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Research Article

Effect of integrating chickpea varieties with insecticides for the management of pod borer (*Helicoverpa armigera Hubner*) (*Lepidoptera: Noctudae*)

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Abstract

Chickpea (*Cicer arietinum L.*) is the world's second most important grain legume after common bean (*Phaseolus vulgaris L.*). Ethiopia is considered as a secondary center of genetic diversity for chickpea. The field experiment was conducted at Ginir district with the objectives to evaluate the effective management option against chickpea pod borer and to determine the optimum frequencies of the insecticide for the management of chickpea pod borer. The experiment was conducted using two chick pea varieties; Habru (*more preferred*) and Arerit (*less preferred)* and two insecticide Highway 50% EC (400ml/ha) and Nimbicidine (3lt/ha). The result revealed that both insecticides are effective against pod borer even if they have slight percent larval reductions. The pod borer damage reduction ranged from 56.83% to 69.94% and on Highway 50% EC treated plots as compared to the control on Habru variety. On the variety Arerit up to 76.30% larval reduction on the Highway 50% EC treated plot was occurred as compared to control. The minimum 36.17% larval reduction was occurred on the plot treated with Nimbicidine on the variety Habru. The Maximum percent of seed yield (57.95% and 57.95%) increased over check was occurred by Highway 50% EC one and two times treaded plots on the variety Arerit, respectively. The plot sprayed one and two times with Highway 50%EC gave the maximum net return ETB 178,959.8ha^{-1}and ETB 178,402ha^{-1} on the variety Arerti and the unsprayed plot of the variety Arerti gave the minimum net returns ETB 15,054ha^{-1}. It is recommended that these insecticides with specially Arerit variety are suggested to the growers for management of the pod borer population below economic threshold level under field conditions.

Background and justification

Chickpea (*Cicer arietinum* L.) is the world's second most important grain legumes after common bean (*Phaseolus vulgaris* L.) [1,2].Ethiopia is a secondary center of genetic diversity for chickpea; the wild relative of cultivated chickpea (*Cicer arietinum* L.), is found in Tigray region of Ethiopia [3,4]. India is the world's leading producer of chickpea followed by other major producer countries such as Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico and Iraq. Ethiopia contributes about 2% of the global chick pea production [5]. The total area covered by chickpea in Ethiopia is estimated at 239,512.43ha and from this a corresponding mean annual volume of 409,733.16 tons of chickpea is produced [6]. Ethiopian chickpea production is predominated by the Desi type which accounts for about 95% of the total production. However, in recent years there has been an increase in the interest of farmers towards growing large seeded Kabuli type chickpea varieties due to their higher market price [7].

Chickpea is a rich source of dietary protein, providing as much as 17- 23% protein as compared with cereals which provide only about 8-10%. Chickpea plays a significant role in improving soil fertility by fixing the atmospheric nitrogen; it can fix up to 60kgN^{-ha} per year [8]. The plant growth promotion and symbiotic performances of the isolates revealed the causes and highlighted the factors for efficient nodulation in chickpea [8]. Chickpea has high potential for domestic and export market. In spite of its nutritional, market and other utilities, an average chickpea yield in Ethiopia on farmers' field is usually below one ton per hectare, far below its potential yield of five tons per hectare [19,10]. This is due to several abiotic and biotic

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yield limiting factors: frost, low moisture stress, high moisture stress (water logging), poor agronomic and cultural practices, weeds, diseases and insect pests [8,11,12].

Among several biotic constraints, chickpea is susceptible to a number of insect pests which attack roots, foliage and pods. Chickpea pod borer (*Helicoverpa armigera* Hubner) (*Lepidoptera : Noctuidae*) is a major field insect pest affecting chickpea production in several agro-ecological zones. It is also listed among pests, which are medium priority in research on chickpea, field pea and faba bean at national level. Besides pulse crops, pod borer also affects fiber crops, vegetables, cereals and oil crops in Ethiopia [13]. This pest cause chickpea yield losses of up to 100% in spite of several rounds of insecticidal applications. . *H. armigera* is a highly polyphagous pest, feeding on a wide range of food, oil and fiber crops. Due to its wider host range, multiple generations, migratory behavior, high fecundity and resistance to insecticides; it has become a difficult pest to manage.

H. armigera selectively feeds upon growing points and reproductive parts of the host resulting in significant yield losses. In chickpea, it feeds on buds, flowers and young pods often resulting in poor yields. The pest status of this species has increased steadily over the last 50 years due to agro-ecosystem diversification by the introduction of host crops such as chickpea [14,15].Commercial chickpea crops are important sources of *Helicoverpa* species [9,10] reported chickpea is attractive to oviposition of *Helicoverpa* moths from as early as 14 days after planting and throughout the growth period. Typical of many chickpea growing areas of Ethiopia, pod borer heavily infests chickpea and other crops such as lentil in the major chickpea belt of Bale Zone, Ginner district. Therefore, this study was conducted in order to devise an integrated management option of pod borer on chickpea, essentially tolerant variety and insecticide at lower rate, and to determine the frequency of insecticide spraying.

Materials and methods

Treatments and experimental design

The experiment was conducted in Ginner district of Bale Zone on farmer's field using two chick pea varieties, namely Arerti which is less preferred by pod borer and Habru which is relatively more preferred by this pest. Two insecticides namely Highway which is synthetic and applied at the rate of 400ml/ha and Nimbecidine which is botanical and applied at the rate of 3 lt/ha were used in the experiment with four insecticide frequencies of spraying i.e 0, 1, 2, 3 at 8 days intervals. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 5.4m^2 (3m × 1.8m) with 6 rows spaced at 0.3m apart between block 1.5m and between plot 1.5m growth and 1.2m net. Recommended agronomic practices were followed for raising the crop. Insecticides were sprayed during the crop growing season following the incidence of pod borer and continued as found necessary.

Data to be collected

Data on pod borer population before and after insecticide application were recorded from 3 randomly selected plants in each plot at the seedling stage after the incidence of the pod borer was evident. The number of larval population per plant from 3 randomly selected plants in each plot before and after first spray of insecticides was recorded. The reduction percentage of larvae was recorded by counting the larval population after spraying. Such an exercise was repeated at 10 days interval. Data on pod damage (visual scoring) and grain yield were also recorded. At harvest, the data on pod damage due to pod borer from samples taken at random were recorded. The percentage pod damage was assessed for *Helicoverpa* damage visually based on the number of healthy and damaged pods and seeds per 10 plants to work out % pod damage at maturity. At maturity, data were also recorded on crop yield to observe grain yield per plot.

$$\%\,\textit{Pod damage} = \frac{\text{Total number of pod produced per plant} - \text{Number of undamaged pods}}{\text{Total number of pods produced}} \text{X100}$$

$$\%\ \textbf{Larval reduction} = \frac{\text{Total number of larval population} - \text{Number of larval population after spray}}{\text{Total number of larval population}} \text{X100}$$

Data were subjected to statistical analysis. Larval population, pod damage and yield data were analyzed separately. Data was subjected to the analysis of variance using GLM Procedure SAS software (SAS 2002). The mean was compared using Duncan's Multiple Range Test (DRMT) (Duncan, 1955) at 0.05 probability level. Insect counts and damage percentages were subjected to square root and arcsine transformation, respectively, before analysis as needed.

Results and discussion

Larval population

Results of the combined analysis revealed that both insecticides were found to be effective against pod borer though their efficacy varied in reduction of larval population. Generally, the larval population of *Helicoverpa armigera* ranged from 1.61 to 3.06 larvae per plant before spraying and 0.5 to 3.34 after spraying. The pest was active during December which coincided with the flowering and pod formation stage of the crop growth. Maximum mortality of pod borer, 79.75 and 64.48% were recorded on the plots of variety Arerit treated with Highway and Nimbicidine, respectively. On the other hand, no observable mortality was recorded on untreated plots on both varieties. These results are in conformity with the findings of who reported the highest mortality of pod borer (94%) in pigeonpeawhen treated with profenofos [16,17]. In contrast, report the population of gram podborer was found to be lowest in plots treated with flubendiamide,chlorantranilip role, spinosad and indoxacarb followed by profenofos and emamectin benzoate [18].

The population of *Helicoverpa armigera* ranged from 1.6 to 3.4 larvae per plant before spraying and 0.3 to 3.2 after spraying during the experimental season. The pod borer damage reduction ranged from 56.83% to 69.94% and on Highway 50% EC treated plots as compared to the control on Habru variety. For

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Highway 50% EC treated plots that were also planted to variety Arerit up to 76.30% larval reduction was achieved as compared to the untreated control. A minimum of 36.17% larval reduction was achieved on plot treated with Nimbicidine and planted to variety Habru. Therefore, the results of the current study show that both insecticides i.e Highway 50% and Nimbicidine were found to be effective in reducing the larval population of bod borer, of course with different levels of efficacy Table 1.

Grain yields and yield components of chickpea

The results of seed yield (Qt/ha) and yield advantage attained over untreated check is presented in Table 2.

From the combined analysis, plots that were sprayed with Highway 50% once and twice on variety Arerit gave maximum yield of 56.92 and 56.89Q/ha, respectively. The minimum seed yield of 23.93Q/ha was recorded from unsprayed plot of variety Arerit.

The maximum yield advantage over unsprayed check was attained by spraying Highway 50% once and twice on variety Arerit i.e 57.95% and 57.95%, respectively whereas the minimum (21.32%) was recorded on plots of variety Arerit three times sprayed with Nimbicidine. At crop harvest, the highest pod damage of 7.20% was recorded from untreated plots of variety Habru.

The minimum percentage of pod damage (3.62%) occurred on the plot that was three times sprayed with Highway 50% EC. The results showed that some chickpea genotypes were more attractive for Helicoverpa moths than the others. The preference or non-preference of chickpea genotypes for oviposition by female moth may be possibly due to different canopy structure of the plants. Another reason for these variations may be the variability in oviposition response of adult females due to chickpea foliar secretions containing high concentrations of malic acid [19]. The amount of foliar exudate and the concentration of malic acid depend on temperature and growth stage and have been shown to increase during the reproductive stages of the plant [20]. When moths were

Table 1: Combined Effect of Insecticides Application on larval population of pod borer (*Helicoverpa spp*) on chickpea in Ginner district, 2017- 2019 cropping season.

Varieties	Insecticides	Frequencies	B spray	Mean after spray	% larval reduction	% Larval reduction over check
Habru	Highway 50% EC	Control	1.88	1.83	-11.84	0
		1 time spray	1.88	0.58	62.48	68.30
		2 times spray	2.40	0.76	55.56	56.83
		3 times spray	2.26	0.55	44.83	69.94
	Nimbicidine	Control	2.00	1.88	11.09	0
		1 time spray	2.10	1.00	40.19	46.80
		2 times spray	1.95	1.20	29.02	36.17
		3 times spray	1.61	0.90	22.82	52.12
Arerti	Highway 50% EC	Control	2.21	2.11	7.75	0
		1 time spray	2.45	0.91	59.74	56.87
		2 times spray	2.81	0.50	79.75	76.30
		3 times spray	1.95	0.54	60.8	74.40
Arerti	Nimbicidine	Control	3.06	3.34	16.23	0
		1 time spray	1.95	0.89	45.20	73.35
		2 times spray	2.45	0.83	47.79	75.15
		3 times spray	2.11	0.77	64.48	76.94
CV(%)			55.63	98.62	119.09	
$LSD_{(0.05)}$			0.49	0.47	19.37	

Table 2: Combined Mean of Seed Yield and Yield Parameters of Chickpea varieties treated with different insecticides

Varieties	Insecticides	Frequencies	No. of Pod /plt	No. of pod damage	% pod damage	HSW	Yield (Qt/ha)	Percent yield increased over check
Habru	Highway 50% EC	Control	70.65	3.65	6.16	298.80	35.65	0
		1 time spray	62.45	2.72	4.85	284.00	47.23	24.51
		2 times spray	72.61	3.00	4.76	308.46	52.62	32.25
		3 times spray	62.16	2.45	4.47	316.03	53.95	33.92
	Nimbicidine	Control	57.78	6.95	13.55	305.26	28.86	0
		1 time spray	77.6	3.03	5.35	301.46	44.19	34.69
		2 times spray	62.28	2.72	4.45	312.06	52.44	44.96
		3 times spray	76.15	2.60	3.68	305.83	46.45	37.86
Arerti	Highway 50% EC	Control	72.50	3.40	5.00	247.00	23.93	0
		1 time spray	72.66	2.60	3.92	241.16	56.89	57.93
		2 times spray	75.11	2.50	3.74	244.13	56.92	57.95
		3 times spray	72.50	2.55	3.62	231.26	51.28	53.33
Arerti	Nimbicidine	Control	76.28	3.26	4.40	240.83	34.90	0
		1 time spray	79.66	3.05	4.12	249.26	46.64	25.17
		2 times spray	56.05	2.72	5.24	256.03	49.98	30.17
		3 times spray	76.90	3.12	4.23	207.60	44.36	21.32
CV (%)			42.77	56.45	80.89	13.16	25.59	
$LSD_{0.05}$			12.29	0.72	1.68	14.64	4.75	

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drawn to chickpea in all growth stages, there was relatively less oviposition activity and damage in resistant cultivars that secreted high concentrations of malic acid [19,21-27].

Simple regression analysis between pod borer larval populations and yield

The estimated slope of the regression line obtained for the chickpea due to larval population was -3.68 and this shows that for each unit increase in mean larval population, there was a grain yield loss of 3.68 Qt/ha (Figure 1). Also the estimated slope of the regression line obtained for the chickpea due to pod damage was -0.86 showing that for each unit increase in percent pod damage, there was a grain yield loss of 0.86 Qt/ha (Figure 2).

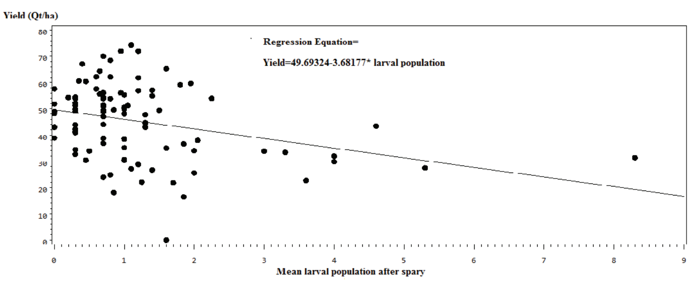

Figure 1: Estimated Relationship Between Losses in Grain Yield with Mean Larval Population after spray at Ginir 2017/19 cropping season.

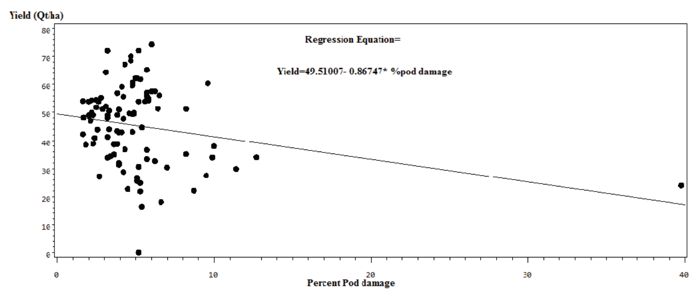

Figure 2: Estimated Relationship Between Losses in Grain Yield with Percent pod damage at Ginir 2017/19 cropping season.

Return and Benefit cost ratio

The result showed that Highway 50%EC once and two times sprayed plot of variety Arerti resulted in the highest gross returns (ETB 194,666.4ha^{-1}and ETB 194,563.8ha^{-1}), respectively and the lowest gross return ETB 81,840.6ha^{-1}was obtained from unsprayed check of variety Arerti (Table 3).

The plot sprayed once and two times with Highway 50%EC gave the maximum net return of ETB 178,959.8 ha^{-1}and ETB 178,402 ha-1 on the variety Arerti and the unsprayed plot of the variety Arerti gave the minimum net returns ETB 15,054 ha^{-1}.

The highest (ETB 714.36) marginal rate of return was obtained from variety Arerti when it was treated with Highway 50%EC once, followed by Arerti (ETB 237.45) treated with Nimbicidine once. In other words, for every ETB 1.00 investment in Highway 50%EC and Nimbicidine cost in spraying variety Arerit, there was a gain of ETB 7.14 and ETB 2.37, respectively (Table 3).

Generally the highest chickpea grain yield, highest gross returns, and marginal rate of return were obtained from Highway 50%EC sprayed once on variety Arerit as compared to the other treatment combinations.

Conclusion and recommendation

The present findings indicated that both insecticides (Highway 50% EC and Nimbicidine) were effective to manage pod borer on chickpea, up to seven days after treatment. The present study indicates that both insecticides were found to be effective against pod borer on chickpea, appreciably reducing larval population of the pest despite slight differences between the two in efficacy. Variety Habru was more preferred by the pod borer than Arerit because the Arerit variety produces a waxy substances which may not preferred by the larvae than Habru variety. The result also showed that Highway 50% EC sprayed two times was enough for the control of pod borer than Nimbicidene that needed more frequency. This may be due to the fact that botanicals break down more rapidly than

Table 3: Return and Benefit Cost Ratio of Treatment for the Control of Pod borer on Chickpea during 2017/19 Cropping Season at Ginir.

Variety	Insecticide	Frequencies	Yield obtained (qt/ha)	Adjusted Yield (qt/ha)	Sale price (ETB/qt)	Total Variable Cost (ETB/ha)	Gross Return (Price x Qt)	Net Return (GR-TVC)	MRR (NR-NR of Control / TVC)
Habru	Highway 50% EC	Unsprayed	35.65	32.085	3800	15561.6	121,923	106,361.4	0
		1 times	47.23	42.507	3800	16430	161,526.6	145,096.6	235.75
		2 times	52.62	47.358	3800	17187	179,960.4	162,773.4	102.84
		3 times	53.95	48.555	3800	17871	184,509	166,638	21.624
	Nimbicidine	Unsprayed	28.86	25.974	3800	15439.4	98,701.2	83,261.8	0
		1 times	44.19	39.771	3800	17165.4	151,129.8	133,964.4	33.54
		2 times	52.44	47.196	3800	18763.8	179,344.8	160,581	14.84
		3 times	46.45	41.805	3800	20106	158,859	138,753	-13.74
Arerti	Highway 50% EC	Unsprayed	23.93	21.537	3800	14350.6	81,840.6	67,490	0
		1 times	56.89	51.201	3800	15604	194,563.8	178,959.8	714.36
		2 times	56.92	51.228	3800	16264.4	194,666.4	178,402	-3.43
		3 times	51.28	46.152	3800	16823	175,377.6	158,554.6	-117.98
	Nimbcidine	Unsprayed	34.9	31.41	3800	14548.2	119,358	104,809.8	0
		1 times	46.64	41.976	3800	16209.4	159,508.8	143,299.4	237.45
		2 times	49.98	44.982	3800	17719.6	170,931.6	153,212	55.94
		3 times	44.36	39.924	3800	19068.4	151,711.2	132,642.8	-107.87

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synthetic insecticides. Spraying with insecticides can control early instar larvae of pod borer but generally, as it holds true for all pest management recommendations, insecticides should be used as a last resort and as a component of Integrated Management where they may be used either at lower rates or reduced frequencies. Besides, as there are some differences among chickpea genotypes in their resistance to pod borer, the development of new varieties with better relative resistance needs to be conducted sustainably to lay a robust foundation for integrated management. The highest chickpea grain yield, highest gross returns, and marginal rate of return were obtained from Highway 50%EC one times treated variety Arerit. The variety Arerit sprayed one and two times were given higher yield. Therefore, it is suggested to the growers/farmers or other stake holders to produce Arerit variety for higher yield and to manage the pod borer population below economic threshold level under field conditions.

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