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Survey and Management of Fall Armyworm (*Spodoptera Frugiperda* JE, Smith) on Maize (*Zea Mays* L.), Ethiopia

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ABSTRACT

Maize is the most important crop in Ethiopia. However, its production is minimal due to several obstacles, mainly insects such as armyworms. The research was initiated to assess the prevalence and manage the fall armyworm using varieties and insecticides in the Dera district, Ethiopia. The assessment was conducted in four potential Kebeles. SPSS was used to evaluate data. For the experiment, a factorial arrangement with a combination of four synthetic insecticides (Dimeto 40% EC, Karate 5%, Agrolambsin supper 315, and Malathion 50%) with control and three maize varieties (BH-540, BH-546, and local) were laid out in a randomized complete block design with three replications. Data on pest, vegetative, and yield-related parameters were collected and analyzed using SAS. The result showed a prevalence of 72.92% and infestation of 30.69%. The main effects of insecticide and variety affect most of the vegetative, pest, and yield-related parameters. The harvest index, plant height, ear length, grain yield, and insecticide-variety interaction effect are all impacted. The application of Agrolambsin supper 315 to BH-546 variety resulted in the highest plant height, ear length, and grain yield; on the other hand, the main effects of insecticide application (Agrolambsin supper 315) and varieties (BH-546) demonstrated the maximum number of ears per plant, number of green leaves per plant, and biomass yield. Even though armyworms considerably impacted every variety of maize examined in this investigation, yield loss may be minimized by using BH-546 in combination with Agrolambsin supper 315 spraying.

Keywords: Infestation, Insecticides, Maize varieties, Pest, Yield.

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INTRODUCTION

844 million tons of maize (*Zea mays* L.) are grown annually on 162 million hectares throughout more than 180 nations. Regarded by the Food and Agriculture Organization (FAO) [1] as one of the most significant cereal crops in Africa, it is grown on 40 million hectares, mostly in smallholder settings, and yields around 81 million tons of grain. The most productive crop, maize, makes a substantial contribution to Ethiopia's economic and social advancement.

The Amhara National Regional State is one of the major maize-growing regions of the country. Its land coverage in the region during the 2019/2020 Production year was 532,483.26 ha with a total annual production of 2,275,120.81 tons and productivity of 4.27 t ha^{-1} [2]. Similarly, South Gondar has the potential for maize production. Its coverage during the 2019/2020 Production year was 57,308.9ha with a total annual production of 220,856.77 tons and productivity of 3.84 t ha^{-1} [2]. However, maize productivity is low due to several constraints: biotic (pests and diseases), abiotic, and socio-economic. Among these insects are the most important factors [3].

The autumn armyworm is a significant biotic restriction that negatively affects maize yield. Tropical and subtropical parts of the Americas are home to the autumn armyworm (*Spodoptera frugiperda* J.E. Smith) (Lepidoptera: Noctuidae)

[1]. It appears that one of the most destructive insect pests imported into Africa in the twenty-first century is the fall armyworm. By 2018, the fall armyworm had been identified in nearly all of Sub-Saharan Africa (except Lesotho, Djibouti, and Eritrea), as well as the Indian Ocean Island nations of Mauritius and the Seychelles. It was initially discovered in Central and West Africa in early 2016 [4].

More than 80 different plant species are suitable food sources for autumn armyworm larvae, such as cotton, rice, sorghum, millet, sugarcane, and vegetable crops. The plant is harmed by fall armyworm larvae because they eat the leaves. As a fall armyworm's characteristic damage sign, holes in leaves are made by young larvae, which primarily feed on epidermal leaf tissue. A dead heart is produced when young plants are fed through the whorl. Larger larvae in whorls on older plants may feed on kernels or cobs of maize, lowering yield and quality [5].

The fall armyworm was introduced in Ethiopia in 2017, and due to favorable environmental conditions and rapid reproductive behavior, it has now been present in eight of Ethiopia's nine regions, reaching up to five generations in the southern part of the country. In the absence of effective and timely management, in Ethiopia, fall armyworm is estimated to cause up to 30% of loss in maize production [6]. About 411 districts, totaling more than 500,000 hectares of land, have been affected by the autumn armyworm infestation. Since they first surfaced in 2017, the bugs have devoured a fourth of the 2.6 million hectares of maize-planting land. Re-infestations and fresh infestations provide significant challenges to pest management. Starting in the south and traveling more than a thousand kilometers to the north, the migratory path passes through areas that are used to raise maize [7].

Since autumn armyworms first appeared in African nations, synthetic pesticides have been often employed as a last resort to reduce damage to maize fields and prevent the pest's growth. There is at present no approved synthetic pesticide for controlling autumn armyworms in African nations, except for treatments permitted under an emergency label. This indicates that screening for synthetic insecticides is desperately needed. Farmers have expressed dissatisfaction over the present synthetic pesticides' inability to effectively prevent the autumn armyworm from damaging their maize crops. They must thus apply large dosages of pesticides often, which will cause the environment to become overstocked with pesticides and hasten the emergence of resistance [8]. Thus, this investigation aimed to assess artificial pesticides' effectiveness against fall armyworms on several types of maize grown in the research location.

MATERIALS AND METHODS

Field survey

Description of the survey area

A field survey was conducted in the Dera district, south Gondar administrative zone of the Amhara National Regional State, during the 2020 main cropping season. Dera district is bordered on the southeast by Abay River, on the west by Lake Tana, on the north by Fogera district, and the east by Estie district. It is located at 11°37′11″N and 37°22′37″E in Ethiopia. It is 47 km south of the regional administrative city Bahir Dar and 607 km northwest of the national capital, Addis Ababa. The total area of the district is estimated to be 149,724 hectares. It is divided into 36 rural *kebele* (lower administrative units) administrations **(Figure 1)** [9].

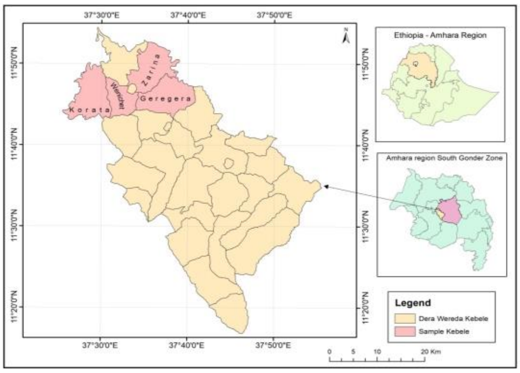

Figure 1. Map of the study area

Survey sampling techniques and size

The study kebele administrations were specifically chosen based on reports of autumn armyworm incidence, the potential for maize production, and the presence of insect pests. In the district, four *kebele* administrations were considered, namely: *Geregera*, *Zara*, *Wonichet,* and *Korata*. In each *kebele* using Yamane's study, the sample size was calculated at a 95% confidence level and P = 0.05. Farmers/farms/

were randomly selected [10]. A Total of 1,006 farmer fields were assessed by randomly traveling along the roadside in the area [11] in each selected *kebele* administration. From May to July of 2020, surveys were conducted. Selected farm families in the examined regions were asked to complete a semi-structured questionnaire that sought information on their socioeconomic profiles, farm characteristics, knowledge, and attitudes regarding the autumn armyworm, the pest's incidence, and management strategies for controlling it.

In each farmer field, the assessment was done by using a Quadrant per field 3.2 m × 4 m = 12.8 m^2 and by walking diagonally using an "X" fashion and then those plants in the Quadrant counted as damaged and non-damaged plants. The sample size was determined by using Yamane's formula as Eq. 1 as follows [10]:

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

Where n is the sample size, N is the population size, and e is the level of precision.

Data collection and analysis

Prevalence: The presence or absence of insects was scored from 1,006 fields of four kebele administrations. Considering Eq. 2 as follows:

$$\text{Prevalence (\%)} = \frac{\text{Number fields exhibited the insects}}{\text{Total number of examined fields}} \times 100 \quad (2)$$

Infestation: From 1,006 farmers' fields 741 fields (pest occurred) were selected for infestation assessment, infested plants per quadrant sample (3.2 m × 4 m), and three times from each field were scored for each *kebele* administration. A plant-showing symptom was collected from the 741 fields assessed and an infected plant collected samples were taken from all plant parts [12]. Considering Eq. 3 as follows:

$$\text{FAW infestation (\%)} = \frac{\text{Number of infested plants}}{\text{Total number of plants assessed}} \times 100 \quad (3)$$

Survey data were summarized, and descriptive statistics (means and percentages) were calculated using the Statistical Package for Social Sciences (SPSS).

Field experiment

Description of the experimental site

The experiment was conducted at the *Geregera* kebele administration farmers' training center site located at 11°75′93″ N and 37°60′06″ E **(Figure 1)**. The altitude of the site is 1500 meters above sea level with Woyna Dega (mid-land) agroecology and red sandy soil type. The rainfall distribution is uni-modal. The main rain season is from May to September, which has an average of 1300 mm annual rainfall with an average temperature of 18 C°. The major crops produced are maize, finger millet, and *tef* [9].

Treatments, experimental design, and procedures

A randomized complete block design (RCBD) with three replications was used to set up the control plots and unsprayed plots. The four synthetic insecticide types—Dimethoate 40% EC, Karate 5% EC, Agrolambasin 315%, and Malathion 50% EC—and the three varieties of maize—BH 540, BH 546, and local variety—were combined in a factorial fashion. Following the design parameters, a field plan was created, and each treatment was allocated to experimental plots within a block at random using a lottery system. The plot was three meters by four meters (12 square meters), with two seeds per hill and 80 centimeters between rows of plants. Each plot and block had 0.5 m and 1 m routes between them, respectively. The maize variety was sown at the recommended seed rate (25 kg ha^{-1}). Sowing was done with rows and using 80cm between rows and 40cm between plants with two seeds per hill. The fertilizer application was based on the regional crop package recommendation [13]. The land was fertilized with artificial fertilizer, phosphorous at a rate of 200 kg P2 O5 ha-1, and nitrogen at a rate of 200 kg N ha-1, by the approved fertilizer application rate [13]. When the plants were 35–40 days old, the entire amount of phosphorous fertilizer (200 kg P2 O5 ha-1) was administered as a band application at planting, and the full rate of nitrogen fertilizer (200 kg N ha-1) was applied as a side dressing at a distance of 3-5 cm until it was ultimately integrated with the soil. The field was manually weeded as necessary [13].

Treatment application: After the first week of infestation and thirty days following planting, the treatments were administered with a backpack sprayer. Before and after the administration of the therapy, the number of larvae was noted. Data on the number of larvae that survived was collected twice due to the application of insecticides.

Scouting and detection: Two weeks following emergence, the presence of egg masses, the newest larvae, and early-instar FAW damage on maize leaves in the form of tiny windowpanes or pinholes (i.e., the number of larvae and the number of damaged plants (damage severity) per plot) were counted for three days before the application of insecticides.

Data collection

Pest parameters

Prevalence: The presence or absence of insects assessed and scored from each plot.

Infestation: plots were assessed and from each plot infested plants were scored. A plant showing symptoms was collected and an infected plant collected samples were taken from all plant parts [14].

Number of damaged plants per plot: documented by the counting of five plants selected at random from the center net plot sections.

Percent of damaged leaves per plant: recorded from the count of five randomly taken plants in the central net plot areas.

Number of larvae per plant: recorded from the count of five randomly taken plants in the central net plot areas.

Number of survived larvae per plant: observed and recorded from the count of five randomly taken plants in the central net plot areas.

Larval mortality percentage: Larva mortality was calculated after each spray

Vegetative parameters

Number of leaves per plant: Five randomly selected plants were counted to determine the total number of green leaves per plant at tasseling, with averages being used to calculate the number of green leaves per plant.

Plant height (cm): was measured as the distance between the soil's surface and the base of the tassels on five randomly selected plants that were physiologically mature and picked from the net plot areas.

Yield parameters

- *Number of ears per plant:* recorded from the count of five randomly taken plants in the central net plot areas.
- *Ear length (cm):* measured from the point where the ear attaches to the stem to the tip of the ear.

Grain yield (GY t/ha): was determined by weighing the grains that had been threshed from the middle two rows of each plot, and after setting the grain moisture content to 12.5%, the weight was converted to kilos per hectare. Listed below formula was used to calculate the moisture adjustment factor. Taking into account Eq. 4 as such:

$$\text{Adjusted Yield} = \frac{100 - \text{Measured moisture content }\%}{100 - 12.5\%} \quad (4)$$

Consequently, 12.5% moisture-adjusted grain yield is equal to moisture correction factors times the grain yield that is acquired from every plot [15].

- *Above-ground dry Biomass (BY t/ha):* Plants taken from two rows of a plot were weighed, and the weight was translated to ton/ha.
- *Thousand-kernel weight (TKW gram):* was ascertained by weighing the 1000 grains that were counted using an electronic automated seed counter and sampling the counted kernels from the net plot using a sensitive balance that had an accuracy of +0.001g. Using a Draminski Gmm small fast moisture tester, the weight of a thousand kernels was measured after the grain was adjusted to 12.5% moisture content.

Harvest index (HI %): Using the Donald, (1962) approach, the percentage ratio of grain (economic) yield to the total biomass (straw + grain) yield per plant was determined based on the harvest index values for each treatment [16]. The findings were expressed in percentile terms. This was carried out while accounting for Eq. 5:

$$\text{Harvest index }(\%) = \frac{\text{Economic yield (t per ha)}}{\text{Total biological yield (t per ha)}} \times 100 \quad (5)$$

Data analysis

SAS statistical analysis software version 9.4 was utilized to perform analysis of variance (ANOVA) on experimental data utilizing statistical methodologies as outlined by Gomez and Gomez.

A partial budget study was carried out to investigate the therapies' economic viability. The CIMMYT partial budget analysis approach was followed to carry out a partial budget, dominance, and marginal rate of return [17].

RESULTS AND DISCUSSION

Survey results and discussion

Fall armyworm prevalence and infestation

About 1006 farmers in maize fields about 72.92% have been already infected by fall armyworm, which is relatively more than the 2019 cropping season as respondents said. The prevalence of this insect in each kebele looks at 58.3%, 66.67%, 91.67%, and 75% for the Geregera, Zara, Wonichet, and Korata kebeles of Dera districts, respectively. The mean infestation of the district for the fall armyworm was 30.69% **(Table 1)**. Ethiopian farmers calculated that the autumn armyworm infection of maize ranged from 24.1% to 39.4%, with an average of 32% [12].

Maize production losses

The percent yield losses caused by fall armyworm were estimated from maize cultivated fields. In the study district, about 77.8% of respondents responded that there was a 20-50% yield loss in the district and about 22.2% of respondents estimated a 51-81% yield loss. From 1,006 respondents in the Dera district, there is about 35-50% infestation in the 2020 cropping season.

Farmer's knowledge and perception

According to the findings, maize production was positively and substantially correlated with farmers' opinions about pesticide applications and their employment of cultural methods to control fall armyworms. It may be inferred from this that farmers who used chemicals or cultural approaches were probably going to produce more than farmers who did not. This might help to partially explain why the farmers thought these management techniques were beneficial. The majority of farmers (99%) in every province of Ethiopia were also aware of the fall armyworm, according to Kumela *et al*. [12]. Corn output was significantly correlated negatively with farmers' perceptions of insect intensity. According to this, there is a greater chance of major maize damage the more autumn armyworm damage occurs.

Table 1. Survey on prevalence and infestation of fall armyworm, Dera district, during 2020

Name of Keble's	No of respondents/ kebele (%)	Prevalence	Infestation		
			Total number of plants assessed	Average number of plants infected	Infestation (%)
Geregera	240	140 (58.30%)	800.00	260.00	32.5%
Zara	222	148 (66.67%)	740.00	262.70	35.5%
Wonichet	267	245 (91.67%)	890.00	258.10	29.0%
Korata	277	208 (75.00%)	923.00	237.80	25.75%
Total	1,006	183.4 (72.92%)	838.00	257.40	30.69%

Field experiment

Effects of variety and insecticide on pest parameters

Number of damaged plants per plot and percent of leaves damage

The maximum (16.20%) number of damaged plants per plot and high (32.26%) damaged plants per plot were recorded on variety BH-546, followed by variety BH-540, which recorded the number of damaged plants per plot (15.21%) and (31.02%) damaged plant per plant. The lowest number of damaged plants number (13.86%) and damaged plants per plant (29.55%) were accounted for in the local maize variety **(Table 2)**. This might be due to leaf hardiness vis-à-vis a thicker epidermis [18].

Number of larvae per plot before spray

The analysis of data revealed that infestations of maize by fall armyworm larvae were higher on improved varieties than local varieties. The maximum number of fall armyworm larvae (71.01%) was recorded on the BH-546 variety of maize at pre-application of insecticide. The lowest number of fall armyworm larvae (65.93%) was observed in the local maize variety **(Table 2)**.

Number of survived larvae per plant

The smallest number of survived larva data (11) was recorded after the first spray from Agrolambasin supper 315 sprayed plots followed by (13.00) recorded when Karate 5% EC was applied on different varieties of maize crop. The highest survived larva (81) was recorded from the control (Unsprayed) plot while the second and their highest survived larva (23.00 and 17.00) were recorded from plots treated by Malathion 50% EC, and Dimethoate respectively. The non-treated control plants had extensive leaf injury by FAW larvae compared to the plants treated with synthetic insecticides **(Table 2).** This result is related to Osae *et al.* [19].

Table 2. Number of Damaged Plants per Plot, Percent of Damaged leaves per plant, Larva Number, and Number of survived larvae as influenced by insecticides

Treatments	Variables				
	NDPPP	DLPP	NLPPBS	NSLPP after 1st spray	NSLPP after 1st and 2nd spray
Insecticides					
Agrolambasin supper 315	15.11a	30.93a	68.67a	11.00e	3.00e
Karate 5% EC	15.10a	30.94a	68.66a	13.00d	5.11d
Dimeto 40% EC	15.10a	30.94a	68.66a	17.00c	7.00c
Malathion 50% EC	15.02a	30.95a	68.65a	23.00b	11.00b
Control	15.12a	30.93a	68.64a	81.00a	89.00a
LSD (0.05)	0.33ns	0.11ns	0.12ns	0.68*	0.53*
SE±	0.07	0.03	0.03	0.14	0.11
Variety					
BH-540	15.21b	31.02b	69.03b	29.00a	28.80a
BH-546	16.20a	32.26a	71.01a	28.80a	23.20a
Local	13.86c	29.55c	65.93c	29.20a	23.06a
LSD (0.05)	0.25**	0.10*	0.01*	0.52ns	0.41ns
SE±	0.24	0.09	0.09	0.50	0.39
CV (%)	2.30	0.39	0.19	2.44	2.42

Means in the column followed by the same letter (s) are not significantly different at a 5% level of significance. NDPPP =Number of Damaged plant per plot, % DLPP =Percent of damaged leave per plant, NLPPBS =Number of Larvae before spray, NSLPP before 1st spray =Number of survived larvae per plot, NSLPP before 1st and 2nd spray = number of survived larvae per plot, LSD (0.05) = Least significant difference at 5% level, SE± = standard error and CV (%) = coefficient of variation in percent

Larva mortality percentage

The highest larval mortality percentage (83.82% and 95.5%) after the first and second spray was recorded from plots sprayed by Agrolambasin supper 315, whereas plots sprayed by Karate 5% EC and Dimethoate recorded (77.95, 76.10 after the first and 91.13, 91.10 after first and second spray) larva mortality percentage respectively. The lowest (63.49 and 82.53) larval mortality percentage was recorded from Malathion after the first and second sprays **(Table 3)**. The plots, which were not sprayed with insecticide, showed no larva mortality percentage recorded except the decrease in larval number due to cannibalism and other natural enemies [20].

Table 3. Larva Mortality percentage as influenced by insecticides

Treatments	Variables	
	LMPA	LMPB
Chemicals		
Agrolambasin supper 315	83.81a	95.58a
Karate 5% EC	77.95b	91.13b
Dimetoate 40% EC	76.10c	90.10c
Malathion 50% EC	63.49d	82.53d
Control	00e	00e
LSD (0.05)	0.83*	0.6*
SE±	0.17	0.12
Variety		
BH-540	60.08a	71.84a
BH-546	60.23a	72.09a
Local	60.49a	71.90a
LSD (0.05)	0.65ns	0.46ns
SE±	0.61	0.44
CV (%)	1.44	0.87

Effects of variety and insecticide on vegetative parameters

Plant height

The highest plant height (2.18 m) was recorded when the BH-546 variety was treated with Agrolambasin supper 315and it was followed by (2.13 m) when the same variety was treated with Karate 5% EC. Maize varieties treated by Malathion and Dimethoate showed statistically similar results (1.60 m) on BH-540 and Local variety **(Table 4)**.

Ear length

The highest ear length (18.55 cm) was recorded in BH-546 variety plants treated with Agrolambasin supper 315, followed by (18.00 cm) recorded when the same variety was treated with Karate 5% EC. Whereas the shortest average ear length (9.63 cm) was recorded when maize insecticides did not treat varieties while the FAW occurred **(Table 4)**. This result agrees with [21].

Plant height

Plant height was significantly ($p < 0.05$) influenced by insecticide application, variety, and their interaction. The highest plant height (2.18 m) was recorded when the BH-546 variety was treated with Agrolambasin supper 315, and it was followed by (2.13 m) when the same variety was treated with Karate 5% EC. Maize varieties treated by Malathion and Dimethoate showed a statistically similar result (1.60 m) on BH-540 and Local variety. The shortest plant height (1.31 m) was recorded when maize plants with the untreated check **(Table 4).** This result shows fall armyworm can affect maize plant height [22].

Ear length

Analysis of data revealed that ear length was highly significantly ($p < 0.01$) influenced by different insecticide application, maize variety, and their interaction. The highest ear length (18.55 cm) was recorded in the BH-546 maize variety treated with Agrolambasin supper 315, followed by (18.00 cm) recorded when the same variety was treated with Karate 5% EC. Whereas, the shortest average ear length (9.63 cm) was recorded when maize varieties were not treated by insecticides while the fall armyworm occurred **(Table 4)**.

Table 4. Plant height and Ear Length as influenced by the interaction effect of insecticides and Maize variety

Insecticides	Variables					
	PH (m)			EL (cm)		
	BH-540	BH-546	Local	BH-540	BH-546	Local
Agrolambasin supper 315	1.91d	2.18a	1.81e	17.55b	18.55a	16.55c
Karate 5% EC	1.79e	2.13b	1.69f	17.55b	18.00ab	15.58d
Dimetoate 40% EC	1.60g	2.00c	1.60g	16.60c	17.41b	16.41c
Malathion 50% EC	1.60g	1.88d	1.61g	14.48e	16.50c	13.86f
Control	1.31h	1.31h	1.31h	9.63h	10.30g	9.86gh
LSD (0.05)	0.05*			0.63*		
SE±	0.04			0.01		
CV (%)	1.70			2.36		

Means in the column followed by the same letter (s) are not significantly different at a 5% level of significance. PH = Plant Height, EL =Ear Length, LSD (0.05) = Least significant difference at 5% level SE± = standard errors and CV = coefficient of variation in percent.

Effects of variety and insecticide on yield parameters

Aboveground dry biomass (ton/hectare)

The highest above-ground dry biomass (16.50 t/ha) was recorded when maize variety was treated with Agrolambasin supper 315 whereas using Karate 5% EC, Dimethoate and Malathion insecticides showed significantly different (16.16, 15.38, and 15.05 t/ha) biomass yield respectively **(Table 5)**.

Thousand kernels weight

The highest thousand kernel weights (292.59 g) were recorded when Agrolambasin supper 315 was applied on fall armyworm-ridden plots of maize crops. Plots treated with Lambda-cyhalothrin insecticide produced the second highest (290.80 g) thousand kernels. The lowest thousand-kernel weight (285.5 g) was measured when the maize variety was planted without any FAW-controlling insecticide application **(Table 5)**.

Table 5. Biomass Yield and Thousand Kernels Weight as influenced by insecticides and Maize variety

Treatments	Variables	
	Biomass Yield (t/ha)	Thousand kernel weight (gram)
Insecticides		
Agrolambasin supper 315	16.50a	292.59a
Karate 5% EC	16.16b	290.80b
Dimeto 40% EC	15.38c	289.77c
Malathion 50% EC	15.05d	289.25c
Control	9.18e	285.51d
LSD (0.05)	0.26**	0.68*
SE±	0.05	0.18
Variety		
BH-540	14.44ab	291.04b
BH-546	14.62a	298.11a
Local	14.29b	288.60b
LSD (0.05)	0.2*	0.52*
SE±	0.01	0.51
CV (%)	1.85	0.24

Grain yield (ton/hectare)

The maximum grain yield (5.90 t/ha) was attained when the BH-546 maize variety was treated with Agrolambasin supper 315; it exceeded the subsequent yield (5.78 t/ha) reported from the same insecticide-treated variety BH-540 by 2%. When Karate 5% EC insecticide was sprayed on BH-546 and BH-540, statistically similar results (5.50 and 5.46 t/ha) were observed respectively. Application of Dimethoate on BH-540, BH-546 and Local variety of maize showed 5.18, 5.21, and 5.02 t/ha grain yield respectively **(Table 6)**.

Harvest index (%)

The highest harvest index of (35.41 and 35.21%) was obtained when Agrolambasin supper 315 was applied to FAW-infested local and BH-546 maize varieties. However, the application of Karate 5% EC and Dimethoate on BH-546 and BH-540 varieties gave statistically similar results under FAW-attacked maize crop **(Table 6)**.

Table 6. Grain Yield and Harvest Index as influenced by the interaction effect of insecticides and Maize variety

Insecticides	Variables					
	Grain yield (t/ha)			Harvest index (%)		
	BH-540	BH-546	Local	BH-540	BH-546	Local
Agrolambasin supper 315	5.78ab	5.90a	5.72b	34.88ab	35.21a	35.41a
Karate 5% EC	5.46c	5.50c	5.32d	33.99bc	33.95bc	32.88cd
Dimetoate 40% EC	5.18e	5.21de	5.02f	33.66bc	33.59c	32.93cd
Malathion 50% EC	4.14g	4.92f	4.03g	27.67e	31.78d	27.52e
Control	2.92h	2.91h	2.93h	31.99d	31.77d	31.95d
LSD (0.05)		0.123*			1.24*	
SE±		0.04			0.19	
CV (%)		1.56			2.28	

Correlation analyses among agronomic parameters of maize

Strong correlations were found between several pest characteristics and attributes associated with yield components, according to quantified correlation analyses among maize agronomic parameters **(Table 7)**. The current investigation resulted in a positive and substantial association between the pest parameter of larval mortality% and the number of larvae that survived (r = 0.99 and 0.98, respectively), following the first and second sprays. The proportion of larval mortality was positively and significantly correlated (r = 0.78*) with plant height. This implies that, in the absence of pesticide treatment, FAW larvae can drastically lower the height of maize plants. The number of surviving larvae (r = 0.92) and the larval mortality rate (r = 0.94) of grain yield, another agronomic metric, exhibited a positive and very significant association. The study found a strong correlation between the variable and its constituents, including plant height (r = 0.85), number of ears per plant (r = 0.71), ear length (r = 0.96), biomass yield (r = 0.87), and thousand kernel weight (r = 0.29). Specifically, an increase in the values of these parameters was accompanied by an associated rise in grain yield **(Table 7)**.

Table 7. Simple correlation analyses among pest, growth, yield, and yield component parameters

	NDPPP	NDLPP	NLPPBS	NSLPPASA	NSLPPSB	LMPA	LMPB	NGLPP	PH	NEPP	EL	GY	BY	TKW
NDPPP	1													
NDLPP	0.94**	1												
NLPPBS	0.95**	0.99***	1											
NSLPPASA	0.03NS	0.04NS	0.01NS	1										
NSLPPSB	0.01NS	0.04NS	0.03NS	0.99**	1									
LMPA	0.01NS	0.06NS	0.06NS	0.99*	0.98**	1								
LMPM	0.00NS	0.01NS	0.05NS	0.99*	0.99*	0.99*	1							
NGLPP	0.15NS	0.14NS	0.14NS	0.38**	0.39**	0.37*	0.39**	1						
PH	0.40**	0.43**	0.42NS	0.79*	0.77*	0.79*	0.78*	0.40**	1					
NEPP	0.36**	0.38**	0.36*	0.61*	0.59*	0.62*	0.60*	0.41**	0.79**	1				
EL	0.22NS	0.23NS	0.23NS	0.94*	0.92*	0.94*	0.93*	0.35*	0.89**	0.93**	1			
GY	0.10NS	0.10NS	0.10NS	0.92*	0.89*	0.94***	0.91*	0.30*	0.85**	0.71**	0.96**	1		
BY	0.02NS	0.04NS	0.05NS	0.99*	0.98*	0.48***	0.98*	0.39**	0.82**	0.65**	0.95*	0.93*	1	
TKW	0.33NS	0.36*	0.35*	0.81*	0.79*	0.82***	0.80*	0.38**	0.92**	0.75*	0.87*	0.87**	0.84**	1
HI	0.24NS	0.19NS	0.19NS	0.27*	0.21NS	0.33*	0.25*	0.03NS	0.47**	0.46*	0.48*	0.60**	0.29***	0.47*

CONCLUSION

The most prolific food plant and one of the oldest grains is maize (*Zea mays* L.), which leads all other cereals in terms of productivity and production. In tropical areas, autumn armyworms are the main insect pest of maize. From the sampled 1,006 farmers in the maize field assessed about 72.92 % had been already infected by fall armyworm which is relatively more than the 2019 cropping season.

The majority of the vegetative, pest, and yield-related characteristics of the maize crop are impacted by both variety and pesticide application, according to the experimental data. When Agrolambasin supper 315 was applied to BH-546 variety plants, the maximum plant height, ear length, grain production, and harvest index were observed. The highest biomass yield and thousand kernels weight was recorded on BH-546 improving a variety of maize after insecticide treatment. In all examined kinds, the values of plant height, ear length, biomass production, thousand-grain weight, grain yield, and yield index were lowest in the control plots. The use of enhanced cultivars with Agrolambasin supper 315-insecticide application has helped decrease yield loss thus far, even if this study showed that autumn armyworm considerably harmed all of the studied maize cultivars during the peak growing season. It should thus be used in an integrated pest control program.

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