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Research Article

Integrated Pest Management of melon borer, *Diaphania indica* (Lepidoptera: Pyralidae) in bittergourd

K. SOUMYA, P. N. GANGA VISALAKSHY*, C. SWATHI, A. KRISHNAMOORTHY and K. GOPALAKRISHNA PILLAI

Indian Institute of Horticultural Research, Division of Entomology and Nematology, Hesaraghatta Lake Post, Bengaluru - 560089, Karnataka, India

**Corresponding author E-mail:* gangesv@iihr.res.in

ABSTRACT: Field trials were conducted to evaluate the efficiency of different IPM treatments (*Trichogramma chilonis*, *Dolichogenidea stantoni*, *Nomuraea rileyi*, *Beauveria bassiana*, *Metarhizium anisopliae* and *Bacillus thuringiensis* subspecies *kurstaki*) for the management melon borer, *Diaphania indica* in bittergourd. Among the different treatments evaluated, T7 (*Bacillus thuringiensis*/ Dipel) and T3 (*T. chilonis* + *D. stantoni*) were more effective; T2 (*D. stantoni*), T4 (*N. rileyi*) and T5 (*B. bassiana*) also gave good control over the *D. indica* population when compared to other treatments and control.

KEY WORDS: Integrated pest management, bitter gourd, insect pests, melon borer

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INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is an important vegetable in the cucurbitaceae family, which has medicinal and nutritive values. The melon borer, *Diaphania indica* (Saunders) (Lepidoptera: Pyralidae) is a potential pest of different cucurbits like, muskmelon, cucumber, gherkin, bottle gourd, bitter gourd, snake gourd and more (Tripathi and Pandy, 1973; Pandy, 1977; Ke *et al*., 1988; Peter and David, 1990; Ravi *et al*., 1997; 1998; Radhakrishnan and Natarajan, 2009), causing 14% – 30% yield loss (Jhala *et al*., 2005; Patel, 1956; Singh and Naik, 2006). In bitter gourd the infestation of the *D. indica* is reported to cause a maximum of 30% crop loss (Hiralal Jana, 2014). Ganehiarachchi (1997) reported that *D. indica* has to undergo five larval instars before it enters pupation. Developmental time from oviposition to adult emergence of *D. indica* was ranged from 16-22 days with an average of 20.35 ± 1.76.

The natural pest control provided by predators and parasitoids is an important ecosystem service that supports agricultural production (Losey and Vaughan, 2006). In India, 25 species of natural enemies were recorded from the *D. indica* that infected cucurbits (Peter and David, 1991a), of which the larval parasitoid *Dolichogenidea stantoni* (Ashmead) (Hymenoptera: Braconidae) was reported as a potential natural enemy (Ganga Visalakshy, 2005; Krishnamoorthy *et al*., 2003). Although integrated pest management of *D. indica* represents a key strategy, its potential has gone largely unrealized in many cucurbit cropping systems throughout the world. The significant factor that disrupts biological control of arthropod pests in most of the cropping systems is the heavy reliance on insecticides (Croft, 1990; Stern *et al*., 1959).

Different workers reported that application of carbaryl, dimethoate and methomyl provide effective control of *D. indica* (Butani, 1979 Schreiner, 1991; Yi and Qui, 1999). But the use of synthetic organic chemicals will have long residual effect on the vegetable. To minimize the use of chemicals efforts should be made to utilize different biocontrol agents to control this pest. Except for *Bacillus thuringiensis* (Berliner) (Bacillales: Bacillaceae) there was no information available on the effectiveness of biopesticide against this pest. Hence the current study was conducted to evaluate bio - efficacy of different biocontrol agents against *D. indica*.

MATERIALS AND METHODS

Experimental plot

The experiment was conducted during January 2015 - December 2015 (for two seasons) in the bitter gourd field of the Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru (12° 8’N; 77° 35’E), India. Field trials were conducted in a Complete Randomized Block Design with seven treatments and a control plot. Each treatment had five replications. Recommended agronomic practices like, weeding, irrigation, fertilization etc. were adopted in each experimental plot. The field was never sprayed with any chemical pesticides, and the soil was fertilized with minerals and/or organic nutrients.

Details of treatments

The details of the treatments are presented in Table 1. The foliar sprays of microbial agents (*Nomuraea riley*, *Beauveria bassiana* and *Metarizhium anisoplie*) were applied to the crop in the morning (during 9-10 am) with the help of knapsack sprayer, using 500 liters of spray solution per hectare. The egg parasitoid, *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) was released in the field in the pharate stage or just before adults begin to emerge from the host egg in the evening (during 4-5 pm).The *T. chilonis* was released in the form of tricho cards @50,000/acre. The cards (tricho cards) were cut into bits neatly along the grids with least damage to eggs and tied the foliage in the upper canopy level at every 4 - meter distance. *Dolichogenidea stantoni* were released in the field at the recommended dose of 450 adults/ha in the morning (during 9-10 am).

Mass production of *Trichogramma chilonis*

The stock culture of the egg parasitoid, *T. chilonis* was collected from Indian Council of Agricultural Research - Indian Institute of Horticultural Research- National Bureau of Agriculturally Important Resources (ICAR-NBAIR), Bengaluru and was mass multiplied on *Corcyra cephalonica* eggs in the laboratory.

Mass multiplication of *Dolichogenidea stantoni*

The stock culture of *D. stantoni* was obtained from field-collected parasitoid cocoons and parasitized host (*D. indica*) larvae. Upon emergence, male and female parasitoids were caged (in 1:2 ratio) until each of the females was mated. The mated females of the parasitoid were maintained in glass tubes (3× 13.5 cm) in at room temperature with 10 % honey as food and were mass multiplied on the early larval instars of *C. cephalonica.*

Mass multiplication of *Nomuraea rileyi*

The fungal pathogen, *Nomuraea rileyi* was isolated by crushing the insect (on which sporulation has occurred) in sterile double distilled water and the homogenate was serially diluted and plated onto potato dextrose agar (PDA). Washed rice (100 g) was soaked for 2 - 3 hours prior to the experiment. Excess moisture in the rice was removed by shade drying for 30 minutes. The substrate was autoclaved at 121^{o}C 15 lbs for 15 minutes in individual 250 ml conical flasks plugged with cotton wool. Subsequent to cooling, 1 ml of fungal spore suspension was inoculated into each conical flask separately under laminar air flow chamber. Later it was incubated in incubator at 28^{o}C for 15 days. The conical flasks were shaken vigorously after 7 days of inoculation to separate the substrate and to break the fungal mycelial mat. 10 g of homogenous sample was taken from each replicates (after 15 days of incubation) and was transferred to 100 ml sterilized distilled water containing Tween 80 (0.05%) solutions in 250 ml conical flasks. A mechanical shaker was used to shake the conical flasks for 10 minutes and then the suspension was filtered through double - layered muslin cloth.

Assessment of pest and natural enemy population

All the treatments were repeated at weekly intervals and observations were recorded from three randomly selected plants/ replication for assessing the pest and natural enemy population. Pre-count (before treatment application) and post- count (after treatment application) were taken on the survival of larvae population/plant from 5 replications

Table 1. Ecofriendly treatments tested against *Diaphania indica* during January 2015 – December 2016

Treatments	Components	Dosage	
T1	*Trichogramma chilonis*	50,000 adults/ha	Mass multiplied in the bio control laboratory of ICAR-IIHR, Bangalore, India
T2	*Apanteles stantoni*	450 Adults/ha	
T3	*Trichogramma chilonis* + *Apanteles stantoni*	45,000 adults/ha + 450 Adults/ha	
T4	*Nomuraea rileyi* (WP)	1.0 x 109 conidia/ml @10g/L	
T5	*Beauveria bassiana (WP)*	1.0 x 109 conidia/ml @10g/L	ICAR-IIHR, Bangalore, India
T6	*Metarizhium anisoplie (Oil based)*	1.0 x 109 conidia/ml @ 0.5 ml/L	
T7	Dipel 8L (Bt)	1ml/litre water	Lupin Agrochemicals Ltd., Vijayawada, Andrapradesh, India
T8	Control	-	-

of each treatment on 5 and 7 days after treatment (DAT). The per cent fruit damage was assessed by counting the number of fruits damaged out of total number fruits in each treatment at every harvest. The yield data were analyzed and pooled. Observations on the population of natural enemies' *viz*, coccinellids (No/plant), spiders (No/plant) and *Dolichogenidea stantoni* (percentage parasitism) were recorded at weekly intervals during the study period.

Statistical analysis

The periodical data on the population of *Diaphania indica* and percentage fruit damage in different treatments were pooled over months and subjected to one-way ANOVAs followed Tukey's honestly significant difference (HSD) tests for multiple comparisons at $P < 0.05$. The population of natural enemies in pre and post treatments was compared with control using student t - test. The statistical analysis was performed using SPSS software (SPSS Inc, version 21).

RESULTS AND DISCUSSION

All the IPM treatments showed significantly lower pest populations compared to control. The population of *D. indica* on bitter gourd on the fifth day and seventh day after treatment was significantly lower in Dipel treatment (T7) in both seasons (0.0 number/ plant) and was superior to all other treatments.

Table 2. Effect of integrated pest management treatments on population of *Diaphania indica* on bittergourd during January 2015- June 2015

Treatments	*Diaphania indica* population (No of larvae / per plant		
	Pre treatment	5 DAT	7 DAT
T1	5.98^{NS}	4.50 ^{c}	3.50 ^{c}
T2	6.50 ^{NS}	3.50 ^{c}	2.50 ^{b}
T3	7.00 ^{NS}	3.00 ^{b}	2.10 ^{b}
T4	6.90 ^{NS}	3.00 ^{b}	2.00 ^{b}
T5	6.00 ^{NS}	2.75 ^{b}	2.00 ^{b}
T6	5.50NS	3.90c	3.00 c
T7	6.00 NS	0.00a	0.00 a
T8	6.10 NS	7.10 d	7.90 d

Means in a column followed by the same letter are not significant (P < 0.05) by Tukey's honestly significant difference (HSD)

The next order after five day of treatment in the first season was T4 (2.00 number / plant), T5 (2.00 number / plant) T3 2.10 number/ plant), T2 (2.50 number / plant), T6 (3.00 number / plant) and T1 (3.50 number / plant).T2, T3, T4 and T5 was significantly superior (less number of pest) when compared to T1, T6 and T8 on 7th day after treatment.

Table 3. Effect of integrated pest management treatments on population of *Diaphania indica* on bittergourd during July 2015- December 2015

Treatments	*Diaphania indica* population (No of larvae / per plant		
	pre treatment	5 DAT	7 DAT
T1	5.90NS	4.00 c	3.00 c
T2	6.20 NS	3.70 c	2.00 b
T3	6.00 NS	2.00 b	1.99 b
T4	6.90 NS	2.20 b	2.00 b
T5	6.10 NS	2.55 b	2.25 b
T6	6.00 NS	3.75c	3.10 c
T7	6.45 NS	0.00a	0.00 a
T8	6.00 NS	6.75 d	7.50 d

Means in a column followed by the same letter are not significant (P < 0.05) by Tukey's honestly significant difference (HSD)

There was no significant difference between the results of two seasons tested. The order of superiority of treatments in the second season after five days of treatment was in the order of T3 (2.00 number / plant), T4 (2.20 number / plant) T5(2.55) number/ plant), T6 (3.75 number / plant), and T8 (6.75 number / plant).The treatments T2, T3 and T5 were superior when compared to the Dipel and control after 7th day of treatment.

The mean data indicated that the extent of fruit damage in the following order T7 < T3 < T4 < T2 < T5 < T6< T1< T8 (control). The average fruit damage during 2015-16 remained significantly lower in T7 (2.20%) and T3 (2.55%), which were on par superior to all other treatments. The extent of fruit damage in treatments T4 (4.75%), T2 (5.25 %) and T5 (5.80%), T3 (5.10%) were on par with each other and significantly superior to T1, T6 and T8 (Table 3).

The population of natural enemies *viz.*, spiders, coccinellids (unidentified) and *Dolichogenidea stantoni* was not significantly different in different treatments. However, a relatively less number of the predators were recorded in treatment 7 in which reduviids were 0.45 and 0.21number/ plant, spiders were 1.10and 0.80 number / plant and coccinellids 3.00 and 1.55 number /plant before and after treatment respectively. There was a significant difference in percent parasitism of the larval parasitoid *Dolichogenidea stantoni* among different treatments and the per cent parasitism increased significantly after treatments (Table 3)

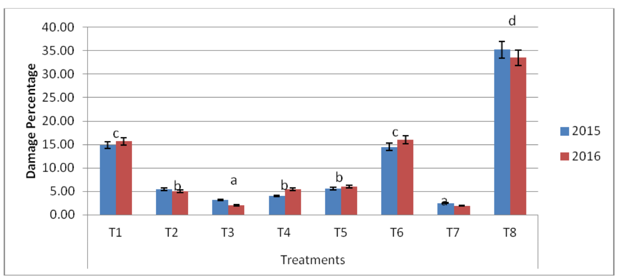
The results of the present study revealed that the integrated pest management treatments T3 and T7 were more effective compared to other treatments. Our results regarding *Bacillus turingiensis* (Dipel) is in agreement with that

Table 4. Influence of integrated pest management treatments on population of natural enemies in bittergourd

Module	Reduviids (No/plant)		Spiders (No/plant)		Coccinellids (No/plant)		*Dolichogenidea stantoni* (% parasitisatism)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
T1	0.16 ^{NS}	0.18 ^{NS}	0.88 ^{NS}	0.80 ^{NS}	1.74 ^{NS}	1.40 ^{NS}	25.00 *	33.50 *
T2	0.15 ^{NS}	0.13 ^{NS}	0.85 ^{NS}	0.75 ^{NS}	1.00 ^{NS}	1.10 ^{NS}	20.56 *	39.90 *
T3	0.19 ^{NS}	0.18 ^{NS}	0.99 ^{NS}	0.89 ^{NS}	1.89 ^{NS}	1.70 ^{NS}	24.15 *	40.50 *
T4	0.41 ^{NS}	0.31 ^{NS}	1.11 ^{NS}	1.10 ^{NS}	2.14 ^{NS}	2.10 ^{NS}	28.00 *	37.00 *
T5	0.15 ^{NS}	0.17 ^{NS}	0.90 ^{NS}	1.00 ^{NS}	1.50 ^{NS}	1.56 ^{NS}	33.45 *	40.00 *
T6	0.45 ^{NS}	0.47 ^{NS}	0.85 ^{NS}	1.00 ^{NS}	1.35 ^{NS}	1.26 ^{NS}	30.00 *	35.56 *
T7	0.56 ^{NS}	0.51 ^{NS}	1.70 ^{NS}	1.80 ^{NS}	3.60 ^{NS}	3.55 ^{NS}	35.00 *	40.15 *
T8	0.32 ^{NS}	0.31 ^{NS}	1.78 ^{NS}	1.80 ^{NS}	1.50 ^{NS}	1.60 ^{NS}	27.56 *	35.50 *

NS: Non Significant *Significantly different (Student t test)

of Schreiner (1991) who had reported that *Bacillus turingiensis* is effective in reducing *D. indica* caterpillar populations. Other treatments like weekly releases of *T. chilonis, Dolichogenidea stantoni*, and bio-pesticide also controlled *D. indica* population.



Bars with different letters indicate the significant difference between damage percent at P<0.05 (One way ANOVA-Tukey HSD test). Vertical lines indicate the SE mean damage percentage

Fig. 1. Effect of integrated pest management treatments on pecentage of damage.

The effectiveness of *T. chilonis* was similar to that reported by Kumar *et al.* (2000); Singh *et al.* (2004); Sardana *et al.* (2005). They reported that the inundative release of *T. chilonis* reduced the incidence of several lepidopteran pests like, *Helicoverpa armigera* and *Spodoptera litura*. *Trichogramma* spp. is most effective against sugarcane stem borers (Metcalfe and Breniere, 1969; Nagarkatti and Nagaraja, 1977; Li, 1994; Smith, 1996).

The present result with *N. rileyi* is in accordance with Burges (1998) who reported greater efficacy of *N. rileyi* formulation, against lepidopteran pests. Vimaladevi *et al.* (2002) reported oil formulation of *N. rileyi* (2×10^{11} conidia/ Lit) greatly reduced the *S. litura* population upto 62.7% in castor. Similarly the results were similar to the reports of Nagaraja (2005) who recorded more per cent mycosis (26.56%) by *N. rileyi* (@ 2×10^{11} conidia per ha) in chickpea.

In summary, T3 (*Trichogramma chilonis* + *Dolichogenidea stantoni*) and T7 (Dipel) are on par and are more effective in controlling *Diaphania indica* compared to other treatments. Hence *T. chilonis* and *D. stantoni* can be used in combination against *D. indica* to increase the yield of bitter gourd in an ecofriendly way in future.

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