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Bio-efficacy of Entomopathogenic microbials and insect growth regulators against *Spodoptera litura* (Fabricius) and *Spilarctia oblique* (Walker)

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ABSTRACT
In the study, bio - efficacy of entomopathogenic microbials and insect growth regulators was evaluated against Spodoptera litura and Spilarctia oblique during kharif 2014, at the Entomology departmental laboratory and experimental farm, College of Agriculture, Jabalpur, Madhya Pradesh. Findings revealed that all six doses of insect Growth Regulator (IGRs), Novaluron + Indoxacarb 4.5 SC (0.25, 0.5, 0.75, 1.0, 1.25 and 1.5 ml/l) were significantly effective against 3rd instar larvae of Spodoptera litura All three doses of Novaluron + Indoxacarb 4.5 SC caused significantly higher mortality. At 7 days after treatment cent percent larval mortality was observed in all the treatments except on untreated control that had 23.34% larval mortality.
Keywords: *Glycine max, Spodoptera litura, Spilarctia obliqua, Beauveria bassiana, Metarhizium anisopliae etc.*

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INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is one of the most important oilseed cash crops of India. Soybean is a major oil seed crop of the world grown in an area of 113.01m ha with production of 283.79 mt and productivity of 2.51 t/ha [1]. The crop is mainly cultivated in USA, China, Brazil, Argentina and India. India contributes more than 90 per cent of the world's acreage [6]. Major soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh, Andhra Pradesh and Gujarat [6]. In the year 2012-13 in India, soybean cultivation reached to 12.03 m/ha recording production of 12.98 mt with an average of 1079 kg/ha. In the year 2012-13 in Madhya Pradesh, soybean is grown over an area of 6.26 m/ha with a production of 5.95 mt and productivity of 950 kg/ha [6].

The defoliators [*Spodoptera litura* (fab), *Spilarctia oblique* (Walker)] are feeding on pods, flower and foliage causing significant yield loss [4]. The *Spodoptera litura* (fab) is a regular and serious pest in Madhya Pradesh. It damages soybean from mid-August to October in *kharif* and from November to March in rabi [7].

To overcome these losses caused by insect pests various control measures have been recommended. Of which chemical control measures are reported to be more effective. Insect Growth regulators (IGRs) act as chitin synthesis inhibitors have been relative non-toxicity to beneficial organisms and their general safety to vertebrates, molluscs and plants and regarded as an excellent integrated control because of their specificity to the target pest[7].

Insect growth regulators (IGRs) are comes under modern pesticides group, which may play a desirable role in integrated pest management [5]. Novaluron (IGR), lufenuron and diflubenzuron was found effective against *Spodoptera litura* (fab) [7].
Use of microbial insecticides and IGR are gaining more importance in recent years. Keeping in mind the above facts, research work was conducted to test the bio - efficacy of entomopathogenic microbials and insect growth regulators against *Spodoptera litura* and *Spilarctia oblique.*

MATERIAL AND METHODS

The present experiments were conducted during kharif 2014, at the Entomology departmental laboratory and experimental farm, College of Agriculture, Jabalpur, Madhya Pradesh, using Complete Randomized Design (CRD) with three replications and fourteen treatments (Table 1).

Against *Spodoptera litura:*

The experiment was laid out in laboratory using completely randomized design. The newly hatched larvae were maintained in the laboratory at 24 ± 2°C temperatures and 78 ± 5 % relative humidity (RH). Five 3rd instar larvae per treatment were used to evaluate bio-efficacy of different insect growth regulators (IGRs). Fresh leaves of JS 97-52 soybean variety were collected from field and treated with different IGRs at different doses i.e. (0.25, 0.50, 0.75, 1.0, 1.25 and 1.50 ml/litre). Treated leaves were fed to larvae for 24 hours and then the leaves were replaced by untreated fresh leaves after every 24 hours till larval mortality / pupation. Observations on larval mortality (%) were recorded at 3, 5, 7 and 10 days after treatment. The dead larvae were transferred to humid chamber and incubated for five days and observed to ensure that the mortality was due to IGRs and not owing to any microbial infection.

Against *Spilarctia obliqua:*

The newly hatched larvae were maintained in the laboratory at 24 ± 2°C temperature and 78 ± 5 % relative humidity (RH). Ten 3rd instars larvae per treatment were used to evaluate bio - efficacy of different insect growth regulators (IGRs) and entomopathogenic microbials. Fresh leaves of JS 97-52 soybean variety were collected from the field and treated with different IGRs and entomopathogenic microbials at different doses i.e. (0.25, 0.50, 0.75, 1.0, 1.25 and 1.50 ml/litre and 1 x 10^{12} spores / ml). Treated leaves were fed to larvae for 24 hours and then the leaves were replaced by untreated fresh leaves after every 24 hours till larval mortality / pupation. Observations on larval mortality (%) were recorded at 3, 5, 7 and 10 days after treatment. The dead larvae were transferred to humid chamber and incubated for five days and observed to ensure that the mortality was due to IGRs and microbial infection.

Statistical analysis:

Statistical analysis after tabulation in to transformed values, the population data of larvae were transformed to $\sqrt{X + 0.5}$ while the data in percentages were transformed to their angular values. The data so obtained were analyzed by using the analysis of variance technique as given below.

Table 1: The skeleton of "Analysis of Variance"

Source of variance	D.F.	S.S.	M.S.S.	F. Cal	F. Table
Replications	(r-1)	SSR	VR	VR / VE	
Treatments	(t-1)	SST	VT	VT / VE	F at 5% (t-1), (r-1) (t-1)
Error	(r-1) (t-1)	SSE	VE	-	-
Total	(r.t-1)	-	-	-	-

Where,
r = number of replications
t = number of treatments
VR= replication mean sum of square
VT=treatment mean sum of square
VE= error mean sum of square

The significance among different treatment means was judged by critical difference (C.D) at the 5% level of significance for comparison among the treatments, for which the marginal mean of each treatment was considered. The following formula was used for estimation of SEm & critical difference.

(1) Standard error of mean = $SEm\pm = \sqrt{\frac{SEm}{r}}$

(2) Critical difference (C.D.) = SEm X $\sqrt{2}$ x t 0.05

Where,

Ems	=	error mean sum of square
t	=	't' value at 5 % level at error d.f.
r	=	number of replications
SEm±	=	standard error of any treatment mean
CD	=	Critical Difference

RESULTS AND DISCUSSION

Bio - efficacy of entomopathogenic microbials and insect growth regulators against *Spodoptera litura* (Fabricius) and *Spilarctia oblique* (Walker) which ultimately help to develop sustainable IPM strategies. Data recorded on the bio - efficacy of entomopathogenic microbials and insect growth regulators against *Spodoptera litura* and *Spilarctia oblique* on larval mortality at 3, 5, 7 and 10 days after treatment (DAT) are presented in Table 2 and 3.

Tobacco caterpillar, *Spodoptera litura*

At the 3rd day after treatment the Novaluron + Indoxacarb 4.5 SC (IGR) caused significantly the higher larval mortality (100%) in all six doses (1.25 ml/l, 1.5 ml./l, 1ml/l, 0.75ml/l, 0.5ml/l and 0.25ml/l) tested followed by Novaluron 10% EC (IGR) @ 0.25ml/l and 0.5ml/l (53.34% and 46.67%, respectively), Novaluron 10%EC@ 0.5ml/l (46.67%). Lower mortality was observed in Novaluron 8.8% SC@ 0.5ml/l and 0.25ml/l (20% and 26.67% respectively), were found intermediate. While no mortality was observed in the Novaluron 8.8% SC @ 1ml/l and control (sterilized water).

At the 5th day after exposure, it was observed that Novaluron 10% EC (IGR) caused 100% mortality at both the doses (0.5ml/l and 0.25ml/l), followed by Novaluron 8.8% EC@ 0.25ml/l and 0.5ml/l (80% and 73.34% mortality, respectively) and both were at par. No larval mortality was observed in the control, Dhawan *et al.* [3] also tested Novaluron (10 EC), an insect growth regulator @ 25, 37.5 *a*nd 50 g a.i./ha for the control of tobacco caterpillar *S. litura* and reported that Novaluron @ 50 g and 37.5 g a.i./ha was most effective against *Spodoptera* sp., bollworms on cotton and it may be fit in IPM strategies as potential component..

At the 7th day after treatment the larval mortality in Novaluron 8.8% SC@ 0.25 ml/l and 0.5 ml/l was 86.67% and 73.34%, respectively and both were significantly different. Wheras larval mortality was less in untreated control (20%) as compared to other treatments.

At the 10th day the Novaluron 8.8% EC treatment @ 0.5 ml/l and 1ml/l recorded 93.34% and 80% mortality, respectively and were significantly different from each other. Except above, all other IGR treatment and doses recorded cent percent mortality at tenth day of treatment.

Bihar hairy caterpillar, *Spilarctia oblique*

`After 24 hrs of treatment none of the treatments exhibited larval mortality. The mortality was seen three days after treatment. Novaluron + Indoxacarb 4.5 SC, 0.25, 0.5, 1.0, 1.5 and 1.25 ml/l caused significantly the higher larval mortality (90, 86.67, 83.34, 83.34, 80.0, 80.0 and 80.0 per cent, respectively) and all were at par. Significantly lower larval mortality was found in Novaluron 8.8% EC @ 0.25 ml/l (53.34%) followed by *Beauveria bassiana* @ 1 x 10^{12} spores/ml (63.34%) and both were at par. Intermediate larval mortality was found in Novaluron + Indoxacarb 4.5 SC @ 0.5 ml/l, Novaluron 10% EC @ 0.25 ml/l, Novaluron 8.8% SC @ 1ml/l and 0.5 ml/l with mortality range between 80% and 70%. No mortality was observed in untreated control (Fig. 4).

At the 5th day after treatment, all the three doses of Novaluron + Indoxacarb 4.5 SC caused significantly higher mortality (100%) followed by Novaluron + Indoxacarb 4.5 SC @ 1.5 ml/l and 1.0 ml/l , Novaluron 10% EC @ 0.5ml/l and 0.25ml/l, Novaluron 8.8% SC @ 1.0 ml/l, *Beauveria bassiana* 1 x 10^{12} spores/ml and Novaluron + Indoxacarb 4.5 SC @ 1.25 ml/l (96.67, 96.67, 93.34, 93.34, 93.34, 90.0 and 90.0 per cent, respectively). Significantly lower

larval mortality was found in Novaluron 8.8% EC @ 0.25 ml/l followed by *Metarhizium anisopliae* @1 x 10^{12} spores/ml and Novaluron 8.8% EC @ 0.5 ml/l (80.0, 86.67 and 86.67 per cent, respectively). Larval mortality (13.34%) was also observed in untreated control.

At the 7th day after treatment cent percent larval mortality was observed in all the treatments except untreated control with 23.34% larval mortality (Table 4).

In the present study of entomopathogenic microbials and insect growth regulators were evaluated against the 3rd instar larvae of *Spodoptera litura* and *Spilarctia oblique*.

According to Srivastava *et al.*[5] reported that population decreased significantly by IGRs treatment as compared to control. During the investigation, it was observed that after 24 hrs of treatment no isolate exhibited larval mortality. The mortality was visible on third day after treatment. Thereafter, mortality increased as the time period was increased.

***Spodoptera litura* (Fabricius)**

Present findings revealed that all six doses of the Insect Growth Regulators (IGRs), Novaluron + Indoxacarb 4.5 SC (0.25, 0.5, 0.75, 1, 1.25 and 1.5ml/L) were most effective against 3rd instar larvae of *Spodoptera litura* recording 100% larval mortality at 3 days after treatment, followed by Novaluron 10% EC with both the doses (0.5 and 0.25ml/L) recording 100% larval mortality at the 5 days after treatments. Present finding is in line of that reported by Dhawan et al. [3]l that Novaluron @ 50 g and 37.5 g a.i./ha was most effective againtst *Spodoptera* sp., and may fit in IPM streategies as potential component. Talikoti *et al.* [7]l also found Novaluron as the highly toxic against third instar larvae of *Spodoptera litura* at the 72 h of exposure by topical application followed by lufenuron.

***Spilarctia oblique* (Walker)**

Findings revealed that all six doses of the Insect Growth Regulators (IGRs), Novaluron + Indoxacarb 4.5 SC (0.25, 0.5, 0.75, 1, 1.25 and 1.5ml/L) were effective against 3rd instar larvae of *Spilarctia oblique* recording (90, 86.67, 83.34, 83.34 80 and 80 per cent larval mortality, respectively at the 3 days after treatment. Novaluron + Indoxacarb 4.5 SC caused 100% larval mortality followed by Novaluron 10% EC @ 0.5ml/l and 0.25ml/l, Novaluron 8.8% SC @ 1.0ml/l and the *Beauveria bassiana* strain 1× 10^{12} spores/ml (96.67, 96.67, 93.34, 93.34 and 90 per cent, respectively) at 5 the days after treatment. At the 7 days after treatment cent per cent larval mortality were observed in all the treatment in the present experiment.

Table 2: Treatment details bio - efficacy of entomopathogenic microbials and different IGRs.

S. No.	Treatments	Doses
1	Novaluron 10% EC	0.5ml/ litre
2	Novaluron 10% EC	0.25ml/ litre
3	Novaluron 8.8% SC	1ml/ litre
4	Novaluron 8.8% SC	0.5ml/ litre
5	Novaluron 8.8% SC	0.25ml/ litre
6	*Beauveria bassiana**	1 x 10^{12} spores / ml
7	*Metarhizium anisopliae**	1 x 10^{12} spores / ml
8	Novaluron + Indoxacarb 4.4SL	1.25ml/ litre
9	Novaluron+Indoxacarb 4.4SL	1.5ml/ litre
10	Novaluron+Indoxacarb 4.4SL	1.0 ml/ litre
11	Novaluron+Indoxacarb 4.4SL	0.75ml/ litre
12	Novaluron+Indoxacarb 4.4SL	0.5ml/ litre
13	Novaluron+Indoxacarb 4.4SL	0.25ml/ litre
14	Untreated control	

* Not against *Spodoptera litura*

Table 3: Larval mortality in different IGR treatments against *Spodoptera litura.*

Treatments	Mean larval mortality			
	3 DAT	5 DAT	7 DAT	10 DAT
T1 Novaluron 10% EC (0.5 ml/litre)	46.67% (43.08)*	100% (90.00)	100% (90.00)	100% (90.00)
T2 Novaluron 10% EC (0.25 ml/litre)	53.34% (46.92)	100% (90.00)	100% (90.00)	100% (90.00)
T 3 Novaluron 8.8% SC (1 ml/litre)	0% (0.00)	33.34% (30.00)	40% (38.85)	80% (68.07)
T4 Novaluron 8.8% EC (0.5 ml/litre)	20% (26.56)	73.34% (59.22)	73.34% (59.22)	93.34% (81.15)
T5 Novaluron 8.8% EC (0.25 ml/litre)	26.67% (30.78)	80% (63.44)	86.67% (72.29)	86.67% (90.00)
T6 Novaluron + Indoxacarb 4.5 SC (1.25 ml/litre)	100% (90.00)	100% (90.00)	100% (90.00)	100% (90.00)
T 7 Novaluron + Indoxacarb 4.5 SC (1.5 ml/litre)	100% (90.00)	100% (90.00)	100% (90.00)	100% (90.00)
T 8 Novaluron + Indoxacarb 4.5 SC (1.0 ml/litre)	100% (90.00)	100% (90.00)	100% (90.00)	100% (90.00)
T9 Novaluron + Indoxacarb 4.5 SC (0.75 ml/litre)	100% (90.00)	100% (90.00)	100% (90.00)	100% (90.00)
T10 Novaluron + Indoxacarb 4.5 SC (0.5 ml/litre)	100% (90.00)	100% (90.00)	100% (90.00)	100% (90.00)
T11 Novaluron + Indoxacarb 4.5 SC (0.25 ml/litre)	100% (90.00)	100% (90.00)	100% (90.00)	100% (90.00)
T 12 Sterilized water	0% (0.00)	0% (0.00)	20% (26.07)	23.34% (30.78)
S EM±	1.695	3.923	3.146	3.732
C . D. at 5%	4.70	10.87	8.72	10.34

DAT – Days after treatment * Angular Transformed Values

Table 4: Larval mortality in different IGR treatments and entomopathogenic microbials against *Spilarctia oblique.*

Treatments	Mean larval mortality		
	3 DAT	5 DAT	7DAT
T1 Novaluron 10% EC (0.5 ml/litre)	83.34% (66.15)	93.34% (77.71)	100% (90.00)
T2 Novaluron 10% EC (0.25 ml/litre)	76.67% (61.71)	93.34% (77.71)	100% (90.00)
T3 Novaluron 8.8% SC (1 ml/litre)	70% (57.00)	93.34% (66.15)	100% (90.00)
T4 Novaluron 8.8% EC (0.5 ml/litre)	70% (57.00)	86.67% (72.78)	100% (90.00)
T5 Novaluron 8.8% EC (0.25 ml/litre)	53.34% (46.92)	80% (67.86)	100% (90.00)
T6 *Beauveria bassiana*@1 x 10^{12} spores/ml	63.34% (52.78)	90% (75.00)	100% (90.00)
T7 *Metarhizium anisopliae*@1 x 10^{12} spores/ml	70% (56.79)	86.67% (68.85)	100% (90.00)
T8 Novaluron + Indoxacarb 4.5 SC (1.25 ml/litre)	80% (63.93)	90 (75.00)	100% (90.00)
T9 Novaluron + Indoxacarb 4.5 SC (1.5 ml/litre)	80% (64.63)	96.67% (83.85)	100% (90.00)
T10 Novaluron + Indoxacarb 4.5 SC (1.0 ml/litre)	83.34% (66.64)	96.67% (83.85)	100% (90.00)
T11 Novaluron + Indoxacarb 4.5 SC (0.75 ml/litre)	86.67% (68.85)	100% (90.00)	100% (90.00)
T12 Novaluron + Indoxacarb 4.5 SC (0.5 ml/litre)	80% (63.44)	100% (90.00)	100% (90.00)
T13 Novaluron + Indoxacarb 4.5 SC (0.25 ml/litre)	90% (71.56)	100% (90.00)	100% (90.00)
T14 Sterilized water	0% (0.00)	13.34% (21.15)	23.34% (28.08)
SEM±	2.899	5.121	1.370
C.D. at 5%	8.03	14.19	3.80

DAT – Days after treatment * Angular Transformed Values

CONCLUSION

Findings revealed that all six doses of the Insect Growth Regulator (IGRs), Novaluron + Indoxacarb 4.5 SC (0.25, 0.5, 0.75, 1.0, 1.25 and 1.5 ml/l) were significantly effective against 3rd instar larvae of *Spodoptera litura* recording 100% larval mortality at 3 days after treatment followed by Novaluron 10% EC that caused 100% mortality at both the doses (0.25 ml/l and 0.5 ml/l) at 5 days after treatments. Novaluron 8.8% SC caused 86.67% and 73.34% larval mortality at 0.25 ml/l and 0.5 ml/l, respectively at 7 days after treatment. Ten days after treatment cent per cent larval mortality was observed in all the treatments except an untreated control (23.34% larval mortality).

Novaluron + Indoxacarb 4.5 SC 0.25, 0.5, 1.0, 1.5 and 1.25 ml/l caused significantly higher mortality of *Spilarctia oblique* larvae at the 5 days after treatment. All three doses of Novaluron + Indoxacarb 4.5 SC caused significantly higher mortality. At the 7 days after treatment cent percent larval mortality was observed in all the treatments except an untreated control that had 23.34% larval mortality.

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