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Bio-efficacy and economics of biopesticides against tobacco cutworm, *Spodoptera litura* Fab. on menthol mint

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ABSTRACT: A field experiment was conducted to study the bio-efficacy and economics of biopesticides against tobacco cutworm, *Spodoptera litura* Fab. on menthol mint during the *kharif* season of 2023 at Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar. Among the treatments, *Bacillus thuringiensis* var. *kurstaki* applied @ 1 l/ha was found to be the most effective, reducing the mean larval population by 42.92 per cent. The next most effective treatment was *Beauveria bassiana* @ 2.5 kg/ha (38.08%) which was statistically comparable to *Metarhizium anisopliae* @ 1.5 l/ha (34.91%) and *Azadirachtin* (1500 ppm) at 0.75 l/ha (32.13%). The least effective treatments were Neem oil (2%) applied at 10 l/ha (28.02%) and NSKE (5%) at 25 kg/ha (24.76%), although both were more effective than the untreated control plot. The highest B:C ratio was observed for *Bacillus thuringiensis* var. *kurstaki* at 1 l/ha (1:1.52) followed by *Beauveria bassiana* at 2.5 kg/ha (1:1.32), *Metarhizium anisopliae* at 1.5 l/ha (1:1.29) and *Azadirachtin* (1500 ppm) at 0.75 l/ha (1:1.26). NSKE (5%) at 25 kg/ha and Neem oil (2%) at 10 l/ha yielded benefit-cost ratios of 1:0.76 and 1:0.70 respectively, while the untreated control plot had the lowest ratio of 1:0.61.

Keywords: Bio-efficacy, biopesticides, economics, tobacco cutworm, menthol mint

INTRODUCTION

Among different essential oils produced in India, *Mentha arvensis* (menthol mint) oil holds prominent position in terms of acreage, production and domestic consumption and export to the world market. India is the largest producer and exporter of natural menthol in the world. The annual turnover of the menthol industry has been in the range of ` 3,500–4,000 crores during the past one decade. Menthol mint is presently cultivated in more than 2.50 lakh hectares in North India. Uttar Pradesh contributes about 70–75% of the total national production of menthol mint oil. Menthol mint yields 130–150 kg mint oil/ha (single harvest) giving a net profit in the range of 60–70,000 in about 3 and a half months (Suryavanshi *et al.*, 2021). Taking the lesson of success of menthol mint cultivation from the farmers of UP, the area under mint is now spreading to other states in the country including Bihar, parts of Punjab.

Japanese Mint (*Mentha arvensis var piperascense*) is an aromatic perennial herb, grown as an annual in sub-tropical parts of north India. Mints belong to the genus *Mentha*, in the family Labiatae (Lamiaceae) which includes other commonly grown essential oil-yielding plants such as basil, sage, rosemary, marjoram, lavender, pennyroyal and thyme. Within the genus *Mentha* there are several commercially grown species, varying in their major chemical content, aroma and end use. Their oils and derived aroma compounds are traded world-wide. All are herbaceous plants, readily sending out runners (rainy season) and stolons (winter) which develop new roots and shoots at the nodes and form plants. The entire aerial shoots together with foliage is a source of essential oil rich in menthol, carvone, linalool and linanyl acetate having use in pharmaceutical preparations and flavour industry. Japanese mint is a perennial ascending herb growing about 60-80 cm. in height and under favourable conditions may attain a height upto 100 cm. It does not produce seed and propagation is through vegetative means only (Kumar *et al.*, 2019).

However, insect pests pose a significant constraint in the production and quality of menthol mint oil. Among these, the *Spodoptera litura* Fab., is a particularly severe pest, substantially reducing the overall herbage yield. It was initially considered a minor pest but now poses significant threat to mint crops and identified as a severe pest for *Mentha arvensis* (Kedar *et al.*, 2023). In order to find safer methods of management of *S. litura*, present studies were conducted to evaluate the bio-efficacy and economics of certain biopesticides.

MATERIALS AND METHODS

The field experiment was conducted on during the *kharif* season of 2023 in the agro-climatic zone of North Bihar, at the Herbal Garden of RPCAU, Pusa

(Samastipur), Bihar. The experiment comprise seven treatments replicated three times in a Randomized Block Design, using plots each measuring 40 cm x 40 cm and an overall plot size of 2m x 2m following the recommended package of practices, apart from insecticidal application. The variety used for the experiment was Kosi with seven different treatments *viz., Bacillus thuringiensis*var. *Kurstaki, Metarhizium anisopliae, Beauveria bassiana,* Neem oil 2 %, NSKE 5%, *Azadirachtin*1500 ppm and Untreated Control.

The foliar spray of all the treatments was done by knapsack sprayer of 15 litres capacity. All the liquid formulations were measured by measuring cylinder and solid formulations were weighed using weighing balance. The spray solution of desired concentration was formed accordingly. The biopesticides are scheduled for two applications throughout the crop season, the 1st at the onset of pest infestation and the 2nd fifteen days following the initial spray. The larval population of pest was recorded from five randomly chosen plants in each treatment before the foliar application. Similarly, the larval population of pest was recorded on 1, 3, 7 and 14 days after first and second spray in each treatment. The yield of the marketable leaves was recorded after harvest and the cumulative yield and economics of each treatment was worked out.

The data collected from the experiments were analyzed statistically according to the experimental requirements. The effectiveness of treatments was also assessed by working out the per cent reduction of larvae over control. The benefit-cost ratio was computed. To compute the benefit-cost ratio, the additional revenue generated over the control plot was divided by the extra cost incurred for pest management.

RESULTS AND DISCUSSION

The cumulative efficiency of different biopestide treatments for the management on tobacco cutworm infesting menthol mint was summarized in (Table 1). The results regarding overall mean of two sprays against tobacco cutworm revealed that the treatment *Bacillus thuringiensis* var. *kurstaki* @ 1 l/ha was counted to be more efficient treatment and the per cent reduction in *S. litura* larval population over control was 42.92 per cent, followed by efficient application was *Beauveria bassiana* @ 2.5 kg/ha, *Metarhizium anisopliae*@ 1.5 l/ha, Azadirachtin 1500ppm @ 0.75 l/ha, Neem oil 2% @ 10 l/ha and NSKE 5 % @ 25 kg/ha also the per cent reduction in *S. litura* larval population over control was 38.08, 34.91, 32.13, 28.02 and 24.76 per cent respectively which were better than control or untreated plot after two successive sprays of biopesticides.

Among the treatments evaluated *Bacillus thuringiensis*var. *kurstaki* applied at 1 l/ha emerged as the most effective, achieving a significant reduction in the mean larval population by 42.92 per cent. This finding aligns with earlier research conducted by Sharma (2000), which demonstrated that formulations

Table 1. Efficacy of biopesticide treatments against tobacco cutworm on mint

Treatments	Dose (kg or l/ha)	1st Spray	2nd Spray	Mean larval population	Per cent reduction over control
T_1-*Bacillus thuringiensis*var. *kurstaki*	1.00	5.42	2.67	4.04	42.92
T_2-*Metarhizium anisopliae*	1.50	5.50	3.42	4.46	34.91
T_3-*Beauveria bassiana*	2.50	4.58	2.42	3.50	38.08
T_4-Neem oil 2 %	10.0	5.50	4.33	4.92	28.02
T_5- NSKE 5%	25.0	5.00	3.50	4.25	24.76
T_6- Azadirachtin1500 ppm	0.75	4.58	3.33	3.96	32.13
T_7-Untreated Control		9.25	9.58	9.42	
SEm (±)		0.41	0.38		
CD at 5 %		1.27	1.20		
CV (%)		11.46	12.61		

of *Bacillus thuringiensis* could lead to mortality rates of 66.66% to 100% within 3 to 5 days, indicating its strong potential as a biopesticide in pest management strategies. *Beauveria bassiana*, applied at 2.5 kg/ha, was the second most effective treatment, reducing the larval population by 38.08 per cent. This is consistent with findings from Suganthy and Sakthivel (2013), who reported that *Beauveria bassiana* was effective in managing *S. litura* populations. The current study also found that *Metarhizium anisopliae* at 1.5 litres/ha and Azadirachtin at 1500 ppm were statistically comparable, with reductions of 34.91 per cent and 32.13 per cent, respectively. The effectiveness of Azadirachtin has been corroborated by Nathan and Kalaivani (2005), who noted its significant impact on the nutritional indices of *S. litura*, further supporting its use in integrated pest management. In contrast, Neem oil 2% @ 10 litres/ha and NSKE 5% @ 25 kg/ha were the least effective treatments, yielding reductions of 28.02% and 24.76%, respectively. However, both treatments were still more effective than the untreated control plot. Previous studies, such as those by Singh *et al.* (2019), have shown that while neem-based products can manage *S. litura* populations, they may not be as effective as synthetic pesticides or other biopesticides. Singh *et al.* (2019) investigated the performance of various neem-based biopesticides in managing *S. litura* larvae that neem oil was the most effective among the neem products, while neem seed kernel and leaf extracts yielded comparable results. Sumanjali *et al.* (2020) conducted a thorough study, monitoring *S. litura* larvae populations at 3, 5, and 7 days after both the first and second sprays and found that *Bacillus thuringiensis* showed better efficacy with larval population reductions of 54.17% and 74.58%. Chandrayudu *et al.* (2015) carried out a field trial over two consecutive *Rabi* seasons to assess botanical and microbial insecticides against *S. litura* and reported that *Bacillus thuringiensis* (*Bt*) spray was highly effective in reducing both larval populations and leaf damage. NSKE (5%) and neem oil at 2 ml/litre were also effective, though to a lesser extent. Swami *et al.* (2019) evaluated various biopesticides against the tobacco caterpillar and found that all treatments significantly reduced pest populations compared to the control, resulting in NSKE and neem oil were less effective, with mean larval populations of 4.97larvae/plant.

Economics of various biopesticide treatments against tobacco cutworm infesting menthol mint

The field efficacy of different biopesticides tested by application of foliar sprays and the economics of treatments on menthol mint estimated which revealed that best returns are obtained which varied from 175 to 102 q/ha and the highest yield obtained from the treatment *Bacillus thuringiensis* var. *kurstaki* @ 1 l/ha (175 q/ha) followed by *Beauveria bassiana* @ 2.5 kg/ha (169 q/ha), *Metarhizium anisopliae* @ 1.5 l/ha (162 q/ha), Azadirachtin 1500ppm @ 0.75 l/ha (158 q/ha), Neem oil 2% @ 10 l/ha (153 q/ha),NSKE 5 % @ 25 kg/ha (127 q/ha) and the untreated check recorded (102 kg/ha) as given in (Table 2).

The net profits calculated by deducting the initial cost of land preparation, biopesticide cost and the labour charge the after that the economics of various treatments the highest ratio was obtained from the treatment *Bacillus thuringiensis* var. *kurstaki* @ 1 l/ha (1:1.52) followed by *Beauveria bassiana* @ 2.5 kg/ha (1:1.32), *Metarhizium anisopliae* @ 1.5 l/ha (1:1.29), Azadirachtin 1500ppm @ 0.75 l/ha (1:1.26), NSKE 5 % @ 25 kg/ha (1:0.76), Neem oil 2% @ 10 l/ha (1:0.70) and the untreated check was recorded (1:0.61) as given in (Table 2).

Table 2: Effect of biopesticides on foliage yield of menthol mint

Biopesticides	Dose (kg or l/ha)	Mean foliage yield (q/ha)	Increased yield over control (q/ha)	Increase in yield over control (%)	B:C Ratio
T_1-*Bacillus thuringiensis* var. *kurstaki*	1.00	175	73	71.57	1.52
T_2-*Metarhizium anisopliae*	1.50	162	60	58.82	1.29
T_3-*Beauveria bassiana*	2.50	169	67	65.69	1.32
T_4-Neem oil 2 %	10.0	153	51	50.00	0.70
T_5-NSKE 5%	25.0	127	25	24.51	0.76
T_6-*Azadirachtin* 1500 ppm	0.75	158	56	54.90	1.26
T_7-Untreated Control	-	102	0	0.00	0.61

CONCLUSION

The effectiveness of different biopesticide treatments against tobacco cutworm infesting menthol mint revealed that *Bacillus thuringiensis* var. *kurstaki* applied at 1 l/ha was the most effective treatment, reducing the mean larval population by 42.92%. The next most effective treatment was *Beauveria bassiana* at 2.5 kg/ha (38.08%), which was statistically comparable to *Metarhizium anisopliae* at 1.5 l/ha (34.91%) and azadirachtin (1500 ppm) at 0.75 l/ha (32.13%). The highest B:C ratio was recorded with *Bacillus thuringiensis* var. *kurstaki* at 1 l/ha (1:1.52), followed by *Beauveria bassiana* at 2.5 kg/ha (1:1.32), *Metarhizium anisopliae* at 1.5 l/ha (1:1.29), and Azadirachtin (1500 ppm) at 0.75 l/ha (1:1.26).

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