EFFECT OF NITROGEN ON THE REACTION OF MAIZE (*Zea mays* (L.) VARIETIES TO STRIGA (*Striga hermonthica*) (Del,) Benth.

By

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A thesis submitted to the Postgraduate School, Ahmadu Bello University in partial fulfilment of the requirements for the Degree of Master of Science in Agronomy

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SEPTEMBER, 1998

DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a Higher Degree.

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CERTIFICATION

This thesis entitled "Effect of Nitrogen on the Reaction of Maize (Zea mays) Varieties to Striga hermonthica (Del.) Benth. by Steve Zemoh Jatau meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to my wife, Grace Hussaina, and children, Gyure, Kishimi and Funom for their love, patience and encouragement during the course of study.

ACKNOWLEDGEMENT

I am highly indebted to Prof. S.T.O. Lagoke, my Major Supervisor, for his invaluable assistance, useful criticisms, suggestions and guidance throughout the course of this study and in the preparation and review of this manuscript. The same sincere appreciation goes to other members of the Supervisory Committee; Dr. W.B. Ndahi and Prof. K.O. Adejonwo (who later left the univeristy) for their outstanding contributions to the successful conduct and completion of this study. My appreciation also goes to the past and present Heads of Department of Agronomy; Dr. Y. Yusuf, Prof. S.T.O. Lagoke and Dr. E.B. Amans for providing facilities for the programme. I wish to thank Prof. M.K. Ahmed and Mr. M.O. Otitoju for the assistance given in data analysis. The assistance of Technical Staff of Weed Science Unit of Agronomy Department is also gratefully acknowledged.

I wish to thank the Ministry of Agriculture and Natural Resources of Kaduna State for the sponsorship. I wish to thank my friends and colleagues for their love and encouragement throughout the course of this study. My profound gratitude goes to my parents, Mr and Mrs. Zemoh Jatau for making what I am today, and mother-in-law Mrs. Lando Bello for her special concern.

My sincere appreciation goes to the Men's and Joy House Fellowship groups, and the entire members of ECWA Grace Covenant Church, Sabon Tasha, Kaduna for their love and prayers. I am also grateful to the Pastor and members of ECWA Church U/Baro, Kaduna for their love and prayers. I am grateful to Joseph S. Yamai and Umaru Byang for typing the manuscript as well as Rotimi Bello for the corrections.

Finally, I wish to thank God for His guidance and protection throughout the course of study. Glory, Honour, Power and Majesty be His for ever and ever Amen.

Steve Zemoh Jatau.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Production and Uses of Maize

Maize (Zea mays (L.) is ranked third after wheat and rice in cereal production of the world. The total world production of maize grain has been put at 392 million tonnes, out of which Africa produced 27 million tonnes representing about 2.9% (Anon, 1980). Nigeria produced 1.5 million tonnes during the same year. The current production of maize in Nigeria was estimated at 6.902m tonnes from 5.426 million hectares in 1994 (Anon, 1994). The major area of production of maize in Nigeria is the savannah where Striga species constitute a major problem (Lagoke, et al., 1994). Brian (1971) and Delorit, et al., (1974), have reported that nearly every part of the corn is useful. The grain is an important source of energy and it is consumed by human in various forms. The fresh immature grain is roasted or cooked and eaten directly. The dried grain is used for the preparation of porridge through the process of milling and boiling. The flour is made into paste and eaten as 'tuwo' with soup. Maize is also used to supplement pulses such as cowpeas for consumption. In comparison with other cereals, it is only surpassed by millet in oil content, and richer than any other in ash and vitamin A content (Brian, 1971).

Maize is also used for the production of livestock feeds and in the industries for the production of spirits, alchohol,

corn starch, beer, etc. The other parts of the plant, including cobs, stalk and cob's grit and made into different products such as cardboard paper, insulation, plastics, tar, etc. The fresh shoots are made into silage while the stalk is grazed by animals. The stalk is usef for building construction, fencing and mulching as well as source of fuel. It has been reported that maize has wider range of uses more than any other cereal (Fischer and Palmer, 1984).

1.2 Constraints to Maize Production

The recent intensification of maize production and its rapid expansion into areas north of latitude 8°N which was hitherto not a maize growing area have subjected the crop to various production constraints including pests, diseases and weeds.

It has, however, been reported that the damage caused by weeds alone in maize is greater than those of other pests and diseases combined together (Crafts and Robinson, 1962; Muzik, 1970). Various workers have reported losses of 50 to 80% in maize grain as a result of weed competition in the Nigeria savannah (Agboola, 1969; Lagoke, 1978; Remison, 1979; Anon, 1982; Magani, 1990). Greater losses may be caused by noxious weeds like itch-grass (Rottboelia cochinchinensis) speargrass, Imperata cylindrica) Sedges (cyperus spp) and parasitic weeds, especially Striga spp (Lagoke, et al., 1991).

With the expansion and intensification of maize production in areas north of latitude 8°N where Striga hermonthica is the endemic weed is a major constraint to maize production especially among the small scale farmers. The problem is further aggravated by the fact that maize is a new host to Striga and it is, therefore, highly vulnerable to the parasite (Ramaiah, 1987; Kim, 1991; Emechebe, et al., 1991).

1.3 Effect of Striga hermonthica on Maize Production

The common Striga spp that have been reported in maize in Nigeria include, Striga asiatica; S. hermontica, S. passergei, S. forbesii and S. aspera (Parkinson, 1985; Lagoke, 1989; (Omidiji et al., 1997).

Among the species S. hermonthica is the most ubiquitous (Parkinson, 1985) causing yield losses of 5 to 91%, and complete crop loss in very serious infestation (Drennan and El-hiweris, 1979; Terry, 1984; Lagoke, 1989; Lagoke et al., 1991). On farmers' fields, where two to three hoe weedings were done, maize grain was depressed as a result of Striga infestation compared with the use of improved Striga control packages which include tolerant/resistant varieties, adequate fertilizer and pre-emergence and post-emergence herbicides (Lagoke, et al., 1997). While previous reports have indicated that Striga hermonthica was present in only 40% of the land devoted to cereals in the country. The recent surveys which covered the Guinea and part of Sudan savannas revealed that

over 90% of the farm units had Striga infestation indicating rapid spread to traditional maize growing areas. Some of the sources of spread that have been implicated include improved seeds, farm implements and machineries, aniamsl and their wastes and man (Lagoke et al., 1994).

In Africa, estimated yield loss caused by Striga in cereals has been put at 40% representing an annual loss of $7 billion US Dollars (M'boob, 1986). This loss caused by Striga hermonthica depends on ecological zones which varies from one country to the other (Dogget, 1965; Ogborn, 1979). Nigeria has been estimated to have lost about $250 million US dollars on sorghum due to Striga infestation annually (Lagoke, 1989).

1.4 Existing Methods of Control and Limitations

Manual methods including hand-pulling, hoe-weeding and up-rooting are the most common control measures used by small scale farmers for the control of Striga in Nigeria. These methods are, however, very tedious, labour - intensive, time consuming, expensive and only adapted to low infestations. At high Striga infestations, they are ineffective. In addition, the methods do not prevent the serious pre-emergence damage caused by Striga which is considered very serious (Stewart et al., 1984; Ransom, et al., 1988). Through these physical removal, severe damage can be done to the crop. Many farmers have also indicated that hoe-weeding and hand-pulling had resulted in increase in Striga shoot proliferation especially

when not properly timed (Ogborn, 1972; Lagoke, 1989). This was attributed to the stimulation of subterranean buds as a result of apical dominance removal during hoe-weeding and hand-pulling (Lagoke, 1989).

Early work indicated that high rates of nitrogen applied as ammonium sulphate or urea delayed the emergence of the plants, caused the stunting of the emerged shoots and reduced the flowering and dry matter production of Striga (Last, 1960a, Agabawi and Younis, 1965; Lagoke and Fisher, 1983; Terry, 1984). However, the effectiveness of nitrogen fertilizers was found to be dependent on the fertility of the soil, time of application and crop variety (Last, 1961). Bebawi (1981) has also indicated that there was no consistent evidence to confirm that host response to nitrogen fertilization would invariably depress Striga infestation. However, Adetimirin and Kim (1997) observed that contribution of nitrogen to yield increase with rate used. Similarly, combination of tolerance and nitrogen gave grain yield increase tremendously. They equally reported that reduction in Striga shoot was achieved with host plant resistance at 120 to 150kgN/ha.

Genetic resistance/tolerance in the host crop is a plausible means of eliminating or reducing yield losses due to Striga. The International Institute of Tropical Agriculture, Ibadan, Nigeria, has developed hybrid and open pollinated maize varieties that have exhibited tolerance to S.

hermonthica (Kim, 1994; Lagoke, et al., 1994). The assessment of the varieties has been based on a quantitative rating scale developed for Striga species symptoms on maize. It was observed that resistance in maize based on S. hermonthica symptoms appears to be due mainly to additive genetic effects, while reduced parasite emergence appears mainly to be due to non-additive gene action (Berner, et al., 1997).

Several herbicides which have been evaluated for the control of S. hermonthica have failed to give season-long effective control possibly due to the resistance being developed by the weed as a result of continuous use of the chemical (Pieterse, 1985). Some of the herbicides that have been found to be relatively effective, still required repeated applications for adequate reduction of the population of Striga in the host crop (Robinson et al., 1967; Lagoke, 1989). The use of herbicide spray is not likely to be adopted easily by farmers because of high cost and lack of skill for effective application. Herbicides may also create environmental problem unless cautions are exercised in the application. In order to avert the problems enumerated, herbicide seed treatment are being suggested for use in the control of parasitic weed in plants. Ransom et al. (1995) have reported reduction of S. hermonthica in maize by seed treatment. High concentrations was, however, reported to injure maize crop. In cowpea, both imidalinone compounds, imazaquine and imezathepyr as well as sulphonylurea herbicides

were also reported to have reduced the incidence and infestation of parasitic weeds, S. gesnerioides and Alectra vogelii in cowpea. Similarly, Adagba (personal communication) has successfully reduced the incidence of Striga on upland rice by treating the seeds with cinosulferon and CGA 152005 at the highest rate used in his study.

1.5 Objective of the Study

It is necessary to develop components for the formulation of sustainable integrated management technology for Striga. Such components would include the use of tolerant host crop and appropriate fertilizer rate in addition to other compatible ones. The objective of the study, therefore, is to evaluate the effect of nitrogen fertilizer on the reaction of some maize varieties to S. hermonthica.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Biology of *Striga* spp

Striga species are obligate parasitic weeds in the crops where many cereals are grown especially in sandy soils of low fertility (Akobundu, 1987; Lagoke, 1989). The *Striga* plant produces minute seeds that can remain dormant in the soil for up to twenty years unless it comes in contact with the host plant (Parker, 1965). A single plant of *S. hermonthica* can produce as many as 50,000 to 500,000 seeds (Parker, 1965; Muzik, 1970).

The roots of the host plant produce an exudate which eventually stimulate the germination of the seeds of *Striga*, provided they have been pre-conditioned for several days in moist soils at a temperature of about 27°C (Sunderland, 1960a; Terry, 1984; Akobundu, 1987). The seedlings then attach to the roots of the host plant and establish vascular connections through haustoria produced in response to chemical stimulus of the host and tap the photosynthates in transit from the shoots to the roots (Terry, 1984; Pieterse, 1985). *S hermonthica* may grow for about four to six weeks before emerging from the soil. The flowering of the emerged plant occurs about a month later (Parker, 1965).

2.2 Host Range and Distribution

The most susceptible cereal crops to *S. hermonthica*

include sorghum, millet, finger millet, maize, sugarcane, rice, hungry rice and teft (Lewin, 1932; Parker, 1965; Ogborn, 1979; Obilana, 1983; Pieterse and Pasch, 1983; Parkinson, 1985; Musselman, 1987; Lagoke, 1989, Lagoke, et al. 1991). Grasses like Rottboelia cochinchinenesis and Pennisetum pedicellatum have also been found to be parasitized by S. hermonthica (Terry, 1984; Ogborn, 1985; Lagoke, 1989). The cross fertilization causes genetic variability which facilitates the adaptation of species and sub-species of the plants to wider conditions and host range (Ramaiah et al., 1983).

Widespread occurrence of S. hermonthica has been reported in the semi-arid zones of northern tropical Africa from 5°S up to 20°N of latitude. From East to West, it is distributed across the width of Africa (Ramaiah et al, 1983). Ogborn (1979) has reported that the weed is found in all the savannah ecological zones of Nigeria, where it mainly parasitizes cereals. In the Sahel regions, it was found to attack sorghum and millet, while in the northern Guinea savannah, millet is not affected. The extent of damage caused by this weed will definitely depend on the ecological zones where it is found (Dogget, 1965; Lagoke and Fisher, 1983).

2.3 Effect of Striga hermonthica on Maize Plant

Although, S. hermonthica is a chlorophyllous plant, the rate of carbondioxide fixation is low while that of dark

respiration is quite high (Steward et al., 1991). This makes the weed to depend absolutely on the carbon of the host plant for its growth (Pieterse, 1985). It has been reported that when the host plant is infested, the symptoms visibly observed include leaf scorching or necrosis, stunting and stalk lodging (Terry, 1984; Lagoke, 1989; Kim, 1994). These factors are believed to cause yield reduction. Some of these symptoms can be noticed before the Striga plant even emerges from the ground (Terry, 1984; Robinson and Dowler, 1990).

The most essential materials extracted by the weed from host plant are nutrients, moisture and manufactured products like, carbohydrates especially sucrose (Okonkwo, 1966b; Pieterse, 1985). Okonkow (1986) has also reported the diversion of photosynthates, mineral salts and water to the parasite from the host plant. The high rates of transpiration and the unusal features of stomatal behaviour exhibited by Striga serves as means of maximizing the flux of resources from host to parasite, thus ensuring supplies of water, and inorganic and organic solutes.

Striga is believed to produce some toxic chemicals which disrupt the hormonal balance of the host, indicating greater damage than mere removal of resources from the host as reported by El-Hiweris (1983). The toxins are known to induce stunting of the shoot, reduction in crop vigour, chlorotic blotches and necrosis on foliage and in extreme cases total collapse and death of host plant (Ramaiah et al., 1983; Dogget

1983).

Estimation of host plant damage based on visual assessment have been reported by various workers. Rating scales of 1 to 5 (Kim et al., 1985) and 1 to 9 (Kim, 1990) that take into consideration the symptoms (i.e reduction in plant height, delay silking, reduced ear size or barraness and leaf drying) of Striga hermonthican at about mid-milking have been developed for maize. Estimated grain yield losses in maize due to Striga hermonthica were placed at over 85% (Parkinson, 1985). Effron (1990) reported drastic yield reduction in two different field plots infested with Striga hermonthica in maize from 5,154kg/ha in the uninfested field to between 3,295kg/ha and 1,755kg/ha in the infested fields. He concluded that the maize yield component mostly affected by Striga hermonthica was the kernel weight.

2.4 Effect of Nitrogen on Striga hermonthica and Maize

It has been observed that continuous cropping and poor fertility status of the soil tend to aggravate Striga (Ogborn, 1983). Researchers also have indicated that the application of nitrogen fertilizer has been reported to reduce the severity of Striga attack and increase the yield of the affected host crops (Last, 1960a; Agabawi and Younis, 1965; Parker, 1965; Egly, 1977; Ogborn, 1984; Lagoke et al., 1994). The level of nitrogen required to suppress Striga is usually high in order to control the weed. While 100-120kgN/ha was

suggested by Lagoke and Fisher (1983) and Terry (1984), Mainsfield (1982) recommended that 150kgN/ha would be required to reduce Striga infestation effectively.

Lagoke et al (1991) have indicated that under Striga infestation, high level management practices, including the use of tolerant varieties, fertilizer application and weed control resulted in higher maize cob yield than that obtained in farmers' field. Kim (1994) has also reported increase in maize plant height with increased nitrogen level. Similarly, increased nitrogen level were found to decrease Striga shoot count and dry weight as well as the syndrome scores on maize plant (Kim, 1990).

Although the general agreement is that increased level of nitrogen suppress Striga growth, Bolfrey et al (1994) reported that high level of nitrogen at about 90kgN/ha increased the incidence of Striga plants. It was earlier suggested nitrogen is applative to the host with enhanced tolerance to the parasite in spite of high infestation as reported by Okonkwo (1994). Ogunremi and Olaniyan (1994) reported that using nitrogen at the rate of 90 to 120kgN/ha plus atrazine application, followed by one hoe-weeding, increased maize yield under Striga infestation. Similar results have been obtained in sorghum where 90kgN/ha was found to adequately produce good yield of grain when tolerant/resistance sorghum varieties were cultivated under high infestation of Striga (Adeosun, 1990; Ngawa, 1991).

The source of nutrient has direct effect on the growth and development of the weed. Striga plants have very low nitrate - N content and obviously obtains most of its nitrogen requirements in organic form from the host (Stewart, et al., 1984; McNally and Stewart, 1987). Early work has indicated that high rates of nitrogen applied as Ammonium sulphate ($NH4_2S0_4$ or Urea $(NH_2)_2C0$) delayed emergence, caused stunting of emerged Striga shoot and reduced flowering and dry matter production of Striga (Last, 1960a; Agabawi and Younis, 1965). Last (1961) observed that the effectiveness of nitrogen fertilizers in reducing Striga problem would depend on its time of application, soil fertility level and crop variety. It thus, appears that certain forms of nitrogen which are benefcial to the host may be harmful to the parasite seedling.

2.5 Resistance/Tolerance of Maize Variety to Striga

Breeding for resistance/tolerance to Striga in maize appears to have considerable potential as a means of controlling the parasitic weed, although it is a slow process and requires time. When breeding for resistance to Striga was initiated at IITA, Ibadan in 1982, none of the varieties of maize exhibited complete resistance to Striga hermonthica (Kim, 1991; Lagoke et al., 1994). It is only of recent that some level of resistance have been reported in some of the varieties to Striga asiatica as reported by Ransom et al (1990).

Host plant resistance to Striga is characterized by either less yield reduction, or reduced host plant damage or reduced support for Striga (Ejeta et al., 1991). However, resistance to Striga has been inferred from number of underground (Emechebe et al., 1991) and emerged Striga shoots (Aggarwal, 1991) in cowpea; and number of emerged Striga plants in sorghum (Ramaiah 1983; Obilana, 1984; Ramaiah, 1991; Vaidya et al., 1991) and maize (Ransom et al., 1990).

In breeding crops for resistance to Striga, germplasm screening and progress from selection depend on the ability of the breeder to differentiate genotypes with resistant and susceptible genes. Kim et al (1985) have identified a number of genotypes in maize that could possibly have some level of tolerance to Striga hermonthica. This was done through selection of STR open-pollinated varieties under heavy infestation of Striga hermonthica, which led to discovery of the first tolerant varieties of maize to Striga hermonthica in Africa. Hybrid varieties 8322-13, now 9022-13,8425 - 19,9044 - 15,9021 - 18 and open-pollinated varieties STR syn - W and SUWAN-1-STR have been bred and found to exhibit tolerance to Striga hermonthica (Kim et al., 1985; Lagoke, et al., 1994). More stable open-pollinated synthetic and composite tolerant varieties have been developed by IITA scientists both for the high and low rainfall environments (Lagoke et al., 1997). It

is, however, important to note that the mechanism of such resistance/tolerance of the maize varieties is not clearly understood (Ramaiah, 1983; Roa et al., 1983; Okonkwo, 1994).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

Field trials were concluded during the wet seasons of 1991 and 1992 on the farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru - Zaria (11°11'N, 07°38'E) in the northern Guinea Savannah ecological zone of Nigeria. In 1991, the field was artificially inoculated with Striga seeds per hill. In 1992, additional block of Striga - free site was used for comparison. The planting hills were inoculated with Striga seeds one week before planting of maize was done in order to pre-condition the seeds of the parasitic weed. The soil of the experimental sites was sandy loam. Details of the physico-chemical characteristics of the soils and the rainfall distribution records during the periods of experimentation are presented in Appendices I and II.

3.2 Cultural Practices

3.2.1 Land Preparation, Planting and Spacing

The sites were ploughed, harrowed at intervals and then ridged at 75cm width. The Striga seeds were thoroughly mixed with sandy loam (5gm/250gm ratio) whose particles past through 150 μm sieve mesh to ensure their uniform distribution in the inoculant stock. This Striga/sand stock was placed in the planting holes at 5cm depth at an intra-row spacing of 25cm and covered with soil. Two seeds per hole of maize were then

planted at about 10 days later and thinned to one plants/sand at 3 weeks after sowing (WAS): Planting was done on the 10th and 7th July in 1991 and 1992, respectively.

As a general weed control measure, tank mixture of primagram plus paraquat at the rate of 3l/ha + 4l/ha was applied pre-emergence at one day after planting. At 3 WAS, supplementary hoe-weeding was done to maintain a clean field at the initial growing period of the crop. Subsequent weed growth other than Striga was removed by hand-pulling.

3.2.2 Fertilizer Application

In the two trials, fertilizers at the rate of 45kg each P_2O_5 and K_2O were applied at emergence while nitrogen was equally split applied at emergence and 6 WAS depending on the treatments using NPK (15:15:15) and Urea at the rate of 45kg respectively.

3.2.3 Experimental Design, Treatment and Plot Sizes

The treatments were laid out in a split-plot design and replicated three times in all the blocks (inoculated blocks in 1991 and each of the two blocks of inoculated and uninoculated fields in 1992). Nitrogen levels and maize varieties were the main-plot and sub-plot treatments respectively. In 1991, the nitrogen levels used were 0 (no fertilizer), 90, 120 and 150kgN/ha while in 1992, 0 (no fertilizers), 60, 90, 120 and 150kgN/ha were used. Maize varieties used were TZSR-Y-1/STR,

SUWAN-1-STR, EV8428-SR-STR and TZESR-W in 1991 and 9022-13 SUWAN-1-STR and TZESR-W in 1992.

The gross and net plot sizes were $9m^2$ and $4.5m^2$ respectively.

3.3.1 Characteristics of the Maize Varieties Used

All the varieties used in the study were developed at IITA Ibadan

i. 9022-13: The hybrid maize variety has an intermediate maturity period of 105 to 119 days. The seed size is medium and is white in colour. The seed texture is either dent or flint. It is tolerance to Striga hermonthica and can be grown under West African lowland conditions and well tolerant to pests/diseases.

ii. SUWAN-1-STR: The improved open-pollinated variety matures in 105 to 119 days. The seed is medium sized and yellow. It is reported to exhibit some level of tolerance to Striga hermothica. The seed has a flint texture that is smooth.

iii. EV8428-SR-STR: The open-pollinated maize variety matures very late in 120 days and more. The seeds are yellow in colour, medium sized and have a dent texture. The variety has been reported to exhibit some level of tolerance to Striga hermonthica.

iv. TZSR-Y-1/STR: The variety which matures very late in 120 days and more is tolerant to Striga hermonthica. The seeds are yellow in colour with the texture either dent

or flint, and it is an open-pollinated variety.

v. TZESR-W: The variety which matures very early in less than 105 days is susceptible to Striga hermonthica. The seed are white in colour and have a dent texture. The variety is also resistant to maize streak virus disease.

3.4 Observation and Data Collection

All the observations and data collection were done in the net plot ($4.5m^2$).

3.4.1 Crop Establishment

Crop stand count was done at 10 days after sowing (DAS), and 6 and 12 WAS and at harvest to assess the effect of treatments on the crop establishment.

3.4.2 Plant Height

The height of five tagged plants were measured at 9 WAS in 1991 and 4 and 8 WAS in 1992 and the average obtained. The plants were measured from ground level to the tip of the highest leaf. This was done by selecting five plants in the4 third row by randomization.

3.4.3 Crop Dry Matter Production

The plants were sampled out from each plot using systematic ramdomization at 4 and 8 WAS. The fresh plants were oven-dried at 70°C to a constant weight for dry matter

determination.

3.5 *Striga* Infestation

3.5.1 Number of Plants Infested with *Striga*

The number of maize plants infested with *Striga* were counted in the net plot and recorded at 6, 9 and 12 WAS and at harvest.

3.5.2 *Striga* Shoot Emergence

The number of emerged *Striga* plants in each net plot were also counted and recorded at 6, 9 and 12 WAS and at harvest.

3.6 Crop Performance

3.6.1 Crop Damage Syndrome Score

The *Striga* syndrome score used for assessing tolerance of maize to *Striga* was based on the damage symptoms or the parasitic weed to the host plant as described by Kim (1991). This is based on a scale of 1 to 9 where 1 indicates no damage symptom while 9 suggest high damage. (See Appendix III). The plants were scored at 6, 9 and 12 WAS and at harvest.

3.6.2 Days to 50% Tasseling and Silking

The number of days to 50% tasseling and silking in the host plant were also recorded.

3.6.3 Harvesting

The maize cobs were harvested in the net plot (4.5m^2) when the grains have attained physiological maturity in October in both years. The yield and yield attributes determined include:

i. Total number of cobs
ii. Total weight of cobs
iii. 1,000-grain weigh (g)
iv. Effective cob length (cm)
v. Yield of maize grains (kg/ha)
vi Weight of air dried stover (kg/ha)

3.7 Data Analysis

The data were subjected to analysis of variance for test of significance, and the treatment means compared using Duncan's Multiple Range Test (DMRT) at 5% level of probability as described by Little and Hills (1977). Correlation coefficient between maize grain yield and yield attributes and maize grain yield and Striga parameters were also determined. Regression analyses of maize grain yield and nitrogen levels in both the infested and uninfested fields were also done.

CHAPTER FOUR

4.0 RESULTS

The effect of nitrogen on Striga parameters viz: number of plants infested with Striga and Striga and shoot count as well as the reactions of maize varieties to Striga hermonthica as reflected in crop damage syndrome score, crop establishment, crop height, crop grain yield and various yield components of maize in 1991 and 1992 wet season at Samaru are presented in Tables 1 to 15.

4.1 Striga Shoot Count

Striga shoot count was significantly affected by nitrogen application at 9 WAS in two years and at 12 WAS and at harvest in 1992 (Tables 1 and 2). In 1991 application of 90kgN/ha resulted in significantly higher Striga shoot count than 120 and 150kgN/ha. Similarly in 1992, 90kgN/ha resulted in higher number of Striga shoot than 60 and 150kgN/ha and no fertilizer treatments at 9 and 12 WAS and 120kgN/ha in addition at 12 WAS. Striga shoot count was only significantly lower with the application of 150kgN/ha at harvest in 1992.

Maize varieties did not differ significantly in support for Striga shoot count in the two trials.

Table 1: Effect of Nitrogen on the Incidence and Infestation of Striga and the Growth and Yield of Maize at Samaru 1991 Wet Season

Treatment	Striga Shoot Count/Plot[1] 9 WAS[2]	Number of Infested Plants/ Plot 9WAS	Crop Damage Syndrome Score[4] 9 WAS	Maize Plant Height (cm) 9 WAS	Grain Yield (Kg/ha)
Nitrogen Level (kg N/ha)					
0	102.8ab[3]	12.4ab	5.9a	85.5c	140b
90	130.1a	13.5a	3.4bc	179.6ab	1598a
120	81.4b	11.3ab	3.9b	185.6a	1609a
150	76.8b	10.6b	2.9c	173.8ab	1676a
SE +	12.89	0.88	0.22	3.78	50.85
Variety (V)					
TZESR-Y-1-STR	109.1	11.8	3.9	163.6a	1180bc
SUWAN-1-STR	103.1	12.7	3.9	156.9a	1269b
EV8428-SR/STR	82.6	11.5	4.4	140.5b	1060c
TZESR-W	85.9	11.9	3.9	166.4a	1513a
SE +	12.89	0.88	0.22	3.78	50.85
Interaction NXV	NS[5]	NS	NS	NS	NS

1. Plot Size = $4.5M^2$
2. WAS = Weeks After Sowing
3. Means followed by the same letter(s) within the column are not significant at P=05 (Duncan Multiple Range Test)
4. Crop damage syndrome score is based on scale of 1-9 where 1 = normal plant growth and 9 = completed death of the plant.

Table 2: Effect of Nitrogen on Striga shoot count on Maize Varieties at Samaru 1992 Wet Season

Treatment	Striga Shoot Count ($4.5m^2$) 6 WAS	9 WAS	12 WAS	HARVEST
Nitrogen (kg N/ha (N)				
0	3.00	11.56b[2]	21.67b	20.56abc
60	2.33	11.44b	24.44b	22.00ab
90	2.78	15.78a	30.56a	23.89a
120	2.44	12.89ab	24.44b	19.33abc
150	3.89	10.89b	21.67b	17.78c
SE +	0.57	1.004	1.68	1.17
Variety (V)				
9022-13	2.87	13.20	27.60	20.33
SUWAN-1-STR	2.27	12.33	22.33	20.73
TZESR-W	3.53	12.00	23.73	21.07
SE+	0.38	0.81	1.54	0.704
Interactions (NXV)	NS[3]	NS	NS	NS

1. WAS = Weeks After Sowing
2. Means followed by the same letter(s) within a column are not significant at P 0.05 (Duncan Multiple Range Test)
3. NS = Not significant

4.2 Number of Plants Infested with Striga Incidence

Nitrogen significantly affected the number of plants infested by Striga at 9 WAS in 1991 and at 12 WAS in 1992 (Tables 1 and 3). Application of 90kgN/ha resulted in higher number of plants infested than 150kgN/ha in 1991. Application of 150kgN/ha resulted in higher number of infested plants than no fertilizer and 60kgN/ha in 1992.

Neither the effect of variety nor the interactions of variety and nitrogen on the number of maize plants infested was significant in both years.

4.3 Crop Establishment

Striga infestation had no significant effect on crop establishment (Table 4) while nitrogen application except 120kgN/ha caused significantly higher maize crop stand count at 12 WAS in 1992. The hybrid 9022-13 also had higher stand count at 12 WAS than the open-pollinated varieties SUWAN-1-STR and TZESR-W in 1992.

The interactions of Striga infestation and variety was significant on maize stand count at 12 WAS in 1992. While no difference was was observed among varieties without Striga infestation, stand count of TZESR-W was significantly lower than that of 9022-13 with Striga infestation (Table 5). The stand count of SUWAN-1-STR and TZESR-W were depressed by infestation, while 9022-13 was uneffected.

Table 3: Effect of Nitrogen on the Number of Maize Plants Infested by Striga at Samaru 1992 Wet Season

Treatment	No of Maize Plant Infested Per Plot[4] 6 WAS[1]	9 WAS	12 WAS	HARVEST
Nitrogen (kg N/ha (N)				
0	1.44	3.67	4.33bc[2]	3.11
60	1.11	3.56	3.89c	4.89
90	1.44	4.11	5.33a	5.89
120	1.33	3.11	5.00ab	5.89
150	1.67	4.22	5.44a	5.44
SE +	0.155	0.303	0.221	0.325
Variety (V)				
9022-13	1.53	3.53	5.00	5.07
SUWAN-1-STR	1.13	3.60	4.53	5.13
TZESR-W	1.53	4.07	4.87	4.93
SE+	0.133	0.214	0.414	0.325
Interactions				
N x V	NS[3]	NS	NS	NS

1. WAS = Weeks After Sowing
2. Means followed by the same letter(s) within a column are not significant at P 0.05 (Duncan Multiple Range Test)
3. NS = Not significant.
4. Plot Size = $4.5m^2$

Table 4: Effect of Nitrogen and Striga Infestation on Stand Count of Maize Varieties at Samaru 1992 Wet Season

Treatment	Stand count at 10 DAS[1]	6 WAS	12 WAS	HARVEST
Infestation (In)				
Infested	12.29	11.78	10.78	9.09
Uninfested	13.03	12.89	12.44	12.20
SE +	0.35	0.34	0.47	0.63
Nitrogen Level (N) kgN/ha)				
0	12.56	12.22	10.67c	9.06
60	12.83	12.44	11.83ab	10.94
90	12.67	12.50	12.00ab	11.22
120	12.44	11.83	11.28bc	10.56
150	12.78	12.67	12.28a	11.44
SE +	0.2	0.27	0.30	0.61
VARIETY (V)				
9022-13	12.83	12.43	11.47b	10.70
SUWAN-1-STR	12.30	11.90	11.2b	10.43
TZESR-W	12.46	12.00	12.00a	11.00
SE +	0.25	0.26	0.24	0.25
Interactions				
N X V	NS[4]	NS	NS	NS
N X In	NS	NS	NS	NS
V X X In	NS	NS	*	NS
N X V X In	NS	NS	NS	NS

1. DAS = Days after sowing
2. WAS = Weeks after sowing
3. Means followed by the same letter(s) within column are not significant P = 0.05 (Duncan Multiple Range Test)
4. NS = Not Significant
5. Plot Size = 4.5m2

* = Significant at P = 0.05 (Duncan Multiple Range Test).

Table 5: Interactions of Variety and Infestation on Crop Stand Count at 12 WAS[1] at Samaru, 1992 Wet Season

	Stand Count/Plot[2]		
Maize Varieties	9022-13	SUWAN-1-STR	TZESR-W
Infestation			
Infested	11.93ab[3]	10.60bc	9.80c
Uninfested	12.40a	12.33a	12.60a
SE+		0.54	

1. WAS = Weeks after sowing
2. Plot size = 4.5m^2
3. Means followed by the same letter(s) across and within columns are not significant at P = 0.05 (Duncan Multiple Range Test).

4.4 Crop Damage Syndrome Score

Nitrogen levels influenced Striga damage syndrome score in maize at 9 WAS in 1991 and throughout crop life cycle in 1992 (Tables 1 and 6). In the two trials, nitrogen application at all levels significantly reduced syndrome score on maize compared with no fertilizer treatment. Application of 150kgN/ha also caused lower scores compared with 120kgN/ha in 1991 and 90kgN/ha at 6 WAS while 120 and 150kgN/ha and 90kgN/ha in addition at 9 WAS caused lower scores than 60kgN/ha in 1992.

Maize varieties differed significantly in syndrome scores only in 1992. In all cases, 9022-13 and SUWAN-1-STR had lower syndrome scores than TZESR-W with 9022-13 exhibiting lower score than SUWAN-1-STR at 9 and 12 WAS.

The interactions of nitrogen and variety on syndrome score on maize was significant only at harvest in 1992 (Table 7). Varieties 9022-13, SUWAN-1-STR and TZESR-W respectively required at least 60, 90 and 150kgN/ha to have syndrome score comparable to the least with 9022-13 given 150kgN/ha.

4.5 Plant Height of Maize

Striga infestation resulted in shorter maize plants at 8 WAS compared with no infestation in 1992 (Table 8). Nitrogen application significantly affected maize crop heights at 9 WAS in 1991 and 4 and 8 WAS in 1992 (Tables 1 and 8). In all cases, nitrogen application resulted in taller maize plants

Table 6: Effect of Nitrogen on Crop Damage Syndrome Score[1] on Maize Varieties at Samaru, 1992 Wet Season

	Crop Damage Syndrome Score			
Treatment	6 WAS[2]	9 WAS	12 WAS	HARVEST
Nitrogen Level (kg N/ha) (N)				
0	3.0a[3]	4.54a	7.41a	8.63a
60	1.83b	2.89b	5.93b	6.97b
90	1.68bc	2.34c	5.97b	6.90b
120	1.48c	2.09c	5.41b	6.63b
150	1.37c	2.40c	5.21b	6.16b
SE+	0.111	0.109	0.289	0.407
Variety (V)				
9022-13	1.77b	2.48c	4.86c	6.43b
SUWAN-1-STR	1.70b	2.83b	6.22b	6.97b
TZESR-W	2.15a	3.25a	6.88a	7.77a
SE+	0.07	0.095	0.222	0.190
Interaction				
N x V	NS[4]	NS	NS	*

1. Crop damage syndrome score based on scale 1 - 9 where 1 = normal plant growth and 9 = complete death plant

2. WAS = Weeks after sowing

3. Means followed by the same letter(s) within a column are not significant at P = 0.05 (Duncan Multiple Range Test).

4. NS = Not significant

* Significant at P = 0.05 (Duncan Multiple Range Test)

Table 7: Interactions of Nitrogen and Variety on Crop Damage Syndrome Score[1] at Harvest Samaru, 1991 Wet Season

	Nitrogen Level				
Maize Varieties	0	60	90	120	150
9022-13	8.60ab[2]	5.57e	5.73de	7.0bcde	5.27e
SUWAN-1-STR	8.47ab	7.77abc	6.90bcde	5.4e	6.30cde
TZESR-W	8.83a	7.57abc	8.07abc	7.abcd	6.90bcde
SE+			0.534		

1. Crop damage syndrome score is based on a scale of 1 - 9 where - 1 = normal plant growth and 9 = complete plant death.

2. Means followed by the same letter(s) across and within columns are not significant at P = 0.05 (Duncan Multiple Range Test).

Table 8: Effect of Nitrogen and Striga Infestation on Plant Height of Maize Varieties at Samaru 1992 Wet Season

Treatment	Maize Plant Height (cm) 4 WAS[1]	8 WAS
Infestation (In)		
Infested	26.4	135.5b
Uinfested	28.1	163.6a
SE+	1.8	1.22
Nitrogen Level (N) kg N/ha)		
0	21.1c[2]	63.59d
60	26.5b	156.96c
90	28.1b	169.99b
120	27.3b	173.93b
150	32.7a	183.21a
SE+	0.94	1.97
Variety (V)		
9022-13	27.79	151.30a
SUWAN-1-STR	27.29	152.33a
TZESR-W	26.63	144.21b
SE +	0.75	1.33
Interactions		
NXV	NS[3]	NS
N X In	NS	NS
V X In	NS	NS
N X V X In	NS	NS

1. WAS = Weeks after sowing
2. Means followed by the same letter(s) within a column are not sigificant at P = 0.05 (Duncan Multiple Range Test)
3. NS = Not significant

than no fertilizer treatment. In 1992, 150kgN/ha resulted in taller plants than the lower rates, while 60kgN/ha also caused shorter plants compared with 90 and 120kgN/ha.

In 1991, EV8428-SR/STR had shorter plants than the other open-pollinated varieties viz: TZSR-Y-1/STR, SUWAN-1-STR and TZESR-W. In 1992, however, TZESR-W had shorter plants than the hybrid 9022-13 and the open-pollinated variety SUWAN-1-STR.

The interactions of various factors on plant height of maize was not significant in the study.

4.6 Crop Dry Matter Production

Striga infestation significantly reduced crop dry matter production at 4 and 8 WAS in 1992 (Table 9). Nitrogen application also resulted in higher dry matter production compared with no fertilizer at 4 and 8 WAS in 1992. At 4 WAS all the nitrogen rates were similar in dry matter production, while at 8 WAS, crop dry matter production increased significantly with nitrogen level. Maize varieties did not differ significantly in crop dry matter production in the trial.

The interaction of nitrogen and variety, nitrogen and infestation as well as nitrogen, infestation and variety were significant at 8 WAS on dry matter production (Tables 10 and 11). At 90kgN/ha, TZESR-W only produced higher crop dry matter than the other two varieties, while no difference was

Table 9: Effect of Nitrogen and Striga Infestation on Crop Dry Matter Production of Maize Varieties at Samaru 1992 Wet Season

	Maize Crop Dry Matter (kg/ha)	
Treatment	4 WAS[1]	8 WAS
Infestation (In)		
Infeste	13.06b[2]	62.5b
Uninfested	20.59a	135.7a
SE+	0.58	5.45
Nitrogen Level (N) kg N/ha)		
0	8.25b	50.4e
60	16.32a	76.4d
90	18.51a	99.1c
120	20.15a	122.8b
150	20.89a	146.7a
SE+	2.14	4.46
VARIETY (V)		
9022-13	17.04	96.4
SUWAN-1-STR	18.22	99.7
TZESR-W	15.22	101.2
SE+	0.94	2.04
Interactions		
N X V	NS[3]	*
N X In	NS	*
V X In	NS	NS
N X V X In	NS	*

1. WAS = Weeks after sowing
2. Means followed by the same letter(s) are not significant at P = 0.05 (Duncan Multiple Range Test)
3. NS = Not significant
4. * - Significant at P = 0.05 (Duncan Multiple Range Test)

Table 10: Interactions of Nitrogen and Variety, Nitrogen and Infestation on Crop Dry Matter Production (g/Plant) at 8 WAS[1] at Samaru, 1992 Wet Season

	Nitrogen Levels (N) kg N/ha				
Maize Varieties	0	60	90	120	150
9022-13	50.3e[2]	75.9cd	89.7cd	120.8b	145.1a
SUWAN-1-STR	49.9e	80.8cd	92.7c	126.1b	148.8a
TZESR-W	50.9e	72.6d	115.0b	121.6b	146.0a
SE +			5.81		
Infestation					
Infested	26.9f	62.6e	69.0de	66.9de	87.1de
Uninfested	73.8de	90.3d	129.2c	178.7a	206.3a
SE +			7.84		

1. WAS = Weeks after sowing
2. Means folloed by the same letter(s) across and within columns are not significant at P = 0.05 (Duncan Multiple Range Test)

Table 11: Interactions of Nitrogen Variety and Infestation on Crop Dry Matter Production (g/Plant) at 8 WAS[1] at Samaru, 1992 Wet Season

Treatment		Maize Varieties		
Infestation	Nitrogen Level kg N/ha)	9022-13	SUWAN-1-STR	TZESR-W
Infested	0	26.2g[2]	22.0g	32.7fg
	60	66.0e	60.1ef	61.7e
	90	68.7e	68.3e	70.0e
	120	72.1e	72.8e	55.9e
	150	84.2de	94.4cd	48.5de
Uninfested	0	74.4	77.9de	69.1e
	60	85.9de	101.4cd	83.5de
	90	110.8cd	117.0c	159.9b
	120	169.4b	179.4ab	187.4ab
	150	206.0a	205.2a	207.6a
SE+		9.44		

1. WAS = Weeks after sowing

2. Means followed by the same letter(s) across and within columns are not significant at P = 0.05 (Duncan Multiple Range Test.

The interaction of nitrogen and variety, nitrogen and infestation as well as nitrogen, infestation and variety were significant at 8 WAS on dry matter production (Tables 10 and 11). At 90kgN/ha, TZESR-W only produced higher crop dry matter than the other two varieties, while no difference was observed at other nitrogen levels. With Striga infestation nitrogen application resulted in similar increase in crop dry matter production compared with no nitrogen. However without infestation 0 and 60kgN/ha were similar and lower than higher rates while 90 resulted in lower crop dry matter production and the higher rates that were similar. The crop dry matter comparable to the maximum obtained (9022-13) on Striga free plot given 150kgN/ha was only obtained with SUWAN-1-STR and TZESR-W given 120kgN/ha without Stria infestation.

4.7 Number of Days to 50% Tasseling and Silking

Striga infestation had no significant effect on the number of days to 50% tasseling and silking (Table 12). Nitrogen application significantly reduced the number the number of days to 50% tasseling and silking compared with no fertilizer treatment. Application of 150kgN/ha significantly reduced the number of days to 50% tasseling and silking compared with lower nitrogen rates. Maize varieties differed significantly in number of days to 50% tasseling and silking. TZESR-W tasseled and silked earlier than 9022-13 and SUWAN-1-

Table 12: Effect of Nitrogen and Striga Infestation on Number of Days to 50% Tasseling and Silking by Maize Varieties at Samaru 1992 Wet Season

Treatment	Days to 50% Tasseling	Days to 50% Silking
Infestation		
Infested	58.07	60.73
Uninfested	57.80	60.44
SE+	0.33	0.22
Nitrogen (N) kg/ha		
0	60.6a[1]	64.11a
60	57.72b	60.00b
90	57.33b	60.00b
120	57.67b	59.83b
150	56.33c	59.00c
SE+	0.20	0.26
Variety (V)		
9022-13	66.67a	62.17a
SUWAN-1-STR	60.63b	62.47a
TZESR-W	52.30b	57.13b
SE+	0.19	0.28
Interactions		
NXV	NS[2]	*
NXIn	NS	*
VXVXIn	NS	*
VXIn	NS	NS

1. Means followed by the same letter(s) are not significant at P = 0.05 (Duncan Multiple Range Test).
2. NS = Not significant
   * = Significant at P = 0.05 (Duncan Multiple Range Test).

Table 13: Interactions of Nitrogen and Variety, Nitrogen and Infestation on the Number of Days to 50% Silking at Samaru, 1992 Wet Season

	Nitrogen Levels (N) kg N/ha				
Maize Varieties	0	60	90	120	150
9022-13	66.50a[1]	61.67bc	61.83bc	61.00bcd	59.83d
SUWAN-1-STR	67.83a	62.50b	61.67bc	60.50cd	59.83d
TZESR-W	58.00e	55.83f	56.50ef	58.00e	57.33ef
SE +			0.57		
Infestation					
Infested	65.44a	59.11de	60.44cd	60.00cd	58.67e
Uninfested	62.78b	60.89c	59.56de	59.67cde	59.33de
SE +			0.39		

1. Means followed by the same letter(s) across and within the columns are not signifiacnt at P = 0.05 (Duncan Multiple Range Test).

less number of days to 50% silking than no fertilizer application. However, in 9022-13 and SUWAN-1-STR, nitrogen application at all rates significantly reduced number of days to silking. In the two varieties, 150kgN/ha caused less days to silking than 60 and 90kgN/ha, while in SUWAN-1-STR, 120kgN/ha resulted in less days than 60kgN/ha (Table 13). Without fertilizer, Striga infestation increased the number of days to silking, while with the application of 60kgN/ha, more days to silking occured on Striga-free plots. Striga infestation had no effect on the number of days to silking at higher rates of nitrogen. With Striga infestation nitrogen application at 60kgN/ha similarly reduced number of days to silking compared with no fertilizer in 9022-13 and SUWAN-1-STR, while no difference was observed in TZESR-W (Table 14). Without Striga infestation 120kgN/ha and 90kgN/ha respectively reduced number of days to silking in 9022-13 and SUWAN-1-STR.

4.8 Yield and Yield Attributes

The effect of nitrogen and infestation of Striga hermonthica on the yield and yield attributes of maize varieties in 1991 and 1992 are contained in Tables 1 and 15, respectively.

4.8.1 Cob's Number and Weight

Striga infestation significantly reduced the number and weight of cobs per plot in 1992 (Table 15). Nitrogen

Table 14: Interactions of Nitrogen, Variety, and Infestation on the Number of Days to 50% Silking At Samaru, 1992 Wet Season

Treatment		Maize Varieties		
Nitrogen Levels	kg N/ha	9022-13	SUWAN-1-STR	TZESR-W
Infestation	0	68.33a1	70.67a	57.33hijk
	60	61.00de	61.33de	55.00k
Infested	90	61.33de	63.00bcd	57.00ijk
	120	60.33defg	60.55defg	59.33efghi
	150	59.67efgh	59.33efgh1	57.00ijk
	0	64.67bc	65.00b	58.67fghij
	60	62.33cd	63.67bc	56.67ijk
Uninfested	90	62.33cd	60.33defg	56.00jk
	120	61.67de	60.67def	56.67ijk
	150	60.00efg	60.33defg	57.67ghijk
SE + =		0.82		

1. Means followed by the same letter(s) across and within the columns are not significant at P = 0.05 (Duncan Multiple Range Test

application increased cob weight significantly compared with no fertilizer. Application of 120 and 150kgN/ha also resulted in higher cob weight than 60 and 90kgN/ha in 1992. The varieties did not differ significantly in number and weight of maize cobs.

4.8.2 Cob Length

All the rates of nitrogen applied similarly significantly increased cob length compared with no fertilizer treatment. Maize variety SUWAN-1-STR produced longer cobs than 9022-13.

4.8.3 Shelling Percentage

Neither Striga infestation, nitrogen application nor variety had significant effect on the shelling percentage of maize cobs. However, the trend shows that lower values were obtained with Striga infestation and higher values with 90kgN/ha and above compared with no fertilizer.

4.8.4 1000-Grain Weight

Striga infestation significantly decreased 1000-grain weight of maize in 1992. Nitrogen application also significantly increased 1000-grain weight compared with no fertilizer treatment. Application of 120 and 150kgN/ha resulted in higher 1000-grain weight of maize than 60kgN/ha. Maize hybrid variety 9022-13 had higher 1000-grain weight than TZESR-W.

4.8.5 Grain Yield

Striga infestation caused 33% loss in maize grain yield in 1992. Nitrogen application significantly increased maize grain yield by 46% to 65.7% in 1991 and 32.4% to 55% in 1992 compared with no fertilizer. In 1991, no differences in grain yield was observed among the nitrogen levels of 90, 120 and 150kgN/ha. In 1992, only 90kgN/ha and above caused higher maize grain yields than no fertilizer treatment. 120 and 150kgN/ha resulted in significantly higher grain yield than 60 and 90kgN/ha.

Maize varieties differed significantly in grain yield in both trials. In 1991, TZESR-W resulted in the highest yield while EV8428-SR/STR gave the least yield. In 1992, the maize hybrid 9022-13 produced significantly higher grain yield than TZESR-W. The yield of the hybrid was also comparable to that of SUWAN-1-STR, whose yield was also comparable to that of TZESR-W.

4.8.6 Stover Weight

All the nitrogen levels significantly and similarly increased the stover weight of maize compared with no fertilizer treatment. Both 9022-13 and SUWAN-1-STR produced higher stover yields than TZESR-W in 1992.

Table 15: Effect of Nitrogen and Striga Infestation on Yield and Yield Attributes to Maize Varieties at Samaru, 1992 Wet Season

Treatment	Cob yield (kg/ha)	Number cobs/plot[3]	Cob length (cm)	Shelling percentage	Stover weight (kg/plot	1000. Grain weight (g)	Grain yield (kg/ha
Infestation							
Infested	1711b[1]	12b	10.9	64.6	1.64	103.5b	1217b
Uninfested	2889a	15a	12.8	73.5	2.34	141.4a	1822a
SE+	0.12	0.37	0.70	3.32	0.38	5.37	146.96
Nitrogen (N) kg N/ha							
0	933a	8b	8.3b	61.3	0.66b	89.9c	689c
60	1756b	13a	12.3a	62.3	2.06a	118.5b	1019bc
90	2022b	14a	12.5a	72.6	2.26a	128.9ab	1488b
120	2911a	17a	13.1a	74.6	2.54a	132.5a	2265a
150	2867a	15a	12.9a	74.5	2.77a	142.4a	2136a
SE+	0.11	1.47	0.79	5.69	0.17	6.42	196.5
Variety (V)							
9022-13	2267	15	11.1b	70.5	2.54a	127.7a	1704a
SUWAN-1-STR	2089	13	12.5a	69.9	2.36a	122.2ab	1542a
TZESR-W	1933	12	11.9a	66.7	1.39b	117.5b	1312b
SE+	0.08	0.09	0.33	1.94	0.11	2.23	128.6
Interactions							
NXV	NS[2]	NS	NS	NS	NS	NS	NS
NXIn	NS	NS	NS	NS	NS	NS	NS
VXIn	NS	NS	NS	NS	NS	NS	NS
NXVXIn	NS	NS	NS	NS	NS	NS	NS

1. Means followed by the same letter(s) within a column are not significnat at P = 0.05 (Duncan Multiple Range Test)
2. NS = Not significant
3. Plot size = 4.5m^2

4.9 Correlation

The correlation between yield and various Striga and crop parameters are shown in Tables 16 to 18. Only crop damage syndrome scoe at 9 WAS in 1991 and at 6, 9 and 12 WAS and at harvest in 1992 was significantly negatively correlated with maize grain yield as shown in Tables 16 and 17 (r = -0.7085, -0.5406, -0.6219, -0.4968 and -0.5059 respectively). The maize plant height was, however, highly positively correlated with the maize grain yield at 9 WAS in 1991 and at 4 WAS and 8 WAS in 1992 (Tables 16 and 18 r = 0.8168, 0.5890 respectively). There was, however, a strong relationship between number of maize plants infested with Striga and Striga shoot count at 9 WAS in 1991 and at 9 and 12 WAS in 1992 as shown in Tables 16 and 17 (r = 0.7588, 0.6277 and 0.7187 respectively).

In contrast, number of plants infested with Striga at 6 and 9 WAS was found to be significantly and positively correlated with maize grain yield in 1992 trials as shown in Table 17 (r = 0.3520 and 0.4197 respectively).

4.10 Regression

The fitted curve for the infested and uninfested field was best described by the Quadratic and Linear equations respectively as indicated below

$$Y_1 = 178.3 + 16.2x - 0.03x^2 \text{ (infested)}$$

$$Y_2 = 891.1 + 11.1x \text{ (uninfested)}.$$

These curves are presented on Figures I and II respectively. The predicted maximum yield under 150kgN/ha, with and without Striga infestation as observed in the regression curves were 1.85 t/ha and 2.55 t/ha respectively. Striga infestation caused 80, 50 35.5, 31.6, 25 and 27.5 percent loss in maize grain yield without nitrogen 0, 30, 60, 90, 120 and 150kgN/ha respectively compared to Striga free plot yields.

Table 16: Correlation between various parameters and yield of Maize at Samaru, 1991 Wet Season

	1	2	3	4	5
1.	1.0000	-	-	-	-
2.	-0.7085*	1.0000	-	-	-
3.	-0.0560	0.1675	1.0000	-	-
4.	-0.0501	0.1492	0.7588**	1.0000	-
5.	-0.8168**	-0.7916**	-0.0401	-0.0295	1.0000

1. Grain yield of maize (kg/ha)
2. Striga crop damage syndrome score
3. Number of maize plants infested with Striga
4. Striga shoot count
5. Maize plant height

** Significant at P = 0.05 (Duncan Multiple Range Test) (r=0.288)

* Significant at P = 0.01 (Duncan Multiple Range Test) (r=0.372).

Table 17: Correlation between grain yield of maize and Striga parameters at Samaru 1992 Wet Season

	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	1.0000												
2.	0.0709	1.0000											
3.	0.0977	0.6593**	1.000										
4.	0.3520*	0.2988*	0.3061*	1.0000									
5.	0.4197**	0.2821	0.1654	0.4311**	1.0000								
6.	0.0022	0.7187**	0.6277**	0.2632	0.1738	1.0000							
7.	0.1276	0.1883	0.1285	0.1415	0.1886	-0.0053	1.0000						
8.	0.0333	0.1994	0.1070	0.1259	0.1996	0.2410	0.5204**	1.0000					
9.	-0.1758	0.0705	0.1371	-0.0786	0.0597	0.0566	0.5010**	0.0372**	1.0000				
10	-0.5406**	0.6339	-0.0193	-0.1845	-0.3742**	0.0672	0.1253	-0.1790	0.0962	1.0000			
11	-0.6219**	0.0342	0.0119	-0.1337	-0.3613*	-0.0187	-0.2581	-0.2970*	0.0508	0.7612**	1.0000		
12	-0.4968**	0.0560	0.1096	-0.1510	-0.2200	0.1002	0.2276	-0.0920	0.1972	0.5934**	0.7199**	1.0000	
13	-0.5059**	0.0793	0.1257	-0.1305	-0.1706	0.1261	-0.1171	0.0120	0.2288	0.5667**	0.7099**	0.8653**	1.0000

1. Maize grain yield (kg/ha)
6. Striga shoot count at 6 WAS
6. Striga shoot count at 6 WAS
6. Striga shoot count at 6 WAS
2. Number of plants infested with Striga at 6 WAS
3. Number of plants infested with Striga at 9 WAS
4. Number of plants infested with Striga at 12 WAS
5. Number of plants infested with Striga at 12 WAS
6. Striga shoot count at 6 WAS
7. Striga shoot count at 6 WAS
8. Striga shoot count at 9 WAS
9. Striga shoot count at 12 WAS
10. Striga sndrome score at 6 WAS
11. Striga syndrome score at 9 WAS
12. Striga syndrome score at 12 WAS
13. Striga syndrome score at harvest

* = Significant at 5% level of probability (r=0.288)

** = Significant at 5% level of probability (r=0.372)

Table 18: Correlation Between Grain Yield of Maize and various Parameters under Striga Infestation in Evaluating Maize Varieties for Striga Tolerance/Resistance at Samaru, 1992 Wet Season

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.	1.0000																
2.	0.1280	1.0000															
3.	0.1700	0.861	1.000														
4.	0.3290**	0.861**	0.788**	1.0000													
5.	0.3740**	0.376**	0.515**	0.781**	1.0000												
6.	0.4300**	0.083	0.193	0.347**	0.396**	1.0000											
7.	0.5890**	0.137	0.167	0.414**	0.495**	0.648**	1.0000										
8.	0.3810**	0.197	0.273**	0.369**	0.393**	0.440**	0.613**	1.0000									
9.	0.5560**	0.203	0.252*	0.420	0.520**	0.480**	0.677**	0.597**	1.0000								
10	-0.051	0.148	0.161	-0.025	-0.108	-0.186	-0.238	-0.070	-0.222*	1.0000							
11	-0.163	0.054	0.050	-0.123	-0.0174	-0.316**	-0.411**	-0.143*	-0.294**	0.820**	1.0000						
12	-0.936**	0.112	0.175	0.347**	0.411**	0.390**	0.609**	0.334**	0.520**	0.119	0.215*	1.0000					
13	-0.617**	0.135	0.253*	0.573**	0.739**	0.557**	0.708**	0.487**	0.686**	-0.12	-0.257*	0.614**	1.0000				
14	0.710**	0.171	0.218*	0.385**	0.404**	0.280**	0.471	0.240	0.439**	0.056	-0.167	0.723**	0.412**	1.0000			
15	0.497**	0.085	0.161	0.385**	0.502**	0.402**	0.389**	0.267**	0.325**	-0.031	-0.087	0.355**	0.464**	0.381**	1.0000		
16	0.576**	0.108	0.175	0.418**	0.595**	0.440**	0.650**	0.437**	0.464**	-0.252*	-0.342**	0.604**	0.783**	0.546**	0.591**	1.0000	
17	0.540**	0.305**	0.359**	0.486**	0.474**	0.575**	0.614**	0.521**	0.422**	0.156	-0.045	0.516**	0.545**	0.431**	0.388**	0.462**	1.0000

1. Maize grain yield (kg/ha)
2. Stand count at 10 DAS
3. Stand count at 6 DAS
4. Stand count at 12 DAS
5. Stand count at harvest
6. Crop height at 4 WAS
7. Crop height at 8 WAS
8. Crop dry matter production at 4 WAS
9. Crop dry matter production at 8 WAS
10. Days to 50% tasseling
11. Days to 50% silking
12. Cob's weight (kg/ha)
13. 1000 seed weight (gm)
14. Cob's number
15. Shelling percentage
16. Cob's length (cm)
17. Stover weight (kg/ha)

* = Significant at P = 0.05 (r=0.205)
** = Significant at P = 0.01 (r=0.267

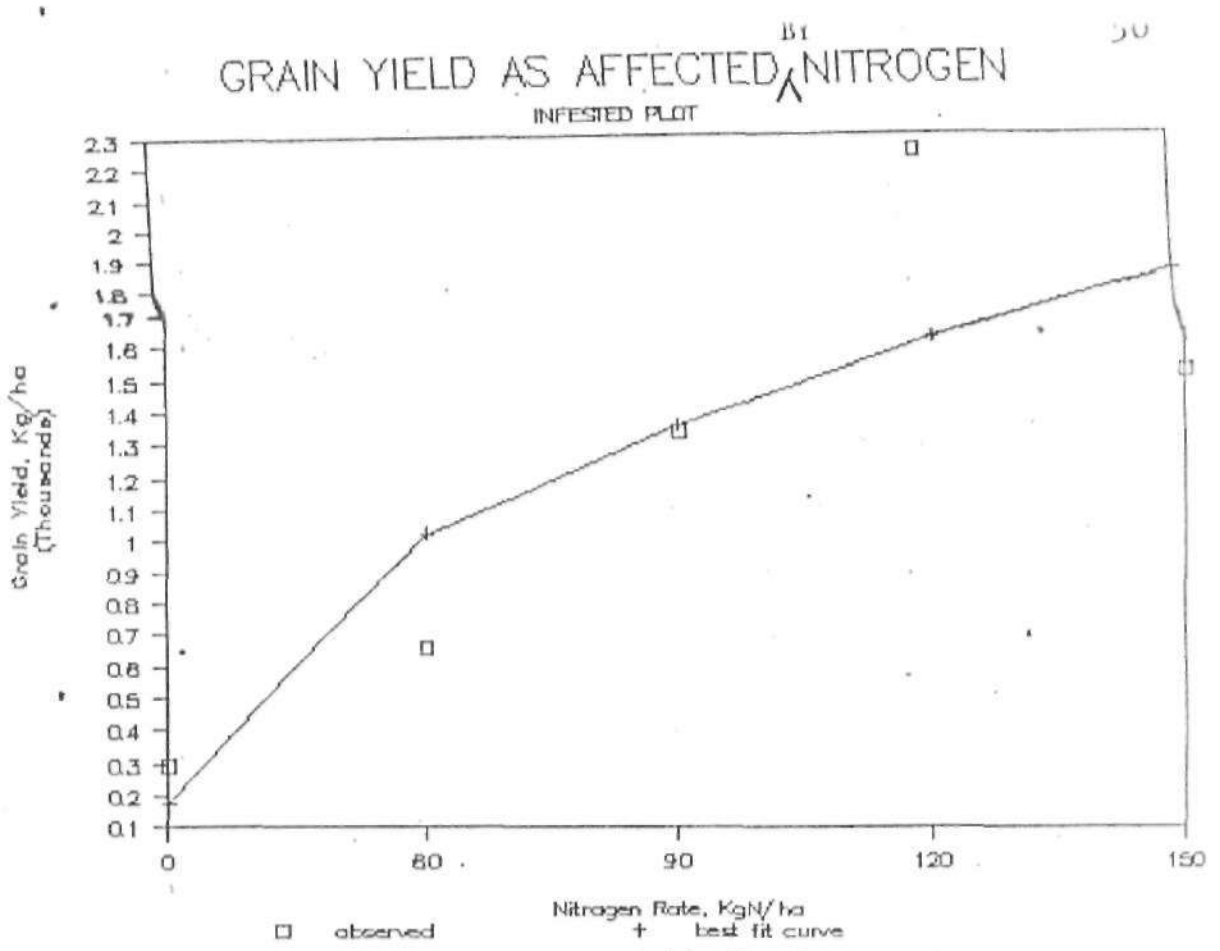


Fig. I. Fitted values of grain yield of maize as affected by nitrogen levels under striga infestation in 1992.

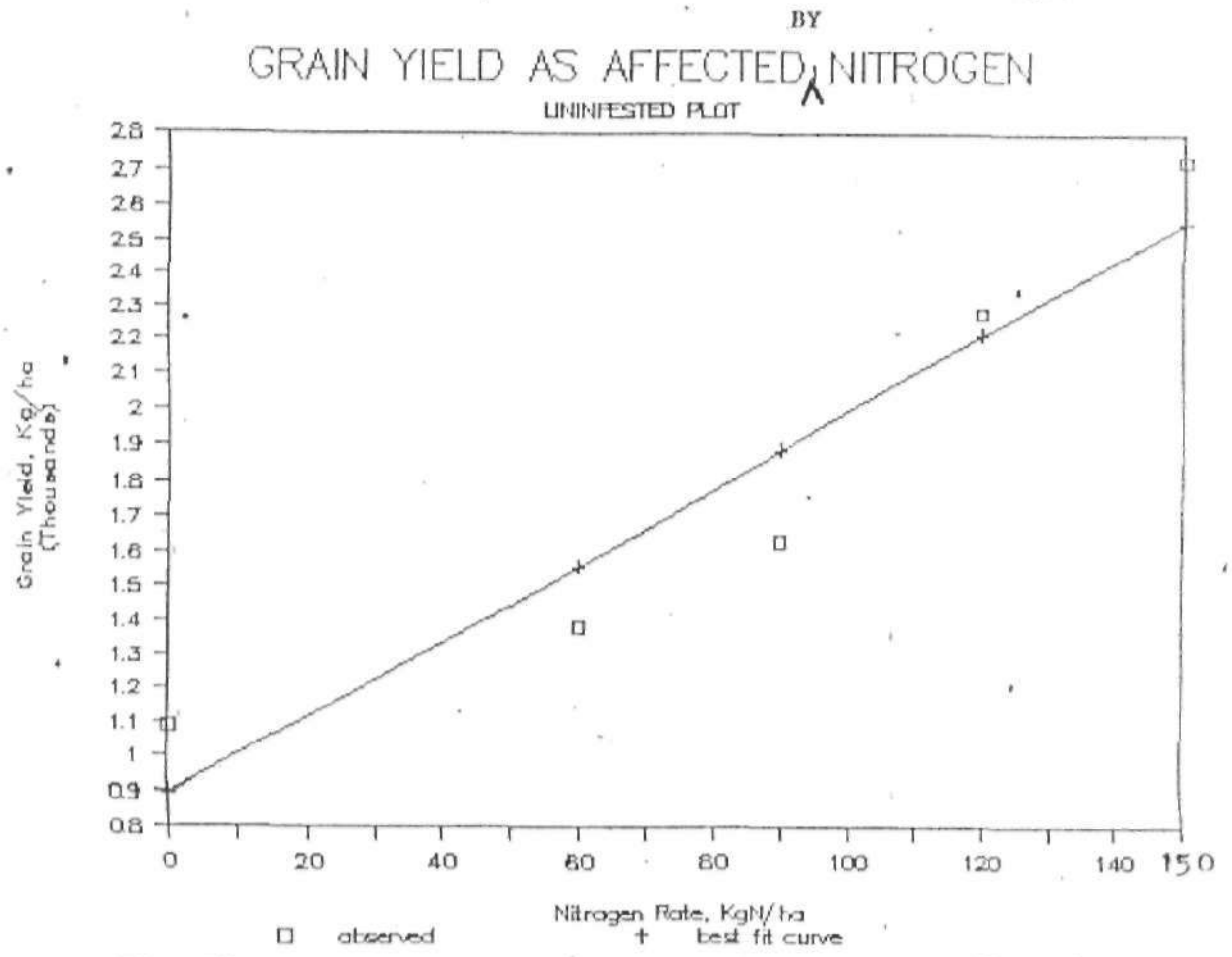


Fig. II. Fitted values of grain yield of maize as affected by nitrogen levels without striga infestation in 1992.

CHAPTER FIVE

5.0 DISCUSSION

The grain yields of 1.26 t/ha and 1.52 t/ha obtained in the trials conducted in 1991 and 1992 respectively are lower than 3.1 t/ha to 3.8 t/ha earlier reported in Nigeria for the same crop (Anon, 1981; Anon, 1988; Effron, 1990). This might be due to high Striga infestation at the sites of the trials (Effron, 1990), coupled with late planting of the crop which have been reported to cause serious decline in yield of the crop (Ologunde, 1981). The higher mean yield obtained in 1992 compared with 1991 could be attributed to the fact that the mean yield obtained in 1992 was for both Striga-free and Striga-infested fields, while the yield of 1991 was for Striga-infested field only.

5.1 Effect of Nitrogen on Striga hermonthica and Maize Varieties

Applied nitrogen has long been reported to reduce Striga infestation (Pieterse and Posch, 1983). The required rate of nitrogen for the management of this noxious weeds has never been consistent. This could be attributed to various factors viz: nitrogen level of the soil, variety and type of crop as suggested by Last (1961). The result obtained in this study shows that up to 90kgN/ha increased Striga infestation while higher rates depressed the parasite. The increase in Striga shoot count with nitrogen level up to 90kgN/ha in this study

supports an earlier observation by Bolfrey et al. (1994) who also found that increase in nitrogen rates increased Striga shoot emergence. Similarly, Carson (1985) had earlier reported that more Striga population could be obtained at higher NPK levels. The failure of 90kgN/ha to depress Striga shoot could be attributed to the fact that the amount of nitrogen in the soil might not be quite adequate to suppress the organism.

In the two years study, 150kgN/ha consistently reduce Striga shoot emergence and number of crop plants infested compared with 90kgN/ha which was found to produce higher shoot count of Striga and number of plants infested compared with no fertilizer treatment in 1991 as well as 60kgN/ha in 1992. These results agree with that of Mainsfield (1982) which indicated that 150kgN/ha was required to effectively reduce Striga infestation in maize. In this study Striga infestation was also reduced by 120kgN/ha compared with 90kgN/ha as earlier reported by Lagoke and Fisher (1983) and Terry (1984).

The mechanism by which high level of nitrogen reduced Striga infestation has been attributed to low germination in stimulant production by sorghum under higher nitrogen (Parker, 1984). This was confirmed by Gworgwor (1993) who reported that under high nitrogen, low level of stimulant was produced for the three weeks only of crop growth which was a clear indication of the inhibitory effect of high nitrogen on stimulant production. Earlier researchers (Parker, 1984;

Sherif and Parker, 1986; Raju et al., 1990) have also shown that high nitrogen has the effect of reducing stimulant production from sorghum with consequent delay in Striga emergence and reduced infestation of Striga compared with low level of nitrogen application. This mechanism might be due to physiological changes in the growth rate of the tissue cells in the active stimulant producing area of sorghum roots. The meristematic parts of the crop utilizes the stimulant produced for cell elongation as reported by Sunderland (1960). Utilization of chemo-stimulant was found to be greatest during the growth in the length of the root cells and consumption falls as the cells mature (Sunderland, 1960). It is therefore, possible that high nitrogen rates promote rapid and vigorous growth and elongation, which demands a lot of stimulant to perform such functions, and hence lead to release of small quantity of stimulant into the soil medium. Reduction of radicle elongation is few germinated Striga seeds could be caused by the application of high nitrogen rates (Pesch and Pieterse, 1982).

In the two years, all the nitrogen levels reduced Striga syndrome score in maize compared with no fertilizer treatment. This obvious amelioration of damage was also reflected in the maize grain yield at all the nitrogen levels resulting in similar but higher grain yields than no fertilizer treatment. The reduction in syndrome score on the maize crop in spite of the increased Striga shoot cound up to 90kgN/ha observed,

could be attributed to the pallative effect of the nutrient suggested earlier by Emechebe et al. (1991), Lagoke et al. (1991), and Magani (1994).

The results obtained in this trial conforms with that of Ogborn (1972) who observed that nitrogenous fertilizer increased the growth of both the parasite and the host crop, which nevertheless produced good yield in spite of infestation. He suggested that nitrogen application inhibited parasitism by Striga, directly by increasing the concentration of nitrogen in the root, and also indirectly by reducing the light at the soil surface as a result of the denser cannopy.

Similarly, Okonkwo (1990) reported that nitrogen is pallative to the host and therefore enhaned its tolerance even to high infestation of Striga. In this trial, high rate of nitrogen resulted in higher crop dry matter production which indicates greater influence of nitrogen on crop production than parasitism by Striga on the host plant (Ogborn, 1972; Oknonkwo, 1990; Adetimirin and Kim, 1997).

Nitrogen application in this study was found to affect days to 50% tasseling and silking, cob length, stover weight and Kernel weight. Generally at 120kgN/ha and 150kgN/ha significantly improved cob and kernel weights and grain yield of maize. The result obtained in the study support those reported earlier that the application of nitrogen fertilizers reduced the severity of Striga attack and increased the yield

of the host crop (Last, 1960a; Agabawi and Younis, 1965; Parker, 1965; Egley, 1977; Ogborn, 1984; Lagoke et al., 1994).

5.2 Reaction of Maize Varieties to Striga

In both trials, all the maize varieties evaluated equally supported high emergence of Striga hermonthica. The open-pollinated varieties did not differ significantly in Striga infestation and incidence as well as crop reaction syndrome score in 1991. In spite of the non-significant difference in the reaction to Striga, TZESR-W produced higher grain yield than the other varieties. SUWAN-1-STR also produced higher grain yield EV8428-S-STR in the trial. The high yield obtained with TZESR-W could be attributed to late planting which normally did not adversely affect they early maturing variety compared with the other varieties used in the trial. Also Striga shoot was observed to be lower on this variety than on the others, although the difference was not significant.

However, in 1992, both the hybrid variety 9022-13 and open-pollinated variety SUWAN-1-STR had lower syndrome score than TZESR-W up to 12 WAS in spite of similar Striga count and crop plant infestation. The hybrid 9022-13 also had lower syndrome score than the open-pollinated SUWAN-1-STR at 9 WAS and 12 WAS. Crop damage syndrome score is being advocated as an important parameter in the determination of tolerance/resitance of maize genotypes to Striga (Kim, 1991;

Adetimirin and Kim, 1997; Lagoke et al., 1997). This is because under severe infestation, the symptoms usually noticed, which include leaf scorching and blotching, affect photosynthetic activity of the host plant, especially at 9 WAS in maize which is a critical period for grain filling in the crop. The lower syndrome scores at 9 WAS obtained in 1992 on varieties SUWAN-1-STR and 9022-13 compared with TZESR-W apparently confirm the relative tolerance of the varieties to moderate level of infestation as obtained in the trials. Earlier reports (Lagoke, 1989; Kim, 1990; Kim and Winslow, 1992; Lagoke et al., 1994, 1997) have indicated that the hybrid variety 9022-13 has moderate tolerance to Striga hermonthica. Similarly Kim and Winslow (1992) and Lagoke et al. (1997) reported that SUWAN-1-STR the open-pollinated variety exhibited low to moderate level of tolerance to the parasite. In 1992, the open-pollinated varieties SUWAN-1-STR and TZESR-W exhibited higher damage syndrome score and had lower stand count than the tolerant hybrid 9022-13 under Striga in festation.

Reduction in the height of host crop has been attributed to Striga infestation. This is believed to adversely affect yield of the host crops as earlier reported (Terry, 1984; Lagoke, 1989; Kim, 1990; Robinson and Dowler, 1990). In this study, varieties EV8428-SR/STR and TZESR-W had shorter plants than the maximum in 1991 and 1992 respectively. This might be a product of inherent genotype and Striga infestation. Striga

plants have been reported to introduce some toxic chemicals into the host plant which disrupt the hormonal balance of the the host thereby inducing stunting of the shoots (El-Hiweries, 1983; Ramaiah et al., 1983; Dogget, 1983). SUWAN-1-STR variety produced the tallest plants in 1992 and was comparable to the tallest obtained in 1991 (TZSR-Y-1/STR).

Number of days required to achieve 50% tasseling and silking in maize varieties are indicators of maturity periods of maize, Kim (1990) had reported that delayed silking or reduced ear size could be injurious to the yield of maize under Striga infestation. Other yield attributes viz: 1000-grain weight (kernel weight) and stover weight have been associated with reduction in yield of maize under Striga infestation (Kim, 1990; Effron 1990; Adetimirin, et al., 1997). SUWAN-1-STR produced the longest cobs in this study and has other yield attributes comparable to tolerant hybrid 9022-13. This makes the variety to produce many grains and consequently high yield which might be traced to inherent genetic ability.

In 1992, Striga infestation was found to reduce grain yield of maize by 33%. Striga infestation reduced grain yields by 7.2%, 21.1% and 28.6% for varieties 9022-13, SUWAN-1-STR and TZESR-W respectively. With the low cob number of SUWAN-1-STR compared with 9022-13, the acceptable yields of SUWAN-1-STR in both trials in spite of moderate infestation can be attributed to the tolerance of the variety to Striga.

This is done probably through reduction in number of cobs produced, compensated for by bigger seed size with consequent increase in grain yield of variety which also has longer cobs than 9022-13. Also being an intermediate to late maturity variety, SUWAN-1-STR would still produce adequate photosynthetic apparatus for the production of assimilates for grain at the later stage of the life cycle. However, only TZESR-W produced lower grain yield and kernel weight as well as stove weight than the hybrid. The similar yield of the open-pollinated SUWAN-1-STR to that of the hybrid 9022-13 may be attributed to the longer cobs obtained with the open-pollinated variety and some level of tolerance which was exhibited by similar syndrome score at harvest. Despite this, the grain yield and size did not differ between the two open-pollinated varieties viz: SUWAN-1-STR and TZESR-W (Lagoke, et al., 1993).

5.3 Interactions

The reaction of maize varieties to Striga infestation was differentially influenced by nitrogen application. The interaction of nitrogen and variety was significant on crop damage syndrome score at harvest in 1992. Application of 60, 120 and 150kgN/ha were required to ameliorate the Striga damage syndrome score on hybrid 9022-13, SUWAN-1-STR and TZESR-W respectively. The interactions of variety and Striga infestation was significant on stand count of maize plants at

12 WAS in 1992. Striga infestation depressed stand count in variety SUWAN-1-STR and TZESR-W. Hybrid 9022-13 infested with Striga had stand count comparable to the uninfested fields. SUWAN-1-STR had comparable stand count to the hybrid 9022-13 under infestation. This confirms the better tolerance of 9022-13 to Striga infestation than the other two open-pollinated varieties. If further confirmed the better tolerance of SUWAN-1-STR than TZESR-W.

With Striga infestation, all the nitrogen rates resulted in similar increase in crop dry matter production compared with no nitrogen. 0 and 60kgN/ha were similar and lower than higher rates, while 90kgN/ha resulted in lower crop dry matter than the higher rates that was similar. The maximum crop dry matter production obtained with 9022-13 on the Striga-free plots given 150kgN/ha was only obtained with SUWAN-1-STR and TZESR-W given 120kgN/ha without Striga infestation. This incidates that without Striga infestation the hybrid 9022-13 respond to nitrogen application up to 150kgN/ha while limit of response of SUWAN-1-STR and TZESR-W is 120kgN/ha. Varieties which exhibited different levels of tolerance (9022-13 and SUWAN-1-STR) required 150kgN/ha under Striga infestation to produce crop dry matter comparable to that of the non-infested crop given 60kgN/ha, thus confirming the pallative effect of nitrogen on even the moderately tolerant crop of maize to exhibit the potential (Kim, 1991; Lagoke et al., 1997 and Adetimirin, et al., 1997.

In 1992, the interactions of nitrogen and variety, nitrogen and Striga infestation as well as nitrogen, variety and infestation were significant on the number of days to 50% silking. From the three-way interactions, variety TZESR-W infested with Striga still had the least number of days t0 50% silking at the lowest nitrogen used (60kgN/ha). This was observed to be comparable to days to 50% silking in Striga-free fields. The variety which has shorter maturity period could possibly mature before any serious infestation could be done by the parasite. In both infested and Striga-free fields, SUWAN-1-STR and 9022-13 all had similar number of days to 50% silking.

5.4 Correlation

The negative correlation between maize grain yield and Striga crop damage syndrome score in the two trials confirms the high vulnerability of maize yield as similarly observed by Effron (1990) and Kim, (1991). This may be attributed to the fact that maize is a new host to the parasite in the savannah (Emechebe, et al., 1991; Kim, 1991). Kim (1990) had also reported such correlation between Striga syndrome score and maize grain yield.

In this trial, high and significant negative correlation of yield with syndrome score could be attributed to the fact that the tolerant varieties allowed germination and subsequent growth of the parasite which had less effect on the growth and

yield of the varieties compared with the susceptible ones. This corroborates earlier results reported by Kim (1991), Adetimirin et al. (1997) and Lagoke et al. (1997) and Berner and Kling, (1997).

5.5 Regression

From the results obtained in regression curves, it shows that increase in nitrogen fertilizer decrease grain yield loss in maize under Striga infestation. This results corroborates earlier reports (Egly, 1977; Ogborn, 1984; Lagoke et al., 1990) that increase in nitrogen fertilizer enhance growth and yield of the host plant. Striga infestation obviously modified crop response to nitrogen application. The best filted curves with and without infestation for the response of athe crop to nitrogen were Quadratic and Linear respectively. Maximum grain yield with without Striga were 1.85 t/ha and 2.55 t/ha respectively. The difference between 120kgN/ha and 150kgN/ha with infestation is less than that without infestation. Application of 120kgN/ha may be adequate as an input for Striga management if a tolerant variety is used.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

Field trials were conducted during 1991 and 1992 wet seasons at Samaru (11°11'N, 07°38'E) in the Northern Guinea Savannah of Nigeria to study of the effect of nitrogen on the reaction of maize varieties to Striga hermonthica (Del.) Benth.

In 1991, the trial was laid out in a split-plot design with four levels viz: 0 (no fertilizer), 90, 120 and 150kgN/ha as the main plot treatments while four maize varieties viz; TZESR-W, SUWAN-1-STR, EV8428-SR/STR and TZSR-Y-1/STR constituted the sub-plot treatments. All the treatments were replicated three times. In this trial, the whole field was inoculated with Striga seeds.

In 1992, two blocks of experiments were used with one block inoculated with Striga seeds while the other block was not inoculated. The experiments were also laid out in a split-plot design. The five nitrogen levels (0 - no fertilizer, 60, 90, 120 and 150kgN/ha) were the main plot treatments while the three maize varieties (9022-13, SUWAN-1-STR and TZESR-W) were the sub-plot treatments.

Nitrogen application obviously modified crop response to Striga infestation. In both trials, application of 120 and 150kgN/ha significantly reduced Striga shoot emergence on maize while the incidence of Striga on maize was also reduced by 150kgN/ha in 1991 compared with 90kgN/ha. Application of

90kgN/ha also resulted in higher Striga shoot cound on maize compared with 0 and 60kgN/ha in 1992. Application of Nitrogen apparently enhanced the tolerance of maize to Striga infestation. Crop damage was reduced while other crop growth and yield parameters viz: Cob's length, 1000-grain weight, were enhanced by nitrogen fertilizer.

All the maize varieties evaluated in the study supported Striga emergence. The varieties did not differ significantly in their support for emerged Striga plants in both years, but exhibited differential reactions to Striga infestation in 1992. Hybrid 9022-13 and open-pollinated SUWAN-1-STR exhibited better tolerance to Striga infestation than the recommended open-pollinated variety TZESR-W. At the critical stage of crop growth i.e. 9 and 12 WAS, 9022-13 also exhibited lower syndrome score than SUWAN-1-STR. Although TZESR-W produced higher yield than the other varieties EV8428-SR/STR, TZSR-Y-1/STR and SUWAN-1-STR in 1991, it produced significantly lower yield than 9022-13 and SUWAN-1-STR in 1992. The yield of SUWAN-1-STR was also comparable to that of the hybrid 9022-13 in the trial. This suggest that the two varieties are tolerant to Striga.

Striga infestation significantly affected the performance of maize in the study, Striga infestation resulted in shorter maize plants and decrease in crop dry matter production compared with no infestation. The grain yield and 1000-grain weight of maize were also significantly reduced by 33% and 27%

respectively under Striga infestation in 1992.

There was a significant interactions of nitrogen, crop dry matter production, and number of days to 50% silking and varieties on maize yield in 1992. The crop dry matter production comparable to the maximum obtained (9022-13) on Striga-free plots given 150kgN/ha was only obtained with SUWAN-1-STR and TZESR-W given 120kgN/ha without Striga infestation. The increase in the number of days to silking caused by Striga infestation without nitrogen was reduced by the application of 90 to 150kgN/ha.

In the study, maize grain yield was negatively correlated with crop damage syndrome score (r = -0.7085, -0.5406, -0.6219, -0.4968 and -0.5059). The maximum grain yield with and without Striga infestation were 1.85 t/ha and 2.55 t/ha. The difference between 120 and 150kgN/ha with infestation is less than that without infestation.

In conclusion therefore, hybrid variety 9022-13 and open-pollinated SUWAN-1-STR exhibited tolerance to Striga infestation compared with TZESR-W and their yields were comparable. Application of 120 and 150kgN/ha suppressed Striga emergence and maize grain yield increase. The effectiveness achieved when these tolerant varieties were fertilized with nitrogen, showed that Striga can bes be controlled using an integrated approach.

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APPENDIX I

CHEMICAL ANALYSIS OF SOIL SAMPLE TAKE FROM EXPERIMENTAL SITES

Soil Composition	1991 Soil depth (cm) 0 - 15	15-30	1992 Soil depth (cm) 0 - 15	15-30
Particle size (%)				
Sand	54	48	51	47
Silt	33	29	30	36
Clay	13	21	10	15
Soil textural class	Sandy Loam		Sandy Loam	
Soil pH in water	5.5	5.9	5.1	5.3
pH in 0.01M $CaCl_2$	5.0	4.9	4.8	4.7
Organic Carbon (%)	0.51	0.41	0.39	0.3
Total nitrogen (%)	0.06	0.04	0.07	0.5
Available P (ppm)	8.71	5.25	9.01	7.3
Exchangeable Bases (Meq/100g of Soil)				
Sodium (Na)	0.12	0.15	0.10	0.1
Potasium (K)	0.29	0.28	0.23	0.9
Magnesium (Mg)	0.41	0.62	0.38	0.1
Calcium (Ca)	0.08	0.81	0.91	0.8
Cation Exchange Capacity (Meq/100g of Soil)	6.1	7.2	5.8	8.1

APPENDIX II

Total Rainfall, Maximum and Minimum Temperatures, Relative Humidity and Sunshine Hours at Ten Days Intervals During the Period of the Experiments 1991 - 1992

Month	Days	Total Rainfal 1991	1992	Max. Temp. 1991	1992	Min. Temp. 1991	1992	Rel. Humidity 1991	1992	Sunshine (Hrs) 1991	1992
July	1-10	71.0	74.3	28.0	28.0	20.0	19.5	79.7	81.5	5.9	6.0
	11-20	22.7	130.9	28.3	19.9	19.9	78.5	84.9	84.9	5.9	6.0
	21-31	95.9	38.4	28.0	28.0	20.1	20.0	82.6	81.3	5.3	6.5
August	1-10	56.9	150.7	27.7	27.7	20.1	19.8	85.0	81.0	4.4	5.3
	11-20	103.2	152.1	27.9	27.9	19.2	19.3	83.1	79.9	5.1	1.6
	21-31	168.9	132.6	28.2	28.2	19.7	19.5	85.2	72.2	5.5	2.7
Sept.	1-10	20.0	56.2	30.6	30.6	20.0	20.4	75.9	80.7	8.4	5.5
	11-20	25.1	80.4	31.4	31.4	19.6	19.8	71.5	86.1	7.6	4.3
	21-31	6.1	72.9	31.9	31.9	20.4	19.9	54.4	83.8	8.3	5.3
Oct.	1-10	28.7	4.7	31.5	31.5	20.3	18.8	73.1	67.1	7.3	8.4
	11-20	-	-	31.7	31.7	17.7	19.4	67.9	70.7	8.9	9.5
	21-31	-	-	32.7	32.7	17.0	15.2	57.8	46.9	9.1	10.4
Nov.	1-10	-	-	31.6	31.6	13.3	16.7	22.1	45.1	9.5	7.8
	11-20	-	-	31.0	31.0	12.7	13.9	21.2	25.8	7.9	9.3
	21-31	-	-	33.0	33.0	12.4	14.6	17.4	26.3	9.4	2.8

Source: Meteorological Unit, Institute for Agricultural Research, Samaru, Zaria, Nigeria

APPENDIX III

Striga Syndrome Ratings (1 - 9) Used for Measurement of Toleranace of Maize to Striga, Based on Striga Damage Symptoms to the Host Plant (1 = Highly Tolerant; 9 = Highly Susceptivle), 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 of about 20 percent of leaves with some 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 scorching on about 40% of leaves with some grey brown necrotic spots. Some stunting and ear and tassel size reduction.
6.	Definite leaf scorching on about 50% of leaves with mostly gray necrotic spots. Definite stunting and stem diameter, ear size and tassel size reduction.
7.	Definite leaf scorching 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 scorching 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 host plant and no ear formation.

BIOGRAPHY

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2. G.S.S. Funtua	1973-1978	WASC
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2. Sch. of Agric., S/Kataf	1984-1990	Lecturer II
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