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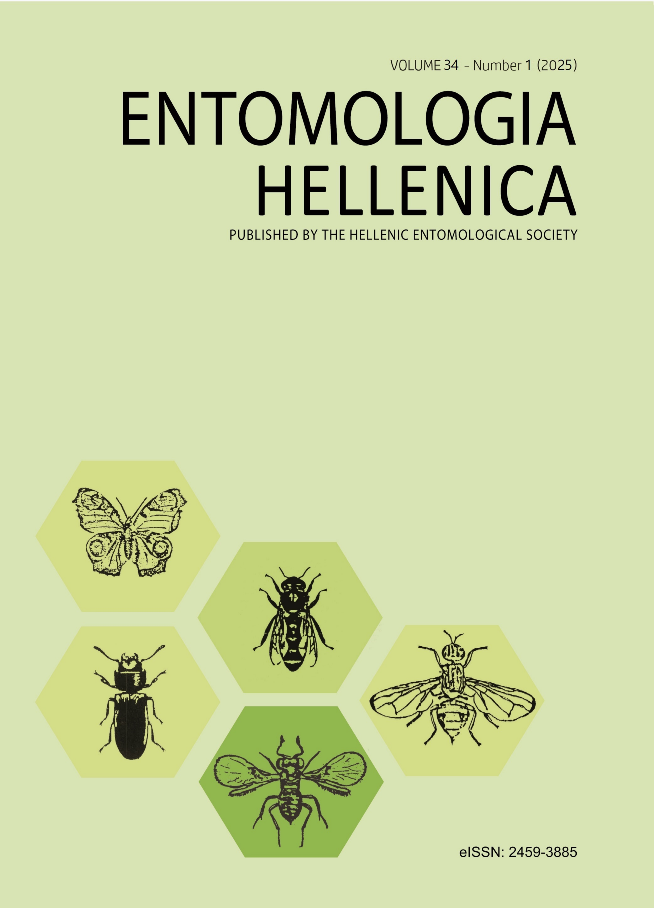

Evaluation of insecticides against the cotton bollworm Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae) under field conditions in Middle Awash, Ethiopia

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Evaluation of insecticides against cotton bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) under field conditions in Ethiopia

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ABSTRACT

The cotton bollworm complex presents a significant challenge to cotton farmers, resulting in substantial yield losses. While insecticides have been employed to manage this pest, ongoing research is crucial for developing new insecticides that mitigate the risk of resistance to current synthetic options. This study aimed to evaluate the effectiveness of selected insecticides against cotton bollworm through a field experiment conducted in the Middle Awash region. Utilizing a randomized complete block design, eight treatments were tested with four replications. Larval population, damage to fruiting bodies, yield, and yield component data were collected and analyzed. Results indicated that the application of various insecticides significantly ($P < 0.05$) influenced larval populations, fruiting body damage, and overall seed cotton yield. Notably, the combinations of profenofos 40% + alpha-cypermethrin 4% EC and profenofos + cypermethrin 44% EC resulted in yield increases of 88.5% and 76%, respectively, compared to the control group. These findings underscore the practical implications for cotton farmers in Ethiopia and similar regions facing pest challenges. The effective use of these insecticides could substantially reduce yield losses attributed to cotton bollworm infestations, thereby enhancing farmers' financial stability. However, further research should focus on the validation and demonstration of these insecticides under different agro-ecologies of the country.

KEY WORDS: *Fruiting damage, insecticide efficacy, insecticide mixture, seed cotton yield*.

Introduction

Cotton, *Gossypium hirsutum* L. (Malvaceae), is one of the world's most important cash crops. Farmers grow cotton for the fiber and the oil extracted from its seeds (Haider et al., 2015; Malinga and Laing, 2022). In sub-Saharan Africa, cotton production plays a crucial role in economic growth and rural development (Amanet et al., 2019). Ethiopia is a prominent producer of cotton, with extensive cultivation in various regions of the Awash Valley, Southern Rift Valley, Gambella, Humera, and Metema (Merdassa et al., 2022). Despite its significance, Ethiopia accounts for only 5% of African cotton production (Melesse et al., 2019).

Cotton cultivation faces significant challenges due to various pests, including African bollworms, cotton aphids, thrips, whiteflies, jassids (Ermias et al., 2009), and cotton mealybugs (Nurhussen et al., 2020). Among these pests, the African bollworm, *Helicoverpa armigera* (Hubner), poses a particularly severe threat to cotton crops in Ethiopia. This pest can cause substantial damage during its larval stage by feeding on

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the reproductive parts of cotton plants, resulting in hole formation and internal feeding (Geremew, 2004; Geremew and Ermias, 2006). Yield losses attributed to *H. armigera* can reach up to 60% (Geremew and Ermias, 2006). The pest population typically begins to increase in mid-June, peaking in August, necessitating timely planting and effective management practices from mid-June to mid-September in the Middle Awash Valley (Ermias et al., 2009).

Chemical control remains the primary management strategy for cotton pests in Ethiopia, accounting for approximately 43% of production costs (EIAR, 2017). Farmers frequently employ a range of chemicals, including pyrethroids, carbamates, and organophosphates, to combat *H. armigera* (Geremew, 2004). Typically, 10-12 pesticide applications are required throughout the growing season to protect crops from insect damage. However, reliance on insecticides with a single mode of action can lead to the development of resistance in *H. armigera* and other pests (Yongqiang et al., 2016). Resistance levels can vary from low to moderate among cotton pests (Geremew, 2004; Hussain et al., 2015; Tossou et al., 2019; Zemedkun et al., 2022).

Recent advancements in integrated pest management (IPM) emphasize on the importance of diversifying control strategies to mitigate resistance risks. This includes incorporation of biocontrol agents and cultural practices alongside chemical applications (Khan et al., 2020; Reddy et al., 2021). Studies have shown that combining biological control methods with conventional insecticides pest management efficacy may be enhanced, while reliance on chemicals is reduced (Bahlai et al., 2020). Additionally, ongoing research on novel insecticides is essential for developing effective rotation strategies that help manage pest resistance effectively (Salama et al., 2013).

Given the challenges posed by *H. armigera* and the need for sustainable pest management practices, this study aimed to assess the efficacy of selected commercially available insecticides against the cotton bollworm in the Middle Awash area. By evaluating new insecticides and their potential role within current pest management strategies, we aim to enhance accessibility and provide valuable insights for Ethiopian cotton farmers facing pest challenges.

Materials and Methods

Description of the study area

The experiments were conducted at the Werer Agricultural Research Center (WARC) under field conditions during the 2021 and 2022 seasons. WARC is located at 90 20' 31" N and 400 10' 11" E, 750 m above sea level. The study area has an inconsistent annual rainfall of 540 mm and mean maximum and minimum temperatures of 34.4 °C and 19.6 °C, respectively. The type of soil is vertisol, with a porosity of 49.06% and a bulk density of 1.35 gm/cm^2 (0-25 cm depth) (Wendmagegn and Abere, 2012).

Planting material

For the present study, the newly released cotton variety Werer-12 was obtained from the Werer Agricultural Research Center.

Insecticides

Seven insecticides that were recommended by the WARC for controlling cotton bollworms on cotton plants were used for the experiment (Table 1).

Treatments and experimental design

The seven insecticides and control were arranged in a randomized complete block design (RCBD) with four replications per treatment. Each plot covered a total area of 63 m^2. The spacing between rows was 90 cm, while the spacing between plants within a row was 20 cm.

TABLE 1: List of insecticides used in the present study.

Trt no.	Trade name	Common name	Chemical group	Rate (ml/ha)
1	Tutan 36% SC	chlorfenapyr	pyrole	225
2	Proof 44% EC	profenofos + cypermethrin	organophosphate + pyrethroid	2000
3	Agro-Lambacin Super 315 EC	profenfos 30%+ lambda-cyhalothrin 1.5%	organophosphate + pyrethroid	400
4	Anticat 48%EC	chlorpyriphos 48% EC	organophosphate	2000
5	Testa	beta-cypermethrin 5% + emamectin benzoate 0.5%ME	pyrethroid + avermectins	750
6	Alphapro 440 EC	profenofos 40% + alpha-cypermethrin 4%	organophosphate + pyrethroid	750
7	Biotrine	abamectin + oxymatrin	abamectin + quinazine alkaloid	2000

Experimental Procedures

Planting dates and methods. The agricultural field was meticulously prepared using a tractor-operated machine to ensure optimal planting conditions. Planting activities were carried out on May 15th in consecutive years to maintain consistency in the growing season. A carefully planned irrigation schedule was followed, with the plots receiving water eight times. The initial irrigation was followed by subsequent watering sessions at a 10-day interval, transitioning to a 15-day interval as the bolls approached 65% opening. Hoeing and hand-weeding procedures were conducted twice throughout the study to combat weed growth and maintain plot integrity. Additionally, all prescribed agronomic practices were diligently followed to promote healthy crop development and ensure uniformity across the experimental plots.

Data collection. Data collection for assessing *H. armigera* infestation in cotton fields was conducted systematically, starting three weeks after germination and continuing until crop maturity. In each plot, a standardized sampling approach was followed, with five tagged plants monitored for pest activity on young shoot leaves, squares, flowers and bolls. Detailed observations were made on cotton bollworm eggs and larvae, damaged squares, flowers, and bolls, as well as the presence of non-target and beneficial insects. Data was collected both before and after spraying at specific intervals (3, 5, 7, and 10 days) to track changes in pest populations and assess the efficacy of control measures. Towards the end of the growing season, the number of healthy bolls per plant was quantified for the designated plants, including those in control plots, to evaluate the impact of pest infestation on yield. Finally, at harvest, the seed cotton plants were weighed to determine the overall crop productivity and the effectiveness of pest management strategies implemented throughout the season.

Data analysis. All data were analyzed using PROC GLM (SAS Version 9.0, SAS Institute, 1999). The PROC UNIVARIATE test was used to test the normality and homogeneity of variance of the data based on the Shapiro-Wilk test. To satisfy the

ANOVA assumptions, the pre-and post-spray count mean data were square root-transformed ($\sqrt{x}$+0.5). When F values were significant (P < 0.05), the means were compared using Fisher's least significant difference (LSD) test. The percent efficacy of each treatment was calculated based on the modified Abbott's formula (1925):

$$\% \text{ efficiency} = [1 - (Ta*Cb)/(Tb*Ca)]$$

where Ta = posttreatment population in treatment, Cb = pretreatment population in check, Tb = pretreatment population in treatment, and Ca = posttreatment population in check**.**

Results

The effectiveness of the tested insecticides in managing cotton bollworm infestations during the 2021 cropping season is summarized in Table 2. Significant differences (P < 0.05) were observed in the number of larvae emerging post-treatment, and the number of damaged squares and flowers across different treatments (Table 2). Notably, plots treated with profenofos + alpha-cypermethrin exhibited the lowest counts of larvae and damaged fruiting bodies, while untreated plots recorded the highest numbers (Table 2). Furthermore, the number of bolls per plant and seed yield showed highly significant differences (P < 0.01) (Table 2). Compared to the untreated control, applications of Alphapro 440 EC and Proof 44% EC led to remarkable increases in seed cotton yield of 95% and 80%, respectively. This was followed by chlorfenapyr (36% SC; chlorpyrifos, 48% EC (70%); profenfos, 30% + lambda-cyhalothrin, 1.5%; betacypermethrin, 5% + emamectin benzoate, 0.5% (60%); and abamectin + oxymatrin (35% (Table 2).

In the 2022 season, significant differences (P < 0.05) were again noted in post-treatment mean larval counts, damaged squares, and seed yields among the treatments (Table 3). The combination of profenofos + alpha-cypermethrin demonstrated the highest efficacy in controlling larvae, resulting in a 70% increase in seed cotton yield. In comparison, plots treated with abamectin + oxymatrine showed the lowest efficacy with only a 22.5% yield increase (Table 3).

Overall, the combined results indicated that treatments significantly influenced post-treatment larval counts, damaged square counts, bolls per plant, and seed yield throughout the year (P < 0.01), although interaction effects were non-significant (P > 0.05) (Table 4). The application of profenofos + alpha-cypermethrin led to increases of 11%, 11%, 20%, 6%, 22%, 29%, and 69% in the number of bolls per plant across various treatments. Additionally, compared to the control, plots treated with profenofos + alpha-cypermethrin and 44% profenofos + cypermethrin achieved yield increases of 82% and 72%, respectively (Table 4). Other treatments, including Anticat, Tutan, Agro-Lambacin Super, Testa, and Biotrin, also contributed to yield enhancements of 69%, 65%, 52%, 47%, and 26%, respectively.

Discussion

The present study on the evaluation of the tested insecticides, particularly the combination of organophosphates and pyrethroids, against the cotton bollworm, *Helicoverpa armigera*, shows promising results in managing the cotton bollworm. Organophosphates, such as proenofos, function by inhibiting acetylcholinesterase, leading to the accumulation of acetylcholine at synapses, which causes continuous stimulation of the nervous system (Zhang et al., 2020). Confirming the findings of this investigation, Chambers et al. (2010), Timchalk (2010), and Carneiro et al. (2014) reported that organophosphorus pesticides have a complex metabolic pathway to reach their primary target, acetylcholinesterase.

Pyrethroids, like cypermethrin or alpha-

TABLE 2. Effects of tested insecticides on ABW population-damaged fruits and yield of cotton plants: Werer, 2021.

Treatment	Larval count/plant		Reduction %	No. of damaged squares/plant		No. of damaged flowers/plant		No. of damaged bolls/plant		Health boll/ plant	Seed cotton yield (ton/ha)
	Pre-spray	Post-spray		Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray		
chlorfenapyr 36 SC/Tutan	0.80 (1.14)	0.17 (0.82)[bcd]	80.56	1.30 (1.33)	0.58 (1.04)[bc]	0.40 (0.95)	0.12 (0.78)[b]	0.10(0.77)	0.0.6 (0.75)	30.6[bc]	3.4[ab]
profenofos + cypermethrin / Proof 44% EC	0.70 (1.10)	0.13(0.79)[cd]	84.44	1.13 (1.27)	0.41 (0.95)[c]	0.18 (0.82)	0.06 (0.75)[b]	0.05(0.74)	0.01 (0.71)	33.1[ab]	3.6[a]
profenfos 30% + lambda-cyhalothrin 1.5%	0.90 (1.18)	0.20 (0.84)[bcd]	79.26	1.45 (1.38)	0.58 (1.03)[bc]	0.33 (0.90)	0.08 (0.76)[b]	0.25(0.85)	0.08 (0.76)	28.8[bc]	3.2[ab]
chlorpyrifos 48%EC/Anticat	0.85 (1.16)	0.16 (0.81)[bcd]	82.61	1.48 (1.40)	0.61 (1.05)[bc]	0.28 (0.88)	0.08 (0.76)[b]	0.18(0.82)	0.09 (0.77)	32.5[ab]	3.4[ab]
beta-cypermethrin+ emamectin/benzoate/Testa	0.85 (1.16)	0.21 (0.84)[bc]	77.12	1.63 (1.45)	0.67 (1.08)[b]	0.23 (0.84)	0.12 (0.78)[b]	0.13(0.79)	0.09 (0.77)	27.3[c]	3.2[ab]
profenofos + Alpha-cypermethrin/Alphapro	0.78 (1.13)	0.11 (0.78)[d]	86.95	1.03 (1.23)	0.42 (0.95)[c]	0.33 (0.92)	0.11 (0.78)[b]	0.10(0.77)	0.05 (0.74)	36.4[a]	3.9[a]
abamectin+oxymatrine/Biotrin	0.78 (1.13)	0.24 (0.86)[b]	71.40	1.40 (1.37)	0.57 (1.03)[bc]	0.33 (0.90)	0.13 (0.80)[b]	0.08(0.76)	0.07 (0.75)	26.1[c]	2.7[bc]
Unsprayed	0.70 (1.10)	0.75 (1.12)[a]	-	1.35 (1.34)	1.23 (1.32)[a]	0.28 (0.88)	0.35 (0.92)[a]	0.18(0.82)	0.21 (0.84)	19.1[d]	2.0[c]
LSD (0.05)	Ns	0.06(***)		Ns	0.12 (***)	Ns	0.06(***)	Ns	Ns	5.1 (***)	7.9 (**)
CV (%)	5.75	4.59		12.91	7.42	9.72	4.94	11.22	6.24	10.6	15.4
S.E±	0.03	0..2		0.16	0.04	0.04	0.02	0.04	0.02	1.7	0.2

Means followed by the same letter (s) within a column are not significantly different from each other at the 5% level of significance. Least significance difference (LSD) was used, CV=coefficient of variation, % efficacy=percent efficacy, NS=not significant. Values in parentheses of pre- and post-spray means were transformed from the roots.

TABLE 3. Effects of tested insecticides on ABW population-damaged fruits and yield on cotton plants, Werer, 2022.

Treatment	Larval count/plant		Reduction %	No. of damage squares/plant		No. of damaged flowers/plant		No. of damaged bolls/plant		Health boll/ plant	Seed cotton yield (ton/ha)
	Pre-spray	Post-spray		Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray		
chlorfenapyr 36 SC/Tutan	0.53 (1.01)	0.13 (0.79)[bc]	80.95	1.05 (1.24)	0.50 (0.99)[bc]	0.45 (0.94)	0.15 (0.79)	0.10 (0.77)	0.15 (0.79)	47.8[ab]	4.3[ab]
profenofos + cypermethrin / Proof 44% EC	0.63 (1.06)	0.13(0.79)[bc]	83.00	1.20 (1.30)	0.25 (0.86)[c]	0.55 (1.02)	0.20 (0.77)	0.10 (0.77)	0.10 (0.77)	45.6[ab]	4.3[ab]
profenfos 30% + lambda-cyhalothrin 1.5%	0.68 (1.08)	0.20 (0.83)[bc]	76.30	1.00 (1.22)	0.60 (1.05)[b]	0.50 (1.04)	0.25 (0.86)	0.25 (0.86)	0.15 (0.79)	44.0[ab]	3.8[bc]
chlorpyrifos 48%EC/Anticat	0.73 (1.11)	0.15 (0.81)[bc]	83.45	1.20 (1.30)	0.40 (0.95)[bc]	0.55 (1.02)	0.15 (0.80)	0.15 (0.79)	0.10 (0.77)	49.9[a]	4.4[ab]
beta-cypermethrin+ emamectin/benzoate/Testa	0.63 (1.06)	0.20 (0.84)[bc]	74.40	1.00 (1.22)	0.55 (1.01)[bc]	0.40 (0.94)	0.15 (0.80)	0.25 (0.86)	0.05 (0.74)	44.4[ab]	3.7[c]
profenofos + Alpha-cypermethrin/Alphapro	0.50 (0.99)	0.08 (0.76)[c]	88.00	0.85 (1.16)	0.25 (0.86)[c]	0.50 (0.99)	0.05 (0.74)	0.20 (0.83)	0.05 (0.74)	51.5[a]	4.6[a]
abamectin+oxymatrine/Bio trin	0.83 (1.15)	0.30 (0.89)[b]	69.91	0.90 (1.18)	0.55 (1.02)[bc]	0.30 (0.89)	0.20 (0.82)	0.15 (0.79)	0.20 (0.83)	41.7[b]	3.3[c]
Unsprayed	0.60 (1.05)	0.75 (1.11)[a]	-	0.95 (1.20)	1.30 (1.34)[a]	0.45 (0.91)	0.55 (1.02)	0.20 (0.83)	0.25 (0.86)	32.9[c]	2.7[d]
LSD (0.05)	Ns	0.11(***)		Ns	0.18 (**)	Ns	Ns	Ns	Ns	7.6	0.6 (***)
CV (%)	6.53	8.74		8.46	12.06	14.02	13.03	11.61	11.38	11.6 (**)	10.7
S.E±	0.03	0..09		0.16	0.04	0.04	0.02	0.04	0.02	2.6	0.2

Means followed by the same letter (s) within a column are not significantly different from each other at the 5% level of significance. Least significance difference (LSD) was used, CV=coefficient of variation, % efficacy=percent efficacy, NS=not significant. Values in parentheses of pre- and post-spray means were transformed from the roots.

TABLE 4. Combined Analysis of the Effects of Insects against ABW Population-Damaged Fruit and Yield on Cotton, Werer, 2021 & 2022.

Treatment	Larval count/plant		Reduction %	No. of damage squares/plant		No. of damaged flowers/plant		No. of damaged bolls/plant		Health boll/ plant	Seed cotton yield (ton/ha)
	Pre-spray	Post-spray		Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray		
chlorfenapyr 36 SC/Tutan	0.70 (1.09)	0.12 (0.78)^{c}	80.78	1.04 (1.23)	0.46 (0.98)^{bc}	0.40 (0.93)	0.13 (0.78)^{b}	0.10(0.77)	0.10(0.77)	39.2^{bc}	3.8^{abc}
profenofos + cypermethrin / Proof 44% EC	0.66 (1.08)	0.13(0.79)^{c}	83.72	1.16 (1.28)	0.33 (0.91)^{c}	0.36 (0.92)	0.08 (0.76)^{b}	0.08(0.75)	0.03(0.73)	39.3^{bc}	4.0^{ab}
profenfos 30% + lambda-cyhalothrin 1.5%	0.84 (1.15)	0.20 (0.83)^{bc}	77.78	1.23 (1.29)	0.59 (1.04)^{b}	0.41 (0.97)	0.17 (0.81)^{b}	0.25(0.86)	0.09(0.76)	36.4^{cd}	3.5^{bc}
chlorpyrifos 48%EC/Anticat	0.83 (1.15)	0.15 (0.81)^{c}	83.03	1.34 (1.35)	0.50 (0.99)^{bc}	0.41 (0.95)	0.11 (0.78)^{b}	0.16(0.81)	0.09(0.77)	41.2^{ab}	3.9^{ab}
beta-cypermethrin+ emamectin/benzoate/Testa	0.78 (1.13)	0.20 (0.84)^{bc}	75.76	1.31 (1.34)	0.61 (1.04)^{b}	0.31 (0.89)	0.13 (0.79)^{b}	0.19(0.82)	0.07(0.75)	35.9^{cd}	3.4^{cd}
profenofos + Alpha-cypermethrin/Alphapro	0.69 (0.08)	0.12 (0.79)^{c}	87.48	1.07 (1.25)	0.42 (0.95)^{bc}	0.45 (0.97)	0.08 (0.76)^{b}	0.15(0.80)	0.10(0.77)	43.9^{a}	4.2^{a}
abamectin+oxymatrine/Biotrin	0.84 (1.16)	0.27 (0.87)^{b}	70.66	1.15 (1.27)	0.56 (1.04)^{b}	0.31 (0.89)	0.17 (0.81)^{b}	0.11(0.77)	0.15(0.80)	33.9^{d}	2.9^{d}
Unsprayed	0.65 (1.07)	0.75 (1.15)^{a}	-	1.15 (1.20)	1.27 (1.33)^{a}	0.36 (0.89)	0.45 (0.97)^{a}	0.9(0.83)	0.23(0.85)	25.9^{e}	2.3^{e}
CV (%)	6.28	6.88		11.42	9.64	12.03	10.49	12.07	9.77	11.8	13.5
Treatment	Ns	***		Ns	***	Ns	**	Ns	Ns	***	***
Year	***	Ns		**	Ns	Ns	Ns	Ns	Ns	***	***
Treatment *Year	Ns	Ns		Ns	Ns	Ns	Ns	Ns	NS	Ns	Ns
LSD (0.05)	0.04			0.07	0.10		0.08			4.4	0.5

Means followed by the same letter (s) within a column are not significantly different from each other at the 5% level of significance. Least significance difference (LSD) was used, CV=coefficient of variation, % efficacy=percent efficacy, NS=not significant. Values in parentheses of pre- and post-spray means were transformed from the roots.

cypermethrin, disrupt the sodium channel function in neurons, resulting in prolonged depolarization and paralysis (Gao et al., 2018). Similarly, El-Sayed et al. (2020) reported that the alpha-cypermethrin insecticide was effective at reducing bollworms.

The combination of organophosphates with pyrethroids can exhibit synergistic effects, enhancing the overall efficacy against *H. armigera*, leading to improved crop yields. This aligns with findings from previous studies that advocate for the use of combination insecticides to enhance pest control and minimize resistance development (Raghavendra et al., 2020; Ahmad et al., 2020) Pesticide mixtures containing profenofos + alpha-cypermethrin 440 and profenofos + cypermethrin 44% EC provide efficient control of bollworms due to potent ovicidal, larvicidal, and acaricidal properties (Chongquing, 2019). Moreover, a combination of pesticides effectively reduces damage caused by bollworm complexes and achieves the highest seed cotton yield (Babariya et al., 2010; Rudramuni et al., 2011; Borude et al., 2018; Rajendran et al., 2021). Many studies have assessed the effectiveness of organophosphate/pyrethroid pesticide mixtures in reducing insect populations and enhancing yield (Mushtaq, 2004; Nayak and Daglish, 2007; Khan et al., 2013; Surpam et al., 2015). This approach assumes that insects are less likely to develop resistance to multiple modes of action simultaneously, suggesting that pesticide mixture is a recommended technique for controlling resistance (Warnock and Cloyd, 2005; Desneux et al., 2007).

The successful management of H. armigera is particularly critical for cotton farmers in Ethiopia, who face economic challenges exacerbated by pest infestations (Prasanna et al., 2020). The results underscore the importance of integrated pest management (IPM) strategies that not only focus on chemical control but also incorporate cultural practices and biological control methods to ensure long-term sustainability.

The implications of these findings extend beyond immediate pest control; they highlight the necessity for a comprehensive resistance management strategy. As H. armigera has shown a propensity for developing resistance to single insecticides, utilizing a combination approach can help delay resistance onset and maintain the effectiveness of existing chemical tools (Naranjo, 2009). Moreover, integrating sustainable practices such as crop rotation, the use of resistant varieties, and biopesticides can further enhance pest management efforts while reducing reliance on synthetic chemicals. This holistic approach not only protects yield but also promotes environmental health, aligning with global trends towards sustainable agriculture.

Conclusions

The use of insecticides can significantly impact larval populations, damaged fruiting bodies, and seed cotton yield. The results of the present study showed that the application of profenofos + alpha-cypermethrin 440 or profenofos + cypermethrin 44% EC had good efficacy in reducing *H. armigera* larvae and increasing cotton yield by 88.5% and 76%, respectively, compared with the control. These findings suggest that using these insecticides can potentially boost cotton yield and improve farmers' financial stability. The promising results from this study serve as a pivotal reference point for future pest control strategies in Ethiopia. By adopting an integrated approach that combines effective insecticides with sustainable practices, stakeholders can foster resilience in agricultural systems while addressing the challenges posed by pest resistance and economic pressures.

Continued research into alternative pest management methods will be essential for ensuring the longevity and effectiveness of these strategies in the ever-evolving landscape of agricultural pest management.

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Conflict of interests

The authors declare that they have no potential financial or personal conflicts of interest that could have influenced the study's findings.

Availability of Data

All data generated or analyzed during this study are included in this published article.

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Αξιολόγηση εντομοκτόνων εναντίον του πράσινου σκουληκιού, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) υπό συνθήκες αγρού στην Αιθιοπία

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ΠΕΡΙΛΗΨΗ

Το πράσινο σκουλήκι του βαμβακιού αποτελεί σημαντική πρόκληση για τους βαμβακοκαλλιεργητές, με αποτέλεσμα σημαντικές απώλειες απόδοσης. Παρά το γεγονός ότι για τη διαχείρισή του χρησιμοποιούνται εντομοκτόνα σκευάσματα, η συνεχιζόμενη έρευνα είναι ζωτικής σημασίας για την ανάπτυξη νέων δραστικών που μειώνουν τον κίνδυνο ανάπτυξης ανθεκτικότητας στις χρησιμοποιούμενες δραστικές ουσίες. Η παρούσα μελέτη στόχευσε στην αξιολόγηση της αποτελεσματικότητας επιλεγμένων εντομοκτόνων εναντίον του *Helicoverpa armigera* μέσω ενός πειράματος πεδίου που διεξήχθη στην περιοχή Middle Awash. Χρησιμοποιώντας ένα σχέδιο πλήρους τυχαιοποίησης, δοκιμάστηκαν οκτώ μεταχειρίσεις σε τέσσερις επαναλήψεις. Συλλέχθηκαν και αναλύθηκαν δεδομένα για το συνολικό αριθμό προνυμφών, της ζημιάς στους καρπούς, και την απόδοση. Τα αποτελέσματα έδειξαν ότι η εφαρμογή διαφόρων εντομοκτόνων επηρέασε σημαντικά ($P < 0{,}05$) τους αριθμούς των προνυμφών, τη βλάβη στους καρπούς και τη συνολική απόδοση του βαμβακιού σε σπόρο. Συγκεκριμένα, οι συνδυασμοί profenofos 40% + alpha-cypermethrin 4% EC και profenofos + cypermethrin 44% EC είχαν ως αποτέλεσμα αύξηση απόδοσης 88,5% και 76%, αντίστοιχα, σε σύγκριση με τον μάρτυρα. Αυτά τα ευρήματα υπογραμμίζουν τις πρακτικές συνέπειες για τους βαμβακοκαλλιεργητές στην Αιθιοπία και παρόμοιες περιοχές που αντιμετωπίζουν προκλήσεις εχθρών. Η αποτελεσματική χρήση αυτών των εντομοκτόνων θα μπορούσε να μειώσει σημαντικά τις απώλειες απόδοσης που αποδίδονται σε προσβολές από το *H. armigera*, ενισχύοντας έτσι την οικονομική σταθερότητα των αγροτών. Ωστόσο, περαιτέρω έρευνα θα πρέπει να επικεντρωθεί στην επικύρωση και επίδειξη αυτών των εντομοκτόνων σε διαφορετικές αγρο-οικολογίες της χώρας.

