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Under The Tile:

Effect of Nitrogen And Phosphorus Fertilizers On *Striga Hermonica Ge*rmination On wheat Crop

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الآية

بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ ﴿١﴾ الْحَمْدُ لِلَّـهِ رَبِّ الْعَالَمِينَ ﴿٢﴾ الرَّحْمَـٰنِ
الرَّحِيمِ ﴿٣﴾ مَالِكِ يَوْمِ الدِّينِ ﴿٤﴾إِيَّاكَ نَعْبُدُ وَإِيَّاكَ نَسْتَعِينُ ﴿٥﴾ اهْدِنَا الصِّرَاطَ
الْمُسْتَقِيمَ ﴿٦﴾صِرَاطَ الَّذِينَ أَنْعَمْتَ عَلَيْهِمْ غَيْرِ الْمَغْضُوبِ عَلَيْهِمْ وَلَا الضَّالِّينَ ﴿٧﴾

صدق الله العظيم

سورة الفاتحة الآيات (1-7)

Dedication

I dedicate this research with much love

To ..

My Dear husband

To

My great mother she supported me by all means

To ..

Soul my father

To ..

My Small and big family

To

My friends and my teachers

To ..

All whom I love and respect.

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I thank allah for giving me the courage and the determination, as well as guidance in conducting this research study, all difficulties.

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My thanks also to my Friends Hajer Marya

List of Contents

Abstract

The root parasitic weeds *Striga* spp. pose a genuine threat to agriculture and food security across many parts of the world. The weeds, at present, are almost uncontrollable. They attack economically important crops and severely reduce yield and quality. Maize, sorghum, millet, are the traditional hosts, however recently wheat was reported susceptible to the parasite. Green house was conducted at the College of Agricultural Studies (CAS), Sudan University of Science and Technology (SUST) at Shambat, during season 2015-2016 to study the effect of nitrogen fertilizer (via Urea at 1N and 2N) and phosporphs (as mono ammonium phosphate- at 1P and 2P) fertilizer on *Striga* emergence on wheat crop. The fertilizers doses added at the sowing. Treatments were arranged in a Randomized Complete Block Design (RCBD) with four replicates. The results showed that Nitrogen as urea and phosphors as mono ammonium phosphate, irrespective of doses reduced *Striga* emergence. Nitrogen at 1N and 2N applied as Urea reduced *S. hermonthica* emergence by 31.3% and 81.3%. However, phosphors at 1P and 2P reduced *Striga* emergence significantly by 93.8%. Nitrogen and phosporphs applied together in the same treatment reduced significantly *Striga* emergence and *Striga* dry weight by 81.3-87.7 and 93%. The results revealed that there were no significant differences in *Striga* length and *Striga* dry weight between the treatments. The results indicated that there were significant differences in plant height between the treatments. *Striga* free soil displayed the highest plant height (control). Nitrogen and phosphors fertilizers, irrespective of doses, reduced wheat dry weight significantly by 40-78.7 and 67.1-83.5%, as compared to control. The results indicated that no significant differences in number of tillers and wheat dry weight between the treatments. Nitrogen at 1N recorded the highest number of tillers (7.9 tillers /plant). However, 2N and 1P treatments displayed the lowest tillers (2.8 tillers /plant). Wheat dry weight reduced significant after applied by nitrogen at 1N and 2N, Phosphors at 1P by 65.7- 71.6%.

خلاصة البحث

الحشائش الطفيلية الجذرية من جنس البودا تشكل تهديداً حقيقياً للزراعة والأمن الغذائي في أجزاء كثيرة من العالم، فهي تصيب الكثير من المحاصيل ذات الأهمية الأقتصادية وتؤدي إلي خفض الإنتاجية والنوعية. وتعتبر الذرة الشامية، الذرة الرفيعة، الدخن، الأرز ومحصول قصب السكر من العوائل التقليدية، وحديثاً وجد أن القمح عرضة للإصابة بالبودا. تم أجراء تجربة مشتلية بكلية الدراسات الزراعية (شمبات) – جامعة السودان للعلوم والتكنولوجيا خلال الموسم الشتوي 2015-2016 وذلك لدراسة أثر إستخدام السماد النايتروجينية (اليوريا - بجرعة واحدة وجرعتين نايتروجين) والسماد الفسفوري (أمونيوم فوسفات آحادي- بجرعة واحدة أو جرعتين) على نمو البودا في محصول القمح. تم إضافة جرعات الاسمدة عند الزرعة. تم إستخدام القطاعات العشوائية الكاملة في أربعة مكررات. أوضحت النتائج بأن التسميد بالنايتروجين والفسفور، بغض النظر عن الجرعة أدي إلي إنخفاض في معدلات إنبثاق البودا. أدي التسميد بمعدلات 1N و 2N إلي تقليل إنبثاق البودا بنسب 31.3% و 81.3%. بينما أدي التسميد بالفسفور (1P و2P) إلي إنخفاض أنبثاق البودا معنوياً بنسبة 93.8%. أدي إضافة النايتروجين والفسفور معاً في نفس المعاملة (1N+1P و2N+2P) إلي تقليل أعداد البودا والوزن الجاف للبودا بنسب تراوحت مابين 81.3-87.8% و 93%. أظهرت النتائج عدم وجود فروقات معنوية في طول البودا والوزن الجاف للبودا بين المعاملات. أعطت المعاملة الخالية من البودا اعلي طول للنبات. بينما نقص طول القمح معنوياً في المعاملة بالسماد النايتروجيني والسماد الفسفوري. أوضحت النتائج عدم وجود فروقات معنوية في عدد الخلف والوزن الجاف للقمح بين المعاملات. سجلت المعاملة 1N أعلي عدد خلف(7.9 خلفة/ النبات)، بينما أعطت المعاملات 2N و1P أقل عدد خلف (2.8 خلفة/النبات). أدت إضافة جرعة واحدة من النايتروجين (1N)، جرعتين من النايتروجين (2N) وإضافة جرعة واحدة من الفسفور(1P) إلي نقصان الوزن الجاف للقمح معنوياً بنسب تراوحت مابين 65.7-71.6%.

CHAPTER ONE

INTRODUCTION

Wheat (*Triticum aestivum* L.) a Poaceae, is a cereal grain, its center of origin in the South West Asia. Wheat was one of first domesticated food crop and for 8000 year has been the basic staple food of the major Civilizations of Europe, West Asia and North Africa. However, at present it is cultivated worldwide. Cereal grains are a major source of energy, protein, and dietary fiber in human nutrition (Belderok *et al*., 2000). Wheat can provides more than half of calorie requirement in a healthy daily diet. It is also a major source of protein compared with other food as it contributes more than 25 % of the protein in the human diet. Wheat has become the most important source of carbohydrate in the majority of countries in the temperate zone. Wheat straw is used as excellent feed for livestock in under developing countries (Rathore, 2005). The plant is cultivated in about 120 countries of the world. The major wheat producing countries are Australia, Canada, Chain, India, Pakistan, Russia, Ukraine and United States, accounting for over 80 % of the world wheat production (FAO, 2010). In 2010, world production of wheat was 651 million tons, making it the third most-produced cereal after maize (844 million tons) and rice (672 million tons) (Belderok *et al*., 2000).

In Sudan, wheat is becoming the staple food of both urban and rural population. It constitutes the second food grain in the Sudan after sorghum. It is planted in the fertile alluvial soils of the Nile in the Northern and River Nile States where winter is relatively longer and cooler. Since the 1960s, however, wheat production has moved south wards and the crop is now cultivated in the Gezira, White Nile, Gedarif, Kassala and Darfur States. The recent construction of the Hamadab Dam has also lead to an expansion of the area under wheat. Demand for wheat in the past was not very high, <100 thousand tons per annum, because the diet of the majority of the Sudanese population was based on sorghum (Ibrahim *et al.*, 2008). At present, wheat consumption has increased to over one million tons. In 2008, wheat was grown in more than 300.000 ha, with an average productivity of 1.9 million / ha (FAO, 2010).

Witch weeds (*Striga* spp.), root-parasitic plants belonging to the family Orobanchaceae, are considered the most serious biotic factor that threatens cereal production over large parts of sub-Saharan Africa, where they affect more than 40% of cereal crops (Ejeta, 2007). *S. hermonthica* (Del.) Benth is widely regarded as the most damaging parasitic plant species in the world causing serious damage to crops such as maize (*Zea mays* L.), Sorghum, pearl millet (*Pennisetum glaucum* L.*)* upland rice *(Oryza sativa* L.*),* and recently wheat. Losses in cereals yield due to *Striga* damage vary from 10% to complete crop loss, depending on crop variety, climatic conditions and seed infestation level of the soil (Rodenburg *et al.*, 2005). *Striga* infestation could become so sever in all major cereal producing regions of Africa. The recent reports on susceptibility of Wheat to the parasite are rather disquieting (Vasey *et al*., 2005). In Southern and eastern Africa, where *Striga* spp. are prevalent, 5.6 million ha of wheat are farmed annually, yielding 9.3 million tons of grain. Curiously, despite the wide host ranges of most *Striga* spp. within the family Poaceae, there are only isolated field reports of *Striga* spp. infecting wheat (Vasey *et al*., 2005). This might reflect the presence of some level of resistance to *Striga* in this cereal. Alternatively, wheat might produce lower levels of the different host derived signals required for parasite development (Vasey *et al.,* 2005).

Various control methods (e.g., hand-pulling, hoe-weeding, trap- and catch cropping) have been tried out with no conclusive and consistent results for the subsistence farmer. This may partly be due to the difficulty to deplete huge amounts of seeds that have accumulated and continue to accumulate in the seedbank over the years.

Nitrogen and Phosphorus deficiency as well as water stress accentuate the severity of *Striga* damage to the hosts. Striga is particularly a pest of low fertile soil and usually the infection decreases if mineral nutrients, especially nitrogen and phosphorus, are applied in sufficient quantities. High levels of *Striga* infestation are often associated with low soil fertility (Oswald, 2005). 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 present work was designed to study the effects of nitrogen fertilizer as urea and phosphors as mono ammonium phosphates on Striga germination on wheat crop.

CHAPTER TWO

LITEATURE REVIEW

2.1. Wheat adaptation

Wheat is adapted to a wide range of climatic conditions, from temperate to tropical zones. The great wheat regions of the world are found in the temperature zones, between latitudes 30 – 60° N and 25 – 40° S, where the average rain-fall varies between more than 1000 mm (Porter and Gawith, 1999). The crop does not succeed in very warm and humid regions. The optimum growing temperature is 25°C, with minimum and maximum growth temperatures of 3° to 4°C and 30° to 32°C, respectively (Briggle, 1980). Wheat is grown in cool winter season in period from November to March in irrigation sector. In the Sudan, the temperature range for crop survival and from a minimum of 3 – 4° C, an optimum of 25°C and maximum daily temperature a round 35°C or more during maturity (Faki, 1996).

2.2. Striga

2.2.1. Economic important and life cycle

Striga spp. has been a serious problem of cereal and legume crops among farmers in sub-Saharan Africa. 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.

Symptoms displayed by infected hosts include severe stunting of the main stem with the internodes failing to elongate properly, yellowing of leaves, wilting, chlorosis, and increase of root:shoot ratio, reduced photosynthetic rate, increased photorespiration and low grain yield (Parker and Riches, 1993). The impact of witchweed on infected cereals is only partly attributable to competition between host and parasite for resources. The parasite exerts major effects on the host through physiological and metabolic perturbations, including disruption of carbon fixation and partitioning, changes in nitrogen metabolism and alterations in hormones balance (Frost *et al.*, 1997).

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 favourable 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 $^{\circ}$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).

2.2.2. Control Measures

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. 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.

Several control methods against *Striga* species have been recommended such as crop rotation, land fallowing, trap cropping, weeding and use of fertilizers. Others include the use of germination stimulants (Ariga and Berner, 1993), herbicides, host resistance (Radi, 2007), and biological control. Moreover, used alone, none of these methods has given a satisfactory suppression of the parasite.

2.2.2.1. Cultural Methods

These comprise of many of the traditional methods, including hand-pulling, intercropping, crop rotation, trap and catch cropping, and nitrogen fertilizers.

2.2.2.1. 1. Hand-weeding

Hand-weeding is the most widely practiced used control method against *Striga* and it is recommended to prevent seed set and seed dispersal. It is necessary to prevent seed production and reinfestation of the soil (Teka, 2014). Due to high labour costs in repeated hand-pulling of *Striga*, it is recommended that hand-pulling should not begin until 2-3 weeks after *S. hermonthica* begins to flower to prevent seeding (Parker and Riches, 1993). Hand-pulling will usually need to be continued for 3-4 years and is most economical on the least infested fields. It is always recommended as a supportive treatment (Parker and Riches, 1993).

2.2.2.1.2. Intercropping

Intercropping is a potentially viable, low cost technology, which would enable to address the two important and interrelated problems of low soil fertility and *Striga* (Fasil, 2002). Intercropping with a false host crop that stimulates *Striga* seed germination without being itself attacked or parasitized, has been thought as a method for depletion of *Striga* seed reserves in soil (Parker and Riches, 1993). Intercropping cereals with legumes and other crops is a common practice in most area of Africa, and has been reported as influencing *Striga* infestation (Teka, 2014).

Parker and Riches (1993) attributed the suppressive effects of intercropping to several factors, including its action as a trap-crop, interference with production of germination stimulants, exudation of germination inhibitors and/or reduction of the parasite transpiration, through decreasing air temperature and increasing humidity. In common with most parasitic weeds *Striga* species have high transpiration rate, associated with stomata which remain open under most if not all conditions (Shah *et al*., 1987).

2.2.2.1.3. 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 (Teka, 2014). The choice of rotational crop should therefore be based 1st on its suitability to the local conditions and only secondarily on its potential as a trap crop (Parker and Riches, 1993).

Practical control measures are effective when a combined program of crop rotation, weeding, sanitation and resistant varieties is included (Teka, 2014).

2.2.2.1.4. Trap and Catch Crops

The use of trap and catch crops that induce the germination of *Striga* but are not themselves parasitized is currently one of the best methods to control agricultural root parasites.

Trap crops cause suicidal germination of the weed, which reduces the seed bank in the soil (Teka, 2014). Common cultivated trap crops include cotton (*Gossypium barbadense*), groundnut (*Arachis hypogaea*), soybean, pigeonpea (*Glycine max*), green or black gram (*Vigna mungo*), lucerne (*Medicago sativa*), sunflower (*Helianthus annuus*) and sesame (*Sesamum indicum*) (Babiker, 2007). Weerasuriya *et al.* (1993) reported that production of *Striga* germination stimulants and concomitantly the efficiency of the false host may be influenced by edaphic and climatic conditions.

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

(Teka, 2014). It is another mean of depleting *Striga* seed reserves in soils. Contrary to trap cropping, which relies on false hosts, catch cropping employs true hosts of the parasite. A thick planting of Sudan grass at 20-25 kg seed per hectare should be sown and either ploughed in or harvested for forage at 6-8 weeks before *Striga* seeds. The main crop could then be planted during the main rains (Parker and Riches, 1993). 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.

2.2.2.1.5. Improving soil fertility

Parasitic plants have acquired the ability to obtain nutrition from host plants and have adapted to prefer less fertile soil (Abu-Irmaielh, 2008). Nitrogen and phosphorus deficiency as well as water stress accentuate the severity of *Striga* damage to the hosts (Teka, 2014). *Striga* is particularly a pest of low fertile soil and usually the infection decreases if mineral nutrients, especially nitrogen and phosphorus, are applied in sufficient quantities. High levels of *Striga* infestation are often associated with low soil fertility. Yoneyama *et al.,* (2007) showed that growing sorghum, a host of both *Striga hermonthica* and AM fungi, in soil deficient in both nitrogen (N_2) and phosphorus (P) markedly enhanced the secretion of the strigolactone, 5-deoxystrigol which is one of the major SLs produced by sorghum hybrids (Awad *et al.*, 2006). AMF play a pivotal role in supplying mineral nutrients, particularly phosphorus to their host plants (Harrison, 2005). Up to 80% of applied phosphorus is not available to plants because it is fixed in the soil due to interactions with other ions which leads to low mobility in the soil and, plants rapidly create a depletion zone for phosphorus around their roots. The fine external hyphae of MA fungi facilitate phosphorus uptake by extending beyond the depletion zone. A root associated with AM fungi transport phosphorus at a rate more than four times higher than that of a root without AM fungi (Epstein and Bloom, 2005).

Several reports have shown that nitrogen at high rates suppresses *Striga* infestation, while at low rates it enhances emergence of the parasite (Bebawi, 1987). However, results of field trials across countries and locations have not been consistent in term of host crop yield or *Striga* numbers (Parker and Riches, 1993). These variations, which may be associated with intrinsic soil or crop variety characteristics, make recommendation of nitrogen as a sole treatment for *Striga* control difficult.

Nitrogen is believed to reduce stimulant production. Root exudate from sorghum grown in hydroponic cultures was considerably more active at 0 mg N/L than at 30 mg N/L. Root exudate produced at 150 mg N/L failed to induce *Striga* seed germination (Raju *et al.,* 1990). Furthermore, possible direct suppressive effect of high nitrogen rates on *Striga* growth was revealed by Igbinnosa, Cardwell and Okonkow (1998). Nitrogen is found in many organic compounds including amino acids and nucleic acids, and thus plants require greater amounts of nitrogen than any other mineral nutrients except for carbon and oxygen (Epstein and Bloom, 2005). The atmosphere contains vast quantities of molecular nitrogen (N_2) about 78% by volume; however, most organisms can't directly access this huge reservoir because of the exceptionally stable triple covalent bond between the two nitrogen atoms. Only certain bacteria can convert atmospheric nitrogen into ammonium, and among them, *Rhizobia* are well known to form symbiotic associations with leguminous plants. AM fungi, benefiting plants by aiding in P uptake from soil, take up and transfer significant amount of nitrogen to their host plants (Hodge, 2006). It was suggested that in sorghum, a non-leguminous plants, N deficiency as well as P deficiency enhances strigolactone exudation, suggesting that non-leguminous plants depend on AMF symbionts for the supply of both N and P (Yoneyama *et al*, 2007).

Sorghum plants exude small amount of 5-deoxystrigol under sufficient nitrogen and phosphorus availability. Accordingly, increasing soil fertility with fertilizers or AMF infestation should decrease exudation of germination stimulants by host plants and that should curtail *Striga* infestation. Nitrogen is believed to reduce stimulant production. Several reports have shown that nitrogen at high rates, suppresses *Striga* infestation (Bebawi, 1987), while at low rates it enhances emergence of the parasite (Osman *et al*., 1991). Mumera (1983) recorded a 64% reduction in *S. hermonthica* emergence in maize using 39 kg N/ ha^{-1} as calcium ammonium nitrate (CAN). Studies in western Kenya show that CAN at 0-140 kg N /ha-1 had no significant effect on maize yield but reduced *Striga* populations. Farmyard manure trials indicated that 100 t/ha^{-1} reduced *Striga* counts and increased maize yield. Mumera and Below (1993) found that although *Striga* infection generally declined with increasing N availability, the impact was partially dependent on the severity of infestation. Application of high dosage of nitrogen fertilizer is generally beneficial in delaying *Striga* emergence and obtaining stronger crop growth (Dugie *et al*., 2008). Also other advantageous effects of fertilizers include increasing soil nitrogen and other nutrients, replenishing the organic matter of the soil and increasing soil moisture holding capacity (Ikie *et al*., 2006). However, results of field trials across countries and locations have not been consistent in term of host crop yield or *Striga* numbers (Parker and Riches, 1993). These variations, which may be associated with intrinsic soil or crop variety characteristics, make recommendation of nitrogen as a sole treatment for *Striga* control difficult.

CHAPTER THREE

MATERIAL AND METHODS

3.1. General:

Green house experiment was undertaken at the College of Agricultural Studies, Sudan University of Science and Technology (SUST) at Shambat, to determine the the effect of nitrogen(urea) and phosphours fertilizers on *S. hermonthica* germination on wheat crop.

3.2. Materials

3.2.1. Plant Materials

The seeds of wheat cultivar, (cv.Wadi Elnile), was obtained from the Agricultural Research Corporation (ABC), Wad-Medani, Sudan.

3.3. Methods:

Pot experiment was conducted at the College of Agriculture Studies (CAS), at shambat during the season 2015-2016.The experiment was conducted under artificial *S .hermonthica*. The experiment was conducted under artificial *S. hermonthica* infestation. Artificial infestation of soil was achieved by mixing 2g of *Striga* seeds with 1kg soil, followed by subsequent dilution with *Striga* free soil to give the required infestation level (32 mg / pot). *Striga* free or infested soil was placed in plastic pots (9 cm i .d) with perforations at the bottoms. Pots filled with *Striga* free soil (0 mg) were included as control for comparison. Wheat seeds (5/pot) were sown early December at 2 cm soil depth. The pots were immediately irrigated. Subsequent irrigations were carried out every two days. Wheat seedlings were thinned to three plants per pot two weeks after sowing. Nitrogen as urea at 40 kg/fed [18.6 kg N/fed (1N)] and 80 kg urea/ fed [37.2 kg N/fed (2N)] was applied at sowing. Phosphorus as Mono ammonium (12-61-0) phosphate at 1P and 2P also was applied at sowing. *Striga* free and infested fertilized or unfertilized were included as control for comparison. Treatments shown in Table (3.1). Treatments were arranged in a Randomized Complete Block Design (RCBD) with four replicates.

Table 3.1. Treatments in the experiments

Number	Treatments
1	Un-infested control
2	Control -0N0P
3	1N
4	2N
5	1P
6	2P
7	1N1P
8	2N2P

- **N: (Nitrogen) P: (Phosphor)**

3.4. Data Collection

3.4.1. Striga

Data collected on *S. hermonthica* included number of *Striga* emergence per pot and Striga dry weight (g). The *Striga* emergence was collected 100 days after wheat sowing from each pot, oven dried at 80^{o}C for 48 hours and then the dry weight of Striga (gram) was recorded

3.4.1. Wheat

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

Plant height (cm), number of tillers per plant, and wheat dry weight (g).

Dry weight (g):

The three plants were harvested from each pot, oven dried at 104^{o}C for 48 hours and then the dry weight (gram) was recorded.

3.5. 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.

CHAPTER FOUR
RESULTS

4.1. Effects on Striga

4.1.1. Striga emergence

The results of analysis of variance showed significant differences in number of *Striga* emergence between the treatments (Appendix 1). Unfertilized treatment (control- 0N0P) displayed highest number of *Striga* emergence (4 plants /pot). Nitrogen at 1N reduced *Striga* emergence by 31.3%, but not significantly as compared to the control (Table 4.1). However, increasing nitrogen dose to 2N reduced *Striga* emergence significantly. Phosphors at 1P and 2P displayed significant reduction in *Striga* emergence by 93.8%. Nitrogen at 1N combination with phosphors at 1P reduced significantly *Striga* emergence by 87.7%, as compared to the control (Table 4.1).The combination Nitrogen (2N) and phosphors (2P) reduced emergence by 81.3%, as comparison to the unfertilized treatment (Table 4.1).

Table 4.1. Effect of nitrogen and phosphors fertilizers on *Striga* emergence

Treatments	Number of *Striga* /pot
Control -0N0P	4.00 a
1N	2.75 a
2N	0.75 b
1P	0.25 b
2P	0.25 b
1N1P	0.50 b
2N2P	0.75 b
LSD	2.08

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

4.1.2. Length and dry weight of Striga

According the statistical analysis it was clear that there were no significant differences in *Striga* length between the treatments (Appendix 2). Nitrogen at 1N displayed highest *Striga* length (7.6 cm). However, nitrogen at 1N combination with phosphors at 1P (1N+1P) sustained lowest *Striga* length (1.5 cm) (Table 4.2).

The results of analysis of variance showed non- significant differences in *Striga* dry weight between the treatments (Appendix 3). Unfertilized treatment (control-0N0P) displayed highest *Striga* dry weight (0.98 g). Application with nitrogen and phosphors, irrespective of doses, reduced *Striga* dry weight, but not significantly ((Table 4.2). Nitrogen combination with phosphors, irrespective of doses reduced significantly *Striga* dry weight by 93%, as compared to the Unfertilized control (Table 4.2).

Table 4.2. Effect of nitrogen and phosphors fertilizers on *Striga* length and *Striga* dry weight.

Treatments	*Striga* length (cm)	*Striga* dry weight (g)
Control -0N0P	6.3a	0.98a
1N	7.6a	0.57a
2N	2.5a	0.62a
1P	6.5a	0.07a
2P	5.0a	0.18a
1N1P	1.5a	0.05a
2N2P	5.9a	0.05a
LSD	10.9	0.9

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

4.2. Effects on wheat

4.2.1. Plant height and Number of Tillers

The results of analysis of variance showed highly significant differences in wheat height between the treatments (Appendix 4). Combination nitrogen and phosphors, irrespective of doses, increased plant height by 31.8-65.9%, but not significantly, in comparison to the *Striga* free control (Table 4.3). In *Striga* infested soil and in absence of added nitrogen and phosphors (0N0P), *Striga* reduced plant height significantly by 50.6%, in comparison to the *Striga* free control (Table 4.3). Nitrogen at 1N and 2N, and phosphors at 1P and 2P, reduced plant height significantly by 40-78.8% and 67.1-83.5%, respectively, as compared to the *Striga* free control (Table 4.3).

Analysis of variance showed that non-significant difference (P = 0.05) in number of tillers per plant between the treatments (Appendix 5). In absence on nitrogen and phosphors, *Striga* reduced number of tillers by 13.6%, but not significantly, as compared to the control (Table 4.4). The result showed that the application of nitrogen at 1N gave highest number of tillers (7.9 tillers/ plant), increased by 79.5%, over the control. However, application by nitrogen at 2N and phosphors at 1P displayed lowest tillers (2.8 tillers /plant) (Table 4.3).

Table 4.3. Effect of nitrogen and phosphors fertilizers on plant height and number of tillers.

Treatments	Plant height (cm)	Number of tillers/plant
Un-infested control	17.0bc	4.4a
Control -0N0P	8.4d	3.8a
1N	10.2cd	7.9a
2N	3.6d	2.8a
1P	2.8d	2.8a
2P	5.6d	5.6a
1N1P	22.4ab	4.4a
2N2P	28.2a	5.6a
LSD	8.5	6.6

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

4.2.2. Wheat dry weight

The results of analysis of variance showed non- significant differences in wheat dry weight between the treatments (Appendix 6). Application by combination nitrogen at 1N and phosphors at 1P (1N+1P) sustained highest wheat dry weight (14.5 g), increased by 42.2%, over the un-infested- control (Table 4.4). In absence on nitrogen and phosphors, *Striga* reduced wheat dry weight by 92%, as compared to the un-infested- control (Table 4.4).The results showed that application by phosphors at 2P and combination nitrogen at 2N with phosphors at 2P (2N+2P), reduced wheat dry weight, but not significantly, as compared to the *Striga* free control (Table 4.4). Application by nitrogen at 1N and 2N, reduced wheat dry weight significantly by 71.6 and 65.7%, respectively, as compared to the *Striga* free control (Table 4.4). Phosphors at 1P reduced wheat dry weight significantly by 69.6%, as compared to the control (Table 4.4).

Table 4.4. Effect of nitrogen and phosphors fertilizers on Wheat dry weight.

Treatments	Wheat dry weight (g)/pot
Un-infested control	10.2a
Control -0N0P	0.8b
1N	2.9b
2N	3.5b
1P	3.1b
2P	7.7ab
1N1P	14.5a
2N2P	9.1ab
LSD	10.8

Means within a column 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 reduce crop yield and quality and present a serious threat to food security in many areas across the world (Parker and Riches, 1993). Parasitic plants have acquired the ability to obtain nutrition from host plants and have adapted to prefer less fertile soil (Abu-Irmaielh, 2008). Nitrogen and phosphorus deficiency as well as water stress accentuate the severity of *Striga* damage to the hosts (Teka, 2014). The results of green house experiment revealed that wheat induced germination of *S. hermonthica.* Similar findings were reported by Vasey *et al*., (2005) and Sahar (2014).Vasey *et al*., (2005) reported that *Striga* spp. require the presence of multiple stimulants derived from the host to trigger germination, haustorium formation, and subsequent development, and all these signals are present in wheat. The results of analysis of variance showed significant differences in number of *Striga* emergence between the treatments. Nitrogen and phosphors, irrespective of doses, reduced *Striga* emergence significantly by 31.3-83.3% and 93.8%, respectively and this is consistent with that reported by Bebawi (1987) and Mumera (1983) recorded a 64% reduction in *S. hermonthica* emergence in maize using 39 kg N/ ha^{-1} as calcium ammonium nitrate (CAN). Mumera and Below (1993) found that although *Striga* infection generally declined with increasing N availability, the impact was partially dependent on the severity of infestation. Application of high dosage of nitrogen fertilizer is generally beneficial in delaying *Striga* emergence and obtaining stronger crop growth (Dugie *et al*., 2008). *Striga* is particularly a pest of low fertile soil and usually the infection decreases if mineral nutrients, especially nitrogen and phosphorus, are applied in sufficient quantities. High levels of *Striga* infestation are often associated with low soil fertility. Several reports have shown that nitrogen at high rates suppresses *Striga* infestation, while at low rates it enhances emergence of the parasite (Bebawi, 1987). Nitrogen is believed to reduce stimulant production. The results showed that in *Striga* infested soil and in absence of added nitrogen and phosphors (0N0P), *Striga* reduced plant height and wheat dry weight significantly by 50.6 and 92.2%, respectively, in comparison to the *Striga* free control. *Striga* reduced number of tillers by 13.6%, but not significantly. Similar results were obtained by Sahar (2014). This is a common effect of *Striga* infection on other cereals, such as maize and sorghum. In general, *S. hermonthica* can affect its host in different ways. Only part of the reduction in growth of the host results from competition for carbon assimilates, water, mineral nutrients and amino acids (Graves *et al*., 1990).

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APPENDICES

Appendix 1: Analysis of variance of Number of *Striga*

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	3	6.964	2.3214		
Treatments	6	64.714	10.7857	5.50	0.0022*
Error	18	35.286	1.9603		
Total	27	106.964			

* Significant differences at 5 % probability level

Appendix 2: Analysis of variance of *Striga* length

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	3	211.05	70.3510		
Treatments	6	119.40	19.8999	0.37	0.8882 Ns
Error	18	966.77	53.7096		
Total	27	1297.22			

Ns: Not significant differences at 5 % probability level

Appendix 3: Analysis of variance of *Striga* dry weight

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	3	0.43536	0.14512		
Treatments	6	2.31357	0.38560	1.11	0.3948Ns
Error	18	6.25214	0.34734		
Total	27	9.00107			

Ns: Not significant differences at 5 % probability level

Appendix 4: Analysis of variance of plant height

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	3	147.91	49.302		
Treatments	7	2437.19	348.171	10.43	0.0000***
Error	21	701.27	33.394		
Total	31	3286.37			

* Highly Significant differences at 5 % probability level

Appendix 5: Analysis of variance of number of tillers

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	3	85.938	28.6458		
Treatments	7	79.505	11.3579	0.56	0.7783Ns
Error	21	424.717	20.2246		
Total	31	590.1660			

Ns: Not significant differences at 5 % probability level

Appendix 6: Analysis of variance of wheat dry weight

Source of variation	Degree of Freedom	Sum of Squares	Mean Square	F. Value	P
Replication	3	320.89	106.962		
Treatments	7	520.40	74.343	1.38	0.2641Ns
Error	21	1129.71	53.796		
Total	31	1971.00			

Ns: Not significant differences at 5 % probability level