بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Agricultural Studies

DEPARTMENT OF PLANT PROTECTION

Effect of Neem, Heglig Leaves aqueous extracts and Nitrogen fertilization on *Striga* and growth Yield of Wheat

تأثير المستخلصات المائية لأوراق النيم، الهجليج والتسميد النيتروجيني على البودا ونمو وإنتاجية القمح

A Thesis submitted in partial fulfillment of the requirements for the Degree of bachelor's (B.Sc.) in Plant Protection

By:

NOSIBA ABDULLA EL-SARRAJ MOHAMED

Supervisor:

Prof. Dr. Mukhtar Abdel Aziz Mohamed

OCTOBER, 2020

الآيـــة

بسم الله الرحمن الرحيم

قَالَ تَعَالَىٰ: ﴿ مَّثَلُ ٱلَّذِينَ يُنفِقُونَ أَمۡوَٰلَهُمۡ فِي سَبِيلِ ٱللَّهِ كَمَثَلِ حَبَّةٍ أَنۢبَتَتۡ سَبۡعَ سَنَابِلَ فِي كُلِّ سُنۢبُلَةٖ مِّاْئَةُ حَبَّةٖۗ وَٱللَّهُ يُضَٰعِفُ لِمَن يَشَآءُۚ وَٱللَّهُ وَٰسِعٌ عَلِيمٌ ﴾

صدق الله العظيم

سورة البقرة الآية (261)

Dedication

This research is dedicated to souls of:

My Mother and my Father

My husband

As well as Sisters and Brothers

Finally , to all my teaching staff of the Plant Protection.

Acknowledgement

First my all thanks and praises is due are Almighty Allah, the beneficent and the merciful, for giving me health and strength to accomplish this work. Further, I would like to express my special thanks and gratitude to my supervisor prof Dr. Mukhtar Abdel Aziz Mohamed who supervised the work throughout the study. Thanks are also to Mr. Osman Yousif Mohammed for helping me with statistical analysis. And all thanks to the plant protection family. Secondly I would also like to thank souls my mother, my father and my husband, who helped me a lot in finishing this project within the limited time.

TABLE OF CONTENTS

Subject	Page No.
الآيه	I
DEDICATION……………………………………………………….	II
ACKNOWLEDGEMENTS ………………………..……………..	III
Table of contents ……………………………………………………….	IV
List of Abbreviations……………………………………………………..	VI
List of Tables …………………………………………………………..	VII
English Abstract ……………………………………………………..	VIII
Arabic Abstract ………………………………………………………	IX
CHPTER ONE: INTRODUCTION ……………………………………..	1
CHAPTER TWO: LITERATURE REVIEW ………………………………	4
2.1. Wheat (2.1.Triticuma estivum L ………………………………	4
2.2. Parasitic plant…………………………………………….	4
2.2.1. *Striga* …………………………………………………	5
2.2.2. *Striga* Life cycle………………………………………...	5
2.3. *Striga* Control Methods…………………………………...	7
2.3.1. Cultural Methods …………………………………………	7
2.3.1. Cultural control Methods …………………………………	8
2.3.1.1. Hand-weeding ……………..……………………………	8
2.3.1.1. Hand-weeding………………………………………..	8
2.3.1.2. Crop rotation ……………………………………………	8
2.3.1.3. Trap and Catch Crops**……………….**…………………...	9
2.3.1.4. Intercropping. …………………………………………...	9
2.3.1.5. Soil fertility……………………………………………...	10
2.3.2. Host plant resistance………………………..……………..	10
2.3.3. Chemical Control methods……………………………...	11
2.3.3.1. Biological control methods……………………………...	11
2.3.3.2. Integrated Management…………………………………	12
2.3.3.3. Fertilizer and botanical extract used in this investigation…	12
2.3.4. Nitrogen fertilizer…………….……………………………	12
2.3.4.1. Botanicals………………..………………………………	12
2.3.5. Neem (*Azadirachta indica)*……….………………………	12
2.3.6. Heglig (*Balanites aegyptiaca*)……..…..……………………	13
CHAPTER THREE: MATERIALS AND METHODS ………	14
3.1. General …………………...………………………………	14
3.2. *Striga hermonthica* seeds …………...………………………	14
3.3. Plant materials…………………………………………………	14
3.4. Plant aqueous extracts…………….…………………………	14
3.5. Crop seeds treatment ……………….………………………	14
3.6. Pots experiment …………….…………………………….	14

3.7. Data collection………………………………………………	15
3.7.1. The parasite……………..…………………………………	15
3.7.2. The crop………………………...………………………	15
3.7.2.1. Vegetative growth………………….……………………	15
3.7.2.1.1. Plant height………………………………………………	15
3.7.2.1.2. Plant shoot fresh weight…………………………………	16
3.7.2.1.3. Plant shoot dry weight……...……………………………	16
3.7.2.1.4. Plant number of tillers…….…………………………….	16
3.7.2.2. Yield component parameter……..…………………………	16
3.7.2.2.3. Grain yield (g)/plant…………………………………….	16
3.7.2.2.4. Total grain yield (kg)/fed………………… …………	16
3.8. Statistical analysis……………………………… …………	16
CHAPTER FOUR: RESULTS ………………………………...	17
4.1. Pots experiment ………………………… ………………...	17
4.1.1. Effects of Neem, Heglig aqueous extracts and Nitrogen on *Striga* and growth and yield of wheat growth……………………..	17
4.1.1.1. Effects on *Striga*………………………… …………….	17
4.1.1.1.1. Striga emergence…………………............. ……….......	17
4.1.1.1.2. *Striga* shoot fresh and shoot dry weight…………………	18
4.1.1.2. Effects on wheat……………………………………….	18
4.1.1.2.1. Effects on growth parameters………………………….	18
4.1.1.2.2. Effects on wheat yield………………………………….	20
CHAPTER FIVE: DISCUSSION………………………………	21
Conclusions and recommendations ……………………………….	22
Conclusion……………………………………………………...	22
Recommendations………………………………………………...	22
References…………………………………………………………	23

List of Abbreviations

%	Percent
ºC	Degree centigrade
G	Gram
Mg	Milligram
SE	Standard Error
CV	Coefficient of variation
et al	and others
WAS	Weeks after sowing
NO	Number
CM	Centimeter

List of Tables

Subject	**Page** No
Table 4.1. Effects of Neem , Heglig aqueous extracts and Nitrogen combinations *Striga* emergence (plants/pot).	17
Table 4.2.Effects of Neeml , Heglige aqueous extracts and Nitrogen combinations on *Striga* shoot fresh and shoot dry weights (g).	18
Table 4.3. Effects of Neem , Hglige aqueous extracts and Nitrogen combinations on wheat growth parameters.	19
Table 4.4. Effects of Neem , Hglige aqueous extracts and Nitrogen combinations on wheat yield.	20

Abstract

Pots experiment was conducted, during the summer season 2019, at the College of Agricultural Studies (CAS), Shambat, Sudan University of Science and Technology (SUST), Bahri Locality, Khartoum State. The experiment was carried out to determine the effects of the Neem (*Azadirachta indica)*, Hglig (*Balanites aegyptiaca)* three different concentrations (2.5%, 5% and 10%) and effect of nitrogen is also three doses (40, 80 and 120kg/fed) on the growth and productivity of wheat cultivar (Imam). The experiment was designed with random sector complete with three replications. The results of the experiment showed that the number of *Striga* plants increased with the number of weeks after the transplant. After 8-14 week, all the concentration of the two plants above and nitrogen kg/fed increased significantly in plant height. After 14 weeks, concentrations of 5% and 10% Neem, Hglige and nitrogen (80, 120kg/fed) reduced the wet weight of the bud . the concentration of 10% of Neem, Hegilg and nitrogen 120kg/fed reduced the dry weight of gram of *Striga* parasite. The concentration of 2.5% of Neem, (2.5%, 5%) of Heglig and nitrogen 120kg/fed significantly increased the wet weight of wheat . the above concentration, in addition to nitrogen 40, 120kg/fed significantly increased the dry weight of wheat, the concentration of Neem, Heglig 10% and nitrogen 80,120kg/fed significantly increased the yield of cereals in g/plant and the grin yield kg/fed acre.

الخلاصة

أجريت تجربة الأصيص، في الموسم الشتوي 2019، في كلية الدراسات الزراعية، شمبات، جامعة السودان للعلوم والتكنولوجيا، الخرطوم بحري، ولاية الخرطوم. أجريت التجربة لتحديد تأثير المستخلصات المائية للنيم والهجليج بثلاثة تركيزات مختلفة (2.5%، 5% و10%) وتأثيرالنيتروجين أيضا بثلاثة جرعات (40،80 و120 كجم/فدان) على البودا ونمو وإنتاجية القمح (صنف إمام). التجربة صمت بالقطاعات العشوائية الكاملة بثلاث مكررات. أظهرت نتائج التجربة أن عدد نباتات البودا المنبثقة يزداد بزيادة عدد الأسابيع بعد زراعة المحصول. بعد 6و14 أسبوع بعد الزراعة.بعد 8-14 أسبوع كل التراكيز من النباتين أعلاه والنيتروجين 80 كجم/فدان زادت بصورة معنوية من طول النبات. وبعد 14 أسبوع التراكيز (5%،10%) من النيم، (5%،10%) من الهجليج والنيتروجين (120،80 كجم/فدان) خفضت الوزن الرطب للبودا. والتراكيز 10% من النيم، 10% من الهجليج والنيتروجين 120 كجم /فدان خفضت من الوزن الجاف (جم) لطفيل البودا. التركيز 2.5% من النيم والتركيز (2.5% ،5%) من الهجليج والنيتروجين بمعدل 120 كجم /فدان زادت بصورة معنوية من الوزن الرطب للقمح، والتراكيز أعلاه من النيم والهجليج بالإضافة للنيتروجين (120،40) كجم/فدان زادت بصورة معنوية من الوزن الجاف للقمح، تركيزي النيم ،الهجليج 10% والنيتروجين (80 ،120 كجم /فدان) زادت بصورة معنوية من إنتاجية الحبوب جرام/نبات وإنتاجية الحبوب كجم/فدان.

CHAPTER ONE

INTRODUCTION

Wheat (*Triticum aestivum* L. em Thell.) is the first important and strategic cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Yang et al., 2009). It exceeds in acreage and production every other grain crop (including rice, maize, etc.) and is therefore, the most important cereal grain crop of the world, which is cultivated over a wide range of climatic conditions and the understanding of genetics and genome organization using molecular markers is of great value for genetic and plant breeding purposes. The grass family *Poaceae* (*Gramineae*) includes major crop plants such as wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), oat (*Avena sativa* L.), rye (*Secale cereale* L.), maize (*Zea mays* L.) and rice (*Oryza sativa* L.). *Triticeae* is one of the tribes containing more than 15 genera and 300 species including wheat and barley. Wheat belongs to the tribe *Triticeae* (= *Hordeae*) in the grass family *Poaceae* (*Gramineae*) (Briggle and Reitz, 1963) in which the one to several flowered spikelets are sessile and alternate on opposite sides of the rachis forming a true spike. Wheats (*Triticum*) and ryes (*Secale*) together with *Aegilops*, *Agropyron*, *Eremopyron* and *Haynalidia* form the subtribe *Triticineae* (Cooper et al., 2012). Linnaeus in 1753 first classified wheat. In 1918, Sakamura reported the chromosome number sets (genomes) for each commonly recognized type. This was a turning point in *Triticum* classification. It separated wheat into three groups. Diploids had 14 (n=7), tetraploids had 28 (n=14) and the hexaploids had 42 (n=21) chromosomes. Bread wheat is *Triticum aestivum*. *T. durum* and *T. compactum* are the other major species. All three are products of natural hybridization among ancestrals no longer grown commercially (Maxed and Kell, 2009).

Cultivation and use of the wheat crop: Wheat is an edible grain, one of the oldest and most important of the cereal crops. Though grown under a wide range of climates and soils, wheat is best adapted to temperate regions with rainfall between 30 and 90 cm. Winter and spring wheats are the two major types of the crop, with the severity of the winter determining whether a winter or spring type is cultivated. Winter wheat is always sown in the fall; spring wheat is generally sown in the spring but can be sown in the fall where winters are mild. Therefore, today wheat is grown all over the world, with different varieties sown according to the various climates. In 2002, the world's main wheat producing regions were China, India, United States, Russian Federation, France, Australia, Germany, Ukraine, Canada, Turkey, Pakistan, Argentina, Kazakhstan and United Kingdom (FAO, 2003). Most of the currently cultivated wheat varieties belong to hexaploid wheat (*Triticum aestivum* L.), which is known as common bread wheat and valued for bread making. The greatest portion of the wheat flour produced is used for bread making. Wheat grown in dry climates is generally hard type, having protein content of 11-15 percent and strong gluten (elastic protein). The sticky gluten of bread wheat entraps the carbon dioxide (CO2) formed during yeast fermentation and enables leavened dough to rise. The hard type of wheat produces flour best suited for bread making. The wheat of humid areas is softer, with protein content of about 8-10 percent and weak gluten. The softer type produces flour suitable for cakes, crackers, cookies, pastries and household flours. Durum wheat (*Triticum turgidum* L.), which is the main tetraploid type, is also important, although its large, very hard grains yield low gluten flour that is the main source of semolina suitable for pasta, couscous, burghul and other Mediterranean local end-products (Dreisigacker et al., 2008). Apparently, no economically important diploid wheats are being cultivated as a crop anywhere in the world. Although most wheat is grown for human food and about 10 percent is retained for seed and industry (for production of starch, paste, malt, dextrose, gluten). Wheat grain contains all essential nutrients; kernel contains about 12 percent water, including carbohydrates (60-80% mainly as starch), proteins (8-15%) containing adequate amounts of all essential amino acids (except lysine, tryptophan and methionine), fats (1.5-2%), minerals (1.5-2%), vitamins (such as B complex, vitamin E) and 2.2% crude fibers. In Sudan it is grown in the northern state and El Jezira and the white Nile ,the importance of wheat yield is due to the quality of bread because its grain contains gluten and is characterized by its high nutritional value as it exceeds the sale of other grains and wheat grains contain 11-15% protein, 2% fat and 63-68% starch. Noodles are also made from pasta biscuits, alcohol and starch. The bran as well as hay resulting from the study of wheat plant is used in the as good food for animals. Wheat consists of two types, which are soft wheat, which is used in the manufacture of bread and the hard type and is used in the manufacture of pastries. The percentage of soft wheat, production is estimated. Is 90% and hard wheat is 10% of world wheat production (El Tayeeb, 2005). Wheat is infected with the Parasitic weed of the *Striga hermonthica (Del)* belong to the Orobanchaceae family and is an imperfect parasite because it can photosynthesize after it appears above the soil surface, *Striga* has a large family of most ofits families from economically important crops such as corn, millet, and maize, and rice is considered one of the most important biological factors that impede the production of food crops. In Africa losses due to Buddha parasitism on corn crops in Africa are about (40% on average). Losses in grain crops are estimated in some countries of the Africa continent, such as Ethiopia and Sudan, at about 65-100% in highly – infected fields (Lane et al., 1993). Striga is due to the nature of growth and revival of the parasite where single plant produces thousands of seeds (50-90) thousand seeds) that can remain static in the soil for more than 10 years, in addition to that the seed only grow by secreting the host root of the germ in stimulant or stimulating germination (Babiker, 2007). Botanical will be of pest control compounds such as *Azadirachta indica*. The current study design toexplorenew environmental friendly pesticide to control weed that to replace the highly toxic chemical. Research in Africa on the control of *Striga* has been going on for about 70years (Henry and Cathey, 2009). Several promising *Striga* control strategies have been developed, from those that relate to soil fertility improvement to those that directly affect the parasite (Rector, 2009). This has accorded farmers with a variety of options to control the parasitic, including the use of chemical herbicide, trap crop, hand-pulling, appropriate fertilizer application, crop-Rotation, intercropping, resistant crops, and biological control (Parker. et.al; 1993). Generally there is a lack of information on effects of nitrogen fertilizer and two medicinal aqueous extracts (Neem and Heglig) and their mixture with nitrogen on *Striga hermonthica*, thus this research was designed to investigate the effects of the above two botanical medicinal aqueous extracts and their mixtures on *Striga hermonthica*. We have been following this approach to exploit the effectiveness of the interaction of these control methods in a sound manner to fulfill the following objectives:

I. To determine the effect of different concentrations of aqueous extracts of Neem, Heglig and their combinations with nitrogen on *Strigah ermonthica* and growth and yield of wheat (Imam).

II. To determine effects of different doses of nitrogen on *Striga hermonthica* and growth and yield of wheat .

CHAPTER TWO

LITRERATUREREVEIEW

2.1. *Triticum aestivum L* :

Triticum aestivum belongs family Poaceae, wheat cultivation in Sudan traditional in the states of the river Nile and the North Sudan, since the earliest time between latitudes 17-22 degrees and its cultivation is confined to the narrow lands on the banks of the Nile where its area does not exceed 30 thousand acre, its production is sufficient for local consumption in those areas, while the rest of Sudan was dependent on corn and heating for its food. During the last four decades, Sudan consummation of wheat increased from less than one hundred thousand tons per year to more than eight hundred thousand tons as a result of the growth of urban societies. The gap between consumption and production was covered by importing from abroad, which constituted a great burden on Sudan foreign exchange resources and even became an element of political pressure at time. These reasons prompted the country to move towards local production, which was more feasible in the irrigated plains of central and eastern Sudan (Mohamed, 1994).

2.3. Parasitic plants:

Over 4100 species in approximately 19 families of flowering plants are able to directly invade and parasitize other plant (Nickrent and musselman, 2004 : Press and phoenix, 2005).However , only very few parasitize cultivate plant . Never the less, these weedy parasites pose atremendous threat to world economy, mainy because they are at present almost un controllable (Parker and riches, 1993: Gressel.et al., 2004) Among parasitic weeds those of the Orobanchaceae received a considerable attention because of their relevance in world agriculture. The family is of interest for evolutionary studies, and because it encompasses closely related parasites with vast difference in their host requirements (Babiker.*et.al*, 1993). The geuns *Striga*, predominant in Africa include 36 species, which are parasitic by nature. *Striga* compensates for its rudimentary root system by penetrating the root of other plant and diverting essential nutrients (Perss and Graves, 1995). The most economically important *Striga spp*- are *S. asiatica*(L) and *S. hermonthica* (Del.)mainly on Sorghum , millet and maize (Oswald, 2005). Heavy *Striga* infection caused land abandondnment leading to nuraexodus. About 40% of cereal crops in Africa are infested by *Striga* and yield can be reduced by up to 100% (ciotolaetal, 1995).

2.2.1. *Striga*:

Strigaspp. (witch weeds) are pernicious, root attachingparasitic plants, a genus of 42 currently described species in the world of which 28 species occur naturally in Africa (Barker, 1990; Cochrane and Press, 1997). The parasites does not have its own root and therefore it compensates by penetrating the roots of host plant to siphon the essential nutrients for growth (Watson et al., 1998). The host plants are stagnated and sometime die from phytotoxic effect within days of attachment (Frost et al., 1997; Khan et al., 2007). A small parasite biomass attachment to the host plant can result in a large reduction in the height, biomass and grain yield (Gurney et al., 1999; Rodenburg *et al*., 2006). The parasite attack the host plant underground and by the time the flowering stem of the parasite appears above the ground damage has been caused (Westerman *et al*., 2007).

Most witch weed are characterized by bright-green stems and leave and small brightly colored flowers. A mature *Striga* plant has high reproductive capacity and is capable of producing 10,000 to 200,000 tiny seeds per plant that can survive in the soil for more than 10 years (Van Ast and Bastiaans, 2006; Hearne, 2009). After germination the parasite must fine the host plant for attachment within 4 days if not it well die (Gurney *et al*., 2006). *Striga* has been a serious problem of cereal and legume crops among farmer in sub-Saharan Africa. Its effect on crops range from stunted growth, through wilting, yellowing; and scorching of leave, to lowered yields and death of many affected plants. Farmers have reportedlosses between 20%and 80%, and are eventually forced to abandon highly infested field (Atera and Itoh, 2011). Grain yield losses even can reach 100% insusceptible cultivars under a high infestation level and drought conditions (Haussmann et al.; 2000). According to (Gressel *et al*., 2004), Estimated 17.2 million hectares (64% of total area) of wheat and pearl millet production in west African are infested with *Striga*. Most of the yield loss (about 75%) occurs before *Striga* emergence (Parker and Riches, 1993).

2.2.2. *Striga* live cycle;

Striga spp. Are obligate hemi-parasitic plant that attach to the roots of their host to obtain water, nutrients and carbohydrates (Kuijt, 1969; parker and Riches, 1993). They are native to the grasslands of the African tropics, reaching their greatest diversity in the region where they have co-evolved with the cereals (Gressel *et al;* 2004). *Striga spp* have a very complex live cycle, which is intimately tied to that of its host and that fallows a series of developmental *Straga* from seed to seed producing plants. After dispersal, the seeds are in a state of primary dormancy for up to six months (Vallance, 1950; Gbehounou *et* *al.*, 1996). Following after-ripening a second prerequisite for germination is the preconditioning of the seed, which requires an imbibitions period of several weeks under human and warm (25-35 C) conditions (Okonkwo, 1991; Kebreab and Murdoch, 1999). After reaching maximum sensitivity, prolonged preconditioning induces secondary dormancy (Matusova *et al.*, 2004). Precondition striga seeds require various secondary metabolites (xenognosins) derived from the host roots and some non-host plants to induce germination and to develop (Estabrook and Yoder, 1998; Yoder 2001). These chemical compounds have been identified as sesquiterpene lactones, released in trace amount in the root exudates (Bouwmeester *et al.*, 2003). This germination stimulant mainly is exuded in a region 3 to 6 mm from the root apex (Hess *et al.*, 1991; Riopel and Baird, 1987; Sunderland, 1960). The germination seed produces a root-like structure, the radical. For successful host attachment, germination must take place within 3 to 4 mm of the host root since *Striga* radicles have limited growth potential (Ramaiah et al.; 1991). Radicle growth is directed toward the host rood under the influence of gradient of chemical concentration of the root exudates (chemotropism) (Saundres,1960). Within four days after germination the radical 1933; Williams needs to find a host root; if not, it will die.

After contact with the host root the development begins which also is initiated and guided by host-derived secondary metabolites (Keyes et al., 2001; Yoder, 2001; Hirsch et al., 2003). The haustorium is a globular-shaped root structure that attaches the parasite to the host root, invades the host tissue, and establishes a vascular continuity through which the parasite translocates host resources (Kuij, 1977; press and Graves, 1995; Riopel and Timko, 1995; Dorr, 1996). The penetration occurs by development intrusive cells at the tip which penetrate the cortex of host root (kper, 1997; lane *et al.*, 1991; Olivier et al., 1991a). Once the haustorium is inside the stele, direct links between parasite and host xylem system develop. This can be established within a few days after attachment (Ramaiah et al,. 1991; Riopel and Timko, 1995). Phloem connectionsare not formed between *Striga* and its host, thus the transfer of nutrients apparently depends on the xylem bridge and some limited diffusion though parenchyma tissues (Parker and Riches, 1993).

The parasite seedlings connected with the host grow underground for approximately 3-6 weeks (parker, 1965; Olivier et al., 1991). During this time the parasite depends totally upon the host for all the substances it needs for growth and development. Subsequently, adventitious root are formed at the base of the *Striga* shoot which, by means of secondary haustoria, attach to the some root to which the primary haustorium is attached or to nearby roots (Parker and Riches, 1993). After emergence the parasite form stems and leaves with chlorophyll and becomes a hemi-parasite that produces assimilates, but remains partially dependent on the host for water, mimerals some assimilates. About one month after emergence. The parasite initiates flowers and, depending upon pollination, seed production begins shortly thereafter. *Striga* seeds are minute (0.20-0.50 mm long), weighing only approximately 3.7-12.4 mg each and are produced in very large numbers, estimates of number of seeds produced per reproductive *Striga* plant can vary from several thousands to over 85,000 depending on species and growing conditions (Saunders, 1933; Kuijt, 1969; Pieterse and Pesch, 1983; Parker and Riches, 1993; Mohamed et al., 1998; Rodenburg *et al.,* 2006a). Seeds are dispersed by cattel, wind, water and shared use of contaminated farm implements and contamination of sowing seed (Press and Gurney, 2000). *Striga spp*. are highly variable due to their obligate out-crossing character, requiring insect pollinators as bee-flies (Bombyliidae Dipter, West Africa) and butterflies (Lepidoptera, Sudan) for fertilization and seed production. Seeds reach maturity 2-4 weeks after pollination (Musselman, 1987; webb and Smith, 1996). Large quantities of the newly produced seed can survive the next dry season and a series of cropping seasons with *Striga*-sensitive host crops will lead to a quick build-up of the *Striga* seed bank (Gbehounou et al., 2003; Weber et al., 1995).

2.3. *Striga* control methods:

The tremendous impact of parasitic plant on world agriculture has prompted much research aimed at preventing infestation. Many potential control methods were developed against the parasite problem physical, cultural, chemical and biological (Jole, 2002). Control of *S. hermonthica* in cereals has so far proven elusive. Economically feasible and effective technologies are still to be developed for the cash strapped subsistence farmers in most of the *Striga*-stricken areas (Debrah, 1994). The control of *S. hermonthica* has also been made very difficult due to the biology of this weed. It is very prodigious as far as seed production is concerned.

2.3.1. Cultural control methods:

A number of practices have been recommended for *Striga* such as crop rotation (Oswald and Ransom, 2001); Intercropping (Udom *et al*,. 2007); transplanting (Oswald et al., 2001); soil and water management (Fasil and Verkleij, 2007); use of fertilizers (Jamil *et al.,* 2011); and hand weeding (Ransom, 2000) to reduce the production of further *Striga* seed. These methods should also reduce the density of *Striga* seeds already in the soil seed bank (Fasil and Verkleij, 2007).

2.3.1.1. Hand weeding:

The removal of buds by hands is one of the most used methods in the world, and it can be applied in small fields with little injury. Studies in East Africa also indicated that this method is considered one of the technologies that gave significant differences in reducing the incidence of millet and increasing the yield of the crop (Ramaiah, 1985). To stop the parasite, it is necessary to conduct the control at flowering and before seed production, and this helps not to expand the infection circle. But when the stock of *Striga* seed in the soil is large and the rate of emergence above the soil surface is high, and manual removal becomes ineffective, especially since this process requires a long time and abundant labor. In addition, removing the parasite at this stage of infection has a limited effect on increasing production. Because most of the damage to the host plant has occurred before the parasites emergence but removing *Striga* reduces the production of new seeds, so seed production can be reduced in the long term (Rispail *et al.*, 2007).

2.3.1.2. 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* seed and leads to decline in the seed population in the soil. The practical limitation of this technique is required more than three years for rotation. The choice of rotational crop should therefore be based on its suitability to the local condition and only secondarily on it is potential as a trap crop (Parker and Riches, 1993 and teke, 2014), to reduce parasite seeds (Esilaba and Ransom, 1997). *Pasture legumes; Mucuna gigantica, Stylosanthes guyanensis and, Desmodium spp*. Were investigated for their ability to induce germination of conditioned *S. hermonthica* seed, for their effect on Striga attachment and on *Striga* shoot emergence. Laboratory experiments showed that, the root exudates of the legumes stimulated up to 70% more *Striga* seeds to germinate than exudates of maize. Maize-Mucuna combination had the highest number of attachments while all other combinations and maize planted in pure stand had lower number of attached. Cowpea varieties, cv. Black eye bean and cv. TVU 1977 OD, produced potent exudates, which were highly compatible with sorghum as intercrops in field trials (Fassil, 2002). In other research findings also reported the effectiveness of the combined use of trap- cropping, fertilization and host plant resistance to control *S. hermonthica* (IIta, 2002; Tesso, *et al.,* 2007).

2.3.1.3. Trap and Catch crops:

Trap crops: Trap-crop cause suicidal germination of the weed, which reduces the seed banc in the soil. Some varieties of cowpea, groundnut and soybean have potential to cause suicidal germination of *Striga* and improve soil fertility (Carsky *et al;* 2000; Schulz *et al.*, 2003). The use of trap crops such as soybean cause suicidal germination of the *Striga* seedling which do not attack the soybean consequently; the *Striga* is ploughed off before flowering there by reducing the seed density of *Striga* in the soil (Umba *et al*., 1999). In IITA, about 40 lines of soybean were screened for their ability to induce *Striga hermonthica* seeds to germinate using the cut roots of soybean plants. The results showed variability among the soybean lines their ability to stimulate seed germination. Hess and Dodo (2003) also found that the use of leguminous trap crops that include varieties of groundnut *(Arachis hypogaea),* soybean (Glycine max), cowpea *(Vigna unguiculata)* and sesame *(Sesamum inaicum)* stimulate the suicidal germination of *Striga* is anther technology to control *Striga* (De Groote *et al.,* 2010).

Catch crops: catch crops are planted to stimulate a high percentage of the parasite seeds to germinate but are destroyed or harvested before the parasite can reproduce. It is anther mean of depleting *Striga* seed reserves in soils. Country to trap cropping, which relies on false hosts, catch cropping employs true hosts of the parasite. A thick planting of Sudan gross at 20-25 kg seed per hectare should be sown and either ploughed in or harvested for forage at 6-8 weeks before *Striga* seed. The main crop could then be planted during the mine rains (Parker and Riches, 1993 and Teka, 2014). The catch crop, when ploughed under is equivalent to green manuring, it is restorative effects on soil fertility (Bebawi, 1987). Catch crops are considered to be less economically favoured than trap crops because of the lack of direct financial returns.

2.3.1.4. Intercropping:

It is intended to plant two crops, one of which is a falls host that is susceptible to infection on the some land and at the same time. The benefits of this cultivation the effect of the false host on reducing the percentage of infection to the production of additional crop from the host the pesudocerase itself, the effect of this method is attributed to the ability of the false host to stimulate the seeds of the parasite.Vegetation resulting from planting two crops simultaneously increases the relative humidity around the parasite this leads to a decrease in transpiration and a decrease in the efficiency of the parasite in the host competition for food (Khan *et al.,* 2000). Many studies have proven that intercropping between the grain of fine corn and many other crops. Legumes such as soybean reduce the number of *Striga* plants (Babiker, 2007). The overlapping between corn and cowpea rot led to a reduction in the *Striga* plant by between 49-83% and weight. Dry parasites by 83-97 and the number of capsules by 52-100%, studies in Kenya indicated and Cameroon, that the intercropping between sorghum or fine sorghum with sweet cowpea led to a reduction in the number of *Striga* plants (Ransom, 1999) intercropping as a future deceptive crop stimulates germination of weed seeds without being attacked or parasitism is thought of as a way to reduce the stock of harmful plant seeds in the soil (Riches and Parker, 1993). Several reports have shown that the number of *Striga* plants decreases significantly when using intercropping with peanuts, corn, cowpea and maize (Babiker et al., 1996). Intrcropping is the method df inexpensive and effective to reduce localized parasites in relatively small farms (Babiker, 2002).

2.3.1.5. Soil fertility:

Nitrogen and phosphorare appliedin sufficient quantities (Adagba et al., 2002 and Teka, 2014). Fertilizer application had significant effect on height, vigour score, reaction score of Sorghum as well as shoot count, days to emergence, dry matter of production and dry weight of *Striga*. The application of high nitrogen (N) increases the performance of cereal crops under *Striga* infestation. This is due to the fact of that nitrogen reduced the severity of *Striga* attack while simultaneously increasingly the host performance (Lagoke and Isah, 2010).

Application of high dosage of nitrogen fertilizer is generally beneficial in delaying emergence and obtaining stronger crop growth (Dugje *et al.,* 2008). Also other advantageous effect of fertilizers include increasing soil nitrogen and other nutrients, the organic matter of the soil and increasing soil moisture holding capacity (Ikie *et al.,* 2006).

2.3.2. Host plant resistance:

Host plant resistance would in all probability be the most feasible and potential method for parasitic weed control. Using biotechnological approaches (including biochemistry, tissue culture, plant genetics, breeding and molecular) 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 (Ejeta *et al,.* 2000). It is potentially an acceptable *Striga* control option to resource-poor farmers (Gurney *et al.,* 2003; Rich *et al.,* 2004).

However, dependence on host resistance alone is not ideal because so far complete resistance agent *Striga* cannot b attained through breeding (Gurney *et al.,* 2002), and usually the newly developed varieties many not fulfill farmers preference traits (Adugna, 2007).

2.3.3. Chemical control methods:

Several herbicides are available for controlling *Striga* infestation in sorghum (Kanampiu *et al.,* 2003). Among selective herbicides reported are 2,4-D and MCPA (2- methyl-4-chlorophenoxyacetic acid) (Ejeta *et al.,* 1996). Selective herbicides that kill the weed before attachment to the host would be extremely valuable for controlling the weed (Kanampiu *et al.,* 2003). A study conducted on sorghum and maize shows that treatment of seeds with 2,4-D provides effective control of *Striga* (Dembele *et al.,* 2005). Development of transgenic herbicide resistant sorghum genotypes is an alternative approach that will allow the use of herbicides without damaging the crop (Kanampiu *et al.,* 2003). They reported the effectiveness of sulfosulfuron herbicide seed coating applied to mutant sorghum lines in controlling *Striga.* Seed coating with herbicides is a low cost treatment due to the requirement of only a small quantity of the herbicide for seed dressing. However, this approach is poorly adopted in the semi-arid regions of Tanzania. The high prices of herbicides, their limited availability, and the lack of technical Knowledge on the use of agrochemicals for weed and pest management are among the main reasons for their limited use in sorghum production (Mrema *et al.*, 2017a). To improve sorghum yield under smallholder farmers conditions, there is a need to develop a *Striga* management programme that is cheap enough for the farmers to adopt.

2.3.4. Biological control methods:

Natural enemies useful in suppressing parasitic weeds including *Striga* species are available in the ecosystems (Templeton, 1982). Among the biological agents, microbes are often hostspecific, highly aggressive, easy to mass produce and show maximum diversity (Ciotola *et al*., 2000). A biological agent has no residual effect in the soil or plant system unlike chemical control (Abbasher *et al.,* 1998). The studies on the potential of soil microbes in *Striga* management found various *Fusarium oxysporum* isolates to be highly pathogenic against *Striga* (Abbasher et al., 1998). The isolate are often overwinter in the soil even in the absence of their host by colonizing crop debris and producing chlamydo spores, which are the dormant resting propagules (Ciotola *et al.,* 2000). In this from microbesare able to withstand extreme environmental conditions (Ciotola *et al.,* 2002). Among *Fusarium oxysporum isolates, Striga (Fos)* is reported to control *Striga* infestation in Soghum offering about 90% *Striga* control (Ciotol *et al.,* 2000). *Fos* grow in the rhizosphere of the Sorghum plant, parasitizes, and inhibits the germination, emergence and development of*Striga* (Mrema *et al.,* 2017c). The bio-control fungus destroys *Striga* plants before they penetrate Sorghum roots. Recent studies have indicated significant reduction in *Striga* numbers as well as the number of days to flowering and maturity in Sorghum seeds coated with *Fos* (Rebeka *et al.,* 2013; Mrema et al., 2017a). Use of*Fos* in *Striga* management in Sorghum fields in East Africa is not yet reported and implemented. There is a need for integrated management of the parasite through host resistance and application of Fos to enhance production and productivity of Sorghum and related cereals affected by *Striga*. There are no reports of negative effects of Fos on Sorghum or related cereal crops. In fact, Fos has been reported to promote the abundance of arbuscularmycorrhizal fungi in the rhizospheres of Sorghum resulting in enhanced crop growth and development (Rebeka *et al.,* 2013; Mrema *et al.,* 2017b). Further, *Fos* has a very narrow host range, which is restart to *S. hermonthica*, S. asiatica and S. gesneroides (Rebeka *et al.,* 2013).

2.3.5. Integrated Management:

Striga management using a single control method is less effective (Rebeka *et al.,* 2013). A combination of several option can be efficient and economical with better control of *Striga* (Tesso *et al.,* 2007). Use of trap-cropping, fertilizer application and resistant genotypes are some of the effective tools that need to be integrated for effective *Striga* management (Tesso*et al.,* 2007). Several *Fusarium spp*.And vesicular arbuscularmycorrhizol (VAM) fungi have been reported to control *Striga* and enhance biomass production of compatible hosts when integrated with resistance genes (Franke *et al.,* 2006). Integrated use of *Striga* resistant wheat genotypes with FOS treatment enhances the effectiveness of the bio-control agent with ultimate yield benefits (Rebeka *et al.,* 2013). Therefore, ISM should be promoted as an effective way of managing *Striga* under smallholder farming systems. An ISM strategy that combines the use of *Striga* resistant wheat varieties compatible FOS is cost effective, environmentally friendly and can easily be adopted by smallholder farmers (Joel; Hearne, 2009).

2.3.6. Fertilizer and botanical extracts use in this investigation:

2.3.6.1. Nitrogen fertilizer:

2.3.6.2. Botanical extracts:

2.3.6.2.1. *Azadirachta indica*:

Neem is a fast-growing tree that can reach a height of 15-20 metres (49-66 ft), and rarely 35-40 meters (115-131 ft) belongs to family Meliaceae. It is evergreen, but in severe drought it may shed most or nearly all of its leaves the branches are wide and spreading (Barstow, 2018). Neem is considered in many areas, including some parts of the Middle East, most of sub-Suharan Africa including West Africa and Indian Ocean states, and some part of Australia. In Sudan can be found cultivation is spread in northern and central Sudan, where Indian settlers introduced it to Africa in the late nineteenth century(Anna *et al.*, 2006).

2.3.6.2.2. *Balanites aegyptiaca*:

The plant small or medium-sized tree belongs to family Balanitaceae that reaches 10 meters in height and rarely exceeds 15 meters. They are evergreen and do not drop their leaves until they are completely dry. It is one of the thorny savanna trees. The flowers are clustered in inflorescences and have a spicy aroma. Spread a wild plant widespread throughout Sudan up to the northern borders. It is found in the low-lying plains in the semi-desert region, low-rainfall and swampy (Mohamed et al., 1999).

CHAPTER THREE

MATERIALS AND METHODS

3.1. General:

The experiment was conducted at the demonstration farm of college of Agricultural Studies, Shambat, Sudan Unversity of Sciences and Technology (SUST), to evaluate tow botanical water extracts (Neem leaves, Heglig leaves) and Nitrogen, on *Striga hermonthica* incidence and growth and yield of wheat.

3.2. *Striga hermonthica* seeds:

S. hermonthica seeds were harvested in (2010) from Sorghum filed at the National center for Research, Khartoum, Sudan, air dried and stored at ambient temperature (30C).

3.3. Plant materials:

Neem leaves were collected from Shambat near the college of Agriculture and a Heglig leaves were collected from Faculty of Agriculture, The plant materials were washed and dried at room temperature and were separately ground into fine powder (<1mm) and stored until use.

3.4. Plant aqueous extracts:

Aqueous extracts at 10% concentration were obtained by pickling at room temperature. Ten grams of powdered part of plant material were placed in a 250ml glass beaker with 100ml of sterile distilled water for 24houer and each suspension was then filtered through tow tools, the first (nylon cloth) served to move big debris and the second (filter paper) to set an homogeneous solution, other concentration (5% and 2.5%) were obtained from 10% concentration (Yonli et al., 2010).

3.5. Crop seeds treatment:

The Wheat seeds were placed in six beakers (three concentration of the Neem water extract and three concentration of the Heglig water extract), the beakers were placed at room temperature for eight (8) hours before planting. The seeds of controls were placed in beaker containing sterile distilled water.

3.6. Pots experiment:

A post experiment was conducted during the winter season (2019)at the demonstration farm, College Agricultural Studies, (CAS), Shambat, Sudan University of Science and Technology, Khartoum Bahri locality, Khartoum State, Sudan (Latitude 15-40 N and Longitude 32-23 E,).

Wheat cultivar (Imam) was obtained from Wed madani Research Station, Agricultural Research Corporation. The experiment was conducted under artificial *S. hermonthica* infestation. Artificial infestation of soil was achieved by mixing two (2) grams of *Striga* seeds with 1kg soil. The repuried level of *Striga* seeds (20mg/pot) was obtained by taking 10 grams of mixed of soil and *Striga* seeds. Striga seed soil mixture was added to *S. hermonthica* free soil thoroughly mixed by hand.wheat cultivar Imam seeds which were treated by three concentration of Neem and three concentration ofHegilg aqueous extracts were sown on 15th July in 2 cmsoil depth, five seeds /pot, later thinned to two plants per pot at three weeks after sowing. Two botanical extracts, Neem and Hegligand nitrogen in the form of urea were used at different single doses and mixtures doses. Nitrogen fertilizer in the form of urea was applied at40, 80 and 120 lbs/fed (½ dose at thinning stage and (½ dose when the plants were knee high), in addition to two controls, the first was negative control treatment which was contained (0mg) *Striga* seeds, the second was positive control treatment which was contained (20 mg) *Striga* seeds, both controls were used for comparison. Irrigation was applied immediately after crop seed sowing and frequently two to three days interval according to temperature and other environmental conditions. This experiment includes 17 treatments arranged in a randomized complete block design (RCBD), with three replicates as follow:

1- Neem, 2.5%, 5% and 10%.
2- Heglig, 2.5%, 5% and 10%.
3- Nitrogen at (40, 80 and 120 Ibs /fed), in the form of urea.
4- Negative control treatment (*Striga* free).
5- Positive control treatment (20 mg of *Striga* seeds).

3.7 Data Collection:

3.7.1 The parasite:

Striga growth components such as number of *Striga* emergence were carried out at 6 and 14 weeks after sowing (WAS). At harvest *Striga* plants collected from each treatment were harvested, weighted to determine fresh weight and air-dried and weighted to determine dry weight.

3.7.2. The crop:

3.7.2.1. Vegetative growth components:

Plants were taken at flowering from each pot. Growth analysis including, plant height (cm), number of tillers, plant fresh weight (g) and plant dry weight (g), plant.

3.7.2.1.1. Plant height (cm):

Plant height was measured from the soil surface (at the base of the plant) to the base of the flower, in each plant, and then the mean height was obtained.

3.7.2.1.2. Plant shoot fresh weight (g)/plant:

The same plants were used to determine the shoot fresh weight/plant in each pot. Roots were detached, then the shoots were weighed by using sensitive balance, then the mean weight was computed as was done by (Mukhtar, 2006).

3.7.2.1.3. Plant shoot dry weight (g)/plant:

The same plants were used to determine the shoot dry weight (g)/plant in each pot. Roots were detached, then the shoots were dried in an oven at 80 °c for 24 hours and then weighed by using sensitive balance, then the mean weight was computed as was done by (Mukhtar, 2006).

3.7.2.1.4. Number of tiller/plant:

The same plants were used to determine the number of tiller/plant in each pot, and then the mean number was obtained.

3.7.2.1.5. Yield components parameters:

At the final harvest each pot was harvested, then heads of the two plants in each treatment were cut and air dried and used for determination of yield characters including, number of heads/plant, head weight (g), 100 seed weight (g), grain yield (g/plant), and total grain yield (kg/fed).

3.7.2.2. Grain yield (g)/plant:

The harvested heads of the same two plants were air dried and threshed in bulk, weighed and the average seed yield per plant was then calculated.

3.7.2.2.1. Total grain yield (kg/fed):

The harvested heads in each pot were air dried and threshed in bulk, then weighed and the total seed yield was calculated according to the following formula (Mukhtar, 2006).

3.7.2.2.2. Statistical Analysis:

The experiment was arranged in randomized complete block design (RCBD) with three replications. Analysis of variance (ANOVA) was carried out on data obtained using the statistical analysis system Statistix 8 User Guide Version 2.0 computer package to detect significant effects among the treatments and populations compared. Mean squares for treatments or populations were calculated. Simple statistics including mean, standard deviation, standard error and coefficient of variation (C.V %) were also calculated.

CHAPTER FOUR
Results

4.1 Pots experiment:

4.1.1 Effects of Neem, Heglig aqueous extracts and Nitrogen on *Striga* and growth and yield of wheat.

4.1.1.1. Effects on *Striga*:

4.1.1.1.1. *Striga* emergence (plants/pot):

Striga count made at 6 and 14 weeks after sowing (WAS) showed that, Striga emergence increased with increasing of the weeks. Statistical analysis showed significant differences among treatments (Table.1).

At 6 WAS, there is no differences among treatments. At 14 WAS Neem 5% and 10%, Heglig 10%, Nitrogen at 40, 80 and 120 lb/fed., and *Striga* free control significantly decreased number of *Striga* emergence as compared to *Striga* control treatment. (Table1).

Table 1 :

Effects of Neem, Heglig aqueous extracts and Nitrogen concentrations on *Striga* emergence (plants/pot)

Treatments	Number of *Striga* (plants/pot)	
	6 weeks after sowing	14 weeks after sowing
Neem 2.5%	1.33 a	2.67 ab
Neem 5%	1.00 a	1.33 c
Neem 10%	1.00 a	1.00 c
Heglig 2.5%	1.00 a	3.33 a
Heglig 5%	1.33 a	2.33 b
Heglig 10%	1.00 a	1.00 c
Nitrogen 40 lb/fed.	1.00 a	1.00 c
Nitrogen 80 lb/fed.	1.00 a	1.00 c
Nitrogen 120 lb/fed.	1.00 a	1.00 c
Striga free control	1.00 a	1.00 c
Striga control	1.00 a	3.00 ab
CV	16.33	40.42
SE±	0.14	0.27

* Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT

4.1.1.1.2. *Striga* Shoot fresh and shoot dry weights (g):

All botanical aqueous extracts and Nitrogen concentrations treatments significantly decreased *Striga* shoot fresh and shoot dry weights (g) as compared to *Striga* control treatment. Neem 5%, 10%, Heglig 5%, 10%, Nitrogen 80 and 120 lb/fed., and *Striga* free control where the best treatments which achieved lower *Striga* shoot fresh weight (g) while Neem10% , Heglig 10%, Nitrogen 120 lb/fed., and *Striga* free control where the best treatments which achieved lower Striga shoot dry weight (g) (Table 2).

Table2: Effects of Neem, Heglig aqueous extracts and Nitrogen concentrations on Striga shoot fresh and shoot dry weights (g)

Treatments	*Striga* shoot fresh weight (g)	*Striga* shoot dry weight (g)
Neem 2.5%	4.67 b	3.00 b
Neem 5%	1.87 cd	1.67 d
Neem 10%	1.00 d	1.00 e
Heglig 2.5%	3.20 bc	2.13 cd
Heglig 5%	3.00 bcd	2.10 d
Heglig 10%	1.00 d	1.00 e
Nitrogen 40 lb/fed.	4.67 b	2.67 bc
Nitrogen 80 lb/fed.	1.87 cd	1.67 d
Nitrogen 120 lb/fed.	1.00 d	1.00 e
Striga free control	1.00 d	1.00 e
Striga control	9.17 a	4.77 a
CV	18.02	27.14
SE±	0.69	0.19

* Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT.

4.1.1.2. Effects on wheat:

4.1.1.2. 1.Effects on growth parameters:

All botanical aqueous extracts and Nitrogen concentrations treatments except (Neem 2.5% and Heglig 2.5% and 5%) significantly increased wheat shoot fresh weight (g)/ plant as compared to *Striga* control treatment (Table 3). All botanical aqueous extracts and Nitrogen concentrations treatments except (Neem 2.5% and Heglig 2.5% and 5% and Nitrogen at 80 lb/fed.,) significantly increased wheat shoot dry weight (g)/ plant as compared to *Striga* control treatment (Table 3). Nitrogen at 120 lb/fed., was the best treatment which achieved highest wheat shoot fresh weight (g)/ plant and gave comparable to that obtained by Striga free control treatment while Nitrogen at 40 and120 lb/fed., were the best treatments which achieved highest wheat shoot dry weight (g)/ plant (Table 3).

All botanical aqueous extracts and Nitrogen concentrations treatments except (Neem 2.5%) significantly increased number of tillers/ plant as compared to *Striga* control treatment. Nitrogen at 80 lb/fed.WAS the best treatment which achieved highest number of tillers/ plant and gave comparable to that obtained by *Striga* free control treatment (Table 3).

Nitrogen at 80 lb/fed., only significantly increased wheat plant height (cm) as compared to *Striga* control treatment and it was the best treatment which achieved more than obtained by *Striga* free control(Table 3).

Table3: Effects of Neem, Heglig aqueous extracts and Nitrogen concentrations on wheat growth parameters

Treatments	Shoot fresh weight (g)/ plant	Shoot dry weight (g)/ plant	Number of tillers/ plant	Plant height (cm)
Neem 2.5%	6.17 g	3.07 f	2.33 d	52.93 de
Neem 5%	11.77 c	4.97 bc	6.67 b	40.53 g
Neem 10%	9.73 d	4.33 cd	6.00 bc	53.40 cde
Heglig 2.5%	8.33 ef	3.30 ef	6.33 bc	44.07 f
Heglig 5%	7.40 f	3.53 def	5.33 c	44.07 f
Heglig 10%	8.67 e	4.13 cde	6.33 bc	55.03 bcd
Nitrogen 40 lb/fed.	12.93 b	6.70 a	6.33 bc	40.50 g
Nitrogen 80 lb/fed.	9.27 de	3.63 def	9.00 a	58.53 a
Nitrogen 120 lb/fed.	13.57 ab	6.17 a	6.33 bc	55.90 abc
Striga free control	13.97 a	5.57 b	8.67 a	56.83 ab
Striga control	7.40 f	3.07 f	2.67 d	56.97 ab
CV	5.65	11.57	12.31	3.25
SE±	0.32	0.30	0.43	0.94

* Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT

4.1.1.2. 2. Effects on wheat yield (kg/fed):

Neem 10%, Nitrogen at 80 and 120 lb/fed., and *Striga* free control significantly increased wheat yield (kg/fed.,) as compared to *Striga* control treatment (Table 4). Nitrogen at 80 lb/fed.,was the best treatment which gave heighest wheat yield and gave more than which obtained by *Striga* free control (Table 4).

Table 4: Effects of Neem, Heglig aqueous extracts and Nitrogen concentrations on wheat yield

Treatments	**Wheat yield**
Neem 2.5%	6.00 e
Neem 5%	4.00 f
Neem 10%	9.33 b
Heglig 2.5%	7.00 de
Heglig 5%	4.67 f
Heglig 10%	7.67 cd
Nitrogen 40 lb/fed.	8.33 bc
Nitrogen 80 lb/fed.	11.00 a
Nitrogen 120 lb/fed.	9.33 b
Striga free control	9.33 b
Striga control	7.97 c
CV	9.01
SE±	0.40

* Means followed by the same letter (s) within each column do not differ significantly at 5% level of probability according to DMRT

CHAPTER FIVE
Discussion

Recent approaches to control crop parasites are oriented towards exploring news alternative sources of herbicides less hazardous and inexpensive. Researchers have indicated that, the plant kingdom is characterized by the presence of chemical substances, in the form of natural products that are used to combat parasitic weeds attack by eliciting strong physiological responses in various stages of parasite life cycle. Botanical herbicides might be a promising source of parasites control compounds such as neem and heglig . The current study aimed at exploring new environmental friendly herbicides to control Striga on wheat.

Striga count made at 6 and 14 weeks after sowing (WAS) showed that, *Striga* emergence increased with increasing of the weeks. Statistical analysis showed significant differences among treatments.

at 14 WAS Neem 5% and 10%, Heglig 10%, Nitrogen at 40, 80 and 120 lb/fed., and *Striga* free control significantly decreased number of *Striga* emergence .Similar results were found by Osman (2019). Possible reason for this, the presence allelopathic effects of concentrations, might be attributed to the hormone –like properties of allelo-chemicals of plants extracts such argelin. Also possible reason for this could be due to *Striga* seeds cannot germinate in the absence of a chemical stimulant, because Nitrogen decreases stimulant production by the host plant. This result is in agreement with that obtained by Rashida et al. (2017) who reported that, Nitrogen reduced the severity of *S. hermonthica.*

All botanical aqueous extracts and Nitrogen concentrations treatments significantly decreased *Striga* shoot fresh and shoot dry weights (g). Neem 5%, 10%, Heglig 5%, 10%, Nitrogen 80 and 120 lb/fed., and *Striga* free control were the best treatment which achieved lower *Striga* shoot fresh weight (g) while Neem10% , Heglig 10%, Nitrogen 120 lb/fed., and *Striga* free control were the best treatments which achieved lower *Striga* shoot dry weight (g). The same results were found by Li et al. (2010).

All botanical aqueous extracts and Nitrogen concentrations treatments except (Neem 2.5% and Heglig 2.5% and 5%) significantly increased wheat shoot fresh weight (g)/ plant. All botanical aqueous extracts and Nitrogen concentrations treatments except (Neem 2.5% and Heglig 2.5% and 5% and Nitrogen at 80 lb/fed.,) significantly increased wheat shoot dry weight (g)/ plant. Nitrogen at

120 lb/fed., was the best treatment which achieved highest wheat shoot fresh weight (g)/ plant and gave comparable to that obtained by Striga free control treatment while Nitrogen at 40 and120 lb/fed., were the best treatments which achieved highest wheat shoot dry weight (g)/ plant. Similar findings were mentioned by Adagba *et al*. (2002) and Teka (2014).

All botanical aqueous extracts and Nitrogen concentrations treatments except (Neem 2.5%) significantly increased number of tillers/ plant. Nitrogen at 80 lb/fed., was the best treatment which achieved highest number of tillers/ plant and gave comparable to that obtained by *Striga* free control treatment.

Nitrogen at 80 lb/fed., only significantly increased wheat plant height (cm) as compared to *Striga* control treatment and it was the best treatment which achieved more than obtained by Striga free control. Similar results were reported by Teka (2014).

Neem 10%, Nitrogen at 80 and 120 lb/fed., and Striga free control significantly increased wheat yield (kg/fed.,). Nitrogen at 80 lb/fed., was the best treatment which gave highest wheat yield and gave more than which obtained by *Striga* free control. Similar findings were found by Teka (2014) and Rashida et al. (2017).

Conclusions and Recommendations:

Conclusions:

- Neem and Heglig aqueous extracts reduced *Striga* emergence and *Striga* fresh and dry weights, this means these two botanicals have effect on *Striga* emergence and growth.
- Nitrogen alone effectively reduced emergence and suppressed *Striga* emergence.
- Effectiveness of these botanicals and nitrogen levels increased by increasing concentrations, and increased Nitrogen levels.

Recommendations:

- Use Neem aqueous extracts at 5% and 10% to control *Striga hermonthica* and decreased their effect on Wheat growth and yield.
- Use Heglige aqueous extracts at 5% and 10% in to control *Striga hermonthica* and decreased their effect on Wheat growth and yield.
- To control *Striga hermonthica* on Wheat can be applied Nitrogen at 80 and 120 Ib/fed.
- *Striga* management requires integrated practices comprising different components such as use resistance variety such as cultivar (Imam) and Neem or Heglig aqueous extracts in combinations with nitrogen 40 Ib/fed**.**

References

Adagba, M. A.; Lagoke, S. T. and Imolehin, E. D. (2002).Nitrogen effect on the incidence of *Striga hermonthica* (Del.) Benth in upland rice.*Agron. Hungarica. 50:145-150.*

Adugna, A (2007). The role of introduced sorghum and millets in Ethiopian Agriculture. *SAT Journal.3. ICRISAT, India.68.*

Anna, Horsbrugh Porter (17 April 2006). "Neem: India's tree of life" .BBC News.

Atera, E. A.; Itoh, K. and Onyango, J. C. (2011). Evaluation of ecologies and severity of *Striga* weed on rice in sub-Saharan Africa. Agr.and Biol. *J. of N. America, 2: 752-760*

Babiker, A. G. T. (2007) - Strig a The Spreading Scourge in Africa.

Babiker, A.G.T. Butler, L. and Ejeta, G. (1996).Integrated use of *Striga* resistant *Sorghum* varieties with cultural and chemical control. In: *The International Conference on Genetic Improvement of sorghum and Pearl Millet*. Taxas A and M University Research and Extension Centre, Luubbock, USA.pp517-524.

Babiker, H. H. (2002). Overview of Sorghum and millet in Sudan.Ministry of Science and Technology, Agricultural Research Corporation, Food Research Centre.

Barker, W. R. (1990).New taxa, names and combinations in Lindernia, Peplidiuni, stemodia and Striga (Scrophulariaccae) mainly in the Kimbcrlcy region, Western Australia. *J. of Adelaide Bot. Gardens, 13: 7*.

Barstow, M.; Deepu, S. (2018)."Neem" . Iucn Red List OfThreatened Species.**2018**:E.T61793521a61793525.Doi:10.2305/Iucn.Uk.2018-1.Rlts.T61793521a61793525.En

Bebawi, F. F.; Eplee, R. E., Harris; C. E. and Norris, R. S. (1987). Longevity of witch weed (*Striga asiatica*) seed. *Weed Science,* ***32****: 494-497.*

Bouwmeester, H.J., Matusova, R., Zhongkui, S., Beale, M.H., 2003. Secondary metabolite signalling in host-parasitic plant interactions. Current Opinion in PlantBiology 6, 358-364.

Carsky, R. J.; Berner, D. K.; Oyewole, B. D.; Dashiell, K.and Schulz, S. (2000). Reduction of *Strigahermonthica* parasitism on maize using soyabean rotation, Int. *J. Pest Manag, 46: 115-120.*

Ciotola, M. A.; Ditommaso, A. and Watson, A. K. (2000). Chlamydo spores production, inoculation, methods and pathongenicity of F. oxysporum

M12-4A, a biocontrol for *Strigahermonthica. Biocontrol Science and Technology, 10: 129-145.*

Cochrane, V. and Press, M. (1997).Geographical distribution and aspects of the ecology of the hemiparasitic angiosperm *Striga asiatica* (L.) Kuntze: a herbarium study. *J. of Trop. Ecol., 13: 371-380.*

Cooper JK, Ibrahim AMH, Rudd J, Malla S, Hays DB, Baker J Increasing hard Winter wheat yield potential vis synthetic wheat : I. path-coefficient analysis of yield and its components. Crop Science. 2012; 52:2014-2022.

Debrah, S. K. (1994). Socio-economic constraints to the adoption of weed control techniques: the case of *Striga* control in the West African semi-arid tropics. *International journal of pest management* ***40****: 153-158.*

De-Groote, H.; Rutto, E.; Odhiamb, O. G.; Kanampiu, F.; Khan, Z.; Coe.; R. and Vanlauw, B. (2010). Participatory evaluation of integrated pest and soil fertility management options using ordered categorical data analysis. *Ag.Sys. dio:10.1016/J.agsy.2009.12.005. (Accessed at October 13/ 2015 at 11 pm.*

Dembele B, Dembele D, Westwood JH (2005) Herbicide seed treatment for control of purple witch weed (*Striga hermonthica*) in sorghum and millet. Weed Technology. 19: 629-635.

Dörr, I., 1996. New results on interspecific bridges between parasites and their hosts.In: Advances in Parasitic Plant Research. Eds M.T. Moreno, J.I. Cubero,

Dugje, I. Y.; Kamara, A. Y. and Omoigui, L. O. (2008). Influence of farmers' crop management practices on *Striga hermonthica* infestation and grain yield of maize (Zea mays L.) in the Savanna zones of northeast Nigeria. *J. Agron. 7(1): 3340.*

Ejeta G, Babiker AG, Mohamed A (1996) Chemical control of *Striga hermonthica* on sorghum. p. 769-773. *In*: Moreno MT, Cubero JI, Berner D, Joel D, Musselman LJ, Parker C. (eds). Advances in Parasitic Plant research. Proceedings of the 6th International Symposium on Parasitic Weeds, Cordoba, Spain.

Ejeta, G., Mohammed, A., Rich, P., Melakeberhan, A., Housley, T.and Hess, D. (2000). Selection for specific mechanisms of resistance to *Striga* in sorghum. *p. 29-40.*

El-Tayeeb MA (2005) Response of barley grains to theinteractive effect of salinity and salicylic acid. Plant GrowthRegul. 45:215-224.

Esilaba, A. O. and Ransom, J. K. (1997). *Striga* in the Eastern and Central African countries: A Literature review.Technical report series, No. *1. African highlands initiative, ICRAF, Nairobi. 39pp.*

Estabrook, E.M., Yoder, J.I., 1998. Plant – plant communications: rhizosphere

Fasil, R. (2002).*Striga hermonthica* in Tigray *(Northern Ethiopia) prospect for control and improvement of crop productivity through mixed cropping*.Ph.D. thesis, Vrije University, Amsterdam, the Netherlands.

Fasil, R. and Verkleij, J. A. (2007). Cultural and cropping systems approach for *Striga* management-a low cost alternative option in subsistence farming. In: Ejeta, G. and Gressel,J. (eds). Integrating new technologies for *Striga* Control: Towards Ending the Witch-hunt.*World Scientific Publishing Co., Singapore.Pp.229-240.*

FAO, (2003).Food and Agriculture Organization of the United Nations Crop Prospects and food situation.

Franke, A.C.; Ellis-Jones, J.; Tarawali, G.; Schulz, S.; Hussaini, M. A.; Kureh, I.; White, R.; Chikoye, D.; Douthwaite, B.; Oyewole, B. D. and Olanrewaju, A. S. (2006). Evaluating and scalingup integrated *Striga* hermonthica control technologies among farmers in Northern Nigeria. *Crop protection, 25: 868-878.*

Frost, D. L.; Gurney, A. L.; Press, M. C. and Scholes, J. D. (1997). *Striga hermonthica* reduces photosynthesis in Sorghum: The importance of stomatal limitations and a potential role for ABA. *Plant Cell Environ.20, 483-492.*

Gbèhounou, G., Adango, E., 2003. Trap crops of *Striga hermonthica*: in vitroidentification and effectiveness in situ. Crop Protection 22, 395-404.

Gbèhounou, G., Pieterse, A.H., Verkleij, J.A.C., (1996). The decrease in seedgermination of *Striga hermonthica* in Benin in the course of the rainy season is dueto a dying-off process. Experientia 52, 264-267.

Graves, J.D., Wylde, A., Press, M.C., Stewart, G.R.,(1990). Growth and carbonallocation in *Pennisetum typhoides* infected with the parasitic angiosperm *Striga hermonthica*. Plant, Cell and Environment 13, 367-373.

Gressel, J., Hanafi, A., Head, G., Marasas, W., Obolana, A.B., Ochanda, J., Souissi,T., Tzotzos, G., 2004. Major heretofore intractable biotic constraints to Africa food security that may be amendable to novel biotechnological solutions. CropProtection 23, 661-689.

Gurney, A. L., Press, M. C. and Scholes, J. D. (1999). Infection time and density influence the response of sorghum to the parasitic angiosperm *Striga hermonthica*. *New phytol, 143: 573-580.*

Gurney, A. L.; Slate, J.; Press, M. C. and Scholes, J. D. (2006). A novel form of resistance in rice to the angiosperm parasite *Striga hermonthica*. *New Phytol, 169: 199-208.*

Gurney, A.L.; Grimanelli, D.; Kanampiu, F.K.; Hoisington, D.; Scholes, J.D.; and Press, M.C. (2003). Novel sources of resistance to *Strigahermonthica* in Tripsicum dactyloides, a wild relative of maize. *New Phytol.160:557-5.*

Gurney, A.L.; Taylor, A.; Mbwaga, A. ; Scholes, J.D.; and Press, M.C. (2002).Do maize cultivars demonstrate tolerance to the parasitic weed *Striga asiatica . Weed Res. 42:299-306.*

Haussmann, B. I.; Geiger, H. H.; Hess, D. E., Hash, C. T. and Bramel, P. (2000).Application of molecular markers in plant breeding. Training manual for a seminar held at IITA. *International Crop Research Institute for the Semi-Arid Tropics* (ICRISAT). *Patancheru 502324.*

Hearne, S. J. (2009). Control –the *Striga* conundrum. *Pest manage. Sci. 65: 603–614.*

Hess, D. E. and Dodo, H. (2003). Potential of sesame to contribute to integrated control of *Striga hermonthica* in the West African Sahel. *Crop Protect, 23:515-522.*

Hess, D.E., Ejeta, G., Butler, L.G., 1991. Research into germination of *Striga* seeds bysorghum root exudates. In: Proceedings of the Fifth International Symposium ofParasitic Weeds. Eds J.K. Ransom, L.J. Musselman, A.D. Worsham, C. Parker,Nairobi, Kenya, CIMMYT, pp. 217-222.

Idris, T. I. M.; Ibrahim, A. M. A. Mahdi, E. M. and Taha, A. K. (2011). Influence of argel (*Solenostemma argel* Del. Hayne) soil applications on flowering and yield of date palm (*Phoenix dactylifera*L.). Agriculture and Biol. *J. North America, 2(3): 538-542.*

IITA (International Institute for Tropical Agriculture), (2002).*Striga* biology and control: Strategies for African farmers. IITA/DFID, Ibadan, Nigeria.(CD-ROOM).

Ikie, F. O.; Schulz, S.; Ogunyemi, S.; Emechebe, A. M.; Togun, A. O. and Berner, D. K. (2006).Effect of soil sterility on soil chemical properties and Sorghum performance under *Striga infestation*. *World J. Agric. Sci., 2(4):367-371*.

Jamil, M.; Charnikhova, T.; Cardoso, C.; Jamil, T.; Ueno, K.; Verstappen, F., Asami, T. and Bouwmeester, H. J. (2011). Quantification of the relationship between strigolactones and *Striga hermonthica* infection in rice under varying levels of nitrogen and phosphorus. *Weed Res., 51:373-385.*

Joel, D. M. (2002). The long-term approach to parasitic weeds control: manipulation of specific developmental mechanisms of the parasite. *Crop Protect., 19: 753-758.*

Kanampiu FK, Kabambe V, Massawe C, Jasi L, Friesen D, Ransom JK, Gressel J (2003) Multi-site, multi-season field tests demonstrate that herbicide seed-coating herbicide-resistance maize controls *Striga* spp. and increases yields in several African countries. Crop Protection. 22: 697-706.

Kebreab, E., Murdoch, A.J., 1999. A quantitative model for loss of primary dormancyand induction of secondary dormancy in imbibed seeds of *Orobanche* spp. Journalof Experimental Botany 50, 211-219.

Keyes, W.J., Taylor, J.V., Apkarian, R.P., Lynn, D.G., 2001. Dancing together. Socialcontrols in parasitic plant development. Plant Physiology 127, 1508-1512.

Khan, Z.R.; Pickett, J. A.; Van den berg, J.; Wadhams, L. J. and Woodcock, C. M. (2000). Exploiting chemical ecology and species diversity: stem borer and *Striga* control for *maize* and *Sorghum* in Africa. *Pest management Science,* ***56****:957-962.*

Kuijt, J., 1969. The Biology of Parasitic Flowering Plants. University of California Press, Berkeley, USA, 246 pp.

Kuijt, J., 1977. Haustoria of phanerogamic parasites. Annual Review ofPhytopathology 17, 91-118.

Lagoke, S. T. O. and Isah, K. M. (2010).Reaction of maize varieties to *Striga hermonthica* as influenced by food legume intercrop, spacing and split application of compound fertilizer. Nig. *J. Weed Sci., 23: 45-58.*

Lane J.A., Bailey J.A., Butler R.C., Terry P.J. (1993) Resistance of cowpea *Vigna unguiculata*(L.) Walp to *Striga gesnerioides* (Willd) Vatke, a parasitic angiosperm, New Phytol. 125,405–412.

Li, Z. H.; Wang, Q.; Ruan X.; Panand, C. D. and Jiang, D. A. (2010).Phenolics and plant allelopathy. *Molecules, 15: 8933-8952.*

Matusova, R., van Mourik, T., Bouwmeester, H.J., 2004. Changes in the sensitivity of parasitic weed seeds to germination stimulants. Seed Science Research 14, 335 344.

Mohamed AH (1999) Some pharmacological and toxicological studies on Balanites aegyptiaca Bark. Phytother Res 13:439–441.

Mohamed, KA (1994). The effect of foliage spray of wheat withZn, Cu, Fe and urea on yield, WUE and nutrients uptake atdifferent levels of soil salinity. Assiut. J. Agric. Sci 25(3):179-189.

Mrema E, Shimelis H, Laing M, Bucheyeki T (2017a) Screening of sorghum genotypes for resistance to *Striga hermonthica* and *S. asiatica* and compatibility with Fusariumoxysporumf.sp. *strigae.* Acta Agriculturae Scandinavica, Section B-Soil and Plant Science. DOI: 10.1080/09064710.2017.1284892.

Mrema E, Shimelis H, Laing M, Mwadzingen L (2017b) Genetic analysis of maximum germination distance of *Striga* under *Fusarium oxysporum* f.sp. *strigae* biocontrol in sorghum. Journal of Integrative Agriculture. DOI10.1016/S2095-3119(17)61790-8.

Musselman, L.J., 1987. Taxonomy of Witchweeds. In: Parasitic Weeds in Agriculture. Volume I. *Striga*. Ed L.J. Musselman. CRC Press Inc., Boca Raton, Florida, 317 pp.

Maxed N, Kell S. Establishment of a networkfor the in situ conservation of crop wild relatives: stuts and needs. Commission on Genetic Resources for food and Agriculture. Rome, Italy: Food and Agriculture Organization of the United Nations; 2009.

Nickrent, D. L. and Musselman, L. J. (2004).Introduction to parasitic flowering plants.The plant health instructor.*Digital Objective identification: 10.1094/ PHI-I-2004-0330-01., pp.* ***1****-7*

Okonkwo, S.N.C., 1991. The germination of *Striga* – a review. In: Proceedings of the5th International Symposium of Parasitic Weeds. Eds J.K. Ransom, L.J. Musselman, A.D. Worsham, C. Parker. Nairobi, Kenya, pp. 144-154.

Olivier, A., Benhamou, N., Leroux, G.D., 1991a. Cell surface interactions between sorghum roots and the parasitic weed *Striga hermonthica*: cytochemical aspects ofcellulose distribution in resistant and susceptible host tissues. Canadian Journal ofBotany 69, 1679-1690.

Olivier, A., Ramaiah, K.V., Leroux, G.D., 1991b. Selection of sorghum (*Sorghum bicolor* [L.] Moench) varieties resistant to the parasitic weed *Striga hermonthica* (Del.) Benth. Weed Research 31, 219-226.

Osman, Y. M. Y. (2019). Effect of Hargel, Jatropha aqueous extracts and Nitrogen fertilization on *Striga* and growth and yield of Sorghum. M. Sc., thesis. Sudan University of Science and Technology, Sudan

Oswald, A, and Ransom, J. K. (2001). *Striga* control and improved farm productivity using crop rotation. *Crop Protect. 20: 113-120.*

Oswald, A. (2005). *Striga* control—technologies and their dissemination. *Crop Prot., 24: 333-342.*

Oswald, A., Ransom, J. K.; Kroschel, J. and Sauerborn, J. (2001). Transplanting maize (Zea mays) and Sorghum (*Sorghum bicolor*) reduces *Striga hermonthica* damage. *Weed Sci., 49: 346-353.*

Parker, C. and Riches, C. G. (1993). Parasitic weeds of the world: Biology and control. CAB International, Wallingford, U. K. pp. 332.

Parker, C., 1965. The *Striga* problem – a review. Pest Articles and News Summaries11, 99-111.

Pieterse, A.H., Pesch, C.J., 1983. The Witchweeds (*Striga* spp.) – a review. Abstractson Tropical Agriculture 9, 9-37.

Press, M.C., Gurney, A.L., 2000. Plant eats plant: sap-feeding witchweeds and other parasitic angiosperms. Biologist 47, 189-193.

Proceedings of the Sixth International Symposium on Parasitic Plants. Cordoba,Spain, pp. 195-201.

Ramaiah, K.V., Childley, V.L., House, L.R., 1991. A time course study of early establishment stages of the parasitic angiosperm *Striga asiatica* on susceptible sorghum roots. Annals of Applied Biology 118, 403-410.

Ransom, L. K. (1999) – The Status Quo of Striga Control CulturalChemical and Integrated aspects In: Krosched, J and Sauerbon,J.(eds) –Advances In Parasitic Weed Control At On Farm Level – Vol. LjointAction To Control Striga In Africa – pp 133-143

Ransom, J. K. (2000). Long-term approaches for the control of *Striga* in cereals: field management options. *Crop Protect, 19; 759-763.*

Rashida, A.; Elfatih, A.; Amani, H. E. and Babiker, A. G. T. (2017). Influence of nitrogen, chlorsulfuron and triclopyr on management of *Striga hermonthica* on Sorghum. *International journal of agriculture & environmental science (IJAES), (4) 6: 32 – 37.*

Rebeka G, Shimelis H, Laing MD, Tongoona P, Mandefro N (2013) Evaluation of sorghum genotypes compatibility with *Fusarium oxysporum* under *Striga* infestation. Crop Science. 53:385-393.

regulation of Plant Growth and Development, 42: 74-87.

Riopel, J.L., Timko, M.P., 1995. Haustorial initiation and differentiation. In: Parasitic Plants. Eds M.C. Press, J.D. Graves, Chapman and Hall, London, pp. 39-79.

Rispail N., Dita M.A., Gonz´alez-Verdejo C., P´erez-de-Luque A., Castillejo M.A., Prats E., Rom´anB., Jorr´ın J., Rubiales D. (2007) Plant resistance to parasitic plants: molecular approaches to anold foe, New Phytol. 173, 703–712.

Rodenburg, J.; Bastiaans, L. and Kropff, M. J. (2006).*Characterization of host tolerance of Striga hermonthica. Euphotic, 14: 353-365.*

Saunders, A.R., 1933. Studies in phanerogamic parasitism with particular reference to*Striga lutea* Lour. South Africa Dept of Agriculture, Science Bulletin 128, 1-56.

Schulz, S.; Hussaini, M. A.; Kling, J. G.; Berner, D. K., and Ikie, F. O. (2003). Evaluation of integrated Striga hermonthica control technologies under farmer management. Exp. *Agric., 39: 99-108.*

Signalling between parasitic angiosperms and their hosts. Plant Physiology 116, 1-7.

Takkar PN, Singh MV, Ganeshmurthy AN (1997). A criticalreview of plant nutrient supply needs efficiency and policyissues of Indian Agriculture for the year 2000. Micronutrientsand trace Elements. pp. 238-264.

Teka, H. B. (2014). Advance research on *Striga* control: A review Ethiopia Institute of Agriculture Research. *African journal of plant science, 8* (***11***)*: 492-506.*

Templeton, G. E. (1982). Status of weed control with plant pathogens. P.29-44, in: Charudattan, R. and Walker, H. L. (eds). *Biological control of weeds with plant pathogens. Wiley, New York.*

Tesso, T.; Zenbaba, G.; Aberra, D, and Ejeta, G. (2007). An integrated *Striga* management option offers effective control of in Ethiopia. In: Ejeta, G. and Gressel, J. (eds). Integrating new technologies for Striga control: towards ending the witch-hunt. *World scientific publishing Co., Singapore. pp. 199-212.*

Udom, G. N.; Babatunde, F. E. and Tenebe, V. A. (2007). Suppression of witch-weed (*Striga hermonthica*) in Sorghum: cowpea mixture as affected by cowpea varieties and planting patterns. Int. *J. Agric. Res., 2: 268-274.*

Umba, U.; Dashiell, K.; Berner, D. and Ebong, U. U. (1999).Effect of soybean cultivars on *Striga* emergence and yield of the subsequent maize crop.Proceedings of regional maize workshop, 4-7th May, 1999, IITA Cotonou, Republic of Benin., pp. 321-329.

Vallance, K.B., 1950. Studies on the germination of the seeds of *Striga hermonthica*.I. The influence of moisture treatment, stimulant dilution, and after-ripening on germination. Annals of Botany 14, 347-363.

Van Ast, A. and Bastiaans, L. (2006).The role of infection time in the differential response of Sorghum cultivars to *Striga hermonthica* infection. Weed Res., 46: 264–274.

Watson, A. K.; Ciotola, M. and Peden, D. (1998).Controlling of the noxious *Striga* weed. International development research centre, Ottawa, Canada. *Weed Res., 35: 303-309*

Webb, M., Smith, M.C., 1996. Biology of *Striga hermonthica* (*Scrophulariaceae*) in Sahelian Mali: effects on pearl millet yield and prospects of control. Weed Research 36, 203-211.

Weber, G., Elemo, K., Lagoke, S.T.O., Awad, A., Oikeh, S., 1995. Populationdynamics and determinants of *Striga hermonthica* on maize and sorghum insavanna farming systems. Crop Protection 14, 283-290.

Westerman, P. R.; Van Ast; A.; Stomph, T. J. and Van Der Werf, W. (2007). Long-term management of the parasitic weed *Striga hermonthica*: Strategy evaluation with a population model. *Crop Prot., 26: 219-227.*

Yang W, Liu D, L I J, Zhang L, Wei H, H u X, Zheng Y ,He Z, Zou Y . Synthetic hexaploid Wheat and its utilization for Wheat genetic improvement in China. Journal of Genetics and Genomics. 2009; 36:539-549.

Yoder, J.I., 2001. Host-plant recognition by parasitic *Scrophulariaceae*. Current Opinion in Plant Biology 4, 359-365.