Susceptibility of African Bollworm, *Helicoverpa armigera* (Hubner)(Lepidoptera: Noctuidae) to selected pyrethroid Insecticides on Cotton

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Research Article

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Abstract

Helicoverpa armigera is the main danger for all cotton production regions in Ethiopia. Pests manage with pesticide from an unmarried chemistry group is not an unusual place exercise in maximum cotton farms, which may also assist the development of insecticide resistance. The research aimed to decide the susceptibility of the sector populace of H. armigera to a pyrethroid pesticide. The experiment was carried out at Werer Agricultural Research Center under the laboratory situation the use of larva immersion and square dip methods. The selected insecticides had been examined in seven dilution levels. In every dilution 30 larvae of third instars, H. armigera had been dealt with in 3 three replications at the side of natural water. A low level of resistance became detected for all examined places to alphacypermethrin and a high resistance ratio to lambda-cyhalothrin and deltamethrin for Gewane and Werer populations. Alphacypermethrin became the maximum poisonous insecticide and its LC50 became low as compared to different examined synthetic pyrethroids. Whereas, deltamethrin became the least poisonous insecticide with high LC50. The LC50 value of the Goffa-Sawla populace became notably exclusive to most of the populations for Werer, Upper-Awash, and Gewane in each bioassay method. The examination concluded that Helicoverpa armigera may have resistance to deltamethrin in Werer and Gewane populations. *Further research on the tracking of resistance is recommended.*

Introduction

African bollworm (*Helicoverpa armigera*) (Lepidoptera: Noctuidae) is a polyphagous insect determinantal many plants which include beans, chickpea, peas, sorghum, cotton, tomato, pepper, sunflower, safflower, flax, and Niger seed (Tsedeke, 1982; Waktole, 1996). The pests of cotton motive a 50-60% yield discount in China (Xiao *et al*., 2002). In Ethiopia, harm because of bollworms *(H. armigera*, *Pectinophora gossypiella*, *Diparopsis watersi,* and *Earias* spp) inflicts 36-60% yield loss ((Tsedeke, 1982; Waktole, 1996); 60% common yield losses (Geremew and Ermias, 2006), of that *H. armigera,* is the maximum crucial pest.

For decades, cotton farmers have in most cases been in the use of chemical insecticide to manipulate pests in Ethiopia. More than six sprays were carried out in keeping with cropping season for controlling a special cotton pest; four spherical sprays are allocated for manage of cotton bollworms and no statistics on its effect on the encompassing region EIAR, 2016; Geremew, 2004). It has become difficult to control these pests with existing pesticides (Geremew, 2004).

Pests manage approach with pesticide from an unmarried group institution is not unusual to place exercise in maximum cotton farm. In the past, improvement of resistance as withinside the case of lambda-cyhalothrin for *H. armigera* species at Dubti (Germew, 2004), dimethoate for aphid species on the Middle Awash (IAR, 1990), and carbamate group (carbosulfan, furathiocarb, and pirimicarb) for aphid species resistance to at Arbaminch, Dubti and Werer (Ermias, 2006). Efficacy discount of endosulfan at Werer area (WARC, 1998) and large-scale farms in Ethiopia (Geremew and Surachate, 2005). Currently, the generally used synthetic pyrethroid pesticide, lambda-cyhalothrin, and deltamethrin have proven efficacy discount in controlling African bollworms withinside the Middle Awash area (Personal communication). This is probably because of the improvement of insecticide resistance through African bollworms (*H. armigera*). Because of those, the existing look at change into undertaken to decide the susceptibility of area populace *H. armigera* to generally used synthetic pyrethroid pesticide under laboratory conditions.

Material And Methods

The experiment was conducted at Werer Agricultural Research Center (WARC), Amibara District, Gebresu zone of Afar National Regional State throughout the 2017 cropping seasons under laboratory conditions.

Laboratory Experiments

African caterpillar (*Helicoverpa armigera)* brute assortment and rearing

African bollworm were collected from unsprayed cotton farms in Middle Awash (Werer (734.4 m.a.s.l, E 40^0 $09^{'}$ $811^{"}$ & N 09^0 21' $243^{"}$), Gewane (567 m.a.s.l, E 040^0 31' $23.0^{"}$& N 09^0 59' 22.5")) and Upper Awash farms (Merti Jeju (1174 m.a.s.l, E 039^0 43' 927" & N 08^0 37' 111")). The larvae were reared victimization cotton squares till pupation. Pupae were collected each morning and transferred to plastic pots (size of 20cm height * 16cm width) embedded with soil. Pairs of male and feminine emerged adult moths were placed in adult rearing cages. A dissolved sugar was equipped within the rearing cage (size of 30cm height *27cm width) for adults to feed. The adult diet was ready from five-gram sugar and two-hundred cubic centimeter water (Geremew and Surachate, 2003). In every adult rearing, cage one plastic cup blocked with plant fiber immersed within the sugar resolution was unbroken for the adults to feed. The adults were allowed to put eggs on cheese shut or a detached cotton branch placed within the cage. The eggs hatch when 3 or four days. The hatched larvae were collected and reared on cotton leaves. Beginning the second arthropod stage, larvae were separated and command severally in a very Petri dish with cotton leaves. The experiment was conducted on the third arthropod larvae. Larvae of ABW were collected from chickpea fields of small-scale farms at Gofa-Sawla space (1260m.a.s.l, E 036^0 $56^{'}$ & N 06^0 19'), Southern Ethiopia, with no pesticide use history within the last six years, were dropped at Werer Agricultural Center and used for comparison with African caterpillar collected from cotton farms which are heavily sprayed for several years.

Serial Dilution of Pesticide

The business pesticide alphacypermethrin **(**Fastac 100G/L**),** lambda-cyhalothrin **(**Karate 5%EC**),** and deltamethrin **(**Decis 2.5% EC) were serially diluted with H_2o bioassayed against completely different strains of African caterpillar. Concentrations of developed pesticides were calculated supported the market out there full-labeled field rate and application volume of two hundred liters/ha.

Laboratory Bioassay Methodology

The bioassay was conducted victimization the fresh molted F_1 generation of third arthropod brute by victimization the square dip and larval immersion bioassay procedure suggested by Geremew *et al*. (2004). The experiments were arranged with a very randomized style (CRD) with 3 replications. For every replicate of a serial dilution, 10 larvae were used.

Experiment One. Larval Immersion Methodology

Thirty larvae were utilized in every treatment and every treatment was replicated thrice. For every treatment, 10 thrid arthropod caterpillar larvae per replication were used. The larvae were lordotic into individual dilutions for 10 seconds and placed on tissue soft trays for gripping excessive liquid from the body. Larvae were transferred into a glass Petri dish with an insecticide-free cotton square. The check treatment was treated with pre-water. The death rate was assessed twenty-four hours when putting the larvae by inquisitory the larvae with a fine even-toed ungulate brush. If the larvae respond for inquisitory it was thought of alive or dead otherwise.

Experiment Two. Square Dip Methodology

Medium size cotton squares that weigh 700-1000 milligrams were collected from the unsprayed cotton field and lordotic into individual dilutions of pesticide for 10 seconds and transferred onto a paper soft receptacle for air-drying. When the hour of drying, single lordotic squares were unbroken in glass Petri dishes, and a one-third arthropod brute was introduced for feeding on the treated squares. The check treatment was treated with pre-water. The death rate was assessed twenty-four hours when putting the larvae by inquisitory the larvae with a fine even-toed ungulate brush. If the larvae respond for inquisitory it was thought of alive or dead otherwise.

Data Collected

The dose-mortality larvae were recorded after twenty-four, 48, and seventy-two hours of treatment for larval immersion bioassay whereas when twenty-four, 36, and forty-eight hours of treatment for square dip methodology bioassay. Larvae were thought to be dead if they are ineffectual to maneuver once probed with a blunt probe or brush. Results were expressed as proportion mortality. The daily minimum and maximum temperature and RH of the laboratory were recorded.

Statistical Analysis

Data from a bioassay were corrected for management mortality victimization Abbott's formula (Abbott, 1925):

$$\text{Percent mortality} = \text{dead larva/total larva treated} * 100,$$

$$\text{Percent corrected mortality} = \left(\frac{\%\ \text{mortality in treatment} - \%\ \text{morality in control}}{100 - \%\ \text{mortality within the control}}\right) * 100$$

The results obtained from the dose-mortality experiments were calculable by probit analysis (Finney, 1971) victimization of the SAS package version nine (SAS Institute, 1999). LC_{50} and LC_{90}, (Lethal Concentrations that kill fifth and nineteenth check larva), slope, and therefore the ninety-fifth Confidence Limit (CL) were determined.

Resistance Ratios were calculated by dividing the LC_{50} values of each field population by the LC_{50} of Gofa-Sawla (susceptible population). The pesticide resistance level was firm victimization the way represented by Torres-Vila *et al.* (2002a, b): susceptible (RF=1), low level of resistance (RR=2-10), moderate resistance (RR=11-30), high resistance (RR=31-100), and extremely resistance (RR>100).

Results And Discussion

Larva Immersion and Square Dip method

Lambda-cyhalothrin

H. armigera larval mortality of 100, 100, 100, and 90% mortality turned into at field rate (5.0×10^{-4}g. a.i/ml) of the insecticide for Goffa-Sawla, Upper-Awash, Werer, and Gewane population, respectively. Four times the decrease dose from the recommended rate (1.25×10^{-4}g. a.i/ml) led to 100% mortality on Gofa-Sawla populace, which turned into higher than field rate dose-mortality (90%) of Gewane and two times lower dose rate mortality percent (96%) Upper-Awash and (86.7%) of Werer population (Table 1). In the squared dip technique the field rate lambda-cyhalothrin (5.0×10^{-4}g. a.i/ml) led to 100, 100, 96.7, and 93.3% mortality on Goffa-Sawla, Upper-Awash, Werer, and Gewane populations, respectively (Table 1). The four-times decrease dose (1.25×10^{-4} g. a.i/ml) precipitated 100% mortality even as the eight-times decrease dose (2.5×10^{-5}a.i/ml) 93.3%) mortality at the Goffa-Sawla population even as

handiest 83.3% mortality turned into recorded for Werer to two times-decrease doses (2.5 x 10^{-4}g. a.i/ml) and 90% mortality of the Upper-Awash populace to field rate dose of Gewane population (Table 1).

Both bioassay techniques showed Goffa-Sawla population was significantly different (P<0.05) from Werer, Upper-Awash, and Gewane populations without any overlap of 95% CL. The result suggests the Goffa Sawla populace is a lot greater touchy to lambda-cyhalothrin as compared to different populace. (Table 2).

This takes a look at discovered that variation in the degree of susceptibility to lambda-cyhalothrin exists in *H armigera* collected from different locations. Both bioassay techniques confirmed that the examined population had a low degree of resistance to lambda-cyhalothrin. The Gewane population has a better resistance ratio in comparison to different examined populations. Several studies have indicated the development of resistance in *H armigera* for pyrethroids. A low degree of resistance to lambda-cyhalothrin became suggested via way of means of Karaagac *et al.* (2013) from Turkey and Avilla and González-Zamora (2010) in Spain. Other research suggested slight to high-degree resistance (Hussain *et al.* (2014) and high-degree resistance (Duraimurugan & Regupathy, 2005) of *H. armigera* to pyrethroids. This locating evaluation with Geremew *et al.* (2004) who discovered in larva immersion and squared dip methods.

Table 1. Percent of mortality of 3rd instar *H. armigera* larvae in different concentration of lambda-cyhalothrin 5% EC 72 hours after treatment with larva immersion bioassay and 48 hours after treatment in squared dip bioassay (29± 2^0C & 48±4% RH) on Gofa Sawla, Upper Awash, Werer and Gewane populations (N=30).

larva immersion					squared dip				
Concentration (µl/ml)	Percent mortality				Concentration (µl/ml)	Percent mortality			
	Gofa Sawla	Upper Awash	Werer	Gewane		Gofa Sawla	Upper Awash	Werer	Gewane
2	100	100	100	90.0	2	100	100	96.7	93.3
1	100	96.7	86.7	70.0	1	100	90.0	83.3	73.3
0.5	100	83.3	70.0	53.3	0.5	100	76.7	63.3	53.3
0.25	83.3	63.3	46.7	26.7	0.25	93.3	56.7	46.7	33.3
0.12	66.7	40.0	23.3	13.3	0.12	73.3	36.7	23.3	16.7
0.0625	50.0	23.3	10.0	6.7	0.0625	56.7	20.0	10.0	3.3
0.03125	16.7	10.0	10.0	3.3	0.03125	23.3	6.7	3.3	3.3
Control	6.7	0	6.7	3.3	Control	3.3	3.3	6.7	6.7

Table 2. Comparative toxicity of lambda-cyhalothrin 5% EC to *H. armigera* populations in larva immersion and squared dip study.

Larva immersion									
Location	N	LC_{50} µl/ml	95% CL (lower-upper)	LC_{90} µl/ml	95%CL (lower-upper)	The fit of probit analysis			RR
						Slope ± SE	χ^2 (df)	P	
Gofa-Sawla	180	0.074	(0.057 -0.094)	0.260	(0.192-0.415)	2.36± 0.333	2.778 (4)	0.5957	_
Upper Awash	180	0.153	(0.118 - 0.199)*	0.693	(0.476 - 1.226)	1.96 ± 0.250	0.512 (4)	0.9723	2.07
Werer	180	0.264	(0.199 - 0.361)*	1.419	(0.886 -3.022)	1.75± 0.236	2.15 (4)	0.7089	3.57
Gewane	180	0.498	(0.364 - 0.763)	2.870	(1.578 - 8.204)	1.69 ± 0.256	0.622 (4)	0.9606	6.73
Squared dip									
Location	N	LC_{50} µl/ml	95% CL (lower-upper)	LC_{90} µl/ml	95%CL (lower-upper)	The fit of probit analysis			RR
						Slope ± SE	χ^2 (df)	P	
Gofa-Sawla	180	0.060	(0.044 -0.075)	0.193	(0.144 - 0.306)	2.52±0.384	0.976 (4)	0.9134	_
Upper Awash	180	0.194	(0.147 -0.258)*	1.007	(0.657-1.969)	1.80 ±0.237	0.113 (4)	0.9985	3.25
Werer	180	0.302	(0.230 - 0.41)*	1.505	(0.949-3.162)	1.84 ±0.249	0.168 (4)	0.9967	5.03
Gewane	180	0.447	(0.334 - 0.651)*	2.338	(1.364-5.869)	1.78 ±0.261	0.797 (4)	0.9389	7.45

N= total number of larva used for probit analysis, LC_{50} = median lethal concentration, LC_{90}= the lethal concentration which killed 90% of the test H. armigera population, 95% CL= the lower and the higher confidence limits at which the LC_{50} and LC_{90} value can fall at 95% probability, SE= standard Error, χ^2 =Chi-square, RR (Resistance Ratio) = LC_{50} of the field population / LC_{50} of Goffa-Sawla population, superscript denoted astric=the collected H. armigera populations were not significantly different (P<0.05) among each other in their susceptibility to lambda-cyhalothrin insecticide.*

Deltamethrin

H. armigera populations of Werer, Upper-Awash, Goffa-Sawla, and Gewane populations exposed to different concentrations of deltamethrin 2.5% EC experienced a varying level of mortality. At field rate (3 x 10^{-4}g. a.i/ml) deltamethrin gave 100, 93.3, 86.7, and 80.0% mortality 72 hours after larvae were immersed for Goffa-Sawla, Upper-Awash, Gewane, and Werer populations, respectively. In squared dip method at field rate (3.0 x 10^{-4} g. a.i/ml) deltamethrin gave 100, 90, 83.3 and 80.0% larval mortality after 48 hours in square dip method of Goffa-Sawla, Upper-Awash, Gewane, and Werer population, respectively (Table 3). The field-collected *H. armigera* larva from Goffa-Sawla experienced 100% mortality at two times lower doses (1.5 x 10^{-4} g. a.i/ml) of deltamethrin which was higher than the field rate mortality of Werer, Upper-Awash, and Gewane populations, respectively (Tables 3).

The LC_{50} values suggests that Werer, Upper-Awash, and Gewane populations have been now no longer extensively distinctive amongst every different, however (P<0.05) from the Goffa-Sawla population with no overlapping 95% CL (Table 4). Probit analysis showed that the Werer population is 8.79 times and Gewane populations 6.45 times more resistant to the susceptible Goffa-Sawla population in larva immersion technique (Table 4). And, in square-dip technique the Werer and Gewane 9.25 and 7.55 more resistant to the susceptible Goffa-Sawla population (Table 4).

According to the resistance grouping of Torres-Vila *et al.* (2002a, b) *H. armigera* in Middle Awash, Ethiopia showed *a* low level of resistance to deltamethrin. Deltamethrin has been wont to control *H. armigera* and sucking pests in cotton for a protracted time. Recently, because of dreath of the ultra-low volume (ULV) formulation, the emulsify concentrate (EC) formulation of deltamethrin has been applied like ULV by mixing with a little volume of water to save a lot of of time and labor (Personal communication). Such misuse of an insecticide against *H. armigera*, may led to choice of resistant forms of the pest population. Development of low to high-level resistance in several strains of *H. armigera* for deltamethrin reported by Faheem *et al.* (2013) and Hussain *et al.*, (2014) in Pakistan.

Table 3. Percent of mortality of 3rd instar *H. armigera* larvae in different concentrations of deltamethrin 2.5% EC 72 hours after treatment with larva immersion bioassay and 48 hours after treatment in squared dip bioassay(29 ± 2^0C & 48 ± 4% RH) on Gofa-Sawla, Upper Awash, Werer and Gewane population (N= 30).

larva immersion					squared dip				
Concentration (µl/ml)	Percent mortality				Concentration (µl/ml)	Percent mortality			
	Gofa Sawla	Upper Awash	Werer	Gewane		Gofa Sawla	Upper Awash	Werer	Gewane
3	100	93.3	80.0	86.7	3	100	90.0	80.0	83.3
1.5	100	76.7	56.7	66.7	1.5	100	76.7	50.0	60,0
0.75	93.3	50.0	30.0	43.3	0.75	96.7	56.7	23.3	33.3
0.375	76.7	26.7	13.3	20.0	0.375	76.7	40.0	3.3	6.7
0.1875	53.3	13.3	3.3	6.7	0.1875	56.7	20.0	3.3	3.3
0.09375	30.0	3.3	0	0	0.09375	26.7	6.7	0	0
0.046875	13.3	0	0	0	0.046875	6.7	0	0	0
Control	3.3	6.7	6.7	6.7	Control	6.7	6.7	0	6.7

Table 4. Comparative toxicity of deltamethrin 2.5% EC to *H. armigera* populations in larva immersion and squared dip study.

Larva immersion									
Location	N	LC_{50} µl/ml	95% CL (lower-upper)	LC_{90} µl/ml	95%CL (lower-upper)	The fit of probit analysis			RR
						Slope ± SE	χ^2 (df)	P	
Gofa-Sawla	150	0.143	(0.104-0.246)	0.572	(0.430-0.966)	2.59 ± 0.563	0.517 (3)	0.915	_
Upper Awash	150	0.690	(0.533 - 0.890)*	2.690	(1.863 - 4.894)	2.17 ± 0.313	0.433 (3)	0.933	4.83
Werer	150	1.257	(0.980 - 1.690)*	4.814	(3.146 - 9.990)	2.20 ± 0.331	0.044 (3)	0.998	8.79
Gewane	150	0.922	(0.717 -1.207)*	3.633	(2.446 - 7.017)	2.15 ± 0.314	0.203 (3)	0.977	6.45
Squared dip									
Location	N	LC_{50} µl/ml	95% CL (lower-upper)	LC_{90} µl/ml	95%CL (lower-upper)	The fit of probit analysis			RR
						Slope ± SE	χ^2 (df)	P	
Gofa-Sawla	150	0.155	(0.097 - 0.234)	0.515	(0.391 - 0.870)	2.74 ± 0.626	0.884 (3)	0.829	_
Upper Awash	150	0.563	(0.400 - 0.758)	3.111	(1.970 - 7.063)	1.727 ± 0.287	0.104 (3)	0.9913	3.63
Werer	150	1.435	(1.137-1.899)*	4.712	(3.199-9.103)	2.48 ± 0.371	1.689 (3)	0.639	9.25
Gewane	150	1.171	(0.935-1.504)*	3.751	(2.643-6.632)	2.53 ± 0.359	0.865 (3)	0.834	7.55

N= total number of larva used for probit analysis, LC_{50} = median lethal concentration, LC_{90}= the lethal concentration which killed 90% of the test H. armigera population, 95%CL= the lower and the higher confidence limits at which the LC_{50} and LC_{90} value can fall at 95% probability, SE= standard Error, χ^2 =Chi-square, RR (Resistance Ratio) = LC_{50} of the field population / LC_{50} of Goffa-Sawla population, superscript denoted astric=the collected H. armigera populations were not significantly different (P<0.05) among each other in their susceptibility to deltamethrin insecticide*

Alphacypermethrin

Alphacypermethrin caused 100% *H. armigera* larva mortality at field rate (1.0 x 10^{-3}g. a.i/ml) on Werer, Upper-Awash, and Gewane populations in both bioassay methods (Table 5). Subsequent dilutions of the insecticide resulted in lower percent mortality of larva to alphacypermethrin (Tables 5).

Probit analysis Goffa-Sawla population was significantly different (P <0.05) from Werer, Upper-Awash, and Gewane populations with non-overlapping 95% CL (Table 6). The resistance ratio in the range of 1.86-1.93 in the larval immersion method (Table 6) and 1.76-1.94 in the square dip techniques (Table 6). The level of resistance to alphacypermethrin was comparatively lower compared with other compounds of the pyrethroids group (lambda-cyhalothrin and deltamethrin) tested.

Alphacypermethrin insecticide is applied one time during peak squaring and flowering period. That could be the reason for a high level of *H. armigera* mortality compared to other insecticides evaluated in this study. Alphacypermethrin is a newer insecticide in the study areas and has not been widely used compared to the other tested insecticides. Alpha-cypermethrin, a third-generation pyrethroid is now one of the top-selling insecticides globally (BASF Chemical Company, 2014). Therefore, alphacypermethrin could be used for the resistance management program as one of the insecticides in the alternation scheme.

Table 5. Percent of mortality of 3rd instar *H. armigera* larvae in different concentrations of alphacypermethrin 100G/L 72 hours after treatment with larva immersion bioassay and 48 hours in squared dip bioassay (29 ± 2^0C 48±4% RH) on Gofa Sawla, Upper Awash, Werer and Gewane populations (N=30).

larva immersion					squared dip				
Concentration (µl/ml)	Percent mortality				Concentration (µl/ml)	Percent mortality			
	Gofa Sawla	Upper Awash	Werer	Gewane		Gofa Sawla	Upper Awash	Werer	Gewane
1.5	100	100	100	100	1.5	100	100	100	100
0.75	100	100	96.7	100	0.75	100	93.3	96.7	90.0
0.375	100	90.0	83.3	83.3	0.375	100	80.0	83.3	76.7
0.1875	90.0	73.3	73.3	63.3	0.1875	86.7	76.7	66.7	56.7
0.09375	76.7	60.0	53.3	46.7	0.09375	70.0	60,0	53.3	43.3
0.046875	56.7	43.3	40.0	30.0	0.046875	53.3	36.7	36.7	26.7
0.0234375	26.7	16.7	16.7	10.0	0.0234375	23.3	16.7	16.7	10,0
Control	0	0	6.7	6.7	Control	10.0	0	3.3	6.7

Table 6. Comparative toxicity of alphacypermethrin 100G/L to *H. armigera* populations in larva immersion and squared dip study.

Larva immersion									
Location	N	LC_{50} µl/ml	95% CL (lower-upper)	LC_{90} µl/ml	95%CL (lower-upper)	The fit of probit analysis			RR
						Slope ± SE	χ^2 (df)	P	
Gofa-Sawla	180	0.043	(0.031 - 0.055)	0.157	(0.114-0.265)	2.28 ± 0.366	0.992 (3)	0.803	_
Upper Awash	180	0.070	(0.051-0.091)*	0.335	(0.232 - 0.591)	1.88 ± 0.261	2.039 (4)	0.729	1.62
Werer	180	0.080	(0.057 - 0.107)*	0.471	(0.310 - 0.922)	1.66 ± 0.236	0.978 (4)	0.913	1.86
Gewane	180	0.083	(0.078 - 0.133)*	0.459	(0.318 - 0.806)	1.97 ± 0.256	2.62 (4)	0.620	1.93
Squared dip									
Location	N	LC_{50} µl/ml	95% CL (lower-upper)	LC_{90} µl/ml	95%CL (lower-upper)	The fit of probit analysis			RR
						Slope ± SE	χ^2 (df)	P	
Gofa-Sawla	180	0.049	(0.036 - 0.063)	0.186	(0.134 - 0.320)	2.21 ± 0.347	1.666 (3)	0.664	_
Upper Awash	180	0.079	(0.055 -0.107)*	0.528	(0.338-1.096)	1.55± 0.228	1.648 (4)	0.8001	1.62
Werer	180	0.086	(0.062 -0.115)*	0.516	(0.336-1.029)	1.65 ± 0.234	0.977 (4)	0.9133	1.76
Gewane	180	0.095	(0.100-0.185)*	0.852	(0.527-1.871)	1.61± 0.226	0.743 (4)	0.9459	1.94

N= total number of larva used for probit analysis, LC_{50} = median lethal concentration, LC_{90}= the lethal concentration which killed 90% of the test H. armigera population, 95%CL= the lower and the higher confidence limits at which the LC_{50} and LC_{90} value can fall at 95% probability, SE= standard Error, χ^2 =Chi-square, RR (Resistance Ratio) = LC_{50} of the field population/LC_{50} of Goffa-Sawla population, superscript denoted astric=the collected H. armigera populations were not significantly different (P <0.05) among each other in their susceptibility to alphacypermethrin insecticide*

Conclusions

The modern-day observation showed a discount in efficacy and the development of a low level of resistance withinside the *H. armigera* populace to lambda-cyhalothrin at Werer and Gewane examined locations. The efficacy of deltamethrin turned into a reasonable decrease and had a better resistance ratio in comparison to lambda-cyhalothrin in Werer and Gewane locations. *H. armigera* may have resistant to deltamethrin; thus, there may be a want to update it with a new pesticide with an extraordinary mode of action. These pesticides had been used for a long time to manipulate cotton bollworms and sucking pests. Alphacypermethrin insecticide may be used for the resistance management program as one of the pesticides withinside the alternation scheme. The observation

protected a constrained range of pesticides out of the commercially registered cotton *H. armigera* manage in Ethiopia. Future research is had to reveal the extent of insecticide resistance

Declarations

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Conflict of interest statement

The authors declare no conflict of interest.

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Figures

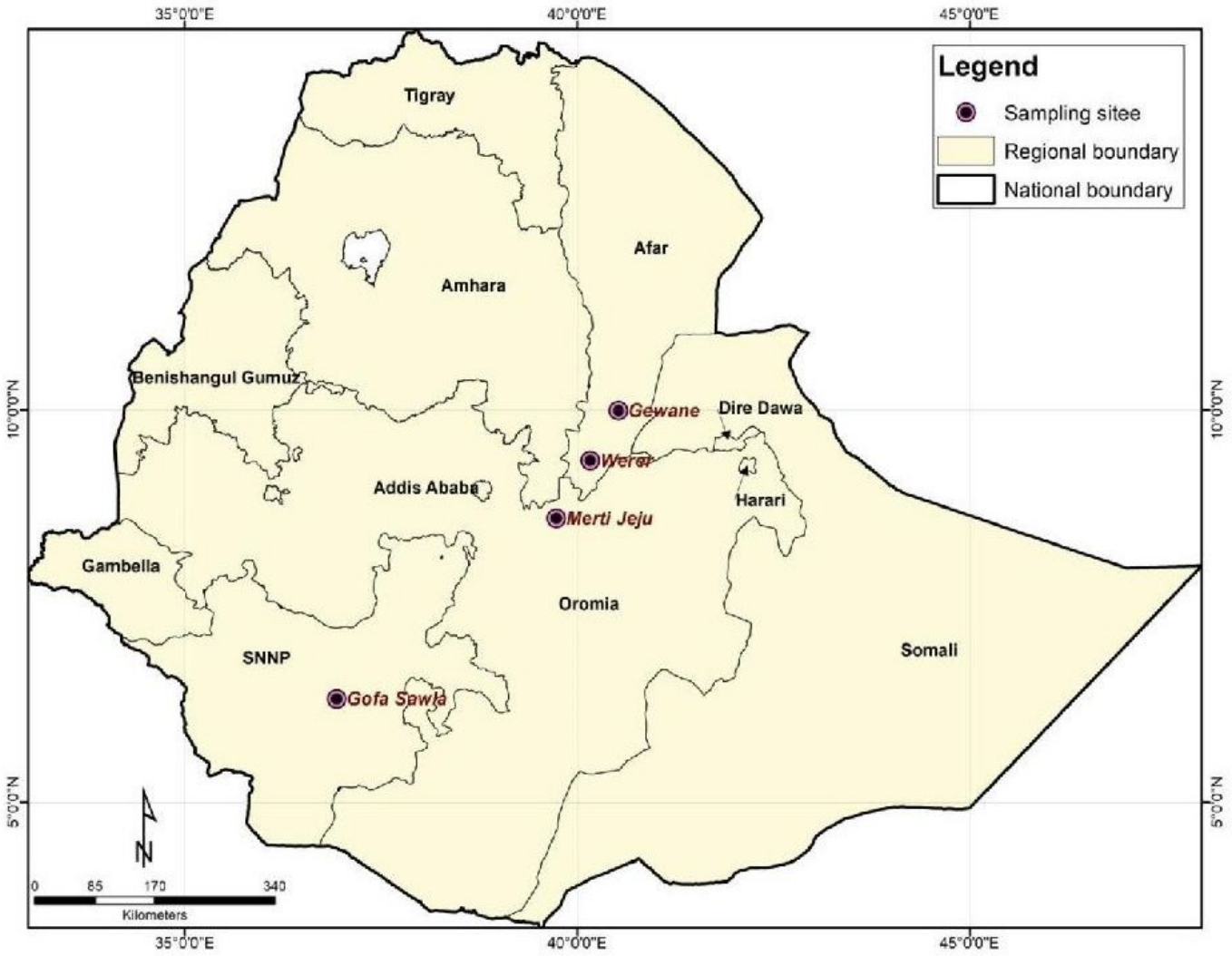

Figure 1

Map of Ethiopia showing sampling location of H. armigera larvae collection.

Figure 2

Adult rearing and hatched larva feeding (A) Adult rearing cage with sugar immersed cotton wool (B) H. armigera adult on top and side of the cage (C) Collection of hatched larva from the adult cages (D) Feeding larva with cotton