INFLUENCE OF WEED CONTROL, POULTRY MANURE AND PLANT DENSITY ON THE PERFORMANCE OF MAIZE (*Zea mays* L.) IN THE NORTHERN GUINEA SAVANNA ZONE OF NIGERIA

BY

Musa Bature, SALISU
B. Agric Tech. (ATBU, 1997), M.Sc. Agronomy (ABU, 2005)
Ph.D/AGRIC./180/2011-2012

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (Ph. D) IN AGRONOMY

DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
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DECLARATION

I hereby declare that this worktitled 'INFLUENCE OF WEED CONTROL, POULTRY MANURE AND PLANT DENSITY ON THE PERFORMANCE OF MAIZE (*Zeamays* L.) IN THE NORTHERN GUINEA SAVANNAZONE OF NIGERIA' has been conducted by me in the Department of Agronomy under the supervision of Prof. D. B. Ishaya, Dr. M. A. Mahadi and Dr. A. I. Sharifai. The information derived from the literature is duly acknowledged in the text and list of references provided. No part of this dissertation was previously presented for the award of another Degree or Diploma at any university or higher institution of learning.

Musa Bature, SALISU ---------- ----------

(Signature) (Date)

The above declaration is confirmed by

_____ _____

Prof. D. B. Ishaya (Date)

Chairman, Supervisory Committee

CERTIFICATION

This thesistitled ‘INFLUENCE OF WEED CONTROL, POULTRY MANURE AND PLANT DENSITY ON THE PERFORMANCE OF MAIZE (*Zeamays* L) IN THE NORTHERN GUINEA SAVANNAZONE OF NIGERIA’ by Musa Bature, SALISU meets the regulations governing the award of the Doctor of Philosophy in Agronomy of Ahmadu Bello University, Zaria and is approved for the contribution to knowledge and literary presentation.

_____ Date _____
Prof. D. B. Ishaya
Chairman, Supervisory committee

_____ Date _____
Dr. M. A. Mahadi
Member, Supervisory Committee

_____ Date_____
Dr. A. I. Sharifai
Member, Supervisory Committee

_____ Date _____
Dr. M. A. Mahadi
Head, Department of Agronomy

_____ Date_____
Prof.S. Z. Abubakar
Dean, Postgraduate School

DEDICATION

This work is dedicated to my late parents; Alhaji Salisu Bature Chalawa and Hajiya Maimuna Chalawa, my children, my wives (A'ishatu Abdullahi and A'ishatu Magaji) and all other members of my family, for the support, inspiration and understanding given to me during the course of the study.

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Finally,I thank Almighty Allah for enabling me to complete this terminal degree, and return all the glory and honor to him.

ABSTRACT

Field trials were conducted during the rainy seasons of 2012 and2013 at the Research Farms of the Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria and the College of Agriculture and Animal Science, Mando Kaduna, in the northern Guinea savanna zone of Nigeria. The treatments consisted of six levels of weed control (S-metolachlor + atrazine at 1.98 and 2.64 kg a.i/ha (primextra gold), butachlor at 1.5 and 2.5 kg a.i/ha (teer), hoe weeding at 3 and 6 weeks after sowing (WAS) and weedy check), three levels of poultry manure (0, 4 and 8 t/ha) and two plant densities (singleand double rowsper ridge). The experiment was laid out in split plot design and replicated three times. Weed control and poultry manure were assigned to the main plots, while plant density was assigned to the sub-plots. Application of S-metolachlor + atrazine at 2.64kg a.i/ha, butachlor at 2.5kg a.i/ha and hoe weeding at 3 and 6 WAS significantly reduced weed population and increased the growth and yield attributes of maize, such as, plant height, crop vigour score, leaf area index, crop growth rate, shoot dry matter, cob weight, cob length, number of seeds per row, number of seeds rows per cob, 100-Grain weight and grain yield. Application of poultry manureat 4 and 8t/ha, resulted in significant increase of total grain yield of maize. Double rows plant density (double rows per ridge) significantly suppressed weed compared with the singlerow density(single row per ridge) and this resulted in lower weed cover score, weed dry weight than that obtained in the single plant density and it also resulted in higher grain yield of maize. Significant correlations were observed between grain yield with stand count at harvest, crop vigour score, plant height, shoot dry matter,crop growth rate, cob length and 100-Grain weight of maize at both Samaru and Mando in both 2012 and 2013. Negative correlations were observed between grain yield withweed cover score and weed dry weight. When the total correlation was partitioned into direct and indirect contribution, plant height(0.4796) and cob length (0.4007) both at Samaru in the meanhad the highest positive direct effect to grain yield, while crop vigour score at Samaru in the mean (0.606)had the least direct effect. The highest indirect effect to grain weight was from shoot dry matter(0.4910) at Mando in 2013 and the least indirect effect was from100-Grain weight(-0.006) at Samaru 2012. The per cent contribution of individual parameters to grain yield, recorded the highest value of (41.12%)with plant height at Mando in 2013 on grain yield, while crop vigour score at Mando in 2012 (0.01%),had the least per cent contribution.The highest positive combined contribution was made from plant height through crop growth rate (59.21%) at Mando in 2013, while crop vigour score through cob length(0.01%) made the least combined contribution in 2012 at Mando. The per cent contributionsnot accounted for were 7.75, 21.1, 4.32, at Samaru in 2012, 2013 and the mean, and 27.27, 12.3 and 14.91 at Mando also in both 2012, 2013 and mean, respectively. Regression analysis indicated that, response of poultry manure to grain yield was linear. Based on the result obtained, it can be concluded that application of S-metolachlor + atrazine at 2.64 kg .i/ha, butachlor at, 2.5 kg a.i/ha, with 8t/ha of poultry manureusing double plant density(double rows per ridge) which gave better weed control and higher grain yield of maize is recommended for northern Guinea savanna of Nigeria.

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LIST OF ABBREVIATIONS

S/NO	Abbreviation	Meanings
1.	NPK	Nitrogen Phosphorus Potassium
2.	ANOVA	Analysis of Variance
3.	CGR	Crop Growth Rate
4.	cm	Centimeters
5.	DMRT	Duncan's Multiple Range Test
6.	Dr.	Doctor
7.	EC	Emulsion concentration
8.	IVI	Importance Value Index
9.	Kg/ha	Kilogram per hectare
10.	Kg a.i/ha	Kilogram active ingredient per hectare
11.	Ha	Hectare
12.	HI	Harvest Index
13.	LAI	Leaf Area Index
14.	PAR	Photo synthetically active radiation
15.	PD	Plant Density
16.	PM	Poultry manure
17.	SP	Shelling percentage
18.	SE	Standard Error
19.	SDM	Shoot Dry Matter
20.	T/ha	Tonnes per hectare
21.	WAS	Week After Sowing
22.	WC	Weed Control

CHAPTER ONE

1.0 INTRODUCTION

1.1 Origin and Distribution

Maize (*Zea mays* L.), is one of the world most important crop. It is the cereal with the highest yield potential (Anon.2017). Maize is a cereal crop that is grown widely throughout the world in a wide range of ecological environments (Prathyusha *et al*., 2013). It is the most important cereal crop of the world after wheat (*Triticum aestivum)* and rice (*Oryza sativa*) (Imran *et al*., 2015). It is believed to have originated from Central America and Mexico and spread to northern France,North Africa and into Italy and southern Europe.ThePortuguese introduced maize into West Africa (Uche and Eruotor, 2012). More maize is produced annually than any other grain crops and about 50 species exist and differ in colour, texture and grain shape and size.White, yellow and red are the most common types. The white and yellow varieties are preferred by most people depending on the region. Maize was introduced into Africa in the 1500s and has since become the Africa's dominant food crop (IITA, 2009).

1.2 Production and Uses

World-wide production of maize in 2016 was 1070.5 million tons with the highest producer being the United States of America (USDA, 2014).In 2014, the Nigerian maize total production was 10,999,500 metric tons from 5,780 hectares, giving average yield of 1.9 tons per hectare. The three top leading states in maize production in Nigeria are Kaduna (413.900 ha giving 729.699 metric tons with an average yield of 1.7 tons/ha) followed by Niger State (394,100 ha, giving 628,073metric tons, with average yield of 1.95 tons/ha) and Plateau States (284.800 haproducing 601,530 metric tons, with average yield of 2.46 tons/ha) (Anon., 2014).

The important maize producing countries in Africa, in order of decreasing importance, are South Africa, Nigeria, Tanzania, Kenya, Zimbabwe, Cote d'Ivoire, Mozambique and Democratic Republic of Congo (Uche and Eroutor, 2012). Ado *et al*. (2001) reported that maize is grown across the ecological zones of Nigeria.

Maize is the most important cereal crop in sub-Saharan Africa and an important staple food for more than 1.2 billion people in the region and also Latin America (IITA, 2012). All parts of the maize plant are of economic importance; the grain,leaves, stalk, tassel and cob can all be used to produce large variety of food and non-food products(Oyelade and Awanane, 2013). It is one of the most important food crop in Nigeria and most dominant grain crop in the savanna zone. It is consumed as fresh vegetable in the forest belt (Onyibe *et al.*, 2014).

Maize is utilized both as raw materials in feed mills and beverage industry and as a domestic crop for producing an array of recipes prepared out of maize flour and grains. Green cobs are roasted or boiled and eaten (Singh *et al.*, 2003), while the grain are milled in to flour or grits for production of breakfast cereal, pudding, soup, fermented paste and couscous. Maize grains are processed into livestock feed for production of meat, milk, egg and other animal products. The leaves and stalks are fed to livestock as silage, hay or fodder (Anon.2004). Industrially,maize is important for the production of starch, oil and alcohol such as gin, whisky and beer (Uche and Eruotor, 2012). The grain is rich in vitamins A, C and E, carbohydrate, essential minerals and contains protein, and it is rich source of dietary fibre and calories, which are good source of energy (IITA, 2009).

1.3 Edaphic and Climatic Requirements

The ideal soil for maize is a deep, medium textured, well drained fertile soil with high water holding capacity. Clay and sandy soils are not very conducive for its growth. It can be grown

in soils with a acidity of between pH 5.5 and 8.0, although the optimum range is 5.5 – 7.0 (Onwueme and Sinha, 1999). It grows well on loose sandy loams with adequate organic matter (Opeke, 2006).

Maize requires considerable moisture and warm weather from germination to flowering. The most suitable temperature for germination is 21^{o}C and 32^{o}C for growth. Extremely high temperature and low humidity, during tasselling can damage the foliage, desiccate the pollen grains and interfere with pollination, resulting in poor grain formation (Singh *et al*., 2003). The best regions for maize production are those which receive an annual rainfall of 600 - 1000mm. The crop is apparently more drought-resistant at the early stage of growth than when fully developed and it is very sensitive to excess water and waterlogging.The submergence of the soil for 3-5 days during the seedling or flowering periods reduces the yield considerably (Onwueme and Sinha,1999).

1.4 Production Constraints

Maize yield potential is high in savanna zone compared to forest zone(Kassam *et al.,* 1975). Despite the high yield potential, the average yield per hectare in Nigeria is still relatively low even with the use of hybrid seed and mechanized system of farming.Although, yield of maize can be up to 10.2 tonnes per hectare on research farms, under traditional Africa production system, production is 2.1 tonnes per hectare (Darlinton, 2015). The factors responsiblefor this are uneven distribution and inadequate rainfall, use of low yielding varieties, and non availability or exorbitant cost of fertilizer for optimum production of the crop (Tarfa *et al.,*2003). In the Nigerian savanna, poor soil fertility, drought and S*triga hermonthica* parasitism can reduce yield by over 70%, even with the use of high yielding varieties (Oikeh *et al.,*2003). Nitrogen is the most deficient nutrient in the soil and most often limits maize

yield (Carsky and Uwuafor, 1995). The relative high demand for nutrientsby maize particularly N, makes it necessary that adequate supply of nutrient fertilizer be made promptly in order to attain and maintain high yield (Onwueme and Sinha, 1991). Weed competition is detrimental to growth and yield of maizeespecially during the early growth period (3–4WAS)due to its slow growth. Maximum weed competition in maize occurs during the period of 2 – 6 WAS (Anon. 2012).*Striga hermonthica* is the most devastating and destructive weed of maize which is capable of wiping out an entire crop (Johnson *et al*., 1997). There are many species of *Striga* but *Striga hermonthica* is said to be responsible for more crop loss in Africa than any other individual weed species (Ahom*et al.,* 2014). It is estimated that over 5 million hectares of sorghum, millets and maize have been infested in six countries of West Africa such as Nigeria,Niger,Ghana, Gambia,Benin and Barkina Faso.(Saueborn, 1991).One plant of *Striga hermonthica* per host is estimated to cause approximately 5% yield losses (Parker and Riches, 1993), while high infestation that is about 20*Striga*plant/host can cause total crop failure (Ahom *et al.*, 2014). The damaging effect of S. *hermonthica* on maize plant derives not only from the direct loss of water, minerals, nitrogen and carbohydrate to the parasite but from a disturbance of the host photosynthetic efficiency and a profound change in root/shoot balance of the host leading to stimulation of the root systems and stunting of the shoot (Press and Graves, 1991).

Water availability is the most critical factor in sustaining crop production in rainfed agriculture. Even if drought-tolerance trait is introduced, if the moisture is not adequate to the crop this can pose crop production risk (IFPR. 2010).

1.5 Justification

Among cereals, maize is the most common and important food crop across Africa (Anon. 2015). Its expanded use in agro-industriesmakes it recognized as a leading commercial crop of high agro-economic value (Muhammed *et al.*,2004). Despite the expansion in production areas, maize yields onfarmers'fields is withinan averageof 2.1 tons per hectare in contrast to the higher yields of about 10.2 tons per hectare (Darliton, 2015). Among the various biotic and abiotic factors which cause reduction in crop yields, weeds, nutrient deficiency and drought are the most important in the Sudanand Sahel zones of Nigeria (Anon. 2004). These factors constitute the major constraints to maize production particularly in the northern Guinea savanna of Nigeria where maize is mostly produced.

Soils in the savanna are mainly Kaolinitic Afisols that are low in organic matter and cation exchange capacity (Casky and Iwuafor, 1995). Nitrogen is the most important nutrient in maize production and maize is a heavy feeder particularly in terms of mineral N. Due to low plant nutrients in West Africa's soils, thecrop cannot be grown without the application of some forms of mineral or organic inputs (Kamara, 2013). The traditional practices aimed at meeting crop nutrient needs like shifting cultivation and extended fallow period employed to restore fertility of savanna soils are no longer sustainable, hence continuous cropping is the common practice. Consequently nutrients and organic matter in the soil havekept depleting and crop yields steadily decreased.

However, because of the increasing population pressure whichcauses the intensification of land use and continuous cropping in order to provide food for the nation, the use of fertilizer has become necessary to restore the depleted nutrients in the soil. But due to high cost and scarcity of supply, inorganic fertilizer use in sub-Saharan Africa is generally limited. An

approach has been taken to improve maize productivity in areas with low nitrogen fertility, through breeding crop varieties that demand low nitrogen (Smith*et al.,* 1995).

Weed as biotic factor, is a big problem in crop production. Grain yield reduction of between 69% and 92% due to weed competition was commonly recorded Akobundu (1987). Non-parasitic weeds have effective control methods since the competition with the crop plants started when they appear physically (after emergence).Parasitic weed like *Striga* which can grow for 4–6 weeks under ground before emergence is very difficult to control (Ahom *et al*., 2014).Lagoke *et al*. (1999) reported that, cereal yield loss caused by *Striga hermonthica* in Nigeria is between 10 to 100% depending on its incidence,level of infestation and distribution,crop variety,location and cultural practice in use.

As soon as the *Striga* germinates a germ tube (an outgrowth produced by spore of spores-releasingorganism during germination), which is in close proximity to the host roots, elongates towards the root of the host. The haustorium, serves as a bridge between the parasite and its host, and it is the channel through which *Striga* deprives host plant of water, mineral nutrients and carbohydrates for the host, causing drought stress and wilting of the host, stunted shoot growth, leaf chlorosis and reduced photosynthesis which contributes to reduction in grain yield (Frost *et al*., 1997). Reda *et al*. (1996) and Lagoke *et al*. (1997) reported that no single method is capable of ensuring sustainable *Striga* control.

The various methods of controlling *Striga* among others are preventive method such as; planting uncontaminated seeds, clean soil and plant debris off machinery, shoe, clothing and tools before entering *Striga* free fields after working on the *Striga* fields (Johnson *et al.*,1997). After the emergence of the parasitic weeds if the populations are low, mechanical measures

can be used such as, hand weeding and hand pulling are also used before seeds are produced(Das, 2008).*Striga* has been controlled through the use of several management strategies including quarantine imposed on affected areas, control of movement of farm implements between infested and uninfested areas, herbicide application and imposed suicidal germination using ethylene gas. Other methods such as trap cropping which involves planting a species in an infested field that will induce *Striga* seeds to germinate but will not support attachment of the parasite. This method has been used in sorghum farm by planting *Celosia argentia* between sorghum stands (Olupot *et al*., 2003). Intercropping cereals crop with legumes has been reported as influencing *Striga* infestation (Ahom *et al*., 2014).Recent results showed that intercropping maize with cowpea and sweet potato can significantly reduce the emergence *Striga* in Kenya (Oswald *et al*.,2002). It was also discovered in Kenya,that inhibition *Striga hermonthica* was significantly greater in maize-silverleaf (*Desmodium incanatum*) than that observed with other legumes,e.g.sun hemp (*Crotalaria* spp),soybean or cowpea (Khan *et al*.,2000).Consequently, the yield of maize was significantly increased by two tonnes per hectre (Ahom *et al*.,2014). *Desmodium* species are legumes that can easily be controlled by regular cutting in order to avoid or minimize the competition with the crop,if any (Ahom *et al*.,2014).The mechanisms by which *Desmodiumincanatum* reduce *Striga* infestation in intercropping was found to be the allelopathic effect in inhibiting the development of haustoria of *Striga* (Khan *et al*.,2001). The used of *Desmodium* spp is very effective in *Striga hermonthica* in maize intercrops (Khan *et al*., 2006). These measures are also effective in controlling *Striga*in maize field: crop rotation, early or late sowing, increasing N dose in the soil, use of atrazine,chlorosulfuron and 2,4-D as chemical control

measures and biological methods such as the use of *Fusarium oxysporum* was found to infect only *Striga* spp and none of the crop tested (Ciotola *et al.,* 2000).

Increasing nitrogen levels in the soil, growing tolerant varieties and trap cropping, and early planting of susceptible crops harvested before witchweed seed is produced can also be used(Sand *et al*., 1990). It is thus suggested that an integration of *Striga* control methods as a package that involves the use of appropriate trap crop in mixture with resistant/tolerant cereal crops will go a long way in reducing *Striga* infestation (Lagoke *et al*., 1999).

Despite the various control methods that have been identified for reducing *Striga* parasitism in cereal crops, the use of host crop resistance has been considered the most important, durable, affordable, cost effective and easily adopted methods (Kim, 1997; Lagoke *et al.,* 1999; Botanga *et al.,* 2002).Lagoke *et al.(*1997) reported that no single method is capable of ensuring sustainable *Striga* control.Applying N fertilizer may not be feasible as a stand-alone solution to managing *Striga* in maize because of the high cost but the combined use of low N*Striga* tolerant/resistant and drought maize varieties, would contribute more in maize production particularly in the northern Guinea and Sudan savanna where the prevalence of *Striga hermonthica* is more pronounced. It is thus suggested that an integration of *Striga* control methods as package that involves the use of appropriate nitrogen fertilizer rate with resistant/tolerant cereal crops will go along way in reducing *Striga* infestation (Lagoke *et al.,* 1999).

This study was therefore undertaken with the following objectives:

1. To assess the effect of *Striga hermonthica* on growth and yield ofmaize varieties.

2. To determinethe performance of tolerant to *Striga* and low- N maize varieties.
3. To determine the effect of N fertilizer on performance of maize and *Striga hermonthica*.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 *Striga* as Parasitic Weed

2.1.1 Classification of *Striga*

The genus *Striga* is an annual obligate root parasite of grasses and legumes. Some species only emerge from below ground to produce flowers, spending much of their life underground and out of sight, robbing their host of nutrients and water (Ahom *et al*., 2014), hence their local African name"witchweed" (USDA. 2015). They are generally seen growing at the base of various host plants (Ahom *et al.*, 2014). The number of species of witchweed is not certain but exceeds 40 (Anon.2012; Mohammed *et al.*, 2001). There are four important species namely *S.hermonthica, S. asiatica, S.densiflora* and *S. gesnerioides*, these are considered most noxious and they are found in Africa. The first three are serious weed of sorghum, maize and millets in Africa while *S. gesnerioides* is a serious weed of cowpea in West Africa (Das, 2008).

2.1.2 Biology of *Striga*

Striga hermonthica is responsible for more crop loss in Africa than any other individual weed species (Ahom *et al.*, 2014). It is characterized by bright green stems and leaves with small bright pink coloured attractive flowers and relatively taller than *Strigaasiatica* (Das, 2008). It is an erect, branched obligate, hemi-parasitic annual herb growing up to 60cm high. It has a weak root system that is incapable of absorbing water and nutrients from the soil. Roots develop from the lower nodes of the plant, spreading and developing secondary haustorium and attachments to make contact with the host root (Visser, 1981). *Striga hermonthica* is very prolific; a single plant can produce 25,000 to 200,000 seeds which remain viable in the soil

for 15 to 20 years (Das,2008, Ahom *et al.*,2014). Seeds are dispersed by wind, water, soil movement, human activities or by adhering to the feet of animals or feathers of birds. The seeds only germinate in close proximity to the roots of suitable host, because of the secretion strigolactate by the host plant which stimulates germination *Striga*. When a host is present, seeds require 1 – 2 weeks of moisture and temperatures of at least 20^{o}C with 25 – 35^{o}C, being optimal for germination. Even when conditions are suitable, only a certain percentage of seeds will germinate while the rest remains dormant to ensure continuity of the next generation. Once a seed germinates the seedling root grows towards the root of the host plant and penetrate the roots outer layers with a specialized structure called haustorium (Ahom*et al*., 2014).Host root exudates certain strigolatones-signaling molecules that promote *Striga*seed germination (Matusova *et al*., 2005). Endosperm nutrients within the seed can only sustain the seedling for 3 to 7 days in the absence of a host (Worsham, 1987). Once attached to the host, the haustorium thickens into a parasiting nodule through which itderivesall water, mineral nutrients and carbohydratesfrom the host plant, causing chlorosis, and wilting of the host plant.Stunting of shoot growthand reduced photosynthesis are also phenomena that can be observed on susceptible host plants which contribute to the reduction of the grain yield (Frost *et al*., 1997). After growing for 4 – 6 weeks underground, the *Striga* plant emerges above the ground and produces green leaves which photosynthesize (Ahom *et al.*,2014).

2.1.3 *Striga* tolerant crop varieties

Host plant resistance would probably be the most feasible and potential method for parasitic weed control (Ahom *et al*., 2014).Using biotechnological approaches (including biochemistry, tissue culture, plant genetics and breeding, and molecular biology), significant progress has been made in developing screening methodologies and new laboratory essays, leading to the

identification of better sources of parasitic weed host resistance (Ejeta *et al*., 2000; Mohammed *et al*., 2001). Full community of host plants to *Striga* has not yet been found. However, several resistant crop varieties are used nowadays in various parts of Africa, Europe and Asia (Ahom *et al.*, 2004). Damage in maize can be reduced by growing varieties that are tolerant or resistant to *Striga* (Carsky *et al.*, 2000). Several *Striga* resistant varieties of maize havebeen released by Institute for Agricultural Research Samaru Zaria and these include:SAMMAZ- 11, SAMMAZ- 14, SAMMAZ- 35 and SAMMAZ- 38 (Anon.2015).

2.1.4 Effect of *Strigahermonthica* on maize

All the major cereal crops in the Nigerian savanna (sorghum, maize, millet and upland rice) are parasitized by *S.* h*ermonthica* (Del.)Benth (Lagoke, 1989). It is recorded that out of the six common species of *Striga* in Nigeria, the most devastating is *S.* h*ermonthica* which has the highest potential of serious economic impact in maize production (Emechebe *et al.*, 1991; Rao, 2004). The parasitic weed has been reported to reduce the yield of maize by up to 100% in Nigeria, when infestation occured at an early stage (Kim *et al.*, 1985; Parkison, 1985).

Striga exerts its greatest impact on maize in-low input subsistence farming areas (Parker and Riches, 1993; Riches and Parker, 1995). The socio-economic implications of*Striga*includethe migration of poor resource farmers to S*triga*-free areas, shifting cultivation, farm abandonment or change of cropping pattern (Riches *et al.*, 1996).

2.2 Nitrogen

2.2.1 Nitrogen as maize nutrient

Nitrogen is the key nutrient in plant growth and productivity, particularly maize, andit is often the limiting nutrient in plant growth and the soil nutrient required in the greatest amount. It is

a constituent of nucleic acid and therefore plays a role in plant heredity. It is also a constituent of proteins and chlorophyll, the primary pigment in photosynthesis. It promotes vegetative growth, making tissues more tender and succulent and promotingplants to grow larger (George, 2011). Hague *et al.* (2001) reported that nitrogen is a component of protein and nucleic acids and when N is sub-optimal, growth is reduced. Itsdeficiency usually expressed as slow initial growth, yellowish green leaves and premature senescence of the lower leaves of maize (Reddy, 2012). It isa major plant nutrient for growthand makes up to 1 to 4% of the dry matter of plants (FAO. 2000). Nitrogen uptake by plants is in the form of NO_3 and NO_4 ions. The dinitrogen (N_2) form, though most abundant in the atmosphere, is not usable directly available to plants. It is very mobile in the plant (George, 2011).

Nitrogen is lost from the soil through various processes during crop growth or fallow period, via crop removal, leaching, gaseous losses or volatilization, chemodinitrfrication, soil erosion and run-off (Reddy, 2012). Soil nitrogen can be regained through various ways, such as decomposition of plants and animal remains, nitrogen fixing by microbes,weathering of minerals from the rocks and application of inorganic nitrogen fertilizers (George, 2011).

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processes in the soil. Crops take up N as either NO_3- or NH_4+ ions. Hence, N should be in these forms in soil for plant up take (Reddy, 2012).

Urea[(Co(NH_2)2] content about 45-46% nitrogen.When urea is applied in the moist soil,it undergoes hydrolysis.

$NH_2 – Co – NH_2$ Urease $(NH_2)_2\ Co_3$
Urea + $2H_2O$ Ammonium Carbonate

2.2.2 Low-N tolerant maize varieties

Maize yields on small scale farms in sub-Saharan Africa and Nigeria in particular are a fraction of those in developed world due to poor soils and farmers inability to purchase enough nitrogen fertilizers. On the average, such farmers supply only 9kg of fertilizer per hectare of cropland, and of this amount, less than half is taken up by the crop, while the rest is leached deep into the soil where plants cannot recover it or otherwise, lost (CYMMYT. 2016). Maize is more responsive to fertilizer application than the other staple cereal crops such as sorghum and millet traditionally grown in the savanna agro-ecological zones, which is constrained by low level of soil nitrogen (IITA. 2014). Estimated yield losses from N stress alone can be as high as 50% (IITA. 2014). Low-N tolerant cultivars with enhanced adaptation to drought prone environments have been bred. The low-N tolerant cultivars are superior in the utilization of available N either due to enhanced uptake capacity or because of more efficient use of absorbed N in grain production (CIMMYT. 2015).

2.2.3 Effect of nitrogen on growth, yield and yield components of maize

Nitrogen is the most limiting factor, in maize production in the Guinea savanna of Nigeria (Singh*et al.,* 2001). It is the most commonly deficient nutrient in most cultivated soils

(Leonard, 1986). Among all the essential nutrients, nitrogen appears to have the most pronounced effect on plant growth and development (Lombin, 1988). It is a component of protein and nucleic acids and when nitrogen is at sub-optimal level, growth is reduced (Hague *et al.,* 2001).When nitrogen is in short supply, plants become stunted with restricted root systems;the leaves turn yellowish green and may drop off (Lombin, 1988). Ayub *et al.*(2002) observed that growth parameters such as plant height, number of leaves per plant, stem diameter, leaf area per plant, green fodder yield and dry matter yield were influenced by application of nitrogen. Wajid *et al*. (2007) evaluated the effect of three nitrogen levels on three maize cultivars, and observed that nitrogen rates significantly affected plant height, 1000-grain weight, grain yield and harvest index. Ologunde and Ogunlela (1985) reported that application of 120kg N/ha gave highest grain yield of maize in southern Guinea savanna of Nigeria. Also, Ologunde (1983) observed similar responses of maize to nitrogen application in the northern Guinea savanna of Nigeria. Tanimu (1999) reported that grain yield and yield related parameters of maize significantly responded to N fertilizer up to 120kg N/ha in two experiments conducted at Samaru. Namakka (2002) reported that nitrogen application increased grain yield which was attributed to positive effect of nitrogen on number of leaves per plant, leaf size, dry matter production per plant, length and number of ears and grain weight.

2.2.4 Effects of N-Fertilizer on the Incidence of *Striga hermonthica*.

The occurrence of S*triga* in the field is often negatively correlated with soil fertility in general and nitrogen status in particular (Pieterse and Varkelj, 1991; Kim *et al.,* 1985; Parkison, 1985). This suggests that *Striga* tends to affect crops where the fertility is low. Thus Lagoke*et al. (*1991) reported that the application of high nitrogen increases the grain yield of cereal

crops under *Striga* infestation. This was due to the fact that nitrogen fertilizers suppressed the severity of *Striga* attack, while simultaneously increasing the host yield (Okonkwo, 1991). Various studies have shown that high N-fertilization has favourable effects on grain sorghum and adverse effect on *Strigahermontica* (Adeosun, 1990; Agbobli; 1991; Dugjie*et al., 2007).* The beneficial effect on grain sorghum and adverse effect on *Striga hermonthica* occurred significantly at 172kg N/ha. Also maximum grain yield increase of 45% and a maximum reduction in *Striga* shoot (36%) occurred at 172kg N/ha. The adverse effects of N-fertilization on *S. hermonthica* include delayed emergence, stunting, reduced flowering and dry matter production of the parasite (Adeosun, 1990).

Many studies have shown varying differences in *Striga* responses involving different sources and rates of nitrogen (Bebawi and Abdulaziz, 1993; Igbinnosa, 1993). They also reported that sulphate of ammonia was more effective than urea in controlling *Striga*. Kim (1991) observed that, greater number of *Striga*seedswas recovered from the soil under high NPK fertilizer application to a susceptible host, thus suggesting that high NPK induces low *Striga* germination.

2.3 Maize Crop

2.3.1 Maize varietyperformance

Modern agriculture is concerned with yield and nutritional quality of crops, but environment does play its role in production of varieties (Derby *et al.,* 2004). It is a known fact that varieties differ in their adaptation to new ecology, yield potential, maturity periods and canopy architecture (Dowsell*et al.,* 1996). It has also been established that varieties differ in physical and chemical properties of the grain, which affect their suitability for various end users (Kling, 1991). Efforts should not be spared to find out which variety would be best

suited for any given cropping system. Sharifai (2004) reported that significant increase in plant height, total dry matter, relative growth rate and grain yields exhibited by varieties TZPB-SR and TZE Comp-3G over variety TZE-R-W could be attributed to more responsiveness to fertilizer throughgenetic make up. Mani *et al.* (2006) reported that five QPM varieties (Obatanpa, Mamaba, Susuma, EV.99 QPM and DMR-ESR QPM) on evaluation showed that some QPM varieties (DMR ESR.QPM and EV.99 QPM) gave significantly higher yields and net return than other QPM varieties.

2.3.2 Drought tolerant maize varieties

Despite maize high yield potential, its production is faced with numerous constraints; one of this is drought both at the beginning and during the growing season which significantly reduced grain yield (Kamara *et al.*, 2006). The occurrence of drought can cause about 90% reduction in maize grain yield (IITA. 2014). The Drought Tolerant Maize for Africa (DTMA) has contributed towards improving seed system in Sub-Saharan Africa (CIMMYT – IITA. 2015).Institute for Agricultural Research Samaru developed several drought tolerant maize varieties viz: SAMMAZ-19, SAMMAZ-20, SAMMAZ-22, SAMMAZ-23,SAMMAZ-24, SAMMAZ-25, SAMMAZ-26 and SAMMAZ-28,among others (Anon.2015).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Sites

Field trials were conducted simultaneously at the Institute for Agricultural Research Farm, Samaru (Lat. 11^{o} 11′ N; Long 07^{o}38'E and 686m altitude) and at Tashar Dauda (Lat. 11^{o} 11′ N; Long 07^{o}47′ and 678m altitude)in the northern Guinea savanna ecological zone of Nigeria during the 2012 and 2013 rainy seasons. Meteorological data were collected from the Institute for Agricultural Research Meteorological Unit,Samaru (Appendix I and II).At Samaru,Field V5 (*Striga* sick plot) was re-infested with *Striga* while Field V3 was the *Striga*-free plot. At Tashar Dauda a farmer provided the *Striga* sick field (which was not re-infested) and the *Striga*-free plot.

3.2 Treatments and Experimental Design

The experiment consisted of four varieties of maize (SAMMAZ-11,SAMMAZ-14, SAMMAZ- 20 and SAMMAZ-26), four levels of nitrogen (N) fertilizer (0, 40, 80 and 120 kg Nha^{-1}), andwith two levels of *Striga*(infestated and uninfested). The treatments were laid out ina randomized complete block designandreplicated three times.

3.3 Soil Analysis

Five soil samples were randomly taken from the trial fields at 0-30cm soil depth before land preparation in each year of experimentation using a tabular auger.The samples were bulked, air-dried and analysed for physical and chemical properties using the standard procedures as described by Black (1965).

3.4 Cultural Practices

3.4.1 Land preparation and layout

The land was harrowed once prior to planting to obtain a fine tilth and ridges of 0.75m width were made, and then marked out into required plots sizes with 1.0mspacing between replications and between plots. The gross plot comprised of six ridges each 0.75m wide and 4m long ($18m^2$)and the net plot consisted of 4 ridges of 0.75m wide, and 4.0m long each ($12m^2$).

3.4.2 *Striga* inoculation

Striga hermonthica seed (25g) was mixed with 1kg of fine sandy soil to constitute the inoculant,and then10g of it was applied per hill at two weeks after planting (2WAS) for properpre-conditioning.

3.4.3 Sowing

Maize seeds were sown on 28th July, 2012 and 1st August, 2012, at both *Striga* infested and un-infested fields at Samaru and Tashar Dauda respectively. In 2013 sowing wassdone on 19th June and 5th July, 2013, at both *Striga* infested and un- infested fields at Samaru and Tashar Dauda respectively. Two seeds were sown per stand at intra-row spacing of 25cm and thinned to one plant per stand at 2 WAS to give 96 plants per gross plot which is equal to 53,333 plants per hectare.

3.4.4 Fertilizer application

At 10 days after sowing, in both years, 60kgP_2O_5as single superphospohate and 60kg K_2O as muriate of potash were applied to all plots, along withhalf of N rate sourced from urea.The remaining half ofN was applied at 6WASusing urea as nitrogen source as per treatment. Each application was in between two stands.

3.4.5 Weed control

Weeds were controlled manually by hoe weeding at 2 WAS followed by hand pulling in the infested fields at 5 WAS and remolding at 6 WAS in un-infected field to ensure a good germination of *Striga*.

3.4.6 Pests and disease control

There were no incidence of pests and diseases observed during the experimental periods.

3.5 Source of planting materials

Seeds of SAMMAZ-11, SAMMAZ-14, SAMMAZ-20 and SAMMAZ-26 were obtained from Seed Production Unit of the Institute for Agricultural Research,Samaru in both years.

3.6 Description of test crop

SAMMAZ- 11 (ACROSS 97-TZL. SDM- 3 COMP 1-W)

Open pollinated maize variety, medium maturity (100-110 days), white-seeded maizewith yield potential of 3 – 4.5t/ha. It is tolerant to *Striga hermonthica.*

SAMMAZ -14 (GH 362-SRC1)

Open pollinated maize variety and medium maturing (106-110 days). Plant height of 150-180cm, white-seeded kernels and has the potential yield of 5.8t/ha. High lysine and tryptophan contents,it is also called Quality Protein Maize (QPM).Resistant to streak,stem borerand virus. It is tolerant to *Striga hermonthica*.

SAMMAZ- 20 (TZE Comp3)

Open pollinated maize variety, earlymaturing (95-100 days) and about 52 days to mid-silking. Plant height of 185 – 195cm, white-seeded kernels and has the potential yield of 3 – 4t/ha. Highly tolerant to drought,resistant to streak, and tolerant to low soil nitrogen.

SAMMAZ- 26 (DTSR-WC2)

Open pollinated maize variety, early maturing (95 - 110 days). Plant height of 185 – 195cm, white-seeded kernels, and has the potential yield of 3 – 4t/ha in drought prone areas. Highly tolerant to drought,resistant to streakand tolerant to low soil nitrogen.

3.7 Harvesting

Harvesting was carried out when the crop matured, that is whenthe husk turned yellow, grains hardened enough andthe blacklayer at the point of grain attachment to the cob formed. The ears from the net plots were harvested and dehusked, the cobs sun-dried, weighed with metter balance and later shelled and winnowed to obtain clean grains.

3.8 Observations and Data Collections.

3.8.1 *Striga* parameters

Number of days to first *Striga*shoot emergence.

This was determined by counting the number of days from sowing to date when *Striga* first emerged in each net plot ($12m^2$.)

***Striga* shoot count**

The number of *Striga*shoots per net plot area was counted at 12 WAS.

Number of flowering Striga shoots

The number of flowering *Striga*shoot per net plot ($12m^2$) was counted at harvest and recorded.

***Striga* syndrome rating**

This was determined at 12 WAS by visual observation of all maize crop in each net plot ($12m^2$) using a scale of 1 – 9. (Appendix III).

Number of maize standsinfested with *Striga*

This was determined by counting the number ofmaize stands infested with *Striga* per net plot ($12m^2$) at 12 WAS.

3.8.2 Crop growth characters

Crop stand count

The number of maize stands per plot was counted and recorded at 4 WAS and at harvest.

Crop vigour score

Crop vigour score was assessed visually from each net plot ($12m^2$) at 4, 8 and 12 WAS using a scale of 1 – 9, Characters that were taken into consideration in crop vigour score included plant height, leaf colour and canopy spread.**(**Appendix IV)

Plant height (cm)

The heights of five randomly taggedplants in each sampling rows were measured from the base of each plant to the highest growing point at 4, 8 and12 WAS. The average height was recorded.

Leaf area index (LAI)

The LAI was determined by measuring the width and length of five leaves of five plants and calculated by dividing the total leaf area of the plant by the area it occupied at 12 WAS as described by Watson (1952):

$$LAI = \frac{\text{Leaf Area (LA)}}{\text{Ground Area}}$$

where: LA = L x W x 0.75 (Length x Breadth of each leaf) x maize crop factor)

0.75 = maize crop factor.

Ground Area = Inter x Intra row spacing

Shoot dry weight.

Five randomly sampled plants were cut from the base outside the net plot at 4, 8 and 12 WAS and oven dried at 70^0C to a constant weight and the mean weight recorded.

Crop growth rate (CGR)

The CGR,was determined by using current shoot dry weight and initial shoot dry weight which is the increase in dry weight per unit time per unit area (Radford, 1967). This was calculated at 8 and 12 WAS.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{GA} \ (g/m^2/wk)$$

where:

CGR = Crop Growth Rate

W_1 W_2 = Total dry weight at times T_1 and T_2

GA = Ground Area (Inter row x Intra row spacings)

Relative growth rate (RGR)

This is dry weight increment per unit plant weight per unit time as described by

Radford (1967):

$$\text{Log e} \frac{W_2 - W_1}{t_2 - t_1} . \frac{1}{W} \ (g/g/wk)$$

WhereW_2 - W_1 and t_2-t_1 are changes in weight and time respectively.

Number of days to 50% tasseling

This was determined by recording the number of days from the date of sowing to the time when about 50% of the plants in the net plot tasseled.

Number of days to 50% silking

This was determined by recording the number of days from the date of sowing to the time when about 50% of the plants in the net plot silked.

Stem lodging count

This was taken at harvest in each net plot. A plant is considered to be lodged when it was inclined at more than 45% from the vertical position or the stem is broken below the ear. The number of lodged plants was counted in eachnet plot.

3.8.3 Yield and Yield Components

Ear height

This was measured from a random sample of five plants in each net plot from the ground level to the base of the node which bears the topmost ear using a meter rule.Then ear height from the five tagged plants was recorded.

Number of cobs per plant

The mean number of cobs per plant was computed from the total number of cobs of the five tagged plants.

Cob length

The lengths of five randomly sampled cobs in each net plot were measured with meter rule and the average recorded.

Cob diameter

The diameter of five randomly taken cobs in each net plot was measured using a venier caliper and the average recorded.

Number of seed rows per cob

The number of seed rows of five randomly taken cobs was counted and the average recorded.

Cob weight per plant

The cobs weight from the five randomly sampled plants was weighed using metter balance and the average recorded.

Seed weight per cob

This was determined by taking five randomly sampled cobs per net plot, shelled, winnowed and weighed. The mean weight of the grains per cob was recorded.

100-seed weight

A random sample of 100-grains from each net plot was weighed and recorded.

Grain yield ($kgha^{-1}$)

The cobs from each net plot were threshed and the weight of the grain yield from each net plot was determined and expressed on per hectare basis.

Shelling percentage

This was computed using the formula:

$$\text{shelling \%} = \frac{\text{Grain weight after shelling}}{\text{Unshelled cob weight}} \times 100$$

Harvest index (HI)

This was obtained by takingthe ratio of the weight of grains to the total dry plant material at harvest.

$$\text{H.I} = \frac{\text{Grain weight}}{\text{Total dry matter}}$$

3.9 Gross Margin Analysis

Gross margin analysis was determined to ascertain the treatment that will give acceptable returns at low risk to farmers as described by Olukosi and Erhabo (1988). Gross margin was determined based on the prevailing market prices of the inputs, operations and out puts. The following concepts were:

1. Gross revenue (GR) in ₦ per hectare is the product of average price of maize and grain yield for each treatment.
2. Total variable cost (TVC) in ₦ per hectare is the cost of labour and inputs which include fertilizers, seeds and chemical.
3. Gross margin (GM) in ₦ invested is the gross revenue (GR) minus the total variable cost (TVC).

3.10 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS structural package (version 9.0) of Statistical Analysis as described by Gomez and Gomez (1984). The treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955). The strength of the relationships between the yield and yield characters were studied using correlation coefficient analysis (Little and Hills, 1978). The direct and indirect effects on grain yield and individual and combined contributions to the yield by some selected characters were determined using path coefficient analysis as described by Dewey and Lu (1959).The polynomial response of grain yield to nitrogen levels was determined using regression analysis as described by Steel and Torrie, (1984).

CHAPTER FOUR

4.0 RESULTS

4.1 Soil Analysis and Weather Data

The results of soil analysis at Samaru in 2012 and 2013 under infested and uninfested fields are presented in Table 1. In both years and fields, the soils were loam, except in 2013 in infested field where the soil was sandy loam. Soils were slightly acidic in both years and fields (pH 6.36 and 6.37) and (pH 6.04 and 6.04) in 2012 and 2013 respectively, low in organic carbon (0.64 and 0.48g/kg) and (0.66 and 0.52g/kg), low total nitrogen (0.39 and 0.29g/kg) and (0.30 and 0.28g/kg), cation exchange capacity (4.40 and 3.90meq/100g) 3.35 and 2.45meq/100g) and available phosphorus (8.99 and 8.11mg/kg) and (8.40 and 9.34mg/kg) for 2012 and 2013 seasons, respectively.

The results of soil analysis at Tashar Dauda during 2012 and 2013, are presented in Table 2. In both years and fields, the soils were sandy loam, except in 2012 under uninfested field where the soil was loam. The soils were slightly acidic (pH 6.59 and 6.49) and (pH 6.54 and 6.57), low in organic carbon (0.67 and 0.54 g/kg) and (0.60 and 0.56g/kg), low total nitrogen (0.36 and 0.32g/kg) and (0.32 and 0.30g/kg), high cation exchange capacity (4.77 and 4.22meq/100g) and (3.50 and 3.30meq/100g), low available phosphorus (8.09 and 7.26mg/kg) and (7.33 and 6.48/mg/kg) for 2012 and 2013 infested and unifested fields respectively.

Details of meteorological data collected during the trial periods are presented in Appendices I and II for Samaru and Tashar Dauda. The highest maximum temperatures for 2012 and 2013 were (27.4 and 29.0) in October and June, respectively and the lowest minimumtemperatures for 2012 and 2013 were in September (23.9 and 25.2), respectively. Highest relative humidity was 82.6% in August 2012 and 83.6% in September 2013

Table 1: Physical and chemical properties of the soil (0 –30cm) of the experimental sites of infested and uninfested fields at Samaru during the 2012 and 2013 rainyseasons.

	2012		2013	
	Infested	**Un-infested**	**Infested**	**Un-infested**
Soil characteristic				
Physical characteristic (g/kg)				
Clay	118	90	120	140
Silt	440	448	320	360
Sand	442	462	560	500
Textural class	Loam	Loam	Sandy loam	Loam
Chemical characteristic				
pH (H_2O) (1:2.5)	6.36	6.37	6.04	6.04
pH (0.01M $CaCl_2$)	6.48	6.43	5.89	5.86
Organic carbon (gkg^{-1})	1.19	1.18	1.10	1.16
Total nitrogen (gkg^{-1})	0.39	0.29	0.30	0.28
Available Phosphorus ($mgkg^{-1}$)	8.99	8.11	8.40	9.34
Exchangeable cation ($cmol\ kg^{-1}$)				
Calcium (a)	3.00	2.00	1.99	1.71
Sodium (Na)	0.20	0.18	0.23	0.24
Potassium (K)	0.27	0.26	0.20	0.15
Magnesium (Mg)	1.26	1.26	1.16	0.35
Cation Exchange Capacity(CEC)	4.40	3.90	3.35	2.45

Source of Soil Analysis: Agronomy Department, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria.

Table 2: Physical and chemical properties of the soil (0 –30cm) of the experimental sites of infested and uninfested fields at Tashar Dauda during the 2012 and 2013 rainy seasons.

	2012		2013	
Soil characteristic	**Infested**	**Un-infested**	**Infested**	**Un-infested**
Physical characteristic (g/kg)				
Clay	40	80	38	98
Silt	420	420	402	282
Sand	540	500	560	620
Textural class	Sandy loam	Loam	Sandy loam	Sandy loam
Chemical characteristic				
pH (H_2O) (1:2.5)	6.59	6.49	6.54	6.47
pH (0.01M $CaCl_2$)	6.24	6.15	6.04	6.01
Organic carbon (gkg^{-1})	1.18	1.15	1.17	1.16
Total nitrogen (gkg^{-1})	0.36	0.52	0.32	0.30
Available Phosphorus ($mgkg^{-1}$)	8.09	7.26	7.33	6.48
Exchangeable cation ($cmol\ kg^{-1}$)				
Calcium (a)	2.60	2.56	1.86	1.79
Sodium (Na)	0.25	0.23	0.20	0.26
Potassium (K)	0.23	0.20	0.22	0.21
Magnesium (Mg)	1.54	1.26	0.43	0.41
Cation Exchange Capacity(CEC)	4.77	4.22	3.00	2.67

Source of Soil Analysis: Agronomy Department, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria.

The total rainfall recorded during the growing seasons was 1326and 973.4mm in 2012 and 2013, respectively.

4.2 Days to First *Striga* Emergence

Effects of nitrogen fertilization and *Striga*infestation on days to first *Striga* emergence on maize varieties are presented in Table 3. In both locations, each increase in nitrogen gave a significant increase in days to first *Striga* emergence,except in 2012, where increasein N increased number of days to first*Striga* emergence only upto80kgN ha^{-1} beyond which increase was not significant. While in 2012 at Tashar Dauda, the control and 40kgNha^{-1} resulted in early *Striga* emergence than 80 and 120kg ha^{-1}which were statistically at par.

There was a significant difference between *Striga* uninfested fields and the infested in both locations and the mean.At both locations, years and the mean, there were no significant varietal differences on days to first *Striga* emergence. There were no significant interactions among the treatment factors on days to first *Striga* emergence.

4.3 *Striga*Shoot Count

Table 4 shows the effects of nitrogen fertilization and *Striga* infestation on *Striga* count of maize varieties. At locations, years and the mean, each increase in nitrogen from 0 – 120kgN/ha significantly decreased the *Striga* count except in the mean at both locations where the control and 40kgN/ha gave statistically similar striga count.At both locations, years and the mean, maize in the infested fields gave significantly higher *Striga* count than the uninfested fields. Significant differences among the maize varieties on number of *Striga* count were observed only in Samaru in 2012 and 2013 where SAMMAZ 11 recorded thehighest number of striga count which was statistically similar to SAMMAZ 20 in 2012 and SAMMAZ 26 in 2013.

Table 3: Effects of nitrogen fertilization and *Striga*infestation on days to first *Striga* emergence of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Days to first *Striga* emergence					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	44.7c[1]	46.9d	45.8d	43.4b	47.2d	45.3d
40	50.1b	54.4c	52.3c	48.1b	52.5c	50.3c
80	58.1a	60.0b	59.1b	58.1a	60.3b	59.3b
120	60.9a	63.3a	63.3a	62.2a	65.0a	63.5a
SE ±	0.42	0.41	0.44	0.75	0.43	0.41
***Striga* Infestation (S)**						
Un-infested	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b
Infested	64a	67a	66a	64a	68a	66a
SE ±	0.5	0.4	0.3	0.5	0.3	0.4
Variety (V)						
SAMMAZ 11	53.8	55.6	54.7	52.2	55.3	53.8
SAMMAZ 14	53.1	56.3	54.7	53.1	56.7	55.0
SAMMAZ 20	53.8	55.9	54.9	52.5	56.1	54.3
SAMMAZ 26	54.2	56.8	55.5	54.1	56.9	55.5
SE ±	0.42	0.41	0.44	0.75	0.43	0.41
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

2 = Not Significant

Table 4: Effects of nitrogen fertilization and *Striga*infestation on *Striga* count at 12 WAS of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Striga countat 12 WAS					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	85.6a[1]	140.0a	112.8a	82.4a	139.5a	110.9a
40	75.9b	137.0b	106.9a	75.1b	136.4b	105.8a
80	47.6c	48.4c	48.0b	48.8c	53.0c	50.9b
120	35.9d	29.0d	32.4c	43.8d	31.3d	37.5c
SE ±	0.56	0.72	4.11	0.75	0.79	4.32
***Striga* Infestation (S)**						
Un-infested	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b
Infested	123a	177a	150a	125a	180a	154a
SE ±	0.4	0.5	2.9	0.5	0.6	3.1
Variety (V)						
SAMMAZ 11	63.3a	90.6a	76.9	63.0	91.0	77.0
SAMMAZ 14	60.1c	87.0b	74.6	62.8	89.6	76.2
SAMMAZ 20	62.0ab	87.8b	74.9	61.5	90.7	76.7
SAMMAZ 26	60.6bc	89.1ab	73.8	62.8	88.9	75.8
SE ±	0.56	0.72	4.11	0.75	0.79	4.32
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

2 = Not Significant

SAMMAZ 14 gave the least *Striga* count in both years but was statistically at par with SAMMAZ 26 in 2012 and SAMMAZ 26 and SAMMAZ 20 in 2013. At both locations, years and the mean, there were no significant interaction, among the factors on *Striga* count at 12 WAS.

4.4 Number of Flowering *Striga* Shoot

Effects of nitrogen fertilization and *Striga* infestation on number of flowering *Striga*on maize varieties arepresented on Table 5. At both locations, years, and the mean, each increase in rate of nitrogen from 0 –120kgNha^{-1}, gave a significant decrease in number of flowering *Striga*.There was a significant difference between the *Striga*uninfested and infested fields both locations, years and the mean. At both locations, years and the mean, maize varieties showed significant differences in number of flowering *Striga* plant,SAMMAZ 26 gave the least number of flowering *Striga* across years, except at in Tashar Dauda where it was statistically at par with all other varieties and the mean.There were no significant interactions observed among the factors on number of flowering *Striga*.

4.5 *Striga* Syndrome Rating

Table 6 shows the effects of nitrogen fertilization and *Striga* infestation on *Striga* syndrome rating of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainyseasons and the mean. Each increase in nitrogen rate from 0 – 120kgNh^{-1}a significantly decreased *Striga* syndrome rating at both locations, years and the mean except at Tashar Dauda in 2013 where application of nitrogen at 80kgNha^{-1} was statistically at par with 120kgNha^{-1}a in 2013. There was significant difference between *Striga* infested and uninfested fields at locations, years and the mean. Infested fields had recording higher syndrome rating than the uninfested fields.

Table 5: Effects of nitrogen fertilization and *Striga* infestation on number of flowering *Striga*in maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Number of flowering *Striga*					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	60.6a[1]	63.5a	62.1a	64.7a	67.1a	65.9a
40	59.1b	62.0b	60.6a	58.5a	67.0a	62.8a
80	29.3c	21.6c	25.4b	27.5b	25.1b	26.3b
120	14.8d	11.5d	13.1c	17.5c	15.5c	16.5c
SE ±	0.50	0.52	0.65	2.23	0.49	1.24
***Striga* Infestation (S)**						
Un-infested	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b
Infested	82a	79a	81a	84a	87a	86a
SE ±	0.4	0.4	0.5	1.6	0.4	0.9
Variety (V)						
SAMMAZ 11	41.5b	41.0a	41.3a	42.8a	44.4a	43.6a
SAMMAZ 14	40.6b	39.8a	39.8a	41.0ab	44.8a	42.9ab
SAMMAZ 20	43.3a	40.3a	41.8a	46.4a	44.3a	45.3a
SAMMAZ 26	38.4c	37.6b	38.0b	38.0b	42.4b	39.7
SE ±	0.50	0.52	0.52	2.23	0.49	1.24
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

2 = Not Significant.

Table 6: Effects of nitrogen fertilization and *Striga* infestation on *Striga* syndrome rating of maize varieties at Samaru and Tashar Dauda during 2012,2013 rainy seasons and the mean .

	***Striga* syndrome rating**[1]					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	7.0a[2]	7.0a	7.0a	5.6a	5.1a	5.4a
40	5.3b	4.5b	4.9b	4.1b	3.5b	3.8b
80	2.8c	2.5c	2.7c	2.6c	1.7c	2.1c
120	1.9d	1.0d	1.5d	1.5d	1.1c	1.4d
SE ±	0.25	0.18	0.15	0.18	0.20	0.13
***Striga* Infestation (S)**						
Un-infested	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b
Infested	4a	4a	4a	5a	4a	4a
SE ±	0.2	0.1	0.1	0.1	0.1	0.2
Variety (V)						
SAMMAZ 11	2.4	2.3a	2,3a	2.6a	2.1	2.4a
SAMMAZ 14	2.0	1.6b	1.7b	2.0b	1.9	1.9b
SAMMAZ 20	2.3	2.0ab	2.1ab	2.6a	2.0	2.3a
SAMMAZ 26	1.8	1.6b	1.8b	2.0b	1.6	1.8b
SE ±	0.25	0.18	0.15	0.18	0.20	0.13
Interaction						

N x S	NS[3]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Striga syndrome rating using scale of 1 – 9.
2 = Means followed with the same letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
3 = Not Significant

Maize varieties showed significant differences in *Striga* syndrome rating. SAMMAZ 11 and 20 gave the highest syndrome rating at Samaru in 2013 and the mean, and Tashar Dauda in 2012 and the mean, which were statistically similar. There was no significant interaction among the treatment factors on *Striga* syndrome rating.

4.6 Number of Maize Stands Infested with *Striga*

Effects of nitrogen fertilization and *Striga* incidecne onnumber of maize stands infested with *Striga* are presented in Table 7. Each increase in nitrogen rate from 0 – 120kgNha^{-1} significantly decreased the*Striga* incidence, in both locations, years, and the mean. There was significant difference between *Striga* infested and uninfested fields at both locations; uninfested fields recorded no*Striga* incicidence. At both locations, years and the mean, SAMMAZ 11 and 20 gave the highest*Striga* incidence, which was statistically at par with all other varieties, except SAMMAZ 14 at Samaru in 2012 and SAMMAZ 26 at Tashar Dauda 2013. There was no significant interaction among the tested factors on*Striga* incidence.

4.7 Stand Count of Maize

Table 8 shows the effects of nitrogen fertilization and *Striga* infestation on stand count of maize varieties. At both locations and years, application of nitrogen had significant effect on stand count of maize at 4 WAS except at Tashar Dauda,where control gave the highest stand count, which was statistically at par with application of nitrogen at 80 and 120kgN/ha.

At both locations, years and the mean, un-infested fields gave significantly higher stand count than infested fields, except at Samaru in 2013 and at Tashar Dauda in 2012 and the mean. At both locations, years and the mean there was no significant differences among the maize varieties in stand count. Similarly, there were no significant interactions among the factors on maize stand count.

Table 7: Effects of Nitrogen Fertilization and *Striga* Incidenceon number of Maize stands infested with *Striga* at Samaru and Tashar Dauda during 2012 and 2013 rainy seasons and the mean.

	Number of Maize stands infested with *Striga*					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	22.3a[1]	15.3a	18.8a	22.6a	16.3a	19.3a
40	16.1b	9.8b	13.1b	14.9b	11.8b	13.3b
80	3.8c	1.8c	2.4c	2.1c	2.9c	2.5c
120	1.0d	0.3d	0.5d	1.0d	1.0d	0.6d
SE ±	0.31	0.40	0.54	0.34	0.35	0.43
***Striga* Infestation (S)**						
Un-infested	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b

Infested	21a	14a	17a	20a	16a	18a
SE ±	0.2	0.3	0.4	0.2	0.1	0.3
Variety (V)						
SAMMAZ 11	11.6a	7.8a	9.7a	10.6a	8.9a	9.8a
SAMMAZ 14	8.6c	6.1b	7.4b	9.8ab	7.6bc	8.7ab
SAMMAZ 20	11.8a	7.1ab	9.4a	10.5a	8.1ab	9.3ab
SAMMAZ 26	10.6b	6.1b	8.4ab	9.4b	6.9c	8.1b
SE ±	0.31	0.40	0.54	0.34	0.35	0.43
Interaction						
N x S	NS2	NS	NS	NS	NS	NS
N x V	NS	NS	NS[2]	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant
.

Table 8: Effects of nitrogen fertilization and *Striga* infestation on stand count of maize varieties at Samaru and Tashar Dauda during 2012 and 2013 rainy seasons and the mean.

Stand Count of Maize at 4 WAS[1]		
	Samaru	Tashar Dauda

Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	55.3	58.5	56.9	59.2	57.9	58.6a[2]
40	55.6	58.7	57.1	56.1	55.6	55.9b
80	56.9	57.1	57.0	56.8	55.5	56.1ab
120	56.6	57.5	57.1	56.3	56.4	56.4ab
SE ±	0.08	0.74	0.70	1.53	0.74	0.88
***Striga* Infestation (S)**						
Un-infested	58.9a	58.8	58.4a	56.4	57.5a	56.9
Infested	53.2b	58.1	55.7b	57.8	55.3b	56.5
SE ±	0.77	0.53	0.49	1.08	0.55	0.62
Variety (V)						
SAMMAZ 11	56.5	57.8	57.1	57.2	56.1	56.6
SAMMAZ 14	56.3	58.4	57.3	55.3	57.1	56.2
SAMMAZ 20	55.8	58.2	57.0	57.6	55.5	56.5
SAMMAZ 26	55.8	57.6	56.7	58.3	56.9	57.6
SE ±	0.08	0.74	0.70	1.53	0.78	0.88
Interaction						
N x S	NS[3]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS

N x S x V	NS	NS	NS	NS	NS	NS

1 = Week After Sowing
2 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
3 = Not Significant

4.8 Stand Count of Maize

Effects of nitrogen fertilization and *Striga* infestation on stand count of maize varietiesis presented in Table 9. Application of nitrogen had a significant effect on maize stand count, however,at Tashar Dauda, in both years and the mean, where application of 80 and 120kgN ha^{-1}, gave comparable maize stand count,and significantly higher than other N rates, except in 2013 when it was comparable to untreated control.

Significant differences of maize stand count between *Striga* infested and uninfested fields, were only observed at Tashar Dauda in both years and the mean, where uninfested fields gave significantly higher stand count of maize than infested fields. At both locations, years and the mean, the significant differences of maize stand count among varieties were only observed at Samaru, in 2013 where SAMMAZ 14 gave significantly higher stand count than SAMMAZ 11, but was statistically similar to SAMMAZ 20 and 26. There were no significant interactions among the factors on maize stand count in both years and locations.

4.9 Crop vigour score of Maize.

The effect nitrogen fertilization and *Striga* infestation on crop vigor score of maize verities are presented in Table 10. In both locations, years and sampling periods, each increase in nitrogen from 0-80kg Nha^{-1}, significantly increased the crop vigor score of maize, beyond which no significant increase in crop vigor score was observed.

At Samaru in 2013, un-infested fields recorded more vigorous plants than infested fields, only at 8 and 12 WAS, while at Tashar Dauda, the significant difference between infested and un-infested fields was in both years at 12WAS, where un-infested fields had more vigorous plants than infested fields. Among the maize varieties, the significant differences on crop vigour score was observed in 2013, at Samaru and at Tashar Dauda in both years.

Table 9: Effects of nitrogen fertilization and *Striga* infestation on stand count of maize varieties at Samaru and Tashar Dauda during 2012, 2013rainy seasons and the mean.

	Maize Stand Countat Harvest					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	46.9	50.2	49.0	46.4b[1]	46.3a	46.3c
40	48.5	50.2	49.3	48.1b	48.6b	48.4b
80	51.6	52.0	51.8	52.8a	52.4a	52.6a
120	52.3	50.9	51.6	54.0a	51.6a	52.8a
SE ±	1.38	1.38	0.97	0.96	0.76	0.64
***Striga* Infestation (S)**						
Un-infested	50.9	50.9	50.9	51.8a	50.9a	51.3a
Infested	49.7	50.2	49.9	46.8b	48.6b	48.7b
SE ±	0.97	0.97	0.69	0.68	0.54	0.45
Variety (V)						
SAMMAZ 11	50.3	49.2b	49.7	48.6	49.2	48.9

SAMMAZ 14	51.1	53.5a	52.3	50.6	50.1	50.4
SAMMAZ 20	48.9	50.3ab	49.6	51.0	50.0	50.5
SAMMAZ 26	48.9	51.3ab	50.1	51.0	49.6	50.3
SE ±	1.38	1.38	0.97	0.96	0.76	0.64
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

2 = Not Significant

Table 10: Effects of Nitrogen Fertilization and *Striga* Infestation on crop vigour score of maize varieties at Samaru during 2012 and 2013 rainy seasons

Treatment	CropVigour Score[1]							
	2012		2013		2012		2013	
	8 WAS[2]	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS
Nitrogen (N) kg/ha								
0	3.8c[3]	2.6c	3.8c	3.3c	3.3c	3.3c	4.0c	3.9c
40	5.9b	5.5b	4.9b	5.5b	4.8b	4.8b	6.0b	5.3b
80	6.9a	7.2a	7.4a	7.3a	6.0a	6.0a	8.0a	7.8a
120	6.9a	7.7a	7.6a	8.0a	6.5a[3]	6.5a	8.3a	8.1a
SE ±	0.26	0.29	0.29	0.29	0.32	0.32	0.30	0.28
***Striga* Infestation (S)**								
Un-infested	5.9	5.7	6.3a	6.3a	5.3	5.7a	6.6	6.6a
Infested	5.9	5.8	5.7b	5.7b	5.0	4.8b	6.4	5.9b
SE ±	0.19	0.21	0.20	0.21	0.23	0.22	0.21	0.19
Variety (V)								
SAMMAZ 11	5.5	5.3	5.8ab	5.4b	5.3a	5.3a	6.3	5.9b

SAMMAZ 14	6.0	5.9	6.4a	6.3a	5.4a	5.4a	6.6	6.3a
SAMMAZ 20	6.0	5.7	5.4b	5.9ab	4.3b	4.3b	6.5	5.9b
SAMMAZ 26	6.0	6.1	6.1a	6.5a	5.7a	5.7a	6.9	7.0a
SE ±	0.26	0.29	0.29	0.29	0.32	0.32	0.30	0.28
Interaction								
N x S	NS[4]	NS	NS	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS	NS	NS

1 = Crop vigour score using a scale of 1 to 9.
2 = Weeks After Sowing
3 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
4 = Not Significant

At Samaru, in 8 and 12 WAS sampling periods, SAMMAZ 14 and 26 significantly recorded the highest crop vigour score, but was comparable to SAMMAZ 11 and 20. At Tashar Dauda in 2012, at both sampling periods, SAMMAZ 20, significantly recorded the least vigorous plants than all other varieties, but in 2012, SAMMAZ 11 and 20 recorded the lower crop vigour score than SAMMAZ 14 and 26.There was no significant interaction observed among the factors.

4.10 Plant Height per Plant

Effect of nitrogen fertilization and *Striga*infestation on plant height of maize varieties is presented in Table 11. At both locations, and the years, each increase in nitrogen from 0-12kgNha^{-1},significantly increased the plant height of maize, except at Samaru in 2012 at 12 WAS, and 2013 at 8WAS, and also at Tashar Dauda in 2013 at 8WAS, where significant increase was observed from 0-80kg ha^{-1}, beyond which the increase was not significant. Uninfested fields significantly recorded taller plants than infested fields, in locations, years, and sampling periods, except at Samaru in 2012 at 12WAS. Among varieties at both locations, years and sampling periods, SAMMAZ 11 significantly recorded the shorter plants which were comparable to the other varieties.Significant differences in plant height were observed among the varieties. SAMMAZ 20 at 120kgN ha^{-1} gave the tallest plants comparable only to SAMMAZ 14 at same N rate. There weresignificant interactions between nitrogen and variety, on plant height at Samaru and Tashar Dauda, in 2012 at 8WAS,and Tashar Dauda at12WAS,and between nitrogen and *Striga* at Tashar Dauda,in 2012 at 12WASand2013 at 8WAS.The interaction between nitrogen and variety on plant height at 8 WAS of maize varieties at Samaru during 2012 rainy seasons (Table 12)showed that each increase in nitrogen from 0-120kgN/ha caused a significant increase in plant height of all the varieties, except SAMMAZ 26, where

thedifferences between 80 and 120kgN ha^{-1},werenot significant. While at 120kgN ha^{-1}, SAMMAZ 14 and 20 had comparable, but each significantly taller plant, than SAMMAZ 11 and 26, in the untreated control, no significant differences in plant height were observed among the varieties. SAMMAZ 20 at 120kgN ha^{-1} gave the tallest plants, comparable only to SAMMAZ 14 at same N rate.

Interaction between variety and nitrogen on plant height at 12 WAS of maize varieties at Samaru during 2013 rainy season is presented in Table 13. Each increase in nitrogen from 0 - 120kgNha^{-1}, significantly increased plant height of all the varieties, except with SAMMAZ 20, where application of 80kgNha^{-1}, gave the taller plants than 120kgNha^{-1}, and SAMMAZ 14, where 40 and 80kgN ha^{-1} gave comparable plant height. Untreated control shows no significant differences among varieties, while at 40kgN ha^{-1}, SAMMAZ 11, gave the shorter plants than all other varieties, which were statistically at par. At 80kgN ha^{-1} SAMMAZ 26 and 20, and also 11 and 14 were statistically at par, while at 120kgN ha^{-1},SAMMAZ 26 gave significantly tallest plant than all other varieties.

Each increase in nitrogen rate from 0 - 120kgN caused significant increase in plant height of all varieties except, SAMMAZ 26 and 14 where thedifferences at 80 and 120kgN ha^{-1} were statistically at par at Tashar Dauda in 20129 Table 14). SAMMAZ 14 produced significantly taller plants than SAMMAZ 26 only in the control, all other nitrogen rates and two varieties had statistically similar plant heights; however, both SAMMAZ 14 and 20 had similar heights at all fertilizer levels.

Interaction of *Striga*infestation and nitrogen on plant height at 12 WAS of maize varieties at Tashar Dauda during 2012 rainy season is presented in Table 15. Theun-infested field hadno significant increase in plant height from 0 to 40kgN ha^{-1}, but the significant increase occurred only from 40 to 80kgN ha^{-1} beyond which the increase wasnot significant. Inthe infested field however, eachincrease in nitrogen from 0 to 80kgNha^{-1}

was significant beyond which further increase of nitrogen recorded no significantincreasein plant height of maizecaused a significant increase in plant height; beyond which the the increase was not significant. At each nitrogen level, maize plants in uninfested fields were taller than those in infested fields.

Interaction between *Striga* and nitrogen on plant height at 8 WAS of maize varieties during 2013 rainy season at Tashar Dauda is presented in Table 16. At 0kgNha^{-1}, no significant difference in plant height occurred between maize grown in infested and uninfested fields, at 40 – 120kgNha^{-1}, however, plants in uninfested fields were significantly taller than those in infested fields. In both infested and uninfested fields each increase in N caused a significant increase in plant height.

4.11 Leaf Area Index.

Table 17 shows the effects of nitrogen fertilization and *Striga* infestation on leaf area index of maize varieties. At both locations, years and sampling periods, each increase in nitrogen from 0-12kg N ha^{-1} significantly increased the leaf area index of maize, except atSamaru in 2012, and at Tashar Dauda 2013, both at 8WAS, where 0 and 40kg ha^{-1} were statistically at par, while at Tashar Dauda in 2012 at 12 WAS, 80 and 120kgN ha^{-1} where comparable to each other. Between *Striga* levels, un-infested fields significantly recorded higher leaf area index than infested, at Samaru in 2012 at 12WAS, and at Tashar Dauda in both locations, at 8WAS. There were varietal differences on leaf area index of maize atlocations, years and sampling periods. SAMMAZ 14 and 26 significantly and consistently produced higher leaf area index than SAMMAZ 11 and 20. There were significant interactions on leaf area index, between nitrogen and varieties at Samaru in both years at 12WAS, at Tashar Dauda in 2012 at 8 and 12WAS and 2013 at 8 WAS, and

then between *Striga* and varieties at Tashar Dauda in 2013 at 8 WAS,and between nitrogen and variety at Tashar Dauda at 8WAS in 2013.

Interaction of variety and nitrogen on leaf area index at 12 WAS at Samaru during 2012 rainy season is presented in Table 18. Each increase in nitrogen from 0-120kgNha^{-1} significantly increased leaf area index of SAMMAZ-11 and SAMMAZ-14 while SAMMAZ-20 at 80 and 120kgN ha-^{1} and SAMMAZ-26 at 0 and 40kgN ha-^{1} had statistically similar LAI. At 0 to 40kgN ha^{-1}, SAMMAZ-20 and SAMMAZ-26 had statistically similar LAI, and at 80kgN ha^{-1} all varieties had statistically similar LAI and at 120kgN ha-^{1} only SAMMAZ-11 and SAMMAZ-26 had similar LAI.

During 2013 rainy season (Table 19), each increase in N rate caused a significant increase in LAI except at 80 and 120kgN ha^{-1} for SAMMAZ 20 and 26 where the differences were not significant. At 0kgN ha^{-1}, SAMMAZ 11, 20 and 26 gave comparable LAI but each significantly lower than SAMMAZ 14; at 40 and 80kgN ha^{-1}. SAMMAZ 26 at 80kgNha^{-1}, produced significantly higher LAI than the other varieties, while at 120kgN ha-^{1} only SAMMAZ 11 and 26 gave comparable LAI with each significantly higher than SAMMAZ 20 and lower than SAMMAZ 14.Nitrogen from 0-120kgN/ha significantly increased leaf area index of all varieties except, SAMMAZ 26 which gave statistically similar leaf area index at 80 and 120kgNha^{-1}.

Interaction of variety and nitrogen on LAI at 8 WAS of maize varieties at Tashar Dauda during 2012 rainy season (Table 20) shows that with each increase in nitrogen from 0-120kgNha^{-1}, LAI of each varietysignificantly.

Table 11: Effects of Nitrogen Fertilization and *Striga* Infestation on Plant height of maize varieties at Samaru and Tashar Dauda during 2012 and 2013 rainy seasons

Treatment	Plant height							
	2012		2013		2012		2013	
	8 WAS[1]	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS
Nitrogen (N) kg/ha								
0	48.9d[2]	50.5c	73.6c	133.9d	50.2d	90.9d	60.1c	125.7d
40	68.8c	84.4b	93.2b	156.3c	67.4c	135.2c	80.5b	146.9c
80	76.9b	95.5a	99.8a	168.1b	73.6b	154.3b	92.1a	165.4b
120	81.8a	101.0a	103.1a	172.9a	77.1a	165.2a	96.4a	174.1a
SE ±	0.49	3.03	1.48	1.53	0.82	1.04	2.79	0.88
***Striga* Infestation (S)**								
Un-infested	78.2a	85.7	95.4a	167.9a	70.2a	142.1a	91.5a	154.0a
Infested	67.9b	79.9	89.4b	147.7b	64.0b	129.7b	73.1b	152.1b
SE ±	0.35	2.14	1.05	1.08	0.58	0.73	1.97	0.62
Variety (V)								
SAMMAZ 11	66.4b	82.5	89.3b	157.3	65.9b	135.5ab	83.1	150.2b

SAMMAZ 14	70.8a	87.2	91.5b	158.4	69.8a	134.4b	79.9	155.3a
SAMMAZ 20	69.6a	79.0	91.6b	155.5	67.0b	138.2a	84.4	150.7b
SAMMAZ 26	69.6a	82.6	97.2a	159.9	65.6b	135.5ab	81.7	155.9a
SE ±	0.49	3.03	1.48	1.53	0.82	1.04	2.79	0.88
Interaction								
N x S	NS[3]	NS	NS	NS	NS	**	*	NS
N x V	**[4]	NS	NS	*[5]	*	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS	NS	NS

1 = Weeks After Sowing
2 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
3 = Not Significant
4 = Highly significant
5 = significant

Table 12: Interaction between variety and nitrogen on plant height at 8 WAS of maize Varieties at Samaru during 2012 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	49.0f	64.2e	72.4d	80.0b
SAMMAZ 14	49.7f	70.3d	79.7b	83.6a
SAMMAZ 20	48.2f	70.0d	76.2c	84.0a
SAMMAZ 26	48.7f	70.8d	79.3b	79.6b
SE ±		0.98		

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT.

Table 13: Interaction between variety and nitrogen on plant height at 12 WAS of maize Varieties at Samaru during 2013 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	70.5j	87.8h	98.8e-g	100.1cd
SAMMAZ 14	73.2j	94.2g	95.6g	103.2b
SAMMAZ 20	71.5j	94.6g	101.6bc	99.0de
SAMMAZ 26	79.4j	96.3fg	103.1b	110.1a
SE ±		0.97		

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT.

Table 14: Interaction between variety and nitrogen on plant height at 8 WAS of maize Varieties at Tashar Dauda during 2012 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	54.5h	64.3g	70.8de	74.2bc
SAMMAZ 14	51.8h	70.2ef	77.1ab	80.2a
SAMMAZ 20	50.7h	66.3e-g	73.3bc	77.8a
SAMMAZ 26	44.1i	68.9e-g	73.2bc	76.4ab
SE ±		1.63		

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

Table 15: Interaction between *Striga* and nitrogen on plant height at 12 WAS of maize varieties at Tashar Dauda during 2012 rany season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
***Striga* Infestation (S)**				
Un-infested	53.2e	70.0e	76.8ab	80..6a
Infested	47.3f	64.9d	70.4c	73.6bc
SE ±		1.46		

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

Table 16: Interaction between *Striga* and nitrogen on plant height at 8 WAS of maize varieties during 2013 rainy season at Tashar Dauda

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
***Striga* Infestation (s)**				
Un-infested	59.6g	91.4c	105.4b	109.5a
Infested	60.6g	69.5f	78.7e	83.4d
SE ±		1.25		

Means followed with the same letter(s) are not significantly different at 5% level of Probability using DMRT

Table 17: Effects of Nitrogen Fertilization and *Striga* Infestation on Leaf area index of maize varieties at Samaru and Tashar Dauda during 2012 and 2013 rainy seasons.

Treatment	Samaru Leaf Area Index				Tashar Dauda Leaf Area Index			
	2012		2013		2012		2013	
	8 WAS[1]	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS
Nitrogen (N) kg/ha								
0	0.980c[2]	1.002d	1.139c	1.110d	0.809d	1.072c	0.835c	1.062d
40	0.965c	1.425c	1.096c	1.509c	1.076c	1.504b	0.820c	1.362c
80	1.183b	1.777b	1.310b	1.840b	1.201b	1.689a	1.207b	1.422b
120	1.355a	1.951a	1.388a	2.023a	1.329a	1.714a	1.356a	1.578a
SE ±	0.0251	0.0177	0.024	0.0067	0.0108	0.0450	0.0073	0.0462
***Striga* Infestation (S)**								
Un-infested	1.119	1.587a	1.226	1.620	1.127a	1.513	1.071a	1.476
Infested	1.122	1.491b	1.240	1.621	1.081b	1.477	1.038b	1.425
SE ±	0.0177	0.0125	0.0167	0.0047	0.0076	0.0318	0.0052	0.0423
Variety (V)								
SAMMAZ 11	1.043c	1.531b	1.155c	1.570c	1.094bc	1.430b	0.984d	1.326b

SAMMAZ 14	1.282a	1.556b	1.283b	1.696b	1.135a	1.584a	1.044c	1.426a
SAMMAZ 20	0.995c	1.439c	1.144c	1.487d	1.075c	1.445b	1.068b	1.348b
SAMMAZ 26	1.164b	1.629a	1.331a	1.729a	1.111ab	1.521ab	1.121a	1.382b
SE ±	0.0251	0.0177	0.0236	0.0067	0.0108	0.0450	0.0073	0.347
Interaction								
N x S	NS[3]	NS	NS	NS	NS	NS	NS	NS
N x V	NS	**[4]	NS	**	**[5]	*[4]	**	NS
S x V	NS	NS	NS	NS	NS	NS	**	NS
N x S x V	NS	NS	NS	NS	NS	NS	NS	NS

1 = Weeks After Sowing
2 = Means followed with the or no same letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
3 = Not Significant
4= Significant
5= Highly significant

Table18: Interaction between variety and nitrogen on leaf area index of maize varieties at 12 WAS at Samaru during 2012 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	0.049i	1.500e	1.736d	1.838bc
SAMMAZ 14	0.812i	1.362f	1.803d	2.246a
SAMMAZ 20	1.041h	1.169g	1.736d	1.811d
SAMMAZ 26	1.107gh	1.070gh	1.833cd	1.909b
SE ±		0.0354		

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

Table 19: Interaction between variety and nitrogen on leaf area index of maize varieties at 12 WAS at Samaru during 2013 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	1.120h	1.484f	1.682e	1.997b
SAMMAZ 14	1.200g	1.564f	1.857c	2.263a
SAMMAZ 20	1.101h	1.190g	1.824d	1.835cd
SAMMAZ 26	1.121h	1.798d	2.000b	1.998b
SE ±		0.0134		

Means followed with the same letter(s) are not significantly different at 5% level of Probability using DMRT.

Table 20: Interaction between variety and nitrogen on leaf area index at 8 WAS of maize varieties at Tashar Dauda during 2012 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	0.777h	1.087f	1.213de	1.298bc
SAMMAZ 14	0.793h	1.071f	1.253cd	1.423a
SAMMAZ 20	0.869g	1.066f	1.088f	1.276bc
SAMMAZ 26	0.799h	1.081f	1.249c-e	1.318b
SE ±		0.0216		

Means followed with the same letter(s) are not significantly different at 5% level of Probability using DMRT

The response of the varieties at120kgNha^{-1} showed that SAMMAZ 14 produced significantly higher LAI than all the other varieties with SAMMAZ 11 producing the least LAI. At 0kgNha^{-1}, SAMMAZ 20 produced higher LAI than all other varieties which were statistically at par. At 40kgNha^{-1},however, no significant differences were observed between varieties when 80kgNha^{-1} was applied SAMMAZ 20 gave the lower LAI than other varieties, which were statistically at par.

Interaction of variety and nitrogen on LAI at 12 WAS of maize varieties at Tashar Dauda during 2012 rainy season (Table 21) shows that LAI increased with increased in nitrogen from 0 – 80kgN ha^{-1}in SAMMAZ 20, 0-40kgNha^{-1} in SAMMAZ 11 and 26,beyond which there is no significant increase in this factor.

Interaction between striga and varieties on leaf area index at 8 WAS at Tashar Dauda during 2013 rainy season is presented in Table 22. Each increase in nitrogen from 0-120kgNha^{-1}, significantly increased the leaf area indexof all varieties, except for SAMMAZ 20 at 40 and 80kgN ha-,^{1} SAMMAZ 11 at 80 and 120kgN ha-^{1} which gave

comparable LAI.At 120kgN/ha, SAMMAZ 14produced the higher LAI followed by the other varieties which were statistically at par.

Interaction of *Striga* and variety on LAI at 8 WAS of maize at Tashar Dauda during 2013 rainy season (Table 23). At 8 WAS under *Striga* infestation, SAMMAZ 14 gave highest LAI comparable only to SAMMAZ 11 in uninfested condition. While SAMMAZ 20 and 26 showed no significant difference in LAI between infested and uninfested fields, SAMMAZ 11 gave significantly higher LAI in uninfested than infested while the reverse was the case with SAMMAZ 14.

Table 21: Interaction between variety and nitrogen on leaf area index at 12 WAS of maize varieties at Tashar Dauda during 2012 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	1.064d	1.490c	1.606b	1.561b
SAMMAZ 14	1.097d	1.550b	1.772ab	1.918a
SAMMAZ 20	1.042d	1.183d	1.770ab	1.785ab
SAMMAZ 26	1.085d	1.794ab	1.710ab	1.495c
SE ±			0.0901	

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

Table 22: Interaction between variety and nitrogen on leaf area index at 8 WAS of maize varieties at Tashar Dauda during 2013 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120

Variety (V)				
SAMMAZ 11	0.811h	0.585i	1.257c-e	1.287bc
SAMMAZ 14	0.794h	0.560i	1.267b-d	1.558a
SAMMAZ 20	0.870g	1.056f	1.066f	1.283bc
SAMMAZ 26	0.864g	1.081f	1.239de	1.301b
SE ±			0.0146	

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

Table 23: Interaction between *Striga* and variety on leaf area index at 8 WAS of maize varieties at Tashar Dauda during 2013 rainy season

	Tashar Dauda 2013			
	Variety (V)			
Treatment	SAMMAZ 11	SAMMAZ14	SAMMAZ 20	SAMMAZ26
***Striga* Infestation (S)**				
Un-infested	1.137ab	0.945e	1.073d	1.130bc
Infested	0.833f	1.144a	1.064d	1.112c
SE ±			0.0103	

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

4.12 Shoot Dry Weight per Plant

Shoot dry weight of maize varieties as affected by nitrogen fertilization and *Striga* infestations are contained in Table 24. At both locations, years sampling periods each increase in nitrogen from 0-120 kgN ha^{-1} significantly increased the shoot dry weight of maize. Significant difference between *Striga* levels was only observed at Tashar Dauda in 2012 at 12 weeks sampling period, where un-infested fields, significantly produced the

higher shoot dry weight then infested fields. Among varieties, the significant differences on shoot dry weight was observed at Samaru in 2012 at 12WAS, where SAMMAZ 26 significantly gave the height shoot dry weight than the other varieties. At Samaru in 2013, SAMMAZ 14, significantly recorded the higher leaf area index than SAMMAZ 20, but was comparable to SAMMAZ 11 and 26. At 12 WAS SAMMAZ 14 and 26 significantly gave the higher shoot dry weight than SAMMAZ 11 and 20.

At Tashar, significant differences was only observed in 2012, where SAMMAZ 26 at 8WAS, significantly produced the highest shoot dry weight than all other varieties, but at12 WAS, SAMMAZ 14 and 26, significantly recorded the highest shoot dry weight than SAMMAZ 11 and 20. There were significant interactions on shoot dry weight, between nitrogen and varieties at Samaru in 2012 at 12WAS and at Tashar Dauda in 2013 at 8 WAS, then between nitrogen and *Striga* at Tashar Dauda in 2012 at 8 and 12 WAS and between *Striga* and varieties at Samaru in 2012 at 12WAS.

Interaction between nitrogen levels andmaize variety on shoot dry weight at 12 WAS during 2012 rainy season at Samaru is presented in Table 25. Except with SAMMAZ 20, where application of 40 and 80kgN/ha were statistically similar, each increase in nitrogen

from 0-120 $kgNha^{-1}$ significantly increased shoot dry weight of all maize varieties.At the same rate of $120KgNha^{-1}$ SAMMAZ14 gave highest shoot dry weightfollowed by SAMMAZ 11. At control all varieties gavecomparable shoot dry weight but with all other N rates significant differences were recorded among varieties.

Interaction between *Striga* infestation and maize variety on shoot dry weight at 12 WAS of maize varieties during 2012 rainy season at Samaru (Table 26) shows that SAMMAZ 26gave highest shoot dry weight under *Striga* infestation followed by SAMMAZ 14 where uninfested gave comparable shoot dry weight with infested.

Interaction between nitrogen levels and *Striga* infestation on shoot dry weight at 8 WAS of maize varieties at Tashar Dauda during 2012 rainy season is presented in Table 27. Maize inuninfested fields showed significant increase in shoot dry weight with eachincrease in N up to 80kgN ha^{-1} beyond which the increase was not significant, while in the *Striga* infested fields, the control and 40KgN ha^{-1} gave comparable maize shoot dry weight beyond which eachfurther increase was not significant.

Interaction between nitrogen and *Striga* on shoot dry weight at 12 WAS of maize varieties at Tashar Dauda during 2012 wet season is presented in Table 28. Maize in infested fields gave significantly higher shoot dry weight than that in uninfested fields at all levels of nitrogen except control wherecrops in both fields were statistically at par. Maize in infested fields treated to 120KgN ha-1 gave highest maize shoot dry weight, followed by uninfested fields at the same fertilizer level.Whether infested or uninfested, each increase in N resulted in significant increase in maize shoot dry weight.

Table 24: Effects of nitrogen fertilization and *Striga* infestation on shoot dry weight of maize varieties at Samaru and Tashar Dauda during 2012 and 2013 rainy seasons

Treatment	Shoot Dry Weight (g plant^{-1})							
	2012		2013		2012		2013	
	8 WAS[1]	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS	8 WAS	12 WAS
Nitrogen (N) kg/ha								
0	31.4d[2]	41.9d	34.9d	44.0d	31.4d	41.2d	37.8d	42.9d
40	70.1c	105.5c	69.4c	105.3c	66.8c	99.6c	67.6c	103.4c
80	111.3b	185.6b	114.9b	197.9b	120.6b	191.8b	115.5b	177.7b
120	136.1a	246.5a	149.6a	252.7a	131.8a	215.5a	138.5a	244.7a
SE ±	0.70	0.48	0.65	0.91	0.29	0.66	1.06	3.32
***Striga* Infestation (S)**								
Un-infested	86.8	145.1	91.9	151.2	87.9	140.3a	90.2	143.2
Infested	87.8	144.7	92.6	148.7	87.4	133.9b	89.5	141.2
SE ±	0.50	0.34	0.46	0.64	0.21	0.47	0.75	2.35
Variety (V)								
SAMMAZ 11	85.8	142.5c	90.7ab	143.9b	85.5d	129.6c	90.8	140.1

SAMMAZ 14	84.8	146.6b	96.3a	154..2a	88.2b	141.3a	89.4	144.3
SAMMAZ 20	86.6	141.5c	88.1b	144.3b	86.8c	135.1b	88.2	142.0
SAMMAZ 26	91.6	149.1a	93.7ab	157.5a	90.2a	142.1a	91.1	142.3
SE ±	0.70	0.48	0.65	0.91	0.29	0.66	1.06	3.32
Interaction								
N x S	NS[3]	NS	NS	NS	**[4]	**	NS	NS
N x V	NS	**[4]	NS	NS	NS	NS	**	NS
S x V	NS	**	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS	NS	NS

1 = Week After Sowing

2 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

3 = Not Significant

4=Highly significant

Table25: Interaction between variety and nitrogen on shoot dry weight at 12 WAS of maize varieties during 2012 rainy season at Samaru

	Nitrogen(N) kgha^{-1}			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	41.3k	104.5ij	175.8f	247.4b
SAMMAZ 14	42.7k	107.1hi	175.4f	261.3a
SAMMAZ 20	40.9k	101.7j	101.9j	241.5c
SAMMAZ 26	42.8k	109.0g	208.7e	236.0d
SE ±			0.95	

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

Table 26: Interaction between *Striga* and variety on shoot dry weight at 12 WAS of maize varieties during 2012 rainy season at Samaru

	Varieties(V)			
Treatment	SAMMAZ 11	SAMMAZ 14	SAMMAZ 20	SAMMAZ 26
***Striga* Infestation (s)**				
Un-infested	144.4c	145.7bc	145.4c	145.0c
Infested	140.6d	147.5b	137.6e	153.2a
SE ±			0.67	

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

Table 27: Interaction between Nitrogen and *Striga*infestation on shoot dry weight at 8 WAS of maize varieties at Tashar Dauda during 2012 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
***Striga* Infestation (S)**				
Un-infested	19.9e	33.4d	50.5a-c	54.0a
Infested	33.7d	32.7d	49.6c	53.5ab
SE ±			1.50	

Means followed with the same or no letter(s) are not significantly different at 5% level of probability using DMRT

Table 28: Interaction between nitrogen and *Striga* on shoot dry weight at 12 WAS of maize varieties at Tashar Dauda during 2012 rainy season

	Nitrogen (N) kgha^{-1}			
Treatment	0	40	80	120
Striga Infestation (S)				
Un-infested	39.8g	97.2f	187.6d	210.6b
Infested	42.4g	102.1e	196.1c	220.5a
SE ±			0.93	

Means followed with the same or no letter(s) are not significantly different at 5% level of probability using DMRT

Except with control (0kgN) all other N rates gave significant shoot dry weight in both infested and uninfested fields. Uninfested fields at 120kgN ha^{-1} gave the highest shoot dry weight comparable only to maize in uninfested at 80kgN ha^{-1} and that in infested at 120KgNha^{-1}.

Interaction between nitrogen and variety on shoot dry weight at 8 WAS of at Tashar Dauda during 2013 rainy season is presented in Table 29. SAMMAZ 11, 26 and 14 experienced significant increase in shoot dry weight with each increase in Nlevels from 0 to 80kgN ha^{-1}, beyond which the increase was not significant.SAMMAZ 26 and 14 gave comparable and highest shoot dry weight at 80 and 120kgN ha^{-1} only. At all levels of N no significant differences in shoot dry weight were observed among the varieties except at 80kgN $ha^{-1}$where SAMMAZ 20 and 11 gave comparable shoot dry weight but were significantly lower than the other varieties which in turn gave statistically similar shoot dry weights.

Table 29: Interaction between nitrogen and variety on shoot dry weight at 8 WAS of maize varieties at Tashar Dauda during 2012 rainy season

	Nitrogen (N) kg/ha			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	19.1d	32.0c	48.9b	49.5ab
SAMMAZ 14	19.1d	33.7c	52.4a	54.9a
SAMMAZ 20	19.4d	33.0c	46.2bc	52.7a
SAMMAZ 26	19.5d	33.6c	52.9a	53.7a
SE ±		2.1		

Means followed with the same or no letter(s) are not significantly different at 5% level of probability using DMRT

4.13 Crop Growth Rate

Table 30 shows the effects of nitrogen fertilization and *Striga i*nfestation on crop growth rate (CGR) of maize varieties. Each increase in nitrogen from 0-120kgNha^{-1} significantly increased crop growth rate in both locations, years and mean. At both locations, there was no significant difference in CGR between maize in *Striga* infested field and uninfested except, at Tashar Dauda in 2012 where maize in uninfested fields gave significantly higher CGR than in infested fields. Significant differences in CGR among varieties were only observed in 2013 at Samaru and 2012 at Tashar Dauda. At Samaru, SAMMAZ 14 gave significantly higher CGR than SAMMAZ 20 but statistically comparable to SAMMAZ 11 and 26, while at Tashar Dauda, SAMMAZ 26 gave highest CGR followed by SAMMAZ 14 and 20. No significant differences in CGR due to interactions among the factors evaluated were observed.

4.14 Crop Growth Rate

Effects of nitrogen fertilization and *Striga* infestation on crop growth rate of maize varieties is presented in Table 31. At both locations, years and mean, each increase in nitrogen from 0- 120kgN ha^{-1} significantly increased the CGR of maize. *Striga*infestation caused a significant increase in CGR only at Tashar Dauda in 2012. Among the crop varieties, significant difference in CGR was recorded at Tashar Dauda in 2012 where SAMMAZ 14 and 26 gave comparable CGR but significantly higher than other varieties,and in themean whereSAMMAZ 14 gave higher CGR comparable only to

SAMMAZ 26 and 20. There were no significant interactions among the factors evaluated on CGR.

4.15 Relative Growth Rate

Table 32 shows the effects of nitrogen fertilization and *Striga* infestation on relative growth rate (RGR) of maize varieties. At Samaru location, years and the mean, applications of nitrogen at 120kgNha^{-1}, gave significantly higher RGR than all other rates of nitrogen except, 40kgN ha^{-1} in 2013, with which it was statistically similar. At Tashar Dauda, in both years, and the mean, increase in nitrogen from 0-80kgNha^{-1}, significantly increased RGR of maize, except in 2013 where 40 and 80kgNha^{-1}were statistically at par. Application of 120kgN ha-^{1}recorded the highest RGR in both years and the mean, which was comparable only to 80kgN ha^{-1}. *Striga* infestation caused significant reduction inRGRonly in 2012 at both locations. The significant difference among varieties in RGR, was only recorded, both at Samaru and Tashar Dauda in 2013. At Samaru SAMMAZ 11,gave significantly higher RGR than SAMMAZ 20, while at Tashar Dauda SAMMAZ 11,

Table 30: Effects of nitrogen fertilization and *Striga* infestation on crop growth rate of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Crop Growth Rate at 8 WAS^{1}(g/m^{2}/wk)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	2.9d^{2}	3.7d	3.3d	3.4d	2.7d	3.1d
40	8.5c	9.8c	9.2c	10.3c	8.6c	9.5c
80	16.5b	15.8b	16.2b	19.6b	16.4b	18.0b

120	21.7a	22.5a	22.1a	21.6a	21.2a	21.4a
SE ±	0.53	0.52	0.04	0.09	0.93	0.49
***Striga* Infestation (S)**						
Un-infested	12.9	13.1	13.0	13.9a	12.7	13.2
Infested	11.9	12.8	12.3	13.5b	11.8	12.6
SE ±	0.37	0.37	0.03	0.06	0.63	0.35
Variety (V)						
SAMMAZ 11	12.1	13.0ab	12.6	13.3c	13.1	13.2
SAMMAZ 14	11.8	13.7a	12.7	13.8b	12.3	13.0
SAMMAZ 20	12.7	11.9b	12.3	13.7b	12.6	13.2
SAMMAZ 26	13.0	13.ab	13.1	14.2a	10.9	12.7
SE ±	0.53	0.52	0.04	0.09	0.93	0.49
Interaction						
N x S	NS[3]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Weeks After Sowing

2 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

3 = Not Significant

Table 31: Effects of nitrogen fertilization and *Striga* infestation on crop growth rate of maize varieties at Samaru and Tashar during 2012, 2013 rainy seasons and the mean

	Crop Growth Rate at 12WAS[1] (g/m^2/wk)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	2.6d[2]	2.2d	2.5d	2.4d	1.3d	1.9d
40	8.9c	8.9c	8.9c	8.2c	8.9c	8.6c
80	18.7b	20.7b	19.7b	17.8b	15.5b	16.7b

120	27.6a	25.8a	26.7a	20.9a	26.5a	23.7a
SE ±	0.58	0.89	0.55	0.14	0.86	0.51
***Striga* Infestation (S)**						
Un-infested	14.6	14.8	14.7	13.4b	13.2	13.1
Infested	14.3	14.0	14.2	14.0a	12.9	12.3
SE ±	0.41	0.63	0.39	0.10	0.61	0.36
Variety (V)						
SAMMAZ 11	14.2	13.3	13.7	11.1c	12.3	11.7b
SAMMAZ 14	15.4	14.5	15.1	13.3a	13.7	13.5a
SAMMAZ 20	13.7	14.1	13.9	12.1b	13.5	12.8ab
SAMMAZ 26	14.4	15.9	15.1	12.9a	12.8	12.9ab
SE ±	0.58	0.89	0.55	0.14	0.86	0.51
Interaction						
N x S	NS[3]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Weeks After Sowing

2 = Means followed with the sameor no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

3 = Not Significant.

Table 32: Effects of nitrogen fertilization and *Striga* infestation on relative growth rate of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean

	Relative Growth Rate at 8 WAS[1](g/g)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	0.117d[2]	0.143c	0.130c	0.145c	0.130c	0.137c
40	0.166c	0.211ab	0.189b	0.240b	0.179b	0.210b
80	0.226b	0.191b	0.208b	0.263a	0.209ab	0.236a

120	0.250a	0.229a	0.240a	0.266a	0.237a	0.251a
SE ±	0.0064	0.0106	0.0112	0.0019	0.0126	0.0070
***Striga* Infestation (S)**						
Un-infested	0.199a	0.201	0.200	0.232a	0.192	0.212
Infested	0.180b	0.186	0.183	0.224b	0.186	0.205
SE ±	0.0046	0.0075	0.0062	0.0014	0.0001	0.0049
Variety (V)						
SAMMAZ 11	0.188	0.208a	0.198	0.227	0.207a	0.217
SAMMAZ 14	0.182	0.198ab	0.190	0.229	0.187ab	0.208
SAMMAZ 20	0.200	0.172b	0.186	0.230	0.195ab	0.213
SAMMAZ 26	0.189	0.196ab	0.193	0.228	0.166b	0.197
SE ±	0.0064	0.0106	0.0072	0.0019	0.0126	0.0070
Interaction						
N x S	NS[3]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Weeks After Sowing
2 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
3 = Not Significant

still gave highest RGR butcomparable to all varieties except SAMMAZ 26. There was no significant interaction among the factors on RGR.

4.16 Relative Growth Rate

Effects of nitrogen fertilization and *Striga* infestation on relative growth rate (RGR) of maize is presented in Table 33. At Samaru location, in both years, and the mean, each increase in nitrogen from 0 – 80kgN ha^{-1}significantly increased RGR except in 2012

where the increase is from 0 – 120kgN ha^{-1}. In both years and the mean, 0kgN ha^{-1} recorded the least RGR which was statistically atpar with 40kgN ha^{-1} at Samaru in 2013.

At Tashar Dauda in 2012 each increased in N significantly increase RGR up to 120kgN ha^{-1}, however, in 2013 and the mean 40 and 80kgN had statistically similar RGR but each significantly higher and lower than the control and 120kgN ha^{-1}, respectively.

The infested field gave significantly higher RGR than uninfested field only at Tashar Dauda in 2012. At Samaru location there were no significant differencesin RGRbetween varieties but at Tashar Dauda in both years and mean all varieties gave significantly higher RGR than SAMMAZ 11 except SAMMAZ 26 in 2013 at Tashar Dauda that was at par.There were no significant interactions among the factors on RGR.

4.17 Days to 50% Tasseling

At Samaru,varying nitrogen levels influenced days to 50% tasseling (Table 34). Nitrogen levels at 0 and 40kgN ha^{-1} in 2012 or 40 – 80kgN ha^{-1} or 80 – 120kgN ha^{-1}at Samaru were statistically similar.At Tashar Dauda, the influence was at 2013 and the mean, in 2013 increase in N levelsfrom 0 to 40KgN ha^{-1}

Table 33: Effects of nitrogen fertilization and *Striga* infetation on relative growth rate of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean

	Relative Growth Rate at 12 WAS[1](g/g)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	0.073d[2]	0.058c	0.065c	0.067d	0.042c	0.055c
40	0.103c	0.089bc	0.096b	0.099c	0.106b	0.103b
80	0.128b	0.145a	0.137a	0.120b	0.105b	0.111b

120	0.134a	0.130ab	0.142a	0.123a	0.142a	0.132a
SE ±	0.0066	0.0153	0.0086	0.0016	0.0067	0.0043
***Striga* Infestation (S)**						
Un-infested	0.118	0.114	0.116	0.095b	0.104	0.020
Infested	0.111	0.097	0.104	0.108a	0.093	0.101
SE ±	0.0049	0.0109	0.0061	0.0011	0.0048	0.0030
Variety (V)						
SAMMAZ 11	0.112	0.082	0.098	0.094b	0.085b	0.089b
SAMMAZ 14	0.126	0.105	0.116	0.105a	0.106a	0.106a
SAMMAZ 20	0.107	0.117	0.112	0.101a	0.107a	0.104a
SAMMAZ 26	0.111	0.118	0.115	0.106a	0.097ab	0.101a
SE ±	0.0069	0.0153	0.0086	0.0016	0.0067	0.0043
Interaction						
N x S	NS[3]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Weeks After Sowing

2 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

3 = Not Significant

Table 34: Effects of nitrogen fertilization and *Striga* infestation on days to 50% tasseling ofmaize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Days to 50% tasseling					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						

0	53.7c[1]	55.2	54.3	54.9	53.4b	54.2b
40	54.4bc	57.4	55.9	55.8	55.6a	55.7b
80	56.1ab	58.4	57.3	56.6	56.9a	56.8a
120	56.4a	58.6	57.5	56.7	56.3a	56.5a
SE ±	0.66	1.28	0.64	0.88	0.60	1.39
***Striga* Infestation (S)**						
Un-infested	55.1	70.1	62.6	65.3	56.1	60.7
Infested	55.1	57.5	56.3	55.3	55.0	55.1
SE ±	0.46	0.91	0.45	0.62	0.42	0.98
Variety (V)						
SAMMAZ 11	52.3bc	53.3b	52.8b	51.8	51.7c	51.8c
SAMMAZ 14	63.3a	63.8a	63.6a	65.3	64.7a	65.0a
SAMMAZ 20	51.2c	53.0b	52.1b	59.4	51.8c	51.6c
SAMMAZ 26	53.6ab	55.0b	54.3b	54.6	54.0b	54.3b
SE ±	0.66	1.28	0.64	0.88	0.60	1.39
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

2 = Not Significant

significantly increased days to 50% tasseling, further increase to 120kgN ha^{-1} did notstatistically influenced days to 50% tasselling. In the mean of the years, increase in N levels from 0 to 40kgN ha^{-1} or 80 – 120kgN ha^{-1} werestatistically at par.Varying infestation did not significantly influenced days to 50% tasseling in both season and the mean of the years. Maize varieties significantly influence days to 50% tasseling at locatons, years and the mean except at Tashar Dauda in 2012 season. At Samaru in 2012 season, SAMMAZ 20 and 11, SAMMAZ 11 and 26 and SAMMAZ 20, 11 and 26 were at par and produced significantlylower days to 50% tasseling than SAMMAZ 14. At Tashar Dauda, SAMMAZ 14 and 11 were at par, followed by SAMMAZ 26 and SAMMAZ 14 significantly took longer days to attain days to 50% tasseling. None of the treatment had interactions on days to 50% tasseling were significant in both years, locations and the means.

4.18 Days to 50% Silking

Varying nitrogen levels influenced bydays to 50% silking (Table 35). At Samaru, application nitrogen at 0 – 80kgN ha^{-1} and 80 – 120kgN ha^{-1} were statistically similar. At Tashar Dauda, the influence was in 2012 and mean, control significantly reduced the days to 50% silking than all the nitrogen levels which were statistically at par. Varying *Striga* infestation influenced days to 50% at Tashar Dauda in 2012 and the mean. Uninfested field significantly recorded prolonged days to 50% silking than the infested field. Maize varieties singnificantly influenced days to 50% silking in locations, years and the mean except at Samaru 2013. At Samaru in 2012 and the mean all the varieties

significantly recorded shorter days to 50% silking than SAMMAZ 14. At Tashar Dauda in both years and the mean, SAMMAZ 11 and 14 significantly recorded the shortest days to 50% silking followed by SAMMAZ 26, while SAMMAZ 14 significantly had prolonged days to 50% silking than all other varieties.This was followed by SAMMAZ 20, 11 and 26 in Samaru and SAMMAZ 26 at Tashar Dauda.Tashar Dauda.There were no significant interactions among the factors on days to 50% silking.

4.19 Stem Lodging Count

Effects of nitrogen fertilization and *Striga* infestation on stem lodging count of maize vatieties are presented in Table 36. At both locations, years and the mean, the untreated control gave the highest stem lodging count than all other N levels except at Tashar Dauda 2012, where there were no significant differences among nitrogen levels. The significant difference between *Striga* infested and uninfested field was only recorded at Samaru location 2012 and the mean where maize in uninfested fields gave significantly less lodging count than the *Striga* infestedfields. There was no significant differences on stem lodging count among the maize varieties in both locations years and the mean except at Samaru in 2012 where SAMMAZ 14 gave highest lodging count than all other varieties which were in turn statistically at par. There were nosignificant interactions among the factors tested on stem lodging count.

4.20 Ear Height

Effects of nitrogen fertilization and *Striga* infestation on ear height of maize varieties is presented in Table 37.

Table 35: Effects of nitrogen fertilization and *Striga* infestation on days to 50% silking of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean

	Days to 50% silking					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	55.8b	56.7	56.3	56.5b	55.8	56.2b
40	55.9b	59.2	57.6	57.5a	57.1	57.3a
80	56.8ab	58.8	57.8	57.8a	57.8	57.8a
120	57.1a[1]	60.7	58.9	58.1a	57.5	57.8a
SE ±	0.33	1.24	0.62	0.29	0.28	0.20
***Striga* Infestation (S)**						
Un-infested	56.5	70.5	63.5	57.9a	57.3	57.6a
Infested	56.3	59.7	58.0	57.0b	56.8	56.9b
SE ±	0.23	0.88	0.43	0.21	0.20	0.14
Variety (V)						
SAMMAZ 11	53.3b	56.0	55.0b	54.3c	53.8c	54.0c
SAMMAZ 14	64.3a	62.2	63.3a	66.4a	66.2a	66.3a
SAMMAZ 20	53.6b	55.5	54.5b	53.5c	53.6c	53.5c

SAMMAZ 26	54.3b	56.1	55.2b	55.7b	54.7b	55.2b
SE ±	0.33	1.24	0.62	0.29	0.28	0.20
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

Table 36: Effects of nitrogen fertilization and *Striga* infestation on stem lodging count of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Stemlodging count					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	13.1a[1]	10.6a	11.8a	12.2	14.1a	13.2a
40	11.4b	6.5b	9.0b	11.5	6.4b	9.0b
80	10.8c	5.6b	8.2b	11.2	5.8b	8.5b
120	10.9c	6.3b	8.6b	11.5	5.3b	8.4b

SE ±	0.15	0.76	0.38	0.61	0.56	0.36
***Striga* Infestation (S)**						
Un-infested	11.3b	6.6	8.9b	11.6	7.9	9.8
Infested	11.8a	7.9	9.8a	11.6	10.7	11.2
SE ±	0.11	0..53	0.27	0.43	0.32	0.29
Variety (V)						
SAMMAZ 11	11.5b	6.4	8.9	11.5	6.7	9.1
SAMMAZ 14	12.1a	7.6	9.8	12.1	7.4	9.8
SAMMAZ 20	11.2b	7.4	9.3	11.2	7.0	9.1
SAMMAZ 26	11.4b	7.7	8.5	11.5	6.2	8.9
SE ±	0.15	0.76	0.38	0.61	0.56	0.36
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

Table 37: Effects of nitrogen fertilization and *Striga* infestation on ear height of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the

mean

	Ear height (cm)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	59.3c[1]	68.6d	64.0d	58.4c	56.4d	57.4d
40	64.5bc	73.2c	68.8c	63.7b	60.9c	62.4c
80	71.1ab	80.2b	75.6b	65.5ab	69.2b	67.3b
120	76.9a	82.9a	79.9a	69.6a	72.3a	71.0a
SE ±	2.83	0.93	1.52	1.70	0.58	0.92
***Striga* Infestation (S)**						
Un-infested	75.2a	78.6a	76.9a	71.0a	69.4a	70.1a
Infested	60.7b	73.9b	67.3b	57.6b	60.0b	58.8b
SE ±	1.99	0.66	1.08	1.20	0.41	0.65
Variety (V)						
SAMMAZ 11	65.8	73.4c	69.6b	63.3	62.5b	62.9
SAMMAZ 14	68.4	80.3a	74.3a	64.3	66.8a	65.5
SAMMAZ 20	67.5	76.3b	71.9ab	64.6	65.7a	65.1
SAMMAZ 26	69.4	75.0bc	72.2ab	65.1	63.8b	64.5
SE ±	2.83	0.93	1.53	1.70	0.58	0.92
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS

N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

At both locations, years and the mean, each increase in nitrogen from 0-120kgha^{-1}, significantly gave higher increase in ear height except, in 2012 at both locations, where application of nitrogen at 80 and 120kgNha^{-1} were statistically at par. Application of nitrogen at 0 and 40kgNha^{-1}consistently recorded the lower ear heights of maize than application of nitrogen at 80 and 120kgNha^{-1}, except at Tashar Dauda in 2012.

At both locations, years and the mean,maize in uninfested fields gave significantly higher ear heights than that in fields infested with *Striga*. Significant differences among varieties in ear height was recorded in 2013 and the mean at Samaru and in 2013 at Tashar Dauda. SAMMAZ 14 at Samaru gave highest ear height which was statistically similar to SAMMAZ 26 in the the mean. SAMMAZ 20, at Tashar Dauda, produced the highest ear height, followed by SAMMAZ 11 and 26 which were at par but each significantly higher than SAMMAZ 14. There were no significant interactions among factors on ear height of maize.

4.21 Number of Cobs perPlant

Nitrogenfertilization and *Striga* infestation effects on number of cobs per plant of maize varieties are shown in Table 38. At both locations, years and the mean, each increase in nitrogen from 0-120 kgNha^{-1} significantly increased number of cobs per plant except in 2012 at Samaru where application of 80 and 120kgN ha^{-1}resulted in number of cobs that were statistically similar.

Uninfested fields gave significantly more number of cobs than infested fields at Samaru in 2013 andthe mean and atTashar Dauda in 2012 and the mean. At both locations years

Table 38: Effects of nitrogen fertilization and *Striga* infestation on number of cobs per plant of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean .

	Number of cobs per plant					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	1.0b[1]	1.0d	1.0d	0.8d	0.8d	0.8d
40	1.0b	1.1c	1.1c	1.0c	1.0c	1.0c
80	1.2a	1.3b	1.3b	1.1b	1.2b	1.2b
120	1.3a	1.4a	1.4a	1.3a	1.3a	1.3a
SE ±	0.02	0.04	0.02	0.03	0.03	0.02
***Striga* Infestation (S)**						
Un-infested	1.1	1.2a	1.2a	1.1a	1.1	1.1a

Infested	1.1	1.0b	1.1b	1.0b	1.1	1.0b
SE ±	0.07	0.03	0.02	0.02	0.02	1.01
Variety (V)						
SAMMAZ 11	1.0	1.1b	1.1b	1.0b	1.0b	1.0b
SAMMAZ 14	1.0	1.2a	1.2a	1.2a	1.1a	1.1a
SAMMAZ 20	1.0	1.1b	1.1b	1.0b	1.0b	1.0b
SAMMAZ 26	1.1	1.3a	1.2a	1.1a	1.1a	1.1a
SE ±	0.02	0.04	0.02	0.03	0.03	0.02
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

and the mean, SAMMAZ 14 and 26 gave comparable but significantly more number of cobs per plant than SAMMAZ 11 and 20, except at Samaru in 2012 where there were no significant differences among maize varieties.There were no significant interactions among the factors on number of cobs.

4.22 Cob Length

Table 39 shows effects of nitrogen fertilization and *Striga* infestation on cob length of maize varieties. At both locations, years and the mean each increase in nitrogen from 0-120kgN/ha significantly increased cob length of maize. Uninfestedfieldsproduced significantly longer cobs than *Striga* infested fieldsat both locations, years and the mean, except in 2012 at Tashar Dauda where the differences was not significant. At both locations, years and the mean SAMMAZ 26 produced significantly longer cobs than all the other varieties. The shortest cobs were produced by SAMMAZ 11 and 14 at both locations in 2013 and the mean. There were no significant interactions among factors on cob length.

4.23 Cob Diameter

Effects of nitrogen fertilization and *Striga* infestation on cob diameter of maize varietiesare presented in Table 40. At both locations varying levels of nitrogen influenced cob diameter of maize. In 2012,at both locations, control and 40kgNha^{-1} were statistically at par and at Samaru, 2013 where 40kgNha^{-1} and 80kgN ha^{-1} were also statistically similar, but for othereach increase in nitrogen from 0 to 120kgN ha^{-1}significantly increased cob diameter of maize. There was no significant difference in cob diameter of maize in fields uninfested and infested with *Striga*. At both locations, years and mean SAMMAZ 14 and SAMMAZ 26produced comparable cob diameter that was higher than all other varieties

Table 39: Effects of nitrogen fertilization and *Striga* infestation on cob length of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean

	Cob length (cm)

	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	13.1d[1]	14.5d	13.8d	13.3d	14.1d	13.7d
40	14.3c	14.9c	14.6c	13.8c	14.5c	14.2c
80	17.7b	18.0b	17.9b	17.4b	17.0b	17.2b
120	19.6a	19.5a	19.6a	19.3a	18.3a	18.8a
SE ±	0.14	0.10	0.09	0.10	0.01	0.09
***Striga* Infestation (s)**						
Un-infested	16.4a	16.8a	16.6a	16.0	16.2a	16.1a
Infested	16.0b	16.6b	16.3b	15.9	15.8b	15.9b
SE ±	0.10	0.07	0.07	0.07	0.05	0.06
Variety (V)						
SAMMAZ 11	16.0b	16.2c	16.1c	15.7b	15.5c	15.6c
SAMMAZ 14	15.9b	16.5c	16.2bc	15.7b	15.6c	15.5c
SAMMAZ 20	15.9b	16.9b	16.4b	15.8b	16.1b	15.9b
SAMMAZ 26	16.9a	17.4a	17.2a	16.7a	16.7a	16.7a
SE ±	0.14	0.10	0.09	0.10	0.08	0.09
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS

S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

Table 40: Effects of nitrogen fertilization and *Striga* infestation on cob diameter of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean

	Cob diameter (cm)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	3.7c[1]	4.2c	4.0d	3.8c	3.8d	3.8d
40	3.9c	4.6b	4.2c	3.9c	4.1c	3.9c
80	4.4b	4.7b	4.6b	4.3b	4.6b	4.4b
120	4.9a	5.0a	5.0a	4.7a	4.9a	4.8a
SE ±	0.04	0.09	0.05	0.05	0.06	0.04
***Striga* Infestation (S)**						
Un-infested	4.3	4.7	4.5	4.2	4.4	4.3
Infested	4.1	4.6	4.4	4.1	4.3	4.2
SE ±	0.03	0.07	0.04	0.03	0.04	0.03

Variety (V)						
SAMMAZ 11	4.1b	4.4b	4.3b	4.0b	4.2d	4.1c
SAMMAZ 14	4.4a	4.8a	4.6a	4.4a	4.6a	4.5a
SAMMAZ 20	4.1b	4.6ab	4.3b	4.0b	4.3bc	4.2c
SAMMAZ 26	4.4a	4.7ab	4.5a	4.3a	4.4ab	4.3b
SE ±	0.04	0.09	0.05	0.05	0.05	0.04
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

except with SAMMAZ 20 in 2013 at Samaru.Cobs with least diameter were recorded by SAMMAZ 11 and 20 at Tashar Dauda 2013 and the mean. There were no significant interactions among the factors on cob diameter.

4.24 Number of Seed Rows per Cob

Table 41 shows the effects of nitrogen fertilization and *Striga* infestation on number of seed rows per cob of maize varieties. At Samaru location, significant differences among

nitrogen levels were only observed in 2013, where 120kgN ha^{-1}gave significantly higher number of seed rows per cob than untreated control which was at par with 40kgNha^{-1}. Similarlyat Tashar Dauda, in both years, and the mean application of 40-120kgN ha^{-1}, gavecomparable number of seed rows per cob but each significantly higher than the untreated control. At Samaru, *Striga* infestation caused significant reduction in number of seedrows per cob in 2013, and the mean, while at Tashar Dauda a similar result was obtained in 2012, and the mean.

Significant differences among varieties in number of seed rows per cob were only observed at Samaru, in the mean, where SAMMAZ 14 produced significantly higher number of seed rows per cob, than all other varieties, which were statistically at par with each other.

4.25 Mean Cob Weight

Nitrogen fertilization and *Striga* infestation effects on mean cob weight of maize varieties are presented in Table 42.Application of 120kgN ha^{-1} at Samaru and Tashar Dauda in both years and the mean, gave theheaviest cobs and was statistically similar to that obtained from 80kgN ha^{-1} in both years andthe mean in both locations as well as 40kgN ha^{-1} in 2013 at Tashar Dauda.

Table 41: Effects of nitrogen fertilization and *Striga* infestation on number of rows per Cobof Maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Number of seed rows per cob					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Means	2012	2013	Mean
Nitrogen (N) kg/ha						

0	13.5	13.8b[1]	13.7	12.1b	12.9b	12.5b
40	12.9	14.3ab	13.6	12.9a	13.5a	13.2a
80	13.4	14.6a	14.1	13.0a	13.9a	13.5a
120	16.5	14.8a	15.7	13.3a	13.8a	13.5a
SE ±	4.91	0.21	0.37	0.19	0.18	0.14
***Striga* Infestation (S)**						
Un-infested	13.9	14.6a	14.3a	13.6a	13.6	13.6a
Infested	13.9	14.1b	13.7b	12.1b	13.4	12.7b
SE ±	1.50	0.15	0.23	0.13	0.13	0.10
Variety (V)						
SAMMAZ 11	13. 1	14.4	13.6b	12.9	13.6	13.3
SAMMAZ 14	14.0	14.6	14.3a	12.8	13.6	13.2
SAMMAZ 20	13.1	14.1	13.6b	12.8	13.5	13.1
SAMMAZ 26	13.0	14.3	13.7b	12.9	13.3	13.1
SE ±	4.91	0.21	0.33	0.19	0.18	0.14
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT

2 = Not Significant

Table 42: Effects of nitrogen fertilization and *Striga* infestation on mean cob weight of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Mean Cob Weight (g)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	64.6c[1]	123.4bc	94.0b	39.8c	73.7b	56.7c
40	70.5b	118.3c	105.2b	56.8b	99.6ab	78.2bc
80	83.6a	140.8ab	125.7a	72.0a	113.7ab	92.9ab
120	85.5a	144.0a	128.7a	77.5a	153.4a	115.4a
SE ±	4.08	6.13	4.20	4.30	5.93	3.60
***Striga* Infestation (S)**						
Un-infested	101.2a	147.9a	124.5a	80.0a	118.9	90.6
Infested	89.2b	115.3b	102.3b	43.1b	101.2	81.0
SE ±	3.63	3.62	2.79	3.04	4.20	6.97
Variety (V)						
SAMMAZ 11	95.2ab	137.2	116.2	62.4b	99.2	80.8
SAMMAZ 14	104.4a	128.3	116.4	69.2a	110.3	84.0

SAMMAZ 20	87.9b	126.2	107.1	59.9b	100.3	80.1
SAMMAZ 26	93.2ab	134.7	114.0	66.6b	130.1	98.4
SE ±	5.13	6.13	4.20	4.30	5.93	3.60
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

At Samaru in both years and the mean, maize in uninfested fieldsgave significantly heavier cobs than that in *Striga* infested fields while at Tashar Dauda the uninfested fields produced significantly heavier cobs than infested fields only in 2012.

At Samaru, SAMMAZ 14 significantly gave heavier cobs in 2012, which was comparable to SAMMAZ11 and SAMMAZ 26, while at Tashar Dauda,SAMMAZ14 significantly recorded the havier cob than all other varieties. There was no significant interaction among the factors on cob weight.

4.26 Seed Weightper Cob

Effects of nitrogen fertilization and *Striga* infestation on mean seed weight per cob of maize varieties is presented in Table 43. At both locations, years and the mean each increase in nitrogen level caused a significant increase in seed weight per cob up to

80kgN ha^{-1} beyond which the increase was not significant. *Striga* infestation caused significant seed weight reduction in locations, years and the mean except in 2012 at Samaru where the difference was not significant. Significantdifferences among maize varieties in seed weight per cob were observed at Samaru in 2012 and Tashar Dauda in 2013. At Samaru, SAMMAZ 14 ,gave significantly heavier seed weight than SAMMAZ 26 only, while at Tashar Dauda, it produced significantly heavier seed than onlySAMMAZ 11 and 26. At Samaru, SAMMAZ 14 producedsignificantly higher seed weight than SAMMAZ 26 which was statistically similar to SAMMAZ 11 and SAMMAZ 20. At Tashar Dauda, SAMMAZ 14 significantly recorded the heaviest seed weight which was statistically at par with SAMMAZ 20. There were no significant interactions among the factors on seed weight per cob.

Table 43: Effects of nitrogen fertilization and *Striga*infestationon mean cob grain weight of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean

	Seed weight per cob (g)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	50.3c[1]	95.6	73.0c	31.0c	46.2c	38.6c
40	70.5b	98.8	84.6b	45.9b	69.7b	57.8b
80	85.5a	110.8	98.1a	61.7a	78.1a	69.9a
120	83.6a	106.7	95.1a	66.1a	76.2a	71.2a
SE ±	4.08	5.12	3.54	3.67	2.58	2.53

Striga Infestation (S)						
Un-infested	74.4	120.6a	97.5a	67.4a	70.4a	68.9a
Infested	70.5	85.4b	77.9b	35.1b	64.7b	49.9b
SE ±	2.89	3.20	2.50	2.60	1.82	1.79
Variety (V)						
SAMMAZ 11	72.0ab	108.6	90.3	48.7	62.0c	55.3
SAMMAZ 14	81.4a	100.6	90.9	49.7	72.7a	61.2
SAMMAZ 20	70.2ab	95.4	82.8	50.0	71.6ab	60.6
SAMMAZ 26	66.2b	107.2	86.7	56.4	64.3bc	60.4
SE ±	4.08	5.12	3.54	3.67	2.58	2.53
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

4.27 100-SeedWeight

N fertilizer and *Striga* infestation effects on 100-seed weight of maize varieties as shown in Table 44. At Samaru location application of 120kgNha^{-1} in 2012 and the mean gaveheaviest 100-seedthat was comparable only to 80kgN ha^{-1}. At Tashar Dauda 120kgNha^{-1} in 2012 gave heaviest 100-seed weight but comparable to 80kgN ha^{-1} while in 2013 and the mean 80kgN ha^{-1} gave heaviest 100-seed weight statistically similar only to 120kgN ha^{-1}. The uninfested fields produced significantly heavier 100-seed than infested fields at Samaru only in 2012 and the mean and at Tashar Dauda only in 2012; in 2013 at Samaru and 2013 and the mean at Tashar Dauda the differences were not significant. At Samaru, among the varieties, SAMMAZ 14 in 2012 and the mean gave significantly heavier 100-seed than the other varieties except SAMMAZ 20 in the mean with which it was statistically similar. At Tashar Dauda SAMMAZ 14 in 2012 gave heviest 100-seed weight but comparable to SAMMAZ 26 and 20. SAMMAZ 26 in 2013 and the mean gave significantly heavier seedthan all other varieties in 2013 but comparable to SAMMAZ 14 and 20 in the mean.There were significant interactions between *Striga* infestation and variety on 100-seed weight at Tashar Dauda 2013.

Interaction between *Striga* infestation and variety on 100-seed weight of maize varieties at Tashar Dauda during 2013 wet season is presented in Table 45.Application of 80kgNha^{-1}toSAMMAZ26 resulted in significantly heavier seed than all other varieties at all other levels, which in turn were statistically at par.

Table 44: Effects of nitrogen fertilization and*Striga* infestationon 100-seed weight of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons

and the mean

	100-Seedweight (g)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	16.2c[1]	26.1	21.1c	16.9c	24.3b	21.0b
40	20.6b	26.0	23.3b	20.1b	24.5b	22.3b
80	23.9a	25.8	24.8ab	21.9a	30.1a	26.0a
120	24.6a	27.7	26.2a	23.0a	25.2ab	23.7ab
SE ±	0.64	0.71	0.55	0.64	1.76	1.08
***Striga* Infestation (S)**						
Un-infested	22.9a	27.1	25.0a	21.2a	26.4	23.8
Infested	19.7b	25.8	22.7b	19.8b	25.6	22.7
SE ±	0.45	0.50	0.39	0.45	1.25	0.77
Variety (V)						
SAMMAZ 11	20.7b	25.3	23.0b	19.4b	24.1b	21.7b
SAMMAZ 14	23.6a	26.9	25.2a	21.6a	24.5b	23.0ab
SAMMAZ 20	21.2b	26.7	23.9ab	20.5ab	24.0b	22.7ab
SAMMAZ 26	19.9b	26.7	23.3b	20.4ab	30.7a	25.5a
SE ±	0.64	0.71	0.55	0.64	1.76	1.08
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS

N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	*[3]	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant
3 = Significant

Table 45: Interaction between variety and nitrogen on 100-seed weight of maize varieties at Tashar Dauda during 2013 rainy season

	Nitrogen (N) kg/ha			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	24.5b	23.2b	26.3b	22.2b
SAMMAZ 14	25.8b	25.8b	22.6b	23.7b
SAMMAZ 20	24.6b	24.8b	23.2b	27.0b
SAMMAZ 26	25.6b	24.4b	48.3a	24.3b
SE ±			3.52	

Means followed with the same letter(s) are not significantly different at 5% level of probability using DMRT

4.28 Grain Yield kgha^{-1}

Effects of nitrogen and *Striga* infestation on grain yield kgha^{-1}of maize varieties are shown in Table 46. At both locations, years and the mean, each increase in nitrogen from 0 – 120kgN ha^{-1} significantly increased grain yield of maize, except at Samaru in 2012

where application of 80kgNha^{-1} was statistically similar to 120kgN ha^{-1}. At both locations, years and the mean, *Striga* infestation caused significant reduction in maize grain yield, except at Samaru in 2013. At both locations, years and the mean, SAMMAZ 14gave higher grain yield than all other varieties, except SAMMAZ 26 at Tashar Dauda and Samaru in 2012 with which it was statistically at par. The least grain yield was recorded by SAMMAZ 11 at Tashar Dauda in 2012.

This same variety gave least yield at Samaru although it was similar to all varieties except SAMMAZ 14. There were significant interactions on grain yield of maize between nitrogen and variety at Samaru in 2013 and at Tashar Dauda in 2012 and 2013 and between *Striga* infestation and variety in 2013 all at Tashar Dauda.

Table 46: Effects of nitrogen fertilization and *Striga* infestation on grain yield of maize varieties at Samaru, Tashar Dauda during 2012, 2013 rainyseasons and the mean

	Grain yield (kg/ha)					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	1120c	1175d	1147d	813d	1235d	1024d
40	2053b	2055c	2054c	1311c	2006c	1658c
80	2759a	3795b	3277b	2403b	3541b	2972b
120	3198a[1]	4263a	3730a	2955a	4033a	3494a
SE ±	51.8	33.0	97.1	31.2	21.5	35.0

***Striga* Infestation (S)**						
Un-infested	2496a	2914	2705a	1986a	2823a	2404a
Infested	2069b	2730	2399b	1755b	2585b	2170b
SE ±	36.7	23.3	68.7	22.0	15.2	24.8
Variety (V)						
SAMMAZ 11	2022b	2736b	2379b	1724c	2573c	2149c
SAMMAZ 14	2683a	3000a	2842a	1948a	2925a	2437a
SAMMAZ 20	2114b	2739b	2442b	1857b	2607c	2232c
SAMMAZ 26	2279ab	2811b	2545b	1953a	2709b	2331b
SE ±	51.8	33.00	97.1	31.2	21.5	35.0
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	**[3]	NS	**	*[4]	NS
S x V	NS	NS	NS	NS	**	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant
3 = Highly significant
4 = Significant

Interaction between varieties and nitrogen on grain yield of maize varieties at Samaru during 2013 rainy season is presented in Table 47. For all varieties only increase in

nitrogen from 80 –120kgNha^{-1} were statistically at par,SAMMAZ 14 recorded significant increased in grain yield from 80-120kgNha^{-1}.

Table 47: Interaction between variety and nitrogen on grain yield of maize varieties at Samaru during 2013 rainy season

	Nitrogen (N) kg/ha			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	1160e	2109e	3556e	4122b
SAMMAZ 14	1183e	2024e	3762de	5022a
SAMMAZ 20	1107e	2135e	3660e	3855cd
SAMMAZ 26	1250e	1943e	4000b-d	4052ab
SE ±		103.7		

Means followed with the same letter(s) are notsignificantly different at 5% level of probability using DMRT

Interaction between varieties and nitrogen on grain yield of maize varieties at Tashar Dauda during 2012 rainy season is presented in Table 48. For SAMMAZ 11 and 14 each increase in nitrogen from 0 – 120kgNha^{-1} significantly increased the grain yield of all varieties, however, for SAMMAZ 20 and 26 increased in yield with increase in N rate occurred up to 80kgN ha^{-1} beyond which there was no significant difference. Maize varieties in the untreated control gave comparable grain yield, at 40kgN ha^{-1} SAMMAZ 14 gave yields significantly higher than all other varieties which were comparable. At80 and 120kgN ha^{-1}SAMMAZ 20 and 26 gave yields that were statistically similar which were higher and lower than SAMMAZ 11 and 14 respectively.

Table 48: Interaction between variety and nitrogen on grain yield of maize varieties at Tashar Dauda during 2013 rainy season

	Nitrogen (N) kg/ha			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	770i	1223gh	1916e	2987b
SAMMAZ 14	848i	1507f	2114d	3322a
SAMMAZ 20	780i	1160h	2722c	2718c
SAMMAZ 26	853i	1354gh	2811bc	2793c
SE ±		62.2		

Means followed with the same letter(s) are notsignificantly different at 5% level of probability using DMRT

Grainyield of maize varieties at Tashar Dauda during 2013 rainy season as influenced by the interaction between varieties and nitrogen is shown in Table 49.

Table 49: Interaction between variety and nitrogen on grain yield of maize varieties at Tashar Dauda during 2013 rainy season

	Nitrogen (N) kg/ha			
Treatment	0	40	80	120
Variety (V)				
SAMMAZ 11	1148i	1807g	3431d	3907b
SAMMAZ 14	1273h	2053f	3467d	4908a
SAMMAZ 20	1222hi	1917g	3608c	3632c

SAMMAZ 26	1245hi	2246e	3660c	3684c
SE ±		43.0		

Means followed with the same letter(s) are notsignificantly different at 5% level of probability using DMRT

Each increase in nitrogen from 0 – 120kgN ha^{-1} significantly increased the grain yield of all varieties except SAMMAZ 26 and 20 which at 80 and 120kgN ha^{-1} were statistically at par with each other. Highest grain yield was obtained with SAMMAZ 14 at 120kgN ha^{-1} followed by SAMMAZ 11 at the same N rate.

Interaction between *Striga* infestation and varieties on grain yield of maize varieties at Tashar Dauda during 2013 rainy season is presented in Table 50. While with SAMMAZ 20 *Striga* infestation resulted in significant yield increase compared with uninfested. SAMMAZ 11 and 26 suffered significant yield reduction when grown in *Striga* infested fields compared with uninfested, and with SAMMAZ 14 no significant difference was observed between maize in *Striga* infested and uninfested fields. In both infested and uninfested field SAMMAZ 14 gave highest yield followed by SAMMAZ 11 in uninfested.

Table 50: Interaction between *Striga* and variety on grain yield (kg/ha) of maize varieties at Tashar Dauda during 2013 rainy season

	***Striga* Infestation**	
	Non-infested	Infested
Variety (V)		
SAMMAZ 11	4102b	3712c
SAMMAZ 14	4922a	4893a

SAMMAZ 20	3401e		3556d
SAMMAZ 26	3756c		3622d
SE ±		30.4	

Means followed with the same letter(s) are notsignificantly different at 5% level of probability using DMRT

4.29 Shelling Percentage

Effects of nitrogen fertilization and *Striga* infestation on shelling percentage of maize varieties is presented in Table 51. At Samaru location, significant differences in shelling percentage were observed only in 2013, where application of 120 and 40kgN ha^{-1} gave comparable and highest shelling percentagesbut each statistically at par to 80kgNha^{-1}.At Tashar Dauda significant differences on shelling percentage was observed in 2012 and

Table 51: Effects of nitrogen fertilization and *Striga* infestation on shelling percentage of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean.

	Shelling percentage					
	Samaru			Tashar Dauda		
Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	77.2	77.7b[1]	77.5	72.7b	77.7	75.2b
40	77.8	81.8a	79.8	77.9ab	80.4	79.9a
80	74.3	79.5ab	76.9	79.5a	79.9	78.9a
120	74.0	81.8a	77.9	78.8a	80.8	79.8a
SE ±	1.62	1.17	0.97	2.02	1.80	1.27

***Striga* Infestation (S)**						
Un-infested	76.8	80.8	78.8	77.9	82.4a	80.2a
Infested	74.8	79.6	77.2	76.5	76.9b	76.8b
SE ±	1.14	0.82	0.69	1.43	1.62	0.90
Variety (V)						
SAMMAZ 11	75.6	78.3b	76.9	76.3ab	78.6	77.6ab
SAMMAZ 14	76.1	82.1a	79.1	79.1ab	82.2	80.6a
SAMMAZ 20	76.0	79.8ab	77.9	73.4b	78.5	76.0b
SAMMAZ 26	75.6	80.8ab	78.2	79.9a	79.5	79.7a
SE ±	1.62	1.17	0.97	2.02	1.80	1.27
Interaction						
N x S	NS	NS[2]	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS
N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

the mean. Applicationof 40-120kgN ha^{-1}resulted in statistically similar shelling percentage and each significantly higher than the control except in 2013 where 40kgN ha^{-1} and control were statistically similar.The significant difference between uninfested and infested fields was observed at Tashar Dauda in 2013 and the mean, wheremaize

inuninfested fields gave significantly higher shelling parentage than that in infested fields. Among varieties in 2013 at Samaru, SAMMAZ 14 gave highest shelling percentage than SAMMAZ 11 but was statistically similar to all other varieties. At Tashar Dauda in 2012 and the mean SAMMAZ 20 significantly gave the least shelling percentage but statistically at par with SAMMAZ 11 and 14 in 2012 and SAMMAZ 11 in the mean. There was no significant interaction among the factors on shelling percentage.

4.30 Harvest Index

Effect of nitrogen and *Striga* infestation on harvest index of maize varietiesis presented in Table 52. At both locations, years and the mean, each increase in nitrogen from 0-80kgNha^{-1} significantly increased harvest indexbut beyond which the increase was not significant. Maize in uninfested fields gave significantly higher harvest index than that in infested fields only at Samaru in 2012 and the mean. At Samaru, in both years and the mean andat Tashar Dauda in 2013, SAMMAZ 14 gave highest harvest index comparable only to SAMMAZ 26 at Samaru 2012 and Tashar Dauda 2013. The least harvest index was recorded by SAMMAZ 11 at Samaru 2012. There was no significant interaction among the factors on maize harvest index.

Table 52: Effects of nitrogen fertilization and *Striga* infestation on harvest index of maize varieties at Samaru and Tashar Dauda during 2012, 2013 rainy seasons and the mean

	Harvest index	
	Samaru	Tashar Dauda

Treatment	2012	2013	Mean	2012	2013	Mean
Nitrogen (N) kg/ha						
0	42.7c	47.7c	45.2c	40.3c	46.8c	43.5c
40	45.2b	50.5b	47.9b	42.9b	50.3b	46.7b
80	49.9a[1]	57.2a	53.2a	48.7a	55.4a	52.0a
120	50.5a	55.9a	53.6a	49.6a	58.2a	53.9a
SE ±	0.59	0.90	0.55	0.70	1.13	0.68
***Striga* Infestation (s)**						
Un-infested	48.1a	53.3	50.7a	45.4	53.3	49.3
Infested	46.1b	52.3	49.2b	45.3	51.9	48.7
SE ±	0.42	0.64	0.39	0.49	0.80	0.48
Variety (V)						
SAMMAZ 11	44.9c	52.6b	48.8b	44.9	51.2b	48.0
SAMMAZ 14	49.2a	56.6a	52.9a	44.5	55.2a	49.9
SAMMAZ 20	46.4bc	50.2b	48.3b	45.9	52.9b	48.6
SAMMAZ 26	47.7ab	51.9b	49.8b	46.2	53.3ab	49.7
SE ±	0.59	0.90	0.55	0.70	1.13	0.68
Interaction						
N x S	NS[2]	NS	NS	NS	NS	NS
N x V	NS	NS	NS	NS	NS	NS
S x V	NS	NS	NS	NS	NS	NS

N x S x V	NS	NS	NS	NS	NS	NS

1 = Means followed with the same or no letter(s) within same column and treatment group are not significantly different at 5% level of probability using DMRT
2 = Not Significant

4.31 Gross Margin Analysis

Gross Margin analysis of nitrogen fertilizer rate and *Striga* infestation on maize varieties are presented in Tables 53 – 60. At Samaru location in 2012 (Table 53) under *Striga* infested field, the highest return of ₦2.02 per naira invested was produced by SAMMAZ 14 in combination with 120kgN ha^{-1} followed by SAMMAZ 26 of ₦1.82 at 80kgN ha^{-1} and SAMMAZ 11 of₦1.80 at 120kgN ha^{-1}. The highest loss of ₦0.37 per naira invested was recorded by SAMMAZ 11 and 26 all at 0kgN ha^{-1} followed by SAMMAZ 14 of ₦0.36 and SAMMAZ 20 of ₦0.33 both at 0kgNha^{-1}. Under uninfested field at Samaru in 2012 (Table 54), the highest return of ₦2.05 per naira invested was produced by SAMMAZ 14 in combination with 120kgN ha^{-1}followed by SAMMAZ 26 of ₦1.92 and SAMMAZ 20 of ₦1.85 both at 80kgN ha^{-1}. The highest loss of ₦0.70 per naira invested was recorded by SAMMAZ 14 at 0kgN ha^{-1}, followed by SAMMAZ 20 of ₦0.56 and SAMMAZ 26 of ₦0.53 at the same rate.

At Tashar Dauda location in 2012 (Table 55) under *Striga* infested field, the highest loss of ₦0.98 per naira invested was produced by SAMMAZ 11 in combination with 80kgN ha^{-1}, followed by SAMMAZ 14 of ₦0.87 and SAMMAZ 26 of ₦0.78 both at 40kgN ha^{-1}. The highest return of ₦1.86 per naira invested was recorded by SAMMAZ 14 in

combination with 120kgN ha^{-1} followed by SAMMAZ 11 of ₦1.67 at the same rate and SAMMAZ 26 of ₦1.62 at 80kgN ha^{-1}. Under uninfested field (Table 56) the highest return of ₦1.89 per naira invested was produced by SAMMAZ 14 at the nitrogen level of 120kgN ha^{-1}followed by SAMMAZ 26 of ₦1.76 and SAMMAZ 20 of ₦1.72 both at 80kgN ha^{-1}.

Table 53: Profitability of four varieties of maize as influenced by four levels of N fertilizer and *Striga* infestation in infested field at Samaru 2012

Treatment	Grain Yield (Kg/ha)	Revenue (₦)	Fixed Cost (₦)	Variable Cost (₦)	Total Cost (₦)	Net Farm Income (₦)	Return Per naira invested (₦)
V_3N_1	506.8	27,874.0	81,500	4,000	85,500	-57,626	-0.33
V_3N_2	1808.7	99,478.5	81,500	8,000	89,500	9,978.5	1.11
V_3N_3	2792.3	153,576.5	81,500	10,000	91,500	62,076.5	1.68
V_3N_4	2868.4	157,762.0	81,500	16,000	97,500	60,262.0	1.62
V_1N_1	582.2	32,021.0	81,500	4,000	85,500	-53,479	-0.37
V_1N_2	1996.4	109,802.0	81,500	8,000	89,500	20,302.0	1.23
V_1N_3	2014.3	110,786.5	81,500	10,000	91,500	19,286.5	1.21
V_1N_4	3186.5	175,257.5	81,500	16,000	97,500	77,757.5	1.80
V_4N_1	572.3	31,476.5	81,500	4,000	85,500	-54,023.5	-0.37
V_4N_2	1999.7	109,983.5	81,500	8,000	89,500	20,483.5	1.23
V_4N_3	3093.7	170,153.5	81,500	10,000	91,500	78,653.5	1.86
V_4N_4	3097.8	170,379.0	81,500	16,000	97,500	72,879.0	1.75
V_2N_1	564.3	31,036.5	81,500	4,000	85,500	-54,463.5	-0.36
V_2N_2	1798.9	98,939.5	81,500	8,000	89,500	19,768.5	1.11
V_2N_3	2932.1	161,265.5	81,500	10,000	91,500	69,765.5	1.76
V_2N_4	3586.3	197,246.5	81,500	16,000	97,500	**99,746.5**	**2.02**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

Table 54: Profitability of four varieties of maize as influenced by four levels of N fertilizer and *Striga* infestation in un-infested field at Samaru 2012

Treatment	Grain Yield (Kg/ha)	Revenue (₦)	Fixed Cost (₦)	Variable Cost (₦)	Total Cost (₦)	Net Farm Income (₦)	Return Per naira invested (₦)
V_3N_1	872.4	47,982.0	81,500	4,000	85,500	-37,518	-0.56
V_3N_2	2388.7	131,378.5	81,500	8,000	89,500	41,878.5	1.47
V_3N_3	3082.6	169,543	81,500	10,000	91,500	78,043.0	1.85
V_3N_4	3100.2	170,511.0	81,500	16,000	97,500	73,011.0	1.75
V_1N_1	807.5	44,434.5	81,500	4,000	85,500	-41,065.5	-0.52
V_1N_2	2113.5	116,242.5	81,500	8,000	89,500	26,742.5	1.30
V_1N_3	2226.8	122,474.0	81,500	10,000	91,500	30,974.0	1.34
V_1N_4	3216.1	176,885.5	81,500	16,000	97,500	79,385.5	1.81
V_4N_1	888.7	44,878.5	81,500	4,000	85,500	-36,621.5	-0.53
V_4N_2	2185.6	120,208.0	81,500	8,000	89,500	30,708.0	1.34
V_4N_3	3156.4	175,802.6	81,500	10,000	91,500	84,302	1.92
V_4N_4	3198.6	175,923.0	81,500	16,000	97,500	78,423.0	1.80
V_2N_1	1086.7	59,768.5	81,500	4,000	85,500	-25,731.5	-0.70
V_2N_2	2096.8	115,324.0	81,500	8,000	89,500	25,824.0	1.29
V_2N_3	3031.0	166,705.0	81,500	10,000	91,500	75,205.0	1.82
V_2N_4	3629.6	199,628	81,500	16,000	97,500	**102,128.0**	**2.05**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,

Price/ton of maize ₦55,000

Table 55: Profitability of four varieties of maize as influenced by four levels of N fertilizer and *Striga* infestation in infested field at Tashar Dauda 2012

Treatment	Grain Yield (Kg/ha)	Revenue (₦)	Fixed Cost (₦)	Variable Cost (₦)	Total Cost (₦)	Net Farm Income (₦)	Return per naira invested (₦)
V_3N_1	692.0	38,060.0	81,500	4,000	85,500	- 47,440	-0.45
V_3N_2	1052.1	57,685.5	81,500	8,000	89,500	-31,634.5	-0.65
V_3N_3	2681.3	147,471.0	81,500	10,000	91,500	55,971.5	1.61
V_3N_4	2542.2	139,821.0	81,500	16,000	97,500	42,3211	1.43
V_1N_1	598.2	32,901.0	81,500	4,000	85,500	-52,599	-0.39
V_1N_2	1122.1	61,715.5	81,500	8,000	89,500	-27,784.5	-0.69
V_1N_3	1632.2	89,771.0	81,500	10,000	91,500	-1,729.0	-0.98
V_1N_4	2963.4	162,987.0	81,500	16,000	97,500	65,487.0	1.67
V_4N_1	724.0	39,820.0	81,500	4,000	85,500	-45,680	-0.47
V_4N_2	1263.2	69,476.0	81,500	8,000	89,500	-20,024.0	-0.78
V_4N_3	2699.7	148,483.5	81,500	10,000	91,500	56,983.5	1.62
V_4N_4	2697.8	148,379.0	81,500	16,000	97,500	50,879	1.52

V_2N_1	708.1	38,945.5	81,500	4,000	85,500	-46,554.5	-0.46
V_2N_2	1422.0	78,210.0	81,500	8,000	89,500	-11,290.0	-0.87
V_2N_3	1982.4	109,032.0	81,500	10,000	91,500	17,532	1.19
V_2N_4	3298.7	181,428.5	81,500	16,000	97,500	**83,928.5**	**1.86**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

Table 56: Profitability of four varieties of maize as influenced by four levels of N fertilizerand *Striga* infestation in un-infested at Tashar Dauda 2012

Treatment	**Grain Yield (Kg/ha)**	**Revenue (₦)**	**Fixed Cost (₦)**	**Variable Cost (₦)**	**Total Cost (₦)**	**Net FarmIncome (₦)**	**Return Per naira invested (₦)**
V_3N_1	868.2	47,751.0	81,500	4,000	85,500	- 37,749	-0.56
V_3N_2	1266.9	69,6795	81,500	8,000	89,500	-19,820.5	-0.78
V_3N_3	2862.2	157,421.0	81,500	10,000	91,500	65,921	1.72
V_3N_4	2894.2	159,181.0	81,500	16,000	97,500	61,681	1.63
V_1N_1	942.6	51,843.0	81,500	4,000	85,500	-33,657	-0.61
V_1N_2	1324.0	72,820.0	81,500	8,000	89,500	-16,680	-0.81
V_1N_3	2198.9	120,939.5	81,500	10,000	91,500	29,439.5	1.32
V_1N_4	3011.2	165,616.0	81,500	16,000	97,500	68,116.0	1.70

V_4N_1	982.7	54,048.5	81,500	4,000	85,500	-31,451.5	-0.63
V_4N_2	1445.0	79,475.0	81,500	8,000	89,500	-10,025.0	-0.89
V_4N_3	2922.3	160,726.5	81,500	10,000	91,500	69,226.5	1.76
V_4N_4	2887.8	158,829.0	81,500	16,000	97,500	61,329.0	1.63
V_2N_1	986.9	54,279.5	81,500	4,000	85,500	-31,220.5	-0.63
V_2N_2	1589.0	87,395.0	81,500	8,000	89,500	-2,105.0	-0.98
V_2N_3	2246.2	123,541	81,500	10,000	91,500	32,041.0	1.35
V_2N_4	3346.6	184,063	81,500	16,000	97,500	**86,563**	**1.89**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

The loss per naira invested of ₦0.98 was produced by SAMMAZ 14 followed by SAMMAZ 26 of ₦0.89 and SAMMAZ 11 of ₦0.81 all at 40kgN ha^{-1}.

At Samaru in 2013 (Table 57) under *Striga* sick field, the highest return of ₦2.82 per naira invested was recorded by SAMMAZ 14 in combination with 120kgN ha^{-1} followed by SAMMAZ 26 of ₦2.40 at 80kgN $ha^{-1}$and SAMMAZ 11 of ₦2.31 at 120kgN ha^{-1}. The highest loss of ₦0.71 per naira invested was produced by SAMMAZ 26 in combination with 0kgN ha^{-1} followed by SAMMAZ 14 of ₦0.66 and SAMMAZ 11 and 20 of ₦0.64 at the same rate. Under uninfested field in 2013 (Table 58). The highest return of ₦2.85 per naira invested was recorded by SAMMAZ 14 in combination with 120kgN ha^{-1} followed by SAMMAZ 26 of ₦2.41 and SAMMAZ 20 of ₦2.34 both at the

same rate. The highest loss of ₦0.90 per naira invested was produced by SAMMAZ 26 followed by SAMMAZ 14 of ₦0.86 and ₦0.85 for SAMMAZ 11 all at 0kgN ha^{-1}.

At Tashar Dauda in 2013 (Table 59) under *Striga* infested field, the highest loss of ₦1.00 per naira invested was produced by SAMMAZ 20, followed by SAMMAZ 11 both at 40kgNha^{-1} and SAMMAZ 26 of ₦0.71 at 0kgN ha^{-1}. The highest return of ₦2.76 was recorded by SAMMAZ 14 in combination with 120kgN ha^{-1} followed by SAMMAZ 26 of ₦2.16 and SAMMAZ 20 of ₦2.13 both at 80kgN ha^{-1}. Under *Striga* uninfested field (Table 60). The highest return of ₦2.78 per naira invested was produced by SAMMAZ 14 in combination with 120kgN ha^{-1} followed SAMMAZ 26 of ₦2.24 at 80kgN ha^{-1} and SAMMAZ 11 of ₦2.31 at 120kgN ha^{-1}. The highest loss of ₦0.96 per naira invested was produced by SAMMAZ 20 followed by SAMMAZ 14 of ₦0.94 and SAMMAZ 26 of ₦0.89 all at 0kgN ha^{-1}.Table 61and Table 62 showed highest return of ₦2.85 and ₦2.78 per naira invested for all varieties,respectively.

Table: 57: Profitability of four varieties of maize as influenced by four levels of N fertilizer and *Striga* infestation in infested at Samaru 2013

Treatment	**Grain Yield (Kg/ha)**	**Revenue (₦)**	**Fixed Cost (₦)**	**Variable Cost (₦)**	**Total Cost (₦)**	**Net Farm Income (₦)**	**Return Per naira invested (₦)**
V_3N_1	1001.3	55,071.5	81,500	4,000	85,500	-30,428.5	-0.64
V_3N_2	1946.9	107,079.5	81,500	8,000	89,500	17,579.5	1.20
V_3N_3	3822.6	210,243.0	81,500	10,000	91,500	118,743	2.30
V_3N_4	3816.2	209,891.0	81,500	16,000	97,500	112,391	2.15

V_1N_1	993.6	54,648.0	81,500	4,000	85,500	-30,852	-0.64
V_1N_2	1932.1	106,265.5	81,500	8,000	89,500	16,765.5	1.19
V_1N_3	3398.3	186,906.5	81,500	10,000	91,500	95,406.5	2.04
V_1N_4	4097.6	225,368.0	81,500	16,000	97,500	127,868.0	2.31
V_4N_1	1100.7	60,538.5	81,500	4,000	85,500	-24,961.5	-0.71
V_4N_2	1826.2	100,441.0	81,500	8,000	89,500	10,941.0	1.12
V_4N_3	3986.9	219,279.5	81,500	10,000	91,500	127,779.5	2.40
V_4N_4	3999.6	219,978.0	81,500	16,000	97,500	122,478.0	2.26
V_2N_1	1032.8	56,804.0	81,500	4,000	85,500	-28,696.0	-0.66
V_2N_2	1986.7	109,268.5	81,500	8,000	89,500	19,768.5	1.22
V_2N_3	3728.3	205,056.5	81,500	10,000	91,500	113,556.5	2.24
V_2N_4	4996.,6	274,813.0	81,500	16,000	97,500	**177,313**	**2.82**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

Table 58: Profitability of four varieties of maize as influenced by four levels of N fertilizerand *Striga* infestation in un-infested at Samaru 2013

Treatment	**Grain Yield (Kg/ha)**	**Revenue (₦)**	**Fixed Cost (₦)**	**Variable Cost (₦)**	**Total Cost (₦)**	**Net Farm Income (₦)**	**Return Per naira invested (₦)**
V_3N_1	1222.0	67,210.0	81,500	4,000	85,500	-18,290.0	-0.79
V_3N_2	2322.6	127,743	81,500	8,000	89,500	38,243	1.43

V_3N_3	3896.2	214,251.0	81,500	10,000	91,500	122,791	2.34
V_3N_4	3894.9	214,219.5	81,500	16,000	97,500	116,719.5	2.20
V_1N_1	1322.0	72,710.0	81,500	4,000	85,500	-12,790.5	- 0.85
V_1N_2	2285.3	125,,691.5	81,500	8,000	89,500	36,191.5	1.40
V_1N_3	3712.6	204,193	81,500	10,000	91,500	112,690	2.23
V_1N_4	4146.3	228,045.5	81,500	16,000	97,500	130,546.5	2.33
V_4N_1	1400.1	77,005.5	81,500	4,000	85,500	-8,494.5	-0.90
V_4N_2	2060.0	113,300.0	81,500	8,000	89,500	23,800	1.27
V_4N_3	4012.7	220,698.5	81,500	10,000	91,500	129,198.5	2.41
V_4N_4	4103.2	225,681.5	81,500	16,000	97,500	128,181.5	2.32
V_2N_1	1332.3	73,276.5	81,500	4,000	85,500	-12,223.5	-0.86
V_2N_2	2081.2	114,466.0	81,500	8,000	89,500	32,566.0	1.28
V_2N_3	3796.5	208,807.5	81,500	10,000	91,500	117,307.5	2.28
V_2N_4	5046.3	277,546.5	81,500	16,000	97,500	**180,046.5**	**2.85**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

Table 59: Profitability of four varieties of maize as influenced by four levels of N fertilizerand *Striga* infestation in infested at Tashar Dauda 2013

Treatment	**Grain Yield (Kg/ha)**	**Revenue (₦)**	**Fixed Cost (₦)**	**Variable Cost (₦)**	**Total Cost (₦)**	**Net FarmIncome (₦)**	**Return Per naira invested (₦)**

V_3N_1	1051.3	57,821.5	81,500	4,000	85,500	-27,678.5	-0.68
V_3N_2	1622.2	89,221.0	81,500	8,000	89,500	-279.0	-1.00
V_3N_3	3542.3	194,826.5	81,500	10,000	91,500	103,326.5	2.13
V_3N_4	3563.4	195,987.0	81,500	16,000	97,500	98,487.0	2.01
V_1N_1	968.7	53,278.5	81,500	4,000	85,500	-32,221.5	-0.62
V_1N_2	1598.8	87,934.0	81,500	8,000	89,500	-1,566.0	-0.98
V_1N_3	3374.7	185,608.5	81,500	10,000	91,500	94,100.5	2.03
V_1N_4	3745.3	205,991.5	81,500	16,000	97,500	108,491.5	2.11
V_4N_1	1102.1	60,615.5	81,500	4,000	85,500	-24,884.5	-0.71
V_4N_2	2192.3	120,576.5	81,500	8,000	89,500	31,076.5	1.35
V_4N_3	3596.8	197,824.0	81,500	10,000	91,500	106,324.0	2.16
V_4N_4	3622.4	199,232.0	81,500	16,000	97,500	101,732.0	2.04
V_2N_1	1089.2	59,906.0	81,500	4,000	85,500	-25,594	-0.70
V_2N_2	1996.6	109,813.0	81,500	8,000	89,500	20,313	1.23
V_2N_3	3426.2	188,441.0	81,500	10,000	91,500	96,941	2.06
V_2N_4	4892.7	269,098.5	81,500	16,000	97,500	**171,598.5**	**2.76**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

Table 60: Profitability of four varieties of maize as influenced by four levels of N fertilizerand *Striga i*nfestation in un-infested at Tashar Dauda 2013

Treatment	**Grain Yield (Kg/ha)**	**Revenue (₦)**	**Fixed Cost**	**Variable Cost**	**Total Cost**	**Net Farm Income**	**Return Per naira invested**

			(₦)	(₦)	(₦)	(₦)	(₦)
V_3N_1	1492.2	82,071.0	81,500	4,000	85,500	-3,429	-0.96
V_3N_2	2209.1	121,500.5	81,500	8,000	89,500	32,000.5	1.36
V_3N_3	3672.8	202,004.0	81,500	10,000	91,500	110,504.0	2.21
V_3N_4	3701.2	203,566.0	81,500	16,000	97,500	106,066.0	2.09
V_1N_1	1326.7	72,968.5	81,500	4,000	85,500	-12,531.5	-0.85
V_1N_2	2014.9	110,819.5	81,500	8,000	89,500	21,319.5	1.24
V_1N_3	3487.2	191,796.0	81,500	10,000	91,500	100,296.0	2.10
V_1N_4	4102.1	225,615.5	81,500	16,000	97,500	128,115.5	2.31
V_4N_1	1386.7	76,268.5	81,500	4,000	85,500	-9,231.5	-0.89
V_4N_2	2300.1	126,505.5	81,500	8,000	89,500	37,005.5	1.41
V_4N_3	3722.5	204,737.5	81,500	10,000	91,500	113,237.5	2.24
V_4N_4	3746.3	206,046.5	81,500	16,000	97,500	108,546.5	2.11
V_2N_1	1456.7	80,118.5	81,500	4,000	85,500	-5,381.5	-0.94
V_2N_2	2110.2	116,061.0	81,500	8,000	89,500	26,561.0	1.30
V_2N_3	3507.0	192,885.0	81,500	10,000	91,500	101,385	2.11
V_2N_4	4922.3	270,726.5	81,500	16,000	97,500	**173,226.5**	**2.78**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

Table 61: Profitability of four varieties of maize as influenced by four levels of N fertilizer and *Striga* infestation in infested and uninfested fields at Samaru 2012 and 2013 raining seasons

Treatment	Samaru infested and uninfested 2012				Samaru infested and uninfested 2013			
	Net Farm Income (₦)	Return Per naira invested (₦)	Net Farm Income (₦)	Return Per naira invested (₦)	Net Farm Income (₦)	Return Per naira invested (₦)	Net Farm Income (₦)	Return Per naira invested (₦)
V_3N_1	-57,626	-0.33	-37,518	-0.56	-30,428.5	-0.64	-18,290.0	-0.79
V_3N_2	9,978.5	1.11	41,878.5	1.47	17,579.5	1.20	38,243	1.43
V_3N_3	62,076.5	1.68	78,043.0	1.85	118,743	2.30	122,791	2.34
V_3N_4	60,262.0	1.62	73,011.0	1.75	112,391	2.15	116,719.5	2.20
V_1N_1	-53,479	-0.37	-41,065.5	-0.52	-30,852	-0.64	-12,790.5	- 0.85
V_1N_2	20,302.0	1.23	26,742.5	1.30	16,765.5	1.19	36,191.5	1.40
V_1N_3	19,286.5	1.21	30,974.0	1.34	95,406.5	2.04	112,690	2.23
V_1N_4	77,757.5	1.80	79,385.5	1.81	127,868.0	2.31	130,546.5	2.33
V_4N_1	-54,023.5	-0.37	-36,621.5	-0.53	-24,961.5	-0.71	-8,494.5	-0.90
V_4N_2	20,483.5	1.23	30,708.0	1.34	10,941.0	1.12	23,800	1.27

V_4N_3	78,653.5	1.86	84,302	1.92	127,779.5	2.40	129,198.5	2.41
V_4N_4	72,879.0	1.75	78,423.0	1.80	122,478.0	2.26	128,181.5	2.32
V_2N_1	-54,463.5	-0.36	-25,731.5	-0.70	-28,696.0	-0.66	-12,223.5	-0.86
V_2N_2	19,768.5	1.11	25,824.0	1.29	19,768.5	1.22	32,566.0	1.28
V_2N_3	69,765.5	1.76	75,205.0	1.82	113,556.5	2.24	117,307.5	2.28
V_2N_4	**99,746.5**	**2.02**	**102128.0**	**2.05**	**177,313**	**2.82**	**180,046.5**	**2.85**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,
Price/ton of maize ₦55,000

Table 62: Profitability of four varieties of maize as influenced by four levels of N fertilizer and *Striga* infestation in infested and uninfested fields at Tashar Dauda during 2012 raining season

	Tashar Dauda infested and uninfested2012				**Tashar Dauda infested and uninfested 2013**			
Treatment	Net Farm Income (₦)	Return Per naira invested (₦)	Net Farm Income (₦)	Return Per naira invested (₦)	Net Farm Income (₦)	Return Per naira invested (₦)	Net Farm Income (₦)	Return Per naira invested (₦)
V_3N_1	- 47,440	-0.45	- 37,749	-0.56	-27,678.5	-0.68	-3,429	-0.96

V_3N_2	-31,634.5	-0.65	-19,820.5	-0.78	-279.0	-1.00	32,000.5	1.36
V_3N_3	55,971.5	1.61	65,921	1.72	103,326.5	2.13	110,504.0	2.21
V_3N_4	42,3211	1.43	61,681	1.63	98,487.0	2.01	106,066.0	2.09
V_1N_1	-52,599	-0.39	-33,657	-0.61	-32,221.5	-0.62	-12,531.5	-0.85
V_1N_2	-27,784.5	-0.69	-16,680	-0.81	-1,566.0	-0.98	21,319.5	1.24
V_1N_3	-1,729.0	-0.98	29,439.5	1.32	94,100.5	2.03	100,296.0	2.10
V_1N_4	65,487.0	1.67	68,116.0	1.70	108,491.5	2.11	128,115.5	2.31
V_4N_1	-45,680	-0.47	-31,451.5	-0.63	-24,884.5	-0.71	-9,231.5	-0.89
V_4N_2	-20,024.0	-0.78	-10,025.0	-0.89	31,076.5	1.35	37,005.5	1.41
V_4N_3	56,983.5	1.62	69,226.5	1.76	106,324.0	2.16	113,237.5	2.24
V_4N_4	50,879	1.52	61,329.0	1.63	101,732.0	2.04	108,546.5	2.11
V_2N_1	-46,554.5	-0.46	-31,220.5	-0.63	-25,594	-0.70	-5,381.5	-0.94
V_2N_2	-11,290.0	-0.87	-2,105.0	-0.98	20,313	1.23	26,561.0	1.30
V_2N_3	17,532	1.19	32,041.0	1.35	96,941	2.06	101,385	2.11
V_2N_4	**83,928.5**	**1.86**	**86,563**	**1.89**	**171,598.5**	**2.76**	**173,226.5**	**2.78**

V_1 = SAMMAZ 11 V_2 = SAMMAZ 14, V_3 = SAMMAZ 20, V_4 = SAMMAZ 26
N_1 = Control (0kgN) N_2 = 40kgN , N_3 = 80kgN, N_4 = 120kgN,

Price/ton of maize ₦55,000

SAMMAZ 14 in combination with 120kgN ha^{-1} under uninfested field in 2013 followed by the same variety in the same combination in the same year under infested field recorded ₦2.82 per naira invested.

4.32 Correlation Coefficient Matrix between Yield and Some Growth, *Striga* and Yield Characters

The correlations coefficient matrix between yield and some growth, *Striga* and yield characters of maize are shown in Tables 63, 64 and 65 at Samaru in 2012, 2013 and the mean, respectively. Grain yield was positively and highly significantly correlated with plant height at 12 WAS, shoot dry weight at 12 WAS, leaf area index, crop growth rate, cob diameter, cob weight and 100-grain weight, except in 2013 where days to 50% tasselling, cob weight and 100-grain weight showed only positive correlation. Grain yield was highly and negatively correlated with *Striga* syndrome rating and *Striga* shoot count at 12 WAS. Days to 50% tasseling showed no significant relationship with grain yield except in 2012. Leaf area index was highly and positively correlated with other growth and yield characters except days to 50% tasseling, cob weight and 100-grain weight in 2013. *Striga* syndrome rating and *Striga* shoot count were negatively correlated with all growth and yield characters of maize.

The correlations between yield and some growth, *Striga* and yield characters of maize are shown in Tables 66, 67 and 68 at Tashar Dauda in 2012, 2013 and the mean, respectivelty. The grain yield was highly and positively correlated with plant height at 12 WAS, shoot dry weight at 12 WAS, leaf area index, crop growth rate, cob diameter, cob weight and 100-grain weight except in the mean where cob weight and 100-grain weight had no significant relationship with grain yield. The *Striga* characters were significantly

Table 63: Matrix correlation coefficient between grain yield, *Striga* and maize crop characters, 2012 at Samaru

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.283	1.000										
3	0.526**	0.214	1.000									
4	0.655**	0.308*	0.752**	1.000								
5	0.588**	0.262*	0.746**	0.905**	1.000							
6	0.639**	0.240	0.703**	0.956**	0.866**	1.000						
7	0.288*	0.162	0.190	0.221	0.243	0.249	1.000					
8	-0.448**	-0.288*	-0.378*	-0.370*	-0.436**	-0.377**	-0.100	1.000				
9	-0.392**	-0.238	-0.326*	-0.296*	-0.380*	-0.310*	-0.075	0.901**	1.000			
10	0.583**	0.275	0.660**	0.849**	0.786**	-0.827**	0.299*	-0.383*	-0.326*	1.000		
11	0.468**	0.229	0.532**	0.595**	0.599**	0.535**	0.261	-0.306*	-0.307*	0.502**	1.000	
12	0.515**	0.259	0.604**	0.642**	0.618**	0.611**	0.398**	-0.448**	-0.434**	0.554**	0.625**	1.000

1. Grain yield
5. Leaf area index
9. *Striga*shoot count at 12 WAS

2. Stand count at harvest
3. Plant height at 12 WAS
4. Shoot dry weight at 12 WAS
6. Crop growth rate at 12 WAS
7. Days to 50% tasseling
8. *Striga* syndrome rating
10. Cob diameter (cm)
11. Cob weight (g)
12. 100-grain weight

** Significance at 1 % level of probability (r = 0.37)

* Significance at 5% level of probability (r = 0.44)

NS Not significant

WAS Weeks after sowing

Table 64: Matrix correlation coefficient between grain yield and *Striga* and maize crop characters, 2013 at Samaru

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.054	1.000										
3	0.738**	0.026	1.000									

4	0.963**	0.033	0.721**	1.000								
5	0.916**	0.041	0.727**	0.917**	1.000							
6	0.891**	0.021	0.677**	0.949**	0.845**	1.000						
7	0.099	0.065	0.1 08	0.0981	0.095	0.079	1.000					
8	-0.483**	-0.074	-0.690**	-0.445**	-0.419	0.243	0.078	1.000				
9	-0.492**	-0.109	-0.696**	-0.412**	-0.375**	-0.179	-0.086	-0.345	1.000			
10	0.541**	0.187	0.468**	0.486**	0.569**	0.422**	0.042	-0.359*	-0.331*	1.000		
11	0.309*	-0.000	0.397**	0.260	0.233	0.228	0.199	-0.400**	-0.448**	0.154	1.000	
12	0.340*	0.083	0.271*	0.232	0.243	0.713**	0.120	-0.434**	-0.290*	0.487**	0.297**	1.000

1. Grain yield
2. Stand count at harvest
3. Plant height at 12 WAS
4. Shoot dry weight at 12 WAS
5. Leaf area index
6. Crop growth rate at 12 WAS
7. Days to 50% tasseling
8. *Striga* syndrome rating
9. *Striga*shoot count at 12 WAS
10. Cob diameter (cm)
11. Cob weight (g)
12. 100-grain weight

** Significance at 1 % level of probability (r = 0.37)

* Significance at 5% level of probability (r = 0.44)

NSNot significant

WASWeeks after sowing

Table 65: Matrix correlation coefficient between grain yield, *Striga* and maize crop characters, the mean at Samaru

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.182	1.000										
3	0.490**	0.145	1.000									
4	0.806**	0.175	0.399**	1.000								
5	0.753**	0.166	0.462**	0.907**	1.000							
6	0.755**	0.160	0.350**	0.952**	0.850**	1.000						
7	0.108	0.063	0.123	0.080	0.090	0.071	1.000					
8	-0.463**	-0.190*	-0.299**	-0.408**	-0.429**	0.404**	-0.069	1.000				
9	-0.401**	-0.137	-0.133	-0.372**	-0.342**	-0.374**	-0.062	0.856**	1.000			

10	0.588**	0.250*	0.570**	0.636**	0.674**	0.587**	0.078	-0.369**	0.250	1.000		
11	0.426**	0.138	0.609**	0.377**	0.405**	0.354**	0.190*	-0.333**	0.138	0.424**	1.000	
12	0.400**	0.208*	0.638**	0.376**	0.418**	0.320**	0.131	-0326**	-0.201*	0.508**	0.559**	1.000

1. Grain yield
2. Stand count at harvest
3. Plant height at 12 WAS
4. Shoot dry weight at 12 WAS
5. Leaf area index
6. Crop growth rate at 12 WAS
7. Days to 50% tasseling
8. *Striga* syndrome rating
9. *Striga*shoot count at 12 WAS
10. Cob diameter (cm)
11. Cob weight (g)
12. 100-grain weight

** Significance at 1 % level of probability (r = 0.37)

* Significance at 5% level of probability (r = 0.44)

NSNot significant

WASWeeks after sowing

Table 66: Matrix correlation coefficient between grain yield, *Striga* and maize crop characters, 2012 at Tashar Dauda

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.554**	1.000										
3	0.857**	0.529**	1.000									
4	0.940**	0.508**	0.889**	1.000								
5	0.643**	0.362*	0.697**	0.677**	1.000							
6	0.921**	0.486**	0.857**	9.991**	0.661**	1.000						
7	0.074	0.252	-0.090	-0.116	-0.087	-0.109	1.000					
8	-0.470**	-0.474**	-0.535**	-0.335*	-0.277*	-0.292*	-0.108	1.000				
9	-0.350*	-0.412**	-0.432**	-0.205	-0.192	0.032	-0.113	0.925**	1.000			
10	0.793**	0.429**	0.643**	0.775**	0.493**	0.772**	-0.025	-0.400**	-0.262*	1.000		
11	0.503**	0.267*	0.531**	0.416**	0.347*	0.366*	-0.038	-0.578**	-0.617**	0.337*	1.000	
12	0.562**	0.271**	0.591**	0.594**	0.473**	0.548**	0.172	-0363**	-0.308*	0.433**	0.651**	1.000

1. Grain yield
2. Stand count at harvest
5. Leaf area index
6. Crop growth rate at 12 WAS
9. *Striga*shoot count at 12 WAS
10. Cob diameter (cm)

3. Plant height at 12 WAS
4. Shoot dry weight at 12 WAS
7. Days to 50% tasseling
8. *Striga* syndrome rating
11. Cob weight (g)
12. 100-grain weight

** Significance at 1 % level of probability (r = 0.37)

* Significance at 5% level of probability (r = 0.44)

NSNot significant

WASWeeks after sowing

Table 67: Matrix correlation coefficient between grain yield, *Striga* and maize crop characters, 2013 at Tashar Dauda

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.457**	1.000										
3	0.861**	0.458**	1.000									
4	0.880**	0.478**	0.840**	1.000								

5	0.294**	0.027	0.271**	0.298**	1.000							
6	0.828**	0.362**	0.771**	0.968**	0.106	1.000						
7	-0.039	0.207*	-0.075	-0.059	0.014	0.045	1.000					
8	-0.434**	-0.477**	-0.485**	-0.368**	-0.030	-0.340**	-0.088	1.000				
9	-0.360**	-0.416**	-0.303**	-0.328**	-0.016	-0.315**	-0.083	0.850**	1.000			
10	0.803**	0.398**	0.682**	0.787**	0.277**	0.757**	0.013	-0.399**	-0.308**	1.000		
11	0.374**	0.131	0.360**	0.289**	0.209*	0.281**	-0.022	-0.214*	-0.110	0.282**	1.000	
12	0.282**	0.168	0.297**	0.279**	0.296**	0.257	-0.150	-0.213*	-0092	0.221*	0.209*	1.000

1. Grain yield
2. Stand count at harvest
3. Plant height at 12 WAS
4. Shoot dry weight at 12 WAS
5. Leaf area index
6. Crop growth rate at 12 WAS
7. Days to 50% tasseling
8. *Striga* syndrome rating
9. *Striga*shoot count at 12 WAS
10. Cob diameter (cm)
11. Cob weight (g)
12. 100-grain weight

** Significance at 1 % level of probability (r = 0.37)

* Significance at 5% level of probability (r = 0.44)

NSNot significant

WASWeeks after sowing

Table 68:Matrix correlation coefficient between grain yield, *Striga* and maize crop characters the mean at Tashar Dauda

S/No.	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.501**	1.000										
3	0.931**	0.461**	1.000									
4	0.634**	0.460**	0.923**	1.000								
5	0.209*	0.047	0.290**	0.129	1.000							
6	0.848**	0.447	0.844**	0.960**	0.228	1.000						
7	0.291*	0.131	0.267*	0.202	-0.059	0.200	1.000					
8	-0.486**	-0.497**	-0.434**	-0.403**	-0.036	-0.390**	-0.157	1.000				
9	-0.500**	-0.458**	-0.402**	-0.420**	-0.031	-0.407**	-0.129	0.912**	1.000			

10	0.819**	0.407**	0.758**	0.810**	0.287**	0.763**	0.413**	-0.390**	-0.398**	1.000		
11	0.249	0.147	0.262*	0.289*	0.217*	0.279*	0.122	-0.091	-0.080	0.235	1.000	
12	0.387	0.027	0.279	0.265	0.333**	0.348**	-0.016	-0.166	-0.116	0.203	0.243*	1.000

1. Grain yield
2. Stand count at harvest
3. Plant height at 12 WAS
4. Shoot dry weight at 12 WAS
5. Leaf area index
6. Crop growth rate at 12 WAS
7. Days to 50% tassling
8. *Striga* syndrome rating
9. *Striga*shoot count at 12 WAS
10. Cob diameter (cm)
11. Cob weight (g)
12. 100-grain weight

** Significance at 1 % level of probability (r = 0.37)

* Significance at 5% level of probability (r = 0.44)

NSNot significant

WASWeeks after sowing

and negatively correlated with grain yield. Days to 50% tasseling showed no significantly relationship with grain yield in both years and the mean.

4.33 Path Coefficient

The path coefficient analysis of growth and yield characters with the grain yield of maize for 2012, 2013 and the mean years at Samaruare presented in Tables 69 and 70 in 2012. In 2012 (Table 69), the highest and positive contribution to grain yield of maize was made by cob diameter (0.6154), followed by leaf area index (0.4618), cob weight (0.2650) and 100-grain weight (0.2099), while crop growth rate had the lowest direct contribution(-0.4860). In 2013, the highest positive direct contribution was by crop growth rate (0.4744), followed by shoot dry weight (0.4454) and cob diameter(0.3441), while the leaf area index had the least direct contribution(-0.4763). In the mean of both years, crop growth rate had the highest positive direct contribution (1.1520), followed by cob diameter (0.2288) and 100-grain weight (0.1393), while shoot dry weight had the lowest contribution(-0.5117). Table70 shows the individual and the combined effects of some growth and yield characters on grain yield of maize at Samaru.The highestindividual contribution was recorded by cob diameter (37.88%), in 2012 followed by (crop growth rate (32.70%), in the mean while leaf area index had the lowest individual contribution which was recorded by the combined years (0.76). When effects of the combined contribution was considered, it was observed that crop vigour versus cob diameter (40.89%), shoot dry weight versus crop growth rate (40.20%), and cob diameter versus cob weight (15.75%), made the highest contribution in the mean, 2013 and 2012 respectively.

Table 69: The Direct and indirect effects of some growth and yield parameters to grain yield of maize in 2012, 2013 and combined at Samaru.

				2012			
Parameters	**Shoot dry weight**	**Leaf area index**	**Crop growth rate**	**Cob diameter**	**Cob weight**	**100-grain weight**	**Total corrected**
Shoot dry weight	**0.1014**	0.4189	-0.4647	0.5225	0.1520	0.1347	0.6550
Leaf area index	0.0920	**0.4618**	-0.0119	0.0483	-0.0151	0.0129	0.5880
Crop growth rate	0.0970	0.0013	**-0.4860**	0.5089	0.4364	0.1282	0.6390
Cob diameter	0.0861	0.0363	-0.4020	**0.6154**	0.1280	0.1190	0.5830
Cob weight	0.0604	-0.0277	-0.2600	0.3089	**0.2650**	0.1311	0.4680
100-grain weight	0.0651	0.0285	-0.2970	0.3489	0.1954	**0.2099**	0.5150
				2013			
Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**Total corrected**
Shoot dry weight	**0.4454**	-0.4368	0.4502	0.4573	0.0538	-0.0098	0.9630
Leaf area index	0.4084	**-0.4763**	0.2451	0.2958	0.2482	-0.0522	0.9160
Crop growth rate	0.4227	-00453	**0.4744**	0.1452	0.0472	-0.1532	0.8910
Cob diameter	0.2165	-0.2710	0.2001	**0.3441**	0.2320	-0.1046	0.5410
Cob weight	0.1158	-0.1110	0.1081	0.0530	**0.2068**	-0.0638	0.3090
100-grain weight	0.1033	-0.1138	0.3382	0.1676	0.0614	**-0.2149**	0.3400
				Combined			
Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**Total corrected**

Shoot dry weight	**-0.5117**	0.0596	1.1416	0.1773	-0.0040	0,0772	0.8060
Leaf area index	-0.3464	**0.0881**	0.7615	0.1128	-0.0332	0.0603	0.7530
Crop growth rate	-0.5071	0.0582	**1.1520**	0.1766	-0.3502	0.2763	0.7550
Cob diameter	-0.3966	0.0434	0.8893	**0.2288**	-0.0323	0.2003	0.5880
Cob weight	-0.0213	0.0306	0.4216	0.0771	**-0.0957**	0.0907	0.4260
100-grain weight	-0/2835	0.0381	0.6313	0.0991	-0.0623	**0.1393**	0.4000

Figures highlighted represent direct effect

Table 70: Direct and combined contribution of some growth and yield characters to the grain yield of maize in 2012, 2013 and combined at Samaru.

Growth and yield characters	2012	2013	Combined
Direct contribution $(pi)^2$*100			
Shoot dry weight	1.03	19.84	26.19
Leaf area index	21.33	22.68	0.78
Crop growth rate	23.63	22.50	32.70
Cob diameter	37.88	11.84	5.23
Cob weight	6.51	4.28	0.91
100-grain weight	4.41	4.62	1.94
Sub-total	94.79	85.26	67.75
Combined contributions (2pipjrij)*100			
Shoot dry weight vs leaf area index	8.50	-38.90	-4.10
Shoot dry weight vs crop growth rate	-9.43	40.20	-16.84
Shoot dry weight vs cob diameter	10.60	14.90	-18.15
Shoot dry weight vs cob weight	3.09	4.79	0.41
Shoot dry weight vs 100-grain weight	2.73	-4.44	-7.90
Leaf area index vs crop growth rate	-1.10	-4.29	13.42
Leaf area index vs cob diameter	4.47	-18.65	-1.99
Leaf area index vs cob weight	-1.41	4.97	-0.58
Leaf area index vs 100-grain weight	1.20	13.79	0.06

Crop growth rate vs cob diameter	-49.48	4.47	40.89
Crop growth rate vs cob weight	-13.27	-4.95	-8.07
Crop growth rate vs100-grain weight	-1.26	2.19	-13.90
Cob diameter vs cob weight	15.76	-7.20	-1.48
Cob diameter vs 100-grain weight	14.65	-2.64	2.75
Cob weight vs 100-grain weight	6.69	14.71	-1.74
Residual	13.48	14.71	18.88
Total	**100**	**100**	**100**

The path analysis of growth and yield characters with the grain yield of maize for 2012, 2013 and the mean years at Tashar Dauda are presented in Tables 71 and 72. In 2012 (Table 71) crop growth rate had the highest direct contribution (0.8139), followed by shoot dry weight (0.8054) and cob weight (0.2170), while leaf area index had the lowest direct contribution (-0.0281). In 2013 shoot dry weight recorded the highest direct contribution (0.5985), followed by crop growth rate (0.5112) and cob diameter (0.4362), while the least contribution was made by cob weight (-0.1576). In the combined years the highest positive direct contribution was recorded by shoot dry weight (0.5301), followed by cob diameter (0.3178) and cob weight (0.2621), while crop growth rate had the lowest direct contribution (-0.5683). Table 72 shows that when the individual and the mean contribution was considered, the highest individual contribution was recorded by shoot dry weight (35.83% in 2013, followed by crop growth rate (33.19%), in 2012 and the lowest was recorded by 100-grain weight (0.08) in 2013. Also when effects of

the mean contribution was considered, it was observed that crop growth rate versus cob diameter (34.02%), shoot dry weight versus cob diameter (26.52%), leaf area index versus 100-grain weight made the highest contribution in 2013, the mean and 2012 respectively. The total percent the mean contribution was recorded by the mean years (36.70%).

Table 71: Direct and indirect effects of some growth and yield parameters to grain yield of maize in 2012, 2013 and combined at Tashar Dauda.

				2012			
Parameters	**Parameters**	**Shoot dry weight**	**Leaf area index**	**Crop growth rate**	**Cob diameter**	**Cob weight**	**100-grain weight**
Shoot dry weight	**0.8054**	-0.0010	-0.0584	0.1360	0.0903	-0.0312	0.9400
Leaf area index	-0.0039	**-0.0281**	0.5378	0.0865	0.0753	-0.0241	0.6430
Crop growth rate	-0.0578	-0.0185	**0.8139**	0.1354	0.0794	-0.0309	0.9210
Cob diameter	-0.0452	-0.0138	0.6281	**0.1754**	0.0731	-0.0244	0.7930
Cob weight	-0.0243	-0.0087	0.2978	0.0991	**0.2170**	-0.0367	0.5030
100-grain weight	-.0.0324	-0.0122	0.4458	0.0760	0.1412	**0.0964**	0.5620
				2013			
Parameters	**1**	**2**	**3**	**4**	**5**	**6**	**Total corrected**
Shoot dry weight	**0.5985**	-0.0110	0.0491	0.0353	-0.0455	0.0076	0.6340
Leaf area index	0.0772	**-0.0852**	0.1165	0.1252	-0.0341	0.0095	0.2090
Crop growth rate	0.0575	-0.0194	**0.5112**	0.3328	-0.0440	0.0020	0.8480
Cob diameter	0.0485	-0.0244	0.3900	**0.4362**	-0.0370	0.0058	0.8190
Cob weight	0.1730	-0.0185	0.1426	0.1025	**-0.1576**	0.0070	0.2490
100-grain weight	0.1586	-0.0284	0.1789	0.0885	-0.0383	**0.0286**	0.3870
				Combined			
Parameters	1	2	3	4	5	6	

Shoot dry weight	**0.5301**	0.0400	-0.5501	0.2501	0.0757	0.0422	0.3880
Leaf area index	0.1580	**0.1343**	-0.0060	0.0088	-0.0055	0.0042	0.2940
Crop growth rate	0.5131	0.0014	**-0.5683**	0.0241	0.7365	0.0389	0.8280
Cob diameter	0.4172	0.0037	-0.0430	**0.3178**	0.0739	0.0334	0.8030
Cob weight	0.1532	-0.0028	-0.1597	0.0896	**0.2621**	0.0320	0.3740
100-grain weight	0.1479	0.0040	-0.1406	0.0702	0.0548	**0.1512**	0.2820

Figures highlighted represent direct effect

Table 72: Direct and combined contribution of some growth and yield characters to the grain yield of maize in 2012, 2013 and combined at Tashar Dauda.

Growth and yield characters	2012	2013	Combined
Direct contribution $(pi)^2$*100			
Shoot dry weight	32.34	35.83	28.10
Leaf area index	0.10	0.73	1.80
Crop growth rate	33.19	26.13	32.30
Cob diameter	3.08	19.02	10.10
Cob weight	4.71	2.48	6.87
100-grain weight	0.32	0.08	2.29
Sub-total	73.74	84.27	81.46
Combined contributions (2pipjrij)*100			
Shoot dry weight vs leaf area index	0.02	-1.32	4.24

Shoot dry weight vs crop growth rate	-9.00	5.87	-58.33
Shoot dry weight vs cob diameter	-1.59	4.23	26.52
Shoot dry weight vs cob weight	-1.06	-5.45	8.03
Shoot dry weight vs 100-grain weight	-3.02	0.91	4.47
Leaf area index vs crop growth rate	-0.49	-1.99	-0.16
Leaf area index vs cob diameter	-0.42	-2.14	0.24
Leaf area index vs cob weight	0.14	0.58	-0.15
Leaf area index vs 100-grain weight	22.10	-0.16	0.12
Crop growth rate vs cob diameter	12.92	34.02	-2.73
Crop growth rate vscob weight	12.92	-4.49	-8.37
Crop growth rate vs100-grain weight	-3.98	0.94	-0.51
Cob diameter vs cob weight	2.57	-3.23	4.70
Cob diameter vs 100-grain weight	-0.86	0.51	2.12
Cob weight vs 100-grain weight	0.16	-0.22	1.66
Residual	0.67	12.38	36.70
Total	**100**	**100**	**100**

4.3.4 Regression Analyses

4.3.4.1 Grain yield against nitrogen rate

The regression analysis of maize grain yield against nitrogen rate for the year 2012, 2013 and the mean years at Samaru are presented in Figure 1. The response of maize grain yield against nitrogen rate in both years and the mean were linear. The linear models had R^2 value of 0.9642, 0.9716 and 0.9775 for 2012, 2013 and the mean years, respectively. The linear for 2012, 2013 and the mean are as follows:

Y = 1214 + 24.826*x* for 2012

Y = 978.3 + 21.81*x* for 2013

Y = 742.58 + 18.70*x* for the mean

The regression analysis of maize grain yield against nitrogen rate for the year 2012, 2013 and the mean years at Tashar Dauda are presented in Figure 2. The response of maize grain yield against nitrogen rate in both years and the mean wase linear. The linear models had R^2 value of 0.9574, 0.9734 and 0.9742 for 2012, 2013 and the combined years, respectively. The linear for 2012, 2013 and the mean are as follows:

Y = 1171.4 + 27.50*x* for 2012

Y = 1206.3 + 22.43*x* for 2013

Y = 1241.9 + 17.28*x* for the mean

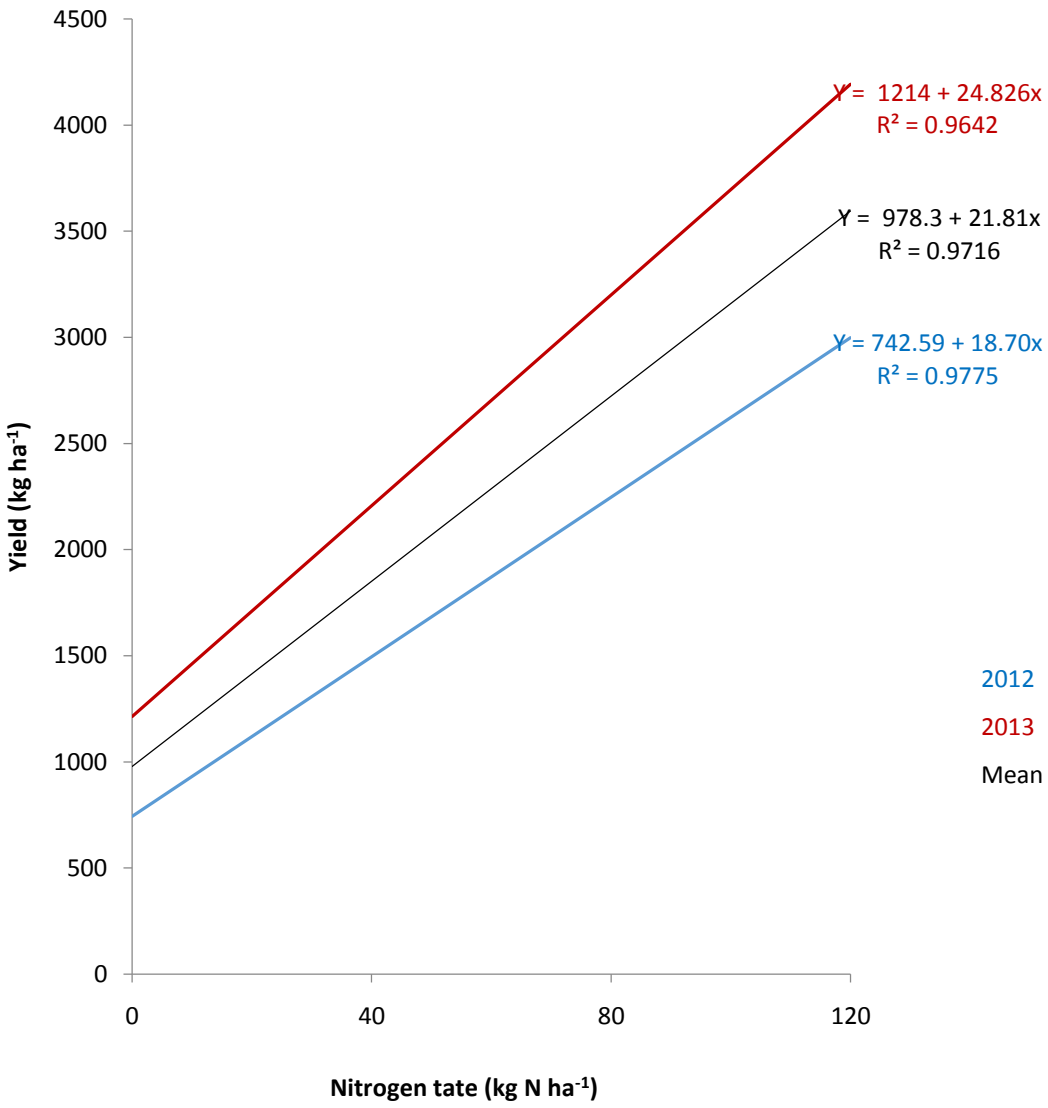


Figure1: Regression of maize grain yield against nitrogen rate in 2012, 2013 and mean years at Samaru

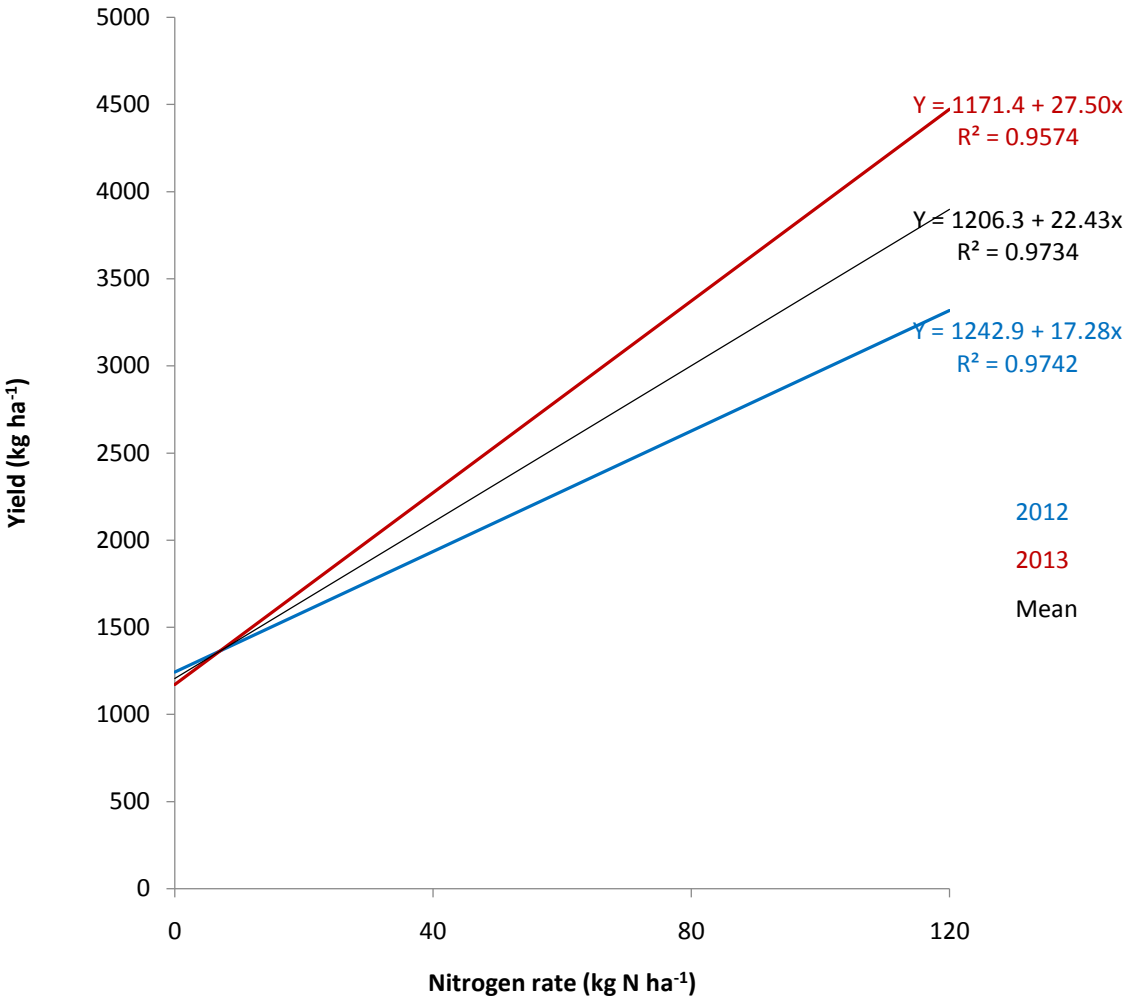


Figure 2: Regression of maize grain yield against nitrogen rate in 2012, 2013 and mean years at Tashar Dauda

CHAPTER FIVE

5.0 DISCUSSION

5.1 General Crop Performances

Generally, the crop yield performance was better in 2013 at both Samaru (4263kgha^{-1}) and Tashar Dauda (4034kgha^{-1})compared to3198kg ha^{-1}and2955kgha^{-1} in the respective locations in 2012. This could be from the increase in almost all the growth and yield attributes of the crop in (2013), as a result of early planting, 19th June and 5th July and an even distribution of rainfall in 2013.While the crop was planted in 2012 on 28th July and 1st August at Samaru and Tashar Dauda, respectively. Studieshave shown that maize yield potential decline as planting is delayed beyond the optimum planting period for a given area (Farnham,2001;Coulter, 2012). Timely planting of full season crop allows it to take full advantage of available growing season. High rainfall at the beginning of the growing period and its absence at the later stage of the crop growth and development could significantly reduce yield (Reshid and Getahum, 2014). In 2012, there was excessive moisture at the early stage and dry spell during grain filling. As the growth stage coincided with a heavy rainfall and the reproductive phase experienced a dry spell in 2012, this could be the reasons for the lower yield of maize in 2012 as the rain appeared to be poorly distributed (697.0mm) during the two months of vegetative period and little rainfall (85.6mm) in October,the pollination and grain filling period. In 2012, the total amount of rainfall was higher than in 2013 but it was poorly distributed in 2012.As reported by earlierworkersthat a total rainfall (481.9mm) in the first two months of July and August, which could caused excessive nutrient leaching at vegetative growth of maize hence the lower yield (Reshid and Getahum, 2014). Onthe other hand the little

amount of rainfall during the reproductive stage in October (85.6mm) in 2012, likely affected negatively the pollination and grain filling of the crop due to moisture stress. Jalel*et al*. (2008) reported that plant growth and development are affected by water stress which affect physiological and biochemical processes such as ion intake, photosynthesis, respiration and translocation. The crop performed better at Samaru in both years even though the vegetative growth characters were better at Tashar Dauda in 2012. This could be attributed to excessive moisture at Samaru at the early stage of crop growth where as at Tashar Dauda, the rainfall pattern favoured the vegetative growth,but the incidence of moisture stress was severe at Tashar Dauda, during reproductive stage than Samaru, which caused decline in yield. This finding corroborates that of Reshid and Getahum (2014), who reported that small amount of rainfall during the reproductive period, was likely to inhibit pollination and grain filling due to moisture stress.

5.2 Response ofMaize and *Striga hermonthica* to Nitrogen Rate

Application of nitrogen in this study significantly influenced *Striga* and the growth and yield of maize. The application of nitrogen up to 120 $kgNha^{-1}$ increased plant height, leaf area and shoot dry weight. This could be attributed to the positive role nitrogen plays on growth and development of cell expansion and division of crops particularly if applied in soils with low fertility as was characteristics of the experimental soils. The larger values of leaf area,recorded as a result of N application, consequently resulted in higher assimilate production per plant thereby leading to production of taller plants (Hassan, 1990; Lawal, 2000; Hussaini *et al.*,2001). The CGR, RGR and crop vigour all responded positively to N application. This could be due to the overwhelming effect of nitrogen on shoot dry weight of maize; Ahmed *et al*.(1993) and Mohsan (1999) reported similar

findings on CGR and RGR of maize. The number of days to 50% tasseling and silking significantly increased with the increase in nitrogen application in all locations and years. This could be due to increase in leaf area, which was point for the formation of chlorophyll,that enhanced efficient photosynthetic processesand subsequently led to production of more assimilate and its translocation to the site of tassel and silking formation, also the time taken for the production and translocation of more assimilates to form the tassels and silks could be responsible for the delay of their formation. Namakka (2012) reported that excessive nitrogen application delayed flower formation in maize.

In both locations and years, application of nitrogen at 120kgN ha^{-1} significantly increased days to first *Striga* emergence and reduced *Striga* count at 12 WAS, number of flowering striga, *Striga* syndrome rating and stands infested with *Striga,* increased crop growth and yield components which resulted in grain yield that was higher than other levels of nitrogen. There was a significant difference between *Striga* infested and uninfested fields. This higher yield at 120kgN ha^{-1} could be attributed to influence of nitrogen indelaying*Striga* emergence, decreased*Striga*stand count, and *Striga* syndrome rating and subsequently reducing the stands of maize infested with *Striga,* as high N reduces stimulant(strigol)production from maize. The absence of such compounds in the host root exudates, can delay *Striga* emergence (Parker,1984) similarly, Lagoke *et al.* (1991) reported that application of higher nitrogen increases the grain yield of cereal crops under *Striga* infestation proposing that nitrogen levels merely improved the crop tolerance to *Striga* and consequently increased the crop yield. Also, Kim and Adetimirin (1997) observed that nitrogen mediated reduction in *Striga* infestation was only apparent at the highest rates. Other reports on the effect of fertilizers have shown that adequate nitrogen

reduced*Striga* infestation and increase host yield (Adagba, 2000), while others have reported that high levels of nitrogen enhanced the growth of both host and parasite (Parker, 1984; Chechin and Press, 1993).

Earlier workers (Parker, 1984; Sharif and Parker, 1986; Raju *et al.,* 1990) have reported that high N has the effect of reducing stimulant(strigol) production from sorghum and can delay *Striga*emergence and infestation compared with low N rate. The reduction of stimulants produced by sorghum under high N might be due to physiological changes in the growth rate of the sorghum roots (Ransom *et al.,* 1996) leading to the alteration of the host partitioning of resources between the roots and the shoot. It is likely that high N encourages rapid and vigorous cell growth and elongation which subsequently increase leaf area and more photosynthetic activity of the crop. Therefore, as a result of that a small quantity of the stimulant is released into the soil medium.

High N also has implication in the reduction of radicle elongation of the few germinated *Striga*such as observed by (Pieterse and Varkleij, 1991).This provides an escape mechanism effect on the attachment of the *Striga* seedlings to the host. It is also possible that the lower percentage of germinated seeds that were successfully attached to the host root at the higher N concentration may also be attributed to the effect of nitrogen on synthesis of cell wall-degrading enzymes by the parasite (Olivier *et al*., 1991). The production of such barriers in turn may be influenced by nitrogen (Chechin and Press, 1993). High N may also stimulate antagonism, that caused the*Striga* to feel dislike of the host crop (Ransom, 1997).

In this study, in the control treatment earlier emergence of *Striga* was observed, 46-63days for 0 and 120kgha^{-1}, respectively. Also the number of *Striga* count at 12 WAS, number of flowering *Striga* and *Striga* syndrome rating were higher at0kgNha-^{1} than all nitrogen rates. Consequently, the adverse effect of *Striga* infestation on the grain yield was significantly higher without nitrogen compared with all other nitrogen rates (0kgN ha^{-1}had 19.0 and 120kgNha^{-1} had no stand infested with *Striga* at 12m^{2} plot). This could be attributed to the role of nitrogen in increasing the photosynthetic activities of maize and toxic effect of nitrogen on *Striga.*

The results is in line with earlier findings of Adagba,(2000), however it contradicts earlier findings of Gworgwor and Weber (1991) who indicated lower *Striga* emergence without nitrogen compared with all the nitrogen rates evaluated in sorghum, attributing it to inadequate nutrient on the sorghum which could not produce enough stimulant to initiate *Striga* germination.

The delay in *Striga*emergence especially at the lower rates of nitrogen (0-40 kgNha-^{1}) in 2012 and subsequent lower number of *Striga* count at 12 WAS and number of flowering *Striga* might be due mid- season flood experienced at the peak of *Striga* emergence, as the *Striga* is associated with drier conditions. This is in line with earlier findings that *Striga* thrives best under modest drought stress, erratic and or limited rainfall (Parker, 1984; Lagoke *et al.*, 1991). The earlier reports have indicated that extremely wet conditions and water logging suppress *Striga* emergence and subsequent shoot development (Saunders, 1933; Mansfield, 1982). This inhibitory effect has been attributed to reduced soil temperature and soil oxygen content as well as leaching and dilution of the root exudates (Andrews, 1945). Higher soil moisture content was also

found to negatively affect the amount of exudates produced by the host roots (Hess *et al.*,1991). Excessive moisture, also causes high degradation rates of the *Striga* seeds due to enhance activity of the soil fauna (Hermann, 1998).

In spite of support for low *Striga* emergence, lower grain yields were produced in 2012. This could be attributed to the poor productivity of late sown crop in a given nitrogen rate in spite of low level of infestation by *Striga* compared with the early sown crop in 2013, it could be attributed to leaching of the fertilizer beyond the root zone as a result of intensive rainfall. Similar finding was reported by (Wild, 1988). The resulting low fertility predisposed the maize to severe *Striga* attack in the late sown trial than early sown trial.

5.3 Response of Maize Varieties to *Striga*

SAMMAZ-14 had lower *Striga* count at 12 WAS, lower *Striga* syndrome rating, lower stands infested with *Striga,* higher number of crop stand count at harvest, longer days to 50% tasseling and silking , higher stem lodging count, higher ear height, number of seed rows, cob weight, grain weight, harvest index and higher grain yield than the other varieties. This could be due to the resistance trait in that variety as described by the breeders.Differences between varieties in both growth and yield characters have been reported by Wailare (2008) who observed that SAMMAZ 11 and 13 performed better than the other varieties in terms of both growth and yield characters. Generally, varieties differ in their adaptation to new ecology, in yield potential, maturity periods and canopy architecture (Dowsell *et al.*, 1996).

Similarly, the two maize varieties SAMMAZ 14 and 26 gave significantly higher CGR, shoot dry weight, number of cobs per plant, number of harvestable cobs, cob length, cob diameter, 100-grain weight, shelling percentage and grain yield than SAMMAZ 11 and 20. This could be as a result of their responsiveness to fertilizer and genetic make up as was earlier observed by Sharifai (2004) when explaining the significant increase in plant height and total dry matter. Higher relative growth rate and grain yield exhibited by varieties TZPB-SR and TZE COMP-36 over variety TZE-R-W. Mani *et al* (2006) reported that five QPM varieties (Obatampa, Mamaba, Susuma, EV.99 QPM and DMR-ESR QPM) were evaluated and the result showed that varieties DMR/ESR., QPM and EV.99 QPM were significantly higher in yields and net returns which were similar to some QPM varieties.*Striga hermonthica* significantly influenced some of the yield characters of maize crop. Uninfested fields produced significantly higher ear height and number of harvestable cobs than infested fields. In some cases, parameters such as number of days to 50% tasselling, stem lodging count and cob diameter, at the infested fields were at par to uninfestated and even higher in some such as CGR. This indicated that the tolerant and susceptible maize varieties with good management and adequate N fertilization can withstand *Striga* and produce yield to the optimum. Kim *et al.* (1992) reported that two tolerant hybrids produced an average of 87% greater grain yield than two susceptible hybrids under low N rates (0-60 kgNha-^{1}) compared to 51% of greater yields under high N (90-150 kgha-^{1}).

The interaction of maize varieties and nitrogen was significant on plant height, leaf area index, and shoot dry weight, 100-weight and grain yield. SAMMAZ 26, 14 and 20 had the taller plants than SAMMAZ 11 at 120kgNha-^{1}. This could be as a result of more

efficient utilization of N by these varieties than SAMMAZ 11, SAMMAZ 14 at 120kgNha^{-1} had the highest leaf area than the other varieties. This could be attributed to more responsiveness to N fertilizer and genetic make up of the variety. Application of nitrogen at (120 kgNha-^{1}) to SAMMAZ 14 and 26 had highest shoot dry weight at both *Striga* infested and uninfested fields could be attributed to the highest shoot dry weight recorded by SAMMAZ 14 and 26 in both *Striga* infested and uninfested fields could be attributed to better efficient utilization of N by the two varieties which translated to better leaf area and resulted in better photosynthetic activity and translocation of assimilate to various sinks. SAMMAZ 26 had the higher 100-grain weight than all other varieties at 80kgNha-^{1}. This could be attributed to the genetic make up of this variety SAMMAZ 14, at 120kgNha-^{1} had the highest grain yield which was comparable to SAMMAZ 26 at Samaru 2013. This could be attributed to the inherent characteristics of the variety of higheryield potential and more responsiveness to fertilizer than the other varieties as reported by Hassan (1999) using two varieties (GH110-28 and SAMMAZ 14 revealed that (GH110-28) produced significantly more leaves per plant, longer days to 50% tasseling and silking.

The interaction between nitrogen and *Striga* infestation was significant on plant height, shoot dry weight and grain yield of maize. Uninfested fields had the tallest plants at 120kgNha-^{1} and were comparable to 80kgNha-^{1}. This could be as a result of role of N fertilizer in boosting the maize growth at optimal level of nitrogen without any *Striga* infestation. The interaction between nitrogen and *Striga* on shoot dry weight indicates that infested fields and uninfested fields had the same shoot dry weight at 120kgNha-^{1}. This could be as a result of efficient performance of higher N fertilizer in delaying

*Striga*emergence, reduction in stands infested with *Striga* and low *Striga* syndrome rating and subsequent suppressing the activity of *striga hermonthica* in damaging the maize crop. Earlier workers (Pieterse and Verkleij, 1991) reported high N has implication in the reduction of radicle elongation of the few germinated *Striga.* The interaction between nitrogen and *Striga* on grain yield shows that uninfested fields had higher grain yield than the infested at all levels of nitrogen rate. This shows that *Striga* had influence on some growth and yield characters of the maize for both resistant and susceptible varieties.

Interaction between *Striga* infestation and variety was significant on leaf area index at Tashar Dauda 2013 at 8 WAS. SAMMAZ 14 under infested field had the highest leaf area which was comparable to SAMMAZ 11 under uninfested field. This variety SAMMAZ 14 significantly reduced the *Striga* count, number of flowering *Striga*; stand infested with *Striga* and *Striga* syndrome rating which was comparable to SAMMAZ 26. Earlier researcher Zemoh (1997) reported that the acceptable yield of SUWAN-1-STR in both trials inspite of moderate infestation could be attributed to tolerance of the variety to *Striga hermonthica.*

5.4 Correlation Coefficient Analysis

The grain yield correlated positively with plant height; shoot dry weight, leaf area index, crop growth rate, number of days to 50% tasseling, cob diameter, cob weight and 100-grain weight. This indicates the importance of these parameters as yield determinants. However, the grain yield was negatively correlated with *Striga* syndrome rating and *Striga* shoot count at 12 WAS. This confirms the vulnerability of maize to *Striga* parasitism with consequent reduction in grain yield. The relationship observed indicates that the *Striga* parameters areuseful in assessing the responses of maize varieties to *Striga*

hermonthica, such as level of tolerance or resistance as has been done in other cereal and legume crops (Magani, 1994; Diallo and Ransom, 1996; Adetimirin *et al*., 1997; Kure,1999., Adagba, 2000).

5.5 Path Coefficient Analysis

The path coefficient analysis showed that the highest contribution among the growth characters to grain yield was from crop growth rate, cob diameters, shoot dry weight and leaf area index. Most of the contribution from the characters was highest via shoot dry weight which revealed the importance of nitrogen fertilizer in boosting the growth of maize and subsequent determining the yield of maize. Optimum N rate increased leaf area index, crop growth rate which promoted growth by enhancing photosynthesis thereby producing higher amount of assimilate which form the final grain yield. The greatest percent contribution was made by crop growth rate followed by shoot dry weight and cob diameter signifying that as the growth increased then the dry matter also increased and it translated the wider cobs which revealed the importance of these characters as major contributors to grain yield. This supported the observation reported by Adesoji *et al*., (2015), that crop growth rate produced highest direct effect (0.6042) whicfh was followed by total dry matter per plant with direct effect of (0.5544).

5.6 Regression Analysis

The regression of grain yield against fertilizer showed that linear model was best fit at both location in both years and combined as increasing fertilizer rate increased the grain yield of maize. This results collaborates earlier reports (Ogborn, 1984; Lagoke *et al.*, 1990) that increase in nitrogen fertilizer enhance growth and yield of the host plant.

5.7 Gross Margin Analysis

Maize production in this study has highest returns per naira investedin the combination of 120kgNha-^{1} and SAMMAZ 14 both under infested and uninfested fields in 2013 at Samaru (₦ 2.85 and ₦2.82), while at lower rate of 80kgNha^{-1} the highest returns per naira invested was recorded by SAMMAZ 26 both under infested and uninfested treatments at Samaru 2013(₦2.34 and ₦2.30).

The results of differences in return per naira invested between uninfested and infested confirmed that SAMMAZ 11 and 14 were *Striga* tolerant varieties, because they consistently produced the least differences between uninfested and infested field at 120kg ha^{-1}. This indicated that at higher rate of nitrogen of 120kgN ha^{-1} and planting SAMMAZ 11 and 14, the *Striga* effect can be mitigated. Similarly, the results showed that at 80kgN ha^{-1} SAMMAZ 26 can suppress *Striga*infestation; this confirmed the characteristics of the variety of low N and drought tolerant as described by the breeders.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Multi-locational trials were conducted simultaneously at the Institute for Agricultural Research farms, Samaru ($11^{o}11'$ N, 07^{o}38E and 686m altitude) and Tashar Dauda ($11^{o}11'$ N, 07^{o}49E and 678 altitude) in the northern Guinea savanna ecological zone of Nigeria during the 2012 and 2013 rainy seasons in a study on "Mitigating the impact of *Striga hermonthica* (Del.) Benth in maize (*Zea mays* L.) using host crop tolerance varieties and nitrogen fertilizer rates in northern Guinea savanna Nigeria". The experiment consisted of four varieties of maize (SAMMAZ 11, 14, 20 and 26) and four levels of nitrogen (N) fertilizer (0, 40, 80 and 120 $kgNha^{-1}$) with two levels of *Striga* (infested and uninfested). The treatments were laid out in a randomized complete block and replicated three times.

Application of 80 and 120 $kgNha^{-1}$ significantly delayed *Striga* emergence on maize and reduced the *Striga* count at 12 WAS, number of flowering *Striga*, *Striga* syndrome rating and stands of maize infested with *Striga*compared to 40 $kgNha^{-1}$and control.Application of 40$kgNha^{-1}$and the untreated control werecomparable in days to first *Striga* emergence, number of *Striga* count and number of flowering *Striga*.Application of nitrogen apparently enhanced the tolerance of maize to *Striga* infestation as crop damage was reduced while other crop growth and yield parameters viz. leaf area index, crop growth rate, shoot dry weight, ear height, number of cobs per plant, cob length, cob diameter, grain weight and 100-grain weight, were enhanced by nitrogen fertilizer application.

The varieties did not differ significantly in their support for the days to first *Striga* emergence in both locations, years and the mean.The varieties exhibited differential to

Striga count at 12 WAS at Samaru in both years and *Striga* syndrome rating at Samaru in 2013 and the mean and at Tashar Dauda 2012 and combined. SAMMAZ 14 had significantly lowest stands infested with *Striga* and lowest *Striga* count than SAMMAZ 11 and 20. The former exhibited better tolerance to *Striga* infestation than the later. SAMMAZ 14 produced higher yield than the other varieties and SAMMAZ 11 produced significantly lower yield than SAMMAZ 26 and 20 which were susceptible varieties. This manifested that with good management and adequate nitrogen fertilizer application even susceptible varieties can tolerate *Striga* infestation and produce a reasonable yield of maize. The yield of SAMMAZ 26 was comparable to SAMMAZ 14 in this trial.

Striga infestation significantly affected the performance of maize in the study, *Striga* infestation resulted in shorter maize plants, ear height and shorter cobs, lighter cobs and grain compared with no infestation.

There were significant interactions of nitrogen on plant height, leaf area index, shoot dry weight, 100-grain weight of maize varieties and on grain yield. SAMMAZ 14 significantly had highest leaf area index at high rate of nitrogen (120kgNha-^{1}) and also had the higher leaf index area with infestation than without infestation.

In the study maize grain yield was negatively correlated with *Striga* syndrome rating and number of *Striga* count at 12 WAS. The maximum grain yield with and without *Striga* infestation for SAMMAZ 14 was 5.0 tons/ha. The lowest yield loss percentage between infested and uninfested was recorded by SAMMAZ 14 of 0.6% followed by SAMMAZ 11 of 3.6%. Application of nitrogen at 80kgNha^{-1}to SAMMAZ 26 had the highest grain yield of 4000kgha^{-1}.

6.2 Conclusion

Based on this study, application of nitrogen at 120kgNha^{-1} suppressed *Striga hermonthica* and enhanced *Striga* tolerance of SAMMAZ 14, while SAMMAZ 26 which was susceptible to *Striga* and tolerant to low N exhibited some level of tolerance to *Striga* under application of 80kgNha^{-1}.

6.3 Recommendations.

Farmers in northern Guinea savanna should embrace maize production using SAMMAZ 14 at 20kgN ha^{-1} under *Striga* infested field, or using SAMMAZ 26 at 80kgN ha^{-1} as a means of mitigating the impact of*Striga hermonthica*on in maize production.

The poor resource farmers in northern Guinea savanna can grow SAMMAZ 26 under *Striga* infested field at 80kgNha^{-1} as a panacea to *Striga hermonthica*.

Farmers should adopt the integrated methods of *Striga* control since there is no single effective method of *Striga* control.

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Appendices

Appendix I: Meteorological data showing mean monthly air temperature, relative humidity, sunshine and total rainfall during the 2012 rainy season at Samaru

Month	Temperature (O^C)		Relative Humidity %		Sunshine (hours)	Rainfall (mm)
	Maximum	Minimum	Morning (10 a.m.)	Afternoon (4 p.m.)		
May	36.1	22.6	70.5	55.7	6.1	263.4
June	32.7	22.1	76.3	57.7	7.1	120.7
July	26.3	25.9	82.6	67.8	5.3	159.0
August	25.4	23.9	82.2	74.0	4.5	426.7
September	26.0	25.6	77.2	73.8	5.0	270.3
October	27.4	26.4	70.2	55.3	7.3	85.6
				Total	=	**1325.7mm**

Appendix II: Meteorological data showing mean monthly air temperature, relative humidity, sunshine and total rainfall during the 2013 rainy season at Samaru

Month	Temperature (O^C)		Relative Humidity %		Sunshine (hours)	Rainfall (mm)
	Maximum	Minimum	Morning (10 a.m.)	Afternoon (4 p.m.)		
May	35.4	25.7	66.8	52.6	8.0	66.5

June	29.0	27.8	69.6	60.25	8.8	167.0
July	26.7	26.0	79.9	67.5	6.0	314.9
August	24.8	25.2	83.6	72.7	4.5	181.4
September	26.9	26.4	77.3	65.6	6.0	233.0
October	27.2	25.9	54.7	42.4	7.9	10.6
			Total	**=**		**973.4mm**

Appendix III: *Striga* syndrome Ratings (1 – 9) used for Measurement of Tolerance of Maize to *Striga*, Based on Damage Symptoms to the Host Plant (1= Highly Tolerant; 9 = Highly Susceptible), Kim (1991)

Rating	Description
1	No Chlorosis, no blotching, and no leaf scorching (firing) and normal plant growth
2	Mild leaf blotching and scorching on about 10 percent of leaves with purplish – brown necrotic spots, almost normal plant growth. No stunting and no ear size reduction
3	Mild definite leaf blotching and scorching purplish – brown necrotic spots. Mild stunting and ear reduction
4	Some definite leaf scorching on about 30% of leaves with some purplish – brown necrotic spots; some stunting and ear tassel size reduction.
5	Definite leaf scorchin on about 40% of leaves with some grey brown necrotic spots. Some stunting and ear and tassel size reduction.
6	Definite leaf scorchin on about 50% of leaves with mostly gray necrotic spots. Definite stunting and stem diameter, ear size and tassel size reduction.

7	Definite leaf scorchin on about 60% of leaves with severe grey necrotic spots and leaf wilting and rolling. Definite stunting and stem diameter, ear size and tassel size reduction, often cause severe stalk lodging and husk opening at late growing stage.
8.	Definite leaf scorchin on about 70% of leaves with definite gray necrotic spots. Conspicuous stunting, leaf wilting, rolling and stem diameter, ear size and tassel size reduction.
9	Complete leaf scorching of all leaves causing pre-mature death of all plants and no ear formation

Appendix IV: Crop Vigour Score Scale

Rating	Description
1	Completely killed
2	Moribund
3	Only few green tissue present
4	Definite growth reduction , severe toxicity symptoms and less likely to survice
5	Definite growth reduction, mild toxicity symptoms and less likely to survice
6	Distinguishable inhibition of growth and other injury symptoms

7	\Distinguishable inhibition of growth and slight discoloration/other injury symptoms
8.	Distinguishable inhibition of growth
9	Slight discoloration and lower vigour/discoloration and necrotic spots

BIOGRAPHY

1. Name: - Mikah,HARUNA
2. Date of Birth: - 25/9/1970
3. Place of Birth: - Unguwar Kogo
4. Local Government Area: - Bakori
5. State of Origin: - Katsina
6. Marital Status: - Married
7. Number of Childred: - Three

8. **Educational Institutions andQualifications WithDates**.

i. Zage-Zagi Primary School: FSLC - 1983.

ii. Govt. Day Sec. Sch. Tsiga: NJSC - 1986

iii. Teachers`Coll.Kafanchan: Grade II - 1989

iv. F.C.E. Zaria: NCE(Inter.Sc.) - 1996

v. ABU Zaria: B.Sc.Ed(Agric.) - 2001

vi. ABU Zaria: M.Sc.Agronomy - 2009

9. Working Experience.

I .Classroom Teacher: Pri.Sch.Tamarke: 1990-1991

ii. Classroom Teacher: Marretta Nur./Pri.Sch.Maichibi 1992-1994

iii. Classroom Teacher: Govt.Girls Arabic Sec.Sch.Kabomo-1997-1998

iv. Classroom Teacher: L.E A Pri. Sch. Bakori 1999-2007

v. Land Resource Officer I: Fed.Min. Of Agric.Abuja 2007-2009

vi.Lecturer;Fed.Coll. Of Land Resources Tech.Kuru,Jos 2009-2011

vii. Asst.Lecturer: Samaru Coll. Of Agric.DAC/ABU Zaria 2011-2014

viii. Lecturer II: Samaru Coll. Of Agric.DAC/ABU Zaria 2014 to date.