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The Compatibility of Natural Enemies and Botanical for Management of *Earias vittella* (Fabricius) (Lepidoptera: Nolidae) and *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) in Bhendi Ecosystem

Aravinda Hubballi [a*], A. N. Shylesha [b], T. M. Shivalingaswamy [b] and B. Shivanna [a]

[a] *Department of Entomology, University of Agriculture Science, GKVK, Bengaluru, Karnataka, India.*
[b] *ICAR-National Bureau of Agricultural Insect Resources, Bellary Road, H.A. Farm Post, Hebbal, Bengaluru, Karnataka 560024, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The current study was conducted to know the compatibility of natural enemies and botanical for management bhendi fruit borers in the bhendi field.
Study Design: Randomized Complete Block Design (RCBD).
Place and Duration of Study: Experiment conducted during 2019-20 and 2020-21 at ICAR-National Bureau of Agricultural Insect Resources, Hebbal, Bengaluru, Karnataka, India.

**Corresponding author: E-mail: aravindabhubballi@gmail.com;*

Methodology: Two field tests were conducted at the entomological research farm, ICAR-NBAIR Bengaluru, Karnataka, India, to know the compatibility of the natural enemies (*Trichogramma chilonis* Ishii (Hymenoptera:Trichogrammatidae) , *Chelonus blackburni* (Cameron) and *Bracon brevicornis* (Wesmael) (Hymenoptera: Braconidae) and botanical (Neem oil 0.5%) for management of *E. vittella* and *H. armigera* on bhendi. Arka Nikita (IIHR) bhendi variety was used for the two trials with different treatments in four replication. The release rates of parasitoids were decided based on the previous parasitic potential studies.

Results: In the first trial, among the treatments, a combination of *T. chilonis* + *C. blackburni* + *B. brevicornis* and *C. blackburni* + *B. brevicornis* recorded the lowest pooled mean larval population reduction over pre-treatment count of *E. vittella* and were on par with each other, recording 40.19% and 37.27%, respectively followed by *T. chilonis* + *B. brevicornis* (31.28%), *C. blackburni* (30.90%), *B. brevicornis* (28.64%), Neem oil 0.5% (27.71%), Neem oil 0.5% + *B. brevicornis* (25.46%) *and T. chilonis* (25.32%). A similar trend was also observed in combination of *T. chilonis* + *C. blackburni* + *B. brevicornis* and *C. blackburni* + *B. brevicornis* against *H. armigera,* which accounted for 47.19% and 37.22% of reduction over pre-treatment count in the respective treatment combination of parasitoids. The next best treatments were *T. chilonis* + *B. brevicornis* (28.21%), *C. blackburni* (26.56%), *B. brevicornis* (22.21%), Neem oil 0.5% (20.37%), *T. chilonis* (17.31%) and Neem oil 0.5% + *B. brevicornis* (16.07%)

Conclusion: From this study we recommend that, for bhendi fruit borers management, release of parasitoids like *T. chilonis* + *C. blackburni* + *B. brevicornis* at 50,000+1000+1000 adults/ha, respectively in bhendi field starting from 35 DAS at 15 days' intervals of duration, two-time release of parasitoids is enough later, they have augmented and reduce the population of fruit borer larvae effectively.

Keywords: Bhendi; fruit borer; pests; biological control; natural enemies; parasitoids.

1. INTRODUCTION

"Okra (*Abelmoschus esculentus* (L.) Moench) which belongs to Family Malvaceae is one of the important vegetable crops grown throughout the tropical and warm temperate regions of the world" [1]. "As many as 72 insect pests' species have been observed on bhendi. Among them, Okra shoot and fruit borers, *Earias vittella* (Fabricius) ,Okra fruit borer, *Helicoverpa armigera* (Hubner); Aphid, *Aphis gossypii* (Glover); Leafhopper, *Amrasca biguttula biguttula* (Ishida) and Whitefly, *Bemisia tabaci* (Gennadius) which cause considerable crop damage and are regarded serious pests of bhendi" [2].

Farmers utilise a wide range of approved insecticides to manage these pests [3]. "The residues of imidacloprid (6.7 ppm), thiomethoxam (3.8 ppm), flubendiamide (7.9 ppm), and chlorantraniliprole (6.5 ppm) in harvested okra fruits were far above the maximum residue limits (MRL), but no pesticides were detected in okra fruits from the IPM plot" [4]. The growing concern for environmental safety and global demand for pesticide-free food compelled the quest for eco-friendly pest management technologies. To address these issues, a biocontrol method utilising possible natural enemies and botanicles that can be successfully included into a solid Integrated Pest Management (IPM) plan is being developed.

"Horticultural crops, particularly vegetables and fruits, provide a stable habitat that allows for biological control in pest management programmes. Among the several classes of biocontrol agents, braconids are well-known parasitoids for the management of various lepidopteran larvae, notably the okra fruit borer complex" [5]. According to King et al. [6], "field release of the braconid parasitoid *Chelonus blackburni* Cameron at 50,000 adults ha-1 resulted in promising control of *E. vittella* with a fruit infection of 11.64%". Mani et al. [7] found "*B. hebetor*, *B. greeni*, and *Trichogramma* spp. on *Earias spp.* in okra feild".

"Among the many plant products examined during the last 25 years, extracts and chemicals from the neem tree (*Azadirachta indica*, *A. Juss*) have piqued the interest of entomologists all over the world. Neem is known to contain a diverse variety of biologically active components, one of which is azadirachtin" [8]. "Neem has antifeedant, antiovipositional, growth disrupting and fecundity reducing properties against different insects and is suitable for inclusion in integrated pest management programmes. DEA surfactant acts as a wetting, dispersing and spreading agent in neem oil pesticide” [9].

However, knowledge on the efficacy and compatibility of parasitoids and botanicals against okra fruit borers is limited. Keeping these considerations in mind, the current research was conducted to determine the efficacy and compatibility of parasitoids and botanicals in contrast to previously advised practises against okra fruit borers under field conditions.

2. MATERIALS AND METHODS

This experiment was conducted during *kharif* 2020-21 at the ICAR-National Bureau of Agricultural Insect Resources - Bengaluru.

2.1 Culture of Parasitoids

The larval parasitoid, *Bracon brevicornis* Wesmael (Hymenoptera : Braconidae) egg larval parasitoid, *Chelonus blackburni* Cam. (Hymenoptera: Braconidae) and the egg parasitoid, *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae) maintained in the Biocontrol Laboratory, NBAIR-ICAR Bengaluru, Karnataka, India. by following the procedures of ICAR-NBAIR Manual of mass multiflication of parasitoids. These reared parasitoids were utilized for the field experiments (Plate 1).

2.2 Field Evaluation Parasitoids and Botanical against Okra Fruit Borers

Two field trials were done at the entomological research farm, ICAR-NBAIR Bengaluru, Karnataka, India, to evaluate the efficiency of the braconid parasitoids, *B. brevicornis* and *C. blackburni*, and *T. chilonis* and botanical Neemoil 0.5% (5ml/l) with the DEA surfactant as dispersing agent (Plate 2) against *E. vittella* and *H. armigera* on bhendi. Arka Nikita (IIHR) bhendi variety was used for the two trials with different treatments (Table 1).

“The treatments were replicated thrice with a plot size of 4 x 5 m. Treatments were imposed at 15-day intervals three times. The sachet made up of tissue paper containing ready to emerge cocoons of *B. brevicornis* and adults of *C. blackburni* were tied individually in the middle of the treatment plots. The mouth of the sachet was tied after inserting a small piece of straw to facilitate the exit of adults” [5]. *Trichogramma chilonis* egg card was stapled in treatment block plants. Neem oil 0.5% is also used in this experimental study to check their efficiency along with natural enemies against target pests. In between each treatment and each replication, a buffer plot sprayed with chemicals at weekly intervals was maintained to restrict the movement of the parasitoids from the released plots. The treatments were imposed starting from pests infestation i.e. 35 DAS (Days after sowing).

Observations on the population of *E. vittella* and *H. armigera* were recorded in 15 randomly selected plants from each plot and collected the fruit borer infected fruits and count the larvae of both two pests species (No. of larvae/10 plants) before and after 4, 8, and 12 days of treatment, and the pooled mean was worked out after three rounds of release /spray.

2.3 Statistical Analysis

The data was statistically analyzed for randomized full block design (RCBD), Duncan's multiple range test (DMRT), and one factor ANOVA, and the results were interpreted.

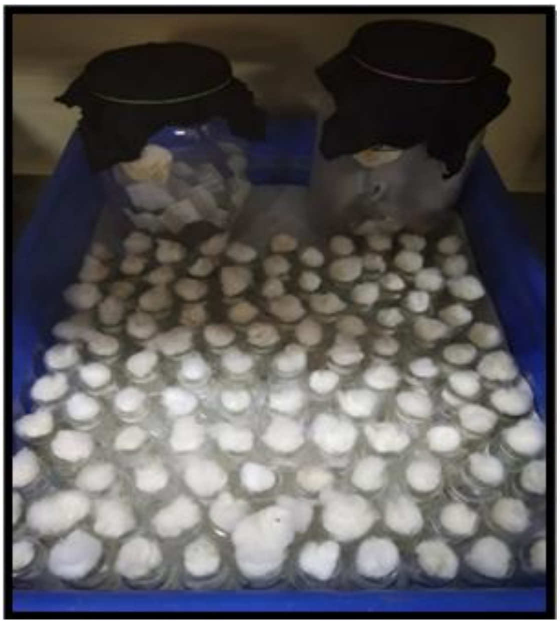
Table 1. Treatment details of field evaluation of selected natural enemies and botanical against bhendi fruit bores

Sl.No	Treatments	Dosage
1	*B. brevicornis*	2000 adults/ha
2	*Trichogramma chilonis*	1,00,000 adults/ha
3	*C. blackburni*	2000 adults/ha
4	Neem oil 0.5%	5ml/l
5	*T. chilonis* +*B. brevicornis*	50,000 + 1000 adults/ha
6	*C. blackburni* + *B. brevicornis*	1000 + 1000 adults/ha
7	Neem oil 0.5% + *B. brevicornis*	2.5 ml/ l+ 1000 adults/ha
8	*T. chilonis* + *C. blackburni* + *B. brevicornis*	50,000+1000+1000 adults/ha
9	Untreated check.	-

Chelonus blackburni

Trichogramma chilonis

***Bracon brevicornis* parasitised *Earias vittella* larvae**



Bracon brevicornis

Plate 1. Rearing of natural enemies

a. *Bracon brevicornis* (Wesmael)

***b. Trichogramma chilonis* Ishii**

***c. Chelonus blackburni* (Cameron)**

d. Neem oil (0.5%)

Plate 2. Parasitoids of bhendi fruit borer a. *Bracon brevicornis* b. *Trichogramma chilonis* c. *Chelonus blackburni* d. botanical (Neem oil (0.5%)

3. RESULTS AND DISCUSSION

"Observations on the larval population showed that the larvae of *E. vittella* preferred to feed on freshly formed and tender fruits, while, *H. armigera* did not show any preference for the stage of fruits. However, the larvae of both species were rarely observed together in a single fruit. Results of both the trials showed that a combination of two braconid parasitoids *viz*., *C. blackburni* + *B. brevicornis* were more effective and were on par with the combination of *T. chilonis* + *C. blackburni* + *B. brevicornis* which was a most superior combination of parasitoids in reducing the *E. vittella* and *H. armigera* larval population" (Table 2) [5].

In the first trial, among the treatments, combinations of *T. chilonis* + *C. blackburni* + *B. brevicornis* and *C. blackburni* + *B. brevicornis* recorded the lowest pooled mean larval population reduction over pre-treatment count of *E. vittella* and were on par with each other, recording 40.19% and 37.27%, respectively followed by *T. chilonis* + *B. brevicornis* (31.28%), *C. blackburni* (30.90%), *B. brevicornis* (28.64%), Neem oil 0.5% (27.71%), Neem oil 0.5% + *B. brevicornis* (25.46 %) *and T. chilonis* (25.32%). A similar trend was also observed in combination of *T. chilonis* + *C. blackburni* + *B. brevicornis* and *C. blackburni* + *B. brevicornis* against *H. armigera* with 47.19% and 37.22% of reduction over pre-treatment count in the respective treatment combination of parasitoids. The next best treatments were *T. chilonis* + *B. brevicornis* (28.21%), *C. blackburni* (26.56%), *B. brevicornis* (22.21%), Neem oil 0.5% (20.37%), *T. chilonis* (17.31%) and Neem oil 0.5% + *B. brevicornis* (16.07%) (Table 2).

In the second trial, observations of the population of *E. vittella* and *H. armigera* revealed similar trends as that of the first trial (Table 2). A significantly lower population of *E. vittella* and *H. armigera* was recorded in the treatments involving the combination of *T. chilonis* + *C. blackburni* + *B. brevicornis* and *C. blackburni* + *B. brevicornis*.

In previous study by Sangwan [10] reported "higher efficacy of *Bracon kirkpatricki* at 3000 adults/ha and *T. brasiliensis at* 1,50,000 adults/ha under field conditions against *H. armigera* and *Earias* spp. on cotton. Efficacy of *C. blackburni*, *B. kirkpatricki* and *Trichogramma* spp. against *Earias* spp. and *H. armigera* on cotton was also reported by earlier workers [11] in agreement with the present findings". Agarwal and Gupta [12] and Forehand et al. [13] reported that "mass releases of egg parasitoids, *T. chilonis* and *T. acheae;* egg larval parasitoid*, C. blackburni* and larval parasitoid, *B. kirkpatriki* during square formation stage, reduced the incidence of all three species of bollworms in cotton like Spotted, Spiny and American boll worm".

Table 2. Efficacy of braconid parasitoids and botanical against the larval population of bhendi fruit borers

Tr. No.	Treatment*	No. of larvae/10 plants											
		E. vittella						***H. armigera***					
		Trail 1		**% ROPTC****	**Trail 2**		**% ROPTC****	**Trail 1**		**% ROPTC****	**Trail 2**		**% ROPTC****
		PTC	**T***		**PTC**	**T***		**PTC**	**T***		**PTC**	**T***	
T_1	*B. brevicornis*	11..25 (3.50)^{a}	8.03 (3.00)^{bcd}	28.64	8.15 (3.03)^{a}	5.33 (2.52)^{cd}	34.56	12.02 (3.61)^{a}	9.35 (3.22)^{abc}	22.21	11.52 (3.56)^{a}	6.82 (2.80)^{cd}	40.81
T_2	*T. chilonis*	11.15 (3.48)^{a}	8.33 (3.05)^{b}	25.32	8.20 (3.06)^{a}	6.33 (2.71)^{b}	22.76	12.44 (3.66)^{a}	10.28 (3.36)^{ab}	17.31	11.48 (3.53)^{a}	8.19 (3.03)^{b}	28.66
T_3	*C. blackburni*	11.35 (3.51)^{a}	7.84 (2.97)^{bcd}	30.90	8.15 (3.03)^{a}	5.16 (2.48)^{de}	36.71	12.41 (3.65)^{a}	9.12 (3.18)^{bc}	26.56	11.44 (3.51)^{a}	6.68 (2.77)^{de}	41.64
T_4	Neem oil 0. 5%	11.25 (3.50)^{a}	8.13 (3.02)^{bc}	27.71	8.17 (3.05)^{a}	5.67 (2.58)^{c}	30.60	12.14 (3.62)^{a}	9.67 (3.27)^{ab}	20.37	11.33 (3.46)^{a}	7.33 (2.89)^{c}	35.30
T_5	*T. chilonis* + *B. brevicornis*	11.01 (3.47)^{a}	7.56 (2.92)^{cd}	31.28	8.12 (3.01)^{a}	4.82 (2.41)^{ef}	40.64	12.40 (3.64)^{a}	8.90 (3.15)^{bc}	28.21	11.12 (3.30)^{a}	6.41 (2.72)^{def}	42.34
T_6	*C. blackburni* + *B. brevicornis*	11.65 (3.56)^{a}	7.31 (2.88)^{de}	37.27	8.13 (3.02)^{a}	4.43 (2.33)^{fg}	45.55	12.63 (3.69)^{a}	7.93 (2.99)^{bc}	37.22	11.73 (3.82)^{a}	6.15 (2.67)^{ef}	47.59
T_7	Neem oil 0. 5% + *B. brevicornis*	10.57 (3.40)^{a}	7.88 (2.98)^{bcd}	25.46	8.10 (3.00)^{a}	4.59 (2.37)^{fg}	43.27	12.57 (3.68)^{a}	10.55 (3.40)^{ab}	16.07	11.27 (3.38)^{a}	6.32 (2.71)^{def}	43.97
T_8	*T. chilonis* + *C. blackburni* + *B. brevicornis*	11.13 (3.48)^{a}	6.66 (2.76)^{e}	40.19	8.17 (3.05)^{a}	4.27 (2.30)^{g}	47.76	12.51 (3.67)^{a}	6.61 (2.76)^{c}	47.19	11.64 (3.75)^{a}	5.94 (2.64)^{f}	48.96
T_9	Untreated check	10.55 (3.40)^{a}	10.55 (3.40)^{a}	-	8.26 (3.09)^{a}	8.58 (3.10)^{a}	-	12.50 (3.68)^{a}	12.54 (3.68)^{a}	-	11.62 (3.70)^{a}	12.96 (3.74)^{a}	-
C.D @ 0.05 %		NS	0.05		N/A	0.04		N/A	1.13		N/A	0.07	
SE(m) ±		0.24	0.02		0.07	0.01		0.23	0.37		0.16	0.02	
C.V.		3.79	7.33		1.52	7.45		3.19	6.84		2.41	7.50	

Values in the parenthesis are square root transformed

T(Treatment): No. of larvae/10 plants (pooled mean of three rounds of releases)*

PTC: Pre-treatment count

*ROPTC **: Reduction over pre-treatment count due to parasitization*

4. CONCLUSION

Due to overlapping generations, pest stages will appear in a staggered manner in the field condition. As a result, releasing a single parasitoid may not produce the desired results as they exclusively target a specific stage of the pest. Indeed, releasing the combination of two or three parasitoid species, they will attack the pests at different stages and it will be more effective. In the present finding, combination of *T. chilonis* + *C. blackburni* + *B. brevicornis* recorded significantly lower pest larval population and in fruit borer larvae than the combination of *C. blackburni* + *B. brevicornis*. The combined release of *C. blackburni* and *B. brevicornis* at fortnightly intervals, starting from flower initiation to pod development stage may give long term benefits in the bio suppression of the fruit borers of okra in an ecofriendly manner.

Bhendi is an important vegetable; now a day's demand for this crop is more. From this study we recommend that, for bhendi fruit borers release of parasitoids *viz., T. chilonis* + *C. blackburni* + *B. brevicornis* at 50,000+1000+1000 adults/ha, respectively twice in bhendi field starting from 35 DAS at 15 days' interval which will be augmented on their own and reduce the population of fruit borers effectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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