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Efficacy of Insecticides and Crop Critical Stage for the Management of Chickpea Pod Borer [*Helicoverpa armigera*] in Central Zone of Tigray, Ethiopia

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ABSTRACT

Chickpea pod borer (*H.armigera*) is a major insect pest constraining chickpea production in Tigray, northern Ethiopia; as there was no recommended management option in the area. Therefore the present study was conducted to assess the efficacy of insecticides and to determine the critical growth stage of the crop for effective spray at Axum agricultural research center. Results indicated that in laboratory profit72% EC (profenofos), abema 3%EC (abamectin20g/l + emamectin benzoit 10g/l), perfecto (imedachloprid + lambda-cyhalothrin) and hamectin (abamectin) reduced the number of larvae by (75, 55, 44 and 34%); (86, 82, 65, 56%) and (83, 83, 66 and 83%) 24, 48 and 72 hours after spray, respectively. Similarly abema 3%EC and profit (Profenofos) 72% EC were the most effective insecticides to give high mortality of pod borer on chickpea under field conditions. These insecticides reduced the number of larva per plant by 51-56.7% five days after spray. The number of damaged pods per plant were very low in both insecticides (0.91 and 1.05) but on the untreated check 3.05. The highest yield was also obtained from chickpea treated with abema 3%EC at podding stage (23.92qt/ha). Comparatively the most effective insecticides against pod borer were abema and profit and the best application time were at podding stage of the crop. Thus chickpea growers in the area should prefer these insecticides for better pod borer management.

Keywords: Chickpea, H. armigera, insecticides, growth stage .

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a legume crop of the Fabaceae family originated in present day south eastern Turkey and adjoining Syria (Sexena and singh, 1987). It is the second most important food legume in the world after common bean.The major chickpea-producing countries are India (67.41%), Australia (6.21%), Pakistan (5.73%), Turkey (3.86%), and Myanmar (3.74%) (FAOSTAT 2015). Ethiopia is considered as secondary center of genetic diversity for chickpea and the wild relative of cultivated chickpea (*Cicer arietinum* L.), is found in Tigray region (Yadeta et al., 2002; Dagne et al., 2018). In Ethiopia the area coverage and the volume of production of chickpea in 2017/2018 was 242703.73 ha and 4994255.5 quintal with average productivity of 2.05 ton/ha. It contributed 15.18% of Ethiopia's total pulse production and stood second after fababeans (CSA, 2017/18). It has the ability to grow on residual moisture which gives farmers the opportunity to engage in double cropping, since chickpea is sown at the end of the rainy season.

Nutritionally chickpea contains 24% protein, 59.6% carbohydrates, and 3.2% minerals (Bakr et al. 2004). Its fiber reduces cholesterol and regulates blood sugar. Hence, it is an important crop as source of food and income commonly used as a green vegetable (Yasin, 2014). It is very important component of cropping systems which can fix up to 140 kg N per ha from air and meet most of its nitrogen requirement. Increases substantial amount of residual nitrogen for subsequent crops and adds some amount of organic matter to maintain and improve soil health and fertility. It saves the fertilizer input cost not only for chickpea but also for the subsequent crops. Chickpea production is important for crop rotation with cereals such as wheat and tef which are widely grown in relatively well-drained black soils (Menale *et al*., 2009)

However, the production of chickpea is challenging because of different insect pests and diseases such as pod borers, cut worms, aphids, jassids, thrips, whitefly and the storage pests (bruchids) are the most devastating pests of chickpea in Asia, Africa, and Australia. Among these gram pod borer *H. armigera* (Hubner) (Lepidoptera: Noctuidae) is a serious obstacle and become a global concern for the production of chickpea.This pest is a cosmopolitan, multi-voltine and highly polyphagous, which attacks a number of crops which have agricultural importance throughout the world (Dabhi and Patel, 2007). Fitt (1989) recorded the crops of maize, sorghum, cotton, common bean, peas, chickpeas, tomatoes, capsicum, vicia and to a lesser extent, okras, cabbages, lettuces, strawberries, tobacco, sunflowers, and many of the other legumes as host plants of the pest. Pod borer is a key pest of chickpea causing 90-95% total damage (Sachan and kathi, 1994). It can cause damage up to 100% in unprotected chickpea fields (Tsedeke *et al*., 1982; Sarwar *et al*., 2009). A single *H. armigera* larva can damage up to 40 pods throughout its larval stage (Khan *et al*., 2009). The chickpea economic threshold is one pod borer larva per one meter row length (Zahid et al., 2008).

Different management options have been practiced against pod borer in different areas and years. Cultural practices such as inter cropping, deep ploughing, trap crops and sowing date have been reported to reduce the survival and damage of *H. armigera* (Romeis *et al*., 2004). Extracts from different parts of neem tree (neem leaf, neem oil and neem seed kernel 5%) influenced negatively both the survival and feeding of the larva of *H. armigera* (Mesfine *et al*., 2012). Insecticides monocrotophos 36 WC, endosulfan 35 EC, carbaryl WP, cypermethrin 25 EC, indoxacarb 14.5 SC, Profenofos 50 EC and coragen 20 SP showed the highest mortality of *H. armigera* larvae on chickpea (Iqbal *et al*., 2014). Mesfin *et al*. (2012) reported synthetic insecticides have resulted in fast and effective pest control and the present study was initiated to select the best insecticides as well as to determine the growth stage of the crop for effective foliar spray against chickpea pod borer.

MATERIALS and METHODS

Description of the study area

The experiment was conducted at Axum agricultural research center (AxARC) research site in Laelay-mychew district which is 3 km east of Axum town. The study area is located at $13^{0}15'40.2''$ N latitude and $38^{0}34'45.8''$E longitude with an altitude of 2148 masl. It is located in northern part of the country in central zone of Tigray region in the semiarid tropical belt of Ethiopia with "*weinadega*" agro climatic zone. It is characterized by low and erratic rainfall with mean minimum and maximum range of 500 to 782.8mm. The rainy season is mono modal concentrated in one season from July to September. The daily average minimum and maximum temperatures are12.6^{0}C and 25.51^{0}C, respectively. The soil type is classified as vertisol with a characteristic feature of clay soil type with P^{H} 7.19.

Treatments and experimental design

The experiment was conducted both at field and laboratory in the same season. It was designed in a factorial randomized complete block design (RCBD)

Table 1. Treatment combinations

Trade name	Common name	Chemical group	Dose Lha^{-1}	Application time
Profit 72% EC	Profenofos	organophosphate	0.75	A,B,C
Agrothoate40% EC	Dimethoat	organophosphate	1	A,B,C
Con-fidence	Imedachloprid	neonicotinoids	0.4	A,B,C
Perfecto	imedachloprid+lambda-cyhalothrin	-	0.4	A,B,C
Hamectin3.6% EC	Abamectin	avermectins	1	A,B,C
Abema3% EC	abamectin20g/l+emamectin benzoit 10g/l	avermectins	1	A,B,C
Untreated	--	-	-	-

Where A,B,C were each insecticide applied twice; (A) Before flowering, (B) at 50% flowering stage and (C) at podding stage

with three replications at field and CRD in the laboratory. Chickpea seed (Dalota variety) was used as planting material.The field was ploughed using oxen and harrowed manually to bring the soil to fine tilth. Fertilizer NPSZnB at the rate of 100kg/ha were used during sowing date. The plot size was 3 x $3m^2$. To manage the chemical drift among plots, spacing between reps and plots were 2 and 1.5m; spacing between rows and plants 30 and 10 cm, respectively.One liter capacity hand sprayer were used for each insecticide to manage the chemical mixtures. Each insecticide was sprayed twice at different growth stage of the crop. Spray was done at wind free time of the day early in the morning up to 2 o'clock. The insecticides were applied at manufacturer rates. Cultivation, weeding and all recommended agronomic practices were performed accordingly.

Data collection

Number of pod borer larva, damaged pods and total pods per plant were collected from five randomly selected and tagged plants in each treatment. the yield were taken from theharvested net plot area excluding the borders. the infestation percentage were captured using the formula

Infestation percentage

$$= \frac{Totalnumberofdamagedpods\ per\ plant}{Totalnumberofpodsoftheplant} x100$$

pod borer larvareduction percentage

$$= \frac{\text{Mean of untreated Mean of treated}}{\text{Mean of untreated}} x100$$

All collected data were analyzed using SAS version 9.1 software and the insect data were transformed using square root transformation before analysis.

RESULTS AND DISCUSSION

The data collected on the comparative efficacy of different insecticides against chickpea pod borer larva tested in laboratory and at field was presented in tables below.

Efficacy of treatments on *H. armigera* larvae population in laboratory and at field

The result showed that all treatments were significantly different ($P<0.05$) from the untreated control after treatment application in the laboratory. profenofos and abema were effective in killing the larvae 24 hours after spray. Moreover, effectiveness of these insecticides varied with the time intervals, maximum effect was found after 72 hours of intervals. Out of thirty 3^{rd}-4^{th} instar larvae only three alive larvae were observed on treatments with profenofos, abamectin20g/l+emamectin benzoit 10g/l and hamectin after 72 hours of spray. However, the immediate killing action within 24 hours of time was observed on profenofos then abamectin 20g/l+ emamectin benzoit 10g/l which reduced the larva by 75 and 55% respectively. The highest reduction percentage up to 83% was observed 72 hours after spray with profenofos and abamectin 20g/l+ emamectin benzoit 10g/l treated plots (Table 2).

In the field experiment insecticide treated plots were significantly different from the untreated control even though there was difference in effectiveness between insecticides. The number of larvae increased with the crop phenological growth. The highest larvae population was recorded at podding stage before treatment application. There was statistical difference in larvae population among treatments before insecticide application; before flowering, at 50% flowering and podding. The lowest number of larvae per plant was observed on the treated plots and the highest on the untreated plots. Three days after treatment application before flowering all insecticides were effective to reduce the larvae population but after time intervals the insecticides lost their effectiveness and consequently the infestation increased again to damage the pods.

Table 2. Effect of different insecticides on 3rd-4th instars larva of chickpea pod borer after spray in laboratory

Treatments	No of larva before spray	24h after spray		48h after spray		72h after spray	
		No. of alive larva	Reduction %	No. of alive larva	Reduction %	No. of alive larva	Reduction %
Profit	30	7^{d}	75.86	3^{d}	86.95	3^{c}	83.33
Agrothoate	30	21^{b}	27.58	15^{b}	34.78	10^{b}	44.44
Confidence	30	21^{b}	27.58	12^{bc}	47.83	10^{b}	44.44
Perfecto	30	16^{bc}	44.83	8^{cd}	65.22	6^{c}	66.67
Hamectin	30	19^{bc}	34.48	10^{bc}	56.52	3^{c}	83.33
Abema	30	13^{c}	55.17	4^{d}	82.61	3^{c}	83.33
Un treated	30	29^{a}	-	23^{a}	-	18^{a}	-
Lsd(0.05)		5		5		3.8	
Cv(%)		17		27		28	

Table 3. Field efficacy of different insecticides on chickpea pod borer larva after spray

Treatments	No of larva before spray	No of larva 3days after spray	Reduction %	No of larva 5 days after spray	Reduction %
Profit x A	1.27^{f}	1.05ij	49.76	0.95^{jk}	54.76
Profit x B	1.75^{abc}	1.31^{ghf}	37.32	1.05^{hijk}	50.00
Profit x C	1.68^{cb}	1.27^{gh}	39.23	1.02^{ijk}	51.43
Agrothoate xA	1.47^{de}	1.37^{efgh}	34.45	1.29^{cdef}	38.57
Agrothoate xB	1.69^{bc}	1.57^{bcde}	24.88	1.43^{c}	31.90
Agrothoate xC	1.86^{ab}	1.78^{b}	14.83	1.70^{b}	19.05
Confidence xA	1.43^{ef}	1.32^{ghf}	36.84	1.25^{efg}	40.48
Confidence x B	1.78^{abc}	1.49^{def}	28.71	1.36^{cde}	35.24
Confidence x C	1.85^{ab}	1.71^{b}	18.18	1.69^{b}	19.52
Perfecto x A	1.32^{ef}	1.24^{hi}	40.67	1.1^{ghij}	47.62
Perfecto x B	1.79^{abc}	1.55^{cde}	25.84	1.33^{cdef}	36.67
Perfecto x C	1.81^{abc}	1.51^{cdef}	27.75	1.22^{efgh}	41.90
Hamectin x A	1.35^{ef}	1.24^{hi}	40.67	1.16^{fghi}	44.76
Hamectin x B	1.63^{cd}	1.48^{defg}	29.19	1.29^{cdef}	38.57
Hamectin x C	1.92^{a}	1.61^{cbd}	22.97	1.41^{c}	32.86
Abema x A	1.29^{ef}	1.02^{j}	51.20	0.91^{k}	56.67
Abema x B	1.72^{bc}	1.25^{hi}	40.19	1.01^{ijk}	51.90
Abema x C	1.79^{abc}	1.27^{h}	39.23	1.02^{ijk}	51.43
Control (untrt	1.94^{a}	2.09^{a}	0.00	2.10^{a}	0.00
Lsd(0.05)	0.19	0.21		0.17	
Cv%	7.16	8.17		8.17	

Where A,B,C were each insecticide applied twice; A = Before flowering, B = at 50% flowering stage and C = at podding stage

Table 4. Field efficacy of insecticides on chickpea yield and yield components

Treatments	No. of Damaged pods/P	No. of un damaged pods/P	Total no of pods/p	Infestation percentage	Yield qt/ha
Profit x A	1.09^{de}	1.97$^{a\text{-}d}$	1.97^{abc}	1.14^{e}	18.93$^{a\text{-}d}$
Profit x B	1.19^{de}	1.91$^{a\text{-}e}$	1.92^{abc}	1.28^{de}	19.04$^{a\text{-}d}$
Profit x C	1.05^{de}	1.98^{abc}	1.98^{abc}	1.05^{e}	19.41$^{a\text{-}d}$
Agrothoate x A	2.64^{ab}	1.94$^{a\text{-}e}$	1.96^{abc}	2.72^{ab}	18.33$^{a\text{-}d}$
Agrothoate x B	1.26^{de}	1.95$^{a\text{-}d}$	1.96^{abc}	1.29^{de}	16.82^{cbd}
Agrothoate x C	1.64^{cd}	1.78^{f}	1.79^{d}	2.01^{bcd}	17.33$^{a\text{-}d}$
Confidence x A	2.89^{ab}	1.87^{def}	1.92^{abc}	3.17^{a}	19.33$^{a\text{-}d}$
Confidence x B	2.23^{bc}	1.94$^{a\text{-}e}$	1.96^{abc}	2.32^{bc}	17.33$^{a\text{-}d}$
Confidence x C	2.49^{ab}	1.91^{bcde}	1.94^{abc}	2.70^{ab}	20.44$^{a\text{-}d}$
Perfecto x A	1.49^{de}	1.99^{ab}	2^{a}	1.51^{de}	22.59^{a}
Perfecto x B	1.29^{de}	1.89^{cde}	1.90^{bc}	1.41^{de}	18.44$^{a\text{-}d}$
Perfecto x C	1.35^{de}	1.88^{cde}	1.89^{cd}	1.49^{de}	15.96^{cbd}
Hamectin x A	1.63^{cd}	1.98^{abc}	1.99^{ab}	1.67^{cde}	20.85^{abc}
Hamectin x B	1.29^{de}	1.94$^{a\text{-}e}$	1.94^{abc}	1.35^{de}	23.96^{a}
Hamectin x C	1.27^{de}	1.89$^{b\text{-}e}$	1.90^{abc}	1.39^{de}	18.67$^{a\text{-}d}$
Abema x A	1.26^{de}	2.01^{a}	1.99^{ab}	1.29^{de}	14.85^{cd}
Abema x B	1.15^{de}	1.91$^{a\text{-}e}$	1.90^{bc}	1.23^{e}	20.70$^{a\text{-}d}$
Abema x C	0.91^{e}	1.94$^{a\text{-}e}$	1.93^{abc}	0.93^{e}	23.92^{a}
Control (untrt)	3.05^{a}	1.84^{ef}	1.89^{cd}	3.46^{a}	13.78^{d}
Lsd (0.05)	0.70	0.1	0.09	0.77	6.97
Cv (%)	25.9	3.2	3.1	26.5	22.2

Where A,B,C were each insecticide applied twice; A = Before flowering, B = at 50% flowering stage and C = at podding stage

However, these insecticides were also applied at 50% flowering and podding stages of the crop. Table 3 indicated that the lowest number of larva per plant (0.91, 0.95 and 1.2) were observed on abema (abamectin20g/l + emamectin benzoit 10g/l) 3%EC, profenofos 72%EC and perfecto treated plots respectively five days intervals applied before flowering. similarly, at podding stage the number of larva per plant were 1.02 on abamectin 20g/l+emamectin benzoit 10g/l and profenofos treated plots. These insecticides reduced the larval population by 83% after five days of spray intervals at podding stage.

The result showed that all treatments were significantly different from the untreated plot in number of damaged pods and infestation percentage. The lowest damage was recorded in treatments sprayed with abema (abamectin20g/l + emamectin benzoit 10g/l) and profenofos (0.91 and 1.05) at podding. comparatively the best insecticides effective against pod borer were Abema (abamectin20g/l + emamectin benzoit 10g/l) and profenofos. The best application time were at podding stage of the crop. Yield was significantly higher on treatments sprayed with (abamectin20g/l + emamectin benzoit 10g/l) at podding stage and abamectin at 50% flowering stage (Table. 4).

DISCUSSION

The current study was carried out to examine the effect of different insecticides against *H. armigera* on chickpea in laboratory and under field conditions. The result in the laboratory showed that insecticide treatments were significantly effective on killing the *H. armigera* larvae. profenofos, abema, perfecto and hamectin reduced the number of larvae by (75, 55, 44 and 34%) after 24 hours of spray; (86, 82, 65, 56%) after 48 hours and (83, 83, 66 and 83%) 72 hours after spray, respectively. This result was in agreement with Iqbal *et al.* (2014) who studied the efficacy of emamectin 1.9 EC. (emamectin benzoate), lannate 40 SP. (methomyl), coragen 20 SP. (rynaxypyr), match 50 EC. (lufenuron), profenofos 50 EC. (profenofos) tested against *H.armigera* on chickpea observed the highest mortality of larvae in plots treated with profenofos (85%, 90% and 94%) and rynaxypyr (85, 90 and 92%) at 3, 5 and 7 days after treatment, respectively.

The field efficacy of different treatments against *H. armigera* larvae was determined on the basis of number of larvae per plant. The data revealed that all the treatments were significantly superior over control. The lowest number of larvae per plant (0.91, 1.01, 1.02) and (0.95, 1.05, 1.02) was recorded on chickpea treated with abema (abamectin20g/l + emamectin benzoit 10g/l) 3%EC and profenofos 72%EC before flowering, at 50% flowering and podding stage of the crop five days after spray. Reduced the number of larva by (56.7, 51.9, 51%) and (54.8, 50, 51%), respectively; whereas the highest number of H. *armigera* larva per plant (2.10) were recorded on untreated control. The present results revealed with findings by Digne et al.(2018) who reported that the highest pod borer larval reduction (90.63%) was found in Diazenon sprayed plot followed by Karate 5% EC (71.87%) sprayed plot. Similarly, Khan *et al. (*2009) conducted a trial against gram pod borer and to assess comparative efficacy of insecticides (thiodan 40EC, lorsban 40EC, ripcord 10EC, nurell-D (chlorpyrifos + cypermethrin 50 + 500 g/L EC) and methomyl 45 WP). Methomyl was found most effective against the tested pest under field conditions.

The current study showed that all insecticides were effective to reduce the number of damaged pods per plant applied before flowering, at 50% flowering and podding stages of the crop, compared to the untreated check. But before flowering application insecticides lost their effectiveness and increased the pod damage. The lower damaged pods and infestation percentage was recorded on insecticides applied at podding stage of the crop. Abema (abamectin20g/l + emamectin benzoit 10g/l) applied at podding stage gives the minimum damaged pods per plant (0.91) and lower infestation percentage (0.93%) with the highest yield (23.9qt/ha). Savita et al. (2014) reported that the lowest number of surviving population of larvae 0.70 larvae/plant, highest yield recorded 15.00q/ha, lower pod damage 8.10% was recorded on chickpea treated with rynaxypyr 20 SC @ 40 g/ha.

CONCLUSION

The experiment was conducted to assess the efficacy of insecticides against *H.armigera* on chickpea and to determine the critical growth stage of the crop for spray. From the present research study, it was concluded that approaches for chemical management of *H. armigera* were found effective. Spraying insecticides at podding stage of the crop were important. The result revealed that abema 3%EC (abamectin20g/l + emamectin benzoit 10g/l) and profit (Profenofos) 72% EC were the most effective insecticides to give high mortality of pod borer on chickpea under field conditions. These insecticides were highly effective in reducing the number of larva, damaged pods and infestation percentage per plant. The highest yield was also obtained from chickpea treated with abema (abamectin20g/l + emamectin benzoit 10g/l) 3%EC at podding stage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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