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Integrated Management of Legume Pod Borer on Common Bean in Guji Zone, Southern Ethiopia

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Research Article

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Abstract

Biotic and abiotic constraints present significant challenges to common bean production. In the study area, the legume pod borer (Maruca vitrata) is the primary insect pest affecting this crop. To evaluate the effectiveness of various synthetic insecticides combined with improved cultivars against the pod borer under field conditions, a field experiment was conducted in the Adola Rede district of the Guji Zone during the 2023–2024 cropping season. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of two bean cultivars (Ibado and Rori) and three insecticides (Diazinon 60% EC, Profit 72% EC, and Helerate 5% EC). The results revealed that while the interaction effect between cultivars and insecticides was not statistically significant while the main effect of the insecticides varied significantly. In contrast, the main effect of the cultivars showed no significant differences. Helerate achieved the highest larval reduction (97.65) and the lowest pod infestation (21.73%), whereas Profit resulted in the lowest larval reduction (78.38) and higher pod infestation (32.28%). Although the number of pods per plant did not differ significantly among treatments, significant variations were observed in seed yield and hundred-seed weight (HSW). The application of Helerate produced the highest seed yield (1780.38kg/ha) and HSW (56.00gm), which was statistically comparable to Diazinon (1601.56kg/ha, 53.08gm) respectively. Conversely, the unsprayed Ibado control recorded the lowest yield and HSW (786.46kg/ha, 39.50gm), which was statistically similar to the unsprayed Rori control (923.61kg/ha, 42.00gm) and the Profit treatment yield (1109.37kg/ha). Economic analysis further indicated that applying Helerate yielded the highest marginal rate of return (3496). Consequently, Helerate is recommended as the most effective insecticide for managing the legume pod borer in common bean production within the study area.

Introduction

Pulse crops are among the most significant legumes globally, providing a staple food for millions of people worldwide, including in Ethiopia (CSA, 2018; FAOSTAT, 2018). Following soybeans, the common bean (*Phaseolus vulgaris* L.) is the second most widely cultivated grain legume, grown primarily for its edible seeds and pods (Celmeli et al., 2018; USDA, 2018). It serves as a vital staple crop in both developed and developing nations, where it is predominantly cultivated by smallholder farmers in tropical and subtropical climates (FAOSTAT, 2018; Snapp et al., 2019). Globally, common bean production in 2018 spanned more than 30 million hectares, yielding over 35 million tons of grain (FAOSTAT, 2018). As a primary source of human nutrition, the crop is relied upon by more than 300 million people across parts of Eastern Africa and Latin America, supplying up to 32% of their dietary energy, 65% of their total protein intake, and a significant portion of essential minerals and folic acid (Petry et al., 2015).

In Ethiopia, the common bean has a long history of cultivation and stands as the country's most important food legume, widely produced across the Central, Northern, Western, Southern, and Eastern regions (Wondimu *et al*., 2017). According to recent agricultural statistics, approximately 0.55 million tons of common beans were produced on 0.31 million hectares of land during the 2020–2021 cropping season (CSA, 2022).

Nevertheless, Ethiopia's average national productivity of 1.8tonha^{-1} remains substantially below the crop's genetic potential of > 3 tonha^{-1} (Shumi, 2018). This yield gap is attributed to various biotic and abiotic constraints (Gudero and Terefe, 2018), among which insect pests are a primary limiting factor. In the major bean-producing regions of Ethiopia, the most destructive insect pests include the bean fly, bean aphid, legume pod borer, blossom bud thrips, and Mexican bean beetle (Abate et al., 2011; MoANR and EATA, 2018). Specifically, damage inflicted by pod borer

larvae on flower buds, flowers, green pods, and seeds accounts for national yield losses ranging from 20.2% to 38.0% (Ahmed et al., 2015).

Effective pest management requires a diverse array of control strategies. Cultural practices such as adjusting sowing dates, optimizing cultivation, employing crop rotation, utilizing resistant varieties, incorporating biological and botanical controls, and integrating multiple management mechanisms—are crucial to mitigating pest populations. However, farmers in the Guji Zone currently rely almost exclusively on Malathion as their primary control measure, and local research evaluating alternative synthetic insecticides remains virtually non-existent. While malathion provides temporary suppression, its repetitive use threatens to trigger insect resistance, rendering it economically inefficient over time. Therefore, incorporating newly available synthetic insecticides and combining them into an integrated management framework is essential to reducing pest pressure. Consequently, this research was initiated to evaluate the field efficacy of selected synthetic insecticides in combination with improved common bean cultivars against the legume pod borer in the Guji Zone.

MATERIALS AND METHODS

3.1. Experimental Materials and Experimental Design

The field experiment was conducted during the 2023 and 2024 main cropping seasons at the Adola sub-site and Kiltu Sorsa kebele onfarm. The treatments were arranged in a 2 times 4 factorial combination, consisting of two common bean cultivars (Ibado and Rori) and four insecticide regimes: Karate 5% EC applied at 350 ml ha^{-1}, Profit 72% EC at 750 ml ha^{-1}, Diazinon 60% EC at the recommended rate, and an unsprayed control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

Each experimental plot measured 3.2m* 3.0 m = 9.6 m^2) and comprised six rows, with inter- and intra-row spacing maintained at 40cm and 10cm, respectively. Blocks were separated by a 1.5m walkway, while individual plots within a block were separated by a 1.00m buffer zone. Blended NPS fertilizer (19% N, 38% P_2O_5, and 7% S) was uniformly applied to all plots at a rate of 150 kg ha^{-1} at planting. All other agronomic practices were implemented uniformly across all treatments as required.

The insecticides were applied at their recommended dosages immediately upon insect detection. Each insecticide was sprayed twice: once during the vegetative stage and once from the flowering to pod-setting stage. To evaluate efficacy, pest population and damage data were recorded four times for each treatment, taking measurements both immediately before and after each insecticide application.

Table 1
The Details of the selected insecticides used information during the research study

Rol no	Trade name	Common	Rate per ha	Water requirements
1	Profit 72% EC	Profenofos	750ml	300Litre/ha
2	Helerate 5%EC	Lambdacyhalothrin	350ml	400Litre/ha
3	Ethiozinon 60%EC	Diazinon 60% EC	1.2L	400Litre/ha

3.2. Data collected

Data collection was broadly categorized into entomological and agronomic parameters.

Entomological Parameters

To evaluate insecticide efficacy and pest pressure, data were recorded on the number of larvae per plant, percentage of larval reduction, number of damaged pods per plant, and percentage of pod infestation for each treatment.

$$\% \text{ Larval Reduction} = \frac{\text{larva of untreated plot} - \text{larva of treated plot}}{\text{larvae of untreated plot}} \text{x}100$$

Agronomic Parameters

Crop performance and yield components were assessed by gathering data on plant height (cm), number of pods per plant, hundred-seed weight (HSW(g)), and total seed yield (kg ha^{-1}).

An economic analysis was performed for all treatments by calculating the total variable costs, gross benefits, and marginal rate of return (MRR) based on current local market prices.

3.3. Data analysis

Insect population and yield data were subjected to Analysis of Variance (ANOVA) using R software. Where treatment effects were significant, means were separated using Tukey's Honestly Significant Difference (HSD) test at a 5% probability level (alpha = 0.05). Additionally, economic analysis was performed for each treatment based on current local market prices.

Results and Discussions

The legume pod borer (*Maruca vitrata*) was identified as the primary insect pest affecting common beans in the study area. The combined analysis of variance (ANOVA) revealed significant differences among the treatments across the study locations for most of the parameters evaluated (Tables 2 and 3). The results demonstrated that the application of different insecticides on the two common bean cultivars had a highly significant ($P \leq 0.001$) impact on insect population parameters specifically the number of larvae per plant, larval reduction percentage (LR%), number of damaged pods per plant, and pod infestation percentage (PI%) as well as agronomic parameters including hundred-seed weight (HSW) and total seed yield (kg ha^{-1}). However, no significant differences were observed for the number of pods per plant (NPPP).

With the exception of HSW, the main effect of the cultivars showed significant variations across treatments. Conversely, the interaction effect between the insecticides and common bean cultivars was not statistically significant for any of the insect population or yield characteristics. Both the number of damaged pods and NPPP proved to be critical indicators of crop performance in plots where chemical control was applied. Furthermore, HSW varied significantly among the individual treatments.

Table 2
Mean square variance of Insect population parameters of common bean insect pest management across location at main cropping season of 2023/24

Treatments	DF	NLAS	LR %	NDPs	PoIfn (%)
Variety	1	0.033ns	7ns	0.00^{ns}	47ns
chemical	4	19.801***	17723***	49.91***	7860***
Location	1	0.012ns	6ns	69.17***	115ns
Variety: chemical	2	0.011ns	9ns	2.94ns	277ns
Location: variety	1	0.022ns	0ns	0.72ns	112ns
Location: chemical	4	0.034ns	2ns	13.16***	331ns
Location: variety: chemical	2	0.000ns	0ns	0.26ns	5ns
Residuals	31	0.047	20	2.08	212

DF, degree of freedom, NLAS, Number of larvae after spray; LR%, larval reduction percentage; NDPs, Number of damaged pods; PoIfn%, Pod infestation

Table 3
Mean square variance of yield parameters of common bean insect pest management across location at main cropping season of 2023/24

Treatments	DF	NPPP	HSW(gm)	Yield(kg/ha)
Variety	1	1.0ns	247.5***	3689ns
chemical	4	45.8ns	410.4***	1692727***
Location	1	1006.3***	3.5ns	110949ns
Variety*chemical	2	9.5ns	15.7ns	50228ns
Location*variety	1	8.0ns	0.0ns	39955ns
Location* chemical	4	8.9ns	1.1ns	164085ns
Location* variety*chemical	2	8.3ns	25.7ns	80587ns
Residuals	31	19.1	14.7	86811
Significant codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 DF, degree of freedom; NPPP, number of pods per plant; HSW, hundred seed weight				

The application of insecticides resulted in highly significant ($P \leq 0.0001$) variations in the larval reduction percentage (LR %), pod infestation percentage (PI %), and the number of larvae per plant post-spray (Table 4). Plots treated with Helerate recorded the lowest post-spray larval population (0.08larvae/plant), followed by those treated with Diazinon (0.46 larvae/plant). Conversely, the highest post-spray larval counts were observed in the unsprayed Rori control (3.42 larvae/plant), which was statistically comparable to the unsprayed Ibado control (3.28 larvae/plant). Helerate achieved the highest larval reduction (97.65%), followed by Diazinon (86.18%). Similarly, the lowest pod infestation was recorded in plots treated with Helerate (21.73%), which was statistically comparable to the Diazinon (27.32%) and Profit (32.28%) treatments. The highest pod infestation rates were observed in the

unsprayed Ibado (89.98%) and unsprayed Rori (80.15%) controls. In contrast, the main effect of the bean cultivars showed no significant differences regarding the number of larvae per plant, larval reduction percentage, number of damaged pods, or pod infestation percentage.

Table 4
Effect of insecticides on the mean of NLAS, LR%, NDPs and PoIfn (%) at main cropping season of 2024/25

Treatments	NLBS	NLAS	LR %	NDPs	PoIfn (%)
Insecticides					
Ibado unsprayed	3.28	3.28a	0.00d	8.30a	89.98a
Rori unsprayed	3.06	3.42a	0.00d	7.01a	80.15a
Profit	1.19	0.74b	78.38c	4.16b	32.28b
Diaznon	1.06	0.46c	86.18b	3.09bc	27.32b
Helerate	0.71	0.08d	97.65a	2.47c	21.73b
LSD		0.25***	5.25***	1.69***	17.16354***
Varieties					
Rori	1.62	1.184583	65.13	4.37	42.60a
Ibado	1.45	1.125417	65.98	4.35	40.59a
LSD		ns	ns	ns	ns
CV %		18.71		33.22	35.04

Means with the same letter are not significantly different to each other. NLBS, Number of larvae before spray; NLAS, Number of larvae after spray; LR%, larval reduction percentage; NDPs, Number of damaged pods; PoIfn%, Pod infestation

The results demonstrated that insecticide application had a significant ($P < 0.05$) impact on bean yield and yield components (Table 5). However, no significant variations were observed among the insecticide treatments regarding the number of pods per plant (NPPP). The highest seed yield was achieved with Helerate (1780.38kg ha^{-1}), which was statistically comparable to Diazinon (1601.56kg ha^{-1}). Conversely, the lowest seed yields were recorded in the unsprayed Ibado control (786.46kg ha^{-1}) and the unsprayed Rori control (923.61kg ha^{-1}). Similarly, the highest hundred-seed weight (HSW) was recorded in the Helerate (56.00g) and Diazinon (53.08g) treatments, whereas the lowest HSW values were obtained from the unsprayed Ibado (39.50g) and unsprayed Rori (42.00g) controls. The main effect of the common bean cultivars showed no significant influence on yield metrics, indicating that the cultivars themselves did not offer differential resistance to the pod borer. These findings align with those of Omar *et al*. (2021), who reported that insecticide applications on common beans significantly reduced larval populations and pod infestation. These authors also observed a 90.07% increase in common bean yield in insecticide-treated fields compared to untreated controls. Similarly, Sunitha *et al*. (2008) documented a significant reduction in legume pod borer populations following chemical insecticide applications. Furthermore, Shinde (2011) evaluated various insecticides against *M. vitrata* and reported a larval mortality rate of 90.87% seven days post-spraying, further supporting the efficacy of chemical interventions observed in this study.

Table 5
Effect of insecticides on NPPP, HSW (gm), and Yield (kg/ha) at main cropping season of 2023/24

Treatments	NPPP	HSW(gm)	Yield(kg/ha)
Insecticides			
Ibado unsprayed	9.08	42.00c	923.61b
Rori unsprayed	9.56	39.50c	786.46b
Profit	12.93	47.58b	1109.37b
Diaznon	14.04	53.08a	1601.56a
Helerate	14.07	56.00a	1780.38a
LSD	ns	7.18***	552.22***
Varieties			
Rori	12.45	47.08b	1346.79
Ibado	12.74	51.63a	1326.389
LSD	ns	2.26***	ns
CV %	34.69	7.62	22.04

Means with the same letter are not significantly different to each other. ns, non-significant; LSD, Least significance Difference; CV, coefficient of variation; NPPP, number of pods per plant; HSW, hundred seed weight

Previous studies have demonstrated that chemical pest management significantly increases the number of pods per plant and overall seed yield in other pulse crops, including lablab, chickpea, and green gram (Shinde, 2011). Furthermore, minimizing insect-inflicted damage reduces the proportion of shriveled and discolored seeds, thereby improving overall grain quality. Cooper and Dobson (2007) noted that the strategic application of synthetic pesticides can increase crop yields by up to fourfold compared to untreated field. Additionally, Bari and Sohel (2017) reported that insecticide applications on bean crops achieved a 68.50% reduction in pod infestation within days of spraying, corroborating the high efficacy rates observed by Shinde (2011).

Pearson correlation analysis on the mean number of pods per plant, Pod infestation percentage per plant, hundred seed weight and grain yield

Correlation analysis revealed a significant positive relationship (r = 0.71) between the number of pods per plant and total grain yield (Table 6), indicating that an increase in pods per plant directly contributes to higher grain yields. Similarly, a positive correlation (r = 0.41) was observed between hundred-seed weight (HSW) and grain yield, demonstrating that heavier seeds are associated with higher overall yields. Conversely, a highly significant negative correlation (r = -0.71) was found between the percentage of pod infestation and grain yield, confirming that severe pest damage leads to a substantial reduction in total grain output.

Table 6
Pearson's correlation coefficient of the number of pods per plant, pod infestation percentage, hundred seed weight and grain yield

Yield	Yield	PoInf	NPPP	HSW
	1			
PoInf	-0.7122	1		
NPPP	0.70981	-0.81111	1	
HSW	0.410249	-0.51833	0.486481	1

PoInf, pod infestation; NPPP, Number of pod/plant; HSW, hundred seed weight

Simple regression analysis between pod borer larval populations and yield (Kg/ha)

The calculated slope of the regression line for the common bean was − 232.94 relative to the mean larval population. This indicates that for every unit increase in the mean larval population per plant, there was an estimated decrease in total grain yield of 232.94kg ha^{-1} (Fig. 1).

Economic analysis

Based on the economic analysis, the application of Helerate achieved the highest gross benefit (107,492.75ETB ha^{-1}) and net benefit (95,192.75ETB ha^{-1}), followed by Diazinon with a gross benefit of 98,671.50ETB ha^{-1} and a net benefit of 83,871.50ETB ha^{-1}. Conversely, the unsprayed Ibado control plot recorded the lowest economic returns, with a gross benefit of 41,485.50ETB ha^{-1} and a net benefit of 29,185.50ETB ha^{-1}. The highest marginal rate of return (MRR) of 34.96% was obtained from the Helerate treatment. Consequently, the use of Helerate insecticide represents the most economically viable management strategy for controlling the legume pod borer in common bean production within the study area and similar agroecological zones.

Table 7
Partial budget analysis result for different insecticides on common bean at 2023/24 main cropping season

Treatments	AY (kg/ha	AJY by 10% (kg/ha) down	GB (ETB/ha)	Variable Cost		TVC (ETB/ha)	NB (ETB/ha)	MRR%
				IC(ETB/ha	LC(ETB/ha)			
Ibad unspray	614.6	553.14	41485.5	9000	3300	12300	29,185.50	0
Rori unspray	635.4	571.86	42889.5	9000	3300	12300	30,589.50	-
Helerate	1807.3	1626.57	121992.8	10200	4300	14500	107,492.75	3496
Diaznon	1461.8	1315.62	98671.5	10500	4300	14800	83871.5	D
Profit	961.8	865.62	64921.5	11000	4300	15300	49621.5	D

AY, adjusted yield; GB, growth benefit; IC, insecticide cost; LC, labor cost; TVC, total variable cost; NB, net benefit; MRR, Marginal rate of return

Conclusion and recommendation

In conclusion, the application of synthetic insecticides significantly suppressed legume pod borer populations while enhancing critical agronomic traits and overall crop productivity. Regardless of the common bean cultivar used, Helerate 5% EC proved to be the most effective insecticide for controlling the pod borer under field conditions. Furthermore, economic analysis confirmed that this treatment yielded the highest financial returns for producers. Therefore, to effectively manage the legume pod borer and maximize economic benefits, common bean growers in the study area and similar agro ecological zones are recommended to apply Helerate 5% EC at the rate of 350 ml ha^{-1}.

Declarations

Authors' Contribution

Conceptualization, Data Curation, Validation, Writing – Review & Editing: Belachew Dabalo and Girma Teshome

Methodology: Kebna Asefa

Project Administration, Analysis and Original Draft Preparation: Belachew Dabalo

Investigation: Belachew Dabalo and Dagne Abu

Resources: Kebna Asefa and Lulu Misgana;

Supervision: Belachew Dabalo and Merga Nebiyu;

Funding Acquisition: Lulu Misgana and Dagne Abu

All authors have read and agreed to the published version of the manuscript.

Ethics and consent to participate: The collection and use of plant materials (common bean, *Phaseolus vulgaris*) in this study complied with relevant institutional, national, and international guidelines and legislation. The cultivated common bean varieties used were handled in accordance with local agricultural research protocols.

Plant material description: The study involved cultivated common bean crops on local farmland with full consent and cooperation from local farmers and agricultural authorities; no special permits or licenses were required.

Consent to publish: *Not applicable.*

Data availability: The data presented in this study are available upon request from the authors.

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References

1. Abate T, Alene A, Bergvinson D, Shiferaw B, Salim S, Orr A, Asfaw S (2011) Tropical grain legumes in Africa and South Asia: Knowledge and opportunities. TLII Research Report No 1. Nairobi: ICRISAT. 104 pp
2. Ahmed MT, Miah MRU, Amin MR, Hossain MM (2015) Evaluation of some plant materials against pod borer infestation in country bean with reference to flower production. Ann Bangladesh Agric 18:71–78
3. Ahmed MT, Miah MRU, Amin MR, Hossain MM, Suh SJ, Kwon YJ (2019) Plant material as an alternative tool for management of aphid in country bean field. Int J Pest Manage 65:171–176
4. Celmeli T, Sari H, Canci H, Sari D, Adak A, Eker T, Toker C (2018) The nutritional content of common bean (*Phaseolus vulgaris* L.) landraces in com-parison to modern varieties. Agronomy 8(9):166. https://doi.org/10.3390/agronomy8090166
5. Central Statistical Agency [CSA] (2018) Agricultural sample survey, 2017/2018 (Report on area and production of crops (Private peasant holdings, main season). Statistical Authority, Addis Ababa, Ethiopia. Statistical Bulletin No. 446. Volume 5. 60 pp
6. FAOSTAT (Food and Agriculture Organization of the United Nation) (2018) Agricultural data: Production and Indices Data Crop Primary. http://www.fao.org/faostat/en/#data/QC/visualize. [Accessed at 15 April 2020]
7. Gudero G, Terefe H (2018) Distribution and association of factors influencing bean common bacterial blight (*Xanthomonas axonopodis* pv. *phaseoli*) epidem-ics in Southern Ethiopia. Archives Phytopathol Plant Prot 51(19–20):1066–1089. https://doi.org/10.1080/03235408.2018.1551043
8. Faruq MO, Md. Abdul Latif, Md. Mohasin Hussain, Khan GP, Das (2021) Population Dynamics and Management of Bean Pod Borer (Maruca Vitrata Fabricius) on Yardlong Bean Cultivation in Chittagong Hill Tracts of Bangladesh. Plant Physiology and Soil Chemistry, 1(2): 63–69
9. Ministry of Agriculture and Natural Resources [MoANR] and Ethiopian Agricultural Transformation Agency [EATA] (2018) Crop production and development package. Amharic Version. Ministry of Agriculture, p 215

10. Petry N, Boy E, Wirth JP, Hurrell RF (2015) Review: The potential of the common bean (*Phaseolus vulgaris* L.) as a vehicle for iron biofortification. J Nutr 7(2):1144–1173. https://doi.org/10.3390/nu7021144
11. Shumi D (2018) Response of common bean (*Phaseolus vulgaris* L.) varieties to rates of blended NPS fertilizer in Adola district, Southern Ethiopia. Afr J Plant Sci 12(8):164–179. https://doi.org/10.5897/AJPS2018.1671
12. Snapp SS, Cox CM, Peter BG (2019) Multipurpose legumes for smallhold-ers in sub-Saharan Africa: Identification of promising 'scale out' options. Global Food Secur 23(1):22–32. https://doi.org/10.1016/j.gfs.2019.03.002
13. United State Department of agriculture [USDA] (2018) November. Foreign Agri-cultural Service: World Agricultural Production Global Analysis (World Agricultural Supply and Demand Report). 31. Circular Series WAP 11–18, DC 20250 – 1051. Foreign Agricultural Service/USDA

Figures



Figure 1

Simple linear regression analysis of Yield and larval population relationships