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EFFICACY OF INSECTICIDES AGAINST FALL ARMY WORM *SPODOPTERA FRUGIPERDA* (J E SMITH) ON SORGHUM

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ABSTRACT

***Spodoptera frugiperda* (J E Smith) is an important pest of sorghum, which is causing heavy losses in Ethiopia. This study was conducted at the Metema experimental site Gondar, Ethiopia during main cropping seasons of 2020 and 2021 to determining appropriate rate of selected insecticides against *S. frugiperda* larvae using randomized complete block design with three replications. Melkam variety used at a seed rate of 15 kg ha^{-1} and plot size of 22.5 m^2 was used. Plots sprayed with Proven and Agrolambacin in company recommendation rate reduced the incidence of larvae and gave higher grain yield. Cost benefit analysis showed that maximum net benefit (ETB 63,410.3 ha^{-1}) was obtained with followed by Agrolambacin 55535 ETB ha^{-1}.**

Key words: Fall armyworm, larvae, sorghum, rate, efficacy, insecticide, economic analysis, agrolambacin, proven

Sorghum (*Sorghum bicolor* L. Moench) is the fifth most important cereal in the world followed by wheat, rice, maize and barley and a major staple diet of people of semiarid tropics (Ismailia, et al*.,* 2010). However, its productivity is limited by a number of factors. Among these, varietal, agronomic, agroecological and pests are important *Colletotrichum* spp, and *Agrotis epsilon*, *Agrotis segetum*, and nowadays *Spodoptera frugiperda*, (J E Smith) are the major limiting factors. *Spodoptera frugiperda* is the principal insect pest that damages sorghum and maize. The larvae mainly attack growing shoots of sorghum causing deformed growth and poor heading, and ultimately reducing productivity. This pest is native to tropical and subtropical regions in the western hemisphere and can multiply throughout the year in suitable environments (Ashley et al., 1989) and where hosts are continually available. Lifecycle may take 30-90 days based on the seasonal variability (Capinera, 2002). In Ethopia, in the lowland of west Gondar it caused 100% field infestation during 2019 main cropping season and ultimately caused significant yield loss. There was phytotoxicity effect due to already recommended insecticides due to non-calibrated dosage during application (e.g. Metema and West Armachiho sorghum farms). Hence, this study to determine rates of already recommended insecticides under natural infestation.

MATERIALS AND METHODS

The study was conducted at the Metema experimental field of Gondar Agricultural Research Center (GARC) during the main cropping season of 2020 and 2021. 12^0 95' Latitude to 36 ^{0}15' 550 to 1608 masl (IPMS, 2005). Three selected insecticides and untreated control were included. The insecticides were applied as per company recommendation rate. The treatments in the following combination were applied: T1 (Proven <50% of company recommendation); T2 (Proven based on company recommendation); T3 (proven $\geq$50% of company recommendation); T4 (Selecron72% EC<50% of company recommendation); T5 (Selecron72% EC based on company recommendation); T6 (Selecron72% EC $\geq$50% of company recommendation); T7 (Agrolambacin <50% of company recommendation); T8 (Agrolambacin based on company recommendation); T9 (Agrolambacin $\geq$50% of company recommendation); and T10 (Untreated control). Randomized complete block design (RCBD) was used replicated three times. The crop was sown on 5 m by 4.5 m with spacing of 1 m between plots and 1.5 m between blocks. All the insecticide had been sprayed twice with manual knapsack sprayer targeting the immature larval stage; first was made when neonates' population crossed ETL (one larva/plant) and the second 10 days after. The collected data (both insect and crop) were statically analyzed using SAS software version 9.00 (SAS Institute, 2004) and means separated using Turkeys' test (p=0.05). The effectiveness of each insecticide against the target insect pest, in comparison to untreated control was calculated using Abbott's formula (Abbot, 1925).

RESULTS AND DISCUSSION

The results from the two consecutive cropping seasons revealed that there was no significant pretreatment difference in larval counts and a week after and two weeks after spray. The result also revealed the larval incidence was non-significant on all assessment dates indicating uniform distribution. Addisu et al. (2022) has reported similar results. This might be due to low intensity of infestation across the growth stages of sorghum in the season. The pooled ANOVA over two years showed that there was no significant difference among treatments on larval counts before insecticides spray; however, there was significant difference ($p<0.01$) after first and second spray and in grain yield (Table 1). The lowest larval count (0.3 and 0.03) was obtained from Proven in company recommendation after first and second spray followed by Agrolambacin in company recommendation week after first spray. These insecticides resulted in higher mortality of larvae (Mintesnot and Ebabuye, 2020). The insecticides rate tested were significantly different maximum efficacy was after first and second spray, respectively, with Proven and Agrolambacin in company recommendation; efficacy increased from first spray to second spray for all insecticides. A week after application, the field efficacy was highest in Proven (company recommendation)followed by Agrolambacin (company recommendation). Mintesnot and Ebabuye (2020) reported similar finding with their bioassay study. Thus, organophosphate+ pyrethroids class of the selected insecticides in company recommendation rate had better efficacy and ultimately improving the crop yield. This finding is in line with that of Addisu et al. (2022) who reported that pyrethroids were effective in maize.

Observations on phytotoxicity viz., injury on leaf tips, chlorosis was recorded on after first and second spray using 1 to 10 score recommended by Central Insecticide Board (Nishantha et al., 2009). These results corroborate with those of Kambrekar et al. (2012) that there was no phytotoxic effect. Due to lower larval incidence and less phytotoxicity effect, maximum grain yield gain and yield were recorded with Proven and Agrolambacin (recommendation rate) observed Saha et al. (2009) reported that application of pyrethroid after pod formation were effective against Apionidae. The pooled data on grain yield and economics revealed maximum grain yield (2868.9 kg ha^{-1}) and (2506.9 kg ha^{-1}) with Proven and Agrolambacin (company recommendation), respectively (Table 2). The grain yield was affected by infestation. There were a significant negative association and a linear relationship between incidence of larvae and grain yield was observed ($y = -193.07x + 2369.8$, $R^2 = 0.5599$) (Fig. 1). The 55.9% variability within grain yield can be attributed to increasing larval incidence.

Table 1. Effects of rates of selected insecticides on larval incidence of *S. frugiperda* and yield of sorghum (Metema, 2020 and 2021)

Treatment description evaluated	LCB (n)	LCAFS (n)	LCSS (n)	GY (kg ha^{-1})	Yield gain (%)
Proven below 50% CR	2.9	3.3	1.4 (2.0)	2010.9	24
Proven FR	3.5	0.3	0.03 (0.07)	2868.9	76.9
Proven above FR	3.7	1.2	0.4 (0.43)	2007.1	23.8
Profenophos below FR	3.6	3.4	1.45 (2.2)	1701.4	4.9
Profenophos FR	3.6	1.7	0.74 (0.97)	2151.1	32.6
Profenophos above FR	4.7	2.7	0.6 (0.47)	1908.8	17.7
Agrolambacin below FR	4.1	3.6	1.56 (2.47)	1829.7	12.8
Agrolambacin FR	4.0	0.8	0.42 (0.28)	2506.9	54.6
Agrolambacin above FR	3.5	0.9	0.07 (0.13)	2444.1	50.7
Untreated	3.7	6.5	2.16 (4.83)	1621.7	-
Mean		2.4	1.37		2105.6
Tukey (p=0.05)		1.9**	3.2**		356.8**
T*year		*	***		NS
CV (%)		42.7	51.2 (35.7)		9.1

LCB=Larvae count before spray, LCAFS= Larvae count after first spray, LCASS=Larvae count after second spray, GY=Grain yield, FR=Factory recommendations=non-significant, CV=coefficient of variance

Table 2. Economic analysis of insecticides against *S. frugiperda* in sorghum

Variables	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Yield kg/ ha (Y*0.9)	1809.8	2582.01	1806	1531.3	1936	1718	1647	2256	2199.7	1459.5
Price of sorghum (Birr kg^{-1})	25	25	25	25	25	25	25	25	25	25
Sale revenue (1*2)	45245	64550.3	45160	38283	48400	42950	41168	56405	54992.5	36487.5
Cost of insecticide (ETB ha^{-1})	470	940	1410	260	520	780	335	670	1005	0
Cost of labour for spray (ETB ha^{-1})	100	200	300	100	200	300	100	200	300	0
Total variable cost (ETB ha^{-1})	570	1140	1710	360	720	1080	435	870	1305	0
Net benefit (ETB ha^{-1})	44675	63410.3	43450	37923	47680	41870	40733	55535	53687.5	36487.5
Cost benefit ratio	78.38	55.62	25.41	105.34	66.22	38.77	93.64	63.83	41.14	0

Cost of labour = 100 Ethiopian Birr Day^{-1} labor^{-1}, price of Sorghum grain=25.00 Ethiopian Birr kg^{-1} T1=proven below 50% FR, T2=proven in FR, T3=Proven above 50% FR, T4=Profenofos below 50% FR, T5=Profenofos in FR, T6=profenofos above 50% FR, T7=Agrolambacin In below 50% FR, T8=Agrolambacin in FR, T9=Agrolambacin above 50% FR, T10=Untreated, FR=Factory recommendation

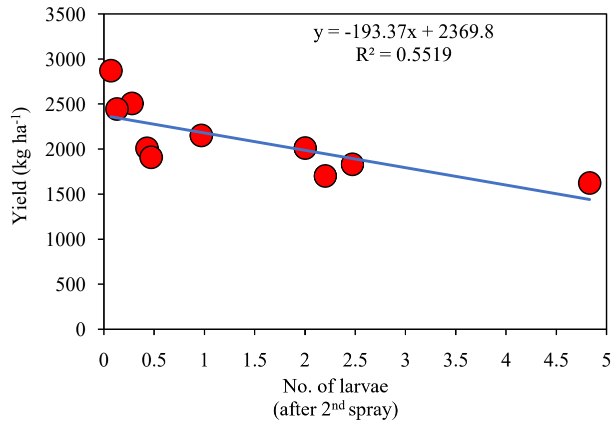

Fig. 1. Relation between larval incidence and grain yield in sorghum

The economics revealed that the higher net return was obtained with Proven (company recommendation) (ETB 63410.3) followed by Agrolambacin (company recommendation) (ETB 55535)). This is because of the relatively lower cost as well as lower phytotoxicity effect of insecticides rate and increased grain yield. Appropriate use of company recommendation rate for the pyrethroid insecticide could minimize maize plant damage and benefits to human and other beneficial insects (Addisu et al., 2022). Among the pyrethroid + organophosphate Agrolambacin (Profen+ L. cyhalothrin) and Proven (profenophos + cypermethrin) in company recommendation rate were more suitable for developing management strategies. Igyuve et al. (2018) reported that lambda-cyhalothrin and cypermethrin in appropriate rate were effective against *S. frugiperda* in maize. Sorghum sprayed with the two pyrethroid +organophosphate insecticides rate had low larval count, low phytotoxicity effect and higher grain yield. Economic analysis showed that the maximum net benefit was obtained with Proven at followed by Agrolambacin at company recommendation rates.

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AUTHOR CONTRIBUTION STATEMENT

As a first author, MW generated the researchable idea, wrote the proposal with detailed background, objectives, literature, experimental design and also playing a great role in the manuscript preparation. YK was a corresponding author and involved in shaping, commenting, and reviewing the draft proposal and acts as a corresponding author of this manuscript by rewriting the draft to fit into the requirements of this publication. MG and MM also conducted the data collection, provide inputs, and prepared a map for this particular work. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST

No conflict of interests.

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