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Research Article

Evaluation of Insecticide Against Fall Armyworm (Spodoptera Frugiperda) Control and Maize (Zea mays L.) Yield in Central Ethiopia

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Abstract

Maize is a staple food crop and a major source of income for many resource-poor farmers in Ethiopia. This experiment was conducted during the maize sub-growing season in the 2025-2026 cropping calendar in the Central Ethiopia Regional State, East Gurage Zone, in the Meskan and South Sodo districts. The objective was to evaluate the performance of Fipronil 5% SC (BAYECURE) at 450ml/ha, Karate 5% EC (lambda-cyhalothrin) at 320ml/ha, and the standard check. The experiment used an RCBD design with three replications, a plot size of 4m x 4 m, and inter- and intra-row spacing of 0.25 m x 0.75m. The results show that insecticide application significantly (P≤0.001) reduced the occurrence of fall armyworm larvae and increased yield and yield components of maize in both locations compared with untreated plots. At both research sites, fewer larvae, less leaf damage, less cob injury, and lower cob severity were recorded in plots treated with Fipronil 5% SC (BAYECURE) at 450ml/ha and Karate 5% EC (lambda-cyhalothrin) at 320ml/ha, along with higher yields and yield components of maize. In contrast, untreated plots recorded more larvae, greater leaf damage%, more cob injury, higher cob severity%, and lower yields and yield components of maize. Based on these results, application of Fipronil 5% SC (BAYECURE) at 450ml/ha and Karate 5% EC (lambda-cyhalothrin) at 320ml/ha significantly reduced the occurrence of fall armyworm larvae and increased the yield components of maize in both locations. Therefore, application of Fipronil 5% SC (BAYECURE) at 450ml/ha and Karate 5% EC (lambda-cyhalothrin) at 320ml/ha, with a dilution of 500lha-1 water, applied at two-week intervals, combined with frequent irrigation and good agronomic practices, is effective for the control of fall armyworm (Spodoptera frugiperda) and increases maize production in the East Gurage Zone.

Keywords

Fall Armyworm, Insecticides, Maize Yield

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1. Introduction

Maize is an important staple food crop in Ethiopia and a major source of income for many resource-poor farmers [44]. “In Ethiopia, 88% of maize produce is used as food prepared in both grain and green cobs” [35]. It is second in area of production and first in productivity among the staple food crops teff, wheat, and sorghum [1]. “Maize possesses great genetic diversity and is grown in a wide range of environments, from the equator to about 50 north latitude and 420 south latitude and as high as 3800 meters above sea level” [37]. “It is one of the high-priority crops to feed the ever-increasing Ethiopian population” [35]. “However, the production of this crop and consequently the livelihood of the growers is constrained by the invasion and widespread infestation of the fall armyworm, which has led to substantial maize yield losses” [2]. It was first reported in Africa in Nigeria and Ethiopia in 2016 and 2017, respectively [15, 24]. Based on recent environmental and climatic analyses of Africa, the fall armyworm is likely to establish permanent and significant populations on the continent [2]. Fall armyworm caterpillars were much more damaging to maize in West and Central Africa than other Spodoptera spp. [29]. The fall armyworm is causing significant damage to maize crops in Africa and has great potential for further spread and economic damage. It has since spread to 28 countries in Africa [16].

Fall armyworms attack all stages of maize, from seedling emergence through ear development. They defoliate leaves and damage ears, leading to poor crop yields [10]. About 100 crops and other plants can host the insect and are susceptible to attack, but it prefers maize, rice, sorghum, and sugarcane [2, 28]. Yield losses of 15-73% were reported when 55-100% of maize plants were infested with fall armyworm during the mid- to late-whorl stage of maize development. Studies have been conducted in various parts of the world to control fall armyworm. Chemical insecticide control for FAW was a common practice in North and South America and in sub-Saharan countries, including Ethiopia [16]. Fall armyworm, Spodoptera frugiperda (FAW), is a highly destructive insect pest that first appeared in Africa in January 2016 and has since spread to all sub-Saharan African (SSA) countries except Lesotho [31, 41, 45].

The sudden invasion of FAW has forced the Ethiopian government and stakeholders to use insecticides as an emergency measure in FAW-affected maize fields [4]. Pesticides are the most common control method farmers use [22]. In Ethiopia, evaluations of synthetic insecticides under controlled and open-field conditions showed that insecticides from different groups reduced foliar damage to maize and recorded promising larval mortality [3, 9, 32]. FAW infests and feeds on maize, sorghum, and other SSA crop species and their wild relatives, causing devastating impacts on agriculture [5, 23]. The moths' ability to fly up to 100 km, their diverse host range, and their lack of a diapause growth phase make them difficult to control, manage, or eradicate [7]. Since its arrival, 11–54% of maize production has been lost annually [4, 14, 38]. FAW can cause a 100% yield loss due to its unforeseen occurrence from the seedling to the cob formation stage [20]. Synthetic chemical insecticides are widely used as a main method of control [18, 19, 26]. However, users are not always satisfied; especially in Ethiopia, 60% of farmers believed insecticides were ineffective due to inappropriate handling [22]. Pesticides may fail to work due to improper use, such as incorrect application rate, wrong dosage, or application after damage has occurred; or the pesticide itself may be ineffective due to fake labeling or adulteration, both of which are thought to be frequent [41].

Objective:

To evaluate the efficacy of BAYECURE (Fipronil 5% SC) and Karate 5% EC (lambda-cyhalothrin) insecticides against Fall Armyworm (Spodoptera frugiperda) in controlling yield and yield components of Maize (Zea mays L.)

2. Materials and Methods

2.1. Study Area Selection and Description

This evaluation was conducted in the East Gurage Zone of Central Ethiopia during the sub-growing season of maize in the 2025-2026 crop growing season, with supplementary irrigation in the Central Ethiopia regional state in the East Gurage Zone at Meskan and South Sodo districts from October to February. Geographically, the experimental area of Meskan district is at 2200 masl with a mean temperature of 15 ℃-25 ℃, while South Sodo district is located at 1900 masl with a mean temperature of 20 ℃-28 ℃.

2.2. Experimental Treatments and Design

The trial was implemented using an RCBD design with three replications. Each of the nine treatments was planted in a 4 m × 4 m plot. The total area of the trial site was 120.25 m^2 per location. To reduce inter-plot effects, the gangway distance within plots and within blocks was 1.5 m. The inter- and intra-row spacing was 75 cm by 25 cm.

Table 1. *Descriptions of insecticides used in the study.*

No.	Trade name	Common name	A. I	Application rate/Ha		Manufacturer
				Insecticide	water	
1	BAYECURE	Fipronil 5% SC	5% SC	450-750ml/ha	500lha^{-1}	Synwill Co.., Ltd China
2	Karate 5 EC	lambda-cyhalothrin	5% EC	320ml	500l ha^{-1}	Syngenta
3	Control (Untreated)	-	-	-	-	-

To evaluate the performance of both insecticides, Fipronil 5% SC (BAYECURE) 450 ml/ha and Karate 5%EC (lambda-cyhalothrin) 320 ml/ha were diluted in 500 L ha-1 of water.

2.3. Experimental Materials and Procedures

To assess insecticide effectiveness, the commonly used susceptible check maize variety BH546 for Fall Armyworm was used. The fields were plowed with oxen and harrowed manually to achieve fine tilth. Fertilizer NPS at 150 kg/ha was applied at sowing, and urea at 100 kg/ha was applied in split doses. The experiment consisted of three treatments (Table 1): unregistered insecticides; Fipronil 5% SC (BAYECURE) at 450 mL/ha, diluted with 500 mL/ha of water; the standard check or registered insecticide, Karate 5% EC (lambda-cyhalothrin) at 320 mL/ha, diluted with 500 L/ha of water; and an untreated check served as the control treatment. Each insecticide was applied twice, and efficacy was assessed after a fifteen-day interval. During the experiment, the experimental site was irrigated three times a week to reduce moisture deficit and support proper crop growth.

Data Management methods

1) After the emergence of maize in the field, the status of fall armyworm larvae was collected within a week before insecticide application.
2) After each insecticide spray, all insect data were collected. Live fall armyworm larvae, the number of infested plants per plot, and other insects (which might be natural enemies) were counted. The extent of leaf damage was measured using the [12] leaf damage score (1-9). Yield was measured from the net plot area.
3) Fall armyworm incidence was taken from the net plots at weekly intervals

$$\text{FAW infestation } \% = \frac{\text{Number of FAW-infested plants}}{\text{Total number of plants observed}} \text{ X } 100$$

Larval reduction was collected after the application of insecticide three times

Larval reduction was calculated using the following formula.

$$\text{Larval reduction} = \frac{\text{Mean of untreated} - \text{Mean of treated}}{\text{Mean of untreated}} \text{ X } 100$$

Grain yield

Grain yield was determined from central rows from each plot by avoiding the border effects and then converted to yield in terms of t ha^{-1}.

Relative yield increment (%)

Grain yield was calculated as the difference between mean yields of protected plots and unprotected plots of the respective variety. Losses were calculated separately for each of the treatments using the formula developed by [40]:

$$RLY\% = \frac{(Y1-Y2)\times 100}{Y2}$$

Where RYL = Relative yield loss; Y1 = mean yield of protected plots (plot with maximum protection). Y2 = Mean yield of unprotected plots (unsprayed plots).

The harvest index and yield loss were also calculated. The harvest index was calculated using the formula

$$\text{HI\%} = \frac{\text{Grain yield}}{\text{Totala boveround drybiomass}} \text{ X } 100$$

Plant damage parameters: Plant and cob damage percentages were visually assessed during the vegetative stage by counting healthy and damaged plants across all treatments.

Foliar and cob damage were scored by visual observation using the scoring scale of 1-9 reported by [12], described below

Table 2. *Fall armyworm (Spodoptera frugiperda) damage scoring scale (1-9).*

Scale	Description	Host reaction
1	No visible leaf feeding damage	Highly resistant (RH)
2	Few pinholes on older leaves	Resistant (R)
3	Several shot-hole injuries on a few leaves	Resistant (R)
4	Several shot-hole injuries common on several leaves or small lesions	Moderately resistant (MR)
5	Elongated lesions (> 2 cm long) on a few leaves	Moderately resistant (MR)
6	Elongated lesions on several leaves	Susceptible (S)
7	Several leaves with elongated lesions or tattering	Susceptible (S)
8	Most leaves with elongated lesions or severe tattering	Highly susceptible (HS)
9	Plant dying as a result of foliar damage	Highly susceptible (HS)

Pest incidence percentage was calculated by dividing the number of infested plants by the total number of plants and multiplying the result by 100.

2.5. Data Analysis

The collected data were subjected to one-way ANOVA using the SAS software version 9.4 PROG GLM procedure [42]. The means were compared using the LSD test ($p < 0.05$). Correlation analyses were performed using the SAS software PROC CORR procedure.

3. Results and Discussions

3.1. Occurrence of Fall Armyworm (*Spodoptera Frugiperda*) Larvae and Their Incidence Before and After Insecticide Application

Before insecticide application, fall armyworm was present at the knee stage of the crops at 10 DAS of maize, with non-significant ($P < 0.05$) levels at both research sites (Table 3). This may be because pupae were present in the previous crop residue. The result aligns with Ghana et al. (2024). The incidence of leaf injury and foliar damage due to natural infestation by fall armyworm was recorded at the knee-high stage (25 DAS) and before the tasseling stage (45 DAS) after treatment application. [6] reported that over 50% of infestations occur at the early whorl stage.

Application of Fipronil 5% SC (BAYECURE) and Karate 5% EC (lambda-cyhalothrin) significantly ($P \leq 0.01$) reduced the occurrence of fall armyworm larvae. The highest number of larvae was recorded in the control plots, 7.33 and 7.5 in Meskan and South Sodo woreda, respectively, whereas the lowest numbers were recorded in the treated plots of Fipronil 5% SC (BAYECURE) and Karate 5% EC, 3.98 and 3.9 in Meskan district and 4.59 and 4.95 in South Sodo district (Table 1). The assessment showed that applying both Fipronil 5% SC (BAYECURE) and Karate 5% EC at the first and second treatments, at the specified frequency, significantly reduced the number of larvae in both locations (Table 3). The result is in line with [25], where insecticide application significantly reduced plant damage compared to the untreated control at all stages of plant growth. Similarly, [6, 8] reported that timing, method of pesticide application, and correct dosages are crucial for the effective control of FAW. [34] found that application is effective when spraying starts early and coincides with the early to mid-vegetative growth stages. [31] found that spraying at the early stages significantly reduces FAW infestation, defoliation, and larval abundance, which may otherwise affect crop productivity. [34] reported that a minimum of two rounds of spray with an insecticide (synthetic or biopesticide) adequately protected the crop against FAW. Kumar and Mohan (2020) reported that insecticides sprayed two times at a 14-day interval would effectively control FAW.

Table 3. Effect of Fipronil 5% SC and Karate 5%EC insecticide on the occurrence and management of fall armyworm on maize in Meskan and South Sodo districts during the 2025/2026 cropping season.

	Number of observed larvae/ plant at Meskan district				Number of observed larvae/ plant at South Sodo district			
Treatments	**Number of Larvae Before treatment**	**number of larvae after 1st treatment**	**Number of Larvae After2nd treatment**	**Average of 1st and 2nd larvae after treatment**	**Number larvae Before treatment**	**Number Larvae After 1st treatment**	**Number Larvae after 2nd treatment**	**average of f1st and 2nd larvae after treatment**
Karate 5% EC	3.3	4.8b	3.03b	3.9b	3.6	5b	3.5b	4.25b
Control	3.1	6.9a	7.75a	7.33a	3.6	6.9a	8.3a	7.5a
CV	14.8	10.8	15.8	9.6	14.2	11.57	8.6	10.28
LSD	0.35	0.22	0.6	0.97	0.35	1.5	0.99	0.65
P≤ value	NS	***	***	**	NS	*	***	***

Means followed by the same letter within a column are not significantly different

3.2. Effect of Insecticide on Number of Fall Armyworm Larvae

Application of BAYECURE (Fipronil 5% SC) and Karate 5%EC (lambda-cyhalothrin) reduced the number of fall armyworm larvae by 46.8% and 45.7% in Meskan district and by 38.8% and 43.33% in South Sodo district, compared with the control plots (Table 4). These results align with [46], who reported that application of chlorantraniliprole significantly reduced FAW populations in maize fields. [21] recorded a reduced larval population in treated plots.

Table 4. Effect of insecticide on the number of fall armyworm reduction.

	Meskan District		South Sodo districts	
Treatment	**Number of Larvae**	**% number of larvae reduction**	**Number of Larvae**	**% number of larvae reduction**
Karate 5%EC	3.9	46.8%	4.25	43.33
Fipronil 5%SC	3.98	45.7	4.59	38.8
Control (Untreated)	7.33	-	7.5	-

3.3. Effect of Insecticides on Areas of Leaf Damage

Application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) significantly (P≤ 0.001) reduced the percentage of leaf damage per plant. The highest levels of leaf damage were recorded in the control plots, at 6.1% and 6.67% in Meskan and South Sodo districts, respectively. The lowest leaf area damage was observed with the application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin), at 3.6% and 3.85% in Meskan and 3.76% and 3.57% in South Sodo, respectively (Table 5). According to [12], maize leaf damage greater than 6% is considered susceptible or high level of damage, and damage less than 3% is considered a lower level of damage. Application of insecticide at the tested frequency significantly reduces the area of maize leaf damage. The result agrees with [13], who reported that poison baits prepared with spinetoram (5 ml/kg of rice bran mixed with 10% jaggery) resulted in maximum larval mortality and minimized leaf damage caused by fall armyworm. [33] reported that leaf injury in insecticide-treated maize plants was lower compared to the untreated control plots.

Table 5. *Effect of Fipronil 5% SC and Karate 5%EC insecticide on the level of maize leaf damage and management of fall armyworm on the maize field at Meskan and South Sodo district during the 2025/2026 cropping season.*

	Levels (%) of leaf damage % at Meskan				Levels (%) of leaf damage % at South Sodo			
Treatments	**% of leaf damage Before insecticide application**	**% of leaf damage after 1st Round insecticide Application**	**% of Leaf damage 2nd round insecticide application**	**% of first and 2nd round insecticide application**	**%of leaf damage Before insecticide application**	**% of leaf damage after first round application**	**% of Leaf Damage after 2nd Round application**	**Average of 1st and 2nd Round application**
Karate5%EC	5.1	4.2b	3.5b	3.85b	5.6a	4.5b	3.67	3.57b
Fipronil5%SC	4.8	4.1b	3.1b	3.6b	5.25b	4c	4.4b	3.76b
Control	5.6	5.7a	6.3a	6.1a	5.25b	5.5a	6.52a	6.67a
CV	12.8	11	8.3	9.5	12.7	13.8	8.4	15.4
LSD	1.4	1.15	0.8	0.97	0.34	0.4	0.92	0.53
P≤	NS	*	***	**	*	**	**	***

Means followed by the same letter within a column are not significantly different

3.4. Effect of Insecticide on the Reduction of Leaf Damage

The application of Fipronil 5% SC (BAYECURE) and Karate 5% EC (lambda-cyhalothrin) significantly reduced leaf damage caused by the Fall armyworm at both locations. In Meskan district, leaf damage was reduced by 36.9% and 41%, while in South Sodo district, leaf injury was reduced by 46.5% and 43.6% compared with the control plots (Table 6). These results align with [30], which reports that FAW primarily causes direct damage by feeding on leaves, leading to defoliation, and occasionally attacks developing maize ears. [11] reported that intensive feeding by FAW larvae during the growth of the maize plant may cause structural damage to the leaf whorl, significant loss of photosynthetic area, impaired reproduction, direct damage to grain, and lodging. [9] observed that leaf damage due to FAW in untreated maize was 80% higher than in insecticide-treated crops. On the other hand, [27] reported that leaf damage in the untreated crop was 2x higher than in the treated maize, resulting in a yield loss of more than 30%.

Table 6. *Effect of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) insecticide on the level of leaf damage by fall armyworm larvae reduction.*

Meskan District		**South Sodo districts**		
Treatment	**Average leaf severity damage %**	**% of Leaf injury damage reduction**	**Average leaf severity damage %**	**% of Leaf severity damage reduction by %**
Karate 5%EC	3.85	36.9	3.57	46.5
Fipronil 5%SC	3.6	41	3.76	43.6
Control	6.1	-	6.67	-

3.5. Effect of Insecticide on the Plant Height

The application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) insecticides had a significant effect (P≤ 0.001) on plant growth. The lowest plant heights were recorded in untreated plots, 179 cm and 193 cm at Meskan and South Sodo districts, respectively. The highest plant heights were recorded in treated plots, 206.7 cm and 195.7 cm at Meskan and 217 cm and 213.87 cm at South Sodo District (Table 7). Plant height varied between treated and untreated plots. This may reflect the effects of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) and of fall armyworm.

Table 7. *Effect of Fipronil 5%SC and Karate 5%EC insecticides on plant height, cob incidence, cob severity, and fall armyworm management in the maize field in the Meskan and South Sodo districts during the 2025/2026 cropping season.*

	Meskan district			South Sodo district		
Treatments	**Plant height (cm)**	**Infected cob Incidence %**	**Damaged cob Severity %**	**Plant height (cm)**	**Infected cob Incidence %**	**Damaged cob Severity %**
Karate 5%EC	195.7a	25b	2.1b	213.87a	25.33b	1.9b
Fipronil 5%SC	206.7a	26.6b	2.06b	217a	27.33b	1.91b
Control	170b	87a	7.17a	193b	83a	7.67a
CV	14.2	12.5	13.6	10.47	41.5	12.3
LSD	17.9	4.34	1.5	5.12	5.97	0.2
P≤	***	***	***	***	***	***

Means followed by the same letter within a column are not significantly different

3.5. Effect of Insecticides on Cobs Incidence

The application of BAYECURE (Fipronil 5% SC) and Karate 5% EC had a highly significant effect on plant growth at both locations (P≤ 0.001). However, at both locations, the application of Fipronil 5% SC and Karate 5% EC was not significant (P≤ 0.05). The lowest cob incidence was recorded with Karate 5% EC and Fipronil 5% SC, at 25% and 26.6% in Meskan district, respectively (Table 7).

In South Sodo district, the lowest cob incidence was recorded in plots treated with Karate 5%EC (lambda-cyhalothrin) and Fipronil 5% SC (BAYECURE), at 25.33% and 27.33%, respectively (Table 7). Application of Fipronil 5% SC (BAYECURE) and Karate 5%EC insecticide significantly reduced cob incidence in treated plots compared with untreated plots. The result is in line with [33], which reported that insecticide-treated maize effectively lowered FAW cob infestation.

3.6. Effect of Insecticides on Cobs Severity

The application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) had a highly significant effect on plant growth in both locations (P≤ 0.001). However, in both locations, the application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) was not significant (P≤ 0.05). The lowest cob severity recorded in the treated plots was 2.1% with Karate 5%EC (lambda-cyhalothrin) and 2.06% with Fipronil 5% SC (BAYECURE) in the Meskan district, whereas 1.9% with Karate 5%EC and 1.91% with Fipronil 5% SC in the South District (Table 7). Application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) significantly reduced cob severity in the treated plots compared with untreated plots. According to [12], cob injury: cobs with leaf damage greater than 6% are susceptible or have a high level of damage, and less than 3% is a lower level of cob damage. The results are in line with [17], which reported that when a pesticide (synthetic or biopesticide) is applied, the treated maize has a low ear rot infection.

3.7. Effect of Insecticide on Above-ground Biomass and Harvesting Index of maize

The application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) had a highly significant effect (P≤ 0.001) on the above-ground biomass of maize crops in both locations. In both locations, the application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) was not significant (P≤ 0.05) for the ground biomass of maize. The higher ground biomass was recorded at 6566.7 Kgha-1 in Karate 5%EC (lambda-cyhalothrin) and 6523.3 Kgha-1 in

Fipronil 5% SC (BAYECURE) at Meskan, and 6550 Kgha-1 in Karate 5%EC (lambda-cyhalothrin) and 5756.67 Kgha-1 in Fipronil 5%SC (BAYECURE) at South Sodo district. By contrast, the lower above-ground biomass was recorded in the untreated plots, at 3316.67 Kgha-1 and 4556 Kgha-1 in Meskan and South Sodo districts, respectively. Application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) significantly increased the above-ground biomass of maize compared with untreated plots (Table 8). This may be because fall armyworm affects the above-ground biomass of maize in both locations.

Application of insecticide increased the harvesting index by 68.7% with Karate 5%EC (lambda-cyhalothrin) and 67.7% with Fipronil 5%SC (BAYECURE) in Meskan District, while 72.2% with Karate 5%EC and 69.33% with Fipronil 5%SC (BAYECURE). Whereas the lower harvesting index was recorded from the untreated plots, which is 41.3% and 28.8% in Meskan and South Sodo districts (Table 8).

3.8. Effect of Insecticide on the Yield and Yield Increment of Maize

The application of Karate 5%EC (lambda-cyhalothrin) and Fipronil 5% SC (BAYECURE) insecticides was highly significant (P≤ 0.01) in both Meskan and South Sodo districts. In both locations, the application of Fipronil 5% SC (BAYECURE) and Karate 5%EC (lambda-cyhalothrin) was not significant (P≤ 0.05) for maize grain yield. The higher grain yields were harvested from the treated plots, with 4496.7 kg ha-1 from Karate 5%EC (lambda-cyhalothrin) and 4416.7 kg ha-1 from Fipronil 5%SC (BAYECURE) at Meskan District, and 4730 kg ha-1 from Karate 5%EC and 4683.33 kg ha-1 from Fipronil 5%SC at South Sodo District (Table 8). Untreated plots had lower grain yields, which may be due to the effects of fall armyworm. The results are in line with [25], which reported that reducing fall armyworm infestation through effective insecticides increased maize grain yield. Similarly, [43] reported higher yields in Spinosad- and spinetoram-treated maize fields. [36] found higher maize yields in treated plots. [39] recorded a grain yield of 5063 kg/ha in protected plots, compared to 3394 kg/ha in unprotected plots. On the other hand, [27] concluded that FAW defoliation as high as 70% at the 12-leaf stage causes a 15% grain yield loss. [33] reported that high grain yields were obtained from plants treated with synthetic insecticides compared to biopesticides and untreated controls.

Compared with untreated plots, Karate 5%EC (lambda-cyhalothrin) increased yield by 69.65% and Fipronil 5% SC (BAYECURE) by 67.7% in Meskan District, while in South Sodo District yields increased by 72.2% with Karate 5%EC and by 71.9% with Fipronil 5%SC (Table 8). Kumar et al. (2022) reported that mean densities of 0.2 to 0.8 larvae per plant during the late whorl stage can reduce maize productivity by 5 to 20%. Given the average larval densities of 0.62–2.06 per plant observed in untreated maize, it is likely to have suffered a >50% reduction in productivity. [27] reported that FAW defoliation as high as 70% at the 12-leaf stage causes a 15% grain yield loss. Similarly, [33] reported that insecticide-treated maize increased yield by 10 to 30% more than the untreated control. [34] reported an increase in grain yields of at least 1.7-fold in maize sprayed three times compared with the untreated control. According to [21], grain yield in insecticide-treated maize was 14.6 to 64.8% higher than in the untreated control. The yield was nevertheless influenced by the type of insecticide used.

Table 8. *Effect of Fipronil 5%SC and Karate 5%EC insecticides on the yield and yield attributes of maize at Meskan and South Sodo during the 2025/2026 cropping season.*

	Meskan district				South Sodo district			
Treatments	**Above ground bio mass (Kgha^{-1})**	**Grain yield (Kg ha^{-1})**	**Harvesting Index %**	**Yield Increment against to untreated Experiment %**	**Above ground bio mass (Kgha^{-1})**	**Grain yield Kg ha^{-1})**	**Harvesting index %**	**Yield increment against to untreated Experiment %**
Karate5%EC	6566.7a	4496.7a	68.70%	69.65%	6550b	4730a	72.00%	72.2
Fipronil 5%sc	6523.3a	4416.7a	67.70%	69.10%	5756.67a	4683.33a	69.33%	71.9%
Control	3316.67b	1366.67b	41.3%	—	4556c	1316.67b	28.8	—
CV	13.05	7.5	7.5	-	10.9	13.74	13.77	
LSD	377.94	586.71	10.136	-	129.79	304	4.8577	
P≤	***	**	**		***	***	***	

3.9. Effect of Fall Armyworm on the Cob Injury and Cob Severity of Maize

The occurrence and invasion of fall armyworm were reduced through insecticide use to increase maize yields in the growing areas. Among the insecticides, Karate 5%EC (lambda-cyhalothrin) and Fipronil 5%SC (BAYECURE) were effective in controlling fall armyworm. In Meskan district, Karate 5%EC (lambda-cyhalothrin) reduced the occurrence of fall armyworm and increased the yield of marketable cobs by 71.3% in cobs injury incidence and cobs severity, and increased marketable cobs by 70.7%. Equivalently, Fipronil 5%SC (BAYECURE) reduced the occurrence of fall armyworm larvae and increased the yield of maize by 70.12%, and reduced cobs injury and cobs severity by 71.3% (Table 9).

In South Sodo district, Karate 5%EC (lambda-cyhalothrin) reduced the occurrence of cobs infection and increased the yield of marketable cobs by 69.5%, while reducing cobs infection severity by 75.5%. Similarly, Fipronil 5% SC (BAYECURE) reduced cobs incidence by 67.2% and cobs severity by 71.3% (Table 9). Based on these results, both Karate 5%EC (lambda-cyhalothrin) and Fipronil 5% SC (BAYECURE) provide rapid knockdown of fall armyworm, offer non-residual activity, and enhance overall control of fall armyworm and other insect pests in maize crop production in both locations.

Table 9. *Efficacy of Insecticide on the level of cob incidence and severity level.*

Meskan District					**South Sodo districts**			
Treatment	**Incidence in%**	**% cob reduction**	**Severity of cob**	**Efficacy**	**Incidence in %**	**% Reduction**	**Severity %**	**Efficacy**
Karate 5%EC	25	71.3	2.1	70.7	25.33	69.5	1.9	75.3
Fipronil 5%SC	26	70..12	2.06	71.3	27.33	67.2	1.91	75.1
Control	87	-	7.17	-	83	-	7.67	-

3.10. Correlation Analysis Among the Effects of Fall Armyworm Larvae and Yield and Yield Components of Maize

A highly positive correlation was recorded between the average number of larvae per plant before insecticide application and the averages of first- and second-leaf damage levels, cob incidence, and cob severity. Plant height was positively correlated with above-ground biomass and the harvesting index. A negative correlation was recorded between the average after insecticide application of first- and second-leaf damage, cob incidence, cob severity, plant height, above-ground biomass, grain yield, and the harvesting index. Average leaf damage was negatively correlated with plant height, above-ground biomass, and grain yield. Cob incidence was negatively correlated with the harvesting index, above-ground biomass, and grain yield. Fall armyworm larvae were negatively correlated with cob severity, plant height, above-ground biomass, and grain yield. Plant height was negatively correlated with the harvesting index, and above-ground biomass was negatively correlated with the harvesting index (Table 10).

Table 10. *Correlation analysis of Maize among the number of observed fall armyworm larvae, leaf damage, cob injury, cob severity, plant height, above-ground biomass, harvesting index, and grain yield of maize.*

	D1NO	**N2N3 Ava.**	**DS1**	**S2S3ava**	**C. Incidence**	**C. Severity**	**Plant height**	**AGBM**	**Grain yield**	**HI**
D1NO	1									
N2N3ava	0.55ns	1								
DS1	0.33ns	0.58*	1							
S2S3ava.	0.61*	0.91***	0.75**	1						
C. incidence	0.54ns	0.69**	0.18ns	0.31ns	1					

	D1NO	N2N3 Ava.	DS1	S2S3ava	C. Incidence	C. Severity	Plant height	AGBM	Grain yield	HI
C, severity	0.53ns	0.77**	0.33ns	0.56ns	-0.55ns	1				
Plant height	-0.53ns	-0.79***	-0.35ns	-0.58***	0.51	-0.99***	1			
AGBM	-0.58ns	-0.934***	-0.48ns	-0.78**	-0.55*	-0.94***	0.96***	1		
Grain yield	-0.58)	-0.85**	-0.57ns	-0.93***	-0.56*	-0.36ns	0.41ns	0.64*	1	
HI	-0.52ns	-0.74**	0.32ns	0.53ns	-0.59*	0.99***	-0.99***	-0.93***	52*	1

Key: D1NO, Number of observed larvae before insecticide application; N2N3Ave., average number of observed larvae after the first and second treatment; DS1. Level of leaf damage before insecticide application, S2S3Ave., Average of leaf damage after first and second insecticide application, C. incidence, cobs incidence, C. Severity, Cobs severity, AGBM., above-ground biomass, HI., Harvesting index

4. Conclusion and Recommendations

This experiment was conducted during the sub-growing stage of maize in the 2025-2026 crop growing season under supplementary irrigation in the Central Ethiopia Regional State, Esat Gurage Zone, in Meskan and South Sodo districts. Geographically, the experimental area of Meskan district is at 2200 masl with a mean temperature of 15 ℃-25 ℃, while South Sodo district is located at 1900 masl with a mean temperature of 20 ℃-28 ℃.

This experiment was conducted to evaluate the performance of Fipronil 5% SC (BAYECURE), an unregistered insecticide, compared with Karate 5% EC (lambda-cyhalothrin), a registered insecticide, and a standard check. During the experiment, the following data were collected at both locations, including the number of observed larvae per plant before and after insecticide application, the rate of leaf damage before and after insecticide application, plant height, cob incidence, the rate of cob infection, ground biomass, harvesting index, and grain yield of maize. To evaluate the efficacy of the insecticides, both were diluted in 500 l ha-1 of water at rates of 450 ml/ha for Fipronil 5% SC and 320 ml/ha for Karate 5% EC.

In both locations, the application of Fipronil 5% SC (BAYECURE) at 450ml/ha and Karate 5%EC (lambda-cyhalothrin) at 320ml/ha significantly ($P \leq 0.01$) reduced the occurrence and leaf damage, cob incidence, and cob severity, and increased plant height (cm), ground biomass (kg ha-1), harvest index (%), and grain yield, thereby improving maize yield and yield components.

In Meskan district, application of Fipronil 5% SC (BAYECURE) at 450ml/ha reduced the number of observed larvae by 45.7%, leaf damage by 41%, cob injury by 70.12%, and cob severity by 71.3%, and increased the yield and yield components of maize by 69.1% as compared to untreated plots. Plant height (206.7cm), ground biomass (6523.3kgha-1), harvesting index (67.7%), and maize grain yield (4416.7 (Kgha-1)) were recorded with Fipronil 5%SC (BAYECURE) application. In Karate 5%EC (lambda-cyhalothrin) 320ml/ha-treated plots, the number of observed larvae was reduced by 36.9%, leaf damage by 36.9%, cob injury by 71.3%, and cob severity by 70.7%, and the yield and yield components of maize increased by 69.65% as compared to untreated plots. Plant height (195.7cm), ground biomass (6566.7kgha-1), harvesting index (68.7%), and maize grain yield (4496.7(Kgha-1)) were recorded from Karate 5%EC (lambda-cyhalothrin) treated plots, whereas untreated plots recorded higher larvae number (7.33), leaf damage (6.1%), cob injury (87), cob severity (7.17%), and lower plant height (170cm), ground biomass (3316.67kgha-1), harvesting index (41.3%), and maize grain yield (1366.67b (Kgha-1)).

In South Sodo district, application of Fipronil 5% SC (BAYECURE) at 450ml/ha reduced the number of observed larvae by 38.3%, leaf damage by 43.6%, cob injury by 67.2%, and cob severity by 75.1%, and increased maize yield and yield components by 71.9% compared with untreated plots. The higher plant height (217cm), ground biomass (kgha-1), harvesting index (67.7%), and maize grain yield (4416.7 (Kgha-1)) were recorded with Fipronil 5% SC application. In Karate 5%EC (lambda-cyhalothrin) 320ml/ha-treated plots, the number of observed larvae was reduced by 36.9%, leaf damage by 36.9%, cob injury by 71.3%, and cob severity by 70.7%, and maize yield and yield components increased by 69.65% compared with untreated plots. Plant height (195.7cm), ground biomass (5756.67kgha-1), harvesting index (67.7%), and maize grain yield (4416.7a (Kgha-1)) were recorded from Karate 5%EC (lambda-cyhalothrin)-treated plots, whereas untreated plots recorded a higher number of observed larvae (7.5), leaf damage (6.67%), cob injury (83), cob severity (7.67%), and lower plant height (193cm), ground biomass (4556kgha-1), harvesting index (28.8%), and maize grain yield (1316.67(Kgha-1)).

Research indicates that insecticide application significantly reduced the occurrence of fall armyworm (Spodoptera frugiperda) larvae and leaf damage, cob incidence, and cob severity, while increasing maize yield and yield components. Therefore, applying Fipronil 5% SC (BAYECURE) at 450 mL/ha and Karate 5% EC (lambda-cyhalothrin) at a dilution of 500 L/ha with water, at a two-week interval, combined with frequent

irrigation and good agronomic practices, is effective for controlling fall armyworm (Spodoptera frugiperda) in Ethiopia.

Abbreviations

FAW	Fall Armyworm
EC	Emulsifiable Concentration

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Author Contributions

Ashenafi Mitiku: Formal Analysis, Investigation, Project administration, Writing – original draft, Writing – review & editing

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Data Availability Statement

The data supporting this study's findings are available and can be requested from the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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