Jimma University

School of Graduate Studies

Knowledge, Attitude and Practices of Farmers on the effect of Barley Shoot Fly *Delia spp* (Diptera: Anthomyidae) and Population Dynamics and its Abundance on Barley in Keshelu Kebele of Yem Special Administrative District, SNNPR, Ethiopia

By

Tigist Woldehana

Thesis submitted to Department of Biology, College of Natural Sciences, School of Graduate Studies, Jimma University, in partial fulfillment of the requirements for the Masters of Science degree in Biology (Ecological and Systematic Zoology)

December, 2014

Jimma, Ethiopia

Knowledge, Attitude and Practices of Farmers on the effect of Barley Shoot Fly *Delia spp* (Diptera: anthomyidae) and Population Dynamics and its Abundance on Barley in Keshelu Kebele of Yem Special Administrative District, SNNPR, Ethiopia

Advisors: Delenesaw Yewhalaw (PhD, Assit. Prof.)

Waktole Sori (PhD)

Thesis submitted to Department of Biology, College of Natural Sciences, and School of Graduate Studies, Jimma University, in partial fulfillment of the requirements for the Masters of Science degree in biology (ecological and systematic zoology)

By

Tigist Woldehana

December, 2014

Jimma, Ethiopia

DECLARATION

I, the undersigned, hereby declare that this thesis is my own original work. It has not been presented in any universities or institutions or colleges to obtain any academic awards. All the sources of materials used for this study have been duly acknowledged.

Name: Tigist Woldehana

Signature ______________

Date ________________

Acknowledgements

First of all, I would like to thank my God which enabled me strong enough and to reach up to this step. I would like to express my deepest gratitude to Dr. Delenesaw Yewhalaw for his valuable support starting from title selection and approval, advising and commenting throughout this study. I also extend my thanks to Dr.Waktole Sori for his technical support and valuable comments for the improvement of the manuscript. My great thanks also go to Yem special administrative district agricultural and rural developmental office and crop protection expert. Also I would like to thank Jimma University, College of Natural Sciences, and Department of biology for their support in review materials, internet access, and SPSS software. Finally, I would like to pass my thanks to my respected families particularly my father and friends, Zemedkun and Ashenafi for the fact that this work had not been successful without their day and night moral as well as material supports.

Table of contents

Contents **Pages**

List of Tables **Pages**

List of Figures **Pages**

Lists of Acronyms and Abbreviations

ARDO = Agricultural and Rural Developmental Office

BSFC = Barley Shoot Fly Count

BSF = Barley Shoot Fly

CACC = Central Agricultural Census Commission

CSA = Central Statistical Agency

FGD = Focus Group Discussion

HARC = Holetta Agricultural Research Center

ICARDA = International Center for Agricultural Research in the Dry Areas

IL = Infestation Level

IPC = Infested Plant Count

NGO = Non – Governmental Organization

PANE = Poverty Association Net Work in Ethiopia

RWA = Russian Wheat Aphid

SARC = Sinana Agricultural Research Center

SE = Standard Error

SNNPRS = Southern Nations and Nationalities Peoples Regional State

spp. = Species

TSCC = Total Stand Crop Count

YDASACPR = Yem District Agricultural Sector Annual Crop Production Report

Abstract

Barley is the fifth most important crop after teff, maize, sorghum and wheat in Ethiopia. However, barley is attacked by different pests and causes a great yield loss. Barley shoot fly (Delia species) is a major pest of barley on the highlands of Ethiopia. Thus, the objective of this study was to assess the knowledge, attitude and practices of farmers towards barley shoot fly and also to determine the abundance and population dynamics of barley shoot fly in Yem district, SNNPR, Ethiopia. The study was conducted from September, 2013 to September, 2014. Community based cross-sectional study and field survey were employed to generate data. Questionnaire, focus group discussion and filed data collection were tools used for data collection. Overall, 185 study participants were selected randomly from 356 households for the questionnaire survey. For focus group discussion, four participants were purposively selected. Moreover, site field survey was employed to assess the abundance and population dynamics of barley shoot fly. The collected data were analyzed using SPSS software package version 16.0 and excel computer programme. P –Value less than 0.05 was considered significant during the analysis. All (100%) of the respondents had awareness about the presence of the barley shoot fly on barley in the study area. Also all (100%) of the respondents cited chemical method as the main shoot fly control method in the study area. The reported estimated mean yield loss in short and main rainy season in the absence of control measure was (91.2%, 87%) and presence of control measures (34.06%, 31.6%) respectively. The mean percentage infestation during the short and main rainy season was 54.3% and 47.6% respectively. The infestation level on average was 54.3% and it was peak in May first week season 1and then dropped indicating that the pest was more favored in the short rainy season than in main rainy season or season 2. In addition, there was significant difference in the abundance of barley shoot fly with respect to seasons ($_F = 4.645, P < 0.05$ *) between season 1 and season 2 in the study area.*

1. INTRODUCTION

1.1. Background

Barley *(Hordeum vulgare* L.*)* is an annual cereal crop, which belongs to the tribe Triticeae of family Poaceae (Harlan, 1976; Martin *et al*., 2006). Barley is the most grown crop over broad environmental conditions. It has persisted as a major cereal crop through many centuries and it is the world's fourth important cereal crop after wheat, maize and rice (Martin *et al*., 2006). Barley is a major crop for large numbers of people living in the cooler, semi-arid areas of the world. In tropical Africa, Ethiopia is the only country where barley is a major crop, being the fifth most important crop both in area under cultivation and in production after teff, maize, sorghum and wheat. It is grown mainly in the highlands of the country and represents approximately an 11% share of the total area where grain is cropped (CACC, 2003). Barley has a long history of cultivation in Ethiopia and it is reported to have coincided with the beginning of plow culture (Zemede, 2002). It is the most important crop with total area coverage of 1,129,112 hectares and total annual production of about 1.7 million tons in main season (CSA, 2010). Barley is also a principal belg season crop second to maize in area coverage and production (Birhanu *et al.,* 2005; CSA, 2008). In the highland of the country, barley can be grown in Oromia, Amhara, Tigray Regional States and part of Southern, Nations, Nationality and peoples Regional State (SNNPRS). It is one of the dominant crops with wide ranges of climate and altitude ranging from 1400m to over 4000 meters above seas level in Ethiopia (Zemede, 2002).

Barley is one of the most important staple food crops in the highlands of Ethiopia (CSA, 2005) and its grain accounts for over 60% of the food of the people in the high lands of Ethiopia, for whom barley is one of the main sources of calories (ICARDA, 2002). Barley is produced in both the main rainy season, meher from June to September and Belg season - the short rainy season from March to May. It is preferred by subsistence farmers because of its ability to grow on marginal farms, unlike other cereals. Traditionally, barley is cultivated under no or little external inputs such as fertilizer or chemicals to control the major pests. Barley has a wide range of uses. Its grain is used as a staple food, for malting and for making local drinks, and is sold for cash. Its straw and stem stubs are used for animal feed and thatching. As barley is early harvested crop, it is popular hunger breaker or relief crop during season of food shortage in some parts of the country (Baye and Berhane, 2006).

The annual average national yield of the crop is only 1,200kg/ha (CSA, 2005). The low national average yield, which is far below the world average, is attributed to a multitude of abiotic and biotic factors. The most important abiotic stresses include low soil fertility, low soil pH, poor soil drainage, frost and drought. The important biotic stresses include diseases, such as scald, net blotch, spot blotch and rusts, which can reduce yields by up to 67%, and insect pests such as aphids and barley shoot fly, which can cause yield losses of 79% and 56%, respectively (Baye and Berhane, 2006). In Ethiopia, barley production is mainly constrained by lack of improved varieties, disease and insect pest problem, weed competition and poor soil fertility. One of the most important factors that are responsible for a low yield is losses resulting from insect pest attack (CSA, 2008).

Barley shoot fly *(Delia spp.)* is one of the most important insect pests of barley that has been recorded in Ethiopia (Davidson, 1969; Jobie, 2003; Jobie *et al*., 2004). Two barley shoot fly species, *Delia arambourgi* Seguy (Davidson, 1969) and *D. flavibasis* Stein (Jobie, 2003), are known to occur in Ethiopia, resulting in considerable yield losses. Both species belong to the order Diptera and family Anthomyidae. *D. flavibasis* has only recently been reported to occur in Ethiopia (Jobie *et al*., 2004) and it has been shown to be a major pest of barley in both Ethiopia and Kenya (Jobie, 2003). It causes significant yield loss and is becoming an important constraint in barley-growing districts of the highlands of Ethiopia, where all the improved varieties are highly susceptible to the pest (Amare, 1993; Jobie *et al*., 2004). At SARC, heavy infestation usually resulted in the failure of several trials. Infestation levels of barley shoot fly in the highlands frequently reach 100% on susceptible varieties such as HB 42, Ardu-10-9-60B, 'Shege', 'Beka', 'Holker' and HB 120; the highlands have become a hot spot for this pest (Amare, 1993; Jobie, 2003). Because of its devastating effects, especially on improved and exotic germplasm of malt barley, the pest is considered to be a major constraint to barley cultivation (SARC, 2004).

Besides the main host, barley shoot fly survives on several alternative hosts in the grass family, like maize (*zea mays*), wheat (*Triticum spp.),* blurish millet *(pennisetum americanum)* and a few grasses (Hill, 1987). Host preference study of *D. flavibasis* conducted at the Sinana Agricultural Research Center (SARC) with barley, teff, wheat, oat and maize revealed that barley and teff were the most preferred crops (SARC, 2004).

Yem District is one of the areas in the country where barley crop grows as one of the main crops by the farmers. The climatic and soil conditions in the district seem to favor well growth and biannual production of the crop. More than 15% of the farmland is covered by this crop (YDASACPR, 2012). However, the farmers are facing very serious devastating crop loss due to barley shoot fly *(Delia spp.)* (YDASACPR, 2012). Yet, there was no published information on barley and barley shoot fly in the district.

Knowledge, attitude and practices of farmers towards the effect of barley shoot fly *(Delia spp.)* on barley and its control methods as well the abundance and population dynamics of the pest were not investigated though such studies were assumed to provide concrete information to aid in management of the pest. Therefore, the current study was aimed to assess the knowledge, attitude and practices of farmers towards the effect of barley shoot fly *(Delia spp.)* on barley, population dynamics, abundance and its control methods in Keshelu kebele of Yem special administrative district.

1.2. STATEMENT OF THE PROBLEM

In Yem district, majority of the residents are agrarian and barley crop is one of their main crops grown. Even though they grow barley, there is lack of knowledge and information on any pests including barley shoot fly attacking barley. Pest attacking barley resulting in great losses of the crop per annum and thus, great economic and social problems are prevalent. Despite the farmers use pest control measures to reduce the negative impacts (crop losses) of the pests on their crop. The pest is still prevalent in the study area. Thus, it is important to assess the knowledge, attitude and practice towards the pest and to determine the abundance and population dynamics of the pest to develop and design effective control strategy.

The major constraints in cultivation of barley during the growing seasons are biotic factors such as pests like barley shoot fly. Barley pest can affect the growth and survival of tillers which can affect initial plant count. Therefore, early barley shoot fly management is vital, as initial plant count is important for successful yield and economic profits. Often, farmers and crop protection experts use pesticides to control barley shoot fly indiscriminately.

In view of the facts discussed above, the present study was under taken to assess the knowledge, attitudes and practices of farmers and crop protection experts on the effects of barley shoot fly *(Delia spp.)* on barley and understand and document the abundance and population dynamics of the fly during barley growing seasons in Yem district. In effect; the present study tried to answer the following research questions.

1. What is the knowledge, attitude and practices of farmers towards the effect of barley shoot fly *(Delia spp.)* on barley in Keshelu kebele of Yem district?
2. Do farmers know the level of damage and the amount of barley crop loss caused by barley shoot fly *(Delia spp.)* in the main growing seasons (short and main rainy seasons) in Keshelu kebele of Yem district?
3. Does the abundance and population dynamics of barley shoot fly *(Delia spp.)* change between barley growing seasons and how it responds to controlling methods applied?

1.3. Objectives of the study

1.3.1. General objective

To assess the knowledge, attitude and practice of farmers towards barley shoot fly *(Delia spp.)* and to determine the abundance, population dynamics and its control methods in Keshelu kebele, Yem special administrative district, SNNPR, Ethiopia.

1.3.2. Specific objectives

- To determine the knowledge, attitude and practices of farmers towards barley shoot fly *(Delia spp.)* in the study area.
- To assess the abundance and population dynamics of barley shoot fly in different seasons *(Delia spp.)* and control methods in the study area.
- To determine the level of yield loss due to barley shoot fly *(Delia spp.)* in the study area.

1.4. SIGNIFICANCE OF THE STUDY

Barley is the fifth most important crop after teff, maize, sorghum and wheat, and it is a cool – season crop that is adapted to high altitude. Barley is susceptible to attack by many kinds of pests, including aphids, shoot flies, grasshopper, crickets, thrips, army worms, cut worms and beetles and their larvae. Of which barley shoot fly is one of the most important insect pest of barley that has been recorded in Ethiopia. It results in considerable yield losses. It causes significant yield loss and is becoming an important constraint in barley growing districts of the high lands, where all the improved varieties are highly susceptible to the pest. Therefore, in order to help and boost barley crop production and productivity in the current study area, the findings of this research will have the following benefits:

- Both the farmers and crop protection experts in Keshelu kebele of Yem district will obtain scientific evidence to update their current knowledge, attitude and practices on their understanding the importance and management of barley shoot fly

- Both the farmers and crop protection experts will get evidence on abundance, population dynamics and pest status of barley shoot fly *(Delia spp.)* in the short and main rainy seasons.
- The farmers will realize the importance of barley shoot fly, positively change their attitude and improve their management practice based on the recommendations given from this study to increase production and productivity of barley.
- The crop protection experts understand the importance of the pest and identify better ways of assisting farmers to manage barley shoot fly time.
- Additionally, this research could be used as a baseline evidence for others who may further conduct scientific research on barley shoot fly *(Delia spp.)* in Keshelu kebele of Yem district and barley producing areas of similar agro-climatic situations.

2. LITERATURE REVIEW

In Ethiopia, many insect pests that attack barley have been recorded. Of these, Russian Wheat Aphid (RWA) and barley shoot fly are the main ones (Adugna and Kemal, 1986). There are two species of barley shoot fly that occur in Ethiopia*:* *Delia arambourgi* Seguy, recorded from the central part of the country (Holetta) (Davidson, 1969) and *D. flavibasis* Stein, recorded from Bale (Jobie, 2003). Further, literature pertaining to barley shoot fly are presented in this chapter as follows:

2.1. Biology and description of barley shoot fly *(Delia spp.)*

Eggs are usually laid on the soil within 2cm of the plant, though occasionally recorded on the tips of young leaves. Hatching takes 3-4 days. The young larvae make their way over the soil surface, climb the plant to just above the first leaf sheaths, and bore down through the tissue to the growing point. This results in the death of the central shoot, producing a ‘dead heart’. The larva remains in this shoot during the first two instars soon after the second moult larva quits that shoot and attacks either another shoots on the same plant or shoots of another plant. The new shoot it penetrated by eating through the leaf sheath and the central shoots are destroyed. The larva moves to a third or even fourth shoot before reaching maturity some 12 days after hatching. Pupation takes place in the soil, amongst the plant roots; the pupal stage takes some seven days. The adult is a medium sized fly about 7-8 mm long and looking rather like a small house fly; the female has a pointed abdomen and is grey; the male is blackish and has a rounded abdomenal apex (Miller and Ghannoum, 1994).

The shoot fly females prefer second leaf, followed by third, first, and fourth leaves for egg laying under laboratory conditions, while third leaf, followed by second, fourth, fifth, sixth, first, and seventh leaf were preferred for oviposition under field conditions (Ogwaro, 1978; Davies and Reddy, 1981). In general, shoot fly females lay only one egg per plant, but under high shoot fly-pressure, there may be several eggs on the same leaf. When more than one egg is present on a plant, these are laid by different females, but under no-choice conditions, more than one egg per plant and more than one larva per plant have also been observed (Dhillon *et al.,* 2005).

2.2. Ecology of barley shoot fly *(Delia spp.)*

Shoot flies are active throughout the year, during the off-season; the insect survives on alternate hosts. Infestations are high when plantings are staggered due to erratic rainfall during short and main rainy seasons. The shoot fly activity and incidence are adversely affected by extremes of temperatures (maximum 30 to 40 ^{0}C and minimum 2 to 14 ^{0}C) and continuous heavy rains. Temperatures above 35 ^{0}C and below 18 ^{0}C and continuous rain fall reduce shoot fly abundance (Taneja *et al*., 1986).

2. 3. Taxonomy of barley shoot fly *(Delia spp.)*

Barley shoot fly is classified under Kingdom – Animalia, Phylum – Arthropoda, Class – Insecta, Order –Diptera, Family–Anthomyidae, Genus–*Delia*, Species - *flavibasis* Stein, *arambourgi* Seguy (Hein, 1989).

2.4. Status and distribution of barley shoot fly *(Delia spp.)* in Ethiopia

In Ethiopia, the first record of barley shoot fly was in 1967. It was first observed at Holetta Agricultural Research Centre and the species was identified as *Delia arambourgi* Seguy (Davidson, 1969). This pest was then expected to infest three crops, barley, wheat and teff, and was considered to be a major pest of barley and a minor pest of wheat and teff (Adugna and Kemal, 1986).

In addition to the previous record, two more shoot fly species, one from wheat and the other from barley, were recorded in 2003 at Sinana. Both species were identified at the Natural History Museum, UK. The species reared from wheat was identified as *D. steiniella* Emden, belonging to family Anthomyidae, Order Diptera, and caused an infestation in the range of 56.5–74.5% on different bread wheat varieties at Sinana, Ethiopia, under field conditions and natural infestations (Jobie and Tadesse, 2005). This is perhaps the first report of *D. steiniella* on wheat. Similarly, specimens of shoot fly reared from barley at Sinana were identified as *D. flavibasis* Stein, belonging to the same family. Hence, currently there are at least two known species of shoot fly that attack barley in Ethiopia: *D. arambourgi* and *D. flavibasis* (Jobie, 2003).

An experiment was conducted at SARC to test the occurrence of infestation of barley shoot fly on wheat and barley during the off-season (non-cropping period). Accordingly, five varieties each of barley and wheat were sown in February 2004 and 2005. The results indicated that, in the non-cropping period of 2004, the infestation level was 7–39% on barley and 12–19% on wheat. In 2005, infestation of barley genotypes during the off-season was 21–54% and that of wheat was 8–12%. The implication is that *D. flavibasis* appears to ensure year-round survival through normal reproduction by infestation of the main host and alternative volunteer crops and wild hosts (SARC, 2005).

At (SARC), heavy infestation usually results in the failure of several trials, particularly those with malt barley and exotic genotypes (SARC, 2004). In contrast, farmers who grow the local barley cultivar, ‘Aruso’, often experience low infestation of barley shoot fly in their barley fields, perhaps because the variety has co-existed with the pest for many years (Jobie, 2003).

Results obtained from sweep net catches indicated the presence of a varying shoot fly population density throughout the study period. The shoot fly population was low until late August. From late August to mid-September the population reached its peak. The shoot fly population started to decline from late September onwards. Shoot fly abundance, as measured by percentage infestation, exhibited significant variation between the resistant and susceptible varieties across all the sowing dates (Jobie, 2003). The highest infestation percentage (100%) was recorded on the susceptible variety, ‘Holker’, from the third to the fifth sowing dates. On the resistant variety, ‘Harbu’, infestation percentage ranged from 45% for the last sowing date to 89% for the third sowing date. The percentage of infestation for ‘Dinsho’ ranged from 38% to 92% in the same order. For all sowing dates, the susceptible variety, ‘Holker’, was more infested than the resistant varieties. However, the resistant varieties were not significantly different from each other in terms of level of infestation. The resistant varieties, ‘Harbu’ and ‘Dinsho’, showed a reduction in infestation and dead heart formation at the second sowing date. In contrast, the percentage dead heart formation for these varieties showed a linear increment until the sixth sowing date. Starting from the sixth sowing dates and onwards, the percentage dead heart formation declined in a similar manner to percentage infestation for both the susceptible and resistant varieties. Dead heart formation was the least (22.5%) on ‘Harbu’ on the last sowing date and reached its peak (72%) on the third sowing date. Similarly, the lowest percentage dead heart formation (18%) was recorded on ‘Dinsho’ at the last sowing dates and the highest (71%). Weekly catches of adult flies per sweeping net were highly correlated with relative humidity and availability of barley seedlings (Jobie, 2003).

2.5. Control of barley shoot fly *(Delia spp.)*

It is important to any pest management system to monitor the population fluctuations and to allow any form of control to exert itself on the population. If small areas are affected such as minimizing traffic movement, adopting best practice hygiene, spraying/removing hosts (indication of area that would need to be managed around initial infestation), restriction of infested soil movement, and hay/stubble should be destroyed by burning. Shoot flies are less abundant during rainy season under moderate temperatures and high humidity. If large areas are affected, control methods would be similar to the control of small areas. There may also be some scope for area wide management through cultural practices (National Academy of Sciences, 1995).

2.5.1. Cultural control methods barley shoot fly *(Delia spp.)*

Crop husbandry practices to suppress shoot fly populations are best suited for growing countries of Africa and Asia. Infestation can be reduced by early sowing, 7 -10 days before the onset of heavy rains, to avoid the active period of shoot fly emergence. If early sowing is not possible then use high seed rate to compensate for later thinning out of the dead hearts from infested fields (National Academy of Sciences, 1995). Shoot fly damage can be influenced by factors that affect plant growth. The application of nitrogen fertilizer and the bio fertilizer Azospirillum together with the physical characteristics of the soil and moisture content can affect plant growth and influence shoot fly incidence. Plant stand has a significant effect on shoot fly infestation. High seeding rate helps reduce shoot fly damage. Seedlings under high planting density have narrow leaves, which are less attractive for egg laying. Inter cultivation can reduce pest populations by exposing the pupae to parasite/ predators and other adverse environmental factors. Pull out infested seedlings and alternate hosts such as fodder sorghums and grasses and their residues, and then destroy by burning (National Academy of Sciences, 1995). Buchs *et al*. (1997) studied the effects of different crop rotation intensities on the arthropod community. They showed that certain pest species were favored by an increase in the intensity of crop rotation, whereas some beneficial insects were unable to establish stable populations in arable crops with intensive rotations. The authors found that the number of individuals, species richness, body length, and reproductive rates of beneficial insects increased with the progressive extensification of crop sequences, particularly in set-aside areas subjected to natural succession. Crop rotation can minimize pest damage by confusing the insects with chemical aromas emitted from non-host plants, and using crop combinations that encourage the activity and abundance of natural enemies. Host plant resistance is an important component for the management of this pest in all areas where the barley shoot fly is a pest. Host plant resistance has been shown to decrease herbivore population development and/ the damage caused by pests significantly (Francis *et al*., 2001; Sharma and Ortiz, 2002; Van Emden, 1991). Trials in southern Africa and Asia have shown significant differences in resistance to this pest damage among varieties tested. Some varieties in southern and eastern Africa have been identified as being medium to high level resistant to attack by shoot fly (National Academy of Sciences, 1995).

2.5.2. Chemical control method barley shoot fly *(Delia spp.)*

Prior to the application of any chemicals to control the pest, an investigation will be required to confirm that chemicals identified are registered and approved for use on the pest and/or host. Care must be taken with the organophosphates as some are phytotoxic and Carbaryl, carbofuran, fenvalerate and endosulfan can be used to control shoot fly. Dusts, granules or sprays may be applied, depending on the time and mode of application. In India, a number of chemicals have been used for the control of this pest – treating the seeds before sowing with imidacloprid or chlorpyriphos or monocrotophos; application of carbofuran or phorate at time of planting in the rows, or spraying with endosulfan after the emergence of seedlings (Singu and Sharma, 2002).

2.5.3. Biological control method barley shoot fly *(Delia spp.)*

There is very little information available on the role of natural enemies in population dynamics and the extent of parasitism/predation. A range of natural enemies attack in other countries – parasitic wasps attack eggs and larvae, and predators cause high mortality of eggs (Singh and Sharma, 2002).

3. MATERIALS AND METHODS

3.1. Description of the study area and period

The study was conducted in Keshelu kebele of Yem district, Southern, Nations, Nationality and Peoples Regional State (SNNPRS) from September; 2013 to September; 2014. It is about 239km South West of Addis Ababa, the capital city of Ethiopia and it is located at 8^0 0' 27'' N and 7^0 37'' N latitude and 37^0 24' 20'' E and 30^0 36'54'' E longitude. It has an altitude ranging from 1000 - 2939 meters above sea level. The mean maximum and minimum temperature is 30^0C and 12^0C, respectively and the mean annual rain fall ranges between 802 – 1400 mm (PANE, 2008).

3.2. Study Design

Community based cross-sectional survey and observation (field study).

3.3. Sample size and sampling techniques

3.3.1. Sample size for community based cross-sectional survey

The sample size of the study was determined by using single population proportion formula (Cochran,1977) by assuming 95% confidence level with 0.05 marginal error and p = 0.5.

$$n = \frac{Z^2 PQ}{D^2} ,$$

Where; $n =$ sample size

$$= \frac{(1.96)^2 (0.5)(0.5)}{(0.05)2}$$

$D =$ margin of error

$$= 384.16$$

$N =$ number of house holds

$$= 384$$

$P =$ proportion of knowledge, attitude and practices of farmers towards the effect of barley shoot fly

$Z =$ level of confidence

$$Q = 1 - P$$

$$D = 0.05$$

$$P = 0.5$$

$$Z = 1.96$$

Since the source population (= 356, number of HH's in Keshelu kebele) was smaller than 10, 000, the following correction formula was used in order to determine the study sample size.

$$nf = \frac{n}{1 + \frac{n}{N}}$$

$$= \frac{384}{1 + \frac{384}{356}}$$

= 184.79 = 185

Thus, 185 study participants were randomly selected from the source population for this study.

3.3.2. Sampling techniques (Study population)

The study area had one Kebele with 356 households with a total population of 1, 834. In the district 96,330 total populations was found and from this majority (85, 796) of the people in the district live in the rural areas (PANE, 2008). By taking the list of households from Kebele administration office, 185 households were selected from 356 households by simple random sampling method.

3.4. Data collection tools

3.4.1. Questionnaire survey

Semi–structured questionnaire (appendix-1) was prepared in English language by the investigator after reviewing similar studies conducted and also taking into account the objectives of the current study. Then, the questionnaire was translated into local language-Yemsa (appendix-2). The questionnaire was validated by advisors. The questionnaire contained a total of 22 questions with two parts namely; introductory questions assessed by 6 items and barley shoot fly related issues assessed by 16 items.

The data were collected through interviewer by administering the semi-structured questionnaire. First, one assistant data collector who completed grade ten was recruited on the basis of educational background and his familiarity with the study area. Training was given to him for a day. Then, the investigator interviewed each of the selected individuals for interview and filled out the questionnaire while interviewing the selected study samples after getting their consent. This was done using house to house interview of selected participants with the assistant. The respondents were initiated to give their response in terms of their knowledge, attitude, practice of the issue requested in the questionnaire. Then, the filled out questionnaires were collected for further processing and analysis by the investigator and the assistant data collector. Data collection was conducted for 17 days from October, 2013 to December, 2013.

3.4.2. Focus Group Discussion (FGD)

The investigator prepared a guideline for FGD (appendix-3) to get relevant information. Here, the investigator facilitated the discussion and recorded the agreed points from the participants. The participants were purposively selected from developmental agents of the kebele, crop protection expert of the woreda, head of the kebele and head of district agricultural and rural developmental office. One participant from each was selected. Thus, a total of four participants were selected for FGD. The discussion was guided and facilitated by the investigator based on pre- prepared guideline for FGD in December, 2013 with estimated duration of one and half hour discussion.

3.5. Field Barley Shoot fly collection

3.5.1. Plot selection `

The study was conducted in Keshelu kebele of Yem district in 2014 during barley growing seasons (short and main rainy seasons). March to June (short rainy season) as season one and July to October (main rainy season) as season two was used to investigate the abundance and population dynamics of barley shoot fly. Two plots (25m x 25m) of barley crop field were used for field survey and randomly 5 quadrats were placed to count the number of barley shoot fly catches per quadrats using sweep net. From the quadrat, samples were taken by moving diagonally. Further the next samples were taken from the nearest other corner again in diagonal movement. The quadrats were also used to estimate the number of barley plants per quadrats of size 2m x2m. Data recorded per plot were number of infested plants, whole stand count, and adult catches per sweeping net. Infestation was scored by counting seedlings showing damage symptoms within the quadrat after seedling emergence. Infestation was considered to be a range of symptoms, from mild and early leaf mining to dead hearts. Subsequently, data on dead hearts were recorded. Dead hearts referred to seedlings attacked by barley shoot fly, the central shoots of which had already dried or showed wilting (Jobie, 2003).

3.5.2 Identification of Barely Shoot fly (*Delia* species)

Shoot flies were sampled from each plot using butterfly sweep net. Adult catches were carried out weekly in the morning from barley seedlings using sweeping nets, starting from seedling emergence until the crop reached pre-maturation stage (Zadoks *et al.,* 1974). Samples were transferred to killing jar containing 70% denatured alcohol. Identification of barley shoot fly was made using identification key with experts on field identification site. The collected samples from each sweep net were recorded on field data recording sheet. Roving survey with absolute count method was applied using netting technique to collect and count the pests. The average weekly catch of adult flies per sweeping net was collected and recorded. Later the percentage of pest infestation level and the number of pests per plant were determined. Additionally, abundance of barley shoot fly was considered.

$$Percentage\ of\ pest\ infestation = \frac{The\ number\ of\ infested\ plant}{Totad\ stand\ count} \times 100$$

$$Density = \frac{Total\ BSFC}{Total\ TSC / plot}$$

$$Abundance = \frac{Total\ number\ of\ indivisuals\ of\ species}{Total\ number\ of\ sample\ blocks}$$ (Brown, 1984)

3.6. Data analysis

Data were checked for correctness and completeness and then, entered in to a computer. The data were analyzed using SPSS software package version 16.0. In addition, excel computer program was used to present the outcome of the study using tables and figures. All tests were considered significant at $P < 0.05$ with confidence level of 95%. One way ANOVA was also used to compare BSFC variation.

3.7. Ethical considerations

The proposal was approved by ethical review committee of College of Natural Sciences of Jimma University. Then, formal letter was written to Yem district administrator from Jimma University requesting their cooperation to allow the investigator to conduct the research in Keshelu kebele of the district. Then, Yem district administration office wrote another letter to the kebele administration office of the district. The respondents were informed that they had the right to withdraw from the study at any time. To ensure secrecy and privacy the participants name were not written on the questionnaire. Additionally, they were informed that their response or data were used only for the intended research purpose and not for anything else without their will to ensure the confidentiality of their response.

3.8. Delimitation of the study

This study focused on knowledge, attitude and practice of farmers and crop protection experts of the district towards the overall understanding of barley shoot fly and also to determine the pest infestation level of barley by shoot fly in the season, its abundance and population dynamics in Keshelu kebele of Yem district. Thus, its scope was limited to the study area.

4. RESULTS

4.1. Socio- demographic characteristics of the respondents

Table 1 shows the socio- demographic characteristics of the respondents. The majority of the respondents were in the age groups 41-50 (n=78, 42.1%) followed by 20-30 (n=15, 8.1%), 31- 40 (n=62, 33.5%), and >50 (n= 30, 16.2%). Regarding the sex of the respondents 85.9% (n=159) were males while 14.05% (n= 26) were females. Regarding their educational status 25.9% (n=48) of the respondents had no formal education, 59.4 % (n=110) of them had primary education while 14.5 % (n=27) had secondary education. All (100%) of the respondents were farmers engaged in mixed farming which practice crop cultivation and livestock rearing.

Table 1: Socio- demographic characteristics of the respondents

Variables	Frequency	Percentage
Age groups		
20-30	15	8.1
31-40	62	33.5
41-50	78	42.1
>50	30	16.2
Sex		
Male	159	85.9
Female	26	14.05
Educational status		
No formal education	48	25.9
Primary education (1-8)	110	59.4
Secondary education (9-12)	27	14.5
Occupation(livelihood activities)		
Only keeping livestock	0	0%
Farming and livestock	185	100

4.2. Knowledge, Attitude and Practice of farmers towards barley shoot fly *(Delia spp.)*

The knowledge of the respondents about barley shoot fly in Keshelu kebele of Yem district was presented in Table 2. All (100%) of the respondents reported that there was pest on barley crop in the area. Concerning with familiarity of the pest name by the respondents, 17.3 % (n=32) of the respondents know barley shoot fly and name it as 'kura' but 82.7 % (n=153) of the respondents did not know name of the pest. Only 1.08% of the respondents was found to be familiar with cause of occurrence of the pest but 98.9% (n=183) of the respondents were not aware of the cause of occurrence of the pest. Regarding the season of barley shoot fly occurrence in the area, 56.2% (n=104) of the respondents replied that the pest occurs in short rainy season (season one) while 43.7% (n= 81) of the respondents replied that the pest occurs in main rainy season (season two).

All (100 %) of the respondents reported the attack of the pest was on the seedling leaves of the crop. Regarding the sign of occurrence of barley shoot fly, all (100%) of the respondents replied that wilting of leaves starting at seedling stage and developing fiber like as the leaves wilt were the sign of barley shoot fly attack on barley. Table 2, shows attitudes of respondents towards the effect of barley shoot fly. All (100%) of the respondents indicated that the impact of barley shoot fly was very high and 100% of the respondents also indicated that the impact level reduces with pesticide application.

Table 2: Respondents' Knowledge and attitude towards barley shoot fly *(Delia spp.)* in Keshelu Kebele, Yem district, SNNPR, Ethiopia.

Variable	n (%)
Presence of barley pest in the area	
Yes	185 (100)
No	0%
Familiarity of the pest name	
Yes	32 (17.3)
No	153 (82.7)
Cause of occurrence of barley shoot fly	
Yes	2 (1.08)
No	183 (98.9)
Season of barley shoot fly occurrence	
Short rainy season	104 (56.2)
Main rainy season	81 (43.7)
Parts of crop attacked by barley shoot fly	
Leaves (seedling)	
Stems	185 (100)
Root	0%
Signs of barley crop due to shoot fly attack	
Wilting of leaves starting at seedling stage	
Leave curled	185 (100)
Leaf spot	0%
Attitude on the impact level of barley shoot fly attack	
Very high impact	185 (100)
Impact level reduces with pesticide application	185 (100)

Figure 1 shows, types of crops attacked by barley shoot fly *(Delia spp.)* reported by respondents. All 100% (n=185), 52.9% (n=98), and 38.3% (n=71) of the respondents cited that barley shoot fly attacked barley, wheat and teff, respectively in the study area.

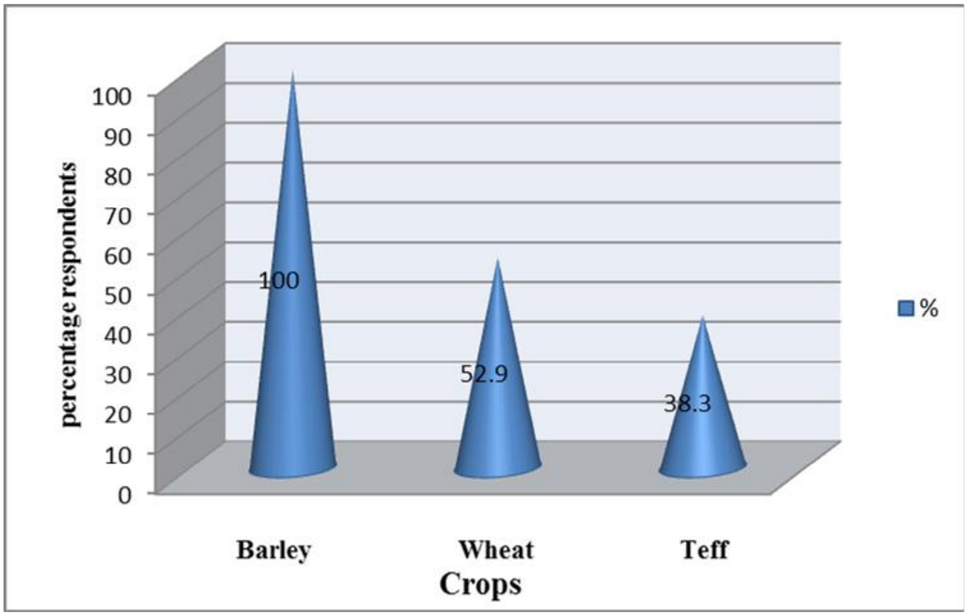

Figure 1: Mean percentage of respondents reported crop types attacked by the barley shoot fly in the study area

As shown in Table 3, all (100%) of the respondents' mentioned that they use chemical method to control barley shoot fly in the study area. Regarding the effectiveness level of the chemicals used to control barley shoot fly, 33.6% (n = 66) of the respondents replied that it was moderately effective while 64.3% (n=119) of the respondents replied that the effectiveness was low. Moreover, all respondents (100%) mentioned there was no any traditional method to control shoot fly infestation on barley in the study area. Generally, as they replied, they apply pesticide when the pest occurs but (100%) of the respondents indicated that they used Malathion to control barley shoot fly though it is less efficacious.

Table 3: Reported control methods of barley shoot fly *(Delia spp.)* by respondents in Keshelu kebele, Yem special Administrative district, SNNPR, Ethiopia.

Variables	n (%)
Method of control	
Chemical method	185 (100)
Cultural method	0%
Biological method	0%
Level of effectiveness	
High	0%
Moderate	66 (35.6)
Low	119 (64.3)
Presence of other traditional method to control Barley shoot fly	
Yes	0%
No	185 (100)

4.3. Land size owned and used for barley production and estimated crop losses by barley shoot fly *(Delia spp.)*

The total land owned by the respondents was 407 hectares while the total land used for barley production was 67.4 hectares. On average, the respondents owned 2.2 hectares of land and of this 0.36 hectares of land were used for barley production which accounted for 16.6%. Of the total land used for barley production in the study area (67.4 hectares), 414 quintals of barley were produced in 2013. On average, 6.14 quintals of barley was produced per hectare in the study area (Appendix - 4).

As shown in Table 5, in season one (March to June) on average, 6.14 quintals of barley were produced per hectare per season. Mean yield loss was estimated to be 91.5 % (5.59 quintals) per hectare. However, mean yield loss was reduced to 34.06% (2.07 quintals) per hectare when control measures were taken against barley shoot fly.

Table 4: Reported estimated yield loss by barley shoot fly *(Delia spp.)* per hectare per season with and without control measure during short rainy season (Season 1: From March – June) in Keshelu kebele, Yem district, SNNPR, Ethiopia.

Number of respondents	Farmland used for barley production in hectare	Yield per season per year (in quintals)	Total yield per hectare(in quintals)	Estimated yield loss per hectare (in quintals)	% of estimated yield loss	Yield loss if control measure is taken	
						Yield loss in quintals	% of Yield loss
33	0.125	1	33	30.5	91.67	13	39.39
79	0.25	1.5	118.5	111.92	94.45	39	32.91
13	0.3	2	26	23.83	91.67	9	34.62
7	0.45	2.5	17.5	16.04	91.67	6	34.29
20	0.5	3	60	56.67	94.45	24	40
26	0.75	4.5	117	105.34	90.03	37	31.62
7	1	6	42	35	83.33	13	30.95
185	**Total**		**414**	**379.05**	**91.5**	**141**	**34.06**

In season two (July - October), on average, 6.14 quintals of barley was produced per hectare per year per season. However, the loss was estimated 87.8 % (5.35 quintals) per hectare per season. The average loss when control measure taken was 31.6 % (1.92 quintals) per hectare (Table 5).

Table 5: Reported estimated yield loss by barley shoot fly *(Delia spp.)* per hectare per season with and without control measure during main rainy season (Season 2: From July – October) in Keshelu kebele, Yem district, SNNPR, Ethiopia.

Number of respondents	Farmland used for barley production in hectares	Yield per season (in quintals)	Total yield per hectare(in quintals)	Estimated yield loss per hectare (in quintals)	% of estimated yield loss	Yield loss if control measure is taken	
						Yield loss in quintals	% of Yield loss
33	0.125	1	33	28.35	85.91	12.5	37.88
79	0.25	1.5	118.5	108.5	91.56	37.85	31.94
13	0.3	2	26	22	84.62	7.75	29.81
7	0.45	2.5	17.5	15.25	87.14	5.35	30.57
20	0.5	3	60	53	88.33	22.85	38.08
26	0.75	4.5	117	102.5	87.61	33.25	28.42
7	1	6	42	34	80.95	11.35	27.02
185	**Total**		**414**	**363.6**	**87.8**	**130.90**	**31.6**

4.4. Results from Focus Group Discussion (FGD)

Four people drawn from developmental agent of the kebele, crop protection expert of the woreda, head of the kebele and head of district agricultural and rural developmental office involved in FGDs. All the FGD participants were males (100%, n = 4). Additionally, 75% of the FGD participants were certified professional while only 25% of the participants were with primary education.

The participants reported that, barley shoot fly *(Delia spp.)* occurred in the district since 2009 and it occurred occasionally with outbreak. The pest starts to attack crop right from its immature stage (larval stage) and mainly attacks the leaves of the crops at seedling stage causing high infestation. Teff and wheat are other crops often attacked by the barley shoot fly *(Delia spp.)*. The participants also explained that, barley shoot fly even though it occurs occasionally, it causes great loss on crop yield in the district and thus, the pest could be regarded as major pest in the area due to its impact. Also, participants mentioned that chemical method of pest control is regularly applied when the outbreak of the pest occurs and pesticide application techniques were used by farmers to control the pest. However, they indicated that this control method is partially effective may be due to pesticide resistance. The participants also cited that, the appropriate time of the pest control in the district is after planting the crop at immature stage.

4.5. Abundance and population dynamics of barley shoot fly *(Delia spp.)*

As shown in Table 7, the mean infested plant count was the highest at the third week (May, 2014) and least at the fifth week (May, 2014) per quadrat. The mean crop population estimate was the highest at the second week (April, 2014) and the least at the fifth week (May, 2014). However, the highest mean percent infestation (56.8%) of the pest was at the third week (May, 2014) and the least (52.9%) at the first week (April, 2014). As indicated in Table 7, the mean percentage infestation of the pest increased and then decreased during short rainy season in the study period from week one to week five (52.9%, 54.4%, 56.8%, 55.5% and 55.08% respectively).

As presented in Table 7, the mean infested plant count was highest at the third week (May, 2014) and the least was at the fifth week (May, 2014) per quadrat (plot 2). The mean crop population estimate was the highest at the first week (April, 2014) and the least at the fourth week (May, 2014). However, the mean infestation level was highest (55.7%) at the fourth week (May, 2014) and it was least (50.6%) at the first week (April, 2014). As indicated in Table 7, the mean percentage infestation during short rainy season for week one, two, three, four and five was (50.6%, 53.07%, 54.2%, 55.7% and 52.9% respectively) for plot 2. The overall mean percentage infestation for both plots was 54.3%. ANOVA analysis as shown that, result for IPC with respect to weeks was ($F = 27.2$, $P < 0.05$). It was significant. That means, there was difference of IPC with respect to the study weeks. However, result for IPC with respect to plots was ($F = 0.03$, $P > 0.05$). It was not significant. That implies, there was no difference or variation of IPC with respect to plots. IL % with respect to weeks was not significant ($F = 2.653$, $P = 0.157$). That means, % IL is not different with respect to weeks. It was not also significant with respect to plots ($F = 2.416$, $P > 0.05$). That implies, there was no difference with respect to plots in the study area in season one. Post hoc test (LSD) result showed that, the variation of IPC/IL% with respect to weeks implies that, it was not significant ($p > 0.05$) between week 1, 4 and 5 while it was significant ($p < 0.05$) between week 1 and week 3. However it was not significant ($p > 0.05$) between weeks 2, 3, 4. But it was significant between weeks 2 and 5. It was significant ($p > 0.05$) between week 3 and week 4, 5. But it was also not significant ($p > 0.05$) between week 4 and week 5.

Table 6: Mean IPC and TSC per plot per week per quadrat and mean percentage infestation, season one

Plot and IL%	W1		W2		W3		W4		W5	
	Mean ±SE		Mean ±SE		Mean ±SE		Mean ±SE		Mean ±SE	
	IPC	TSC	IPC	TSC	IPC	TSC	IPC	TSC	IPC	TSC
Plot 1	486±22.23	918±44.88	500.8±23.52	920±15.54	512±20.03	901±33.38	481±17.32	866±13.15	471±15.58	855±18.74
Plot 2	486±23.54	960±42.94	501±25.52	944±50.96	503±22.74	928±12.78	488±16.75	876±12.86	464±22.83	877±24.43
IL %,	52.9		54.4		56.8		55.5		55.08	
IL%, plot-2	50.6		53.07		54.2		55.7		52.9	

Remarks: IPC = Infested Plant Count; TSC =Total Stand Count of the crop; SE = Standard Error ;

W = Week; IL = Infestation Level

As shown in Table 8, the mean infested plant count was highest at the third week (September, 2014) and the least at the first week (August, 2014) per quadrat (plot 1). The mean crop population estimate was the highest at second week (August, 2014) and the least at the first week (August, 2014). However, the mean percentage infestation was highest (52.3%) at the third week (September, 2014) and it was least (30.5%) at the first week (August, 2014). As indicated in Table 8, the mean percentage infestation during main rainy season for week one, two three, four and five was 30.5%, 49.5%, 52.3%, 51.7 and 49.5% respectively.

As indicated in Table 8, the mean infested plant count was highest at the third week (September, 2014) and least at the first week (August, 2014) per quadrat (plot 2). The mean crop population estimate was highest at the second week (August, 2014) and least at the first week (August, 2014). However, the mean percentage infestation was highest (53.4%) at the third week (September, 2014) and it was least

(34.5%) at the first week (August, 2014). As presented in Table 8, the mean percentage infestation during the main rainy season for week one, two, three, four and five was 34.5%, 49.9%, 53.4%, 52.6 and 50.1% respectively. The overall mean percentage infestation for both plots was 47.6%. ANOVA analysis as shown that, IPC was significant with respect to weeks ($F = 76.98$, $P < 0.05$). That means, IPC was different with respect to the weeks during the study periods. However, the IPC was not significant with respect to plots ($F = 0.063$, $P > 0.05$). That implies, there was no difference of IPC with respect to plots. IL% was significant with respect to weeks ($F = 76.9$, $P < 0.05$).That means, there was difference in IL% among the study weeks in the study area. However, it was not significant with respect to plots ($F= 0.68$, $P > 0.05$). This implies that the IL% was not different between the plots in the study area in season two. Post Hoc analysis (LSD) result showed that the variation of IPC/ IL% with respect to weeks was significant between weeks and the remaining weeks 2,3,4 and 5($p<0.05$). But the variation between week 2 and 1, was also significant while the variation between week 2 and the rest weeks 3,4 and 5 were not significant ($p > 0.05$). It was also significant ($p < 0.05$) between week 3 and 1, week 4 and 1, and week 5 and 1. However, it was not significant between week 3 and week 2,4 and 5, week 4 and week 2,3,and 5 and also between week 5 and week 2,3 and 4 ($p > 0.05$).

Table 7: Mean IPC and TSC per plot per week per quadrats and mean percentage infestation, season two, 2014

Plots & IL%	W1		W2		W3		W4		W5	
	Mean ± SE		Mean ± SE		Mean ± SE		Mean ± SE		Mean ± SE	
	IPC	TSC	IPC	TSC	IPC	TSC	IPC	TSC	IPC	TSC
Plot 1	264.4± 34.5	867± 29.1	483.2± 19.9	975.2 ±37.2	495.6± 14.8	946±27 .7	485±29 .7	936.8± 21.3	476±21 .4	960±40 .1
Plot 2	304.8± 23.1	883± 17.8	488.4± 22.8	977.4 ±40.7	505.8± 22.3	946.6± 21.3	505.6± 29.1	959.4± 3	472.8± 22.4	943.4± 25.9
IL%, Plot-1	30.5		49.5		52.3		51.7		49.5	
IL%, plot-2	34.5		49.9		53.4		52.6		50.1	

Remarks: IPC = Infested Plant Count; TSC =Total Stand Count of the crop; SE = Standard Error ; W = week; IL = =Infestation Level

As shown in Figure 2, the mean pest population was highest at the third week (May, 2014) and least at the fifth week (May, 2014) per season 1 per week. In season 2, the mean pest population was also highest at the third week (September, 2014) and least at the fifth week (September, 2014) per season 2 per week. The mean pest population increased and then decreased during the study period from week one to week five in both seasons.

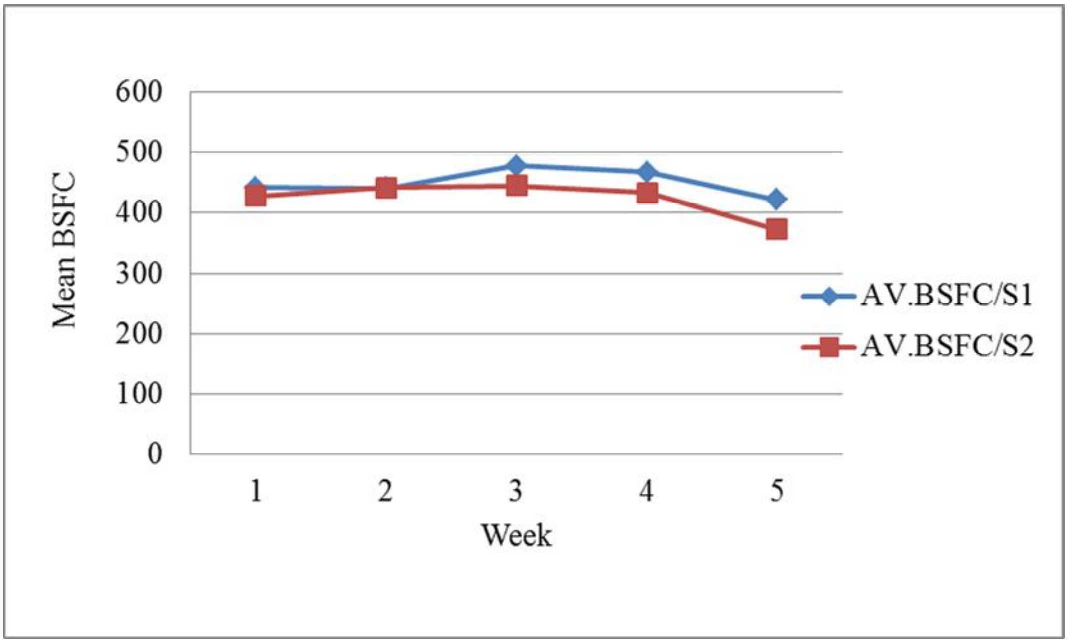

Figure 2: Mean BSFC per season in the study area.

Remarks: AV.BSFC /S1= Average barley shoot fly count per season 1

AV.BSFC /S2= Average barley shoot fly count per season 2

The abundance of BSFC was 225 and 212 insects per plot for season 1 and 2 respectively. The abundance of BSFC was statistically significant with respect to seasons of growing barley ($F = 4.64$, $P < 0.05$). That means, there was significant variation in the abundance of BSFC between season 1 and season 2 in the study area. The density of BSFC was 0.50 and 0.45 insects/plant/quadrat in season 1 and 2 respectively.

5. DISCUSSION

The study revealed that respondents knew the presence of barley shoot fly in the study area but they were not familiar with the name of the pest. The pest occurred in the district for the first time in 2009 and it was causing a devastating effect still know. Most respondents did not know the cause of occurrence of the pest. Only very few (< 2%) of the respondents knew the cause of occurrence of the pest. However, all the respondents knew the sign of the pest attack. This result is supported by result of the study by Jobie (2003) who reported that dead hearts referred to seedlings attacked by barley shoot fly, the central shoots of which had already dried or showed wilting and thus, considered as visible signs for farmers. Furthermore, infestation was considered to be a range of symptoms, from mild and early leaf mining to dead hearts. Regarding season of barley shoot fly *(Delia spp.)* occurrence, it was reported by respondents that the pest can occur in both growing seasons (short and main rainy seasons). This result is similar with the findings of the study by Birhanu *et al*. (2005) and CSA (2008) which indicated that barley shoot fly occurs in both barley growing seasons.

There was disparity among the respondents with regard to their familiarity with barley shoot fly in that some of the respondents reported that they were familiar with the name of the pest while majority of the respondents reported that they were not familiar with the name of the pest. This finding is consistent with the study report from Bale by Baye and Berhane (2006) in which the majority of the respondents did not know the name of the pest. The reason barley shoot fly was not familiar to most respondents relative to other pests could be that the larvae which is responsible for the seedling damage are found burrowed deep inside the shoots, the eggs are thinly spread and located in the soil, and the adults are small and not easily visible.

According to the respondents, there was a difference in susceptibility to barley shoot fly among crop hosts. Barley was cited as the main host followed by wheat and teff. Respondents also cited that they were familiar with barley shoot fly as a major pest of barley in the study area. This finding was in agreement of with the finding of a similar study by Hill (1987) barley shoot fly *(Delia spp.)* survives on several alternative hosts in the grass family. Moreover, host preference study conducted at SARC shows that barley, teff, wheat, oat and maize were the preferred crop hosts with high preference by barley shoot fly to barley and teff (SARC, 2004).

According to the results of this study, in season one (March to June) and in season two (July to October), on average, 6.14 quintals of barley were produced per hectare per year per season. This was very low yield compared with the national and worldwide mean annual product of the crop. This finding was partly in agreement with the reports of national proceedings on barley Mulatu and Grando (2011) who explained that barley productivity in production fields has remained very low (about 1.3 t/ha compared with the world average of 2.4 t/ha). This is primarily due to the low yielding ability of farmers' cultivars, which are the dominant varieties in use; the influence of several biotic and abiotic stresses; and the minimal promotion of improved barley production technologies (Mulatu and Grando, 2011). In the current study area, the respondents on average owned 2.2 hectares of land and from this on average 0. 36 hectares of land is used for barley production which accounted for 16.6% for barley crop production. This was in line with land nationally covered by barley which was between 0.8 and 0.9 million hectares (< 20% of the total land covered by crops per year) (Mulatu and Grando, 2011).

As results of this study cited that, the mean loss was estimated to be 91.5 % per hectare in season one. The mean loss of barley crop due to barley shoot fly *(Delia spp.)* was estimated 87.8 % per hectare in season two. This implies that the percentage infestation was less in season two. The overall mean of the infestation level was 54.3% in season one (short rainy season) while in season two (main rainy season), the overall mean of infestation percentage was 47.6%. Thus, there was significant variation in the abundance of BSFC between season 1 and season 2 in the study area. This finding is in agreement with the study results of Jobie (2003) who described that in main rainy season, infestation was 7–14%, whereas in short rainy season the infestation was 52–100%, indicating that the pest is more favored in the short rainy season than in main rainy season. This result was also similar with the reports of Mulatu and Grando (2011) who explained that at national level the loss of yield by the pest was 56%. Additionally, the reports of CSA (2008) indicated that one of the factors responsible for yield losses in Ethiopia is due to insect pest attack.

This result is also in agreement with the reports of Amare (1993) and Jobie *et al*. (2004). According to them, report on infestation level of barley shoot fly from Bale highlands, Ethiopia, frequently reaches 100% on susceptible barley cultivars and causes considerable yield loss. Because of its devastating effect especially on malt barley, improved cultivars and exotic germplasms, the pest has become a major constraint to barley cultivation in the Bale highlands of Ethiopia (Amare, 1993; Jobie *et al*., 2004). Furthermore, there was an experiment conducted at SARC in 2004/5 to test the occurrence of infestation of barley shoot fly on wheat and barley during the off-season (non-cropping period). The results indicated that, in the non-cropping period of 2004, the infestation level was 7–39% on barley and 12–19% on wheat. In 2005, infestation of barley genotypes during the off-season was 21–54% and that of wheat was 8–12%. The implication is that barley shoot fly appears to ensure year-round survival through normal reproduction by infestation of the main host and alternative volunteer crops and wild hosts. This could intensify its high devastating effect when it occurs year round.

Additionally, the level of adoption of improved barley production technologies by farmers is low, which is associated mainly with their minimal participation during the research process and the lack of knowledge. Respondents also believe that the increment of barley shoot fly *(Delia spp.)* population decreases as the rain becomes heavy. This finding is consistent with the finding by (Jobie, 2003) which indicates the pest population is higher in short rainy season than main rainy season; this is probably due to low and erratic rainfall with humid condition which makes favorable condition for the pest increment.

Results obtained from sweep net indicated the presence of a varying shoot fly population density throughout the study period. The shoot fly population in short rainy season was low until late April. From late April to mid-May the population reached its peak. The shoot fly population started to decline from late May onwards. In main rainy season, the shoot fly population was low until mid- August. From mid- August to late- September the population reached its peak. The shoot fly population started to decline from late September on wards.

This result was consistent with the report of Goftishu *et al.* (2009), who reported that the highest numbers of eggs per seedling were laid from late August through mid-September. The highest number of infestation and dead heart percentages were observed starting from early September to late September. The number of flies trapped affects the number of eggs laid per seedling, which determines the extent of infestation and dead heart formation. There was a drastic decrease in the insect population, percentage infestation and dead heart formation starting from early October. This might, presumably, be due to unfavorable climatic factors (very low moisture and relative humidity), which are crucial for leaf surface wetness, as dryness reduces larval movement to the leaf base, resulting in less infestation and dead heart formation (Raina, 1981; Taneja and Leuschner, 1985; Nwanze *et al.,* 1992). Similar report also indicates that weekly catches of adult flies per sweeping net were highly correlated with relative humidity and availability of barley seedlings. Similar observations were reported on sorghum shoot fly, *A. soccata*, by Sileshi (1994) in Ethiopia and by Ogwaro (1979) in Kenya, where fluctuations in numbers of adults were related to relative humidity. Leite *et al.* (2005) similarly reported that white fly population dynamics were apparently determined by environmental factors and crop phenology. It has been reported that one principal component of shoot fly management is adjustment of sowing dates (SARC, 2004). In spite of some degree of infestation by shoot fly, early sown barley cultivars recovered from shoot fly damage and gave relatively better yield by fully exploiting the available moisture (SARC, 2004).

The use of insecticide (Malathion) was the main means to control BSF in the study area. However, based on this study the effectiveness of Malathion is under question. Most respondents (64.3%) opined that Malathion is poor in its effectiveness against BSF and all the respondents' response was the non-existence of alternative tools to control BSF in the area. Moreover, there was no continuous supply of the pesticides to the area compounding the probable of BSF.

In view of the fact that the desired effect of a pesticide can be obtained only if it is applied by appropriate method at appropriate time, in the study site, regarding pesticide distribution and application there are some problems occurred. In addition, financial problems because of farmers' low income is common. According to Jobie (2003) many Ethiopian barley landraces have been reported to possess relative resistance to the barley shoot fly. Especially exotic genotypes and malt barley are in contrast highly susceptible to the pest (SARC, 2001; Jobie, 2003). The insecticides, carbofuran, aldicarb, cyfluthrin and deltamethrin are reported to be effective against the shoot fly (Thewodros, 1982; Hussien *et al*., 1993). An insecticide trial conducted at SARC with imidacloprid, tubuconazole, thiamethoxam and heterahabditis showed that thiamethoxam (at 250 and 375) and imidacloprid at 250 g per 100 kg seed were effective as seed dressing against the pest (SARC, 2001). Imidacloprid reduced infestation and also resulted in excellent control of barley shoot fly (SARC, 2004).

.

6. CONCLUSIONS

The damage to barley crop by barley shoot fly and the subsequent yield losses at harvesting was economically significant since farmers in the study area are with little alternative incomes from their staple and cash crops. Respondents ranked barley shoot fly as number one pest of barley, probably because they are least able to control them compared to the other pests. In the district respondents had the knowledge gap regarding its name, causes of the occurrence of the pest and practice of various traditional method of controlling the pest. But, they knew the symptoms when they detect damages on their crop leaves in the field in which it shows wilting of the leaves and eventually death of the whole plant.

Barley shoot fly occurs in both seasons during the short rainy season and heavy rainy season. But it shows significant variation with respect to season. During these barley growing seasons, the peak periods of the pest infestation level was found between May week one and May week two for season one while for season two the peak periods of the pest infestation level was found between September week one to September week three.

Study of the abundance and population dynamics of barley shoot fly has practical implications. Thus, it enables determination of the period of peak activity of shoot fly and to utilize this information to obtain minimum shoot fly pressure by control exercising. On the other hand, as the shoot fly remains active throughout the growing season with differences in density, adjustment of planting time was found to be the best practice to avoid heavy infestations. Generally, early sowing will significantly minimize infestation and will result in higher yields than late sowing. Hence, early sowing extending from late July to early September and from early April to late May will be preferred. Results obtained from sweep net catches, average infestation percentages indicated that early planting provided enough moisture to be retained in the soil; this could be used as a means of reducing the infestation of barley shoot fly. To find out the key factor in the abundance and population dynamics of barley shoot fly, it’s necessary to undertake studies in both seasons (main and short rainy seasons) across years. As barley is a major crop in the study area and barley shoot fly causes a very serious yield loss in the area in both seasons. There is a need to develop effective methods. The estimated yield loss in both seasons showed a small difference between seasons in the presence and absence of control measure (91.2%, 34.06% and 87%, 31.6%) respectively. But the chemical control measures do not completely reduce the pest infestation in the area and also, the respondents did not have the practice of using various traditional pest controlling methods.

7. RECOMMENDATIONS

Based on the results of this study, the following recommendations were forwarded:

- Farmers should be trained and try about the cultural and other methods of barley shoot fly control methods rather than depending only on pesticides.

- Crop protection experts should help the farmers to use appropriate chemical insecticides against the major insect pests. Because the desired effect of a pesticide can be obtained only if it is applied by appropriate method at appropriate time.

- Crop protection experts and farmers should know the possibility of using pesticides before planting and use it when necessary. In the study area, crop pest protection experts only apply chemical insecticide after planting or sowing but it is possible before planting and after planting. Before planting use of seed dressing insecticides were found to be very important because after harvesting the pest will remains in the hay/ and starts to cause damage. Thus, it helps to avoid such cases.

- Farmers should be trained by crop protection experts and use cropping system options for improved crop productivity like crop rotation for sustainable barley production.

- Farmers should practice early sowing which significantly minimizes the infestation and will result in higher yields than late sowing.

Future line of work

- No research has been carried out on cultural, biological and physical control methods of barley shoot fly in the study area. Due to this, the development of an integrated control method has never been achieved. Thus, the crop protection experts, woreda administrator and the agricultural and rural developmental office should have concern and encourage researches on this and other aspects of the pest.
- For effective controlling method there should be constant pest monitoring and surveillance applied by crop protection experts of the district.
- Population dynamics of the pest should be done for longer periods (years).
- Crop protection experts should pay due attention in early control and protection of barley crop by participating farmers and others on time to avoid the huge crop losses.

REFERENCES

Adugna, H. and Kemal, A. (1986). A review of research on the control of insect pests of small cereals in Ethiopia. pp 57–75, in: Tsedeke Abate (ed.). *A Review of Crop Protection Research in Ethiopia.* Proceedings of the First Ethiopian Crop Protection Symposium, 4 –7 February, 1985, Addis Ababa, Ethiopia.

Amare, A. (1993). *Infestation and damage level of barley shoot fly (Delia arambourgi) at Sinana*. p 28, in: Proceedings of the Joint Conference of the Ethiopian Phytopathological Committee and the Committee of Ethiopian Entomologists. Crop Protection Society of Ethiopia (CPSE), Addis Ababa, Ethiopia.

Baye, M.and Berhane, L. (2006). *Barley research and Development in Ethiopia- an overview*. In: Mulatu B. and Grando S. (eds). Barley Research and Development in Ethiopia. Proceedings of the 2nd national barely research and development Review workshop. 28-30 November 2006, HARC, Holetta, Ethiopia.

Birhanu, B., Fekadu , A. and Berhane, L. (2005). Food barley in Ethiopia. pp. 53 - 82.

Brown, J.H(1984). On the relationship between abundance and distribution of species. *Am Nature* **124**:255-279.

Buchs, W., Harenberg, A. and Zimmermann, J. (1997). The invertebrate ecology of farmland as a mirror of the intensity of the impact of man?—An approach to interpreting results of field experiments carried out in different crop management intensities of a sugar beet and an oil seed rape rotation including set-aside. Biol. Agric. Hortic.15, 83–107.

CACC (Central Agricultural Census Commission) (2003). Ethiopian Agricultural Sample Enumeration, 2001/02. *Statistical report on socio-economic characteristics of the population in agricultural households, land use, and area and production of crops-* PART-I. Addis Ababa, Ethiopia.

Cochran, W. G. (1977). **Sampling Techniques.** 3rd ed. New York: Wiley.

CSA (2005). Federal Democratic Republic Ethiopia: Central statistics Authority, Agricultural Sample Survey 2004/5 (1997E.C) (Sep 2004-Feb 2005) Vol. 1. Report on Area and Production of crops (private peasant holdings, Meher season) *Statistical Bulletin* No. 331. Addis Ababa, Pp.1- 48. ICARDA. (2002).

CSA (2010). Area and production of crops (private peasant holdings, Meher Season). *Statistical Bulletin*. Addis Ababa, Ethiopia.

CSA (2008). Area and production of crops: Private peasant holders, Belg season. *Statistical Bulletin,* Addis Ababa Ethiopia.

CSA (2008). Statistical abstracts for 2007. Federal Democratic Republic of Ethiopia, Central Statistical Agency, Addis Ababa, Ethiopia.

Davidson, A. (1969). Effect of some systemic insecticides on an infestation of the barley fly *Delia arambourgi* in Ethiopia. East African Agricultural and Forestry Journal, 34: 422–425. Addis Ababa, Ethiopia.

Davies, J. C. and Reddy, K. V. S. (1981). Observations on oviposition of sorghum shoot fly, *Atherigona soccata* Rond. (Diptera: Muscidae).Sorghum Entomology,Progress Report4. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India.

Dhillon ,M. K., Sharma, H. C., Ram Singh and Naresh, J. S. (2005). Mechanisms of resistance to shoot fly *Atherigona soccata in* sorghum. Euphytica 144: 301-312.

Francis, F., Lognay, G., Wathelet, J. P. and Haubruge, E. (2001). Effects of allelochemicals from first (Brassicaceae) and second (Myzus persicae and Brevicoryne brassicae) trophic levels on Adalia bipunctata. J. Chem. Ecol.27, 243–256.

Goftishu, M., Tefera, T. and Getu, E. (2009). Biology of Barley Shoot Fly *Delia flavibasis* Stein (Diptera: Anthomyiidae) on resistant and susceptible barley cultivars. *J. pest sic*.**82**:67-71.

Harlan, J.R. (1976). Barley. pp. 93-98. In: Evolution of crop plants. NW. Simmonds (ed).Longman Press. UK.

Hein, B. (1989). Insect pests of cereals in Ethiopia identification and control methods FAO/UNDP Project ETH/86/029 Crop Protection Phase II, Addis Ababa.

Hill, D.S. (1987). Agricultural insect pests of temperate regions & their control Cambridge University Press.

Hussien, M.L.A., Melde, C. and Wetzel, T. (1993) Investigations on the effects of seed treatment of winter wheat with Decis (deltamethrin), Filitox (metamidophos) and Baythroid (cyfluthrin) against larvae of the wheat bulb fly (*Delia coarctata* Fall). *Journal of Phytopathology and Plant Protection*, **28**: 147–154.

ICARDA. (2002). ICARDA and Ethiopia: Ties that bind, Issue No.16, ICARDA, Aleppo, Syria, Pp: 1-16.

Leite, G.L.D., Picanco, M., Jham, G.N. and Mcreira, M.D. (2005). White fly population dynamics. *Pesquisa Agropecuaria Brasileira*, **40**: 19–25.

Martin, J.H., Walden, R.P. and Stamp, D.L. (2006). Principle of field crop production. Pearson Education, Inc. USA.

Miller, R. and Ghannoum, M. (1994). Current distribution of wheat and barley insect in Syria and some implication for cereal pest management *Arab Journal of plant of plant protection*. **12**(1): 80 - 82.

Mulatu, B. and Grando, S.(eds). (2011). Barley Research and Development in Ethiopia. Proceedings of the 2nd National Barley Research and Development Review Workshop. 28-30 November 2006, HARC, Holetta, Ethiopia.

National Academy of Sciences. (1995).Ecologically Based Pest Management: New Solutions for a New Century. National Research Council, Board on Agriculture, Washington, DC: National Academy Press.

Nwanze, K.F., Pring, R.J., Sree, P.L.S., Buttler, D.R., Reddy, Y.V.R. & Soman, P. (1992). Resistance in sorghum to the sorghum shoot fly, *Atherigona soccata*: epicuticular wax and wetness of the central whorl leaf of young seedlings. *Annals of Applied Biology*, 120: 373–382.

Ogwaro, K. (1978). Ovipositional behavior and host plant preference of the sorghum shoot fly, *Atherigona soccata* (Diptera: Anthomyiidae). *Entomologia Expermentaliset Applicata* **23**: 189- 199.

Ogwaro, K. (1979). Seasonal activity of the sorghum shoot fly, *Atherigona soccata* (Diptera: Anthomyidae). *Entomologia Experimentaliset Applicata*, **26**: 74–79.

PANE (Poverty Association Network in Ethiopia) (2008). Poverty Association Network civic society organization report in Ethiopia.

Raina, A.K. (1981). Movement, feeding behavior and growth of larvae of the sorghum shoot fly, *Atherigona soccata*. *Insect Science and its Application,* **2**: 77–81.

SARC (Sinana Agricultural Research Centre) (2001). Entomology Progress Report 1993–2001. SARC, Sinana, Ethiopia.

SARC (Sinana Agricultural Research Centre) (2004). Entomology Progress Report, 1996–2004.

SARC (Sinana Agricultural Research Centre) (2005). Entomology Progress Report for 2004/05. SARC, Sinana, Ethiopia.

SARC (Sinana Agricultural Research Centre) (2006). Entomology Progress Report for 2005/06. SARC, Sinana, Ethiopia.

Sharma, H. C., and Ortiz, R. (2002). Host plant resistance to insects: An eco-friendly approach for pest management and environment conservation. *J. Environ. Biol*.**23**, 111–135.

Sileshi, G. (1994). Management of the sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) in the Eastern Hararghe. MSc thesis. School of Graduate Studies of Alemaya University, Ethiopia.

Singh ,B.U. and Sharma, H.C. (2002). Natural enemies of Sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae). *Bio control Science and Technology*. **12**(3), 307-32.

Jobie ,T. (2003). Mechanism(s) of resistance in barley accessions to shoot fly, *Delia flavibasis* Stein (Diptera: Anthomyidae). MSc thesis. School of Graduate Studies of Alemaya University, Ethiopia.

Jobie, T., Tadesse, G. and Sakhuja, P.K. (2004). Ovipositional antixenosis in some barley accessions to barley shoot fly. *Pest Management Journal of Ethiopia*, **8**: 51–57.

Jobie, T. and Tadesse, G. (2005). *Delia steiniella* Emden: newly recorded pest of wheat (*Triticum aestivum*) and its infestation level at Sinana, Ethiopia. *Pest Management Journal of Ethiopia*, **9**: 83–85.

Taneja, S. L., Seshu Reddy, K. V. and Leuschner ,K. (1986). Monitoring of shoot fly population in sorghum. *Indian Journal of Plant Protection* **14**: 29-36.

Taneja, S.L. and Leuschner, K. (1985). Resistance screening and mechanisms of resistance in sorghum to shoot fly. pp 1115–1126, in: Proceedings of the International Sorghum Entomology Workshop, 15–21 July 1984, India. Texas A&M University, College Station, TX, USA

Thewodros, M. (1982). Studies on the sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) with special reference to its biology and control measures. MSc thesis, Addis Ababa University, 88 p.

Van Emden, H. F. (1991). The role of host plant resistance in insect pest mis-management. *Bull. Entomol. Res*.**81:** 123–126.

YDASACPR (2012).Yem District Agricultural Sector Annual Crop Production Report.

Zadoks, J.C., Chang, T.T. and Konzak, C.F. (1974). A decimal code for the growth stages of cereals. *Weed Research,* **14**: 415–421.

Zemede, A. (2002). The Barley of Ethiopia. pp 77-108. In: Stephen, B. Brush(ed). Genes in the Field: On farm Conservation of Crop Diversity.

Appendix 1: Questionnaire

JIMMA UNIVERSITY

COLLEGE OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGY

QUESTIONNAIRES TO BE FILLEDOUT BY INTERVIEWER

The main purpose of this questionnaire is to collect relevant information on the knowledge, attitude and practice of farmers and crop protection experts towards the effect of barley shoot fly and its control in Yem district south west Ethiopia.

The objective of the study will realized only when you sincerely participate in giving valid and reliable information through this questionnaire. The researcher kindly request your sincere response and acknowledges your cooperation to greater excellent.

House hold questionnaire for local community (farmers) of keshelu kebele

A. Socio- demographic information

1. Respondent Woreda……………… 2. Keble ……….................

3. Age................... 4. Sex.....................

5. Educational level

a. no formal education............. b. primary education(1-8)……

c. secondary education(9-12)...... d. beyond secondary education................

6. What is your livelihood activity?

a) Crop production b) keeping livestock

c) Farming and livestock keeping d) Trade e) other (mention)………….

B. knowledge and attitude of farmers about barley shoot fly and its pest nature related issues

1. Is there a pest that damages barley in your environment?

   A/ yes B/ no

2. Do you know the name of the pest?..

3. Do you have knowledge towards the occurrence of the pest (barley shoot fly)?---

4. When does it occur? Is it A/ during short – rainy season B/ during the heavy – rainy season C/ both seasons

5. In which season do the occurrence of the pest (barley shoot fly) population is high and damages more? ……………………………………………………………………………….

6. Does the pest (barley shoot fly) attack only barley or other crop species?

   ....

7. Which part of the crop specially attacked by the pest (barley shoot fly?

   ....

8. Do you know the symptom of damage by the pest(barley shoot fly ?

   ....

9. What is your attitude towards the impact level?...

10. What measures do you think should be taken by the following in order to prevent the crop damage caused by barley shoot fly?

    A/ by the agricultural office of the district……………………………….

    B/ by the private sectors…………………………………………………

C/ by local community…………………………………………………..

C. Practice of farmers towards barley shoot fly

11. What kind of controlling method do you apply?

A/ cultural method B/ biological method

C/ chemical method

12. Does the controlling method effective?..

13. Do you have any traditional method, where you use to control the pest?

....

14. If it is present, does the method effective?...

D. Land used for barley production, crop loss estimation and related issues

15. How many hectares of land do you have?.........., Land size used for barley production ……..,

Amount of barley production in quintals under no shoot fly infestation…………

16. Amount of crop loss in quintals ………., Amount of barley crop loss in quintals in season one and two without control measure taken------------------; and loss with control measure taken--------- respectively.

Thank you!

Appendix 2: Questionnaire translated to local language (Yemsa)

Agewini towanen (Kuranen) Faa Chowini Mamisu

1. Han keesta Agewason mafa Kura (towa) faaro?

   A/ Faar B/ Affa

2. Aes Agewason mafa kurasi (towasi) sunanon Azifeniyo/ Azinisefeniyo? ....

   ………………………………………………………………………………………….

3. Ase kura (towas) kiito Akkak testefana matto Azinsefeniyo (Azifeniyo)?.......................

   ……………………………………………………………………………………………

4. Agewini kuras (towas) Agenba bestefana?

   A/ Kasho irroni kabak

   B/ Akama yeshuni kabak

5. Agewaso mafa kuras (towas) aro Asasi kontefa?..

6. Agewason mafa kuras (towas) ooma meeyason mafawa annen?.....................................

   ……………………………………………………………………………………………….

7. Agewas Awubasin Arkiron merosik ottefaar?..

   ……………………………………………………………………………………………

8. Agewsi kura (tobas) ottobasik malatoba Amba?..

   ………………………………………………………………………………………………

9. Agwni kuras (towas) Awunefaro mi’refa?...

   ……………………………………………………………………………………………

10. Agewini towason (kurason) tishikuk handakalo feese baaso Awuzagisefatene Wayane?

    A/ Woreda gibirina B/ Gilini Dirijity C/ Taga hizibiis

11. Kurason (towason) tishikuk Awuzagisefeni?

A/ Ibesa / Bahilawi B/ Biologicali C/ Chemicali

12. Westota fesha kurani (toni) tishikuni uginas wagiba faaro?..

13. Omma Ibesa Agewini kurani (toni) tishikuni ugina faaro?..

…………………………………………………………………………………………

14. Kuras (towas) Agewasta bestefan, tishikuni bahilawi malas wagiba faaro? …………

…………………………………………………………………………………………

15. Apun hectare da fare neki?................................., apun hectarestamba hagewa bukfeni?…,……, apun quntali danfene?…….

16. Apun quintali turkifene?……………………, aeta fafanak tishfanak apuno turkifene kasho erony kabake… …………………………., akama erony kabakka?

Galatefeny!

Appendix 3: Questions for FGD

JIMMA UNIVERSITY

COLLEGE OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGY

QUESTIONS FOR FOCUS GROUP DISCUSSIONS (FGD)

The main purpose of this FGD is to collect relevant information on the knowledge, attitude and practice of farmers and crop protection experts towards the effect of barley shoot fly and its control in Yem district south west Ethiopia. The objective of the study will be realized only when you sincerely participate in giving valid and reliable information through these questions. The researcher kindly requests your sincere response and acknowledges your cooperation to greater excellent.

A. Socio- demographic information

1. Respondent Woreda……………… 2. Keble ……….................

3. Age................... 4. Sex.....................

5. Educational level

a. diploma b. degree c. beyond degree

B. Questions for Focus Group Discussion (FGD) on Knowledge, attitude and practice related issues of the effect of barley shoot fly

Crop protection experts, Developmental agents and Head of district agricultural and developmental office will participate in FGD.

1. When does the pest for the first time occurs in the district?...................................

2. What is the frequency of the outbreak of barley shoot fly in the district?

A/ Regularly (occurs every season) B/ Occasional (occurs every few season)

C/ Rare (occurs every few season)

3. In which season do the pest highly occurs and attacks the crop more?

A/ during heavy –rainy season B/ during short – rainy season

4. Why do you think that the barley shoot fly highly damages the crop in the Selected Season (Q.No.3)?..

5. From which developmental stage do the pest starts to cause damaging effect?

A/ larva stage B/ pupa stage C/ adult stage

6. Which body part of the crop specially damaged by the pest?

A/ stem B/ root C/ leaf D/ seed

7. At which stage does the pest (barley shoot fly) damages the crop?

A/ planting B/ seedling C/ vegetative D/ Harvesting

8. Is there any other crop attacked by the pest?..

9. Is it major or minor pest for the environment?...

10. What kind of controlling method do you apply?

A/ cultural B/ chemical C/ biological D/ other

11. Which of the following techniques of shoot fly was practiced by farmers in the kebele?

A/ pesticide B/ filed sanitation C/ trapping D/ sanitation and pesticides

12. Dose the controlling method effective?...

13. Is there pest resistance towards the controlling?...

14. Do you think that the most appropriate time for barley shoot fly control in the district?

A/ before planting B/ after planting

15. Do you educate the farmers towards the different modes of protection against the pest?--

Thank you!

Appendix 4: Land size owned, used for barley production and crop yield

Table 1: Land size owned by the respondent farmers

Land size in hectare	Frequency	Percentage (%)
1	26	14.05
1.5	40	21.62
2	46	24.86
2.5	20	10.81
3	33	17.85
4	20	10.81
Total	185	100

Table 2: Land size used for barley production from the total land owned by the respondents

Total land size owned	Land size used for barley (AV.)	Percentage (%)
1	0.125	12.5
1.5	0.1875	12.5
2	0.25	12.5
2.5	0.375	15
3	0.625	20.83
4	0.875	21.86

AV. = Average

Table 3: Yield of barley in quintals per hectare

Total land used for barley	Land size used for barley/ hectare	Amount obtained in quintals	Total respondents	Total products
4.12	0.12	1	33	33
19.75	0. 25	1.5	79	118.5
3.90	0.30	2	13	26
3.15	0.45	2.5	**7**	17.5
10	0.5	3	20	60
19.5	0.75	4.5	26	117
7	1	6	7	42
67.4(Total)			185	414

Appendix 5: Mean of Barley shoot fly count (BSFC)

Table 4: Mean of Barley shoot fly count (BSFC) per plot per week (plot 1and2)

(April 3rd to May 3rd weeks), Season one

Plot		W1	W2	W3	W4	W5
1	Mean	460.6	441	488.6	457.4	424.4
	SE	33.53	24.42	20.92	25.34	32.15
2	Mean	422.8	441.2	468	476.4	419.8
	SE	24.55	23.98	18.51	12.86	19.55
Overall	Mean	441.7	441.1	478.3	466.9	422.1
	SE	6.34	0.86	3.85	8.82	8.90

Remarks: W = Week; SE= Standard Error

Table 5: Mean of barley shoot fly count (BSFC) per plot per week (plot1and 2)

(August 3rd to September 3rd weeks), Season two

Plot		W1	W2	W3	W4	W5
1	Mean	427	447.8	448.6	425	392.2
	SE	20.83	12.85	13.26	18.89	33.02
2	Mean	428	435.6	441.8	441	353.4
	SE	23.66	21.87	26.80	21.74	23.76
Overall	Mean	427.5	441.7	445.2	433	372.8
	SE	2.00	6.37	9.57	2.01	6.54

Remarks: W = Week; SE= Standard Error

Appendix 4. Different plates


Barley crop at growing stages


Barley crop attacked by pest (barley shoot fly)

Plate 1. Barley crops growing and affected by pest


The investigator when trapping the pest using sweeping net

Adult barley shoot fly

When the investigator taking data of stand and infected barley plant count

Plate2. Sample field data collection by the investigator

Plate 3. Sample of data collection using questionnaire and FGD