**ADDIS ABABA UNIVERSITY**
**SCHOOL OF GRADUATE STUDIES**
**COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES**

# Efficient practices of farmers` to control *Striga hermonthica* weed infestation on sorghum: a case study of Ensaro District, Central Ethiopia

Solomon Demissie Kassu

A Thesis Submitted to the Department of Zoological Sciences and Presented in Partial Fulfillment of the Degree of Master of science in Biology

September 2018

Addis Ababa Ethiopia

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This is to certify that, the thesis prepared by Solomon Demissie Kassu entitled: "*Efficient practices of farmers` to control Striga hermonthica weed infestation on sorghum: a case study of Ensaro District, Central Ethiopia*" and submitted in partial fulfillment of the requirements for the degree of master of science in biology complies with regulation of the university and meets the accepted standards with respect to originality and quality.

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## ABSTRACT

**Efficient practices of farmers` to control *Striga hermonthica* weed infestation on sorghum: a case study of Ensaro District, Central Ethiopia.**

Solomon Demissie Kassu

Addis Ababa University, 2018

The study was conducted in Ensaro District lowland (*Kolla*) areas found in North Shoa Administrative Zone, Amhara National Regional State with the aims to identify, describe and evaluate the control practices of *Striga hermonthica* weed infestation on sorghum by farmers of the study area. Data were collected through Participatory Rural Appraisal using semi-structured interview, questionnaire, field observations and group discussion. The different control practices of this weed infestation in the study area were analyzed using descriptive statistics, preference ranking and paired comparison. The more efficient control practices of the study area were combinations of post emerging herbicides, hand weeding and use of inorganic fertilizers. About 68 % of the interviewed member of the local communities and Agricultural extension workers had positive attitude on the effectiveness of the practices. Since the area is highly infested by the *Striga hermonthica* weed for a long period of time as a result the grain yield of Sorghum doesn't meet the expectations of the farmers. Although the controlling practices are better solutions than using none, there is still a need to put more effort for irrevocable solution.

**Key Words**: Ensaro District, *Striga hermonthica*, Sorghum,

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# ACRONYMS

| | |
|---|---|
| AATF | African Agricultural Technology Foundation |
| CIMMYT | International Maize and Wheat Improvement Center |
| HWT | Hoe Weeding Tillage |
| IITA | International Institute of Tropical Agriculture |
| IRM | Imazapyr- Resistant Maize |
| masl | meters above sea level |
| MCPA | 2-Methyl-4-chlorophenoxyacetic Acid |
| MT | Minimum Tillage |
| NGOs | Non-Governmental Organizations |
| PPS | Proportional to Size |
| qns | quintals |
| SADC | South African Development Community |
| SHH | Sampled House Holds |
| SSA | Sub Saharan Africa |
| STA | Southern Tropical Africa |
| THH | Total House Holds |
| USA | United States of America |

# CHAPTER ONE

## 1. INTRODUCTION

### 1.1 Background of the Study

Agriculture remains the main source of food and provides the primary source of livelihood for most of the world`s population. In Sub-Saharan Africa (SSA), 2/3 of the working populations are still making their living from agriculture (Defoer, 2000). Ethiopia is among these countries running an agriculture-based economy. Ensaro District, is one of the rural districts in Ethiopia, where agriculture is the most important economic sector employing about 90% of the labor force. Over 90% of this economic sector is still relying on rain-feed system (Agricultural Department of Ensaro District, 2015). Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important staple crops and grown as rain fed crop with little or no external inputs by subsistence farmers (Aad, 2006). Sorghum is one of the crops cultivated in East African countries. Historians believe that sorghum is originated in Northeast Africa, where a large variability in wild and cultivated species is still found. It probably was domesticated in Ethiopia, 5000–7000 years ago (Wayne and Frederickson, 2000). The crop then distributed along trade routes around the African continent and through the Middle East to India about 3000 years ago (Aad, 2006). Sorghum is the fifth major cereal crop in terms of production, after maize, wheat, rice and barely (Sarmiso, 2016). 90% of the world`s cultivated land producing sorghum is in the developing countries, mainly in Africa and Asia. Major world`s producers include Sudan, Nigeria, India, USA, Mexico, Ethiopia, China and Argentina (Mazen *et al*., 2017).

Sorghum is, a largely self-pollinating crop, primarily is a crop of hot, semi-arid tropical areas with 400–600 mm rainfall that are too dry for maize cultivation. Its deep penetrating roots are mainly responsible for this drought tolerance, but the plant has other morphological and physiological characteristics that also contribute to its adaptation to dry condition (Aad, 2006). Over the past 40 years, sorghum production in Africa has increased steadily from 10.9 million metric tons to 20.8 million metric tons in 1965 and 2005 respectively (FAOSTAT, 2005). Sorghum yield per hectare in Africa are very low (853 kg/ha in 2005), due to constraints of nutrient, loss of organic matter and poor erratic rainfall (Aad, 2006). Sorghum production is also negatively influenced by the parasitic weed *Striga hermonthica* weed (Aad, 2006; Mazen *et al*., 2017).

*Striga* weed (*Striga hermonthica* (Del.) Benth) is an obligate root hemi parasite that belongs to the family Orobanchaceae. The plant has been identified as weed being one of the major biological threats to sorghum production in the Savannah Zones of Sub-Saharan Africa (SSA) (Mazen *et al*., 2017). *Striga hermonthica* weed is endemic to Africa, constitutes one of the most severe constraints to cereal production in SSA (Ellis *et al*., 2004). Mazen *et al.* (2017) described that the parasite causes huge loss ranging from 40% to 90%, depending on crop variety, climatic conditions and seed infestation level of soil and up to 75% damage occurred during the subterranean stage of the host's development. It infests some of 40% of the cereal producing areas of SSA resulting to crop loss estimated at US $ 7-13 billion annually, affecting livelihoods of approximately 100-300 million people (Gebisa Ejeta, 2007; Zeyaur *et al*., 2006). The most affected human population is the subsistence farmers losing about 20% to 80% of their yield (Atera *et al*., 2011).

*Striga hermonthica* weed infestation is mostly a consequence of mono cropping with the cereals that host the parasite and declining soil fertility that weakens the host plant to *Striga hermonthica* weed attack. The infestation attaches itself to the sorghum roots from which it draws its moisture and nutrient requirements, inhibiting plant growth, reducing yields and in extreme cases, causing plant death (Manyong *et al*., 2008). Symptoms exhibited by infected host plants include stunting, wilting, leaf chlorosis, and yield reduction. All of these symptoms become severe after emergence of the *Striga hermonthica* plants above the soil surface. From this stage, the high rates of transpiration by *Striga hermonthica* weed result in competition with the host for water and probably nutrients and there is a decrease rate of photosynthesis by the host (Smith *et al*., 1995).

Controlling *Striga herminthica* weed becomes an enormous task considering the seed production rate of 10000-500000 seeds per plant, which remains viable in the soil for 14-20 years (Ikie *et al*., 2006). Farmers in Ensaro District are the victims of *Striga hermonthica* weed infestation to their Sorghum crop. Due to repeated scenario of such infestation and loss of harvest, the farmers have developed knowledge in controlling the infestation.

### 1.2 Statement of the problem

Lack of awareness in controlling mechanisms of *Striga hermonthica* weed infestation has become series cause of yield reduction in food crops cultivated in Northeast Africa. Farmers in Ensaro District have been affected by this weed losing their crops, especially sorghum. According to the report from Ensaro District Communication Office (2016), the yield from a hectare of sorghum plantation infested by *Striga hermonthica* weed can be affected in such a way showing reduction rate from 40% to 80%. The total households affected as a result of low yield production in Ensaro district is estimated up to 15162.

In Ensaro District there are different *Striga hermonthica* weed infestation controlling practices observed being efficient by the local communities. However, no scientific study, such as the proposed one, has been conducted to document the useful knowledge. This study is initiated to document the practices and their efficiency in controlling Sorghum infestation by *Striga hermonthica* weed. The outcome will provide baseline information for developing the controlling mechanism for use in higher scale.

### 1.3 Hypothesis

Due to the problem faced by the farmers in Ensaro district with regard to *Striga hermonthica* weed infestation, a remarkable knowledge in controlling this weed has been developed.

### 1.4 Research questions

This study resolves around the following research questions:

1. What are the different control practices of *Striga hermonthica* weed infestation on sorghum?
2. What is the level of efficiency of the practices in control of *Striga hermonthica* weed infestation?

### 1.5 Objectives

#### 1.5.1 General Objectives

To document efficient practices of farmers` to control *Striga hermonthica* weed infestation on sorghum crop in Ensaro district.

#### 1.5.2 Specific Objectives

i. To verify the extent of *Striga hermonthica* weed infestation on Sorghum crop.

ii. To identify and list the different control practices of *Striga hermonthica* weed infestation on sorghum crop.

iii. To evaluate the efficiency of the farmers practices in controlling *Striga hermonthica* weed infestation.

iv. To estimate sorghum grain yield after the application of the control practices.

# CHAPTER TWO

## 2. LITERATURE REVIEW

### 2.1 Origin, Distribution and Occurrence of *Striga hermonthica* weed

The genus *Striga hermonthica* weed is common throughout Northern Tropical Africa. It possibly originated from a region between the Semien mountains of Ethiopia and the Nubian Hills of Sudan, which probably could also be the birthplace of domesticated sorghum (Hayelome Berehe Teka, 2014). Although this genus is generally native to Semi- arid tropical areas of Africa, it has been recorded in more than 40 countries (Steve *et al.,* 2016).

*Striga hermonthica* weed is distributed Southward from SSA, Southern Tropical Africa (STA), including Angola, Namibia, Madagascar and Tanzania as well as to Democratic Republic of Congo and Senegal (Steve *et al.,* 2016). Its distribution extends from Western Arabian region southwards to Angola and Namibia (Berhane Sibhatu, 2016). The species *Striga hermonthica* weed is commonly distributed in Eastern Africa (especially in Sudan, Ethiopia, Yemen, Kenya, and Uganda); Western Africa (especially in Nigeria, Ghana, Burkina Faso, Niger, Chad, Mali, Senegal, and Mauritania); and the South Africa Development Community Countries SADCC (especially in Angola, Tanzania, and Mozambique) (Ramiah, 1984; Obilana, 1987; Atera *et al*., 2011).

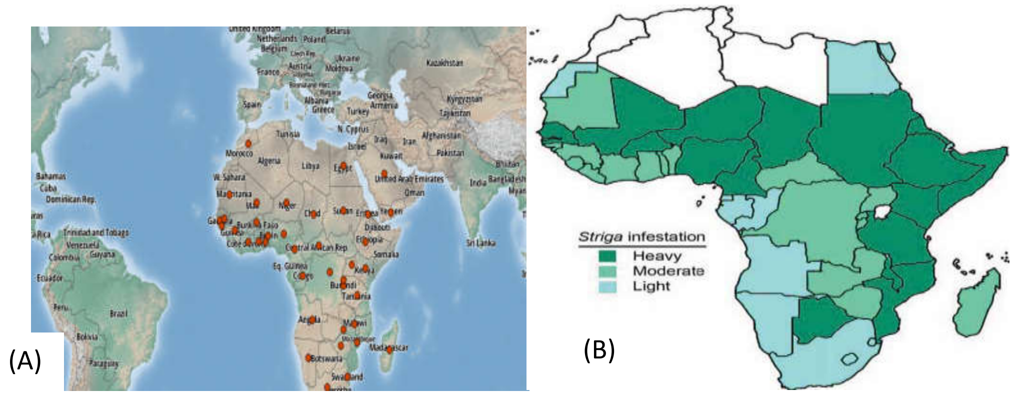


**Figure 1** ***Striga hermonthica*** **weed Distribution in the World (A) and Africa (B)**

**(Source: CABI, 2018)**

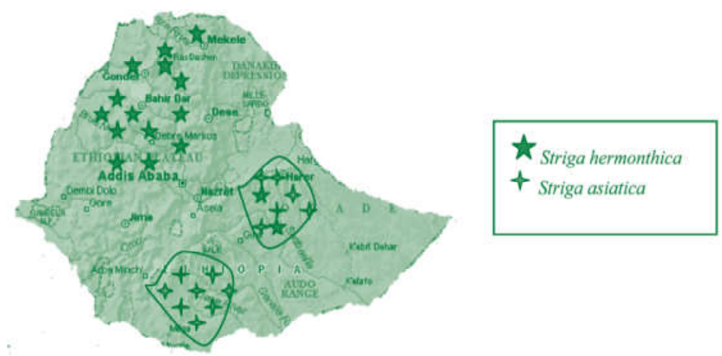


**Figure 2 Distribution of** ***Striga hermonthica*** **weed in Ethiopia**

(**Source: Gebisa Ejeta and Gressel, 2007**)

## 2.2 *Striga hermonthica* weed infestation and effects

The vast geographic distribution of the species aggravated its adverse impact on staple crops of the continent. Particularly, sorghum, maize, and millet are highly affected (Hayelom Berehe Teka, 2014). Its infestation is also spreading to other crops and many of the wild grasses (Berhane Sibhatu, 2016). This turned the weed to become a severe pandemic in Africa and thus, become seriously affecting the economy of millions (Hayelom BereheTeka, 2014).

The parasite infests about 40% of the cereal producing areas of SSA resulting to crop losses estimated at $ 7-13 billion annually, affecting livelihoods of approximately 300 million people (Gebisa Ejeta, 2007). It has been estimated that about 40–70 million hectares are severely or moderately infested in West African countries (Emechebe *et al*., 2004). Severe *Striga* infection can cause 70-80 % crop loss in sorghum and losses can be much higher under heavy infestations, even resulting in total crop failure (Ellis *et* al., 2004; Ijoyah, 2014). Farmers often have to abandon infested agricultural lands as a result of high soil infestations, by *Striga hermonthica* weed. Recent trends away from traditional prolonged fallow and intercropping towards continuous cereal mono cropping to meet the needs of increasing population have intensified *Striga hermonthica* weed problem (Salle, 1991). The reproductive capacity of the weed aggravated the situation in that a single plant can produce about 500000 seeds, which can remain viable in the soil for 15–20 years (Ikie *et al*., 2006).

## 2.3 Genetic Diversity of *Striga hermonthica* weed

### 2.3.1 Genetic diversity due to geography

Geography appears to play the greatest role in determining genetic differences among the populations of *Striga hermonthica* weed. Its distribution ranges from an elevation of 2134 m a. s. l. to the very high mountains in Ethiopia, which could result in ecoclinal variation (Mulugeta Kebede *et al*., 2007). Rift valley also appears to be a genetic barrier for, resulting in genetic differences between populations on the East and West sides of the valley. Differentiation from these geographic barriers is probably a recent phenomenon and reflects the spread of *Striga hermonthica* weed in recent evolutionary time (Mulugeta Kebede *et al*., 2007).

Although the proportion of genetic variation that could be attributed to the presence of the rift valley was significant, it was relatively low (5%), indicating the current spread of *Striga hermonthica* weed (Welsh *et al.*, 2011).

### 2.3.2 Genetic diversity due to host specificity

*Striga hermonthica* weed has two host specific strains, one for sorghum and another for pearl millet. This is true in areas where only sorghum or pearl millet is used as a food crop, either because of limitations by climatic conditions or because of humans` food preferences (Musselman and Herrer, 1986). The apparent lack of genetic differentiation based on host specificity may suggest that specialization of *Striga hermonthica* weed to its host may be a recent phenomenon, with insufficient time for genetic differences to arise (Oliver *et al*., 1998). This is consistent with the observation that when a sorghum field infested with *Striga hermonthica* weed is replaced by millet, the new crop will be infested by *Striga hermonthica* weed after a few years; this is independent on the intensity with which a particular crop is grown in the absence of others in a given area (Oliver *et al.,* 1998). Origins of host species may also play a role in genetic differences between populations. Sorghum is native to Ethiopia, and *Striga hermonthica* weed populations are characterized by fairly high genetic differentiation (Welsh *et al.*, 2011).

## 2.4 Conditions favoring *Striga hermonthica* weed growth

*Striga hermonthica* weed infestation is steadily increasing as a result of continuous cultivation of cereal crops (Zeyuar *et al.,* 2007; Oswald and Woomer, 2005). Overused, depleted and infertile soils have resulted to high infestation of *Striga hermonthica* weed. Pressure on land for continuous cropping of high yield cereal crops without rotation or moving to other new areas has resulted to exhausted soils. These are the soils that favor

*Striga hermonthica* weed infestation in addition to soil moisture stress conditions. Less shading due to poor growth of the host crop on poor soils contributes to heavy infestation. Infestation in some areas has reduced yield to the extent that abandonment and migration is necessary. Improper management of *Striga hermonthica* weed has contributed to its existence in SSA for a long time (Atera *et al*., 2011). Generally, *Striga hermonthica* weed prefer infertile soils in open grasslands and savannah in semi-arid tropical areas. Their seeds are well adapted to hot, dry conditions, remaining dormant until rain (Steve *et al*., 2016).

### 2.5 The biology and life cycle of *Striga hermonthica* weed

*Striga hermonthica* plants have green opposite leaves, bright irregular flowers with corolla tube slightly bent at the middle. The flowers are pink. There is a considerable variation in flower color. The plant is characterized by herbaceous habit, small seeds and parasitism. The seeds of *Striga hermonthica* weeds are extremely small, about 0.2X0.3 mm, weighing about 0.7 µg (Berehane Sibhatu, 2016; IITA, 1997). The minimal length of the life cycle of the parasite, from germination to seed production comprises an average of 4 months (Berehane Sibhatu, 2016).

This weed is an annual chlorophyllous plant grows up to 80cm with hairy, hard quadrangle – shaped and fibrous stem, narrow leaf, and spike – shaped raceme inflorescence bearing up to 60 flowers for the terminal and 10 – 20 for the lateral inflorescence with bright pink, rose red, white or yellow color ( Babiker, 2007). For germination *Striga hermonthica* weed seed requires a period of pre-treatment, conditioning in a moist warm environment for 2 to 16 days before they have potential to germinate. Its infection results in chlorosis, wilting, stunting, and death, with losses ranging from slight to 100% (Koua, 2011; IITA, 1997 and Lucy *et al.,* 1995).

Since *Striga hermonthica* weed is a parasitic weed, the seedlings cannot sustain themselves on their own resources, particularly, for long after germination. Therefore, they need to find a host root shortly after germination and the germination needs to be perfectly timed with the presence of a host root (Berhane Sibhatu, 2016). Exogenous germination stimulants called strigolactones are produced by the host`s root and also by some non- host (usually referred to as trap crops) roots (*Gossypium sp*.). They are plant hormones that inhibit shoot branching but also signals to seeds of parasitic weeds such as *Striga hermonthica* weed to start germinate (Gomez *et al.,* 2008). Strigol, a synthetic compound belonging to the Strigolactones, was first isolated from cotton and used as a germination trigger for *Striga hermonthica* weed (Cardoso *et al.,* 2010). When the seed have been germinated, the seedlings can live for 3–7 days without a host. After that, it will die if it is not attached to a root and there has been able to create a parasitic link to that particular root. The seedling finds its way to the host root by chemical signals and then creates the xylem to phloem connection between the seedling and the root. However, the seedlings cannot be at a greater distance from the root than 2–3 mm to find its way there. On plant can host many *Striga hermonthica* plants and *Striga hermonthica* weed affects the plant mostly before its emergence (Berehane Sebhatu, 2016).

Subsequent to germination, which occurs in close proximity of the host roots, a haustorium (organ of attachment and a physiological bridge between the host and the parasite) is produced on perception of a host – derived chemical signal (Babiker *et al.,* 1993). Haustorium initiation, which represents the switch from the vegetative to the parasitic mode of life, occurs on or near the host. The haoustorium attaches, penetrates the host root and establishes connection with the host xylem (Babiker *et al.,* 1993). Following attachment, the parasite remains subterranean for 6–8 weeks. During this period, the parasite is completely dependent on its host and is most damaging (Berehane Sebhatu, 2016).

*Striga hermonthica* weed have very complex life cycle which is intimately tied to that of its host and that follows a series of developmental stages from seed to seed producing plants. After dispersal, the seeds are in a state of primary dormancy for up to six months (Vallence, 1950). Following after ripening, a second pre–requisite for germination is the preconditioning of the seeds, which require an imbibitions period of several weeks under humid and warm conditions (25–35$^{O}$C). After reaching maximum sensitivity, prolonged preconditioned *Striga hermonthica* weed seeds require various secondary metabolites (xenognosis) derived from the host roots and some non-host plants to induce germination and to develop (Aad, 2006).

The germinating seeds produce a root–like structure, the radicle. For successful host attachment, germination must take place within 3–4 mm of the host root since *Striga hermonthica* weed radicles have limited growth potential. Radicle growth is directed toward the host root under the influence of chemical concentration of the root exudates (chemotropism). Within four days after germination the radicle needs to find a host root; if not, it will die (Aad, 2006).

After germination, a series of chemical signals directs the radicle to the host root where it attaches and penetrates. Once penetration has occurred, an internal feeding structure (haustorium) is formed, and the parasite establishes host xylem connections. The host photosythate is derived to the developing parasite, which also utilizes the host root system for water and mineral uptake (IITA, 1997; Aad, 2006).

After the host matures, the parasite emerges, begins to produce chlorophyll, and photosynthesizes. After emergence, host symptom development is intensified. Parasite reproduction can be initiated before emergence. Following reproduction, seeds are dispersed and the cycle is reinitiated. The relative success of each stage of the cycle governs the volume of seed production. At each stage, there is a potential opportunity for control (IITA, 1997; Aad, 2006).

Life cycle and symptoms of *Striga hermonthica* weed parasitism are broadly similar, regardless of the host–parasite combination, although there are some minor variations. Seeds are the sole source of inoculums (IITA, 1997).

After dispersal, seeds may remain dormant for several months; during this time, seeds will not germinate even if conditions are ideal. According to Vallance (1950), as cited by IITA (1997), this period is termed after–ripening and it may be an evolutionary adaptation to prevent germination during the last rains of the season, when there are no hosts around. After this period seeds will germinate only under conditions of favorable moisture and temperature (free moisture adequate for seed imbibitions and at temperatures between $20^{o}C$ and $33^{o}C$) and only in the presence of a germination stimulant, usually exuded from plant roots (IITA, 1997).

There are two steps termed ``conditioning or preconditioning``. It is a pre germination requirement of exposure to moisture, combined with temperatures above $20^{o}C$ for a period of 1 week or more. This requirement is probably a survival adaptation, which prevents the seed from germinating during the irregular first rains, before the rainy season has become well established (IITA, 1997).

The next requirement is a signal by a specific chemical germination stimulant from the proper host root. This stimulation requirement ensures that *Striga hermonthica* weed, with its minimal food reserves in the seed, does not germinate until it has received a signal that a host root is nearby it. Here the growth is chemotropic, because it grows directly towards the source of the stimulant (IITA, 1997).

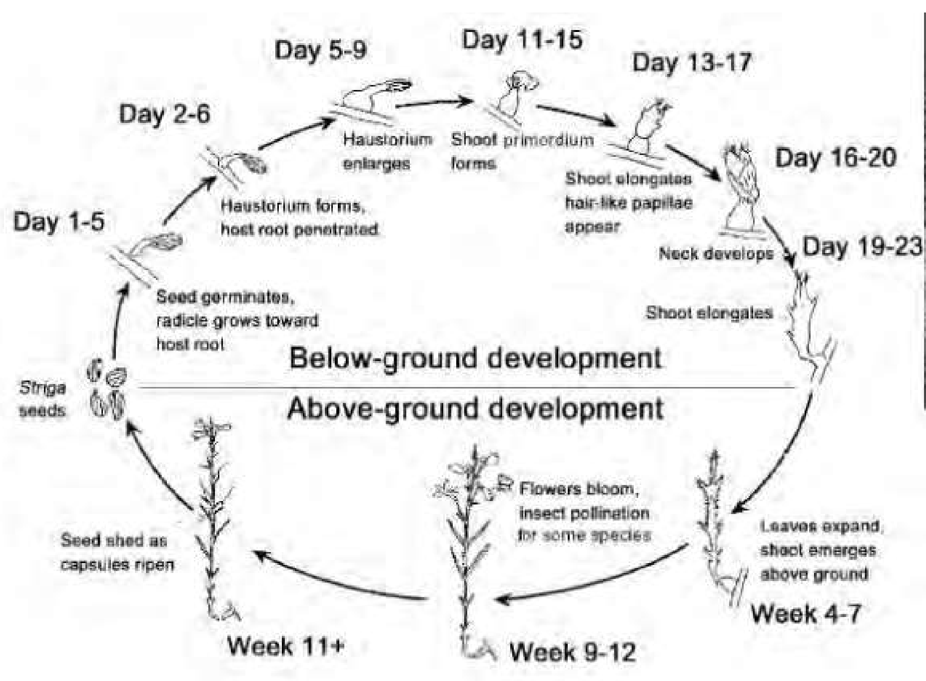


**Figure 3 General life cycle of *Striga hermonthica* weed**

**(Source: IITA, 1997)**

### 2.6 Socioeconomic importance of *Striga hermonthica* weed

The effect of *Striga hermonthica* weed damage on crops is a reduction in yield. The extent of yield loss is related to the incidence and severity of attack, the host`s susceptibility to *Striga hermonthica* weed, environmental factors (Edaphic and Climatic) and the management level at which the crop is produced (Berehane Sebhatu, 2016). Its effects on crop range from stunted growth, through wilting, yellowing, and schoriching of leaves, to lowered yields and death of many affected plants (Koua, 2011; IITA, 1997 and Lucy *et al.,* 1995). The annual sorghum losses attributed to *Striga hermonthica* weed in SSA are estimated at 22–27 % and specifically at 25% in Ethiopia, 35% in Nigeria, and 40% in Mali. In terms of monetary value, the annual cereal losses due to *Striga hermonthica* weed are estimated US$ 7 billion in SSA. In Ethiopia, the annual losses are estimated at US $ 75 million (AATF, 2011 as cited by Berehane Sebhatu, 2016).

The success of *Striga hermonthica* weed as a parasitic weed is due to several of its characteristics, related somehow with the farming systems in semi–arid areas where its hosts are grown, *Striga hermonthica* weed seeds survive in arid soils for 15 years (Obilana and Ramaiah, 1992).

In terms of crop yields, *Striga hermonthica* weed damage has been most significant. In the eastern Africa region, Grain yield loss for susceptible sorghum varieties was estimated to be 59% (Doggit, 1965). In resistant cultivars, there is 5% loss of potential, 95% in susceptible varieties; and 45–63 % in tolerant sorghums. Where *Striga hermonthica* weed infestation is intense and varieties are susceptible, 100% crop losses in farmers` fields are common (Obilana and Ramaiah, 1992).

## 2.7 Control Methods of *Striga hermonthica* weed infestation

### 2.7.1 Cultural and Mechanical control method

A number of cultural practices have been recommended for *Striga hermonthica* weed control such as crop rotation, intercropping, transplanting, soil and water management, use of fertilizers and hand weeding, style of plot plowing to reduce the production of further

*Striga hermonthica* weed seed. These methods should also reduce the density of *Striga hermonthica* weed seeds already in the soil seed bank (Hayelom Berehe Teka, 2014; Ramaiah, 1992; Aad, 2006).

**Hand – weeding and sanitation**

Today the most used control method against *Striga hermonthica* weed is hand weeding. It is recommended to prevent seed set and seed dispersal. Weeding the small *Striga hermonthica* plants is a tedious task and may not increase the yield of already infected plants, it is necessary to prevent seed production and re-infestation of the soil (Hayelom Berehe Teka, 2014).

Sanitation consists of taking care of not infest areas and to isolate them (Hayelom Berehe Teka, 2014). It is not practical to hand weed dense infestations, and weeding is often ineffective, particularly since it is time consuming and labor –intensive. It is practical, at a low level of infestation before *Striga hermonthica* weed flower and in combination with herbicides or fertilizers (Parker and Riches, 1993).

**Crop rotation**

Crop rotation of infested land with non-susceptible crops or fallowing is theoretically the simplest solution. Rotation with non–host crops interrupts further production of *Striga hermonthica* weed seed and leads to decline in the seed population in the soil. The practical of this technique is required more than three years for rotation. The choice of rotational crop should therefore be based first on its suitability to the local conditions and only secondarily on its potential as a trap crop. In Ethiopia rotating the infested sorghum areas to wheat or barely, pulses, are viable and effective options. In Ethiopia two years of cropping to a non-host was reported to reduce *Striga hermonthica* weed infestation by 50% (Shank, 2002 as cited by Hayelom Berehe Teka, 2014).

**Intercropping**

Intercropping cereals with legumes and other crops is a common practice in most areas of Africa, and has been reported as influencing *Striga hermonthica* weed infestation. Intercropping is a potentially viable, low–cost technology, which would enable to address the two important and interrelated problems of low soil fertility and *Striga hermonthica* weed (Fasil Reda, 2004*)*. Growing of sorghum in association with cowpea and haricot bean was effective against *Striga hermonthica* weed and produced significantly improved yield per unit area in preliminary trials in Ethiopia (Hayelom Berehe Teka, 2014).

**Use of fertilizers**

Nitrogen and phosphorous deficiency as well as water stress accentuate the severity of *Striga hermonthica* weed damage to the hosts (Ramaiah, 1992; Aad, 2006 and Hayelom Berehe Teka, 2014). Fertilizer application had significant effect on height, vigor score, relation score of sorghum as well as shoot count, day to emergence, dry matter of production and dry weight of *Striga hermonthica* weed (Esilaba *et al.,* 2000). The application of high nitrogen increases the performance of cereal crops under *Striga hermonthica* weed infestation. This is due to the fact of that nitrogen reduced the severity of *Striga hermonthica* weed attack while simultaneously increases the host performance (Hayelom Berehe Teka, 2014). Application of high dosage of nitrogen fertilizer is generally beneficial in delaying *Striga hermonthica* emergence and obtaining stronger crop growth (Lagoke and Isah, 2010).

### 2.7.2 Biological control methods

The objective of weed biological control is not the eradication of weeds but the reduction and establishment of a weed population to a level below the economic threshold (Rajini and Mukerji, 2000). Means of biological control of weeds comprise herbivorous insects, microorganisms (especially fungi), and smother plants (Saureborne and Kroschel, 1996). The method, involves importation, colonization, and establishment of exotic natural enemies, which include predators and parasitoids (Hayelom Berehe Teka, 2014).

Efforts to manage weeds using biological control have been gaining momentum throughout the world, especially in the recent past (Delfosse, 2004). Biological control is considered as a potential cost–effective, safe and environmentally beneficial alternative mean of reducing weed populations in crops, forests or rangelands (Hayelom Berehe Teka, 2014).

Biological control is unattractive as a private entrepreneurial effort. This is because the intensive use of chemical herbicides came under security due to several areas of concern, which include the development of herbicide resistant or tolerant weeds and environmental contaminations, comprehending effects on non–target organisms as well as the population of soil, underground water and food (Hayelom Berehe Teka, 2014).

**Biological control using insects**

The insects that attack *Striga hermonthica* weed can be classified according to their damage as defoliators such as *Junonia species*, gall forming as *Smicronyx species* (Coleopteran; Curculionidae) in India and Africa; shoot borers as *Apanteles species* Miners as *Ophiomyia strigalis*, Spencer (Diptera; Agromyzidae) in East Africa; inflorescence feeders as *Eulucastra species* in India (Hayelom Berehe Teka, 2014).

The use of herbivorous insects could play a role in an integrated control package, lowering the *Striga hermonthica* weed population by reducing its preproduction capabilities and spread (Hayelom Berehe Teka, 2014).

**Biological control using pathogens**

Most organisms have natural enemies that balance their populations, avoiding excessive abundance. Biological control of *Striga hermonthica* weed using *Fusarium oxysporum* is considered as one of the novel management strategies (Sauerborne *et al*., 2007). Fungi are preferred to other microorganisms as bio- herbicides they are usually host specific, highly aggressive, and easy to mass produce and are genetically diverse (Hayelom Berehe Teka, 2014).

The effectiveness of integrated use of *Fusarium oxysporum* compatible and *Striga hermonthica* resistant sorghum genotypes to control *Striga hermonthica* weed have been studied in Ethiopia (Hearne *et al*., 2009; Hayelom Berehe Teka, 2014). However, integrated *Striga hermonthica* weed management approach relies on the use of resistant host genotypes and *Striga hermonthica* pathogenic *Fusarium oxysporum* application to control *Striga hermonthica* weed emergence and growth lead to effective results (Hayelom Berehe Teka, 2014).

### 2.7.3 Chemical control method of *Striga hermonthica* weed

**Germination stimulants**

Certain chemicals such as ethylene, ethephon, strigol analogous can induce germination of *Striga hermonthica* weed seeds in the absence of a suitable host and therefore seed reserves in the soil (Hayelom Bereehe Teka, 2014).

**Pre- emergence herbicides**

African Agricultural Technology Foundation (AATF), The International Maize and Wheat improvement center (CIMMYT), Badische Anlin and Soda Fabric and other stakeholders have made efforts in bringing Imazapyr- Resistant Maize (IRM) technology to farmers as assistance for *Striga hermonthica* weed control (Hayelom Berehe Teka, 2014; Ramaiah, 1992; Aad, 2006). Herbicide seed treatment using Imazaypyr appears to be a promising approach for the control of *Striga hermonthica* weed in maize or sorghum has also reported coating sorghum seed with herbicide reduced *Striga hermonthica* weed infestation, *Striga hermonthica* weed flowering and *Striga hermonthica* weed seed set, and it is considered as the most effective approach as it does not affect sorghum biomass (Hayelom Berehe Teka, 2014).

**Post – emergence herbicides**

Herbicides rested for the selective control of *Striga hermonthica* weed mostly acts through the foliage, although some have soil residual effects (Abdul *et al.,* 2000). Among the herbicides tested, 2, 4 – D has been the most selective and is the cheapest. 2- Methyl – 4 - Chlorophenoxyacetic acid (MCPA), a compound closely related to 2, 4 – D, has also been effective especially when mixed with bromoxynil. Post emergence application of 2, 4- D (1liter product per hectare), Gufisinate (2liter product per hectare) and Oxyflourfen (1liter product per hectare) was effective in preventing the top growth of *Striga hermonthica* weed (Gebisa Ejeta *et al*., 1996*)*.

Unfortunately, most of those products had narrow window of application and the only safe treatment for the crop was targeted spray of 2, 4–D. a combination use of urea and dicamba effectively controlled *Striga hermonthica* weed between 62–92% on sorghum, while chlorsulforon in combination with dicamba controlled *Striga hermonthica* weed as much as 77–100% on sorghum (Babiker *et al*., 1996).

However, results of the experiments showed that pre and post emergence herbicides do not prevent crop yield loss, because they cause their impact after *Striga hermonthica* weed has already attached and damage the host (Hayelom Berehe Teka, 2014; Ramaiah, 1992; Aad, 2006).

#### 2.7.4 Host plant resistance

Host plant resistance would probably be the most feasible and potential method for parasitic weed control. Using biotechnological approaches (including biochemistry, tissue culture, plant genetics and breeding, and molecular biology) significant progress has been made in developing screening methodologies and new laboratory assays, leading to the identification of better sources of parasitic weed host resistance (Gebisa Ejeta *et al*., 2000). However, reliance on host resistance alone is not ideal because so far complete resistance against *Striga hermonthica* weed cannot be attained through breeding, and usually the newly developed varieties may not fulfill farmers' preference traits (Hayelom Berehe Teka, 2014). Identifying source germplast with different resistance mechanisms can facilitate combining several resistance genes to obtain more durable and stable polygenic resistance to *Striga hermonthica* weed in cereals (Gebisa Ejeta *et al*, 2000; Ramaiah, 1992; Aad, 2006).

Basically, the resistant varieties were low yielding and not desirable in other agronomic characteristics. However, integrating genetic resistance with other control measures is the smartest option possible both for effectiveness of control as well as for increasing durability of resistance genes (Gebisa Ejeta, 2007).

## 2.8 Controlling practices that improve sorghum grain yield

In Ethiopia, uncontrolled weed growth leads to at least 44% and 30% yield loss in maize and sorghum. Mainly parasitic weed *Striga hermonthica* weed on average causes 60–80% loss and often the damage is greater on sorghum (Abreham Tadesse, 2008). The high weeding intensity treatment had lower weed growth in both crops and better sorghum yield than low weeding intensity. The high hand weeding intensity treatment reduced total weed biomass by 48% composed to low hand weeding treatment (Torreson, 2003). Hoe weeding was done either four times (high weeding intensity) or twice (low weeding intensity) during the cropping season. Labor required for hoe weeding in semi-arid areas and needs about 133–173 person hour per ha (Mashingidze, 2004; Chikoye *et al.,* 2007; Gianessi, 2009).

In sorghum, weeding four times within the cropping season properly can reduce weed biomass and density. The high weeding treatment reduced weed density by 36% and weed biomass by 53% compared to the low weeding intensity treatment (Torreson, 2003). Frequent hand hoe weeding, as demonstrated in a number of studies throughout Africa can properly reduce both weed emergence and growth across the cropping season (Torreson, 2003). It was also effective in reducing early season weed growth in sorghum grown under minimum tillage (MT). The minimum tillage (MT) systems are associated with increased labor requirements for hoe weeding with mulch ripping requiring 173 person hours per ha and hoe weeding tillage (HWT) 204 person hour per ha. The minimum tillage (MT) systems had poor crop establishment, which translated into low yields. The poor sorghum establishment in minimum tillage (MT) systems translated into low grain yield (Mashingidze, 2004; Chikoye *et al.,* 2007; Gianessi, 2009).

The hand weeding practices also yielded more sorghum grain yield than the unweeded. Comparing the yield from hand weeded practice with the herbicide practice, it was founded that, the yield from hand weeded practice was more than all the herbicide practice. A study conducted by (Stroud, 1989) on sorghum revealed that three times weeding at monthly interval gave the highest yield of 2700 Kg $ha^{-1}$. Weeding once at 25–30 days after emergence, or when the crop reaches 15 cm height, leads to a comparable yield grain of 2500 Kg $ha^{-1}$. Weeding late, i.e., at grain filling stage, resulted in a heavy crop loss (Stroud, 1989). A study was conducted at *Bako* on sorghum to compare the recommended twice weeding at 25–30 and 55–60 days after planting with farmers practice for grain yield and labor saving advantages (Abdol *et al*., 2000).

The labor requirement for the recommended hand weeding was 226 hours per ha but only 15 ox plus 127 horse labor hours $ha^{-1}$ for farmers practice. It was assumed that this could be the reason why farmers preferred their traditional practice rather than other control options (Gemechu Gedeno and Legesse Dadi, 1989).

Intercropping is a low cost cultural practice that improves soil fertility and optimum crop densities so can minimize weed grow and increase grain yield. Fasil Reda (2002) found that intercropping of sorghum and cowpea was superior in crop productivity and *Striga hermonthica* weed control and increase sorghum grain yield. Row planting of sorghum and legumes with staggered planting of the crops (sowing of legume intercrops 3 – 4 weeks after the sorghum), was more productive and led to overall reduction in infestation, over two seasons (Fasil Reda, 2002). Fertilizer use was eminent and inorganic fertilizer alone improved crop preference and suppressed *Striga hermonthica* weed at the site (Fasil Reda, 2002).

Yearly rotation of sorghum with either cowpea or haricot bean resulted in significantly higher crop yield but failed to lead to concomitant reduction in *Striga hermonthica* weed infestation (Fasil Reda and Wondimu Bayu, 2001). Using of some herbicides requires that information on soil PH, organic matters and clay content be known to determine appropriate application rates. This information is largely unknown to most smallholder farmers (Fasil Reda, 2002). The infestation level on time of planting did not result in significant differences in sorghum grain yield (Fasil Reda and Wondimu Bayu, 2001).

# CHAPTER THREE

## 3. RESEARCH METHODOLOGY

### 3.1 Study area description

**Geography**

The study was conducted in Ensaro District, North Shoa Administrative Zone, Amahara National Regional State. The District`s altitudinal average elevation ranges from 1800 to 2400 m a.s.l. Ensaro District is among the 24 Districts in North Shoa Administrative Zone with total area coverage of 39723.75 ha. Out of this, 16864ha is farmland (42.5%), 4036ha is grazing land (10.2%), forest covers 10743ha (27.1%), 1995.75ha is the proportion of homesteads (5.02%), and 6085ha is used for various other purposes (15.3%) (Agriculture, 2016). The capital town of Ensaro District is Lemi town, which is located 130 km North from Addis Ababa and 98 km North from Zonal Capital town called Debre Birehan. The District shares boundaries with Siyadebrina Wayu from East, Merhabete from North, Moretina Jiru from North East, Girar Jarso from West, Wuchalena Jida from South and Debrelibanos from South West. Currently it is sub-divided in to 14 (fourteen) Kebele Administrations and one urban town with total population of 68602. The number of men in the District are 35231 (51.4%) and women 33371 (48.6%) and those that are urban inhabitants are 5534 (8.1%), 2526 (45.6%) are male and 3008 (54.4%) are female, and rural inhabitants are 63068 (91.9%), 32705 (51.9%) are male and 30363 (48.1%) are female. Based on the religion 99.9% are Ethiopian Orthodox Christianity. There are two largest ethnic groups with 70.27% Amhara and 29.58% Oromo (Managment, 2017).

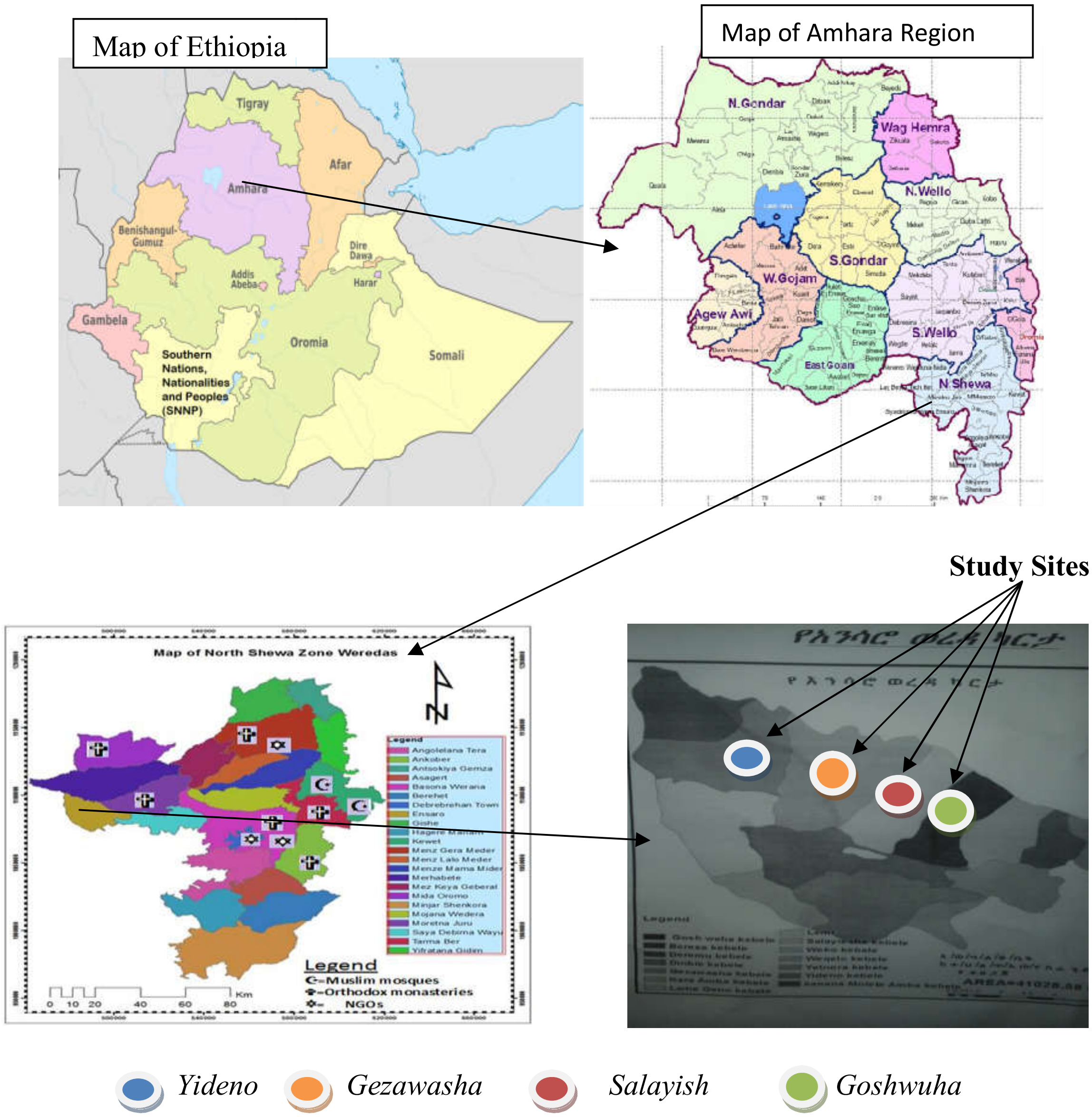


**Figure 4 Map of Ensaro District**

**(Source: Ensaro district land management office, 2016)**

**Climate and farming system**

Ensaro District is composed of three climatic zones, traditionally named as *Kolla* (46% of the district), *Weynadega* (33% of the district) and *Dega* (21% of the district). Most of the Kebele administration units are found in the lowland (*Kolla*).

The annual temperature ranges between $6^0$C and $24^0$C in the high land and $24^0$C and $28^0$C in the low land agro-ecological zones, and mean annual temperature is $15^0$C. The annual rainfall is bimodal in the *Dega* Agro-ecological areas of the District. The small rainy season occurs from mid-February to May while the long rainy season occurs from June to mid-September. The average amount of annual rainfall is 995.6 mm in the highland (*Dega*) and 900mm (*Kolla*) in the lowland area.

Ensaro District is characterized by subsistence farming system. The great majority of the populations get their livelihoods by cultivating a variety of crops. A few numbers of farmers in highland (*Dega*) harvest crops biannually during Meher and Belg growing seasons. Sorghum, Maize and Teff are important elements of the overall farming system. Most crops are grown with rain fed farming system.

**Livelihoods**

Based on the information gathered from different sectors in the District, the livelihoods of farmer in the District highly depend on subsistence agriculture-crop production. Agriculture in the District is characterized by lack of access and use of modern technology, low productivity, heavy dependence on rainfall and backward weeding system to control *Striga hermonthica* weed infestation.

## 3.2 Sampling techniques and sampling procedures

Farmers who produce sorghum were targeted for provision of information in this study. Thus, purposive sampling method was used and 120 farmer informants selected. Four Agricultural extension workers were also included in this study to have more intensive information.

Study sites were also selected based on prior information about farmers' challenge due to *Striga* infestation. Four kebele administrations were selected as study sites. Two villages from each four kebele were re-sampled, which are eight villages in total. The eight villages are named as *Belbelit* and *Kokebmesk* from *Salayish* Kebele, *Girgir* and *Mugarge* from *Goshwuha*, *Totilish* and *Dalota* from *Gezawasha*, and *Geba* and *Mererie* from *Yideno*. See Figure 6.

The Agricultural Extension Workers (AEW) were tasked to make the list of all the households from each Kebele and then I selected 120 households purposely based on their efficiency to control *Striga hermonthica* weed infestation in their sorghum farmland. From 120 number of respondents, 106 (88.3%) are males and the rest 14 (11.7%) were females, age of >50 were 3 (2.5%) and of 41-50 were 71 (59.2%) and the rest 46 (38.3%) were between age 30-40, the married were 90 (75%) and the rest 9 (7.5%) and 21 (17.5%) were widowed and divorced. In addition to this, 44 (36.7%) were tried informal basic education, 29 (24.2%) were started primary education, 26 (21.7%) were not educated and the rest 21 (17.5%) were educated secondary level and above. Based on their occupation, most are farmers 70 (58.3%), 39 (32.5%) were both farmers and employed and 11 (9.2%) were businessmen/women. The selection is from each village which is about 12 - 18 number of farmers selected. Out of these 12-18 number of farmers from each villages, 24-36 number of farmers were selected purposely by considering the level of *Striga hermonthica* weed infestation on their sorghum farmlands from each Kebele to form 120 numbers of households involved in this efficient practices of farmers to control *Strigahermonthica* weed infestation on sorghum.

The sample size of the study was 120 households. Four Kebeles were covered in eight villages. Therefore, the total number of households in the study area is 4414.

**Sampling Procedure**

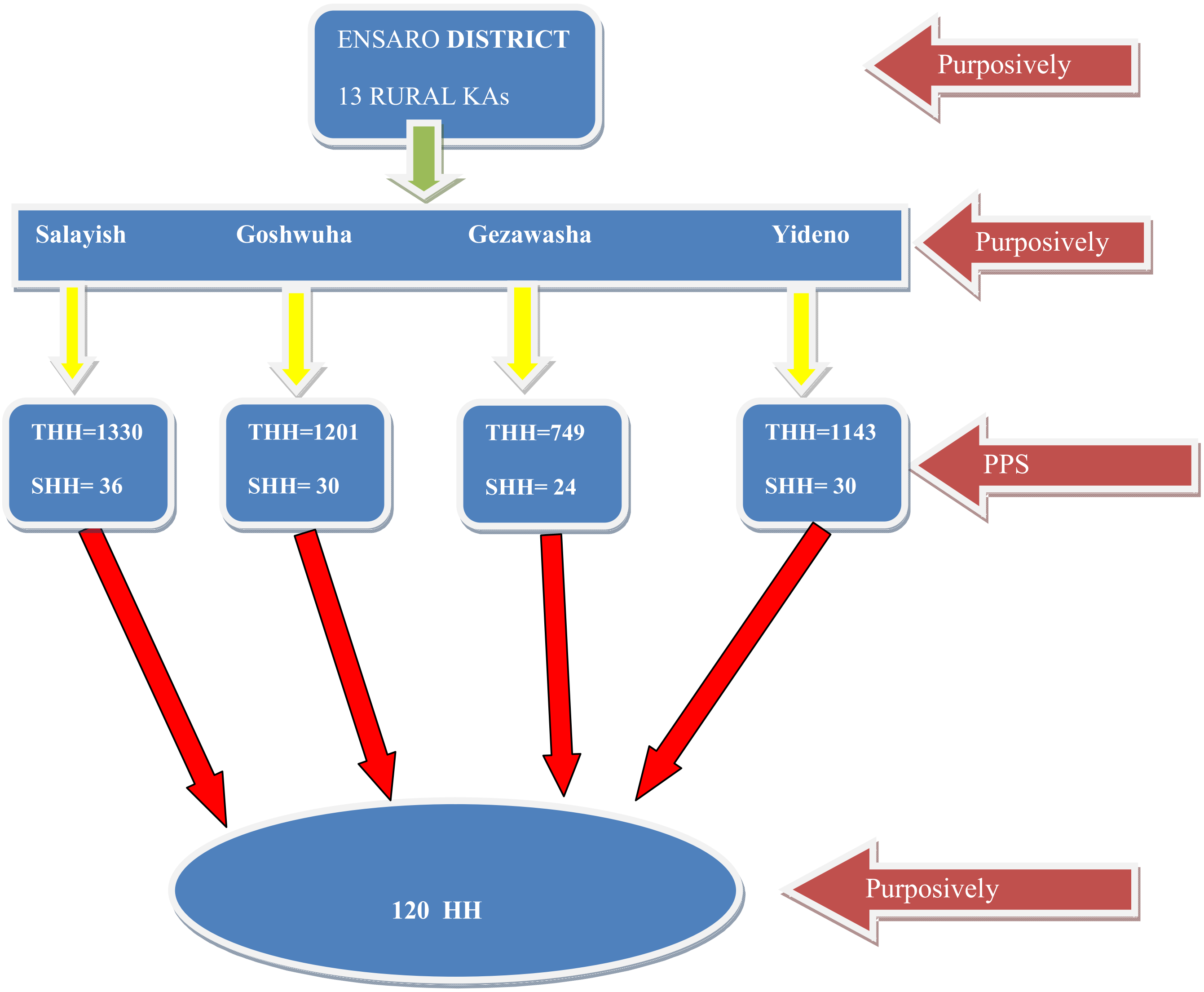


**Figure 5 Sampling procedure**

Then to get relatively similar Kebeles, the *Striga hermonthica* weed infestation level in the area were conducted by discussion with the elder farmers of the district who know more about the *Striga hermonthica* weed infestation level of the given area with the efficient control practices of this weed. Focus group was composed of men, women, representatives, community leaders and elders. The group participants defined and outlined *Striga hermonthica* weed infestation level criteria`s according to their consequently based on their control practice methods, three groups were identified; namely better off, medium and poor control practices of *Striga hermonthica* weed infestation on sorghum.

### 3.3 Data Sources and Method of Data Collection

The primary sources of data were the informants who involved in this research. Data from the sample farmers was collected through structural interview and questionnaires. It focused on the weather condition, fertility of soil, *Striga hermonthica* weed infestation level, the decrease or increase of sorghum grain yield, the efficient control practices, the spreading mechanisms of *Striga hermonthica* weed seeds, the benefits and/or effects observed from each control practices were selected before the actual data collection. After the pretest finding the interview and questionnaire schedule was upgraded.

Qualitative/quantitative data were collected through questionnaires distributed to farmers and Agricultural Extension Workers (AEW). The questionnaire were focused on the knowledge of farmers on the weed *Striga hermonthica,* famers attitude on the spread of *Striga hermonthica* weed seeds, the efficient control practices of *Striga hermonthica* weed infestation on sorghum and sorghum grain yield from each control practices.

Additional data were gathered from secondary data sources like research journals and articles, internet sources, reports about sorghum yield from the District communication and/or Agricultural office (crop production department) and observation.

### 3.3.1 Reconnaissance survey

Reconnaissance survey was employed three times first on September 30, 2017, second December 6, 2017 and last on February 18, 2018 in order to select sample site and gather preliminary information from the local community about the efficient control practices of *Striga hermonthica* weed infestation on sorghum by farmers of the study area.

### 3.3.2 Group discussion

Group discussions were made during data collection with informants by the help of the Districts` Agricultural Extension Workers (AEW) on specified time in each Kebele`s. At the end of the discussion, there is a reward for each informant with appreciation, indicating the value of their knowledge in efficient control practices of *Striga hermonthica* weed infestation on sorghum by farmers of the study area.

### 3.3.3 Semi structured interview

To collect more information about the study area, there were semi structured interview prepared for those that can`t read and write. Then after, there were brief explanations about the interview with the respondents on how they give response for the questions forwarded to them. Then, the responses were documented on paper by writing the responses of the respondents and collected for analysis.

### 3.3.4 Questionnaire

There is an open ended and closed ended questionnaires were prepared in English language for Agricultural Extension Workers (AEW) and in Amharic language for farmers that can write and read properly. Then, before distribution of the questionnaire to the respondents, there were a brief discussion was given on how to fill the questionnaires. Finally, it is distributed to the respondents then collected after they fill it and documented properly for analysis.

### 3.4 Data Analysis

The data collected was analyzed using descriptive statistics, paired comparison and preference ranking following discussion for the farmers` efficient control practices of *Striga hermonthica* weed infestation on sorghum. Here there is ranking and scoring methods on the types of efficient control practices, sorghum grain yield level from each control practices were employed to test the consistency of responses and to obtain more scrupulous results. The data collected was analyzed and then presented in the form of tables, graphs and words.

#### 3.4.1 Descriptive statistics

Descriptive statistical methods, percentage and frequency were employed to analyze and summarize the data on the farmers` efficient control practices of *Striga hermonthica* weed infestation on sorghum. The most use full information gathered on the study reported by local people like infestation level, the different control practices, sorghum grain yield from each control practices were analyzed.

In order to evaluate the reliability of recorded information, each informant had been visited two times for the same ideas and the validity of the information was proved and recorded. Based on the level of infestation and efficient control practices by farmers of the study area, the informants were also asked to assign the value of each attribute; and the lists of attributes included infestation control results and different control practices` sorghum grain yield. Thus, by summing up the scores, it was possible to compare the control types of the infestation and the sorghum grain yield from different control practices.

### 3.4.2 Preference ranking

In this study a total of four preference ranking activities were carried out. These were for the mostly practiced control and the least one including the sorghum grain yield of each according to the report of key informants. Accordingly, four purposely-selected key informants (one from each kebele) were asked to rank their efficient control practices of this weed infestation including sorghum grain yield from more practiced one to the least one. Finally, total score were identified and the rank of control practices with the sorghum grain yield was stated by integer values. These helped to indicate the most commonly practiced control techniques with sorghum grain yield.

### 3.4.3 Paired comparison

This method of data analysis was applied to determine the most commonly known control practices including sorghum grain yield of each practices based on the information perceived by the informants. After identifying the control practices of this weed on sorghum with sorghum crop grain yield by preference ranking, paired comparison was carried out.

# CHAPTER FOUR

## 4. RESULTS AND DISCUSSION

### 4.1 Results

#### 4.1.1 Farmers` knowledge on *Striga hermonthica* weed control

Most respondents (92.3%) replied that, most farmers were aware of the mode of spread of *Striga hermonthica* weed seeds and thus explained it easily. They identified the agents of *Striga hermonthica* weed dispersion (Figure 6) as wind (10.8%), animals (42.5%), farm tool (35.8%), and water runoff (10.8%). Water runoff was rated least because most farms have gentle slopes and hence experienced less soil erosion. Farm tools and animals dominated the dispersal ways because farm crops are harvested at the time when the *Striga hermonthica* weed had flowered and some at the seed forming process thus easily dispersed. Since, in grazing management animals are left to wander from one farm to another, they move along with the *Striga hermonthica* weed seeds. The seeds that are dispersed by animals are usually blown by wind to the neighboring fields.

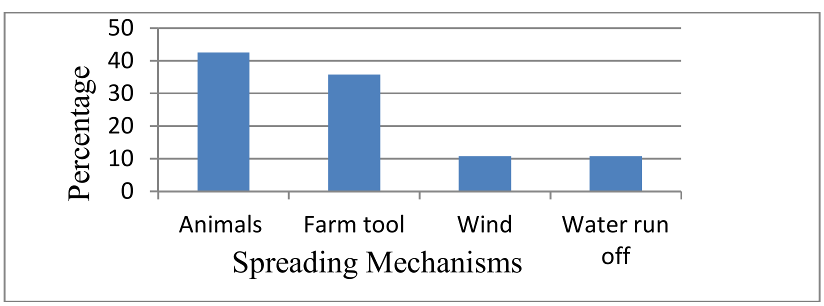


**Figure 6 Spreading mechanisms of *Striga hermonthica* weed seeds**

#### 4.1.2 Farmers` attitude towards *Striga hermonthica* weed control

Respondents of (76.4%) ranked *Striga hermonthica* weed is the first hindrance to crop production than poor soil fertility. *Striga hermonthica* weed is ranked first as it comes with devastating effects that farmers have longed to overcome, among their yield losses.

The respondents differently expressed farmers' attitude on *Striga hermonthica* weed. Farmers understand that, *Striga hermonthica* weed seeds had a tendency of staying in the soil for longer periods before losing their viability and would sprout once a host plant becomes a viable.

Lack of enough money to purchase farm implements such as hand hoe and ox-plough had necessitated 67.8% of farmers to share farm tools with the spread of the weed from one farm to the other. About (79.8%) of the respondents noted that, some control technologies like intercropping and use of *Striga hermonthica* weed resistant sorghum were too expensive for small scale farmers. The lost can be traced right from the implementation stage to the final stage. (44.2%) respondents noted that, there is lack of adequate information about the known efficient control practices was another factor that contributed to the low technology adoption. Most of the information farmers needed existed but informs farmers cannot access.

Respondents of (62%) informed that, most of these technologies (hand weeding and use of fertilizers and herbicides) required labor and money and the rest (38%) of respondents informed that, there is both hired and family labor applied for effective control of the weed. Families with few members were unlikely to adopt technologies that were labor intensive unless where they could pay for hired labor.

There is intercropping mung bean with sorghum but abandoned it because the system required more land, that is, at least 42.6% of an acre (0.4047 ha) to be implemented effectively. These make those with small farms to shy away from the technology and also they think that it takes time and money. Because of this reason it is not commonly used by all farmers of the study area.

### 4.1.3 *Striga hermonthica* weed control practices

There are about 18 types of control practices of *Striga hermonthica* weed infestation on sorghum in the study area listed by key informants (Table 1) and most of the types 10 (55.6%) are combination of one control system with the other and the remaining 8 (44.4%) were used independently. From the combined control practices, 4 (40%) control practices are commonly practiced and the rest 6 (60%) are uncommon control practices by farmers of the study area. From the independently used control practices 8 (44.4%), the commonly used control practices by all farmers were 3 (37.5%) and those that are uncommon were 5 (62.5%). Generally, the commonly used control practices of *Striga hermonthica* weed infestation on sorghum were 7 and they are the efficient control practices (39%) and the remaining 11 (51%) were not used by all farmers of the study area. Labor was the only resource required. The farmers depend mostly on family labor as well as hired labor, which was sometimes lacking. Due to labor constraints, some control practices were applied twice but not effective for better yields.

**Table 1 List of control practices of *Striga hermonthica* weed infestation on sorghum that are listed by key informants of the study area.**

| No. | Lists of control practices of *Striga hermonthica* weed infestation on sorghum | Remark |
|---|---|---|
| 1 | Hand weeding only more than two times | Common |
| 2 | Intercropping, use inorganic fertilizer and hand weeding | Uncommon |
| 3 | Early planting, use inorganic fertilizer and hand weeding | Uncommon |
| 4 | Early planting, use inorganic fertilizer, use post emergence herbicide chemicals and hand weeding | Uncommon |
| 5 | Use inorganic fertilizer only | Common |
| 6 | Plowing before >2X before sowing sorghum, use inorganic fertilizer, use post emergence herbicide chemical and hand weeding | Uncommon |
| 7 | Use inorganic fertilizer then hand weeding | Common |
| 8 | Use post emergence herbicide chemical only | Common |
| 9 | Use post emergence herbicide chemical and hand weeding | Common |
| 10 | Use inorganic fertilizer and post emergence herbicide chemical | Common |
| 11 | Use inorganic fertilizer, post emergence herbicides chemical and hand weeding | Common |
| 12 | Intercropping | Uncommon |
| 13 | Intercropping and hand weeding | Uncommon |
| 14 | Crop rotation | Uncommon |
| 15 | Early planting | Uncommon |
| 16 | Early planting and hand weeding | Uncommon |
| 17 | Plowing >2X before sowing sorghum | Uncommon |
| 18 | Use *Striga hermonthica* weed resistant sorghum crop | Uncommon |

Most of the respondents (32.5%) noted that, the farmers used artificial fertilizers like Urea on the same day after sowing sorghum then plowing the farm land, then they spray the post emergence herbicide chemicals after the weed *Striga hermonthica* weed is emerged out and this technique is followed by hand weeding two days after spraying herbicide chemical. After hand weeding most of the farmers remove the *Striga hermonthica* weed away from the farm land burn the weed on the sides of their farm plots. About 24.2% of respondents reported that, some farmers that have money but no labor force used artificial fertilizers followed by herbicide chemicals. On the other hand about 20.8% of the respondents reported that, farmers that have labor force but no money apply herbicides followed by hand weeding to get rid of *Striga hermonthica* weed in their farms. Respondents of this study also reported that in the family with enough labor can apply hand weeding more than two times (5.8%) and others used post emerging herbicides only (1.7%). Use of inorganic fertilizers only is also practiced in the farmers (0.8%). Most respondents (96.2%) believe that hand weeding after other control practices become effective on removing of young *Striga hermonthica* weed seeds.

Very few respondents informed me that, intercropping was another control practice used by few farmers, mostly farmers intercropped sorghum and mung bean or sometimes with chickpea. Even though it is easily practiced and low cost it was not done by all the farmers because they expect it is expensive and the action takes large areas of farmland. Therefore, intercropping is one of the uncommon control practice of *Striga hermonthica* weed infestation on sorghum.

**Table 2 Percentage against each Kebele on the efficient control practices of *Striga hermonthica* weed infestation in sorghum**

| No. | Efficient control practices | Kebele of respondents | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Salayish | % | Yideno | % | Goshwha | % | Gezawasha | % | Total | % |
| 1 | Fertilizer, herbicide and hand weeding | 16 | 44.4 | 6 | 20 | 9 | 30 | 8 | 33.3 | 39 | 32.5 |
| 2 | Herbicide and fertilizers | 6 | 16.7 | 7 | 23.3 | 9 | 30 | 7 | 29.2 | 29 | 24.2 |
| 3 | Herbicide and hand weeding | 8 | 22.2 | 12 | 40 | 4 | 13.3 | 1 | 4.2 | 25 | 20.8 |
| 4 | Fertilizer hand weeding | 3 | 8.3 | 3 | 10 | 5 | 16.7 | 6 | 25 | 17 | 14.2 |
| 5 | Hand weeding >2X | 1 | 2.8 | 2 | 6.7 | 2 | 6.7 | 2 | 8.3 | 7 | 5.8 |
| 6 | Herbicide | 1 | 2.8 | 0 | - | 1 | 3.3 | 0 | - | 2 | 1.7 |
| 7 | Fertilizer | 1 | 2.8 | 0 | - | 0 | - | 0 | - | 1 | 0.8 |
| | Total | 36 | 100 | 30 | 100 | 30 | 100 | 24 | 100 | 120 | 100 |

#### 4.1.4 Sorghum grain yield gained with the application of the efficient control practices of *Striga hermonthica* weed infestation.

The comparison of sorghum grain yield for the application of each efficient control practices (Table 3), the productivity is best with the utilization of combined control methods. Respondents of (38.3%) informed that, use of artificial fertilizers and herbicides followed by hand weeding is ranked the first efficient control practices of *Striga hermonthica* weed infestation than use of herbicides and hand weeding (25.8%), use artificial fertilizers and hand weeding (18.3%).

**Table 3 Sorghum grain yield from the efficient control practices in the study area**

| Efficient control practices | Kebele of respondents | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Salayish** | **%** | **Yideno** | **%** | **Goshwha** | **%** | **Gezawas** | **%** | **Total** | **%** |
| Fertilizer and Herbicides followed by hand weeding | 15 | 41.7 | 10 | 33.3 | 10 | 33.3 | 11 | 45.8 | 46 | 38.3 |
| Herbicide and hand weeding | 8 | 22.2 | 9 | 30 | 10 | 33.3 | 4 | 16.7 | 31 | 25.8 |
| Fertilizer and hand weeding | 6 | 16.7 | 4 | 13.3 | 6 | 20 | 6 | 25 | 22 | 18.3 |
| Fertilizer and herbicides | 4 | 11.1 | 5 | 16.7 | 3 | 10 | 1 | 4.2 | 13 | 10.8 |
| Hand weeding only >2X | 3 | 8.3 | 2 | 6.7 | 1 | 3.3 | 2 | 8.3 | 8 | 6.7 |
| Total | 36 | 100 | 30 | 100 | 30 | 100 | 24 | 100 | 120 | 100 |

From the table above, the more efficient control practice of *Striga hermonthica* weed infestation the best grain yield of sorghum. Most of the respondents (38.3%) replied that, the first ranked efficient control practices of *Striga hermonthica* weed infestation (Fertilizer and Herbicides followed by hand weeding) give better sorghum grain yield than the rest.

### 4.1.5 Preference ranking

When there are different control practices of *Striga hermonthica* weed infestation for improvement of sorghum grain yield, farmers show preference of one over the other. Preference ranking of seven control practices (commonly used by all farmers) of *Stiga hermonthica* weed infestation that were reported for improving sorghum grain yield was conducted after selecting four key-informants. The key-informants were asked to compare the given efficient control practices of *Striga hermonthica* weed infestation on sorghum based on their efficacy, and give the highest number (7) for the efficient control practice of *Striga hermonthica* weed infestation in sorghum which they thought effective in improving sorghum grain yield and the lowest number (1) for the least effective control practices of *Striga hermonthica* weed infestation on sorghum for improving grain yield.

**Table 4 Preference ranking of efficient control practices of *Striga hermonthica* weed infestation on sorghum to improve sorghum grain yield**

| Efficient control practices | Informants labeled 1-4 | | | | Total | Rank |
|---|---|---|---|---|---|---|
| | $I_1$ | $I_2$ | $I_3$ | $I_4$ | | |
| Herbicide, fertilizer and hand weeding | 7 | 6 | 7 | 7 | 27 | 1st |
| Herbicide and hand weeding | 6 | 7 | 6 | 6 | 25 | 2nd |
| Fertilizer and hand weeding | 5 | 5 | 4 | 5 | 19 | 3rd |
| Herbicides only | 2 | 1 | 2 | 3 | 8 | 6th |
| Hand weeding only >2X | 3 | 3 | 3 | 2 | 11 | 5th |
| Herbicide and fertilizer | 4 | 4 | 5 | 4 | 17 | 4th |
| Fertilizer only | 1 | 2 | 1 | 1 | 5 | 7th |

As indicated in the table above, preference ranking for seven efficient control practices of *Striga hermonthica* weed infestation in sorghum used to improve sorghum grain yield shown that, the combination use of inorganic fertilizer, post emerging herbicide chemicals and hand weeding ranked first, followed by use of use of post emerging herbicide chemicals and hand weeding.

### 4.1.6 Paired comparison

For the efficient control practices that were identified by the informants to be used in improving sorghum grain yield against *Striga hermonthica* weed infestation, a pair wise comparison was made among pairs of five efficient control practices of *Striga hermonthica* weed infestation in sorghum (Table 5).

Four key-informants did the pair comparison of pairs of four commonly used combination use of efficient control practices of *Striga hermobthica* weed infestation on sorghum and the value of sorghum grain yield is summarized. It was found that use of inorganic fertilizer and post emerging herbicide chemicals followed by hand weeding stood first for improving sorghum grain yield and use of post emerging herbicide chemicals and Hand weeding, inorganic fertilizer and hand weeding, use of inorganic fertilizer and post emerging herbicide chemicals will be 2nd, 3rd, and 4th respectively against *Striga hermonthica* weed infestation. This rank is because of the efficacy of the control practices at least in the knowledge of local farmers.

**Table 5 Paired comparison of efficient control practices of *Striga hermonthica* weed infestation on sorghum to improve sorghum grain yield**

| | Informants labeled 1-4 | | | | | |
|---|---|---|---|---|---|---|
| Combined efficient control practices | $I_1$ | $I_2$ | $I_3$ | $I_4$ | Total | Rank |
| Herbicide and fertilizer | 1 | 1 | 1 | 1 | 4 | 4th |
| Fertilizer and Herbicides followed by hand weeding | 4 | 3 | 4 | 4 | 15 | 1st |
| Fertilizer and hand weeding | 2 | 2 | 2 | 2 | 8 | 3rd |
| Herbicide and hand weeding | 3 | 4 | 3 | 3 | 13 | 2nd |

## 4.2 Discussion

### 4.2.1 Farmers` knowledge on *Striga hermonthica* weed control

This study showed that, most of the farmers have better knowledge on the severe damage of *Striga hermonthica* weed on sorghum yield. The result agreed with the findings of (Manyong *et al.,* 2008) who had also high incidence of pest and disease. This knowledge of farmers on the severe damage of *Striga hermonthica* weed on sorghum yield made them to adopt different control practices that are not to eradicate but to reduce the level of infestation.

The major source of farmers` knowledge on *Striga hermonthica* weed of this study showed that, there were informal sources like previous relatives (grandparents) and other elder farmers, but some farmers observed few sources like media (television) when they came to the town to buy or sale market products. The result agreed with the findings of (Debrah *et al*., 1998) who had found the major sources of farmers` knowledge on *Striga hermonthica* weed was informal (personal observations, relatives, parents and other farmers) and few farmers getting knowledge from formal sources (Medias). This transfer of knowledge from one form to the other is mainly through informal sources. Most of these informal sources are previous relatives like grandparents, other farmers and those that had better knowledge about *Striga hermonthica* weed. Due to lack of electronic media access, the transfer of knowledge through formal sources is very low.

This study showed that, animals and farm tools are the major agents for *Striga hermonthica* weed seed dispersal. It is similar with the findings of (Oswald, 2005 and Hearne, 2009) who had found that, the major agents of *Striga hermonthica* weed seed dispersal were animals and farm tools. These two agents are under the control of human beings. Because human beings are using animals and farm tools for preparation of farm plots. Due to less care on the utilization of those agents, the *Striga hermonthica* weed seeds can easily spread from place to place. Therefore, there must be a great care is available by human beings to reduce *Striga hermonthica* weed seed dispersal from place to place.

### 4.2.2 Farmers` attitude towards *Striga hermonthica* weed control

Even though the study is conducted from September – February, the findings showed that, *Striga hermonthica* weed is the number one constraint. Because the study area is the area with low rainfall and climatically dry (*Kolla*). In addition to this as the information is gathered from the farmers of the study area, the same weed is the major constraint for the delay in yield of sorghum. The study agreed with the findings of (Hassen *et al.,* 1995) who had showed that, *Striga hermoonthica* weed was still the number one constraint in areas of low and erratic rainfall for Ethiopian lowlands. Probably, the reason for the high ranking of this climatic factor in Ethiopian lowlands was that the survey was conducted at the period when there was a severe drought. Therefore, in the lower rainfall areas most of the soil condition is sandy and so, this soil condition was the good condition for the survival of *Striga hermonthica* weed to germinate and grow easily in the presence of host.

In this study, the major attitudes farmers develop in *Striga hermonthica* weed control were related to lack of farm materials, lack of financial incomes to buy farm tool and seasonal nature of *Striga hermonthica* weed seeds. The study is agreed with the findings of (Odendo *et al.,* 2002) who had showed that, the most attitudes farmers develop in *Striga hermonthica* weed control are in line with farm tools, low soil fertility, lack of financial incomes to buy inputs and the active nature of *Striga hermonthica* weed seed over time. The lack of farm tools and financial income obligate farmers to share farm tools between them. This sharing of farm tools between farmers cause the *Striga hermonthica* weed dispersal and farmers think to develop different control techniques of *Striga hermonthica* weed. The development of attitudes on *Striga* weed control by farmers results to know how *Striga hermonthica* weed seeds spread from place to place, the control strategies of the *Striga hermonthica* weeds from their farm plots, the hosts that is affected by the *Striga hermonthica* weed and the season and time that the *Striga hermonthica* weed seed germinates and infests their farmland.

In this study, group discussion is the main way of technology transfer between farmers. In addition to this, farmers share their ideas through trainings given by Agricultural Extension Workers (AEW) on the control technologies of *Striga hermonthica* weed infestation on sorghum. So, most of the farmers were aware about the *Striga hermonthica* weed control through group discussion and trainings. The study agreed with the findings of (Asfaw Abay and Admassie Asefa*,* 2004) who had argued that, awareness in control technology transfer is very important. The *Striga hermonthica* weed control technology transfer for farmers is mainly when there is a brief discussion about the problems caused by *Striga hermonthica* weed on the host plant. This brief discussion between or within farmers increase their awareness on the control technologies of *Striga hermonthica* weed infestation on sorghum. So, the increasing the awareness on *Striga hermonthica* weed control technologies on sorghum results the practice of the more efficient control methods of *Striga hermonthica* weed on sorghum to have better sorghum grain yield.

Labor is the major inputs for control of *Striga hermonthica* weed infestation. This study showed that, the access of labor in the family had the ability to increase the labor force required during the introduction of new control methods. It is similar with the past study by (Ayuya *et al.,* 2011) who had noted that, large households had the capacity to relax the labor constraints required during the introduction of new technologies. Therefore, the higher the labor in the family the more the efficient control practices to be implemented properly. The access of labor force is the major availability, but if there is low access of labor force in the family it results the increasing of infestation level of *Striga hermonthica* weed on sorghum. In addition to access of labor force in the family, there must be an availability of financial income. Because in the low access of labor force in the family if there is enough financial income, the farmer can buy hired force, but if both are in low access the control technologies are not successfully implemented and so, there would be higher level of *Striga hermonthica* weed infestation on sorghum.

In this study, the farmers' attitude on the application of easily practiced and low cost control practices were very low. This indicates that, not all farmers are practicing intercropping to control *Striga hermonthica* weed infestation on sorghum. Because most of the farmers think that, intercropping takes time and money and also no more grain yield is harvested. The study is disagreed with the findings of (Zayaur *et al.,* 200) who had found that, intercropping had reduced *Striga hermonthica* weed infestation and increase grain yield. Introducing new *Striga hermonthica* weed control technology would be implemented by all farmers inhabited around the sites of *Striga hermonthica* weed infestation. From the control technologies intercropping is the one that can reduce *Striga hermonthica* weed infestation level and increase the fertility, quality and healthy condition of soil. If farmers intercrop legumes with sorghum, the *Striga hermonthica* weed infestation level is reduced in a higher rate, but there were (few) farmers who implement intercropping of mung bean with sorghum to reduce the level of *Striga hermonthica* weed infestation on sorghum.

### 4.2.3 *Striga hermonthica* weed control practices

In this study, there are eighteen types of control practices of *Striga hermonthica* weed infestation on sorghum (Table 1). Most of these types were not used independently, but they are a combination use of one control practice to the others. The more efficient control practices that are commonly used by all the farmers are the combining use of inorganic fertilizers followed by post emerging herbicides and hand weeding. The study is disagreed with the findings of (Manyong *et al.,* 2008) who had found that only hand weeding of *Striga hermonthica* weed is the most common, use of fertilizers was the second one, but it is agreed to the findings of (Mashingaidze, 2004; Chikoye *et al.,* 2007; Tadesse, 2008 and Gianessi, 2009) who had showed that, the better control techniques on *Striga hermonthica* weed infestation on sorghum were combined practices of hand weeding, use of herbicides and use of fertilizers. Those combined practices of *Striga hermonthica* weed infestation are commonly used by all farmers and were adopted as the more efficient control practices of *Striga hermonthica* weed infestation on sorghum.

From the eighteen types of control practices of *Striga hermonthica* weed infestation on sorghum, there were control practices that are not commonly practiced by all farmers. Those uncommon control practices are identified on this study and they are intercropping, crop rotation and use of *Striga hermonthica* weed resistant sorghum crop. These control practices (except resistant host) play a vital role in improving soil fertility and increasing the quality and health of soil besides weed control. This is agreed with the findings of (Midnouna *et al.,* 2011) who had showed that intercropping sorghum with legumes reduced *Striga hermonthica* weed infestation and also the study with the findings of (Vanlauwe *et al.,*2008) who had found that crop rotation and intercropping helped in improving soil fertility and enhancing soil health and quality in addition to weed control. The fertility, quality and healthy condition of the soil can properly hinder the germination of *Striga hermonthica* weed seeds by blocking stimulant chemicals for the growth and germination of this weed seeds secreted from the root of sorghum plant. Therefore, the growth of *Striga hermonthica* weed under fertile soil is very low or almost none.

Other control practices of *Striga hermonthica* weed infestation on sorghum identified on this study were early planting, plowing farm plots more than two times before sowing sorghum were also uncommon control practices. Farmers used these practices if there is rain at February or March. Farmers believe that these two practices can reduce the level of the *Striga hermonthica* weed infestation on sorghum but it is implemented depending on the presence of rain. Early planting cannot reduce *Striga hermonthica* weed infestation independently, but it is followed by hand weeding after the emerging of *Striga hermonthica* weed, but here, the sorghum plant cannot be affected by the *Striga hermonthica* weed because it is on the stage of resisting the weed infestation. Plowing farm plots more than two times before sowing sorghum is also not used independently, but it is followed by hand weeding. Plowing the plots before sowing sorghum helps to allow free aeration and decomposition of garbage on the farm plots. As the garbage on the plot decomposed it results the fertility of soil and so can reduce the germination and growth of *Striga hermonthica* weed.

Generally, in this study there is one common practice that is used in line with others. This control technique, which was identified is that, the application of hand weeding after using other control practices of *Striga hermonthica* weed infestation on sorghum. Hand weeding is used independently on small scale famers who had no labor and financial income, but it is used in combination of other techniques like herbicides, fertilizers, intercropping, plowing before sowing sorghum and early planting. The general findings of this study on the more efficient control practices of *Striga hermonthica* weed infestation were application of inorganic fertilizer after plowing the sowed sorghum and then after there is spraying of herbicide chemical at the start of emerging of *Striga hermonthica* weed, finally it is followed by hand weeding to remove the died weeds from the farm plot. After hand weeding the weeds are taken far away from the area of the farmland.

### 4.2.4 Sorghum grain yield from the efficient control practices in the study area

In this study, farmers were used the more efficient control practices of *Striga hermonthica* weed infestation on sorghum to harvest more sorghum grain yield. Based on the finding of this study the more efficient control practices of *Striga hermonthica* weed infestation on sorghum were the combination use of fertilizer, herbicides and hand weeding. This combination use of control practices of *Striga hermonthica* weed infestation on sorghum gives more sorghum grain yield compared to control techniques that are used independently. The study disagreed with the findings of (Fasil Reda, 2002 and Abreham Tadesse, 2008) who had showed that, the commonly used control techniques on *Striga hermonthica* weed infestation when compared to the uncommon ways of control practices, the uncommon ways (intercropping, crop rotation and *Striga hermonthica* weed resistant sorghum crop) gives more sorghum grain yield. The reason that, most farmers do not apply the uncommon control practices of *Striga hermonthica* weed infestation on sorghum is due to lack of financial income to buy legumes intercropped with sorghum, to buy additional farmland for application of intercropping, to buy *Striga hermonthica* weed resistant sorghum crop. The lack of financial income for access of those inputs made farmers to shy and ignore the uncommon control technologies of *Striga hermonthica* weed infestation on sorghum.

The efficient control practices preferred by all farmers were seven and from these preferred control practices four control practices were combination of one control practice to the other (paired control practices) see table 4 & 5. From the preferred and paired control practices of *Striga hermonthica* weed infestation on sorghum, the first raked efficient control practices of *Striga hermonthica* weed infestation on this study (combination use of fertilizer, herbicides and hand weeding) on sorghum were commonly used by all farmers and gives more sorghum grain yield.

# CHAPTER FIVE

## 5. Conclusions and recommendations

### 5.1 Conclusions

The study revealed that farmers perceived *Striga hermonthica* weed to be a big menace and major cause of crop yield losses in their farm plots. It was also found that, the most common source through which farmers got information was group discussion in their villages. The group discussion in their village comprised of other agendas; thus, do not provide full details of alternative *Striga* control options. Farmers showed different attitudes towards the existing *Striga* control technologies and that was the key reason as to why the technologies were not adopted and implemented by all farmers. These attitudes included, in order of highest to lowest, lack of adequate information by farmers, followed by labor intensive and expensive technologies, long time dormancy and through ability of *Striga hermonthica* weed seeds and large farms needed for the case of intercropping technology.

About eighteen control technologies of *Striga hermonthica* weed infestation on sorghum were known in the study area. The results showed that, all of those types are not used by all farmers but instead farmers prefer the more efficient control practices of *Striga hermonthica* weed infestation (application of hand weeding in combination with herbicides and artificial fertilizer). In addition to this, they prefer other technology like use of fertilizers (artificial fertilizers) with herbicides but no hand weeding on their sorghum farm plots. The adoption of technologies like, use of *Striga hermonthica* weed resistant sorghum, crop rotation and intercropping technologies were to improve farmers' livelihoods if not fully implemented by all farmers for a longer period because it needs time, money and large area farm plots. This suits in a mixed farming situation to which most farms belong. When we compare sorghum grain yield from each control practices the more efficient control practices of *Striga hermonthica* weed infestation on sorghum results more grain yield.

Among the eighteen control practices of *Striga hermonthica* weed infestation on sorghum, the more practiced technologies like hand weeding in combination with herbicides and artificial fertilizer brings more grain yield of sorghum. However, this condition depends on the labor force of the households and amount of financial income of the farmers`.

## 5.2 Recommendations

From the findings, the following recommendations were the following:-

- There must be an access of information that include trainings for farmers, medias, use of brochures translated in local languages understand by farmers for full adoption of efficient *Striga hermonthica* weed infestation control technologies to increase farm yield, meet family food and income needs .
- Government and other stakeholders provide resources that are crops resistant to *Striga hemonthica* weed, herbicide chemicals and inorganic fertilizers. In addition to this, there is need for sensitization and awareness creation for farmers on *Striga hermonthica* weed regarding its spread and control.
- Concerted efforts involving researchers, extension agents and private sectors are required for a wide scale dissemination and adoption of the already developed *Striga hermonthica* weed control technologies.
- To develop successful *Striga hermonthica* weed control technologies in the area, focus should be on those factors that affect farmer`s decision to adopt technology. These factors are technological knowhow, capital credit access, information holders and attitudes and social and cultural aspects, putting into consideration escalating

poverty and small farms holding, which continue to escalate as a result of farm sub-divisions.

- To harvest more grain yield of sorghum there must be an implementation of modern control technologies like intercropping, crop rotation and application of using the *Striga hermonthica* weed resistant host plants on their farmlands. Therefore, there must be better supports given by the governments for the implementations of such control technologies .

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**Appendix 1 Questionnaire**

# ADDIS ABABA UNIVERSITY COLLEGE OF NATURAL and COMPUTATIONS SCIENCE

## DEPARTMENT OF BILOGICAL SCIENCE

Questionnaires for Ensaro Wereda farmers and Agro-officers of the study area

The aim of this questionnaire is to study efficient control practices of *Srtiga hermonthica* weed infestation on sorghum in the study area. Therefore, your real answer is essential for the success of the study. Because it is valuable important for other researchers who want to study about *Striga hermonthica* weed.

Please do not write your name Tick `X` on the space in front of your answer.

Thank you for your participation

1. Kebele Salayish………. Yideno……… Goshwuha……… Beresa………….
2. Gender Male……… Female……….
3. Age 30 - 40 year……….. 41-50 year………. >50 year……..
4. Marital status Married………… Divorced………. Widowed…….. Widower……… Single……..
5. Occupation Farmer……… Employed…….. Both farmer & employed…….. Business man & woman………….
6. Level of education none………… informal basic primary………. primary…….. secondary and above………

7. For how long you lived in this area? 10-20 years………. 21-30 years………. >30 years…….

8. The major problems that hinders crop production *Striga hermonthica* weed infestation……… Soil fertility……… Labor force………. Lack of money……….

9. Areas of *Striga hermonthica* weed infestation is about? 50-100 ha…….. 100-200 ha………. >200 ha…….

10. Climatic condition of *Striga hermonthica* weed infestation is? Kolla (lowland)…………. Weynadega (midland)…….. Dega (highland)……….

11. The type of the soil for the growth of *Striga hermonthica* weed is? Sandy soil……….. clay soil……… silt soil……

12. The crop plant produced more in this area sorghum………….. maize………. Teff…..

13. The more infected crop plant by this weed is? Sorghum……….. Maize………. Teff……..

14. The source of information on the control technologies of *Striga hermonthica* weed infestation group discussion……. From neighbors……….. training………….

15. Awareness of *Striga hermonthica* weed control strategies by farmers? Excellent……….. good……….. poor……….

16. Awareness on the spread of *Striga hermonthica* weed seeds high………. Medium……… low………..

17. The spreading mechanisms of *Striga hermonthica* weed seeds wind…….. animals…….. farm tools………. Water runoff……….. other………

18. How much yield is reduced as a result of this weed infestation? 50-100 quintals……… 100-200quintals………. >200 quintals………..

19. List different control practices of *Striga hermonthica* weed infestation on sorghum then identify the more efficient control practices?

20. Sorghum grain yield from each control practices listed above.

| Control practices of *Striga hermonthica* weed infestation on sorghum | Sorghum grain yield | | | Remark |
|---|---|---|---|---|
| | High | Medium | Low | |
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21. Which control practice is more efficient control practice of *Striga hermonthica* weed infestation on sorghum in the area? Please from more efficient control practices to the least one?

22. For how many times that farmers use those control methods?

    only 1times…… 2 times…………. ≥3 times………

**Appendix 2** በአማርኛ ቋንቋ የተዘጋጀ መጠይቅ

**አዲስ አበባ ዩኒቨርስቲ የተፈጥሮና ኮምፒውተሽናል ሳይንስ ኮሌጅ**

**የባዮሎጂካል ሳይንስ ትምህርት ክፍል**

የዚህ ጥናት ዓላማ ገበሬዎች የለሊሳ (አቀንጭራ) አረም ወረራን ከማሽላ እርሻቸው የሚቆጣጠሩበት / የሚከላከሉበትን መንገድና ያስገኘዉን ለዉጥ ለማጥናት ስለሆነ የርሶ ትክክለኛ መልስ ለጥናቱ ዉጤታማነት ጉልህ አስተዋፅኦ አለው፡፡ ስለሆነም ለሚጠየቁት ጥያቄዎች ትክክለኛዉን መልስ ያስቀምጡ፡፡

ስለትብብርዎ ከልብ አመሰግናለው

ስም መፃፍ አያስፈልግም በጥያቄው ፊትለፊት በተቀመጠው ባዶ ቦታ ላይ የ "X" ምልክት ያስቀምጡ

1. የሚኖሩበት ቀበሌ ሳላይሽ.............. ይድኖ........... ጎሽዉሃ............. ገዛዋሻ............
2. ጾታ ወንድ............ ሴት.............
3. ዕድሜ ከ30 – 40.............. ከ41 – 50............. ከ50 በላይ................
4. የጋብቻ ሁኔታ ያገባ.............. ያላገባ................. ፈት............ ሌላ............
5. የስራ ሁኔታ ገበሬ.............. የመንግስት መስሪያ ቤት ተቀጣሪ............. ገበሬና ተቀጣሪ............... የግል ንግድ.....
6. የትምህርት ሁኔታ ት/ቤት ያልገባ............. መሰረተ ትምህርት.................. አንደኛ ደረጃ ትምህርት.......... ሁለተኛ ደረጃና በላይ..............
7. ለምን ያህል ጊዜ በዚህ መንደር ቆይተዋል ከ10 – 20 ዓመት............ ከ21 – 30 ዓመት............... ከ30 ዓመት በላይ..............
8. በአካባቢዎ በከፍተኛ ደረጃ የሚመረተው ምርት ማሽላ............. በቆሎ............ ጤፍ........... ሌሎች ካሉም
9. በአካባቢዎ ከሚመረቱ ምርቶች ዉስጥ ከፍተኛ ምርት መቀነስ የሚታየው በማሽላ........... በበቆሎ.......... በጤፍ............ ሌላም ካለ
10. የዚህ ምርት መቀነስ ዋነኛ ምክንያት ለሊሳ አረም........... የአፈር ሁኔታ........... ሌላ ካለ

11. የለሊሳ አረም የሚያጠቃው የእርሻ ስፋት በሄክታር ከ50 – 100.......... ከ101 – 200......... ከ202 በላይ............

12. የለሊሳ አረም የሚበቅልበት የአፈር ዓይነት አሸዋማ......... ሸክላማ......... ለም........

13. የለሊሳ አረም የሚመቸው የአየር ንብረት ሁኔታ ቆላማ........... ወይናደጋማ............. ደጋማ...........

14. ስለለሊሳ አረም ምንነት መረጃ ከፈለጉ የሚያገኙት ከቡድን ዉይይት......... ከጓደኛ.......... ከስልጠና.......

15. በለሊሳ አረም ዙሪያ ያሎት ግንዛቤ ከፍተኛ........... መካከለኛ........... ዝቅተኛ.............

16. የለሊሳ አረም ከቦታ ቦታ የሚሰራጭበት መንገድ እንስሳት.......... የእርሻ መሳሪያዎች............. ጎርፍ........ ንፋስ............. ሌላ ካለ

17. የለሊሳ አረም ከቦታ ቦታ የሚሰራጭባቸው መንገዶች ያሎት ግንዛቤ ከፍተኛ......... መካከለኛ........ ዝቅተኛ.....

18. በለሊሳ አረም ምክንያት የሚታይ የምርት መቀነስ በኩንታል ከ50 – 100........... ከ101 – 200........ ከ200 በላይ............

19. የለሊሳ አረምን ለመከላከል/ ለመቆጣጠር የሚጠቀሙበት ዘዴዎችን በዝርዝር ያስቀምጡ

20. የለሊሳ አረምን በመቆጣጠርዎ ምክንያት የተገኘ የማሽላ ምርት ዉጤታማነቱ በእያንዳንዱ መቆጣጠሪያ መንገድ ያስቀምጡ

21. በአካባቢዎ የትኛዉን የለሊሳ አረም መቆጣጠሪያ መንገድ ነው በከፍተኛ ሁኔታ ከዓመት እሰከ ዓመት የሚጠቀሙት

22. እነዚህን የመቆጣጠሪያ መንገዶች ለምን ያህል ጊዜ ተጠቅመዉበታል

**Appendix 3 Lists of control practices of *Striga hermonthica* weed infestation on sorghum in the study area**

| No. | Lists of control practices of *Striga hermonthica* weed infestation on sorghum | Remark |
|---|---|---|
| 1 | Hand weeding only | Common |
| 2 | Intercropping, use inorganic fertilizer and hand weeding | Uncommon |
| 3 | Early planting, use inorganic fertilizer and hand weeding | Uncommon |
| 4 | Early planting, use inorganic fertilizer, use post emergence herbicide chemicals and hand weeding | Uncommon |
| 5 | Use inorganic fertilizer only | Common |
| 6 | Plowing before > 2X before sowing sorghum, use inorganic fertilizer, use post emergence herbicide chemicals and hand weeding | Uncommon |
| 7 | Use inorganic fertilizer then hand weeding | Common |
| 8 | Use post emergence herbicide chemicals only | Common |
| 9 | Use post emergence herbicide chemicals and hand weeding | Common |
| 10 | Use inorganic fertilizer and post emergence herbicide chemicals | Common |
| 11 | Use inorganic fertilizer, post emergence herbicides chemicals and hand weeding | Common |
| 12 | Intercropping | Uncommon |
| 13 | Intercropping and hand weeding | Uncommon |
| 14 | Crop rotation | Uncommon |
| 15 | Early planting | Uncommon |
| 16 | Early planting and hand weeding | Uncommon |
| 17 | Plowing once >2X before sowing sorghum | Uncommon |
| 18 | Use *Striga hermonthica* weed resistant sorghum crop | Uncommon |

**Appendix 4 Lists of control practices of *Striga hermonthica* weed infestation in sorghum that are more implemented in the study area**

| No. | Control practices of *Striga hermonthica* weed infestation in sorghum that are more implemented | Remark |
|---|---|---|
| 1 | Herbicide | |
| 2 | Fertilizer | |
| 3 | Hand weeding >2X | |
| 4 | Fertilizer, herbicides and hand weeding | |
| 5 | Herbicides and hand weeding | |
| 6 | Herbicides and fertilizer | |
| 7 | Fertilizer and hand weeding | |

**Appendix 5 Lists of efficient control practices of *Striga hermonthica* weed infestation on sorghum which are implemented by all farmers that give more sorghum grain yield**

| No. | Efficient control practices of *Striga hermonthica* weed infestation on sorghum that give more sorghum grain yield which all farmers implement. | Remark |
|---|---|---|
| 1 | Fertilizer and herbicides | |
| 2 | Herbicide and hand weeding | |
| 3 | Fertilizer and Herbicides followed by hand weeding | |
| 4 | Fertilizer and hand weeding | |

## DECLARATION

I decline that this thesis entitled "*Efficient practices of farmers` to control Striga hermonthica weed infestation on sorghum: a case study of Ensaro District, Central Ethiopia*", is my original work and all references used are duly acknowledged. It also has never been presented in any university for fulfillment of any degree program.

Name: Solomon Demissie Kassu

Signature ______________________ Date _______________________

This work has been done under my supervision

Name: Tigist Wondimu (PhD)

Signature _______________________ Date _______________________