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EFFICACY OF NATIVE, COMMERCIAL *BACILLUS THURINGIENSIS* AND FUNGAL FORMULATIONS AGAINST OKRA SHOOT AND FRUIT BORER

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ABSTRACT

Okra shoot and fruit borer commonly known as spotted bollworm is a major pest of the economically important crops, viz., cotton and okra. Field experiment was conducted with 13 treatments including seven native *Bt* isolate treatments viz., 49, 51, 52, 55, 16, HD1 and 493 along with commercial *Bt* treatment (Dipel), three Entomopathogenic fungal treatments viz., *Metarhizium anisopliae, Beauveria bassiana, Metarhizium rileyi,* one chemical check viz., chlorantraniliprole and untreated control. The cumulative efficacy of treatments tested for the management *E. vitella* on okra during kharif 2021-2022 revealed that all the treatments were found effective over untreated control (20.08%). Among the treatments, Chlorantraniliprole 18.5% SC @ 0.27 ml l^{-1} was found superior with lowest mean fruit infestation (8.05%) and it was on par with *M. rileyi* ($1x10^8$ CFU g^{-1}) @ 5 g l^{-1} (9.70%), isolate 493 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} (9.17%), *M. anisopliae* ($1x10^8$ CFU g^{-1}) @ 5 g l^{-1} (9.90%) and isolate 16 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} (9.87%).

Key words: *Earias vittella*, okra, chlorantraniliprole, *Metarhizium anisopliae*, *Beauveria bassiana*, *Bacillus thuringiensis*, management, cumulative efficacy.

Earias vittella commonly known as spotted bollworm or okra fruit and shoot borer is a major pest of the economically important crops, viz*.,* cotton and okra (Memon et al., 2004). Since the introduction of *Bt* cotton, the insecticidal usage was drastically reduced for the management of *E. vittella* in cotton, at the same time there are many reports on increased infestation of *E. vittella* in okra crop (Suman et al., 1984). The okra cultivators frequently spray chemical insecticides, to kill the larvae before they enter into the shoots or fruits. The indiscriminate use of insecticides creates problems like insecticide resistance, pest resurgence, adverse effect on the non target species, environmental pollution. Pesticide residues in harvested okra fruits are hazardous to the consumers (Jat and Pareek, 2003). The current tendency in pest management is to use chemical pesticides judiciously, particularly on vegetables, not only to save money but also to reduce pollution, residue-free crop produce and to prevent the development of insecticide resistance in insect pests. According to estimates, *Earias* sp. can cause a 36-90% loss in okra production (Misra et al., 2002). The toxin from *B. thuringiensis* enters the insect via ingestion and binds to glycoprotein receptors on the targeted insect's midgut epithelium, disrupting the cytoplasmic membrane and causing cell lysis (Hilder and Boulter, 1999). The integration of all control measures is highly valued in today's era, the era of IPM. Hence, there is renewed interest in search for new biopesticides, and the present study evaluates some of the native *Bt* isolates and commercial entomopathogenic fungus.

MATERIALS AND METHODS

The field experiment on the evaluation of efficacy of insecticides was carried out at the Agricultural College Farm in Bapatla, Guntur district, Andhra Pradesh during kharif 2021-2022. The experiment was laid out using a Randomized Block Design (RBD) with thirteen treatments replicated twice. Each plot was 20 m^2 (5x4 m) in size, with a row to row and plant to plant spacing of 60x30 cm. *B. thuringiensis* treatments: Six native *Bt* isolates as well as the reference *Bt* strain (HD 1) and the commercial *Bt* formulation Dipel were included in the field experiment. Entomopathogenic Fungal treatments (EPF): The EPFs used in this study were commercial formulations namely *M. anisopliae*, *B. bassiana*, and *M. rileyi*. These were applied as a foliar spray on the crop using pre-calibrated knapsack sprayer when the pest incidence reach above ETL. Second spray was repeated after 15 days of the first spray. For the observations, ten plants were selected at random from each treatment. Border rows were not included in the observations. The observations, which included the total number of fruits and the number of damaged fruits per ten plants per plot were recorded one day before each spray as pre-treatment data and three, five, seven, and ten days later as post-treatment data (Malik et al., 2013).

The incremental cost-benefit ratio was calculated by dividing the additional benefit gained from increased yield by the additional cost incurred for each treatment. Total cost included the cost of insecticides as well as labour charges for spraying insecticides. To determine the most cost-effective management method for spotted bollworm in okra, the incremental cost-benefit ratio of each treatment was calculated. Randomized block design (RBD) was used to statistically analyse the data collected from field studies. Data was subjected to ANOVA after arc sine transformation, and treatment means were compared by LSD (Least significant difference), using ADEL-R (Analysis and design of experiments with R-3.2.0 for Windows) version 2.0 (Angela et al., 2017) software.

RESULTS AND DISCUSSION

The cumulative efficacy of different treatments tested for the management *E. vittella* on okra during kharif 2021 revealed that (Table 1) all the treatments were found effective over untreated control (20.08%). Among the treatments, chlorantraniliprole 18.5% SC @ 0.27 ml l^{-1} was found superior with lowest mean fruit infestation (8.05%) and it was on par with *M. rileyi* [1×10^8 Colony Forming Units (CFU) g^{-1}] @ 5 g l^{-1} (9.70%), Isolate 493 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} (9.17%), *M. anisopliae* (1×10^8 CFU g^{-1}) @ 5 g l^{-1} (9.90%) and Isolate 16 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} (9.87%). However Isolate 52 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1}, Isolate 49 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1}, Isolate 55 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1}, Isolate 51 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1}, and *B. bassiana* (1×10^8 CFU g^{-1}) @ 5 g l^{-1} were least effective treatments with 11.89, 12.78, 13.40, 13.53 and 13.95 % respectively, which were on par with each other.

Highest mean % population reduction over untreated control was recorded 59.90 in case of chlorantraniliprole 18.5% SC @ 0.27 ml l^{-1}. The next best was Isolate 493 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} which recorded 54.34 mean % population reduction over untreated control. Remaining treatments showed 51.69 to 30.50 mean % population reduction over untreated control. The present results are in accordance with Hosamani et al. (2011) and Venkanna et al. (2015) where the fruit yield of 87.72 t ha^{-1} and 88.36 t ha^{-1} respectively were recorded in plants protected with the spray treatment of rynaxypyr 20 SC @ 0.4 ml l^{-1}. Whereas, Biswas et al. (2009) and Bansode et al. (2015) also reported the highest yield obtained in plants protected with spray treatment of flubendiamide 480 SC @ 0.25 ml l^{-1}.

From the data presented in the Table 1, revealed that all the treatments recorded better fruit yield over untreated control (9.02 t ha^{-1}). Among the treatments chlorantraniliprole 18.5% SC @ 0.27 ml l^{-1} recorded highest fruit yield i.e. 11.23 t ha^{-1} with incremental cost benefit ratio 1:6.56 followed by Dipel ES (5×10^9 CFU ml^{-1}) @ 3 ml l^{-1} (1:4.031), HD1 Strain ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} (1:3.41), *M. rileyi* (1×10^8 CFU g^{-1}) @ 5 g l^{-1} (1:3.16), *M. anisopliae* (1×10^8 CFU g^{-1}) @ 5 g l^{-1} (1:3.07) and Isolate 493 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} (1:2.97). Least ICBR recorded was 1:0.19 in Isolate 51 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} treatment. Results pertaining to ICBR were supported by Gurve et al. (2016) who reported on economics of spray treatments, additional income over control obtained in rynaxypyr 20 SC @ 0.4 ml l^{-1} was highest (Rs. 11200/- ha^{-1}) followed by flubendiamide 48 SC @ 0.25 ml l^{-1} (Rs. 98800/- ha^{-1}). The incremental cost benefit ratio (ICBR) was 1:10.0 and 1:10.3 in spray treatment of rynaxypyr 20 SC @ 0.4 ml l^{-1} and 174 flubendiamide 48 SC @ 0.25 ml l^{-1} respectively. Damage caused to fruits directly affected the yield of marketable quality of okra fruits. In case of untreated okra plants the fruit infestation was 35.55% limiting the fruit yield of 6.75 t ha^{-1}. Yields of fruits were significantly more in respect all evaluated spray treatments, except azadirachtin 10,000 ppm (8.42 t ha^{-1}) and NSKE 5% (7.89 t ha^{-1}). The experiment results indicated that chlorantraniliprole 18.5% SC @ 0.27 ml l^{-1} recorded the best control measure with highest fruit yield followed by native *Bt* Isolate 493 ($1x10^{10}$ CFU g^{-1}) @ 3 g l^{-1} and *M. rileyi* (1×108 CFU g-1) @ 5 g l^{-1} treatment.

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AUTHOR CONTRIBUTION STATEMENT

Author 1: Collected data, performed the statistical analysis, wrote the paper; Author 2: Designed the experiment, Monitored during the experiment, Contributed data and analysis and corrected the manuscript; Author 3, 4 & 5: Monitored during the experiment and corrected the manuscript.

Table 1. Efficacy of bioinsecticides against *E. vitella* on okra (kharif 2021-2022)

Tr. No.	Treatments	Dose	% infestation (No. basis)					
			First spray	Second spray	Third spray	Mean	Yield of okra t/ ha	ICBR
T_1	Isolate 16 (1x10^{10} CFU g^{-1})	3 g l^{-1}	11.04 (19.41)^{abc}	10.17 (18.59)^{a}	8.40 (16.85)^{bc}	9.87 (18.31)^{abc}	10.28	2.73
T_2	Isolate 49 (1x10^{10} CFU g^{-1})	3 g l^{-1}	13.98 (21.95)^{bcd}	13.69 (21.72)^{c}	10.66 (19.05)^{cd}	12.78 (20.94)^{de}	10.23	2.59
T_3	Isolate 51 (1x10^{10} CFU g^{-1})	3 g l^{-1}	14.13 (22.08)^{bcd}	14.74 (22.57)^{d}	11.74 (20.04)^{de}	13.53 (21.58)^{e}	9.42	0.19
T_4	Isolate 52 (1x10^{10} CFU g^{-1})	3 g l^{-1}	14.58 (22.44)^{d}	11.72 (20.02)^{b}	9.39 (17.85)^{bcd}	11.89 (20.17)^{cde}	9.48	0.36
T_5	Isolate 55 (1x10^{10} CFU g^{-1})	3 g l^{-1}	14.40 (22.30)^{cd}	13.94 (21.93)^{d}	11.86 (20.14)^{de}	13.40 (21.47)^{e}	9.86	1.49
T_6	Isolate 493 (1x10^{10} CFU g^{-1})	3 g l^{-1}	10.51 (18.92)^{a}	9.39 (17.85)^{ab}	7.59 (16.00)^{ab}	9.17 (17.62)^{ab}	10.36	2.97
T_7	HD-1 Strain (1x10^{10} CFU g^{-1})	3 g l^{-1}	12.83 (20.99)^{abcd}	10.09 (18.52)^{ab}	8.45 (16.90)^{bc}	10.46 (18.87)^{bcd}	10.51	3.41
T_8	Dipel ES (5×10^{9} CFU ml^{-1})	3 ml l^{-1}	13.10 (21.22)^{abcd}	10.34 (18.76)^{abc}	7.63 (16.03)^{ab}	10.36 (18.77)^{abcd}	10.58	4.03
T_9	*M. anisopliae* (1×10^{8} CFU g^{-1})	5 g l^{-1}	10.88 (19.26)^{ab}	9.90 (18.34)^{ab}	8.93 (17.38)^{bc}	9.90 (18.34)^{abc}	10.27	3.07
T_{10}	*B. bassiana* (1×10^{8} CFU g^{-1})	5 g l^{-1}	16.30 (23.81)^{de}	11.39 (19.72)^{bcd}	14.17 (22.11)^{e}	13.95 (21.93)^{e}	10.01	2.22
T_{11}	*M. rileyi* (1×10^{8} CFU g^{-1})	5 g l^{-1}	10.38 (18.79)^{a}	8.96 (17.42)^{ab}	9.76 (18.20)^{bcd}	9.70 (18.15)^{abc}	10.3	3.16
T_{12}	Chlorantraniliprole 18.5% SC	0.27 ml l^{-1}	10.15 (18.58)^{a}	7.98 (16.41)^{a}	6.02 (14.20)^{a}	8.05 (16.48)^{a}	11.23	6.56
T_{13}	Untreated Control	--	18.87 (25.74)^{e}	20.36 (26.82)^{e}	21.00 (27.27)^{f}	20.08 (26.62)^{f}	9.02	-
SE (m)±		--	0.953	0.965	0.831	0.773	0.526	-
CD ≤ 0.05		--	2.935	2.974	2.561	2.380	1.619	-
CV (%)		--	6.362	6.867	6.319	5.480	7.337	-

*Values in parentheses are arc sine transformed values; In a column means followed by same letters do not differ significantly by LSD (P = 0.05).

CONFLICT OF INTEREST

No conflict of interest.

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