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Comparative Study of Synthetic Insecticides with Biopesticides against Spotted Stem Borer, *Chilo partellus* (Swinhoe) on Maize (*Zea mays* L.)

Abhishek Garhwal [a*] and Usha Yadav [a]

[a] Department of Entomology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007, Uttar Pradesh, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Spotted stem borer, *Chilo partellus* (Lepidoptera: Pyralidae) regarded as one of the most significant and prevalent insect pests of maize and its mystic aspect of feeding makes it challenging to control. Hence current study aims to evaluate comparative study of synthetic insecticides with biopesticides against *Chilo partellus*. Eight treatments viz., azadirachtin 10,000ppm, neem oil 3%, karanj oil 3%, neem oil 3% + imidacloprid 17.5%SL, karanj oil 3% + imidacloprid 17.5%SL, imidacloprid 17.5%SL, spinosad 45%SC and untreated control were tested under field condition in randomized block design with three replications. Among the treatments, lowest larval population of Chilo partellus per plant were recorded in karanj oil 3% + imidacloprid 17.5%SL (1.99) followed by neem oil 3% + imidacloprid 17.5%SL (2.42), imidacloprid 17.5%SL (2.71), spinosad 45%SC (3.17), neem oil 3% (3.73), karanj oil 3% (3.95) and azadirachtin 10,000ppm (4.44) were found superior over the

**Corresponding author: E-mail: garhwalabhishek77@gmail.com;*

untreated control (7.24). The highest yield was recorded in karanj oil 3% + imidacloprid 17.5%SL with 39.20 q/hectare and most economic treatment was imidacloprid 17.5%SL with highest cost benefit ratio (1:2.2). The lowest cost benefit ratio was recorded in untreated control (1:1.4).

Keywords: Chilo partellus; maize stem borer; management; insecticides; biopesticides; efficacy; highest yield.

1. INTRODUCTION

Maize (*Zea mays* L.) was domesticated in Central America. It is the world's leading crop, widely cultivated as cereal grain. Globally, maize is known as queen of cereals because of its highest genetic yield potential [1] that the crop is used for variety of purposes including foods and fodder using diverse plant parts, such as grain, leaves, stalks, tassels and cobs [2]. It is an important source of vitamins, minerals, lipids, protein, starch and fiber and also highly nutritious for cattle and poultry [3]. In terms of nutrition, maize grains include 4% oil, 70% carbohydrates, 2-3% crude fiber, and 10% protein in addition to vitamins A and E, riboflavin and nicotinic acid [4]. Maize contributes over 20 per cent of food calories of Asian population [5]. The global consumption pattern of maize is, feed-61%, food-17% and industry-22%. It has attained a position of industrial crop globally as 83% of its production in the world is used in feed, starch and bio-fuel industries. Further, using maize directly or indirectly more than 3000 products are being made providing a wide opportunity for value addition. Because of its myriad uses, it is a prime driver of the global agricultural economy. With a yield of 1423 million T, it is grown on 188 million hectares of land in 170 countries across the globe. China has maximum area under maize followed by the USA, both together representing 39% of world maize area. Since 2005, India ranks 4th in terms of area with 9.89 million hectares land under maize [6]. Production of Maize in the country during 2023-24 is estimated at record 224.82 lakh tones [7].

Notable insect pests of the crop are *Helicoverpa armigera* (Hubner) and *Mythimna separata* (Walker). *Spodoptera frugiperda*, *Atherigona soccata* (Rondani), *Rhopalosiphum maidis* (Fitch), and *Chilo partellus* (Swinhoe) [8]. Scientists have undertaken numerous investigations and come to the conclusion that the maize stem borer, *Chilo partellus* is a significant pest of pearl millet (*Pennisetum typhoideum* (Rich), sorghum (*Sorghum bicolor* L.), and maize (*Zea maize* L.) across Asia and Africa [9]. It was also noticed infesting Rice (*Oryza sativa*), Sugarcane (*Saccharum officinarum*) and several millets and grasses [10]. *Chilo partellus*, a member of the Pyralidae family of insects, is a notable biotic barrier to maize cultivation worldwide [11]. It is most significant pests in Asia and Africa [12]. Approximately 139 distinct insect pest species attack maize; among these, *Chilo partellus* is a major pest in various agroclimatic zones of India [13]. It is very difficult to control the *Chilo partellus*, because of cryptic and nocturnal habits of adult moths [14].

Chilo partellus lay oval-shaped, creamy white eggs of around 0.8 mm long. It takes 4–8 days for the eggs to develop into larvae and takes 28–35 days for the larvae to develop into pupa. Larvae in their final instar measure 25–30 mm long, and their bodies have rows of dark spots. Pupae are long, cylindrical and dark brown colored, males are smaller than females. The pupal period is 5-12 days. The moths are pale brown colored with an approximate wingspan of 20-30 mm. These moths have 3–8 days lifespan. When they attain maturity, they mate and lay eggs. The life cycle of *Chilo partellus* takes 25–50 days to complete [15]. Since maize has more sugars and amino acids than other gramineous hosts, it is more vulnerable to harm from stem borer infestation [16]. It starts to infest the crop three to four weeks after sowing and continues to do so until the crop reaches maturity [17]. The leaf-eating and stem-tunneling activity of the larvae is the most common symptom of *Chilo partellus* damage to maize plants. In a natural field, the first signs of infestation are characteristic leaf lesions and scarification caused by the first and second instars of *Chilo partellus* [18]. After hatching, stem borer larvae move over the plant, gather in the funnel, and feed on the curled leaves for a few days before approaching the stalk and stem [19]. When the infestation is severe, the larvae, either in the leaf whorl or in the stem, can cut through the meristematic tissues; the central leaves dry up to produce the 'dead heart' symptom [20]. Exit holes and tunnels in the main stem inhibit plant growth and promote bacterial and fungal diseases [21]. Dead hearts reduce translocation, ear damage, lodging, initial leaf senescence and in severe cases complete crop failure [22,23]. The yield losses exhibit significant regional variations, with a range of 25-40% depending on the pest population density and crop phenological stage of infection [24].

2. MATERIALS AND METHODS

The study was conducted during *Kharif,* 2023 at Central Research farm, SHUATS, Prayagraj, Uttar Pradesh, India. Experimental design employed was a Randomized Block Design (RBD) consisting of eight different treatments including untreated control, each being replicated thrice with a plot size of was 2m×1m and treatments were assigned randomly. The treatments included azadirachtin 10,000ppm (1ml/l) neem oil 3% (30ml/l), karanj oil 3% (30ml/l), neem oil 3% + imidacloprid 17.5%SL (30ml/l+0.25ml/l), karanj oil 3% + imidacloprid 17.5%SL (30ml/l+0.25ml/l), imidacloprid 17.5%SL (0.5ml/l), spinosad 45%SC (0.5ml/l) and untreated control. Two sprays were carried out at an interval of 15 days. Five plants were randomly selected in each treatment and observations were taken one day before spraying and three, seven and fourteen-days after spraying. Insecticides and biopesticides were applied at their recommended doses at economic threshold level (ETL = 10% infestation) [25].

The healthy marketable yield from different treatments were collected separately and weighed. The treatment cost and common cost of cultivation per hectare was calculated. Total income was realized by multiplying the total yield per hectare by the prevailing market price; while the net benefit was obtained by subtracting the total cost of plant protection from total income.

3. RESULTS AND DISUSSION

The data on the larval population of spotted stem borer on 3rd, 7th and 14th days after first spray revealed that all the treatments were significantly superior over control. Among the treatments, the lowest larval population of *Chilo partellus* was recorded in karanj oil 3% + imidacloprid 17.5%SL (2.48) followed by neem oil 3% + imidacloprid 17.5%SL (2.91), imidacloprid 17.5%SL (3.13), spinosad 45%SC (3.66), neem oil 3% (4.20), karanj oil 3% (4.44) and azadirachtin 10,000ppm (5.00) were found to be less effective when comparing all the treatments, which were significantly superior over the control (6.93). Among all the treatments (karanj oil + imidacloprid, neem oil + imidacloprid, imidacloprid), (imidacloprid, spinosad), (spinosad, neem oil), (neem oil, karanj oil) and (karanj oil, azadirachtin) were found statistically significant at par with each other.

The data on the larval population of spotted stem borer on 3rd, 7th and 14th DAS days after the second spray revealed that all the treatments were significantly superior over control. Among all the treatments lowest larval population of *Chilo partellus* was recorded in karanj oil 3% + imidacloprid 17.5%SL (1.50) followed by neem oil 3% + imidacloprid 17.5%SL (1.93), imidacloprid 17.5%SL (2.30), spinosad 45%SC (2.68), neem oil 3% (3.26), karanj oil 3% (3.46) and azadirachtin 10,000ppm (3.88) were found to be less effective when comparing all the treatments, which were significantly superior over the control (7.55). Among all the treatments (neem oil and karanj oil) were found statistically significant at par with each other.

The data on the larval population of *Chilo partellus* on mean (3rd, 7th and 14th DAS) days after first and second spray revealed that all the treatments were significantly superior over control. Among all the treatments lowest larval population of spotted stem borer was recorded in karanj oil 3% + imidacloprid 17.5%SL (1.99) followed by neem oil 3% + imidacloprid 17.5%SL (2.42), imidacloprid 17.5%SL (2.71), spinosad 45%SC (3.17), neem oil 3% (3.73), karanj oil 3% (3.95) and azadirachtin 10,000ppm (4.44) is found to be least effective then all the treatments and was significantly superior over the control (7.24). Among all the treatments (karanj oil + imidacloprid, neem oil + imidacloprid, imidacloprid), (neem oil + imidacloprid, imidacloprid, spinosad), (spinosad, neem oil, karanj oil) and (neem oil, karanj oil azadirachtin) were found statistically significant at par with each other.

The highest yield was recorded in karanj oil 3% + imidacloprid 17.5%SL with 39.20 q/ha followed by neem oil 3% + imidacloprid 17.5%SL with 36.50 q/ha, imidacloprid 17.5%SL with 34.40 q/ha, spinosad 45%SC with 32.50 q/ha, neem oil 3% with 30.70 q/ha, karanj oil 3% with 29.85 q/ha, azadirachtin 10,000ppm with 27.40 q/ha and untreated control 19.35 q/ha were recorded which was least yield.

Among all the treatments studied, the best and most economic treatment was imidacloprid 17.5%SL with cost benefit ratio of 1:2.2, followed

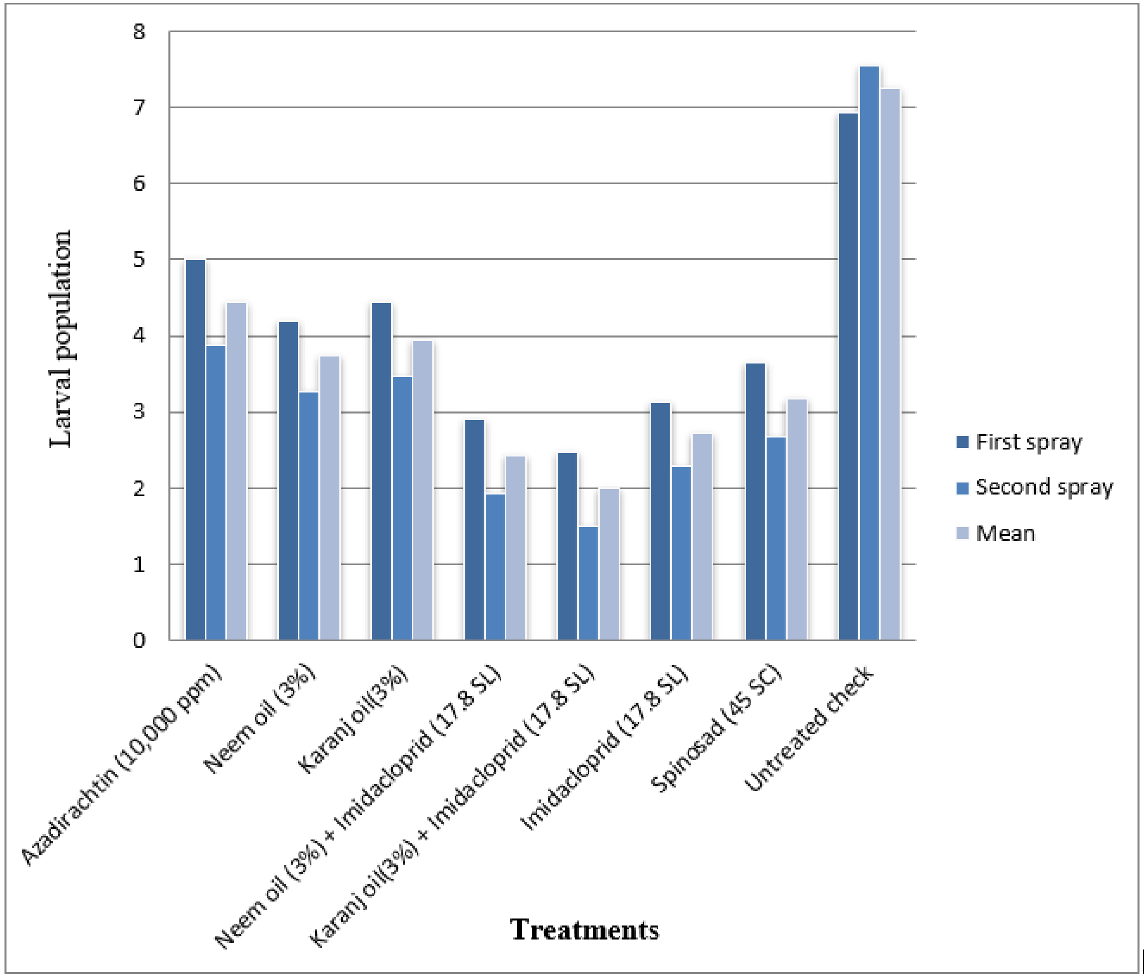

Fig. 1. Comparative study of synthetic insecticides with biopesticides against spotted stem borer, *Chilo partellus* (Swinhoe) after first and second spray

Table 1. Comparative study of synthetic insecticides with biopesticides against spotted stem borer, *Chilo partellus* on Maize

S.No.	Treatments	Dosage	Larval Population of *chilo partellus/ 5 plants*										Yield (q/ha)	C: B Ratio
			First spray					Second spray				Overall mean		
			1DBS	3DAS	7DAS	14DAS	Mean	3DAS	7DAS	14DAS	Mean			
T_1	Azadirachtin (10,000 ppm)	1 ml/lit	5.80	5.60^{b}	4.40^{b}	5.00^{b}	5.00^{b}	4.13^{b}	3.60^{b}	3.93^{b}	3.88^{b}	4.44^{b}	27.40	1:1.7
T_2	Neem oil (3%)	30 ml/lit	5.93	5.06^{c}	3.26^{d}	4.26^{c}	4.20^{cd}	3.40^{d}	3.13^{c}	3.26^{c}	3.26^{c}	3.73^{bc}	30.70	1:1.5
T_3	Karanj oil(3%)	30 ml/lit	5.60	5.33^{bc}	3.66^{c}	4.33^{c}	4.44^{bc}	3.73^{c}	3.26^{bc}	3.40c	3.46^{c}	3.95^{bc}	29.85	1:1.6
T_4	Neem oil (3%) + Imidacloprid (17.8SL)	30ml/lit + 0.25 ml/lit	5.80	3.86^{e}	2.13^{e}	2.73^{e}	2.91^{f}	2.20^{f}	1.66^{e}	1.93^{f}	1.93^{f}	2.42^{de}	36.50	1:1.7
T_5	Karanj oil(3%) + Imidacloprid (17.8SL)	30ml/lit + 0.25 ml/lit	6.06	3.40^{f}	1.73^{f}	2.33^{f}	2.48^{f}	1.66^{g}	1.33^{e}	1.53^{g}	1.50^{g}	1.99^{e}	39.20	1:2.0
T_6	Imidacloprid (17.8SL)	0.5 ml/lit	5.73	4.06^{e}	2.33^{e}	3.00^{e}	3.13^{ef}	2.46^{f}	2.13^{d}	2.33^{e}	2.30^{e}	2.71^{de}	34.40	1:2.2
T_7	Spinosad (45 SC)	0.5 ml/lit	5.73	4.46^{d}	3.00^{d}	3.53^{d}	3.66^{de}	2.86^{e}	2.46^{d}	2.73^{d}	2.68^{d}	3.17^{cd}	32.50	1:1.9
T_8	Control		6.06	6.60^{a}	6.93^{a}	7.26^{a}	6.93^{a}	7.40^{a}	7.60^{a}	7.66^{a}	7.55^{a}	7.24^{a}	19.35	1:1.4
F-Test			NS	S	S	S	S	S	S	S	S	S		
S.Ed.(±)			NS	0.15	0.18	0.13	0.32	0.13	0.13	0.16	0.13	0.81		
CD (0.05)			NS	0.32	0.38	0.28	0.67	0.28	0.28	0.33	0.28	0.95		

DBS- Day before Spraying, DAS- Day after Spraying, NS- Non significant, S- Significant by karanj oil 3% + imidacloprid 17.5%SL (1:2.0), spinosad 45%SC (1:1.9), neem oil 3% + imidacloprid 17.5%SL (1:1.7), azadirachtin 10,000ppm (1:1.7), karanj oil 3% (1:1.6), neem oil 3% (1:1.5) and untreated control (1:1.4).

4. CONCLUSION

The excessive use of synthetic insecticides and its associated detrimental effects have been widely criticized. Insects quickly develop resistance to synthetic insecticides when they are frequently exposed to them but biopesticides contain a variety of naturally occurring active ingredients with unique modes of actions, such as antifeedant, repellent, oviposition deterrent and synergistic effects, making resistance difficult to develop. Therefore, when synthetic insecticides and biopesticides are used together, they have substantially greater efficacy than when they are applied separately because of their synergistic and complimentary effects on each other. In present study, karanj oil 3% + imidacloprid 17.5%SL followed by neem oil 3% + imidacloprid 17.5%SL resulted highest efficacy with highest yield 39.20 and 36.50 q/hectare respectively against *Chilo partellus* but economically best treatment was imidacloprid (17.8SL) which recorded highest cost benefit ratio (1:2.2). Combinations of synthetic insecticides with biopesticides have lower cost benefit ratio to some extent compared to synthetic insecticides because of the high dosages and expense of biopesticides but it considered as a feasible alternative for synthetic insecticides and reduces adverse acute and chronic effects in environment along with bioaccumulation and biomagnifications.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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