ADDIS ABABA UNIVERSITY

FACULTY OF NATURAL AND COMPUTATIONAL SCIENCES

GRADUATESTUDIES PROGRAM DEPARTMENT OF ZOOLOGICAL SCIENCES

THE STATUS OF MAJOR INSECT PESTS ON MAJOR CROPS GROWN IN HADIYA ZONE AND THEIR MANAGEMENT PRACTICES IN CENTRAL REGIONAL STATE OF ETHIOPIA

BY

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A Research Paper Submitted to the School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirement for the Degree of Master of Science in Biology

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DECLARATION

I declare that this entitled ‘’the status of major insect pests on major crops grown in Hadiya zone and their management practices in Central Ethiopia’’ my own work conducted under the supervision of Professor Emana Getu, in Addis Ababa University. I further proclaim that this thesis is not submitted to any other institution anywhere for the award of degree either in this University or any other University.

Name: Adane Niguse Abiyo

Signature ----------

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As members of the Examining Board of the final MSc open defense, we certify that we have read and evaluated the Thesis prepared by: **Adane Nigusse** entitled ‘’**The Status of major Insect Pests on Major Crops Grown in Hadiya Zone and Their Management Practices in Central Ethiopia’’** and recommend that it be accepted as fulfilling the thesis requirement for the degree of Master of Science in Biology

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Department chairperson	Signature	Date

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LIST OF ABBREVIATIONS

APR	Annual Progress Report
CSA	Central Statistical Agency of Ethiopia
DAs	Developmental Agents
EBADO	East Badewacho Woreda Agricultural Development Office
EIAR	Ethiopian Institute of Agricultural Research
FAOSTAT	Food and Agriculture Organization Statistics
GDP-	Gross Domestic Products
IPM	Integrated Pest Management
MASL	Meter above Sea Level
ICRISAT-	International Crops Research Institute for the semi-Arid tropics
SSA-	Sub-Sahara Africa
SPSS	Statistical Package for the Social Sciences

ABSTRACT

Insect pest causes enormous losses through direct and indirect invasion on various plant parts. The present study was conducted from August 2023 to June 2024 to assess the status of insect pests on major crops grown in Hadiya zone and their management practices in Central Ethiopia. Data were collected by using observation of farmers' farmland, by interviewing farmers and village extension workers and by reviewing recorded document from office of agriculture of the study areas. The study was conducted on the selected 60 households and 12 development agents. The collected data were analyzed by using descriptive statistics using SPSS version20 statistical software. The findings indicated that the major key insect pest in the study areas were fall armyworm, Shoot fly and weevil. Among, the insect pests in cultivated crops at field condition pollen beetle (Mylabris sp.) and cut worm on common bean, fall armyworm (Spodoptera frugipedra) and weevil (Sitophilus zeamais) on maize and shoot fly(Atherigona hyalinipennis) on teff (Eragrotis abysinicus) were the major insect pests that cause high damage on each crop. Behind to this the way to farmer's control those insect pests of crops were chemical methods and cultural methods like crop rotation, sanitation early crops and removing debris. These results indicated that farmers are incurring a substantial grain loss to insect pests. Hence, there is an urgent need to devise appropriate tactics for protecting the losses in farm and stored crop in Ethiopia.Iintegrated pest management approach should be introduced in the study area to control key insect pests.

Keywords: *Assessment, Insect pest, Interview, Major crops*

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Ethiopia is heavily depending on agriculture as a main source of employment, income and food security for a vast majority of its population (CSA, 2016). Agriculture generates 40% of gross domestic products (GDP), and accounts for 85% and 90% of total employment and exports, respectively (UNDP, 2014). Crop production in Ethiopia is complex, involving substantial variation in crops grown across the country's different regions and ecologies (Alemu *et al*., 2012). Cereals are the most cultivated and traded crops for food, feed, and industrial uses worldwide. Among other producing regions, Africa hosts 27% of the world's total cereal production. Like other staple crops, the production of cereals such as maize, rice, wheat, millet and sorghum in Sub-Saharan Africa is threatened by herbivorous pests and weeds leading to significant losses (Benjamin *et al.,* 2024).

Five major cereals (Teff, Wheat, Maize, Sorghum, and Bean) are the core of Ethiopia's agriculture and food economy, accounting for about three-fourths of the total area cultivated, 29 percent of agricultural gross domestic product (GDP) in 2005/06 (14 percent of total GDP), and 64 percent of calories consumed (FAOSTAT, 2014). Insect pests are a major challenge to smallholder crop production in sub-Saharan Africa (SSA), where access to synthetic pesticides, which are linked to environmental and health risks, is often limited. Biological control interventions could offer a sustainable solution, yet an understanding of their effectiveness is lacking (Paude *et al.,* 2022). Factors that contribute to choices about insect management include the market value of the crop, the cost of controlling the pest relative to its potential for causing crop loss, the susceptibility of the crop to the pest and the environment, all of which are variable. Consequently, effectively managing insect pests of field crops requires considerable knowledge about the pests and the factors that affect their populations (FAO, 2021).

Insects are the most diverse species of animals living on earth. Insect pests cause enormous loss through direct and indirect invasion on various plant parts. Insects are organisms considered as the significant and primary pests of stored products that present damage to the grains through direct feeding during some of their lifecycles; resulting large populations and considerable

damages (Rees, 1990). The higher level of insect infestation and the associated percentage grain damage, weight loss and germination loss that occurred in all of farmers traditional storages methods in the present study also confirmed that the quantity, quality, resources, labor and income, and food security of poor farmers is affected (Berhanu and Emana, 2018).

Insect pests inflict damage to humans, farm animals and crops. Insect pests have been defined by (Williams, 1947) as any insect in the wrong place. Depending on the structure of the ecosystem in a given area and man's view point, a certain insect might or might not be considered a pest (Gwinner *et al*., 1996). One major reason why there are pests is the creation of manipulated habitats, that is, agro-ecology that fulfill man's needs, where crops are selected for their large size, high yield, nutritious value, and clustered in a confined area (Kerin, 1994). This does not only satisfy man's demand, but provides a highly conducive environment for herbivorous insects at the same time. There are different types of insect pest in different parts of the world. Insect pest has been growing problem in Ethiopia which needs clearly controlling mechanism and assessing their damage level. Thus, assessing the insect pests and their damage level is important for to secure the crops (Hassan *et al.,* 2021).

1.2. Statement of Problem

The economic impact of pests and weeds on cereal production in Africa is significant. These losses can be attributed to reduced yields, quality, and marketability of cereal crops, as well as increased costs associated with disease and pest control measures (Mesterhazy *et al.,* 2020). Therefore, the above constraints are important in major crops production areas of the country, with little variation across locations. Hadiya Zone is one of the crop grown areas of Central Ethiopia facing these typical constraints. With the aim of setting up more rational approaches to control insect pests, Pucci *et al.,* (2003) noted that basic research is needed on the key factors regulating population dynamics of major deleterious insect pests; a numbers of phytophagous insects are known to feed on crops in the field and store. However, there is lack of precise and up-to-date comprehensive information on infestation of major insect pests and management options of major crops grown in Hadiya Zone, Central Ethiopia.

1.3. Objectives

1.3.1. General objectives

- To assess the status of major insect pests of the major cereals grown in Hadiya zone and their management practices

1.3.2. Specific objectives

- To identify insect pests on the major cereal crops in Hadiya Zone.
- To investigate the extent of damage and/or losses major crop insect pests cause to different crops.
- To determine the insect pest management practices farmers use against major crop insect pests.

1.4. Research Questions

1. What are the major insect pests on major crops in study areas?
2. What is the ectent of insect pests damage on crops at farm and storage level?
3. What kinds of mechanisms farmers use to manage insect pests damage?

1.5. Significance of the study

The study contributes important information about the status of the major insect pests on major crops grown in Hadiya zone and their management practices, Central Ethiopia. The study may provide a better understanding of the impacts of insect pests on crop damage. It also may serves as base line information to facilitate ideas among farmers, developmental agents, researchers, policy makers and other stakeholders by creating awareness on how to manage insect pest damage on crops effectively.

1.6. Scope of the study

The study was conducted on the status of the major insect pests on major crops grown in Hadiya zone and their management practices in Central Ethiopia. The study focused more on farming dependent segment of population. The study area was selected purposely based on the researcher's previous and current knowledge for the districts and the sample Kebles' were selected randomly.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Cereal Production and Productivity

Cereals are cultivated on large hectares of land annually in Ethiopia to ensure adequate provision of grain for the entire population. Grains are the most important sources of food for man and his animals worldwide and they constitute a major source of energy of high biological value, vitamins and roughages (Turaki *et al*., 2012). Cereals are major staple food crops that are cultivated on approximately 75% of the arable land (484 million ha) in the tropics and contributing about 1.71 billion tons (65.7%) of the total world cereal production (FAO, 2014). The four most important cereals in the tropics are rice, maize, sorghum and pearl millet (Bragg *et al.*, 2016).

Cereal crops play a major role in smallholder farmers' livelihoods in sub-Saharan Africa (SSA), with maize being the most important food and cash crop for millions of rural farm families in the region (Cairns *et al.*, 2013). Therefore, proper storage significantly contributes to food security (Tefera, 2012). On average, an estimated 20–30% of cereal produce, amounting to more than US$4 billion annually is lost to storage pests (FAO, 2010).

2.1.1. Maize (Corn)

Maize *(Zea mays* L.) plays a significant role in world-wide agricultural production. It is one of the most important cereal crops in the world and, together with rice and wheat, provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries (Shiferaw *et al.*, 2011). Africa alone utilized 30.0% of the world's maize, with Sub-Saharan Africa (SSA) accounting for 21.0% of the consumption (Okon *et al.*, 2022). It is estimated that maize is being cultivated on approximately 8.12 million ha with annual production of 19.77 million tons (Dass *et al.*, 2008; FAO, 2014). The highest amounts of maize consumed are in southern Africa at 85 kg/capita/year; and contributing more than 40% of total calories (Shiferaw *et al.*, 2011). More than 300 million people in SSA depend on maize as source of food and livelihood (FAOSTAT, 2015). Maize, Africa's most widely grown cereal, is used for various purposes. In East and Southern Africa, it is the primary staple food and is consumed in multiple forms, including maize

flour, meal, and porridge (Galani *et al*., 2022). It also used as a source of animal feed, an essential ingredient in producing beer and other alcoholic beverages (Dabija *et al.,* 2021). It is the most widely-grown staple food crop in sub-Saharan Africa (SSA) occupying more than 33 million ha each year (FAOSTAT, 2015). Smallholder farmers cultivate an estimated 35-40 million hectares of maize in SSA (Boddupalli *et al.,* 2020). This crop is essential for providing energy and protein to over 300 million impoverished and malnourished Africans, as well as weaned infants (Dey *et al.,* 2015; Semagn *et al.,* 2015). Additionally, maize is a crucial unprocessed material for livestock feed production (Naz *et al.,* 2019) and serves as a fundamental ingredient in various food and industrial products such as confectionery, starch, oil, beverages, fuels, and plastics (Kaul *et al.,* 2019; Gamage *et al.,* 2022). The demand for maize in SSA is projected to triple by 2050, highlighting its potential to enhance food security and uplift farming communities out of poverty (Cock *et al*., 2017; Kumela *et al.,* 2019).

Maize is attacked by about 139 insect-pests with varying degree of damage under field and storage conditions (Dhaliwal *et al.,* 2010; Dhillon *et al.,* 2014). Insect pests reduce maize production by directly attacking roots (rootworms, wireworms, white grubs, and seed-corn maggots), leaves (aphids, armyworm, stem borers, thrips, spider mites and grasshoppers), stalks (stem borers and termites), ears and tassels (stem borers, earworms, adult rootworms and armyworm), and grain during storage (grain weevils and grain borers) (Kfir *et al.,* 2002; Hill, 2008).

2.1.2. Wheat

In all African countries, wheat consumption has been steadily increasing during the past 20 years as a result of growing population, changing food preferences and a strong urbanization trend which has led to a growing 'food gap' in all regions, largely met by imports. In 2013 alone, African countries spent over $12 billion dollars to import more than 40 million metric tons of wheat, equating to about a third of the continent's food imports. During 2010-2013, the average quantity of wheat import in SSA was about 17.5 Million metric tons per annum, which is close to 80% of the total domestic wheat consumption in these countries (USDA, 2014).

Ethiopia is the largest wheat producer in the Sub-Saharan Africa with about 0.75 million ha of durum and bread wheat. Wheat is one of the major cereal crops in the Ethiopian highlands,

which range between 6 and 16 N, 35 and 42 E, and from 1500 m to 28 m. At present, wheat is produced solely under rain fed conditions. About 60 percent of wheat area is covered by durum and 40 percent by bread wheat. Of the current total wheat production area 75.5 percent is located in Arsi, Bale, and Shewa regions. 6 percent of the 13 million ha classified as highly suitable for wheat production is located in Arsi, Bale, and Shewa. Altitude plays an important role in the distribution of wheat production through its influence on rainfall, temperature, and diseases (Thenkabail *et al.,* 2012). Wheat is the most important cereal crop for majority of the world‘s population. It is the staple food of about two billion people (36% of the Global population) and is in increasing demand in countries undergoing urbanization and industrialization. Wheat crop attacked by wheat aphid, Grasshopper, White grubs, Ghujia weevil, and Termites etc. (Farook, *et al*., 2019).

2.1.3. Teff

Ethiopia, located in eastern Africa, is considered the center of origin of teff (National Research Council, 1996). Currently, Ethiopia produces over 90% of the world's teff. But, because of its growing popularity, its production has attracted other countries including; Australia, China, India, South Africa, and the US. The grains are a daily food staple for about 50 million people – about 60% of the country's total population (Ayalew *et al*, 2011). Nutritionally, 100 g of teff grains have 357 kcal, similar to that of wheat and rice (Cheng *et al.,* 2017). Yet, its grains are comparably rich in iron, calcium, and fiber (FAO, 2015).

Teff is a staple crop in Ethiopia and Eritrea, where it is used mainly to make injera - a spongy flatbread that is eaten with most meals. Teff products accounted for 12% of Ethiopian food expenditures in 2011, making it the most important cereal crop in the country. Teff is valued for home consumption and as a cash crop due to its higher price per kilogram, compared to other cereals. Teff is also valued for its fine straw which is used for animal feed and as a construction material. Teff is made up of complex carbohydrates and has similar protein content to wheat. Compared to other cereals, teff is a good source of fatty acids, fiber, calcium, and iron. (Minten, *et al*., 2018).

2.1.4. Bean

Common bean (*Phaseolus vulgaris* L.) is a multipurpose leguminous crop and since it is high in nutrient content (Mwanauta *et al.*, 2015). It is second important in terms of production and area of productivity due to early maturity intercrop with other crop like maize, improver soil fertility, animal feed and become to commercial potential. It also important and more diversified due to several things such as good sources of food, income, improver soil fertility, wider adaptation, early maturation, intercrop with stalk plant, etc. (Demelash, 2018). More, it has substantial role in to provide balance diet, and provides amino acid like folic acid. Similar study reported as it contributed around 57% dietary protein and 23%of carbohydrate. In Ethiopia, more than half of annual production from the Rift Valley areas at the central parts (Tumsa *et al.*, 2015). As a result, area of production and productivity steadily increased for last two decades. It is the second most important legume crop in terms of area planted and volume of production (second only to faba bean, *Vicia faba*); production in 2020/21 was around 0.55 million tons from 0.31 million hectares (CSA, 2021).

Common bean (*Phaseolus vulgaris* L.) production in Ethiopia is injured by several insect pest and diseases. The major insect pests which attack common bean in pre and post harvests are the bean maggot (*Ophiomyia phaseoli*), bruchids, *Z. subfasciatus*, *C. maculates*, ootheca (*Ootheca bennigseni*) and aphids (*Aphis fabae*). These pests affected yield and yield components of common bean through direct and indirect of the total production. Some insects like Aphid is used as the way of transmitting other diseases like mosaic virus from plant to plants, in addition to direct reducing common bean production (Daba, 2020).

2.2. Major Insects Pests of Crops

The major crop pests in the Ethiopia were desert locust (*Schistoceria gregoria*), Lepidopterous pests (butterflies and moths), coleopteran pests (beetles), pests of stored products, especially stored cereals crops (beetle and moth) (Joseph, 1999). Insect pests inflict their damage on stored products mainly by direct feeding. Some species feed on the endosperm causing loss of weight and quality, while other species feed on the germ, resulting in poor seed germination and less viability (Santos *et al*., 1990).

However, several challenges including unproductive soil, drought, scarcity of improved seeds and inputs, virulent pests and diseases outbreaks contribute to lower average maize yields in SSA compared to the world-wide average (Badu-Apraku *et al*., 2017; Boddupalli *et al.,* 2020). Insect pests and fungal diseases pose significant threats to maize production in SSA due to their destructive nature and ability to cause substantial yield losses, especially under favorable environmental conditions (Midega *et al*., 2016). Notable *Lepidopterous* insects affecting maize include *Busseola fusca, Eldana saccharina, Sesamia calamistis, Mussidia nigrivenella, Chilo partellus, and Spodoptera frugiperda* (Goergen *et al.,* 2016). Maize ear rot, capable of producing mycotoxins and grey leaf spot are common and problematic diseases in SSA (Badu-Apraku *et al.,* 2017). The economic impact of major insect species like *C. partellus*, *B. fusca*, and *S. frugiperda* in sub-Saharan Africa ranged from $18.2-80 billion since 1970 (Ratto *et al*., 2022).

2.2.1. Black maize beetle (Heteronychus arator)

The black maize beetle, a highly destructive pest with a broad range of hosts that includes maize, various cereals (such as wheat and barley), and sugarcane, is primarily found in West Africa but is native to Southern, Eastern, and Central Africa (Musikavanhu, 1996). According to Ahad and Bhagat's study (2012), significant damage can be caused by as few as five beetles per square meter. The establishment and spread of *H. arator* are influenced by environmental factors such as temperature, moisture content, and soil organic matter (Mansfield *et al.,* 2016).

2.2.2. Fall armyworm (Spodoptera frugiperda)

The fall armyworm (FAW) has caused varying degrees of crop damage in several countries. The impact of FAW invasion on resource-poor farmers in sub-Saharan Africa (SSA) has worsened (Wightman, 2018). A report revealed that in the absence of proper management measures, FAW significantly reduced yields by 21 to 53 percent annually in twelve maize- producing countries in Africa (Abrahams *et al.,* 2017). The estimated economic impact of these losses was projected to be between USD 2.48 and 6.19 million, according to Abrahams *et al.* (2017) and Day *et al.* (2017). In Kenya and Ethiopia, FAW infestation resulted in yield losses of 0.77 to 1.0 t ha-1, with farmers reporting that approximately 32% (Ethiopia) and 47.3% (Kenya) of their fields were infested during the season, and they anticipated a continued rise in invasions in the future

(Kumela *et al*., 2018). According to Prasanna *et al.* (2018) the impact of fall armyworm has resulted in anticipated reductions in crop yields across various regions.

The African fall armyworm, *Spodoptera exempta* (Walker), is a major widespread migratory insect pest that is a perennial threat to cereal production over much of eastern and southern Africa (Grzywacz *et al.*, 2014). In 2007/08, severe armyworm outbreaks in Ethiopia affected >279,000 hectares of cropland (USAID, 2008). Outbreaks of a similar scale occurred in southern Africa in 2012/13, when in Zambia alone armyworm were reported in seven of the country's ten provinces and more than 96,000 hectares of maize and pasture were infested, affecting close to 73,000 farmers (USAID, 2013). Fall armyworm *Spodoptera frugiperda* (J.E. Smith), an invasive species, was reported on the African continent for the first time in 2016 (Goergen *et al.*, 2016). Recently, this pest was reported for the first time in southern Africa (Malawi, Mozambique, Namibia, South Africa, Zambia and Zimbabwe) and it is causing considerable damage to maize (FAO, 2017b). The fall armyworm is a voracious pest and, given its polyphagous nature, it is expected that its accidental introduction in the African continent will constitute a lasting threat to several cereal crops.

2.2.3. Spotted stem borer

Stem borers are the most important field pests in maize cultivation in the tropics (De Groote, 2001; Kfir *et al.*, 2002). Five species of stem borers (*Chilo partellus* (Swinhoe), *Busseola fusca* (Fuller), *Sesamia calamistis* (Hampson), *Eldana saccharina* (Walker) and *Mussidia nigrivenella* (Ragonot) are the dominant pests (De Groote, 2001; Kfir *et al.*, 2002; Culliney, 2014). Damage is from feeding by the larvae and yield losses of up to 88% – depending on the cultivar, plant developmental stage at infestation and prevailing environmental conditions – have been reported (Kfir *et al.*, 2002).

It is responsible for 15 to 60% crop losses globally, significantly lowers maize production as revealed. Substantial losses of between 24 and 75% in Africa's key maize-belt countries are devastated singly by the pest. In Kenya, study disclosed that stem borers were found to cause (10-100%) losses (Ong'amo *et al*., 2006). Stem borer ears destruction predisposed sizeable grain to mycotoxins and storage insect pest infestations prior harvest (Njeru *et al*., 2020). *C. partellus*, commonly known as maize borer, has the highest impact on grain yield, leading to significant

impairment of maize stalks (80%) when infestations occur at 20 days old. However, when identical infestations happen at later stages of crop development, minimal damage is observed (Van den berg, 2009).

2.2.4. Aphids (Aphis Fabae)

Aphid's fabae are approximately 2 mm long and very often carry a powdery white secretion on the abdominal segments at adult stage. In the moist agro ecologies, reproduction is only by parthenogenesis. *Aphis fabae* is affected leguminous species in Africa, and more severe based on agroecologies (Khaemba *et al*., 1985). Aphid more harmful and make visible during dry season, and thus infestations are more severe during the dry season. While, during moisture and humid weather, their colonies are often eliminated by members of the Entomophtoraceae (Jousselin *et al.*, 2010).

2.3. Insect Pest Management Methods

Preventive and curative strategies are schemes harnessed by farmers to checkmate pre and post-harvest insect pests and fungal diseases of maize in field and storage. The primary methods employed for managing wild pests encompass a variety of strategies, including cultural practices, biological controls, chemical interventions, host plant resistance, and the use of plant-based pesticides, among others. There are different techniques of pest management practices normally used were physical, mechanical, regulatory methods, biological, chemical, integrated, genetic methods, resistance varieties, cultural, natural control, legislative control and traditional methods.

2.3.1. Natural methods

Measures that checks or destroy pests without depending on human for their continuance or success. No human involvement it's in the hands of nature to control the pests. Natural control includes climatic factors such as wind, temperature, sunshine and rain, topographic features such as rivers, lakes and mountain can influence pest movement. Naturally occurring predators, parasites and pathogens regulate also pest populations (Emana Getu *et al*., 2008).

2.3.2. Physical control

Includes the use of electricity, sound waves, infrared rays, or light to kill insects or attract them to killing mechanisms. The most common physical methods are those, which employ heat or cold. No insects can survive temperature of 60 to 65ºc for very long (Emana Getu *et al.,* 2008).

2.3.3. Cultural methods

Cultural practices are considered as traditional forms of pest management. Techniques are based on the modification of cropping systems to ensure pest and disease evasion or avoidance during the most susceptible crop growth stage or pest population peak. Cultural strategies also strive to enrich the crop-growing environment to promote crop immunity and also create a discouraging environment that retards the proliferation of destructive organisms (pests and diseases). The merits of cultural applications lie in their manageability, minimal cost, and suitability for economically stressed smallholder farmers (Haouas and Hufnagel, 2020). It includes good tillage, pruning fertilization, selection of crop plant varieties timing of planting and harvesting, irrigation management, crop rotation and use of trap crops help reduce population of weeds, microorganisms, insects, mites and other pests. Use proper soil, water, PH, fertilizers applications to ensure maximum plant vigor (Sarwar, 2012).

2.3.4. Mechanical control

It's a method in the control of populations by means of a device which affects them directly or which alter their physical environment radically. For example, people used to pick their personal parasites such as lice from their body. These methods include cultivation (control weeds. It also used some insects and other soil inhabiting pests), exclusion (is a mechanical control technique that consists of using barrier to prevent pests from getting into an area), trapping (physically catches insects pests within an area or building) (Emana Getu *et al*., 2008). Regulatory pest control government agencies are authorized to destroy weeds and plant that cause fire hazards harbors harmful pathogens or animals or are noxious to people or livestock's in and around agricultural areas. Includes, Quarantine (prevent movement of designated pest within a state to prevent spread of pests to non- infested area), eradication (the total elimination of the pests from a designated area) (Kenis *et al*., 2019).

2.3.5. Biological control

Biological control is the use of beneficial organisms to help control pest organisms. These beneficial organisms are often referred to as “bio control agents” or “natural enemies. The objective of biological control is to employ and manage natural enemies to ensure that pest populations remain below the threshold at which economic damage occurs (known as the economic injury level or EIL). Macro and microorganisms present potential bio control agents (Haouas and Hufnagel, 2020). Its regulation by natural enemies: predators, parasites and pathogens. Cultural methods such as crop rotation, tillage, mixed cropping, removal of crop residues and adjustment of harvest or sowing times may also be considered as biological control (Emana Getu *et al.,* 2008). Biological control or bio-control constitutes a deliberate attempt to use natural enemies either by introducing new species into the environment of the pest or by increasing the effectiveness of those already present. Traditionally, this method employed to control insect pests by parasitoids, predators and pathogens and among these we rely mostly on the predators (Rizwan, 2010; Haouas and Hufnagel, 2020).

2.3.6. Genetic method

Host plant resistance refers to the inherited genetic characteristic of plants that enables them to withstand attacks from pests and diseases, as well as recover from the damage caused by such attacks (Togola *et al*., 2017). The use of sterile male technique in controlling medically important insects and fruit eating pests were well documented. As far as cereal pests are concerned the use of genetically modified organisms (Emana *et al.,* 2008). Resistant maize cultivars had proven to be reliable, cost-effective, and ecologically sustainable approach to managing GLS disease (Zhang *et al.,* 2012). In Ethiopia, inbred lines BH546, BH547 and BH661 were identified to possess genes resistant to foliar diseases, including grey leaf spot disease (Keno *et al.,* 2018).

2.3.7. Chemical method

Chemical approach presents a major and integral component of pest management. Globally, synthetic pesticides are consistently utilized in controlling pests and diseases, with varying levels of attainment. For instance, effective management of the larger grain borer has relied intensely

on the application of organophosphates that include pirimiphos-methyl, fenitrothion, permethrin, and bromophos dilute dust (Kimenju and De Groote, 2010). Industrial insecticides had been universally harnessed over decades to reduce the menace of *S. zeamais* and associated storage pests on a commercial level (Gbaye and Holloway, 2011; Sisay *et al.*, 2018).

2.3.8. Integrated Pest Management

Integrated Pest Management is a pest population management system that utilizes all suitable pest control techniques in a compatible manner to reduce pest populations and maintains them at levels below those causing economic injury (Smith and Reynolds, 1966). It is a broad-based approach that integrates a range of practices for economic control of pests with, least possible hazard and environmentally sounds. Before applying IPM program comprehensive information on the life cycles of pests, ecology and plant pest interaction required (Binyam, 2015). The process of crop managements of integrating two or more recommended crop protection technology is called integrated pest management. This method is more preferred and practices directly by intention and at most parts of small scale farmers practices without the purposes of integration (Daba, 2020).

Integrated pest management (IPM) is a systematic plan that brings together different pest-control tactics into one program. The primary objective is to keep pest intensity below an economic injury threshold and prevent reductions in crop yield and quality (Hill, 2008). In an IPM program, use of pesticides is reduced and emphasis is placed on using cultural, biological, genetic, physical, regulatory and mechanical control methods. The goal is to prevent pests from reaching economically damaging levels (Ehler, 2006). Success of an IPM program depends on careful observation, a thorough knowledge of the pest and the damage caused, and an understanding of all available control options.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. Descriptions of the Study Area

The study was conducted in two districts of Hadiya Zone, Central Ethiopia namely: Ghibe and East Badewacho Districts. Hadiya Zone is found in the Central Ethiopia. Its capital city, Hossana, is 230 km away from Addis Ababa, the capital city of Ethiopia. It has 13 woredas and 7 Town administrations, namely, Soro, Lemo, Ana-lemo, Shashogo, East Badawacho, West Badawacho, Siraro Badawacho, Duna, Gombora, Misha, Gibe woradas, Shone and Hossana Town Administration. Hadiya Zone is bordered in the South by Kembata Tembaro Zone and Alaba Special Woreda, on the West by the Omo River which separates it from Oromiya Region State and the Yem Special Woreda, in the North by Gurage and Silite Zones, and in the East by the Oromiya Region State with an estimated area of 346958.14 hectares (Figure 1) (Solomon, 2008; cited in Daniel, 2018).

Ghibe district is the first study site, which is located in Hadiya Zone, Central Ethiopia. It is 264km far away from Addis Ababa and 32 kilometers far away from Hossana or Hadiya. It comprises 26 peasant associations (PAs), from these 19 rural kebeles and 6 urban towns are presented which are associated with three different agro-ecological zones. The district is bordered on the south by Gombora district of Hadiya zone, on the west by the Yem Special Woreda and on the north and east by Misha district of former Konteb Woreda, Hadiya zone. According to Gibe district Finance and Economy Development Office (GWFEDO, 2016) report that the district had three basic agro climatic conditions (Based on altitude) namely highland (Dega) (14.2%), midland (Woyina dega) 53.1% and lowland (Kola) 32.7%. Its geographical location is between 7^0 37’53”-7^0 42’43’North Latitude and $37^0$37’07 - 37^0 44’25 East Longitudes. The altitude of the area ranges between 840-2850 m.a.s.l. The mean annual rainfall ranges between 600 and 1200 mm and average temperature is from 17.6 0C to 25 0C (GWFEDO, 2016).

East Badewacho district is the second study site, which is located in Hadiya Zone, Central Ethiopia. It is 95Km from south of Hosanna and 360Km south of Addis Ababa. Topographically, it is located at an altitude range of 1150-1650 meter above sea level. Geographically, it is located $07^{o}90$ and $8^{0}15$ North latitude and 35^{0} and $40^{0}15$ East latitude. The average temperature is 14-30^{0}c with lower temperature fluctuation climatically. According to East Badewacho agricultural statistics information, the agricultural production system of the district is mixed type (EBADO, 2019).

Figure 1: Map of Study area (Daniel, 2018).

3.2. Study Design and Methods

Survey was conducted in order to assess the status of insect pests on major crops grown in Hadiya zone and their management practices in Central Ethiopia in two districts which were purposively selected. Both quantitative and qualitative data were collected from the primary and

secondary sources. The primary sources include observation, interviews to farmers and developmental agents, while the secondary sources were internet, progress reports of Agricultural office.

3.3. Sampling and Sample Size Determination

The two districts considered for the study were Ghibe and East Badewacho as these districts were relatively good potential for crop production. Moreover, they were more accessible. From each districts three administrative Kebeles (PAs) were selected based on production potential. From these kebeles, a total of 60 farm households (10 from each kebele) were selected randomly on which interview data and questionnaires administered, while 18 fields of the selected households (3 fields from each Kebele) were observed randomly. From each Kebele 2 DAs (total 12 DAs) were involved in filling the questionnaire.

3.4. Data Collection

The study was conducted from August 2023 to June 2024 and data were collected from September to April at farm and at house hold level. Data on the infestation level of insect pests under field conditions were collected through observations and interview with farmers and DAs. Using a questionnaire, individual interviews were conducted in the different study sites. Seventy-two respondents (60 farmers and twelve Development Agents) were randomly selected from all the study areas and interviewed. Interviews were conducted in local languages translation(Hadiya language). Within each study site, farmers were randomly selected for individual interviews based on the lists prepared by the local authorities. The household heads were the targeted respondents, although any adult in the household who was familiar with crop production were interviewed if the head of the households were absent. Structured questionnaires were focus on importance of insect pest and management options used to control insect pests of major crops grown in Hadiya zone, Central Ethiopia.

3.4.1. Interviews

Using information on a questionnaire, individual interviews were conducted in the different study sites. Interviews were conducted in Hadiya language. Within each study site, farmers were randomly selected for individual interviews. Both open and close ended questionnaires were distributed to randomly selected respondents' farmers and development agents. Generally, the questionnaires were made to have two parts with all items consisting of both close and open-ended types. The first part was in both cases designed to seek personal information of respondents while the second part assess the status of insect pests on major crops grown in Hadiya zone and their management practices.

3.4.2. Field observations

Field observations were made at harvesting, storage and planting season.

3.5. Data Analysis

Field collected data and semi-structured interviews were summarized using descriptive statistics such as frequencies and percentage with Statistical Package for the Social Sciences (SPSS) version 20.0. For all the analysis a statistical significance at $P<0.05$ were used.

3.6. Ethical consideration

Ethical considerations were kept during the research as the principles of confidentiality secrecy. Before carrying out the research, the researcher got permission from stakeholders of both districts. The researcher explained to the farmers, developmental agents and other stakeholders, the purpose of study and the methods to be used to carry out the study. Information given from respondents and their identity during the study was kept in the private.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1. Characteristics of the Respondents

The focus of this section is to summarize the important demographic characteristics of the respondents. Thus, the characteristics of the respondents were examined in terms of sex, age, years of service, education level, marital status and occupational status T Seventy two farmers and developmental agents were involved in the servey. From these 53(73.6%) were males and 19(26.4%) were females. The sample size for females was far less than that of their male counterparts.

Table 1 shows that the age interval of the respondents and the majority 38 (52.8%) of the respondents were found in the age interval of 30-39 years which signifies that the mature and well experienced farmers who have productive and potential prospects. Following 21 (29.2%) of the respondents were found in the age of 40-50 and the rest 5 (6.9%) of the respondents were fall under the age category ranging between above 50 years. Generally, the majority of the respondents of the farmers were middle aged by taking ILO (2013) as a reference implying that they could have good productive prospects. With regard to marital status, as it is indicated in the table below, the majority of the respondents 33 (45.8%) were married, 28 (38.9%) were single and the rest are divorced and widowed. On the basis of educational level, the majority of the respondents have no formal education (n=27, 37.5%) where as 27.8% and 26.4% of the respondents are primary school and above secondary level, respectively. Only 6 individuals are identified to have secondary school level.

Table 1: Demographic characteristics of the respondents

Item	Characteristics of respondents	No. of respondents	Percent (%)
Sex	Male	53	73.6
	Female	19	26.4
Age	20-29	8	11.1
	30-39	38	52.8
	40-49	21	29.2
	Above 50	5	6.9
Marital status	Married	33	45.8
	Single	28	38.9
	Divorced	7	9.7
	Widowed	4	5.6
Occupational status	Farmer	60	83.3
	Development agent	12	16.7
Education level	No formal education	27	37.5
	Primary school	20	27.8
	Secondary school	6	8.3
	Above	19	26.4
Total		72	100

Table 2. shows that the total number of respondents were seventy two in number and the researcher distributed questionnaire for randomly selected respondents from each kebele's.

Table 2: Demographic characteristics of the respondents in each district

District	Kebele	Sex	Frequency	Percentage
Ghibe district	Amola	M	10	83.3
		F	2	16.7
	Sodda	M	9	75
		F	3	25
	Addayye	M	8	66.7
		F	4	33.3
East Badewacho	Wera	M	9	75
district		F	3	25
	Lakkole	M	9	75
		F	3	25
	Amburse	M	8	66.3
		F	4	33.3
Total			72	100

4.2. Major crops grown in the study area

Table 3 Shows the most of the people in the study area grow maize 22(30.55%) which is followed by wheat 20(27.78%) while 17(23.6%) of Teff grown in the area.

Table 3: Major crops grown in the study area

Item	Response	No of respondents	Percentage
Names of crops	Maize	22	30.55
	Wheat	20	27.78
	Teff	17	23.6
	Bean	13	18.05
Total		72	100

4.3. The Purposes of Major Crops are grown in Study Area

The present finding shown that, the highest proportion (73.6%) of respondents grows major crops for the purpose of consumption while 19.4% grown for commerciall purpose. Only few (7%) grow crops for industrial purpose (Table 4). Cereals are said to be poor man crop as their market value is low in relation to other crops like coffee, oil crops and vegetable crops among others. Abraham *et al.* (2008) demonstrated that pest control using chemicals is unaffordable by cereal growers as the crops are mainly used for consumption which is in line with the current findings.

Table 4: Purposes for which cereals crops are grown in study area

Purpose	**No. of respondents**	**Percentage (%)**
Consumption	53	73.6
Commercial use	14	19.4
Industrial	5	7
Total	**72**	**100**

4.4. **Major Insect Pest of Crops in Study Area**

The present study revealed that the highest damage was recorded on teff grain by shootfly. Weevils mainly the genus Sitophilus caused damage to maize, wheat and common bean. Lesser grain borer only recorded on maize. Due to the agro-ecological nature of the study area the overall stored grain damage by stored grain insect pest is high.

4.4.1. Major insect pest of Maize

Fall armyworm (FAW) (*Spodoptera frugiperda*) was the dominant and existed all over the surveyed fields of both Ghibe and East badewacho districts, Hadiya zone. The fall armyworm (FAW) has caused varying degrees of Maize damage in study area. This result is in line with Day *et al*. (2017) and Prasanna *et al*. (2018) the impact of fall armyworm has resulted in anticipated reductions in crop yields across various regions. Specifically, in West Africa, the predicted yield losses range from 22% to 67%, while in East Africa, it is estimated to be around 32%. The entire continent has experienced yield losses ranging from 21% to 53%. In Kenya and Ethiopia, FAW

infestation resulted in yield losses of 0.77 to 1.0 t ha-1, with farmers reporting that approximately 32% (Ethiopia) and 47.3% (Kenya) of their fields were infested during the season, and they anticipated a continued rise in invasions in the future (Kumela *et al*., 2018).

The respondents replied that maize weevil is the risky insect pest in maize storage, poses a significant threat to stored maize grains (Table 5). The maize weevil, known as a destructive pest that affects maize grains from the field to storage, is a global concern (Adedire *et al*., 2011). According to a study by Lale and Ofuya (2001) maize weevil has the ability to perforate and invade grain kernels, leading to a decrease in their nutritional and seed value and ultimately rendering them aesthetically unattractive in both domestic and international markets. The present finding is also agree with the previous report of Nwosu, (2018) and Ileke *et al.* (2020), the maize weevil, the primary insect pest in maize storage, poses a significant threat to stored maize grains. Demissie *et al.* (2008) reported that the weevil begins its infestation in the field and the majority of the harm takes place during the storage period. These damages, as highlighted by Tefera *et al*. (2011) and Napoleão *et al*. (2013) often result in decreased grain weight and nutritional content, reduced seed germination, and ultimately lower marketability. The infestation level of stem borer (*Busseola fusca*) in maize fields was 20% in surveyed districts.

The above mentioned species were reported as the main storage insect pests of cereal grains in several parts of Ethiopia (e.g., Mendesil *et al*., 2007; Demissie *et al*., 2008; Tadesse *et al*., 2008; Tefera, 2016) and other African countries (e.g., Tefera, 2012; Midega *et al*., 2016; Abass *et al*., 2018), in both studied districts and storage types, Sitophilus spp. were the foremost abundant species, which is corroborated by the findings of varied studies, like Mlambo *et al*. (2017). Angoumois moth is a cosmopolitan insect and therefore it is the dominant species attacking different cereal crops in Africa (Mlambo *et al*., 2017).

4.4.2. Major insect pest of Wheat

The current study revealed that status of wheat weevil was 95.8% of farmers replied as a major pest of wheat (Table 5 followed by shoot fly. Infestation of wheat by shoot fly has been on record in Ethiopia but the damage has been attributed only to *D. arambourgi* Seguy, which was

supposed to be minor pest of wheat and tef (Crowe *et al.,* 1977; Tadesse 1979; Adugna and Kemal, 1986; Hill 1989 and Amsal *et al.*, 1997).

Figure 2: Weevil damage to wheat grain in storage

4.4.3. Major insect pest of Teff

The current study revealed that status of teff shoot fly was 62.5 % of farmers replied as a major pest of teff. This result is in line with a report of Tedesse (1987). It caused 4.9% up to 24 % yield loss in Tigray Region, East and South West Showa zone (Bayeh *et al*., 2008) with more than 90%of panicle damage (Silashi, 1997). Similarly, Bayeh *et al*., (2009) also reported that shoot fly cause serious damage on seedlings and panicle stages of teff.

4.4.4. Major insect pest of Bean

The present study showed that farmers stored their beans in different types of storage. However, farmers' storage practices did not vary significantly among the study districts. Storing bean seed is one of the important postharvest operations where farmers store for different reasons such as for home consumption, as a source of seed for next planting, and to speculate the selling price

(Jones, 1999). Most (93.2%) of the farmers had knowledge about storage pests. However, there was a difference in farmer's knowledge of storage pest and the bean weevil. For example, some of the farmers in the study area mentioned maize weevils as a pest of stored beans whereas other farmers mentioned bruchids( ) as pests of both maize and common bean Figure 3. Shows faba bean damage by bruchids.

Figure 3: Bruchids damage to faba bean in the storage

Table 5: The major insect pests of crop in the Hadiya zone

Crop type	Name of crop	Major insect pest	No. of respondents	Percentage %
Cereal crop	Maize	Fall army worms	68	94.5
		Cut worm	26	36.1

		Maize weevil	65	90.3
		Stem borer	15	20.8
	Wheat	Weevil	69	95.8
		Shootfly	25	34.7
	Teff	Shoot fly	45	62.5
Pulse Crops	Faba bean	Storage weevils (bruchids)	57	79.2
		Pollen beetle (Mylabris sp.)	46	63.9
		Aphid	33	45.8

Among, the 18 field of maize assessed about 16 fields were infested by fall armyworm (*Spodoptera frugiperda*) pest. Thus, the fall armyworm damages on maize from the fields, accounts estimated for about 45% of maize damage percentage in this study (Figure 4).The fall armyworm (FAW) has caused varying degrees of crop damage in several countries. The impact of FAW invasion on resource-poor farmers in sub-Saharan Africa (SSA) has worsened (Wightman, 2018). In Ethiopia, when the infestation occurred during the late whorl growth stage, specifically stage 1.5 of maize growth, it led to a 30% reduction in yield (Assefa and Ayalew, 2019).

. . .. A B . . .

Figure 4: The insect pest of bean(A) and maize(B) at field level.

The current finding revealed that maize weevil is the primary insect pest in maize storage, poses a significant threat to stored maize grains in study area (Figure 2). This result agreed with report of Ileke *et al*. (2020), the maize weevil, the primary insect pest in maize storage, poses a significant threat to stored maize grains. Similarly, the maize weevil (*Sitophilus zeamais*), known as a destructive pest that affects maize grains from the field to storage, is a global concern (Adedire *et al*., 2011). The significant impact of post-harvest losses caused by *S. zeamais* on Africa's food security has been widely recognized (Abebe *et al*., 2009; Tefera *et al*., 2011). Figure 4. Shows infestation of flower beetle (Glycyphan stolata) to faba beans and infestation of maize by fall army worm. Also figure 5. Shows Faba beans, maize, and wheat seeds infestation symptoms caused by stored grain insect pests.

A **B** **C**

Figure 5: Insect pest's damage on bean (A), maize (B) and wheat (C) grain in the storage

4.5. Insect pests damage on different part of crops

Table 6 shows that most of the respondents 30(41.7%) confirmed that stored seed part infestation by different insect pests followed by leaf parts 20(27.8%) However, 12(16.7%) respondents confirmed that stalk (stem) part infestation by different insect pests. Moreover, 6(8.3%) respondents were agreed that germinated seed infestation by insect pests followed by root parts 4(5.6%). This is similar study so far conducted (Kfir *et al*., 200, Hill, 2008).

This implied that most respondents were agreed that insect pests more damage stored seed part and leaf parts of major crops grown in the study area.

Table 6: **Insect pests damage on different part of major crops in the study area**

Crop parts	Frequency	Percentage
Stored seed	30	41.7
Leaf	20	27.8
Stalk (stem)	12	16.7
Germinated seed	6	8.3
Root	4	5.6
Total	72	100

4.6. Stages and Season of Crop Damage by Insect Pests

Table 7 Shows high amount of crops damaged before harvest 39(54.17%) and during September -November 24(33.33). On the other hand, low amount crops were damaged during harvest 7(9.72%) and during December-January 9(12.5%).

Table 7: Stage and season of crop damage by insect pests in the study area

Items	Response	No of Respondents	Percentage
Stage of crop damage	Before harvest	39	54.17
by insect pests	After harvest	26	36.11
	During harvest	7	9.72
	Total	72	100
Season of insect	June-August	20	27.78
Pest affects	December-January	9	12.5
Crop more	September-November	24	33.33
	March-May.....19		26.39
	Total 72		100

4.7. Insect pests infestation on major crops leads to economic crisis on farmer's life

Table 8 shows 50(69.44%) of respondents agreed and 17(23.61) of the respondents strongly agreed. However, 3(4.7%) of respondents disagreed with the given idea. Moreover 2(2.78%) respondents strongly disagreed with the infestation of insect pests on crops leads to economic crisis on farmers' life. This implies that the most respondents agreed and strongly agreed with the idea in the study area.

Table 8: Insect pests infestation on crops lead to economic crisis on farmers

Response	Frequency	Percentage
Strongly disagree	2	2.78
Disagree	3	4.17
Agree	50	69.44
Strongly agree	17	23.61
Total	72	100

4.8. Insect pests make great loss of crop production rate, weight, quality and germination

Table 9 indicates that 43 (59.8%) of respondents agreed and 15(20.8%) of respondents strongly agreed with the insect pests infestation make loss of production rate. However, 6(8.3%) of respondents disagreed with the idea. Moreover 8(11.1%) of respondents strongly disagreed. This implied that the most respondents agreed and strongly disagreed on the given statements. This is similar study so far conducted (Santos *et al*,. 1990).

Table 9: Insect pests make great loss of crop production rate, weight, quality and germination.

Response	Frequency	Percentage
Agree	43	59.8
Strongly agree	15	20.8
Strongly disagree	8	11.1
Disagree	6	8.3

Total	72	100

4.9. Management Practice to Control Insect Pest of Major Crops

Most of farmers 49 (68%) were use chemical to control insect pests from their crop grown followed by crop rotation mechanism 14 (19.5%) while 6 (8.3%) of respondents were use Sanitation method to control key insect pest. In the other hand, 3 (4.3%) of respondents were use early cropping method for their crop grown on field. This finding is in line with the investigation of (Tefera *et al.*, 2011) to control insect pest various control mechanisms have been evaluated including chemical, cultural, host plant resistance and biological in different parts of Africa.

Table 10: Insect pests control methods under practice at Hadiya zone on major crops.

Control methods	No. of respondents	Percentage (%)
Chemical use	49	68
Crop rotation	14	19.5
Sanitation	6	8.3
Early cropping	3	4.2

CHAPTER FIVE

5. CONCLUSSION AND RECOMMENDATIONS

The insect pests were very harmful to produce the quality crops. The crop cultivation at the study area shows increasing rate of production from year to year. and the crop mostly cultivated at the area were maize, wheat, common bean, and teff. Agricultural pests are the major constraining factors for crop production at Hadiya zone. The insect pests are the key in limiting the crop production and productivity and it needs high attention to overcome the destructions occur with insects on the cultivated crop at field and storage conditions. Among, the insect pests in cultivated crop at field condition pollen beetle (*Mylabris sp.)* and cut worm on common bean, fall armyworm on maize and shoot fly on teff were the major insect pest that causes high damage on each crop. Weevil also causes high damage on maize, wheat and bean at intorage. Therefore, the producers should use different management methods such as crop rotations, field sanitation, and as a last option applying insecticides developed/formulated for respective insect species at a right time.

Based on above conclusive remarks, the following recommendations are forwarded:

- ✓ In order to minimize insect pests spread farmers should adopt good agronomic practices and seed store in proper storage methods.
- ✓ Awareness creation should be given for farmers to use improved crop varieties, technologies and related knowledge and information on good agricultural practices and pest management.
- ✓ Collaborative research is necessary to improve and expand area-wide management strategies in partnership with farmers to encourage widespread adoption of these technologies and gather feedback from users.
- ✓ It is critical to highlight the integrated pest management systems sustainability and effectiveness of approaches for long-term storage of seeds and grains in a variety of situations.
- ✓ Training both farmers and extension workers on insect pest identification and their management early to protect crops from insect pests to reduce the yield losses.

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7. Appendices

ADDIS ABABA UNIVERSITY

FACULTY OF NATURAL AND COMPUTATIONAL SCIENCES

GRADUATE STUDIES PROGRAM DEPARTMENT OF ZOOLOGICAL SCIENCES

QUESTIONNAIRE TO BE FILLED BY RESPONDENTS

Dear Respondents,

The purpose of this questionnaire is to gather information about on infestation of major insect pests and management options of major crops grown in Hadiya Zone, Central Ethiopia. Right at the onset, the researcher would like to assure you that your response would be used only for research purpose and would be kept confidential. The quality and success of this study depends on the validity and reliability of the information provided by you.

Therefore, you are kindly requested to supply your genuine responses to each item of the questionnaires.

Thank you in advance for your cooperation!!

- **The type of questionnaires**
  - Multiple choice
  - Open end

PART-I:Background of the Respondents

Instruction: - **show your answer by encircling the letter provided.**

1. Sex: A) Female B) Male
2. Age A) 20-29 B) 30-39 C) 40-49 D) above 50 years
3. Marital status: - A) Married B) Single C) Divorced D) Widowed
4. Educational status: A) No formal education B) Primary school C) Secondary school D) Above
5. Occupational status:- A) Farmer B) DA C) Other workers----------

PART II: Respondents Knowledge on Insects Pests of Major Crops

6. Major crop plants are grown in your area?

A. Teff B. Bean C. Wheat D. Maize E. All

7. Please, specify if there is any other crops that can grow?----------

8. For what purpose can the farmers cultivate the crops?

A . Consumption B. Commercial uses C. Industrial purpose D. Other (specify)----------

9. Which crop is mainly cultivated at your local site? ----------

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10. What methods do you use to cultivate those crops? ----------

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11. Is there insect pest that cause crop damage in your area?----------

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12. What are the main pests that can damage the major crops?----------

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13. Which insect pest affects your crops seriously? ----------

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14. Which types of insets pests can affects each stored crops?----------

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15. At what stage your crop damaged by insect pest----------

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16. At what season insect pest affects your crop more?----------

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17. Do you have knowledge and damage of crops by the insects?

A. Yes B. No

18. From the following alternatives of insects' pests management practices, which methods can you use to control the damages of stored cereals crops?

A. Chemical use B. Crop rotation C. Sanitation D. Early-cropping E. Combinations

19. What control methods you use for these pests other than above mentioned?----------

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20. Where did you store your crops after harvesting? Please mention each of them you use to stored your products?----------

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21. Is there economic loss by pest problem? How much estimated?----------

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Thanks for your cooperation!!