بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Agricultural Studies

Department of Agronomy

Effects of *Striga hermonthica* on Growth of three maize cultivars

تأثير البودا علي نمو ثلاثة من أصناف الذرة الشامية

A Dissertation Submitted To the Sudan University of Science and Technology in for Degree of B.Sc. in Agriculture (Honors) Partial Fulfillment of the Requirements

By:

Samia Adam Yagoob Hassan

Rayan Salah Abd-Elmajeed

Supervisor:

Dr: Amani Hamad Eltayeb Hamad

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الآيــة

بسم الله الرحمن الرحيم

قال تعالى:

**اللّـهُ نُورُ السّمَاوَاتِ وَالْأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ
الْمِصْبَاحُ فِي زُجَاجَةٍ الزُّجَاجَةُ كَأَنّهَا كَوْكَبٌ دُرّيٌّ يُوقَدُ مِن شَجَرَةٍ
مُّبَارَكَةٍ زَيْتُونَةٍ لّا شَرْقِيّةٍ وَلَا غَرْبِيّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ
تَمْسَسْهُ نَارٌ نُّورٌ عَلَى نُورٍ يَهْدِي اللّـهُ لِنُورِهِ مَن يَشَاءُ وَيَضْرِبُ
اللّـهُ الْأَمْثَالَ لِلنّاسِ وَاللّـهُ بِكُلِّ شَيْءٍ عَلِيمٌ ﴿٣٥﴾**

صدق الله العظيم

سورة النور الآية (35)

Dedication

I dedicate this research with much love

TO

Dedication to the spirit of my father

TO

My mother

TO

My brothers and sisters

Acknowledgments

Thanks and gratefulness firstly and lastly to Allah who gave me mind, determination and patience to carry out this work successfully.

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Abstract

The root parasitic weed *Striga* spp. Pose a genuine threat to agriculture and food security across many parts of the world. The attack economically important crop and severely reduce yield and quality. Maize, sorghum and millet, are the traditional host. Green house experiment was conducted at the College of Agricultural Studies (CAS), Sudan University of Science and Technology (SUST) at Shambat, during season 2016-2017 to study the effect of *Striga* seedbank size on growth of three cultivars of maize (Dongla, cultivar 113 and Hudeiba 2). The experiment was designed in a Randomized Complete Block Design (RCBD) with three replicates. Parameters recorded included number of *Striga*, *Striga* dry weight, plant height, number of leaves/plant, Leaf area and shoot dry weight. *Striga* emergence on all maize cultivars increased with seedbank size reached a maximum and then declined. At 75 DAS, Dongla displayed highest *Striga* number (5.6 plants /pot), followed by descending order by Hudeiba 2 (4.8 plants /pot). However cultivar 113 sustained the lowest *Striga* emergence (2.0 plants /pot). *Striga* dry weight, irrespective of maize cultivars increased with increasing the seedbank size. Maize height, irrespective of maize cultivars progressively decreased with increasing seedbank size (Table 4.1). The different cultivars displayed differential response to the parasite. *Striga* irrespective of seedbank size decreased plant height of Dongla and cultivar 113 by 19.1-28.2 and 57.6-72.2 %, respectively. *Striga* at seedbank size of 16 -32 mg /pot decreased number of leaves on cultivar 113 and Dongla by 13.2-35.9 and 33.3-41.0%, respectively. However, on Hudeiba 2, *Striga* at all seedbank size did not reduce plant height, number of leaves. *Striga* irrespective of seedbank size reduce leaf area and shoot dry weight on Dongla and Hudeiba 2, while Cultivar 13 significantly, did not show reduction at all *Striga* seedbank size.

الملخص

الحشائش الطفيلية الجذرية من جنس البودا تشكل تهديداً حقيقياًللزراعة و الأمن الغذائي في أجزاء كثيرة من العالم، فهي تصيب الكثير من المحاصيل ذات الأهمية الاقتصادية وتؤدي إلى خفض الإنتاجية والنوعية. وتعتبر الذرة الشامية، الذرة الرفيعةو الدخن من العوائل التقليدية. تم إجراء تجربة مشتليه بكلية الدراسات الزراعية (شمبات)، جامعة السودان للعلوم والتكنولوجيا خلال موسم 2016-2017، وذلك لدراسة آثر معدلات مختلفة من البودا على ثلاثة أصناف من الذرة الشامية(دنقلا، الصنف113 وحديبة 2). وضعت التجربة في تصميم القطاعات العشوائية الكاملة على ثلاثة مكرارات، وتم رصد قياسات النمو و التي اشتملت على عدد البودا والوزن الجاف للبودا طول النبات، عدد الأوراق، مساحة الورقة،و الوزن الجاف للنبات. إنبثاق البودا في كل أصناف الذرة الشامية إزداد بزيادة مخزون البذور حيص يصل لأعلي معدل ثم يبدأ في الإنخفاض. بعد 75 يوم من الزراعة، أعطي الصنف دنقلا أعلي عدد للبودا (5.6 نبات/ الأصيص) وأعقبه تنازلياً حديبة 2 (4.8 نبات/ الأصيص)، بينما الصنف 113 أعطي أقل إنبثاق للبودا (2.0 نبات/ الأصيص). الوزن الجاف للبودا بغض النظر عن أصناف الذرة الشامية يزداد بزيادة حجم مخزون. ينخفض طول الذرة الشامية تدريجياً بزيادة مخزون بذور البودا، أدت البودا وبغض النظر عن مخزون البذور إلي نقصان في طول النبات في دنقلا والصنف 113 بنسبة 19.1-28.4% و 57.6-72.2%، علي التوالي. أدت البودا عندما كان مخزون البذور 16-32 ملجرام/الأصيص إلي نقصان عدد الأوراق في الصنف 113 ودنقلا بنسب 13.2-35.9% و 33.3-41.0%، علي التوالي، بينما في الصنف حديبة 2 كل معدلات مخزون بذور البودا لم تؤدي إلي خفض في طول النبات وعدد الأوراق. أدت البودا وبغض النظر عن مخزون البذور إلي نقصان في مساحة الورقة والوزن الجاف للمجموع الخضري في دنقلا وحديبة 2، بينما في الصنف 113معنوياً لم يلاحظ إي إنخفاض في كل معدلات مخزون بذور البودا.

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List of Abbreviations

%	Percent
ºC	Degree centigrade
cm	Centimeter
g	Gram
mg	Milligram
LSD	Least significance different
SE	Standard Error
h	Hours
ha	Hectare
CV	Coefficient of variation
et al	and others
DAS	Days after sowing
No.	Number

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CHAPER ONE

INTRODUCTION

Maize (*Zea mays* L.) belongs to the family Poaceae, is an important cereal crops in many developed and developing countries of the world. The probable center of origin is the Central American and Mexico region. Maize has a wide range of plasticity to the environmental conditions. It is grown from latitude 58 N to 40 S on a range of 400 – 900 mm rain and temperature of 20- 30^{0}C (Moaveni *et al*., 2011). As regards to area and production maize ranks third in world production following wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) (Houshmandfar and Asli, 2011). It has great yield potential and attained the leading position among cereals based on production as well as productivity (Keskin *et al*., 2005). It is extensively grown in temperate, subtropical and tropical regions and grown principally during the summer season in the world.

Maize is high yielding, easy to process, readily digested, and costs less than other cereals. According to Khawar *et al*, (2007), maize has a variety of uses. Its grain is a rich source of starch, vitamins, proteins and minerals. These crops also serve as sources of income to small and large scale farmers in developing countries (Ahmed and Yusuf, 2007). Maize is used as forage and in the manufacture of livestock feed, food stuffs, sweeteners, beverage and industrial alcohol, and oil (Moyin-Jesu, 2010). The six major types of corn are dent corn, flint corn, pod corn, pop corn, flour corn, and sweet corn (Press, 2013). Every part of the maize plant has economic value; the grain, leaves, stalk, tassel, and cob can all be used to produce a large variety of food and non-food products.

Maize is a promising cereal crop in Sudan with the potential usefulness for both human beings and livestock (Salih *et al.*, 2008). It ranks the fourth important cereal crop in Sudan after sorghum, wheat and pearl millet. Name in Sudan Aisha Arleef (Mohammed, 2006). Maize has been known and grown for long time on small scale areas at different locations under rain-fed and irrigation condition. It ranks fourth after sorghum, wheat and millet. The crop is less popular as food; hence it received intention as potential food crop. Most of the improved varieties growth are open pollinated as variety 113, composite Giza2, Mugtam 45, Judea 1, and 2 (Aquino *et al.*, 2003). Maize was growth as rain fed crop, mainly in the Nubba Mountains, southern Blue Nile and southern Dar fur. It's also produced in the irrigated areas as a winter crop, and food in the Northern and River Nile stats.

Parasitic weeds of the genus *Striga* (Orobanchaceae) strongly affect host crops such as maize, sorghum (*Sorghum* bicolar (L.) Moench), pearl millet (*Pennisetum glaucum* (L.), rice and cowpea (*Vigna unguiculata* L. Walp) as a consequence, these weeds are important growth reducing factors in crops in vast areas of the Savannah zone in Africa (Parker, and Riches, 1993).

Of all *Striga* species, *Striga hermonthica* (Del.) Benth is the most economically important parasitic weed in the Nigerian Savanna Sudan *S. hermonthica* a root parasitic weed that inhibits host growth by competing for nutrients and impairing photosynthesis is one of the most important biological constraints to maize production in sub- Saharan Africa. Yield reduction caused by *S. hermonthica* can be up to 79% even under good management.

The objective of this investigation was therefore to evaluate the effect of *S. hermonthica* (sorghum strain) on growth of three maize cultivars.

CHAPTER THREE

LITERATUREREVIEW

2.1. Maize

2.1. Botanical Description:

Maize is a coarse annual grass belonging to the large and important family graminaeae tribe maydeae, genus *Zea* and species *mays* (Lorroki, 2009*)*. It is a monoecious, annual grass which can grow to a height of about 1-4m depending on variety (Muiru, 2008). The root system mainly consists of adventitious roots that usually develops from the lower nodes of the stem below and often just above the soil surface, usually they are limited to the upper 75cm of the soil (Jugenheimer, 1985), maize stems are simple and solid with well defined nodes and internodes ranging from 8-21 (George and Karin, 2004). The male and female inflorescence are separate but on the same plant (Sinclair *et al*., 2004). The female inflorescence usually referred to as the ear is a modified spikes usually it develops from the axil of one of the largest leaves about halfway the stem. It is enclosed by 8-13 modified leaves known as the husks (Georg and Karin, 2004). The male inflorescence is known as tassel consists of a terminal panicle up to 40cm long (George and Karin, 2004). Flower initiation is generally 20-30 days after germination. The period from planting to harvesting varies from 70-200 days (Muiru, 2008). Climatic conditions, latitude and altitude influence growth duration of the crop (George and Karin, 2004).

2.2. *Striga*:

Striga spp. is hemi-parasitic plants that parasitize the root systems of their hosts. The genus *Striga,* family Orobanchacecae, comprises about 41 species that are found in the African continent and parts of Asia; Africa is the presumed region of origin (Wolfe *et al.,* 2005). By parasitizing crop species, they can cause substantial yield losses and are therefore considered agricultural pests.

S. hermonthica, S. asiatica (L.) kuntze *and S. gesnerioides* (Willd.) Vatke are recognised as the largest biological constraint to food production in Africa; In particular, they cause immense losses to major staple crops in sub-Saharan Africa. The genus *Striga* comprises about 30 obligate root-parasitic plants (Babiker, 2007; Aly, 2007). The root parasitic plants witchweeds (*Striga* spp.), are considered the most serious biotic factor that threatens cereal (sorghum, maize, millet and rice) production in the rain fed agriculture of the semi-arid tropics (SAT) including Sudan (Parker and Riches, 1993).

In Sudan, more than 500,000 hectares under rain fed cultivation are heavily infested with *Striga*, which commonly results in significant yield losses of 70-100% (Babiker, 2002). *S. hermonthica* and *S. asiatica* (L.) Kuntze are the major biotic constrains to crop production, in addition *Striga* infestation is associated with low soil fertility, low soil moisture and intensive monocropping of susceptible hosts (Bebawi, 1987).

2.2.1. Economic Important of *Striga*

Striga has been a serious problem of cereal and legume crops among farmers in sub-Saharan Africa. As a result of *Striga* infestation, growth inhibitors (abscisic acid and fernasol) in the host increase, and growth promoters (cytokinins and giberrallins) decrease due to host stress response, generally, impairing the host growth and reproduction (Frost, 1997). Its effects on crops range from stunted growth, through wilting, yellowing, and scorching of leaves, to lowered yields and death of many affected plants. According to Gressel *et al*., (2004), 21.9 million hectares of Sorghum and Millet fields in Africa are affected by *Striga* compared to an overall 26.43 million hectares of all cereal crops.

S. hermonthica can affect its host in different ways. Only part of the reduction in the growth of the host results from competition for carbon assimilates, water, mineral nutrients and amino acids (Graves *et al*., 1990). However, *Striga* does not only act as an additional sink but the parasite also has a strong 'toxic' or 'pathological' effect on the host (Press and Gurney, 2000). Parts of these effects are caused by the disturbed hormonal balance in *Striga*-infected host plants, characterized by increased levels of abscisic acid and decreased levels of cytokinins and gibberellins (Frost *et al*., 1997). By altering the host's hormonal balance, *Striga* affects host biomass allocation, resulting in the root systems of infected plants being greatly stimulated, while the shoot is stunted and reduced (Parker and Riches, 1993). The parasite also negatively affects host photosynthesis. Parasite induced reduction in host photosynthesis has been reported as the most important mechanism of growth reduction. Graves *et al*. (1989) estimated that 80% of the decrease in host growth rate can be attributed to the impact of *Striga* on host photosynthesis. Furthermore, *Striga* strongly affects the water economy of its host by its high transpiration rate and by reducing the stomatal conductance of the host plant (Grimanelli *et al*., 2000).

2.2.2. Life cycle of Striga:

Striga spp. are obligate hemi-parasitic plants that attach to the root of their host to obtain water, nutrients and carbohydrate (Parker and Riches, 1993).

The intimate association between *S. hermonthica* and its host and the complexity of its life cycle makes it a difficult to control weed with conventional methods. The parasite is a copious seed producer. One *Striga* plant produces a large number of tiny seeds (up to 100.000) measuring 0.15 x 0.3 mm in size with a longevity of up to 30 years. The seeds are dispersed by wind, shared use of contaminated farm implements and contamination of grain stock. Normally seeds mature and are shed onto soil towards the end of the rainy season. Freshly harvested seeds remain dormant for several months depending on the species, strains and environmental conditions under which the seeds were produced (Ejeta *et al.*, 1993). This period is referred to as after –ripening.

Striga spp. have complex mechanisms for detecting the presence of suitable host roots. *Striga* seed germination is controlled by a double-check system by which the parasite determines both that conditions are favorable for growth and an appropriate host within close vicinity. The first check is the conditioning period which requires a suitable temperature range between 25- 35 °C and soil moisture near field capacity. Conditioning includes a lag period of few days (2 to 3 days) during which the seeds are not yet fully responsive to germination stimulants. As time increases sensitivity to germination stimulant also increases, gets to the maximum in 14 days and start to decline with time and eventually the seed enters into a stage of secondary or wet dormancy which breaks on drying (Parker and Reid, 1979). The second check is the chemical germination signal from host root which indicates that a suitable host is within close proximity of the seed. The low solubility of the stimulants in water and their rapid deactivation, suggest that only those close to the host root would be stimulated to germinate (Press and Gurney, 2000). Low water solubility and limited stability are advantageous to the parasite as the limited reserves in the seeds cannot sustain the seedlings for a long time. Accordingly germination in absence of or away from the host root is suicidal and leads to reduction of the parasite soil seeds reserves. Un-germinated seeds would be viable for another season.

The physiological mechanisms pertaining to conditioning, germination, haustorium initiation, attachment and penetration involve genes interactions and enzymes and protein synthesis (Babiker, 2007). Germination stimulants, natural and synthetics, induce ethylene biosynthesis in *Striga* seeds (Babiker *et al*., 1993). Ethylene initiates a biochemical cascade that culminates in germination. Genes encoding the key enzymes in ethylene biosynthesis, ACC synthase and ACC oxidase, are regulated by germination stimulants and conditioning (Babiker *et al.*, 2000).

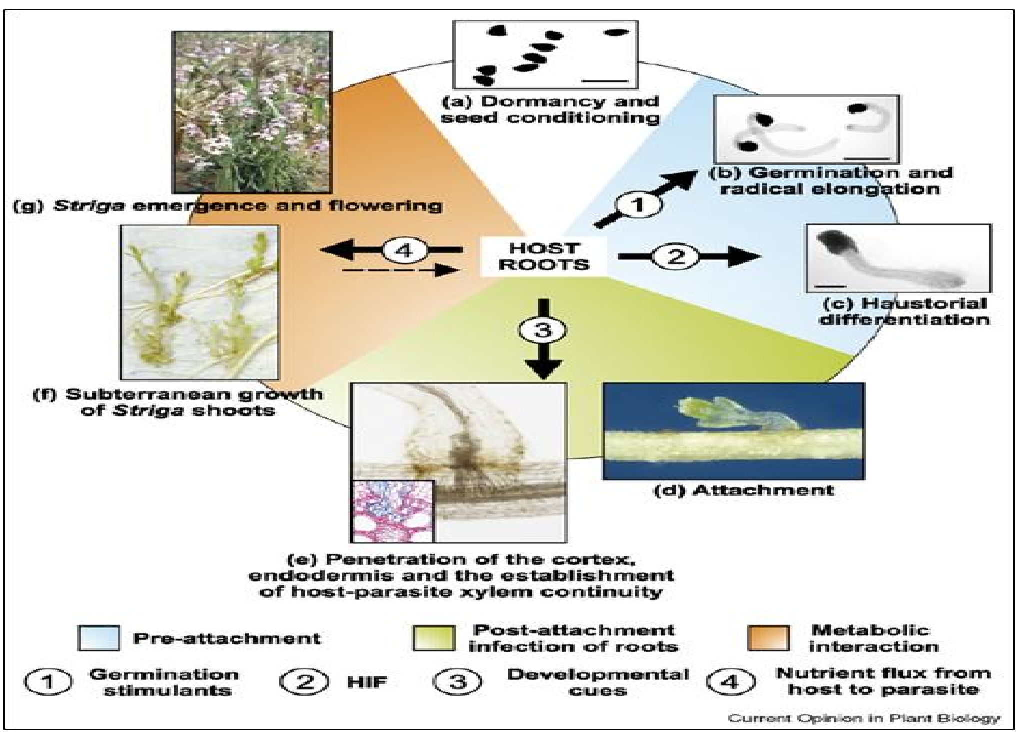

Plate 2.1. *Striga* life cycle adapted with few modifications from Scholes and Press (2008).

2.2.3. Control Methods:

Compared with non- parasitic weeds, control of parasitic weeds has proved to be exceptionally difficult (Parker and Riches, 1993; Babiker, 2007). The ability of the parasite to produce a tremendously high number of seeds, which remain viable in soil for more than ten years and their intimate physiological interactions with their host plants, are the main obstacles that limit the development of successful control measures that can be accepted and used by subsistence farmers (Elzein and Kroschel, 2003). However, several methods have been tried for the control of parasitic weeds, including preventive methods, mechanical and cultural methods (crop rotation, trap and catch cropping, fallowing, hand pulling, nitrogen fertilization, time and method of planting and intercropping), physical (solarization), chemical (herbicides, fertilizers, artificial seed germination stimulants and fumigants), use of resistant varieties and biological control (Parker and Riches, 1993; Joel, 2000). So far these methods, however, have only had a limited impact on the parasites and up to-date there is no single control method that can effectively solve the problem (Joel, 2000; Ejeta, 2005).

Management of the hemi-parasite needs an integrated approach that includes host plant resistance, cultural practices, and chemical treatments. With integrated management, it is important to understand the interaction of the host plant, sorghum, with the biotic and a biotic environment (Lendzemo, 2004). The best solution in the control of *Striga* is an integrated approach that includes a combination of methods that are affordable and acceptable by farmers.

There are several methods that are used or have been tried to control *Striga* infestation in maize. Crop rotation of a cereal with legumes such as soybean can be a highly effective means of reducing the amount of *Striga* seeds in the soil (Berner *et al.*, 1997) but this practice may not be viable in the smallholder sector of South Africa where land holdings are small and farmers always require their staple maize. Intercropping cereal with cowpea in the same row gave the highest yield in Cameroon and in Ethiopia (Mbwaga *et al*., 2001). Intercropping with legumes also improves soil fertility through fixation of atmospheric nitrogen. Addition of nitrogen to the soil is generally considered to alleviate the effects of *Striga* and to lower the amount of *Striga* supported by the host. The effectiveness of cereal/legume intercropping to influence *Striga* germination depends on the effectiveness of the produced stimulants/inhibitors, root development, fertility improvement, shading effect and its compatibility to *Striga* species because the response of *Striga* to management options is specific (Mbwaga *et al*., 2001).

CHAPTER THREE

MATERIALS AND METHODS

3.1. Experimental site:

Green house experiment was undertaken at the College of Agricultural Studies, Sudan University of Science and Technology (SUST) at Shambat, Khartoum North, during the season (2016-2017) to study the effect of *S. hermonthica* on growth and yield of three Maize cultivars. The soil type is loamy clay with PH of 7.8-8.5, characterized by a deep cracking, and moderately a lake line low permeability nitrogen content (Abdel-Hafez, 2001)

3.2. Material:

3.2.1. Plant material:

The seeds of maize cultivars (Dongle, Hudeiba2 and 113) were obtained from the Agricultural Research Corporation (ABC), Wad-Medani, Sudan.

3.2.2. Striga seed

S. hermonthica seeds (sorghum strain) was obtained from Weed Research Laboratory, SUST.

3.3. Methods:

The experiment was conducted under artificial infestation of soil was achieved by mixing (1g) of Striga seeds with 1Kg soil, followed by Subsequent dilution with *Striga* free soil to give the required infestation level (8,16 and32mg/pot). Striga free or infested soil was placed in plastic pots (10 cm diameter) with perforations at the bottoms. Pots filled with Striga a free soil (0 mg) were included as control for comparison.

3.4. Sowing

After soil preparation, *Striga* seeds were added to soil surface with different rate zero (control), 8, 16, and 32mg, and then four seeds of maize were planted at 2 cm soil depth. The pots were immediately irrigated. Subsequent irrigations were carried out every two days. Maize seedlings were thinned to three plants per pot two weeks after sowing

3.5. Data collection:

3.5.1. Striga

Data collected on *S. hermonthica* included number of *Striga* emergence per pot and Striga dry weight (g). Number of *Striga* for each treatment was counted 30, 45 and 75days after sowing. The *Striga* emergence was collected 90 days after maize sowing from each pot, sun dry and then the dry weight of Striga (gram) was recorded

3.5.2. Maize parameters

From the three plants for each pot, the following parameters were recorded:

Plant height (cm), number of leaves /plant, number of tillers /plant, Leaf area and maize dry weight (g).

The Leaf area was calculated as follow:

LA (cm) = length x width x 0.75

The maximum length and width of the leaf at the fourth inter node was measured in each of the three tagged plant

3.6. Statistical analysis

Data on wheat growth attributes and *Striga* were subjected to analysis of variance (ANOVA). Mean separations were made by Least Significance Difference test (LSD) at P > 5% using statistic8 computer program.

CHPTER FOUR

RESULTS

4.1. Effect on *Striga*

4.1.1. *Striga* emergence

At 45 and 75days after sowing (DAS), statistical analysis showed significant differences in number of *Striga* between maize cultivars (Appendix1). At 45 DAS, *Striga* emergence on Dongla was 1.7 plant /pot at the lowest seedbank size. Increasing seedbank size to 16 and 32 mg /pot increased *Striga* emergence to 3.3 plants /pot (Fig 4.1 A). On cultivar 113, all seedbank level displayed low and comparable *Striga* emergence (1.6 plant /pot). At seedbank size of 8, 18 and 32 mg /pot, Hudeiba 2 showed a mean of 1.3, 2.6 and 1 plants /pot, respectively (Fig 4.1 A).

Striga count made 60 DAS showed that *Striga* emergence on all maize cultivars increased with seedbank size, reached a maximum and then declined (Fig 4.1B). On Dongla, the *Striga* displayed an average of 3.6 plants /pot at the lowest seedbank size (8mg/pot). Increasing seedbank size to 16mg/pot increased *Striga* emergence to 5.6 plants /pot. A further increase in seedbank size to 32 mg/pot reduced *Striga* number to 4.0 plants /pot (Fig 4.1B)

At the lowest seedbank size (8mg /pot) cultivar 113 and Hudeiba 2 showed an average of 1.0 and 4.0 plants/pot. Increasing *Striga* seedbank size to 16 and 32 mg/pot, increased *Striga* emergence. However, the increment in emergence (2.0-4.3plants/pot), but substantial were not significant (Fig4.1B).

At 75 DAS, Dongla displayed highest *Striga* number (5.6 plants /pot), followed by descending order by Hudeiba 2 (4.8 plants /pot). However cultivar 113 sustained the lowest *Striga* emergence (2.0 plants /pot). At seedbank size of 8mg/pot *Striga* number was 5.0, 1.0 and 6.0 plants /pot on Dongla, cultivar113 and Hudeiba2, respectively (Fig 4.1C). A further increase in *Striga* level to

16mg/pot increased emergence to 7.6 and 2.3 plants /pot on Dongla and cultivar 113, respectively, but not significantly. On Hudeiba2 *Striga* number reduced to 5.6 and 2.6 plant/pot when increased seedbank size to 16 and 32mg/pot respectively, but not significantly (Fig4.1C).

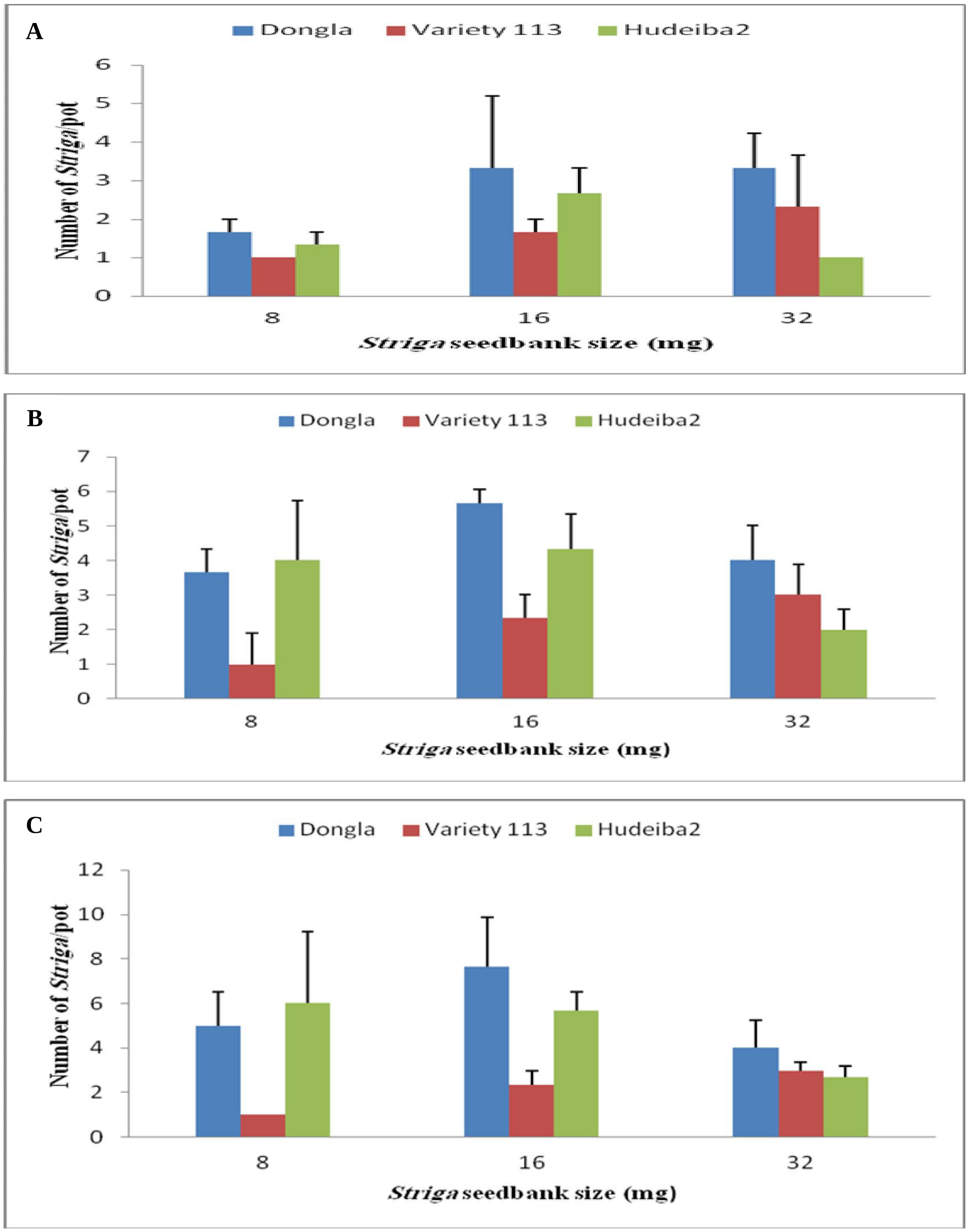

Fig 4.1. Effect of *Striga* seedbank size on *Striga* emergence A) 45 DAS, B) 60 DAS and 75 DAS. Error bars represents standard error of means.

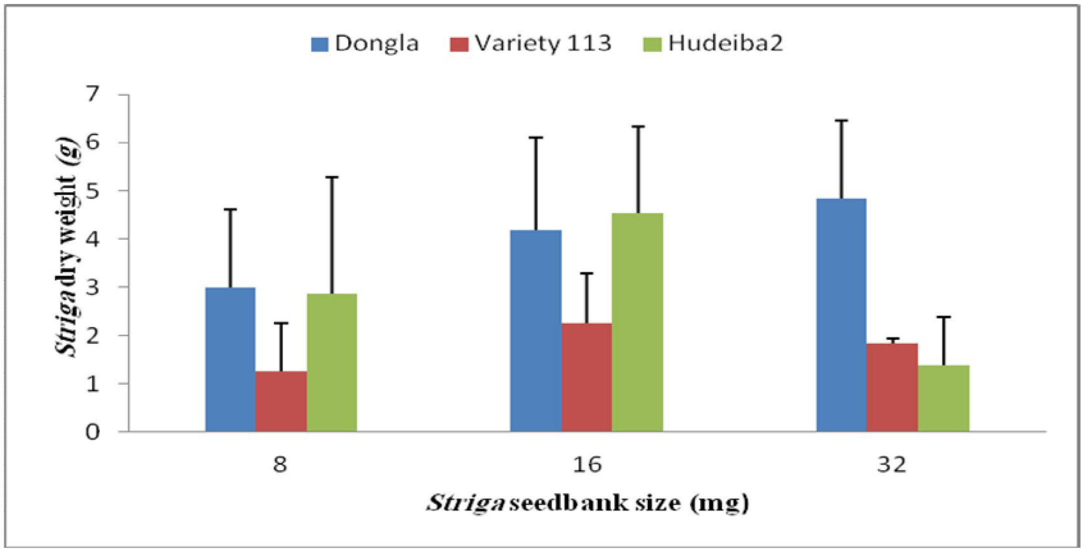

Fig 4.2. Effect of *Striga* seedbank size on *Striga* dry weight. Error bars represents standard error of means.

4.1.2. Effects on *Striga* dry weight

Statistical analysis showed no significant differences in *Striga* dry weight between maize cultivars and also between *Striga* seedbank sizes (Appendix 1). *Striga* dry weight, irrespective of maize cultivars increased with increasing the seedbank size (Fig 4.2). At the lowest seed bank size, *Striga* dry weight on three cultivars was very low (1.2 -2.9 mg /pot). However, increasing *Striga* seedbank size to 16 mg /pot increased the parasite dry weight to 4.19, 2.25 and 4.52 on Dongla, cultivar113, Hudieba 2, respectively. At the highest seedbank size (32 mg /pot) *Striga* dry weight decreased on cultivar 113 and Hudeiba 2, but not significantly (Fig 4.2). However on Dongla increasing seedbank level to 32 mg /pot displayed slight increased in *Striga* dry weight, but not significantly (Fig 4.2).

4.2. Effects on maize cultivars

4.2.1. Plant height (cm)

The results of statistical analysis showed no significant differences on plant height between maize cultivars (Appendix 2). Maize height, irrespective of maize cultivars progressively decreased with increasing seedbank size (Table 4.1). The different cultivars displayed differential response to the parasite. At seedbank size of 16 and 32 mg /pot, *Striga* decreased height of Dongla by 19.1 and 28.2 %, respectively, albeit not significantly, in comparison to the parasite free control (Table 4.1). *Striga* at seedbank size of 8 mg /pot decreased cultivar 113 height significantly by 62.2%, as compared to un-infested control. However, increasing *Striga* seedbank to 16 mg /pot reduced plant height on cultivar 113, but not significantly (Table 4.1). A further increase in seedbank level to 32 mg /pot reduced cultivar 113 height and the observed reduction was considerable (72.7%). On Hudeiba 2, *Striga* at all seedbank size did not reduced plant height (Table 4.1)

Table 4.1. Effect of *S. hermonthica* on maize height

Plant height(cm)					
Striga seed bank size/pot (mg)					
Maize cultivars	**0**	**8**	**16**	**32**	**Mean (cultivars)**
Dongla	13.1 BC	15.4 BC	10.6 BC	9.4 C	12.1 A
Cultivar 113	27.8 A	10.5 BC	21.8 AB	7.6 C	16.9 A
Hudeiba 2	10.5 BC	14.9 BC	12.2 BC	13.9 BC	12.9 A
Mean(seed bank)	17.1 A	13.6 A	14.8 A	10.3 A	
LSD for cultivars	**5.9634**				
LSD for seed bank	**6.8860**				
LSD for interaction	**11.927**				

Means within a column and/or row followed by the same letter(s) are not significantly different according to LSD-Test.

4.2.2. Number of leaves:

Statistical analysis showed significant differences in number of leaves between maize cultivars (appendix 3). Hudeiba 2 and Dongla displayed number of leaves, while cultivar113 displayed the lowest. On Dongla, *Striga* at seedbank size of 16 and 32 mg /pot, decreased number of leaves by 41.0 and 33.3%, respectively, but not significantly (Table 4.2). On cultivars 113, number of leaves per plant reduced by 13.2% at the seedbank size of 16 mg /pot, but not significantly, as compared to the un-infested control. However, increasing seedbank to 32 mg /pot, decreased significantly number of leaves and the observed decreased was considerable (35.9 %). On Hudeiba 2, number of leaves did not show reduction at all *Striga* seedbank size (Table 4.2).

Table 4.2. Effect of *S. hermonthica* on Number of leaves/plant

Number of leaves/plant					
***Striga* seed bank size/pot (mg)**					
Maize cultivars	**0**	**8**	**16**	**32**	**Mean (cultivars)**
Dongla	3.9 ABC	5.2 AB	2.3 C	2.6 C	3.5B
Cultivar113	5.3 A	5.7 A	4.6 AB	3.4 BC	4.7A
Hudeiba 2	4.8 AB	4.7 AB	5.5 A	5.6 A	5.2A
Mean(seedbank)	4.7 AB	5.2 A	4.1AB	3.9 B	
LSD for cultivars	**0.9280**				
LSD for seed bank	**1.0716**				
LDS for interaction	**1.8561**				

Means within a column and/or row followed by the same letter(s) are not significantly different according to LSD-Test.

4.2.3. Leaf area:

The results of statistical analysis showed no significant difference in leaf area between maize cultivars (Appendix 4). On Dongla, *Striga* at seedbank size of 8 and 16mg/pot reduced leaf area by 30.0 and 17.1 %, respectively, but not significantly, as compared to *Striga* free control (Table 4.3). *Striga* at seedbank size of 16 and 32 mg /pot reduced leaf area on Hudeiba 2 by 32.6 and 36.1%, respectively, as compared to the control. However, the observed reduction was not significant (Table 4.3). Cultivar 13 significantly, did not show reduction in leaf area at all *Striga* seedbank size, in comparison to the un-infested control (Table 4.3).

4.2.4. Dry weight:

Statistical analysis showed significant differences between plant cultivars and between *Striga* seedbank size in maize dry weight (Appendix 5). Cultivar 113 displayed highest plant dry weight, while Dongla and Hudeiba 2 displayed comparable and lowest dry weight. On Dongla, *Striga* at seedbank size of 16 and 32 mg/pot, reduced shoot dry weight by

56.0 and 24.0 %, respectively, but not significantly, as compared to the control (Table 4.4). On cultivar 113, shoot dry weight reduced at all seedbank size, but not significantly, as compared to the control. However, the reduction was considerable (69.2-75.6%). Cultivar 13 significantly, did not show reduction in shoot dry weight at all *Striga* seedbank size, as compared to the un-infested control (Table 4.4).

Table 4.3. Effect of *S. hermonthica* on leaf area

Leaf area (cm^2)					
***Striga* seed bank size/pot (mg)**					
Maize cultivars	**0**	**8**	**16**	**32**	**Mean (cultivars)**
Dongla	44.7 ^{A}	31.3 ^{A}	37.1 ^{A}	62.0 ^{A}	43.8 ^{A}
Cultivar 113	30.6 ^{A}	31.9 ^{A}	32.3 ^{A}	65.8 ^{A}	40.1 ^{A}
Hudeiba2	57.0 ^{A}	51.9 ^{A}	39.7 ^{A}	40.7 ^{A}	47.3 ^{A}
Mean(seed bank)	44.1 ^{A}	38.4 ^{A}	36.4 ^{A}	56.2^{A}	
LSD for cultivars	**23.979**				
LSD for seedbank	**27.689**				
LSD for interaction	**47.958**				

Means within a column and/or row followed by the same letter(s) are not significantly different according to LSD-Test.

Table 4.4. Effect of *Striga* seed bank on maize dry weight

Maize dry weight (g)					
***Striga* seed bank size/pot (mg)**					
Maize cultivars	**0**	**8**	**16**	**32**	**Mean (cultivars)**
Dongla	2.5 ^{B}	2.1 ^{B}	1.1 ^{B}	1.9 ^{B}	1.9 ^{B}
Cultivar113	7.8 ^{A}	1.6 ^{B}	2.4 ^{B}	1.6 ^{B}	3.4 ^{A}
Hudeiba2	1.3 ^{B}	2.3 ^{B}	1.7 ^{B}	2.3 ^{B}	1.9 ^{B}
Mean(seed bank)	3.9 ^{A}	2.0 ^{B}	1.7 ^{B}	1.9 ^{B}	
LSD for cultivars	**1.3478**				
LSD for seed bank	**1.5563**				
LSD for interaction	**2.6956**				

Means within a column and/or row followed by the same letter(s) are not significantly different according to LSD-Test.

CHAPTER FIVE

DISCUSSION

Striga spp. are obligate root parasitic plants. They are of economic importance as they reducer crop yield and quality and present a serious threat to food security in many areas across the world (Parker and Riches, 1993). *S. hermonthica* emergence, was affected by maize cultivars. *Striga* emergence on all maize cultivars increased with seedbank size reached a maximum and then declined. At 75 DAS, Dongla displayed highest *Striga* number (5.6 plants /pot), followed by descending order by Hudeiba 2 (4.8 plants /pot). However cultivar 113 sustained the lowest *Striga* emergence (2.0 plants /pot). The variability in *Striga* emergence, noted between the maize cultivars, with seedbank size could be related to a multitude of factors including differential stimulant production, differential compatibility between the host and the parasite or to failure of the host to sustain emergence of most of the attached parasite seedlings. The parasite developed more slowly on Dongle and Hudieba2 on than cultivar113, this may be due to difficulty of obtaining nutrients and or metabolites essential for sustenance of the parasite growth. The observed increase in *Striga* emergence with seed bank size indicates the importance of the seed bank in determining the level of infestation and damage.

Striga dry weight, irrespective of maize cultivars increased with increasing the seedbank size (Fig 4.2). At the lowest seed bank size, *Striga* dry weight on three cultivars was very low and this may attributed to the *Striga* number. Similar finding were obtained in research article by (Samia *et al*., 2014), results showed that sorghum cultivars inoculated with *Striga* at the lowest infestation level displayed the lowest *Striga* dry weight.

Maize height, irrespective of maize cultivars progressively decreased with increasing seedbank size (Table 4.1). The different cultivars displayed differential response to the parasite. *Striga* irrespective of seedbank size decreased plant height of Dongla and cultivar 113 by 19.1-28.2 and 57.6-72.2 %, respectively. *Striga* at seedbank size of 16 -32 mg /pot decreased number of leaves on cultivar 113 and Dongla by 13.2-35.9 and 33.3-41.0%, respectively. However, on Hudeiba 2, *Striga* at all seedbank size did not reduce plant height, number of leaves. *Striga* irrespective of seedbank size reduce leaf area and shoot dry weight on Dongla and Hudeiba 2, while Cultivar 13 significantly, did not show reduction at all *Striga* seedbank size. The effect of *Striga*, irrespective of seedbank size on maize growth attributed to a common effect of *Striga* infection on cereals. A recent study examining the responses of sorghum to different levels of parasite infection demonstrated that even low levels of infection (one or two parasites) can have a dramatic effect on host growth and yield (Gurney *et al*., 2000). It is known that during the subterranean phase the parasite seedlings are totally dependent on the host and competition between seedlings for mineral nutrients, carbohydrates, hormones and water is expected to arise with increasing infestation. The observed reduction in shoot dry weight could be attributed, as previously pointed by Parker and Riches (1993), to reduction in photosynthesis, differential allocation of photosynthate, and/or hormonal imbalance

REFERENCES

Ahmed, B. I. and Yusuf, A. U. (2007). Host-plant resistance: A viable non-chemical and environmentally friendly strategy of controlling stored products pests-a review. *Emir. J. Food Agric*. **19**(1): 01-1

Ali, F.M. (1991). Maize agronomy. Annual report 1990/91, Agricultural Research Corporation, Gezira Research Station., Wad Medani, Sudan.

Babiker, A.G.T. (2007). *Striga:The spreading scourge in A frica. The Japanese Society for Chemical Regulation of plants, **42**:74-87.*

Babiker, A. G. T. (2007). *Srtiga: The spreading scourage in Africa. Regulation of Plant growth and Development, **42**:74-87.*

Babiker, A G. T (2002). *Striga control in Sudan :An integrated approach In:* Leslie, J. F (ed.). *Sorghum and millet diseases Iowa state press.* pp159-163.

Babiker, A. G. T., Ejeta, G., Bulter, L. G. and Woodson, W. R. (1993). Ethylene biosynthesis and Strigol-induced germination of *Striga asiatica. Journal of plant physiology*, ***88**:359-365*

Bebawi, F .F. (1987). Cultural practices in Witch weed management In: Musselman, L .J. (ed). *Parasitic Weed inAgriculture .1. Striga.CRC press, Boca Raton,* pp159-171

Elzein, A. E and Kroschel, J. (2003). Progress on management of parasitic weeds.In: Labrada, R. (ed.). *FAO Plant Production and Protection. Weed Management for Developing Countries. Paper 120 Addendum 1, Food and Agriculture Organization of the United Nations*, Rome. pp 109-144.

Ejeta, G., Butler, G. and Babiker, A. G. T. (1993). New approaches to the control of *Striga :Striga* research at purdue University. Agriculture Experiment Station .Research Bulletin No 991, West Lafayette, pp27

Ejeta, G. and Butler, L G. (1993). *Host-parasite interaction throughout the Striga life cycle, and their contribution to Striga resistance. African crop science Journal, **1**:75-80*

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

Gressel, J., Hanafi, A., Head, G., Marasas, W., Obilana, B., Ochanda,J., Souissi, T. and Tzotzos, G. (2004). Major heretofore intractable biotic con straints to African food security that may be amenable to noval biotechnological solutions. *Crop Protection,* ***23****:661-689.*

Grimanelli, D. F., Kanampiu, G., Odhiambo, P. M., Bogo, M. and Hoisignton, D. (2000). Identification of genes for tolerance to Striga in maize using transposable elements. In: Haussmann, B. I.G.(ed.). *Breeding for Striga resistance in cereals. Margrafverlag Weikersheim,* Germany.pp187.

Graves, J. D., Press, M. C. and Stewart, G. R. (1989). A carbon balance mode of the sorghum-*Striga hermonthica* host-parasite association. *Plant Environmen*t, ***12****:101-107.*

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

Houshmandfar, A. and Asli, D. E. (2011). Response of Corn (*Zea Mays* L.) to Seed Pyridoxine-priming and Different Levels of Nitrogen. *Advances in Environmental Biology*, **5(1**): 53-57.

Joel, D. M. (2000). A new virulent race of *Orobanche crenata. Haustorium, 37. Available at haustorium/haustorium37.shtml.*

Khawar J., Zahid, A. and Muhammad, F. (2007). Maize: Cereal with a Variety of Uses. DAWN– Business.http://wwwdawn.com/2007/03/12/ebr5.htm.

Keskin B., Yilmaz, I. H. and Arvas, O. (2005). Determination of some yield characters of grain corn in eastern Anatolia region of Turkey. *J. Agron*. **4**(1):14-17.

Moaveni, P., Farahani, H. A. and Maroufi, K. (2011). Effects of Planting Density on Some of Yield Parameters in Maize (*Zea Mays* L.). *Advances in Environmental Biology*, **5(8):** 2245-2248.

Lendzemo, V. W. (2004). *The tripartite interaction between Sorghum, Striga hermonthica, and arbuscular mycorrhizal fungi, Wageningen University; Ph. D.Thesis.*

Mbwaga A. M., Massawe, C.R., Kaswende, A. M. and Hella, J. P. (2001). On-farm verification of maize/cowpea intercropping on the control of *Striga* under subsistence farming. *Seventh Eastern Africa regional maize conference*, pp. 165-167.

Moyin-Jesu, E. I. (2010). Comparative evaluation of modified neem leaf, wood ash and neem leaf extracts for seed treatment and pest control in maize (*Zea mays* L.). *Emir. J. Food Agric*. **22**(1): 37-45.

Parker, C. and Riches, C. R. (1993). *Parasitic Weeds of the World :Biology and control .CAB International ,Wallingford, Oxon,UK. pp332.*

Parker, C. and Reid, D. C. (1979). Host specificitiy in *Striga* species some preliminary observations. *In:* Musselman, L. J., Worsham, A. D. and Eplee, R. E. (eds.). *Proceeding of the second Sympoosium on parasitic Weed .North Carolina, Stat University Raleighm NC.* pp 79-90.

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

Samia, O. Y., Mohammed, M. H., Migdam, E. A. G. and Abdel El Gabar. E. B. (2014). Screening Sorghum for Resistance to *Striga Hermonthica* (Del.) Benth. Nova. *Journal of Medical and Biological Sciences,* **3**(3): 1-5.

Salih, M. A., Ali, E. S, Babiker, E. A. and Ali, N. A. (2008). Effects of nitrogen source on yield and nitrogen use efficiency of two maize (*Zea mays* L.) varieties. *Sudan Journal of Agricultural Research*, **12**:11-22.

Wolfe, A. D., Randle, C. P., Liu, L. and Steiner, K.E. (2005). Phylogeny and biogeography of Orobanchaceae. *Folia Geobotanica* 40, 115.

APPENDICES

Appendix 1: Two way ANOVA and F- values for number of *Striga* emergence and *Striga* dry weight

Source of variation	Number of *Striga*/pot (45 DAS)	Number of *Striga*/pot (60 DAS)	Number of *Striga*/pot (75 DAS)	*Striga* dry weight/pot
Cultivars (C)	0.2455 Ns	0.0179 *	0.0545 *	0.2689 Ns
Seedbank size (Sbs)	0.2551 Ns	0.2069 Ns	0.3590 Ns	0.6026 Ns
C*Sbs	0.6739 Ns	0.2410 Ns	0.4938 Ns	0.7864 Ns

*=P<0.05, **=P<0.01, ***=P<0.001, ^{ns}=non-significant.

Appendix 2: Analysis of variance of plant height

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	2	24.20	12.101		
Seedbank size (Sbs)	2	160.02	80.010	1.61	0.2220
Cultivars (C)	3	220.18	73.393	1.48	0.2476 Ns
C*Sbs	6	690.61	115.101	2.32	0.0690*
Error	22	1091.45	49.611		
Total	35	2186.46			

*=P<0.05, Ns =non-significant.

Appendix 3: Analysis of variance of Number of leaves

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	2	4.4067	2.20333		
Seedbank size (Sbs)	2	18.1950	9.09750	7.57	0.0031**
Cultivars (C)	3	9.2844	3.09481	2.58	0.0797*
C*Sbs	6	17.6206	2.93676	2.44	0.0579*
Error	22	26.4333	1.20152		
Total	35	75.9400			

*=P<0.05, **=P<0.01, Ns =non-significant.

Appendix 4: Analysis of variance of Leaf area

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	2	6847.4	3423.69		
Seedbank size (Sbs)	2	311.0	155.48	0.19	0.8252 Ns
Cultivars (C)	3	2138.5	712.85	0.89	0.4624 Ns
C*Sbs	6	2739.2	456.54	0.57	0.7504 Ns
Error	22	17647.3	802.15		
Total	35	29683.4			

Ns =non-significant.

Appendix 5: Analysis of variance of maize dry weight

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	2	12.903	6.45150		
Seedbank size (Sbs)	2	16.902	8.45084	3.33	0.0543*
Cultivars (C)	3	27.320	9.10657	3.59	0.0298*
C*Sbs	6	59.116	9.85259	3.89	0.0085**
Error	22	55.751	2.53413		
Total	35	171.991			

*=P<0.05, **=P<0.01