**Efficacy of Synthetic insecticides against Sesame webworm (*Antigastra catalaunalis* Duponchel) in North West Amhara Region**

*Yohannes K\*, Birhanu F, Mintesnot W, Misganaw G, Gizat A, Simachew K, and Yismaw D.*

*Gondar Agricultural Research Center, P.O. Box 1337, Gondar, Ethiopia*

*\*Corresponding author, e-mail: kefaleyohannes@gmail.com*

**ABSTRACT**

*Sesame (Sesamum indicum L) is one of the most important edible oil crops in the world.* *While its production is challenged by different pests and inappropriate agronomic practices. Antigastra catalaunalis is the most serious pest of sesame, which is causing heavy losses in lowland areas, in northwestern, Ethiopia. Therefore the field experiment was conducted at Metema and Abrhajira both on the experimental site and on farm Gondar, Ethiopia during the main cropping seasons of 2022 and 2023 to identify effective and economical insecticides for the management of sesame webworms using Randomized Complete Block Design with three replications. The treatment consists profenofos 40%, Dimethoate 40%,* *Profenofos 40%+ Lambda-cyhalothrin, Ethiozinon 60% EC, Neem oil 5%, Profenofos 40%+ Cypermethrin 4%EC,* *Deltamethrin, Alphacypermethrin,* *Lambda-cyhalothrin and Control were evaluated against sesame webworm. Sesame variety Gander 1 which is under production used at a seed rate of 4 kg ha-1 and plot size of 12 m2 was used.* *Data on larvae counts and yield and yield-related parameters were recorded. The combined analysis revealed that Plots sprayed with Profenofos 40%+ Cypermethrin 4%EC and Lambda-cyhalothrin had a low number of larvae and higher grain yield. Economic analysis showed that the maximum net benefit (ETB 71102.1 ha-1) was obtained on plots treated with Profenofos 40%+ Cypermethrin 4%EC followed by (66302.25 ETB ha-1) Lambda-cyhalothrin treated plots.* *Hence these insecticides are recommended for the management of sesame webworm in the study areas and similar agroecologies.*

**Keywords:** Sesame, Efficacy, Economic analysis, Insecticide,Webworm

**INTRODUCTION**

Sesame (*Sesamum indicum*) is a vital oil crop produced in the tropical and subtropical parts of the World. Ethiopia is one of the major producers of sesame in the World. The crop is named the white golden because of its foreign exchange capability. Sesame is an annual plant that belongs to the Pedaliaceae family. It is a short-day plant and is normally self-pollinated although it has cross-pollination ranging from 5 to over 50% occurs (Pathirana, 1994). It is an erect herbaceous annual plant that has two growth characteristics: indeterminate and determinate, with heights of up to two meters. Most varieties show an indeterminate growth habit, which is also shown as a continuous production of new leaves, flowers, and capsules as long as the environment remains suitable for growth (Carlsson et al*.*, 2008). The growth period ranges from 70 to 150 days, depending on the variety and the conditions of cultivation. It is becoming the most important oil crop for Ethiopia’s export earnings and for increasing the potential of generating income for the local population (Ashri, 1998).

Sesame is the second largest agricultural commodity for the source of foreign currency and a good source of cooking oil through local extraction. In the Amhara region, it covered about 224, 220.29ha of land with a production of 1,538,097.33qt and an average productivity of 6.86qt/ha (CSA, 2021). In West Gondar, the crop covered 129,500.16 ha of land with a production of 908,145.6 qt and an average productivity of 7.0 qt/ha (CSA, 2021). Despite the increasing demand and price of sesame in the world market, the productivity of sesame is declining from 0.8 to 0.3 t/ha (Geremew et al*.,* 2012).

Production of sesame in the country is very crucial in many aspects but there are many hurdles to its production and productivity, like insect pest infestation and disease occurrence, seasonal delay, low yielding, postharvest loss, poor storage facility, difference in capsule maturity, shattering, and so on (Yohannes et al*.,* 2021). Out of which sesame webworm (A. catalaunalis) is the most important insect that affects sesame during various growth stages starting from two weeks after emergence (Suliman *et al*., 2013b) and causes 25%-35% yield loss (Geremew et al., 2012). Sesame webworm, (*Antigastra catalaunalis* Duponchel) is a well-established and widely distributed insect pest of sesame. It can be called sesame leaf roller, sesame capsule borer, or sesame leaf Webber (Ahirwar et al., 2010). It is a pest on sesame (*Sesamum indicum)* in the tropics, and it is present in all continents, except Antarctica. Sesame webworm (leaf roller) is the most serious pest of sesame accounting for approximately 90% of yield losses (Egonyu *et al*., 2005).

SWW is an important and widespread insect that damages sesame at all stages of development in Ethiopia (Negash 2015). Studies on chemical applications to control sesame webworm is limited in the study areas. Although producers sprayed insecticide many times they did not control the sesame webworm effectively, because due to repeated use of insecticides belonging to the same class (particularly organophosphate e.g.malathine) which resulted in the development of resistance. Hence minimizing resistance development and knowing the efficacy of insecticides belonging to different classes is mandatory.

**MATERIALS AND METHODS**

**Description of the study area**

The experiment was conducted in the main cropping season of Metema and Abrhajira both on station and onfarm at Gondar Agricultural Research Center (GARC) during the main cropping season of 2022 and 2023. Metema district is located 912 Km from the capital city, Addis Ababa, and 200 Km from Gondar. It is bordered by Sudan. Abrhajira is located 922 km from the capital city of Ethiopia and 210 km from Gondar. However, most of the rainfall is received during July and August. The study area had a mono-modal rainfall characteristic. The experimental areas are characterized by an unimodal rainfall condition with only one distinct growing season which is called Meher‘ which is the main rainy season from June to September. The location represents the major sesame-producing agroecology of the region and it is a hot spot environment for the sesame webworm. Some of the major crops grown in the district include rice, sorghum, cotton, soybean, and finger millet. The sesame variety Gonder 1 was used for the experiment since it is popular among the farmers in the study areas.

Table 1. Descriptions of the study areas (Source: IPMS, 2005)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Location | Elevation(m) | Total RF (mm) | Temperature | | Latitude | Longitude | Soil type |
| Min | Max |
| Metema | 550-1608 | 1030.2 | 19.5 | 35.9 | 12 950N | 36 150E | Vertisol |
| Abrhajifra |  |  |  |  |  |  |  |

RF = rain fall, Min=minimum, Max=maximum, source (IPMS, 2005)

**Experimental materials for the study**

The experiment was arranged in three replications with a Randomized Complete Block Design. The crop was sown on 5m by 2.4m plot area with a spacing of 1m between plots and 1.5m between blocks. Sesame variety Gonder 1 with plant and row spacing of 0.1m and 0.4m respectively was planted. Fertilizer at the rate of 121 Kgha-1 NPS (all at planting) and UREA 100 ha-1 (half at planting, and half at tillering) were applied. All the insecticides had been sprayed with manual knapsack sprayer in their factory recommendation. The insecticides were selected based on their mode of action. All insecticides used in this experiment were collected directly from original producers through the importers and a summary of details of each treatment is indicated in Table 2 below. The first spray was made when the neonates‘ population crossed ETL (one larva/plant) and the second spray was at 10 days after. All other agronomic practices were implemented as per the general recommendations for sesame production.

Table 2: List of insecticides and treatment set up of the Trail

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment number | Treatment description | /Chemical name of insecticides | Class/group | Application rate  Lit/ ha |
| Treatment 1 | Profit 72 SC | Profenofos | Organophosphat | 1 L/ha |
| Treatment 2 | Agro-Thoate 40%EC | Dimethoate 40% | Organophosphat | 1.5 L/ha |
| Treatment 3 | Agrolambacin | Profenafos+ Lambda Cyhalothrin | Organophosphate pyrethroid | 0.4 L/ha |
| Treatment 4 | Diazinon 60 % EC | Ethiozinon 60% EC | Organophosphat | 1.5 L/ha |
| Treatment 5 | Nimbiciden | Neem oil | Botanical/plant extract | 3 L/ha |
| Treatment 6 | Proven 44 % EC | Profenafos cypermethrin | Organophosphat pyrethroid | 1L/ha |
| Treatment 7 | Fastac100 G/L EC | Alphacypermethrin | Pyrethroid | 0.3 L/ha |
| Treatment 8 | Karate 5% EC. | Lambda-cyhalothrin | Pyrethroid | 0.4 L/ha |
| Treatment 9 | Decis 2.5% EC | Deltamethrin | Pyrethroid | 0.3 L/ha |
| Treatment 10 | Untreated control | No chemical | - | - |

**Data collected and analysis**

The larvae population was estimated by observing ten plants selected randomly from each treatment for the presence of larvae one day before insecticide application and after 10 days of first and second application using destructive sampling. Webbed plant percentage (WPP) was recorded before and after treatment application on a plot basis by counting the total number of plants and infested plants (plants whose shoots were rolled by webworm) from the central rows of a plot. Data on plant height (PH), number of pods per plant (NPP), number of seeds per pod (NSPP), thousand seed weight (TSW), and grain yield (GY) data were collected at appropriate stages and times pertinent for each parameter. The collected data was subjected to an analysis of variance as suggested by Gomez and Gomez using SAS software (version 2002) (Gomez and Gomez, 1984). Mean separation was made based on the LSD technique at 5% probability level. Partial budget analysis was done using CIMMYIT partial budget methodology (CIMMYIT, 1988).

The effectiveness of each insecticide against the target insect pest, in comparison to untreated control, was calculated using Abbott’s formula:

Insecticide efficacy (E) (%) = (T- t)\*100……………………….. (Abbot, 1925)

T

Where T is the mean number of alive larvae on control treatment and t is the mean number of alive larvae on each insecticide treatment.

Yield gains were calculated based on the differences between sprayed and unsprayed yields expressed as proportions of the unsprayed plot yields (Jail *et al*., (2014):

Grain yield gain (%) = (Gain yield of sprayed – Grain yield of unsprayed) \*100

Grain yield of unsprayed

**RESULTS AND DISCUSSION**

**Efficacy of insecticides on sesame webworm larvae counts**

The experiment was executed in one trial site in 2022 and the treatments didn’t show significant differences in sesame webworm intensity and other agronomic parameters before insecticide application. However webbed percentage after treatment applications was a significant difference among treatments at Metema for the 2022 season(p<0.05). The lower webbed percentage was recorded in insecticide-treated plots as compared to untreated control(Table 3). About the effect of insecticide application, there was a minimum webbed percentage (33.3%)recorded on the profenfos sprayed plots followed by Lambda-cyhalothrin(36.7%) sprayed plots. While the highest webbed percentage (50%) was recorded on the control plot after treatment application(Table 3). A similar study revealed that leaf and capsule damage were significantly lower on the lambda-cyhalothrin sprayed plot, whereas there were higher in the unsprayed plots (Akinyemi A, et al. 2015) .

Table 3: Effects of selected insecticides on a larval population of Sesame webworm - Metema research station 2022.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Treatments | PH | TSW | GY | WPB1 | WPA1 | WPA2 |
| Profit 72 SC | 151.7 | 1.9 | **672.5a** | 71.7 | **33.3d** | 22.13 |
| Ethiothoate 40% | 150.2 | 2.1 | 429.9b-e | 81.7 | 36.7cd | 33.8 |
| Agrolambacin | 143.8 | 2.1 | 430.3b-e | 73.3 | 38.3b-d | 33.3 |
| Ethiozinon 60 EC | 150.2 | 1.8 | 451.6b-d | 80 | 43.3a-c | 33.6 |
| Nimbiciden | 148.1 | 2.1 | **574.6ab** | 76.7 | 45ab | 34.4 |
| Proven 44 % EC | 150 | 1.9 | **516.5bc** | 76.7 | 45ab | 31.3 |
| Fastac 100 EC | 143.4 | 1.8 | 295.7e | 76.7 | 43.3a-c | 29.3 |
| Karate 5 SC | 146.6 | 1.6 | 367.7c-e | 66.7 | **36.7cd** | 30.7 |
| Decis 2.5% EC | 157.4 | 1.9 | 488.8b-d | 65 | 40bcd | 33.7 |
| control | 151.1 | 1.8 | **360.2de** | 70 | **50a** | 30.7 |
| GM | 149.2 | 1.8 | 458.7 | 73.8 | 41.2 | 19.8 |
| CV(%) | 4.3 | 24.8 | 19.8 | 11.8 | 10.4 | 33.2 |
| LSD(5%) | 11 | 0.8 | 155.7 | 15.1 | 7.3 | 11.3 |
| Pr>F | NS | NS | \*\* | NS | \*\* | NS |

*PH=Plant height, TSW=thousand seed weight, GY=grain yield kgha-1, WPBA1=wepped perecentage before first spray,WPA1=webbed percentage after first spray,WPA2=webbed percentage after second spray LSD=east significance difference, CV = coefficient of variation*

The combined analysis over the location in 2023 showed that there was no significant difference among treatments on larval counts before insecticide spray (Table 4). The larval population has not statically differed (P < 0.01) among the insecticide applications after the first spray, however, there were significant differences with unsprayed plots (Table 5). The result revealed that the insecticide-treated plots had a significantly lower population density of webworm larvae compared to the untreated control plots (Table 5). The lowest larval count (0.3 ) was obtained from T6 and T4(Diazinon and proven) on the count after spray. A similar result was reported by (Mintesnot Worku *et al*., 2024), who reported that a proven factory recommendation rate reduced the infestation level of *S. frugiperda* larvae(Lepidopetra family) on sorghum under field conditions.

In addition, the overall analysis of variance showed that there was no significant difference between treatments (p < 0.05) on larvae population at all experimental sites in the 2023 main cropping season before treatment application (Table 4). However, treatments did show significant differences in the mean larvae population of sesame webworm in all experimental sites during the 2023 cropping season (Table 4). Profenofos 40%+Cypermethrin 4%EC and lambda-cyhalothrin treated plots recorded lower mean larva populations with 0.5 and 0.5 respectively while the control plot recorded with mean larvae population of 1.3 (Table 4). The overall combined analysis revealed all the insecticides evaluated were found effective in controlling the insect. Hence, the number of mean larvae per plant was significantly lower in treated plots as compared with the untreated check. Similar findings on the efficacy of insecticides were reported by Ibekwe et al. (2014) who reported that lambda-cyhalothrin and deltamethrin were most effective against pod borer. This result is also in line with that of Geremew et al.(2012) who reported that sesame webworms can be controlled using Lambdacyhaolathrin 5% EC in infested fields.

Table 4 : Effects of selected insecticides on a larval population of *A. catalaunalis* Duponchel and yields of Sesame – 2023/2024 overall combined

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | PH | NPP | NSPP | GY | TSW | LBS | NLAS | ML |
| Profit 72 SC | 152.9 | 33.3 | 65.6a-c | 830.5ab | 2.7 | 0.8 | 0.4b | 0.6b |
| Ethiothoate | 156.3 | 31.6 | 67.3ab | 770.4a-c | 2.8 | 0.7 | 0.4b | 0.51b |
| Agrolambacin | 152.2 | 31.2 | 65.5a-c | 718.6bc | 2.7 | 1.0 | 0.5b | 0.7b |
| Ethiozinon 60 | 157.3 | 37.6 | 65.3a-c | 739.1a-c | 2.8 | 0.8 | 0.3b | 0.55b |
| Nimbiciden | 160.1 | 32.0 | 62.3c-e | 773.1a-c | 2.8 | 1.1 | 0.5b | 0.8b |
| Proven 44 % | 158.8 | 33.5 | 67.9a | 850.9a | 2.7 | 0.7 | 0.3b | 0.5b |
| Fastac 100 | 154.8 | 34.0 | 60.6de | 709.7bc | 2.8 | 0.8 | 0.4b | 0.6b |
| Karate 5 SC | 155.3 | 33.0 | 63.6b-d | 789.5ab | 2.6 | 0.8 | 0.5b | 0.5b |
| Decis 2.5% EC | 155.1 | 31.8 | 58.9ef | 662.8c | 2.8 | 1.0 | 0.6b | 0.8b |
| control | 154.5 | 30.0 | 56.1f | 475.5d | 2.7 | 1.2 | 1.3a | 1.3a |
| GM | 155.7 | 32.8 | 63.8 | 732.1 | 2.7 | 0.8 | 0.5 | 0.6 |
| CV(%) | 5.2 | 25.1 | 5.9 | 18.3 | 8.6 | 58.3 | 62.4 | 56.6 |
| LSD(5%) | 7.5 | 7.7 | 3.5 | 126.6 | 0.2 | 0.4 | 0.3 | 0.3 |
| Pr>F | NS | NS | \*\* | \* | NS | NS | \*\* | \*\* |

*PH=plant height, NPP number of pod per plant , NSPP=number of seed per pod, GY=Grain yield in kg per hectare , TSW=thousand seed weight ,NBS=number of larvae before spray, NLAS=Number of larvae after spray , ML=mean number of larvae, GM=grand mean, LSD=east significance difference, CV = coefficient of variation*

**Efficacy of insecticides on sesame webworm**

The tested insecticides were significantly different in their effect on the larvae of sesame webworm. The result revealed that the highest efficacy (76.9%) and yield gain(78.9%) were recorded from plots sprayed with Profenofos 40%+Cypermethrin 4%EC and Profenofos insecticides (Figure 1). Insecticide efficacy increased and the number of larvae per plant significantly decreased from the first spray to the second spray for all insecticides. This might be due to the increment in the number of insects on unsprayed plots. Hence, 10 days after insecticide rate applications, the field efficacy and grain yield were highest in Profenofos 40%+Cypermethrin 4%EC followed profenofos, and lowest in Deltamethrin followed by untreated control, while others had intermediate values (Figure 1). Mintesnot and Yohannes (2020) reported that similar finding in a bioassay study of these insecticides on fall armyworms.

Fig 1. Efficacy and yield gain of tested insecticides

**Effect of insecticide application on grain yield and yield component of sesame**

The combined analysis result revealed that most yield traits showed insignificant differences among the treatments however there were significant differences among treatments in the number of seeds per pod and grain yield of sesame webworm(Table 4). The grain yield and number of seeds per pod were highly affected by sesame webworm infestation. All the treatments were significantly superior over control (untreated) regarding grain yield and number of seeds per pod. The maximum grain yield (850.9kgha-1) and (830.5 kgha-1) were recorded from plots receiving treatment of Profenofos 40%+Cypermethrin and profenfos, respectively while the lowest (475.5kgha-1) was from untreated plots (Table 4). The highest number of seeds per pod (67.9 and 67.3, correspondingly) was recorded on the Profenofos 40%+Cypermethrin sprayed (T6) and Dimethoate 40%(T2) sprayed plots while the lowest(56.1) was recorded on the control plot Zenawi et al., 2016 reported similar results. The result also revealed that there was a significant negative association and a linear relationship between the population of larvae and grain yield of sesame (y = -396.63x + 993.7, R² = 0.8111) (Figure 2). The 81.1% variability within grain yield can be attributed to the increasing larva density of webworm. From this regration result we confirmed the lowest population level of the insect (1-1.4) per plant can cause a reasonable yield loss on sesame. Wazier *et al*. (2016) on his study stated that the economic injury level of the sesame webworm is 0.25 larva per meter square.

Figure 2. Linear regression of grain yield and Mean larvae

**Economic analysis**

Besides, the effectiveness of treatments on the protection of the grain yield of sesame was also evaluated through economic analysis comparing the marginal rate of return of each treatment by considering the overall mean grain yield (Table 5). Results of the partial budget analysis indicated that insecticide application of proven 44% EC(Profenafos + cypermethrin) 71102.1 ETB ha-1 ) with acceptable MRR(1066.6%) followed by karate 5 SC (Lambdacyhaolathrin 5% EC) (66302.25 ETB ha-1) with MRR(2137.5%) is better for controlling sesame webworm(Table 6). Hence, the use of Profenafos + cypermethrin and/or Lambdacyhaolathrin 5% EC is economically profitable and relatively low risk to non-target organisms and the environment. This result is in line with the result obtained by (Igyuve *et a.,* 2018); who reported that lambda-cyhalothrin and cypermethrin are effective to manage *S.frugiperda(*Lepidoptrea family).

Table 5: Partial budget analysis of insecticide sprays for sesame webworm management in the study areas

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Treatment | **Variables** | | | | | | | |
| Adj.yield kg/ha(Y\*0.9) | Price of Sesame (Birr kg) | Sale revenue (1\*2) | Cost of insecticide (ETB ha-1) | Cost of labor for spray (ETB ha-1) | Total variable cost (ETB ha-1) | Net benefit (ETB ha-1) | MRR |
| control | 427.95 | 95 | 40655.25 | 0 | 0 | 0 | 40655.25 | - |
| Karate 5 SC | 710.55 | 95 | 67502.25 | 600 | 600 | 1200 | 66302.25 | **2137.5** |
| Fastac 100 | 638.73 | 95 | 60679.35 | 630 | 600 | 1230 | 59449.35 | D |
| Ethiothoate | 693.36 | 95 | 65869.2 | 1000 | 600 | 1600 | 64269.2 | D |
| **Proven 44 %** | **765.81** | **95** | **72751.95** | **1050** | **600** | **1650** | **71101.95** | **1066.6** |
| Agrolambacin | 646.74 | 95 | 61440.3 | 1100 | 600 | 1700 | 59740.3 | D |
| Profit 72 SC | 747.45 | 95 | 71007.75 | 1200 | 600 | 1800 | **69207.7**5 | D |
| Decis 2.5% EC | 596.52 | 95 | 56669.4 | 1200 | 600 | 1800 | 54869.4 | D |
| Nimbiciden | 695.79 | 95 | 66100.05 | 2200 | 600 | 2800 | 63300.05 | D |
| Ethiozinon 60 | 665.19 | 95 | 63193.05 | 2400 | 600 | 3000 | 60193.05 | D |

Adj yield = yield adjusted to the farmers’ yield

**CONCLUSION AND RECOMMENDATION**

The study result revealed that all insecticides evaluated were found effective in controlling the insect. The number of mean larvae per plant was significantly lower in treated plots as compared with the untreated check. The efficacy of the insecticides rate was varied. The highest efficacy (76.9%) and yield gain(78.9%) were recorded from plots sprayed with Profenafos + cypermethrin and Profenafos insecticides in factory recommendation. The highest grain yield (850.5kg ha-1) was obtained from sesame sprayed with Profenafos + cypermethrin followed by Profenafos treated plots (830.9kg ha-1) while the lowest (475.5kg ha-1) was reordered from untreated plots. The partial budget analysis revealed that, the application of Profenafos + cypermethrin 44% EC 71102.1 ETB ha-1) with acceptable MRR (1066.6%) followed by Lambda-cyhalothrin 5 SC (66302.25 ETB ha-1) with MRR (2137.5%) is better for controlling sesame webworm. Hence the application of Profenafos + cypermethrin 44% EC (1 L ha-1) and Lambda-cyhalothrin (0.4 L ha-1) two times with 10 days intervals can be advised for the management of sesame webworm in the study areas and similar agroecology.

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Competing interests

Authors have declared that no competing interests exist

**References**

Abbot, W.S. (1925). A Method of Computing the Effectiveness of an Insecticide. *J of Economic Entomolog*y. 18: 265-267.

Ahirwar, R.M., Gupta, M.P. and Banerjee, Smita (2010). Bio-Ecology of Leaf Roller / Capsule Borer Antigastra catalaunalis Duponchle (Lepidoptera: Pyraustidae). Advances in bioresearch, 1: 90 – 104.

Akinyemi A, et al (2015). Susceptibility of sesame (Sesamum indicum L.) to major field insect pests as influenced by insecticides application in a sub-humid environment. African Entomology.;23(1):48-58

Ashri, A.(1998). Sesame Breeding. Plant Breeding Reviews, 16, 179-228.

Carlsson, A.S., N.P. Chanana, S.Gudu, M.C. Suh, and B.A.Were (2008). Sesame. In: Kole, C., et al. (Eds.) Compendium of transgenic crop plant- Transgenic oilseed crops. pp. 227-246. Texas, USA: Wiley Blackwell; 2. ISBN 978-1-405-16924-0.Center), Mexico.

CSA (Central Statistical Agency) (2021). *Agricultural sample survey*, 2020/2021 (Report onarea and production of crops (Private peasant holdings, main season). Statistical Authority, Addis Ababa, Ethiopia. Statistical Bulletin No. 590.

Egonyu, J., Kyamanywa, S., Anyanga, W. & Ssekabembe, C.(2005). Review of pests and diseases of sesame in Uganda. *African Crop Science Conference Proceedings*, 2005. 1411 -1416

Geremew T, Wakjira A, Muez B and Hagos T (2012). Sesame Production Manual.EIAR/Embassy of the Kingdom of Netherlands, Ethiopia, 49p.

Gomez, K.A. and A.A. Gomez, (1984). Statistical procedures for agricultural research. 2nd Edn., New York: John Wiley and Sons.pp: 680.

Igyuve, T. M., Ojo, G. O. S., Ugbaa, M. S., and Ochigbo, A. E. (2018). Fall army worm (Spodoptera frugiperda); its biology, impact and control on maize production in Nigeria. *Nigerian Journal of Crop Science*. 5(1) .78

IPMS (2005). ―Metema learning site diagnosis and program design,‖ ILRI (International Lives. Res. Institute), Ethiopia.ha-1 .

Jail, M. Urkude, R. and Deshmukh, L (2014). Evaluation of effect of different pesticides on pigeon pea using statistical tools in field experiment. *Journal of Environmental Science*, Toxicology and Food Technology. 8(8):24-27.

Mintesnot W, Yohannes K, Misganw G and Moges M (2024). Efficacy of Insecticides against Fall Army Worm Spodoptera frugiperda (JE Smith) on Sorghum. *Indian Journal of Entomology*, 1-4.

Mintesnot W and Ebabuye,Y. (2020). Evaluation of efficacy of insecticides against the fall army worm Spodoptera frugiperda. *Indian Journal of Entomology*, 81(1. P), 13

Negash A (2015). Status of production and marketing of Ethiopian sesame seeds (*Sesamum indicum* L.): A Review. *Agricultural and Biological Sciences Journal*, 1, 217-223.

Pathirana R (1994). Natural cross-pollination in sesame (*Sesamum indicum* L.). Plant Breed. 112(2), 167-170.

Suliman, E.H., Bashir, N.H., El tom, E.M.A. and Asad, Y. O. H.( 2013b). Biology and Webbing behaviour of Sesame webworm, Antigastra catalaunalis Duponchle (Lepidoptera: Pyraustidae). *Global Journal of Medicinal Plant Research*, 1: 210- 213.

Wazire N, Patel J, Determination of Economic Injury Level (EIL) for leaf webber and capsule borer, A. catalaunalis (Duponchel) in sesamum. *International Journal of Life Science*. 2016;A6:169-172.

Yohannes K., Asfaw A., Mintesnot W and Misganw G. (2021). Assessment of Major Insect Pests and Diseases of Sesame (Sesamum orientale L) in West Gondar Zone, Ethiopia. *Abyssinia Journal of Science and Technology*, 6(1), 6-11.

Zenawi G, Dereje A and Ibrahim F (2016). Insecticide application schedule to control sesame webworm Antigastra catalaunalis (Duponchel) Humera, North Ethiopia. *J. Agric. Ecol. Res. Int*, 8, 1-8.