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Research Article

Efficacy of Emamectin Benzoate 5%+Lufenuron 12% WDG Insecticide against Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera, Noctuidae) in Maize

Zerhun Tomas Lera*

Department of Plant Protection, South Ethiopia Agricultural Research Institute, Areka Agricultural Research Center, Areka, Ethiopia

ABSTRACT

Maize is among the leading cereal crops selected to achieve food self-sufficiency in Ethiopia. However its production is constrained by biotic and abiotic factors. Among biotic factors Fall Armyworm (FAW) is the key insect pest of maize in Ethiopia. To manage the pest currently there are a few registered synthetic insecticides in the country others are allowed for only an emergency label, suggesting an urgent need for synthetic insecticide screening. Bearing in mind this challenges field experiment was conducted to verify the effectiveness of the Emamectin benzoate 5% +Lufenuron 12% WDG insecticide relative to another promising standard insecticide, Lambda-cyhalothrin 50 g/L), for the control of fall armyworm in maize production for registration purpose. The experiment was conducted at around Wolaita zone in two districts ((Humbo (Ella-kaballa) and Areka sites) in South Ethiopia) on farmers' field in a Randomized Complete Block Design (RCBD) with five replications during 2023 cropping season. The result of this verification study also exhibited plots sprayed with Emamectin benzoate 5%+Lufenuron 12% WDG (the new insecticide) showed highest percent efficacy, lowest fall armyworm larva population and long-lasting effect by controlling and minimizing fall armyworm larva per plant as compared to the Lambda-cyhalothrin 50 g/L and unsprayed checks though statistically significant ($p<0.05$) difference. During the growing periods, no foliar toxic effect was observed from the effect of any tested insecticides. In nutshell Emamectin benzoate 5%+Lufenuron 12% foliar application at the rate of 200 g/ha with 400 liter of water was highly effective in controlling fall armyworm pest of maize.

Keywords: Maize; Fall armyworm; Insecticides; Efficacy

INTRODUCTION

Maize (*Zea mays* L.), a member of the *Poaceae* family, is one of the world's most important cereal crops, contributing to food security in the majority of poor countries. Ranking second to wheat and used as a staple food in the tropics and is a valuable source of raw material for many industrial products. Maize is the most versatile crop, adapted to different agro-ecological and climatic conditions. Maize is among the leading cereal crops selected to achieve food self-sufficiency in Ethiopia. Maize is widely grown in Ethiopia and ranks first in total production and yield per hectare and next to teff in the area coverage of 1, 77 ml ha with a production of 39 ml Qt. The major constraints to maize production in the country include both abiotic and biotic factors, such as a drought, nutrient deficiencies, weeds, diseases and insect pests. Among biotic factors insect pest Fall Armyworm (FAW) is the key insect pest of maize in tropical regions. The occurrence of FAW was reported in Africa for the first time in late 2016 in West Africa. Subsequently, FAW has rapidly spread throughout Sub-Saharan Africa (SSA) and currently, its occurrence has been confirmed in 44 African countries. FAW is a highly polyphagous insect pest that attacks more than 80 plant species, including maize, sorghum, millet, sugarcane and vegetable crops; nevertheless, maize is the main crop affected by FAW in Africa [1]. Given the importance of maize in Africa as a primary staple food crop, the recent invasion of FAW threatens the food security of millions of people in a region that will likely have an aggravated drought due to climate

Correspondence to: Zerhun Tomas Lera, Department of Plant Protection, South Ethiopia Agricultural Research Institute, Areka Agricultural Research Center, Areka, Ethiopia; E-mail: zerhuntomas1977@gmail.com

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change/El Nino in SSA. FAW larvae cause damage to the plant by consuming foliage. Young larvae mainly feed on epidermal leaf tissue and also make holes in leaves, which is the typical damage symptom of FAW. Feeding on young plants through the whorl causes dead heart. In older plants, the larger larvae in the whorls can feed on maize cob or kernels, reducing yield and quality. As is common with other major agricultural pests, the primary management strategy for FAW in the Americas is the use of synthetic insecticide sprays. Nevertheless, FAW has developed resistance to several synthetic insecticides, for example, according to Abrahams et al., FAW resistance has been reported to mode-of-action categories 1A (Carbamates) 1B (Organophosphates) and 3A (Pyrethroids-Pyrethrins). This suggests the need for an integrated management strategy for the sustainable control of this invasive pest. Since the occurrence of FAW in African countries, synthetic insecticides have been widely used as an emergency response to slow the spread of the pest and minimize damage to maize fields. Currently there are no registered synthetic insecticides for FAW control in African countries, except applications allowed through an emergency label, suggesting an urgent need for synthetic insecticide screening. Farmers have complained that the currently used synthetic insecticides are not effective against FAW; hence, they are forced to use high doses with frequent applications, which will lead to the accumulation of pesticides in the environment and speed up resistance development. Thus, pests are developing resistance against pesticides in many areas of the world; there is a need for alternative and effective insecticide through the introduction of a new insecticide or different formulations of the existing insecticides with the same active ingredient that may continue to be introduced by the pesticide companies. To increase the availability of effective insecticide for the growers, the efficacy of the newly introduce insecticide on fall armyworm should be regularly tested and verified before introducing to the farming community [2]. The efficacy of insecticide is highly influenced by environmental factors, insect population load, application time and rates of insecticide. Therefore, evaluation of the insecticide across the locations is greatly important to get an insight into the effects of the insecticide. Based on the above background, Areka Agricultural Research Center has been designated by the Ministry of Agriculture through Southern Agricultural Research Institute to test the efficacy of the new insecticide, Emamectin benzoate 5%+Lufenuron 12% WDG, against fall armyworm during the 2023 cropping season in two locations, Humbo (Ella-kaballa) and Areka sites of Wolaita Zone. Therefore, the objective of the verification trial was to evaluate the efficacy of the insecticide Emamectin benzoate 5% +Lufenuron 12% WDG relative to another promising standard insecticide, Lambda-cyhalothrin 50 g/L, for the control of fall armyworm in maize production for registration purpose [3].

MATERIALS AND METHODS

Descriptions of the study site

The verification trial was conducted during the 2023 main cropping season in an open environment to convince the objectives of the current verification trial around Wolaita Sodo in two locations (Humbo (Ella-kaballa) and Areka sites) in South Ethiopia. The two experimental sites are geographically located at 07° 4' 24'' N and 037° 41' 30'' E (at Areka) and 06° 44' 0'' N and 037° 45' 0'' E (at Humbo (Ella-kaballa). The sites are found at an elevation of 1830 (at Areka) and 1440 (Ella-kaballa) meters above sea level. Bimodal rainfall pattern is the major characteristics of the study area, short rainy season (March and April) and the main rainy season (mid-August to mid-November). Thus, Humbo (Ella-kaballa) areas receive a total annual rainfall and average temperatures were 152.44 mm and 20.65°C, respectively. Whereas Areka district receives average annual rainfall is 1520 mm and mean monthly temperatures varies from 14-26°C. The soils are sandy-loam with a pH of 5.2. The soil is Alisols, which is very deep (>150 cm), very dark brown to black in colour and clay loam in texture. The pH (of surface soil is 4.7 which is strongly acidic [4].

Treatments, design of experiment and trial management

The trial was conducted in an open environment to assure the insect pest destiny as well as to increase the natural prevalence at the starting of the experiment. The areas are known for maize fall armyworm. The total width and length of the layout were designed at 34 × 33 m with a unit plot size of 10 × 10 m, respectively. Plots were spaced at each other by 1.5 m and blocks separated by a safeguard path of 2 m to prevent the drifts or cross-contamination. The experiment was layout in a randomized complete block design with three replications. The maize variety, BH-540, was used as a test crop. Planting was done at main cropping season. Seeds were planted in rows with two seeds per hill at a rate of 25 kg/ha in a plot consisting of six row each of 6 m long and 5 m wide and seedlings were thinned into one plant per hill four weeks after emergence. The inter row spacing was 0.75 m, while the intra row spacing was 0.25 m. Fertilizers were applied at the rate of 100/100 kg/ha NPS/Urea. Urea was applied in split (half at planting and the other half at knee height). First weed control was carried out after three weeks of planting and after 21 days of planting. Total of three treatments, including control, were comprised during the study. Insecticides such as Emamectin benzoate 5%+Lufenuron 12% at the rate of 200 g/ha with 400 liter of water (Candidate insecticide), Lambda-cyhalothrin 50 g/L at the rate of 500 ml/ha with 300 L (Standard check) and unsprayed check were used. For the candidate insecticide, the rate of insecticide per hectare and amount of water for mixing of insecticide was performed as suggested by the manufacturer. The insecticides application was performed starting from first appearance of fall armyworm at both locations (Ella-kaballa and Areka). The insecticides were applied for two times within the 12-days intervals on each plot. Unsprayed plots were left for each replication as controls to allow maximum insect infestation [5].

Data collection

Data were collected from 10 randomly selected plants per plot before first spray and 6^{th} and 12^{th} day after each successive spray. Observations and data collection were made after 6^{th} and 12^{th} days after each spray. The pre-treatment observation of FAW (*i.e.,* number of larvae per plant) were recorded 1 day before spraying and the post-treatment observations were taken at 6 and 12 days after spraying by destructive sampling method on 10 randomly selected plants per plot.

Data analysis

FAW larvae per plant assessment data was taken from randomly selected plants within the central rows mean values were used for data analysis. The treatment means were separated using the Fishers protected Least Significance Difference (LSD) test at 5% probability level. The data analyses were conducted using the general linear model procedure of the SAS software version 9.2. The efficacy of the insecticide was determined following the formula suggested by Shiberu and Negeri (2014) as follows [6].

$$\text{Fall armyworm larva reduction } (\%) = \frac{\text{mean of untreated plot} - \text{mean of treated plot}}{\text{mean of untreated plot}}$$

RESULTS AND DISCUSSION

Effect of Emamectin benzoate 5%+Lufenuron 12% WDG insecticide on fall armyworm larva per plant and yield of maize

The observations revealed that the data on fall armyworm larval population was consistent across all the treatments prior to the application of the insecticides, indicating that the pest was distributed evenly throughout the experimental plots. The post treatment observations showed that all the insecticides were significantly superior to the untreated control. Results showed that after first and second spray significantly lowest larval population was recorded in plots treated with Emamectin benzoate 5%+Lufenuron 12% WDG (2.25, 2.6 larvae/plant), followed by Lambda-cyhalothrin 50 g/L (2.83, 3.1 larvae/plant) at Ella-kaballa and Areka districts, respectively. While it was maximum in untreated control (5.34 larvae/plant. The data also shows that application of Emamectin benzoate 5%+Lufenuron 12% WDG and Lambda-cyhalothrin 50 g/L on fall armyworm larva showed no statistically significant difference in the fall armyworm larva per plant at 6 days of the treatment application on both sites at two spray rounds even though Emamectin benzoate 5%+Lufenuron 12% WDG has highest larval reduction percentage (57.8, 55.2) when compared with Lambda-cyhalothrin 50 g/L (47, 46.5) but it showed statistically significant ($p<0.05$) difference after 12 days of treatment application in both locations [7]. This indicates that effectiveness of these insecticides varied with time intervals. The long-lasting and durable effect was observed on Emamectin benzoate 5% +Lufenuron 12% WDG as compared to Lambda-cyhalothrin 50 g/L especially after 12 days of application. Comparatively, Emamectin benzoate 5%+Lufenuron 12%WDG was found to be effective and showed a long-lasting effect by controlling and minimizing fall armyworm larva per plant when compared with Lambda-cyhalothrin 50 g/L on both locations at two application rounds. On unsprayed plots, fall armyworm larva per plant were progressively increased and consequently resulted in the highest fall armyworm larva per plant during the growing period in both locations. Regarding grain yield, statistically significantly ($P<0.05$) difference was observed among treatments at both locations [8]. At Ella-kaballa and Areka sites highest grain yields were recorded on plots sprayed with Emamectin benzoate 5%+Lufenuron 12% WDG with (61.5 q/ha, 55.5 q/ha) while the lowest grain yields were recorded from the unsprayed control plot (30.1 q/ha, 28.9 q/ha) respectively. The grain yield was highly affected by number of fall armyworm larva found in maize plant. At Ella-kaballa and Areka sites the results of the experiment revealed that the treatments with high fall armyworm larva/plant had minimum grain yield (30.1 q/ha, 28.9 q/ha); whereas the treatments with maximum protection (Emamectin benzoate 5%+Lufenuron 12% WDG) give higher grain yield (61.5 q/ha, 55.5 q/ha) followed by Lambda-cyhalothrin 50 g/L (46.3 q/ha, 43.3 q/ha) respectively (Tables 1 and 2) [9].

Table 1: Effect of insecticides on fall armyworm larva per plant and yield of maize after spray (first and second) at Ella-kaballa location during 2023 main cropping season.

Treatment	Mean no. of FAW larvae/plant (1^{st} spraying)			Mean no. of FAW larvae/ plant (2^{nd} spraying)		Mean of two sprays	Reduction in larval population over control (after two sprayings)	Yield q/ha
	Before spray AV. no larva/ plant	AV. no larva 6 days AS	AV. no larva 12 days AS	AV. no larva 6 days AS	AV. no larva 12 days AS			
	5.1^{a}	2.3^{b}	2.18^{b}	1.62^{b}	0.08^{c}	2.25^{b}	57.8	61.5^{a}
Lambda-cyhalothrin 50 g/L	4.9^{a}	2.82^{b}	2.53^{b}	2.3^{b}	1.63^{b}	2.83^{b}	47	46.3^{b}
Unsprayed	4.80^{a}	5.2^{a}	5.4^{a}	5.65^{a}	5.67^{a}	5.34^{a}	0	30.10^{c}

LSD (5%)	7.8	1.89	2.4	2.73	1.34	2.4	8.6	12.7
CV (%)	10.6	8.4	9.7	6	8.3	14.2	10.43	18.4

Note: Means in the same column followed by the same letters are not significantly different at 5% level of significance. AS: After Spray; AV. No: Average number of larva; CV: Coefficients of Variation (%); and LSD: Least Significant Difference at p<0.05 probability level

Table 2: Effect of insecticides on fall armyworm larva per plant and yield of maize after spray (first and second) at Areka location during 2023 main cropping season.

Treatment	Mean no. of FAW larvae/plant (1st spraying)			Mean no. of FAW larvae/ plant (2nd spraying)		Mean of two sprays	Reduction in larval population over control (after two sprayings)	Yield q/ha
	Before spray AV. no larva/ plant	AV. no larva 6 days AS	AV. no larva 12 days AS	AV. no larva 6 days AS	AV. no larva 12 days AS			
Emamectin benzoate 5% +Lufenuron 12% WDG	5.8[a]	2.9[b]	2.3[b]	1.92[b]	0.1[c]	2.6[b]	55.2	55.5[a]
Lambda-cyhalothrin 50 g/L	5.82[a]	2.97[b]	2.48[b]	2.38[b]	1.77[b]	3.1[b]	46.5	43.3[b]
Unsprayed	5.64[a]	5.8[a]	5.86[a]	5.89[a]	5.9[a]	5.8[a]	0	28.9[c]
LSD (5%)	3.7	2.53	3.14	2.86	1.44	1.97	7.7	10.3
CV (%)	15.3	10.7	11	8.3	15.6	17	15.7	21

Note: Means in the same column followed by the same letters are not significantly different at 5% level of significance. AS: After Spray; AV. No: Average number of larva; CV: Coefficients of Variation (%); and LSD: Least Significant Difference at p<0.05 probability level

CONCLUSION

Fall armyworm is a highly destructive pest of maize crop in all maize growing areas and causes serious problems in the study areas during the production season. The grain yield of maize was highly affected by number of fall armyworm larva found in maize plant. At Ella-kaballa and Areka sites the results of the experiment revealed that the treatments with high fall armyworm larva/plant (untreated control) had minimum grain yield (30.1 q/ha, 28.9 q/ha); whereas the treatments with maximum protection (Emamectin benzoate 5%+Lufenuron 12% WDG) give higher grain yield (61.5 q/ha, 55.5 q/ha) followed by Lambda-cyhalothrin 50 g/L (46.3 q/ha, 43.3 q/ha) respectively. In line with this Emamectin benzoate 5% +Lufenuron 12% at the rate of 200 g/ha with 400 liter of water acted significantly in reducing the infestation of fall army larva per plant and consequently increased grain yield of maize as compared to the standard check (Lambda-cyhalothrin 50 g/L) and unsprayed checks in both locations. The result of this verification study also exhibited plots sprayed with Emamectin benzoate 5%+Lufenuron 12% WDG (the new insecticide) showed highest percent efficacy, lowest fall armyworm larva population and long-lasting effect by controlling and minimizing fall armyworm larva per plant as compared to the Lambda-cyhalothrin 50 g/L and unsprayed checks though statistically significant (p<0.05) difference. During the growing periods, no foliar toxic effect was observed from the effect of any tested insecticides. Generally, results showed that Emamectin benzoate 5%+Lufenuron 12% foliar application at the rate of 200 g/ha with 400 liter of water was highly effective in controlling fall armyworm pest of maize. Therefore, it is recommended for registration to the management of fall armyworm in maize production.

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