_{50} values of different insecticides for the field collected larvae of *Spilosoma obliqua* (leaf dip-bioassay and 24 hrs exposure).

Insecticide	Heterogeneity χ^2 (5)	Regression equation (y=)	LC_{50} (ppm)	Fiducial limits	Relative toxicity
Flubendiamide	7.86	3.22x+1.87	6.71	2.41-9.72	60.21
Chlorfenapyr	7.24	4.21x-2.02	22.5	12.6-41.4	17.96
Spinosad	3.68	1.76x+3.86	8.7	2.39-11.62	46.44
Emamectin benzoate	6.42	2.41x+0.672	7.2	2.17-14.6	56.11
B.t	8.69	6.14x-1.41	177	118-336	2.28
Novaluron	7.86	3.22x-0.79	226	121-442	1.79
Pyriproxyfen+Bifenthrin	6.54	2.94x+1.23	404	209-814	1
Pyriproxifen+Fenpropathrin	7.32	3.26x-0.87	637	428-832	1.20
Profenofos +Cypermethrin	5.46	3.37x+1.38	69.6	40.2-107.5	5.80

Table 4: Dose mortality response (LC_{50}) of different insecticides for the larvae of different pests (laboratory rearing and field collected larvae).

Insecticides	LC_{50} (ppm) of larvae of *Spilosoma obliqua*		
	Laboratory rearing larvae	Field collected larvae	Resistance index
Flubendiamide	4.49	6.71	1.49
Chlorfenapyr	19.5	22.5	1.15
Spinosad	6.54	8.7	1.33
Emamectin benzoate	4.87	7.2	1.48
B.t	150	177	1.18
Novaluron	371	226	0.61
Pyriproxyfen+Bifenthrin	416	404	0.97
Pyriproxifen+Fenpropathrin	624	637	1.02
Profenofos+Cypermethrin	42.3	69.6	1.65

synergistic effect against BHC. Susceptibility to profenofos +cypermethrin between laboratory reared and field collected larvae showed the highest variation compared with the other insecticides; high selection pressure due to excessive exposure in field will be the possible reason behind this. Sujayanand *et al.* (2021) opined that *S. obliqua* is highly susceptible than *H. armigera* undergone through survival analysis. The variation in efficacy of insecticides in laboratory and field conditions may be explained by the fact that in laboratory controlled conditions, only biotic and abiotic factors are interrelated with each other.

CONCLUSION

From the above result of the present study, it can be concluded that insecticides are critical weapon to combat the incidence of insect pest. Depending on selection of insecticides the level of protection may vary. All the test insecticides were proved lethal towards *S. obliqua* but the magnitude of protection is quite high in spinosad followed by flubendiamide compared to insecticides pyriproxifen +fenpropathrin and pyriproxyfen+bifenthrin. However the LC_{50} value indicated that flubendiamide showed the highest toxicity. Selection of insecticides should be done based on the LC_{50} value, as it is the measure of toxicity that is coupled with the effective protection against the targetted insects.

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