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Research Article

Efficacy of insecticides against chickpea pod borer (*Helicoverpa armigera*) at Sodo district Gurage Zone, Southern Ethiopia

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Abstract

Pod borer is a major insect pest constraining chickpea production in southern Ethiopia. This experiment was then conducted in the Sodo district with the objective to evaluate the efficacy of different insecticides for the control of pod borer of chickpeas. The experiment was conducted using one chickpea variety; Habru and five insecticides Diaznon (1.2l/ha), Diamethoate (1L/ha), Apron star (600g with 500l of water ha^{-1}), Endosulfan (250g/ha) and Karate (400ml/ha). The result revealed that all insecticides were effective against pod borer with differences in the percent of larval population reduction. The pod borer damage reduction by insecticide treatment ranged from 35.4% to 68.6 % and 39.5% to 76.7% compared to that in control. Diazinon and Karate resulted in a maximum seed yield of 1561.20 kg/ha and 1498.90 kg/ha, in 2017 and 1391.40kg/ha, 1421.29 kg/ha in 2019, respectively. The highest larval reduction was obtained from a plot treated with Diaznon followed by Karate 5% EC 68.6%, 64% during the 2017 cropping season respectively and in the 2019 cropping season highest larval reduction was obtained from a plot treated with insecticide Karate 5% EC 76.7% followed by Diaznon treated plot 67.2%. In both 2017 and 2019 experimental years better yield increment was recorded from Diaznon and Karate 5% EC treated plot. During the 2017 cropping season, the maximum yield increment was obtained from Diaznon treated plot at 27.3% followed by Karate at 24.2% while in the 2019 cropping season, Karate 5% EC treated plot yield increased by 32.6% followed by Diaznon treated plot 31.2%. Thus, chickpea growers in the area should prefer a mix of Karate and Diaznon 5% EC for better pod borer management.

Keywords: Chickpea; *Helicoverpa armigera*; Insecticides; Pod borer

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1. Introduction

Ethiopia is considered as secondary center of genetic diversity for chickpea and the wild relative of cultivated chickpea (*Cicer arietinum* L.). An average chickpea yield in Ethiopia on farmers field is usually below1t/ha although it's potential is more than 5t/ha (Melese, 2005). Chickpea is susceptible to a number of insect pests, which attack on roots, foliage and pods. Among insect pests, chickpea pod borer (*Helicoverpa armigera*. Hubner) is a major constraint for lower yield of chickpea in Ethiopia by feeding on all stages of the crop from seedling to maturity and generally cause 37- 50 % loss in grain yield (Iqbal et al., 2014; Ahmed & Awan, 2013). Chickpea pod borer successfully established as key insect pest of chickpea crop in spite of acid exudates on plant parts which deter insect foraging.

It is highly polyphagous insect feeding on many other crops such as cotton, tobacco, safflower, tomato, maize, cabbage, peanuts and pulses (Javed, 2013) Chickpea pod borer (*Helicoverpa armigera* Hubner) (*Lepidoptera:Noctuidae*) is a major field insect pest affecting pulses in several agro-ecological zones. Single larva can damage 40pods and selectively feeds up on growing points and reproductive parts of the host plant. The 1^{st}, 2^{nd}, and 3^{rd} instar larvae initially feed on the foliage (young leaves) of chickpeas and a few other legumes, but mostly on the flowers and flower buds of cotton, pigeon pea, etc. Larvae shift from foliar feeders to developing seeds and fruits as larval instar development progresses. Larger larvae bore into pods and consume the developing seeds inside the pod. It feeds on floral buds, flowers and young pods of the growing crop (Khan, 2009). Mostly, leaving out all other approaches of insect management insecticides application appears as an easy, popular and effective technique.

There is a high infestation of pod borer on chickpea, in chickpea growing districts of Gurage Zone (Damtew & Ojiewo, 2017). *H. armigera* control with insecticide on chickpea is not common in Ethiopia; rather the majority of the farmers follow a "do nothing" strategy. Ethiopian agriculture is fast transforming from subsistence to commercial farming system and use of pesticides is expected to increase rapidly as scales of production increase. The indiscriminate use of pesticides to tackle losses caused by *H. armigera* can increase cost of production, affect human health, biodiversity and the environment. Besides, several chemical control methods have been evaluated but the pest keeps developing resistance to synthetic chemicals (Lande & Sarode, 1995).

Therefore, judicious use of pesticides following established guidelines and in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment is recommended. However, the wise use of effective insecticides is important to avoid their drastic side effects on the environment, humans, animals and natural bio-control agents (Suhail, 2013). For effective insecticide chemicals for the management of this insect pest (pod borer) is required. Thus, to alleviate such limitation the experiment was initiated to evaluate the efficacy of five insecticides against chickpea pod borer (*Helicoverpa armigera* Hubner) under field conditions.

2. Materials and Methods

2.1. Description of study area

The experiment was done at the Sodo district during the 2017-2019 crop seasons. The location is suitable for the experiment because pod borer appears in the area every year under natural conditions. Specifically, the experiment was conducted at a location of $8^0$19'N latitude and $38^0$39'E longitude with an altitude of 1947 meter above sea level. According to meteorological data the average annual rainfall is 1050mm ranging between 800mm and 1200mm with average minimum and maximum temperature of 13^0C and 30^0C. Sodo is characterized by a verity ofsoil type.

The chickpea variety Habru was used as per standard agronomic practices during 2017-2019. The plot size was 1.8m × 2m (3.6m^2), keeping the spacing of 30×10 cm between rows and plants, respectively.

2.2. Treatments and experimental design

The experiment was conducted using one chickpea variety; Habru. Fiveinsecticides namely Diaznon (1.2l/ha with 100L of water ha^{-1}), Diamethoate (1L/ha with 150L of water ha^{-1}), Apron star (600g with 500ml of water ha^{-1}), Endosulfan (250g/ha with 1000ml of water ha^{-1}) and Karate (400ml/ha with 150-200L of water) were used in the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were six treatments including the control. All the treatments were administered in the field as the foliar spray applied manually with a knapsack sprayer. Insecticideswere sprayed at their recommended doses. A distance of 100 cm between the plots and 150 cm between the replications was maintained as the buffer zone.

2.3. Data collection

Observations were started after 30 days of sowing in one-meter length from each plot during the vegetative stage so to determine the economic threshold level (one larva per meter per row) of chickpea pod borers for timely application of chemicals. Five plants were selected at random from each treatment and the population of gram pod borer was observed to record the number of larvae plant^{-1} of chickpea.

The sprays of particular treatment were applied when the larval population was above the ETL to protect the crop from further heavy losses. Post treatment data on the percentage mortality of caterpillars of pod borers was taken after 7 days, for comparison with pretreatment observation (24 hours before spray). The data from the five sprays were pooled and the average percent mortality was calculated. The mean percent reduction of pod borer's population with respect to pre-treatment data was calculated by the formula given by Abbott et al. (1925). The reduction and yield increase percentage of the larvae was recorded by counting of the larval population over check (Eqs. 1-2).

$$LR (\%)= \frac{\text{Total larval population} - \text{Number of larval population after spray}}{\text{Total number of larval population}} \times 100 \quad (1)$$

$$PYIC (\%) = \frac{\text{Larval population of sprayed} - \text{Larval population ofunsprayed}}{\text{Larval population of sprayed}} \times 100 \quad (2)$$

Where, % LR = Percentage of larval reduction, PYIC = Percentage of yield increase over check

2.3.1. Pod Damage in percent (%)

On maturity of crop, the percent pod damage was determined by counting total number of pod and number of damaged pods from randomly selected five plants out of each treatment, using formula shown below. Percentages of pod damage (Eq. 3), relative yield loss (Eq. 4), and yield increase (Eq. 5) were calculated based on the equestions given here.

$$\text{Pod damage } (\%) = \frac{\text{Total pods produced per plant} - \text{Number of undamaged pods}}{\text{Total number of pods produced}} \times 100 \quad (3)$$

$$RYL (\%) = \frac{\text{Yield of maximum protected} - \text{Yield of other treatment}}{\text{Yield of maximum protected}} \times 100 \quad (4)$$

$$YI (\%)= \frac{\text{Grain yield of treated plot} - \text{yield of control plot}}{\text{Yield of control plot}} \times 100 \quad (5)$$

2.3.2. Grain yield

The yield of grains per plot was recorded at harvesting including control and this was converted into Kg/ha. Data on the larval population of Helicoverpa armigera caterpillars, pod damage and yield corresponding to each treatment was subjected to statistical analysis.

2.4. Statistical analysis

The data collected during experimentation was analyzed statistically by using analysis of variance (ANOVA) and means were separated by least significance difference (LSD) test at a 5% probability level using SAS version 2.0.

3. Result and Discussion

Data collected on the comparative efficacy of five insecticides tested for the management of pod borer on Chickpea was presented in tables.

3.1. Larval population

Five plants were randomly selected from each plot. The result revealed that insecticides were effective against pod borer even if they have different percent larval reductions in both years.

In 2017, according to the data in Table 1 the pest population of Helicoverpa armigera ranged from 2.83 to 3.53 larvae per plant before spray and 1.10 to 3.50 after spray during the season. It indicated that the pest was active during December. This period coincided with the flowering and pod formation stage of the crop. The pod borer damage reduction by different treatments ranged from 35.4% to 68.6 % compared to the control. The highest pod borer larval reduction 68.6 % was found in Diaznon sprayed plot followed by Karate5% EC 64 %

sprayed plot. The efficacy of these insecticides was supported with the result of Suneel Kumar & Sarada (2015) who recorded the lowest number of *Helicoverpa armigera* larva in plots treated with chlorantraniliprole 20% SC against an unsprayed control plot.

Table 1. Average larval populations of pod borer (*Helicoverpa armigera*) on chickpea before and after spray of insecticides in 2017 cropping season.

Insecticides	Mean larval population/Plant		Reduction % over check
	Before spray	After spray	
Control	2.83	3.50	_
Apron star	2.93	2.26	35.4
Endosulfan	3.50	1.35	61.4
Karate	3.46	1.26	64.0
Diaznon	3.53	1.10	68.6
Diamethoate	3.36	1.67	52.3

In 2019 the result revealed that Karate was effective against pod borer. The data summarized in Table 1 revealed that the pest population of Helicoverpa armigera ranged from 1.73 to 1.90 larvae per plant before spray and 0.60 to 2.58 after spray during the season. The pod borer damage reduction by different treatments ranged from 39.5 % to 76.7 % compared to control. The highest pod borer larval reduction 76.7% was found at Karate 5% EC sprayed plot followed by Diaznon 67 % sprayed plot. The present study was in agreement with the findingby Dagne et al. (2018) who reported that the highest pod borer larval reduction (90.63%) was found on Diaznon sprayed plot followed by Karate 5% EC (71.87%) treated plot.

Similar findings were reported by Chowdary et al. (2010), chlorantraniliprole was highly effective against *Helicoverpa armigera in okra.* The insecticide Apron star showed the least effective against chickpea pod borer which was in consistent with the work of Khanna et al. (2009) reported that NSKE 5% was the least effective against the pod borer of chickpea among the different insecticidal treatments during both experimental both years.

Table 2. Average larval populations of pod borer (*Helicoverpa armigera*) on chickpea before and after spray of insecticides in 2019 cropping season.

Insecticides	Mean larval population/Plant		Reduction % over check
	Before spray	After spray	
Control	1.81	2.58	-
Apron star	1.90	1.56	39.5
Endosulfan	1.73	0.98	62.0
Karate	1.90	0.60	76.7
Diaznon	1.82	0.85	67.0
Diamethoate	1.73	0.90	65.2

3.2. Yield of chickpea

The data of seed yields (kg/ha) and increased percent over check is presented in Table 2. From the result obtained at Sodo, Diaznon resulted maximum seed yield 1561.20 kg/ha, followed by Karate 5% EC1498.90 kg/ha, and where as the minimum seed yield 1135.58

kg/ha on unsprayed plot. Maximum percent of seed yield 27.3 % was increased over check by Diaznon. The second maximum percent of seed yield 24.2% was increased over check by Katare5% EC. The present finding is in agreement with work of Sreekanth et al. (2014) who reported the lowest pod damage and highest seed yield was obtained from plots treated with chlorantraniliprole.

Table 3. The grain yield of chickpea at Sodo 2017/18 cropping season

Treatment	GY(kg/ha)	Percent yield increase over check
Control	1135.58	-
Karate	1498.90	+24.2
Apron Star	1137.90	+0.2
Endosulfan	1466.70	+22.6
Diaznon	1561.20	+27.3
Diamethoate	1459.00	+22.2

GY=Grain Yield; kg=Kilogram; +=Iincrement

In 2019, Karate 5% EC resulted maximum seed yield 1421.29 kg/ha, followed by Diaznon 1391.40 kg/ha, and where as the minimum seed yield 957.67 kg/ha on unsprayed plot (Table 4). Maximum percent of seed yield 32.6% was increased over check by Karate 5%EC. The second maximum percent of seed yield 31.2% was increased over check by Diaznon. Similarly, Adsure and Mohite (2015) reported that Rynaxypyr treated plots had maximum yield and minimum pod damage by pod borer in comparison to indoxacarb and spinosad.

Table 4. The grain yield of chickpea at Sodo 2019/20 cropping season.

Treatment	GY (kg/ha)	Percent yield increased over check
Control	957.67	-
Karate	1421.29	+32.6
Apron Star	1134.60	+15.6
Endosulfan	1333.40	+28.2
Diaznon	1391.40	+31.2
Diamethoate	1389.00	+31.0

GY: Grain Yield; kg: kilogram; ha: hectare; +: increment

3.3. Economic analysis of insecticidal treatment

In 2017, the result showed that Diaznon sprayed plot provided the highest gross returns (ETB 62,440/ha) and the low gross return (ETB 45,400/ha) was computed from the untreated plot (Table 5). The plot sprayed with Diaznon gave the maximum net return ETB 61,890 /ha and the unsprayed plot gave a low net returns birr 45,400/ha (Table 5).

In 2019, Karate 5EC sprayed plot provided the highest gross returns (ETB 63,958/ha) and the lowest gross return ETB 43,095/ha was computed from untreated. The plots sprayed with karate 5EC gave the maximum net return ETB 63,005/ha. The unsprayed plot gave comparably low net returns ETB 43,095/ha (Table 6).

Table 5. Return and economic analysis of treatment for the control of Ppod borer in chickpea during the 2017/18 cropping season

Treatment	Yo (kg/ha)	Sale price (ETB/kg)	Fc and Ac (ETB/ha)	Gross return (Price x kg)	Net return ((GR- (Fc + Ac))
Control	1135.58	40	-	45,400	45,400
Karate	1498.90	40	840	59,920	59,080
Apron star	1137.90	40	300	45,480	45,180
Endosulfan	1466.70	40	600	58, 640	58,040
Diaznon	1561.20	40	550	62, 440	61,890
Diamethoate	1459.00	40	600	58, 360	57,760

Yo=Yield obtained Fc=Fungicide cost; Ac=Application cost; GR=Gross return; ETB=Ethiopian birr

Table 6. Return and of economic analysis treatment for the control of pod borer in chickpea during 2019/20 cropping season

Treatment	Yo (kg/ha)	Sale price (ETB/kg)	Fc & Ac (ETB/ha)	Gross return (Price x kg)	Net return ((GR- (Fc +Ac))
Control	957.67	45	-	43,095	43,095
Karate	1421.29	45	940	63,958	63,005
Apron star	1134.60	45	700	51,056	50,330
Endosulfan	1333.40	45	750	60,003	59,253
Diaznon	1391.40	45	650	62613	61,963
Diamethoate	1389.00	45	700	62505	61,805

Yo=Yield obtained; Fc=Fungicide cost; Ac=Application cost; GR=Gross return; ETB= Ethiopian birr

4. Conclusion

The result revealed that Diaznon and Karate5% EC were the most effective insecticides to give high mortality of pod borer on chickpea under field conditions. The most economical benefit for pod borer management was obtained from Diaznon sprayed plot and followed by Karate sprayed plots. It has been indicated from the present study that insecticides such as Diaznon and Karate were the most effective against the pod borer on chickpea resulting in the maximum reduction of the percentage of larval population even if they have a slight difference on efficacy at both years. Farmers should have used both insecticides for the management of pod borer in chickpea. One insecticide can be used in the absence of the other as an option/alternative to increase productivity and also quality of chickpea. Therefore, we suggested/recommended that these effective insecticides (Karate %EC and Diaznon) in mixed up at recommended rate were suggested to the growers for management of the pod borer population below economic threshold level under field conditions and to inhibit the resistance development of the pest.

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Conflict of the Interest

The authors declare that there is no conflict of interest

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