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Screening of Management Options and Efficacy Evaluations against Fall Armyworm (*Spodoptera Frugiperda*) (J. E. Smith) (Lepidoptera: Noctuidae) on Maize in Assosa, Ethiopia

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Abstract

Fall armyworm (FAW), Spodoptera frugiperda (Lepidoptera: Noctuidae), is a key pest of maize. Yield damages have been conveyed between 30 -70% in the Americas, 11 - 100% in Africa, and 32% in Ethiopia. In this study, we evaluated two types of bioassay and synthetic chemicals efficacy against fall armyworm during high infestation year under laboratory. Treatments contained dissimilar rules of insecticide applications that delivered defence damage against fall armyworms and recorded percent of larvae mortality within three consecutive days after application. In vitro, experiment and efficacy evaluations of different management options were tested seven types of plant extracts, seven types of synthetic chemicals, and two types of entomopathogenic fungi. Among chemicals as evaluated management options, Dursban 48%, Best 5EC, karate 5 EC, Dimethote, Radient, Cioragen and Bravo 5EC (80%-93.3%) caused the highest percentage of fall armyworm mortality after 72hrs. Among botanicals, *Azadirachta indica, Jatropha carcus, Candle bush, Chenopodium ambrosoids, Eucalyptus globulus* and *Grewinia tenaxi* were evaluated. Percent of larval mortality recorded (71.6%-85.0%) after 72hrs.The entomopathogenic fungi Matharazium aniospolioe and Beauveria basiana causing 70-81.6 % larval mortality after 72hrs.

Keywords: Fall Armyworm; Botanicals; Chemicals; Entomopathogen; Efficacy

Abbreviations: FAW: Fall Armyworm; CRD: Completely Randomized Design; PDA: Potato Dextrose Agar.

Introduction

Background and Justification

Fall armyworm (FAW), Spodoptera frugiperda (Lepidoptera: Noctuidae), infests maize during all plant growth stages, with infestation during vegetative stages leading to serious leaf-feeding injury, while late infestations lead to ear damage [1,2]. The damage results are in both quantitative and qualitative losses [3,4]. FAW damage to maize during the late growth stages, just prior to tassel emergence, may result in ear damage and comparatively higher yield losses [5]. Management of fall armyworm through only one approach is unimaginable so, different methods should be used botanicals, chemicals, entopathogenic fungi were the way in order to control fall armyworm infestation [6]. Thus, the purpose of this study was to determine efficacy of some insecticides against fall armyworm under laboratory (in vitro), to evaluate efficacy of synthetic chemicals, Plant extracts and Entomopathogenic fungi against fall armyworm under laboratory.

In technical terms, synthetic pesticides that have a high acute or chronic toxicity or hazard to the environments are under the current prevailing condition to use in African countries, are advisable to primarily avoid the use of highly hazardous pesticides. Similarly, high mortality of

fall armyworm was recorded sprayed in this insecticide as compared to non-sprayed [1]. Several plant extracts include Neem *(Azadirachta indica), Persian Lilac, Melia azadirach, Pyrethrum, Tanacetum cinerariifolium* (Acacia sp); wild sage, Lantana camara west African pepper, Piper guineense ,Jatropha, Jatropha curcas , Chillies (Capsicum spp), onion (*Allium sativum, Allium cepa*) ; Lemon grass, Tobacco (Nicotina spp) are showing efficacy in the management of armyworms [6]. Botanical insecticides are not only effective against crop pests but remain safer to natural enemies. Among many botanicals, plants such as *Azadirachta indica, Milletia ferruginea, Croton macrostachyus, Phytolacea docendra, 9 Jatropha curcas, Nicotina tabacum and Chrysanthemum cinerariifollium* were successfully used to control insect pests [7].

Materials and Methods

Laboratory Experiment

All laboratory experiments in this study were conducted at Assosa University College of Agriculture and Natural Resource in the Plant science Department laboratory during 2022. Assosa University is found in the Benishangul Gumuz Regional State of Ethiopia at Assosa town, approximately 662 km west of the capital city Addis Ababa.

In Vitro Evaluation of Selected Insecticides against FAW: Effect of seven selected insecticides namely Best 5 EC, Bravo 5EC, Dursban 48%, Coragen 200 SC, Radiant 120SC, Dimethoate 40% EC and Karate 5 EC were tested against fall armyworm larva in Plant Protection laboratory of Assosa University the method employed by Sisay, et al. [8]. Collect fresh in good physical shape leaves from highly susceptible BH546 maize variety and cutting middle parts of leaves at 10cm height and 60gm weighed were placed in a beaker. Then five 3rd instar larvae collected from purposely cultivated isolated field were released five larvae at 3rd stage growth, insert into the beaker on prepared leaves as feed and feeding damage level record in percent .After evaluation of the damage of feeding applied chemicals 20ml per beaker per 5 larvae as following the method of Birhanu, et al. [8]. The experiment was laid out in a completely randomized design (CRD) with three replications with think through of untreated plots. Then finally the insect mortality in percent was assessed 24, 48, and 72 hrs, after chemical application. Tested insecticides were listed below in Table1.

Trade Name	Active Ingredient	Formula-n	Manufacture	Rate of Application/Ha	
				Insecticide	Water
Karate 5 EC	lambda-cyhalothrin	EC	Syngenta	320 ml	500L
Bravo 5EC	lambda-cyhalothrin2.5%	EC	India limited	400ml	250L
Best 5 EC	Lambda- cyhalothrin	EC	Bharat lim india	450ml	300-850L
Coragen 200 SC	Chlorantraniliprole	SC	DuPont	250ml	500
Dursban48%	Chlorpyrifos	EC	Shangai bosman	1.25l	300L
Radiant 120SC	Spinetoram	SC	Dow AgroSciences	130ml	500
Dimethoate 40% EC	Dimethoate	EC	Adami Tuluui	1.5L	200

Table 1: List of evaluated synthetic insecticides and their application rate.

In Vitro Evaluation of Plant Extracts against FAW: Collection and preparation of the plant extracts: Botanical plants were collected from different locations of Benishangul Gumuz Region (Assosa town, Amba 18 village and Gumu village. Collected plants were dried under shade, chopped and ground with Mortal and Pistle to fine fermentable powder. The powder of each botanical/plant extracts was socked in 20ml of distilled water for each beaker and distilled by sheath cloth after well fermented botanical extracts for 24 hr. After filtering, the aqueous extracts were used for the test within the effective dose and list of botanicals described (Table 2). In vitro bioassay: Effect of seven selected botanicals namely Grewnia tenax, Candle bush, Lantana camara, Azadirachta indica , Chenopodium ambrosoids ,Eucalyptus globulus ,and Jatrogha carcus were tested against fall armyworm larva in Plant Protection laboratory of Assosa University. Collect fresh healthy leaves from highly susceptible BH546 maize variety and chopping middle parts of leaves at 10cm height and 60gm weighed were placed in a beaker. Then five 3rd instar larvae collected from purposely cultivated isolated field were released five larvae at 3rd stage development, insert into the beaker on prepared leaves as feed in artificially favorable environment for 3-4 days and feeding, then recorded damage level in percent .After evaluation of the damage, then applied fermented plant extracts 20ml per beaker per 5 larvae as following the method of Birhanu et al [9]. The experiment

was laid out in a completely randomized design (CRD) with three replications through consider of untreated plots. Finally the insect mortality in percent was assessed 24, 48, and 72 hrs, after applied. Tested botanicals were listed below in Table 2.

Name of Botanicals	Common Name	Used Parts	Dose (Gm)	References
A. indica	Neem	Seed	5	Feyissa and Tebkew(2015)[10]
Lantana camara	Lantana	Seed	40	Feyissa (2015)[10]
Sena alata L.	Candle bush	leaf	10	Kokwaro,j.o.(1993)[11]
Grewinia tenax	Drone fly	leaf	8	Kokwaro,j.o. (1993) [11]
Jatropha curcas	Physic nut	Seed	11.5	Kokwaro,j.o. (1993) [11]
Chenopodium ambrosoids	Amadamddo	Leaf	35	Addisu et al., 2014[7]
Eucalyptus globulus	Bahar Zaf	Seed	25	Tadele et al., 2013[9]

Table 2: List of botanical plants and recommended dose.

Evaluation of Entomopathogenic Fungi against FAW: The experiment was conducted to evaluate the efficacy of Metarhizium anisopliae and Beauveria bassiana against fall armyworm. Entomopathogenic fungi were obtained from Ambo Agricultural Research Center and determined their antagonistic activity (Table 3).

Type of Fungal Spp	Isolates	Obtained From	Host	Year
Beuveria Basiyana	APPR-1	AARC	soil	2021
Matharazium Aniospolioe	APPR-2	AARC	soil	2021

APPR-1(Ambo plant protection research isolate -1), APPR-2(Ambo plant protection research isolate -2, AARC (Ambo agricultural research center)

Table 3: List and description of entomopathogenic fungi in the study.

Spore Preparation: Inoculums of each of the Entomopathogenic fungi were prepared separately by sub-culturing on potato dextrose agar (PDA). After two weeks growing of the fungus in Incubator at 25ºC and washed the spore from the stock with distilled water in the required amount. Completely mixed by stirred the fungal spore with distilled water and the solution used by dropper in to hemocytometer, count the spore and adjusted concentration on standard concentration of 108conidial suspensions per ml., from concentrated amounts of 20 ml fungal suspension were applied on five 3rd instars of larvae in each Beaker.

Pathogenicity Test against FAW: Effect of two selected entomopathogenic fungi namely Beuveria Basiyana and Matharazium Aniospolioe were tested against fall armyworm larvae. Collect fresh healthy leaves from susceptible BH546 maize variety and slicing middle parts of leaves at 10cm height and 60gm weighed were placed in a beaker. Then five 3rd instar larvae collected from purposely cultivated isolated field were out five larvae at 3rd stage development, pullout into the beaker on prepared leaves as feed in artificially favourable environment for 3-4 days and serving damage level record in percent .After evaluation of the damage of feeding, then applied 108 concentration of fungal suspension, 20ml per beaker per 5 larvae as following the method of Sisay, et al. [8]. The experiment was laid out in a completely randomized design (CRD) with three replications with deliberate of untreated plots. Mortal indications were the larvae inverted to dorsal.

Data collection

The data were collected within three consecutive days after applications of different management options depend on efficacy of the treatments based on mortality of larvae in percent.

Data analysis

Laboratory data's were analysed using the SAS version 9.4 Computer software (PROC GLM procedure) followed by fishery least significant different (LSD) test (α = 0.05) for mean separation of statistical agricultural software (SAS, 210).

Results

Evaluation of Synthetic Chemicals against FAW

There were highly significant different between chemicals in terms of mortality of larvae in percent was

P value <0.001. Among treatments the highest larvae mortalities were verified Bravo5EC (93.3%), followed to next Coragen 200SC, Radiant 20 SC and Karate5EC (90.0%) than Best 5EC (83.3%) and the least percentage of larvae mortality observed Dursban 48 %(80%) on average after applications of 72hrs. Under check (16.6%) mortality were observed by means of 20ml of water logged effect (Table 4).

Synthetic Chemicals	Percent Mortality of the Larva after		
	24hr	48hr	72hr
Bravo5EC	48.3±1.6[a]	75.0±2.8[a]	93.3±3.3[a]
Best 5 EC	51.6±6.0[a]	61.6±6.0[b]	83.3±1.6[bc]
Karate 5 EC	51.6±1.6[a]	68.3±1.6[ba]	90.0±2.8[ba]
Dursban 48%	50.00±2.8[a]	66.6±4.4[ba]	80.0±2.8[c]
Coragen 200 SC	49 ± 5.78 [a]	78.8 ± 7.03 [a]	92 ± 10 [a]
Radiant 120SC	52.2± 5.36[a]	80 ± 0 [a]	91.2±3.5[a]
Dimethoate 40%	37.8+ 7.44 [b]	81.1 + 5.59 [a]	87.5+ 3.38 [b]
check	3.6±1.3[c]	8.3±1.6[c]	16.6±1.6[d]
Mean	41	56	72.66
LSD *(α = 0.05)*	10.1	11.7	8.1
CV%	13.5	11.5	6.1

Table 4: Mean percentage (±SEM) of FAW mortality response of chemicals.

Means within a column followed by different letters are significantly different and the same letters are not significant different at P <0.05 (LSD test).

Mortality Evaluation of Entomopathogenic Fungi

The highest larvae mortality was observed from *Beauveria bassiana*/APPRC-1(81.6%) than *Matharazium aniospolie*/APPRC-2(70%) inoculated after 72hr. The lowest mortalities were documented from untreated (8.3%) on average. Among the treatments higher mean larvae mortality was observed from *Beauveria bassiana*/APPR-1 than *Matharazium aniospolioe*/APPR-2 (Table 5). There was significantly at P<.0001 different percentage of larvae mortality.

Entomopathogenic Fungi	Percent Mortality of the Larva After		
	24hr	48hr	72hr
B. basiana/APPR-1	26.6±1.6[a]	43.3±3.3[a]	81.6±1.6[a]
M. aniospolae/APPR-2	18.3±1.6[b]	38.3±1.6[a]	70.0±2.8[b]
Untreated/check	2.00±1.5[c]	5.00±2.8[b]	8.3±4.4[c]
Mean	15.66	28.88	53.33
LSD *(α = 0.05)*	5.6	9.4	11
CV%	17.9	16.3	10.3

Table 5: Mean percentage (±SEM) mortality response of entomopathogenic fungi in Assosa at 2022.

Different letters within a column significant and the same letters were not significantly different at P < 0.05 according to LSD test.

Efficacy Evaluations of Botanicals against FAW under Laboratory

There were significant at P<0.001 differences between botanicals in causing larvae mortality. The highest larvae mortality were caused extracts of Grewinia tenax(85%),Candle bush (81%) and Jatrophacarcus (76.6%) on average after 72hr.The least larvae mortality was verified from the treatments of Azandricha.indica(71.6%), Chenopodium ambrosoids 40%, Eucalyptus globulus 30% and Lantana camara(65%) application of after 72hr (Table 6).

Botanical Extracts	Percent mortality of the larva after		
	24hrs	48hrs	72hrs
Jatropha carcus	36.6±1.6^{b}	60.0±2.8^{bc}	76.6±1.6^{ba}
Neem seed	31.6±1.6^{b}	53.3±4.4^{c}	71.6±3.3^{bc}
Lantana camara	33.3±4.4^{b}	53.3±3.3^{c}	65.0±2.8^{c}
Candle bush	46.6±3.3^{a}	65.0±5^{ba}	81.6±3.3^{ba}
Grewia Tenax	48.3±3.3^{a}	71.6±3.3^{a}	85.0±5.7^{a}
Chenopodium ambrosoids	23±2.04^{c}	35.27 ± 2.04^{d}	40 ±4.27^{d}
Eucalyptus globulus	15 ± 0^{d}	25±2.02^{de}	30 ±7.75^{de}
Untreated/check	3.6±1.3^{c}	10.0±2.8^{d}	15.0±2.8^{d}
Mean	33.38	52.22	65.83
P-value	<.0001	<.0001	<.0001
LSD *(α = 0.05).*	8.8	11.4	10.8
CV%	14.8	12.3	9.3

*Values in columns different letters are significantly (P < 0.05) different with each in LSD test
Table 6: Mean percentage (±SEM) mortality of FAW larvae after 24, 48 and 72 hrs.

Discussion

Screening of Synthetic Chemicals against FAW

Insecticides tested in this study were toxic to FAW larvae, and some of them recorded high toxicity to the larvae in in laboratory evaluation. The highest larval mortality affected Bravo 5EC 93.3%, Coragen 200 SC 92%, Radiant 120SC 91%, Karate 5EC 90.0%, Dimethoate 40% 87%, Best 5EC (83.3%) & Dursban 48 %(80.0%) after application of 72hrs. The results were obtained in vitro study demonstrated significantly increase larvae mortality compared to untreated [9]. Similar investigations reported larvae mortality in laboratory and green house by karate 86.7% [10]. Also similar findings reported 77.8 % after 24hrs, 96.7 % after 48hrs and 96.7% after 72hrs FAW mortality respectively after application of synthetic insecticides. In Florida, FAW is one of the most important sweet corn pests, and synthetic insecticides are applied against FAW to protect both the vegetative stages and reproductive stage of corn [11]. The response of maize plants to FAW damage is influenced by several biotic and abiotic factors. These include plant growth stage and plant health, the incidence of infested plants, the severity of foliar damage symptoms, duration of larval feeding and whether or not re-infestation of the crops takes place [12]. Ecological and climatic conditions within a given terrestrial district are also important factors that decide the necessity of insecticide application for the control of FAW larvae [13].

Mortality Evaluation of Entomophagus Fungi against (FAW)

In this study of Beauveria basiana was the highest mortality of FAW larva 81.6% were recorded in 72 hrs after application. Matarazium aniospolioe was the lowest mortality followed 70.0% after application of at concentration of 1x108 conidial/ml on 3rd instars larvae García, et al. [14] reported 96.6% and 78.6% mortality with *B. bassiana* and *M. anisopliae* strains, respectively on 2nd instars larvae of the FAW at a concentration of 1 × 109 conidia/ml Aktuse, et al. [15] reported that, *M. anisopliae* and *B. bassiana* isolates showed 92% and 97% mortality on FAW eggs and neonate larvae, respectively on 2nd instars larvae, whereas only *B. bassiana* showed 30% mortality on 3rd instars larvae of FAW in Kenya Cruz-Avalos et al [16] reported that, M. anisopolioe and *B. bassiana* isolates showed 19 and 100% mortality on FAW eggs and neonate larvae, respectively Morales-Reyes, et al. [17] reported that *M. anisopliae* and *B. bassiana* at 106, 107 concentrations showed in the range of 45 to 65% mortality, respectively, on the 3rdinstar larvae of FAW in laboratory bioassay Fang, et al. [18] reported that entomophagus fungal enzymes play an important role on virulence of insect pests, which varies with different strains Kalvnadi, et al. [19] also reported that in line with the research, entomophagus fungi can also disrupt insect normal growth.

Efficacy of Plant Extracts Against FAW In Laboratory

Botanical pesticides are environment friendly, less harmful to farmers, consumer and safe to natural enemies of pest. In this study plant extracts were in Grewina tenax (85%), Candle bush (81%), Jatropha carcus (76.6%), A. indica (71.6%) and Lantana Camara(65%) caused percentage mortality after applications of 72hr. Similar findings with the present study application of 0.25% Neem oil extract under

laboratory condition showed 80% larval mortality Tavares & Maredia [20,21] also closely the same findings reported that Neem seed powder was very effective to control fall armyworm that can cause over 70% of larval mortality in laboratory. (Sisay 2019) a little beat contradict findings from the present study reported Lantana camara 46.7% larvae mortality at 72hrs. Jatropha carcus, 90% mean percent larvae mortality was recorded at 72 hrs.

Conclusion

Screening of FAW (fall armyworm) management options in laboratory evaluation were tested for their efficacy against (FAW). Extracts of A. indica, Jatropha carcus, Candle bush and Grewinia tenax larvae mortality showed statistical results were (71%-85%) on average after evaluations of 72hr. Efficacy evaluations of Entomopathogenic fungi isolates of *Matharazium aniospolie*/APPR-2 and *Beauveria bassiana*/APPR-1 were tested larvae mortality of fall armyworm(70-81.6%) respectively inoculated after 72hr .Efficacy tested on this study among synthetic insecticides, Dursban 48%, Best 5EC, Karate 5EC and Bravo 5 EC evaluated on mortality of FAW larvae (80-93%). Among the evaluated botanical/plant extracts, Grewinia tenax and candle bush, among entomophagus fungi (EPF), Beauveria bassiana and screening of synthetic chemicals Best 5EC, Karate 5EC, Coragen 200 SC, Radiant 120SC , Dimethoate 40% and Bravo 5EC could be recommended for the management of FAW in maize after validation under laboratory condition. Familiarizing and demonstrating IPM approach against FAW and revision critical time of FAW infestation and identify of favourable environmental circumstance and seasons are also needed. Over locations and different agro-ecologies (mid altitude, highland and moisture stress) area also looked-for

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