EVALUATION OF SOWING DATE, NITROGEN LEVEL, VARIETY AND HERBICIDE FOR THE CONTROL OF *Striga heraionthica* (DEL.) BENTH IN SORGHUM (*Sorghum* blcplor (L) KOENCH)

BY

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FEBRUARY, 1990

DECLARATION

I hereby declare that this thesis entitled EVALUATION OF SOWING DATE, NITROGEN LEVEL, VARIETY AND HERBICIDE FOR THE CONTROL OF *Striga hermonthica* IN SORGHUM 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 titled "Evaluation of sowing date nitrogen level, variety of sorghum and herbicide for the control of Striga hermonthica (Del.) Benth. in sorghum (Sorghum bicolor (L) Moench)"by James Olasunkanmi Adeosun, meets the regulations governing the award of 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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D E D I C A T I O N

This work is dedicated to the memory of my beloved Mother, Mrs Julie Bola Adeosun, for all she was to me.

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"Better is the end of a thing than the beginning thereof" (Ecc. 7:8a).

ABSTRACT

A greenhouse study was conducted at the Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria (11°11' N 07°E) in the Northern Guinea Savanna Ecological Zone and two field trials during the 1988 wet season on the commercial farm of Ahmadu Bello University, Mokwa (09°18'N 05' 04°E) in the Southern Guinea Savanna Ecological Zone to evaluate dates of sowing, nitrogen levels, crop varieties and herbicides for the control of Striga hermonthica in sorghum.

Early sowing of sorghum on 23 June, 1988 resulted in more vigorous crop growth and grain yield increase of 64.2% over the late sowing of 14th July. The effect of nitrogen was significant on leaf area per plant at 3 weeks after sowing (WAS) and on grain yield. The effect of variety was significant on leaf area at 8 WAS, Striga score, percentage of Striga - infested sorghum plants, Striga count, head weight, grain yield and the weight of 1000 seeds. Increasing nitrogen from 60kg N/ha to 90kg N/ha increased the grain yield by 21.7%. The most promising variety which supported low number of emerged Striga shoot and produced the highest grain yield was S.35 with 76.5% grain increase over the more susceptible variety L.187, which also had 57.9% lower striga count than variety L.187. Variety ICSV 1007 consitently exhibited the highest level of resistance to Striga hermonthica both in the greenhouse and under field condition as reflected in the number of emerged Striga shoot but its yield was low. Significant interactions between sowing date x nitrogen, nitrogen x variety, sowing date x variety and second order interaction between sowing date x nitrogen x variety on various parameters studied were also observed. Grain yield was negatively

correlated with Striga count (r = - 0.28*).

Among the herbicide treatments evaluated, atrazine plus terbuthylazine at 1,25 + 1.25 kg a. kg a.i/ha and diflufenican plus atrazine at 0.40 + 1.00 kg a. i/ha applied pre-emergence alone, respectively increased grain yield by 76.7% and 74.1% over the unweeded control, and *32.8%* and 25.3% over two hoe-weedings. Supplementary hoe-weeding apparently encouraged Striga emergence. Grain yield was also correlated with the Striga count (r=s -26*) and percentage of Striga infested sorghum plants (r=-0.32*).

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CHAPTER 1

INTRODUCTION

1.1 Production and Economic Importance of Sorghum

Grain sorghum or guineacorn (Sorghum bicolor L. Moench) is extensively cultivated in the tropics, sub-tropics and in temperate zones. It ranks fourth in importance amongst the world cereals, coming after wheat, maize and rice. Sorghum is the most important cereal of the Nigeria savanna. It occupies about 44% of the total land area devoted to cereals in Nigeria (FAO, 1984), although a production of 4 to 6 million tonnes was reported for 1980 by Obilana (1983).

Sorghum is a staple food crop grown primarily for human consumption and sometimes as stock feeds. The grain is higher in protein and starch but lower in fat content than maize kernel (Komolafe et al, 1979). The flour derived from grain sorghum is used for preparing various local dishes, thick paste and liquid porridges. Industrially, sorghum grains are used for the manufacture of baby food and such items as sugar and wax (Richard et al, 1974; Egharevba, 1979; Nwasike, 1987). The stalk can be grazed directly by animals or as hay or silage, for feeding animals during the dry season. The stalk is also used for fencing and building huts, as as fuel (Curtis, 1965; Dogget, 1970).

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1.2 Effect of Striga hermonthica on Sorghum Production

The production level of sroghum in Nigeria has remained low over the years because of various problems including diseases, insect pests, birds and weeds. The most important weed causing serious losses in sorghum are various species of parasitic weeds such as Striga spp and Buchnera hispida which belong to the family

Scrophulariaceae. Of the twenty-three species of Striga reported in Africa, six are of common occurence in Nigeria. These common species are S.hermonthica, S.aspera, S.asiatica, S.passengei, S. forbesii and S.gesnerioides (Parkinson, 1985). Of the six species identified in Nigeria, S.hermonthica is the most unbiquitous and economically important. The specie is the most common in sorghum producing areas of Nigeria, occuring in ecological zones extending from latitude 7°N to 14°N (Obilana, 1981).

In Africa, a conservative estimate of crop losses due to Striga has been put at an average of 40% representing an annual loss of US$7b (seven billion US Dollars) worth of cereals (Mbooh, 1986). In a very severe infestation field yield loss can be up to 95% (Drennan and El-Hiweris, 1979). The percentage loss in crop yield however vary with countries, depending on the ecological zones in which they are situated, being more severe in savanna or/and sahel zone than in forest zones. In East Africa, yield losses has been estimated to range from 20% to 95% of total yield in sorghum and millet (Dogget, 1965). In Nigeria a range of 10 to 91% losses in sorghum yield has also been attributed to Striga with an annual estimated grain yield loss value of US$250m (Ogborn, 1979; Lagoke and Fisher, 1983; Lagoke, 1986).

1.3 Existing Methods of Control and Limitations

The most common method employed for the control of Striga is hand-pulling which is only feasible under low infestation of Striga. With high infestation, especially in a large scale production, hand pulling becomes less feasible because it is expensive, labour-intensive and vary strenous. The method has also been observed by Ogborn (1972) to stimulate Striga emergence. Hoe-weeding has the

same limitations as that of hand pulling.

Various alternative methods to hand pulling have also been used for the control of Striga in sorghum. Breeding of sorghum for resistance/tolerance to Striga has been a major scientific effort to combat the effect of S.hermonthica. Inspite of the efforts that have been made by the Institute for Agricultural Research Samaru, for the past 18 years (Lagoke et al, 1988) and by International Crop Research Institute for Semi-arid Tropics (ICRISAT) of recent, it has been difficult to obtain an immuned variety. Tolerant varieties which allow the growth of some plants of Striga may be source of re-infestation of the field the following year, as each plant is capable of producing up to 50,000 seeds (Parkinson Pers. Comm). It has also been reported that varieties developed in Africa and India have not shown any long-term impact on Striga problem (Parker, 1981). This is because good resistant variety loses its resistance with time due to build-up of more virulent Striga population, especially where continuous cropping is practised. Ramaiah (1983) also indicated that the devleopment of new strains of Striga through cross-fertilization could be responsible for the break-down in the crop variety resistance/tolerance to Striga. The production of unacceptable yield and low quality grain by the resistant varieties limits their adoption for use to control Striga through breeding (Ramaiah, 1986).

Control through artifical stimulation of Striga seeds to germinate in the absence of a host remains one of the most direct control measures available (Ogborn, 1979; Parker, 1981; Pieterse, 1985). However, the cost and the difficulty of application, especially by the unskilled farmers of this country, make such a method non-feasible in Nigeria. The effectiveness of the treatment may also be limited because of after-ripening dormancy and requirement for

certain adequate pre-condition for germination which may lead to erratic Striga germination. Moreover, not all the seeds of Striga would be exposed to ethylene at the same time.

Herbicides that have been evaluated for the control of Striga hermonthica have failed to give acceptable season-long effective control. Also, it has been difficult to identify a selective herbicide that would prevent the attachment of Striga haustoria to sorghum without crop phytotoxicity. For example, 2,4-D which is commonly used in controlling Striga hermonthica at low rates of 0.5 to 2.0 kg a.i/ha has been shown to be injurious to some sorghum varieties (Pieterse, 1985). Even at 2.0 kg a.i/ha of 2,4-D multiple application is required to effect appreciable control (lagoke, 1989). Although some of the chemicals that have been used reduce further seeding, they hardly prevent Striga seed germination to enable the crop to escape injury (Mabasa, 1988).

High rate of fertilizer, especially nitrogen has been reported to suppress Striga population in sorghum by inhibiting germination of Striga seeds (Leach et al., 1981; Clark et al, 1989) and increase crop tolerance to Striga (Lagoke, 1981). The recent high cost of fertilizer and the scarcity may limit the adoption of the method by small-scale farmers with low resource base. Furthermore the result obtained with nitrogen has hot been consistent enough, while the mechanism of reaction of both crop and Striga to high nitrogen still not clear (Lagoke, 1989). While in some cases the population of Striga hermonthica was increased, it was reduced in some cases with the application of high rate of nitrogen (Ogborn, 1979; Pieterse, 1985).

Other cultural control methods which have also been tried with little success due to socio-economic problems include fallow, deep cultivation, rotation, trap cropping, catch cropping and crop hygiene.

It is obvious that effective control of S.hermonthica in sorghum requires integration of various weed control components. This project which was undertaken to identify such components has the following objectives:

1. To evaluate some varieties of sorghum grown at different sowing dates and levels of nitrogen for their reaction to Striga hermonthica.
2. To evaluate some herbicides for the control of Striga hermonthica in a susceptible variety of sorghum.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Ecology of Striga hermonthica

Striga hermonthica is an obligate parasite of sorghum. According to Pieterse (1985), the seed of S.hermonthica produces radicle which when it is about 2 to 4 mm changes into haustorium on contact with a host plant root. This is as a result of chemical called "Haustorial initiation factor", secreted by the host plant. The haustorium then develops into vascular tissues and establishes contact with the host xylem. S.hermonthica may grow for about 4-6 weeks before emerging from the soil. Flowering of the emerged plant occurs about a month later.

Each S.hermonthica plant is capable of producing between 40,000 and 50,000 seeds. The size of a mature seed of S.hermonthica may vary from 0.20 to 0.50mm with undistinghished embryo. The seeds of the parasite which can remain viable in the soil for up to twenty years will not germinate unless appropriate conditions prevail. It requires such conditions as after-rippening dormancy for a period of months and adequate pre-conditioning of intermittent moderate moisture and optimum temperature between 30 and 35°C from one to two weeks. It also requires an impulse from chemical stimulant which is present in the exhudate of roots of host plants and certain non-host plants (Parker, 1965; 1984; Pieterse et al, 1985).

2.2 Host Range and Distribution

Striga hermonthica is cross pollinated and highly prolific. The cross pollination which creates genetic diversity both within the species and sub-species has enhanced its wide adaptation in terms of host range. It has also been successfully crossed with S.aspera, which has similar morphology and very common in cereals (Kim pers.

comm). The host range of S.hermonthica in Nigeria includes sorghum, maize, millet, rice and sugar cane (Ogborn, 1979; Obilana, 1983; Parkinson, 1988). S.hermonthica parasitism has also been reported on non-cereal crops such as groundnut (Arachis hypogea L.) and Sesamum indicus L. (Ogborn, 1985).

Ogborn (1979) related the detailed status of cultivated hosts in Northern Nigeria. According to him, sorghum is a host in all savanna ecological zones, while "gero" (early millet) which is cultivated more in the Northern Guinea Savanna and Sudan Savanna as well as Sahel zones, is a host in the Northern Sudan Savanna and Sahel zones where it is most cultivated. "Maiwa" (late millet) is however a host in the Southern Guinea Savanna. Maize is a host in all the savanna ecological zones while rice is parasitised in the southern and northern Guinea and Southern Sudan Savannas. Early planted sugar cane is attacked in all ecological zones. The occurence of specific crop strain such as millet and sorghum physiological strains has been stressed (King and Zumo, 1977; Parker and Reids, 1979). Kim (pers. comm.) has also observed that only strains of S.hermonthica collected on millet attacked maize, sorghum and millet, while those collected on maize and sorghum only attack these crops but not millet. These physiological strains exist in various zones and exhibit differential parasitism suggesting possibility of ecological specificity (Obilana, 1981).

2.3 Effect of Striga hermonthica on Sorghum Plant

Although S.hermonthica is chlorophyllous, due to structural and biochemical characteristics of its leaves, rates of CO_2 fixation are low and rates of dark respiration are high. The consequence of this is an absolute requirement for host carbon to support the growth

of the parasite (Stewart et al, 1988).

It has also been observed that host carbon can be transfereed to the parasite and accumulation of variety of 14C-labelled metabolites has been demonstrated (Okonkwo, 1966; Roger and Nelson, 1967). Reduced growth of the host plant also results due to reduction in photosynthetic activity (Press et al, 1987). The quantum efficiency of CO_2 fixation was reportedly reduced from 0.037 to 0.025 in affected sorghum plant (Stewart, 1988).

S.hermonthica reduces the growth and markedly alters the architecture of sorghum plant, as a result of its total reliance on the host for water, nutrients and some reducing sugars (Okonkwo,1966). In a quantitative growth study of sorghum cultivar (CHS-1 carried out by Graves et al (1988), grain and stem weights were reduced by 95 and 66% respectively whilst leaf and root biomass were maintained.

According to Musselman (1980), the effect of S.hermonthica on sorghum involved more than just the removal of water and other nutrients, it also causes some other changes in sorghum physiology possibly, due to changes in hormonal balance due to the reduction in growth hormones such as cytokinins and gibberellins (El-Hiweris, 1983). Apart from the changes in hormonal balance of the host, S. hermonthica also produces toxins which is symptomised in the host plant by chlorotic blotch, chlorosis of leaves, necrosis, stunting of the shoot and failure of panicle formation, while in severe cases death do occur (Pieterse, 1965; Parker, 1984; Lagoke and Adeosun 1989).

2.4 Effect of Nitrogen on Striga hermonthica and Sorghum Yield

Different sources and rates of nitrogen have been used to suppress S.hermonthica and consequently increase sorghum grain yield. Bebawi and Farah (1981) used nitrophoska at three rates of 43, 86, 129 kg N/ha and observed an increase in grain yield of 46, 97 and 159% respectively over the no-nitrogen control. Urea at three rates of 43, 80 and 172 kg U/ha also increased sorghum grain yields by 14, 25 and 45% respectively and decreased Striga yield by 14, 21 and 35% compared with the untreated control (Bebawi and Abdulaziz, 1983).

When Sherif (1983) used ammonium sulphate and nitroform as sources of nitrogen to control S.hermonthica in sorghum, he observed that high level of nitrogen directly increased the tolerance of sorghum to Striga but had no direct effect on germination and establishment of Striga on sorghum. He further stressed that nitrogen application did not seem to influence the production of Striga germination stimulant or the formation of haustoria. Pesch and Pieterse (1985) however later reported that nitrogen reduces the germination of Striga. Ogborn (1979) reported that though high level of nitrogen increased sorghum grain yield, it also resulted in increased number of emergent Striga plants. In Gambia, Carson (1985) also observed that average Striga count per 10m row was 3.3 with the application of 60 kg N/ha and 40kg P_2O_5/ha and 3.0kg K_2O/ha were applied without nitrogen.

Although nitrogen has been reported to suppress Striga development with consequent increase in sorghum grain yield by various researchers, the mechanism involved is less understood. The effect of nitrogen on both the host and parasite has been attributed to various reasons. Agbawi and Younis (1965) reported that nitrogen

delayed Striga emergence, caused stunting of emerged shoots and reduced flowering and dry matter production. Parker (1984) suggested that the effect of nitrogen can partly be attributed to its tendency to influence the host partitioning of resources between shoot and root. Ogborn (1984) suggested that nitrogen application has both direct and indirect effect on Striga. He indicated that direct effect might be due to the fact that increased nitrogen concentration in the host root inhibited parasitism by Striga. The indirect effect was attributed to reduction in light intensity at the lower stratum of Striga as a result of denser crop canopy due to increased crop vigour caused by nitrogen application.

The effect of nitrogen to enhance substantial sorghum grain yield in the presence of Striga depends on the total nitrogen absorbed by the sorghum plant which would substantially increase its grain yield and also decrease S.hermonthica yield has been observed to be an interplay between the nutrient status of the soil, time of nitrogen application and sorghum varietal response (Last, 1960; Egley 1971; Bebawi, 1981). Last (1960) observed that early application of nitrogen were more effective than late application. According to the author, nitrogen applied at 3 weeks after sowing (WAS) of sorghum resulted in large grain increase than later applications made at 6 and 9 WAS. This was in agreement with the report of Egley (1971) who observed that Striga that emerged 34 days after sorghum was planted (early attack) reduced host yield more than those that emerged 49 days (later attack) after planting. Bebawi (1981) applied five levels of nitrogen at 43, 86, 129, 172 and 215 kg N/ha to sorghum cultivars at planting and observed that maximum response was observed at 215kg N/ha in terms of straw and grain yields. He also observed differences

in cultivar responses to nitrogen in the presence of Striga. While in some cultivars, application of nitrogen decreased Striga yield, in some, Striga was increased. Last (1960) also observed similar varietal responses in Sudan. He observed that sorghum variety "Feterita" had maximum Striga population when 44.8 kg N/ha was applied, whereas it was not maximum even at the rate of 89.0k N/ha in variety "Debekri". He therefore suggested that the inherent poor soil fertility might be responsible for the increase in Striga population when nitrogen was applied even at higher rate.

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2.5 Effect of Date of Sowing on the Incidence of Striga hermonthica

The emergence of Striga hermonthica seedlings have been found to be related to differences in sowing date as influenced by moisture availability (Vallance, 1950). Remaiah (1988) observed that farmers in Africa plant local varieties of sorghum very early in the season, with the first heavy rainfall which favour early emergence of Striga. The same observation was made in Ethiopia and Sudan (Andrew, 1945; Remaiah, 1987). The authors further stressed that on the contrary, sorghum planted late is less attacked but grain yields of photosensitive sorghum varieties were also reduced. In a field experiment by Ogborn (1975) less than 3,000 Striga stand/ha that emerged on 20 August died before the last heavy rainfall on 25 September. A massive emergence occured during the next three weeks after which it stopped completely. Parker (1973) however reportdd that the main emergence of S.hermonthica occurred in late August and September. He did not quite agree with the impression that the inability of Striga to emerge in the early stage of crop growth was due to "wet dormancy". Ramaiah (1983b) also reported that planting early on 9 June resulted

in higher Striga emergence compared with later planting of 23 June and 19 July in Burkina Faso. He also observed that despite reduction in Striga emergence, late planting in season adversely affected crop growth and the ultimate grain yield of sorghum in the trial.

2.6 Resistance of Sorghum Varieties to Striga hermonthica

The use of resistant varieities of sorghum has been suggested more useful in Striga hermonthica infested field than cultural and chemical control measures (Obilana, 1979). According to Ramaiah (1983b), attempts to identify resistant varieties in sorghum started in 1930s in South Africa and in India and later in Nigeria, Sudan and Burkina Faso. Lagoke et al (1988) reported that screening of over 200 lines for resistant/tolerance to S.hermonthica was carried out in 1970 at the Institute for Agricultural Research Samaru, Nigeria, and that actual breeding programme started in 1976. According to them, the procedures involved in breeding for resistance include hybridization through crossing the elite lines with the known Striga-tolerant lines followed by pedigree selection using individual head rows to produce pure lines. This has led to the identification of resistant line SRN 4841 which is being used to develop more acceptable resistant sorghum lines in various breeding programmes. In the East and South Africa, Framida and N13 have reported to exhibit good resistance to S.hermonthica (Lagoke et al, 1988). Obilana (1983b) reported that only about 10% of the indigenous sorghum in Savanna ecological zones of Nigeria is resistant. According to him, such resistant varieties include N13, Framida, SRN6838A, L.187, SRN4841 and BES.

Ramaiah (1986) opined that direct field evaluation is a less successful approach for developing resistant lines than a combination of laboratory testing and field assessment. Ramaiah (1983b) had

2.7.2 Anti-haustorial factors

These factors do not allow Striga haustoria to successfully penetrate into the xylem of the host. It has been suggested that some mechanical barrier like highly lignified endodermal cells, lignified pericycle or substances termed host defence chemicals are produced in response to invasion of Striga (Dogget, 1975; Matti et al, 1978).

2.7.3 Antibiosis factors

This is a mechanism arising from incopatibility between the host and the parasite, leading to premature death of parasite (Dogget, 1970). This could be manifested after successful invasion of the host vascular bundle. It was suggested that phenolic acid compounds may contribute to this mechanism of resistance since the infested plants produce higher level of phenolic acids, compared with the uninfested ones (Drennan and El-Hiweris, 1979).

2.7.4 Tolerance

Tolerance is an ability of sorghum to grow and reproduce normally inspite of supporting a Striga population nearly equal to that damaging a susceptible host. Ramaiah (1983b) had indicated that a number of factors which influence Striga emergence such as date of sowing, moisture regime, the amount of seed previously present in the soil and sorghum grain yield might not permit easy assessment of tolerance variety. Obilana (1981) reported that about 60% of indigenous sorghum grown in Savanna ecological zones is tolerant. Such tolerant varieties include KSV 7, KSV 11, KSV 12, SSV 3, SSV 9 and SSV 10.

2.8 Chemical Control of Striga hermonthica in Sorghum

Various chemicals are being used for the control of Striga in sorghum. Recent identification of germination stimulant and haustorium

initiator in sorghum offer new opportunities for effective control of S.hermonthica (Butler, 1988). Ethylene can rid the soil of up to 90% of the viable conditioned Striga seeds.

Pre-emergence herbicides that have been used either singly or in mixture include pendimethalin, trifluralin, DCPA, benefin, fluchloralin, oxyfluorfen, fomesafen fenac, dichlobenil, terbuthylazine/atrazine mixture, atrazine/diflufenican mixture, terbutryn/terbuthylazine mixture (Anon., 1983a) Lagoke and Fisher, 1983; Hamdoun and Babiker, 1986; Pretorius, 1987; Eplee et al, 1988; Parkinson et al, 1988).

Eplee et al (1988) reported that pendimethalin at the rate of 1.7kg a.i/ha applied pre-emergence to both crop and Striga gave 100% reduction in early Striga emergence in sorghum in United States of America (USA). Pre-plant soil incorporation of trifluralin, benefin and fluchloralin at the rate of 0.5 to 0.75kg a.i/ha well incorporated into soil at a depth of about 2.5 to 10cm have also been found to prevent Striga emergence (Anon., 1983b).

The commonly used post emergence herbicides for the control of Striga in sorghum include 2,4-D, MCPA ametryn, linuron, oxyfluorfen formesafen, lactofen, dicamba dimethanetryne, bromoxynil paraquat and glyphosate (Anon, 1983a), Lagoke and Fisher, 1983; Eplee et al, 1988; Kikiro, 1988).

Eplee et al (1988) reported that dicamba has provided excellent control of Striga when applied 35 to 40 days after crop emergence. The authors further reported that dicamba at the rate of 0.25kg a.i/ha used in the fields of corn and sorghum reduced Striga by 84% and 100% respectively. The report of Hamdoon and Babiker (1986) on the effectiveness of pre-emergence application

of high rate of atrazine in controlling Striga indicated that when mixture of foliar-active chemical such as bromoxynil, dimethametryne and dicamba with soil residual atrazine and more potent cyanazine, multiple applications was required for season-long Striga control (Mansfield, 1982; Bakut et al, 1985).

Ogborn (1975) has used dinoterb formulated as 60% urea granule, applied three times at 1.11kg a.i/ha on August 5, September 17 and October 10 and found that August application was too early and October application too late. In August Striga emergence had just started while the absence of rain reduced the effectiveness of herbicide in October.

2.8.1 Atrazine

Atrazine (2-chloro-6-ethylamid 4-isopropylamid 1,3,5-triazine) is a soil residual herbicide. It has a solubility of 70 ppm in water at 25°C. Its acute oral, LD_{50} for rats is 3,080 mg/kg body weight (Anon, 1982b).

The mode of action of atrazine is by inhibiting the Hill reaction of photosynthesis, reducing carbohydrate sysnthesis and consequently inhibit growth. It is absorbed primarily through the roots although little foliar absorption occurs in most plants in the field condition, depending on such factors as species of plant and environmental conditions. Following absorption through roots and foliage, it is translocated acropetally in the xylem, accumulates in the meristems and leaves of plants. Atrazine is readily metabolized by tolerant plants to hydroxy-atrazine and amino acid conjugates. Micro organisms play important role in its breakdown in the soil (Akobundu, 1987). It is more readily adsorbed on muck or clay soils than on soil of low clay and organic matter. It is usually leached

in the soil and this reduces its persistent effect under moist conditions but it persists longer under dry and soil for maximum chemical or biological activities (Eberf and Burrifor, 1976).

Atrazine may be applied pre-plant, pre-emergence or early post-emergence to control both grasses and broad-leaved weeds in cereals, yam and potato. It may be formulated as wettable powder or flowable. The rate of application vary from 2.74 to 4.45kg a.i/ha (Singh and Rao, 1976). It can also be mixed with other chemicals to improve the spectrum of weed control. When mixing with other chemicals rates of 1.0 + 2.5kg a.i/ha are usually used. Higher rates are used for non-selective control (Anon. 1983b).

Bebawi and Farrah (1983) used atrazine to control Striga and observed sorghum grain yield increase of 6.27 and 35% over the control plot without atrazine when 0.75 and 1.75kg a.i/ha rates of atrazine were used respectively. Wicks and Burnisida (1972) in Nebraska observed that pre-emergence application of 2.24 kg a.i/ha of atrazine gave the highest yield of sorghum grain compared with pre-plant application of the same rate. They also stressed further that cultivation improved weed control on all the atrazine treated plots. Ndahi (1986) observed that pre-emergence atrazine at 0.5kg a.i/ha followed by post-emergence cyanazine or terbutryn gave yields similar to the lower herbicide rate of 0.5 to 1.0 kg a.i/ha not supplemented by one hoe-weeding, but significantly lower than the unweeded higher rate of 2.0 kg a.i/ha and the weed-free control in sorghum. However, Anon.(1980) had earlier recommended atrazine at 1.0kg a.i/ha and the mixture with terbutrylazine at 0.3 + 0.8kg a.i/ha for controlling weeds in sorghum. Similar mixture of atrazine and terbutryne at 0.5 + 0.5kg a.i/ha was

recommended for effective week control in sorghum (Anon. 1983a). Bischof (1978) realised substantial decrease in Striga yield when he used 2.0kg a.i/ha of atrazine combined with 50 kg N/ha.

2.8.2 Diflufenican

Diflufenican (2,4-difluro-2-(x-x-x-trifluro-m-tolyloxy) nicotinemilide) is a white crystalline solid. It is under development as pre-emergence and post-emergence treatment for broad-spectrum weed control in certain cereals (Cramp et al, 1985).

Diflufenican is a soil acting herbicide which is taken up by the shoot of germinating seedlings. It acts as an inhibitor of carotenoid biosynthesis and indirectly interferes with plant photosynthesis. It is strongly adsorbed by soil and not easily leached. Diflufenican, separately or in mixture with other herbicides, is being formulated as wettable powder and as an aqueous suspension concentrate.

Diflufenican is a selective herbicide used to control broad-leaved weeds and grasses in vegetables, some oil crops and cereal crops. The rate of application is between 125 and 250 g/ha. These rates have been shown to control practically all trouble-some broad-leaved weeds in cereals. It is also applied as pre-emergence to crop and/or weeds.

Robert and Bond (1986) observed that diflufenican at 125, 250 or 500g a.i/ha gave a complete kill of weeds such as Viola arrensis, Cheropodium album, Lamum amplexicanle, Stellaria media, Trifolium rapens, Vicia linsta, Vernonia persica, Polygonium persicaria and Capsella bursapastoris in vegetables while small number of Poa annua survived when rates of 125 and 250g a.i/ha were used. It also killed completely weeds like Solanum nigrum and Matricarca perforata.

Cramp et al (1985) also reported that diflufenican at the rate of 0.062 to 0.25kg a.i/ha were effective against a range of grasses and broadleaves such as Galium sp, Veronica sp and Viola sp in winter wheat and barley. Kydt et al (1985) reported that in all three season field trials in United Kingdom, Irish Republic, Scandinavia and Western Europe, difluenican at the rates of 0.18 to 0.25kg a.i/ha were effective in controlling broad leaved spectrum of weeds such as Galium aparine, Viola sp as well as Veronica sp in winter cereals. Parkinson et al (1983) reported that when diflufenican was mixed with 2,4-D amine and applied to Striga or with dimethanethryn and applied post-emergence to Striga at 30% infestation, gave persistent control of newly emerged Striga and seedlings of other weeds especially grasses.

2.8.3 Terbuthylazine

Terbuthylazine (2-tert-butylamino-4-chloro-6-ethyl-amino-1,2,3,5-atrazine) which belongs to S-triazine group of herbicides is a systemic herbicide taken up mainly by roots. It has acute oral LD_{50} of 2,100 mg/kg body weight.

As soon as terbuthylazine is absorbed by roots, it is translocated apoplastically to the shoots of susceptible plants. It is more persistent in the soil than simazine or atrazine (BEPC, 1979). Terbuthylazine is a pre-emergence herbicide used in sorghum. It is also used for selective weed control in maized, millet, vineyard, citrus and pomefruits. Its application rate ranges from 1.2 to 1.8 kg a.i/ha. Either mixture of 0.75kg a.i/ha terbutryn + 0.75kg a.i/ha terbuthylazine or 0.8kg ai/ha terbuthylazine + 0.80kg a.i/ha atrazine has been recommended for effective weed control of weeds in sorghum (Anon, 1980). In an experiment conducted at six locations across two

zones, in the savanna ecological zones of Nigeria, Choudhary and Lagoke (1980) observed that terbutryne + terbuthylazine (1:1) at 1.2 and 2.4kg total a.i/ha gave sorghum grain yield comparable with two hoe-weedings .

2.8.4 Bromoxynil

Bromoxynil (3,5 dibromo-4-hydroxybenzonitrile 4 cycro-2, 6-dinitrophenol) which belongs to benzonitrile group of herbicides, is mainly applied post-emergence for the control of broadleaved weeds in many monocotyledonous plants (Anon, 1983b). It has an LD_{50} of 440mg/kg body weight.

Bromoxynil is a foliar active herbicide which inhibits photosynthesis and respiration in the susceptible plants. It has relatively little movement once it is absorbed (Akobundu, 1987). The oil-soluble amino and ester formulations have the capacity to resist removal from foliage by rain. It may be hydrolysed to benzoic acid.

The rate of application of bromoxynil is usually 0.5 to 1.12kg a.i/ha. It can also be mixed with other chemicals such as 2,4-D and MCPA (Akobundu, 1987), but its compatibility with the chemical in question has to be tested otherwise it may reduce its effectiveness. Its acidic formulation may be affected by hard water but ester formulation is not affected (Anon, 1983b).

Mansfield (1982) has successfully used bromoxynil at the rate of 0.74kg a.i/ha to control S. hermonthica in sorghum. He also observed that 0.74kg a.i/ha of bromoxynil in combination with 80kg N/ha gave a significant grain yield over either bromoxynil or nitrogen used separately. Bukut et al (1985) observed that high level of nitrogen (100kg N/ha) enhanced the effectiveness of ..

bromoxynil plus cyanazine at 1.0 + 1.0kg a.i/ha in reducing the number of Striga count at 12 WAP of sorghum. Parkinson et al (1988) also observed on the farmers' field in Cameroun that plots treated with MCPA/bromoxynil mixture at the rate of 1.0kg a.i/ha each had 55.5% of the sorghum plants infested with Striga, compared with 7.5% of plots treated with the same rate and followed by 2,4-Damine at 2.0kg a.i/ha.

2.8.5 Dimethametryne

Dimethametryne (2-(1,2, dimethylpropylamino)-4-ethyl-amino-6-methyl-thio-1,3,5-triazine) which is a triazine, is an oily liquid used as a selective post-emergence herbicide for the control of broadleaved weed in cereals. It has a solubility of 50mg/l at 20°C and acute oral LD_{50} of 3,000 mg/kg body weight. Its application rate ranges from 0.5 to 3.0kg a.i/ha (Kasasian) 1971). Diemthametryne is an inhibitor of Hill reaction of photosynthesis.

Bakut et al (1985) observed that both the mixture of dimethametryne and cyanazine at 1.0 + 1.0kg a.i/ha successfully reduced the number of Striga count at 12 WAP when applied together with 100kg/ha of nitrogen. Good control of newly emerged Striga plants was observed when dimethametryne was mixed with diflufenican and applied at 30% Striga infestation in Cameroun (Parkinson et al, 1988).

2.8.6 MCPA

MCPA [(4-chloro-O-tolyl) oxy/acetic acid] belongs to chlorophenoxyl group of herbicides. It is a light brown solid which has a melting point of 118 to 119°C. It has oral LD_{50}(mice) of 800mg/kg body weight (Anon, 1983b). It is essentially insoluble in water but soluble in organic solvent such as ethanol, toluene, ether and xylene. MCPA is also formulated as amine and ester and sodium and potassium

salts. The amine and salt formulations are water soluble.

MCPA is a 2,4-D related compound used as selective foliage broadleaved killer but more selective than 2,4-D at equal rates on cereals, legumes and flax. The rate of application ranges from 0.13 to 1.2kg a.i/ha. It is usually compactible with other herbicides such as bromoxynil.

It may be absorbed through leaves or roots. It can easily be washed by rain if it follows soon after application but wetting agent may increase absorption. It is readily translocated in plant and move with food materials and concentrated at meristematic regions of growing plant. It has a hormonal stimulatory effect on plant. Low volatile esters are more effective on hard-to-control weeds than salsts of MCPA.

MCPA is readily leached from soil but has a longer residual effect in dry soil. It may be persistent up to one month in the moist condition and up to six months under drier climates (Anon, 1983b).

In Cameroun, Parkinson et al (1988) observed that post-emergence MCPA/bromoxynil mixture of 1.0kg a.i/ha was less effective in controlling Striga in sorghum as this led to 55.5% striga-infested plant and 4.9 and 3.3 respectively of Striga and other weed scores at harvest.

2.8.7 2,4-D

2,4-D (2,4-Dichlorophenoxy aceticeacid) belongs to chlorinated phenoxy group of herbicides. Both inorganic salt, amine and ester formulations are available either in solid or liquid form. Its acute oral LD_{50} for rat is 300 to 1000mg kg/body weight.

2,4-D is a systemic herbicide which is widely used to control

broadleaved weeds in cereal crops, sugar cane, turf, pastures and non-crop land. Most dicotyledonous plants are susceptible at normal herbicide rates. The salt and long chain ester formulations of sufficiently low volatility that with care may be used near fairly susceptible crops if spray drift is prevented. Salt formulations are safest, they do not release enough vapours to cause damage to the treated areas.

2,4-D is usually applied as post-emergent treatment at the rate of 0.5 to 1.5kg a.i/ha (Akobundu, 1987). The usual carrier is water, diesel oil or both, depending upon the formulation used. Low volume are generally used for aerial application and higher volume are used for ground application.

Plant roots absorb polar (salt) forms of 2,4-D most readily, leaves, absorb non-polar (ester) forms most readily. A rain-free period of 4 to 6 months is adequate for uptake and effective weed control. The ester of 2,4-D tends to resist washing from plants and are rapidly converted to acid by plants.

Following foliar absorption, 2,4-D is translocated within the phloem, probably in the photosynthate. Following root absorption it may move upward in the transpiration stream. The translocation is influenced by the growth status of the plant. Accumulation of herbicide occurs principally at their merismatic regions of the shoots and roots. 2,4-D causes abnormal growth response and affect respiration, food reserves and cell division in susceptible plants. It can also act as a plant growth regulator and low rates can induce rooting blossom set. Also it controls the ripenning of banana and citrus fruits and delays pre-harvest dropping of some fruit (Anon, 1983b).

Salts of 2,4-D are leached in sandy soils. It also undergoes microbial breakdown in warm, moist soil, depending upon temperature, moisture, organic matter and other soil characteristics, which affect microbial activity. It may undergo minor plant decomposition. It persists generally for 1 to 4 weeks in warm moist soil and toxic to wild life and fish (Anon, 1983b).

Although 2,4-D has been reported as an effective post-emergent herbicide against Striga hermonthica in sorghum and consequently reduce further seeding but they hardly prevent germination of the parasite seeds to enable the crop to escape injury (Mbasa, 1988). Rao and Reddy (1984) reported that 2,4-D at 2.0kg a.i/ha applied four weeks after sowing but pre-emergence to Striga increased sorghum grain yield compared with no herbicide control but the same rate of 2,4-D when applied after Striga emergence killed the emerged Striga plants without increasing crop yield. Yaduraju and Hosma (1979) reported that the application of 2,4-D at 30 days after sowing gave a season long control of Striga in sorghum and millet in India with respect to population and dry weight of the weed. However, the highest sorghum yield was obtained when the application was repeated 70 days after sowing. Last (1960) had earlier reported that the effectiveness of 2,4-D sprays to control S.hermonthica in sorghum were as a result of delay in development of aerial stem of the parasite. He also stressed that although 1.79kg a.i/ha of 2,4-D decreased S.hermonthica population more than 0.9kg a.i/ha of 2,4-D, there was no appreciable difference in sorghum grain yield when spraying were made at two and three weeks after sowing in Sudan.

Prabharars and Hosmani (1987) also reported that 1.0kg a.i/ha

2,4-D (as post-emergent) following a pre-emergence application of 1.0kg a.i/ha atrazine gave a good reduction of Striga 40 days after sowing in sorghum var. CSH-1.

It appears the effectiveness of 2,4-D as a post emergence herbicide invariably depend on the pre-emergent herbicide treatment previously given. It was observed that when 2.0kg a.i/ha atrazine was applied as pre-emergent treatment followed by 0.5kg a.i/ha 2,4-D as post-emergent treatment to rainfed sorghum markedly decreased the population and dry weight of the weeds and gave grain yield similar to hand weeded plots. However, when 1.0kg a.i/ha atrazine was applied pre-emergence at 1.0kg a.i/ha supplementary post-emergent 2,4-D at the same rate was less effective. Parkinson et al (1988) reported that two application of 2,4-D amine at the rate of 3.24kg a.i/ha gave adequate control of emerged Striga and other weeds except grasses. The authors also observed that 2,4-D amine plus diflufenican at the rate of 2.0 + 0.4kg a.i/ha or 2,4-D amine plus dimethametryn at the rate of 2.0 + 1.0kg a.i/ha was better than 2,4-D amine alone.

CHAPTER 3

MATERIALS AND METHODS

3.1 Green-House Experiment

The experiment was conducted between February and March, 1988 in the green-house of the Institute for Agricultural Research (IAR) A.B.U. Samaru-Zaria (11°, 10° 7° 35'E) located in the Northern Guinea Savanna ecological zone of Nigeria. Details of the meteorological records during the period of the experiment are shown in Table 1.

3.1.1 Experimentation

Mixture of sand and soil (0-15cm) was used for this study. The sand was collected from the river bank of the Ahmadu Bello University's dam, Samaru, while the soil was collected from an uncropped land behind the building of the Department of Soil Science, Ahmadu Bello University, Zaria. Both samples were air-dried for five days while all the clumps were broken and extraneous particles such as stones and plant materials were removed. Each sample was then sieved through a 2mm-sieve and weighed before mixing a total composite weight of 5520 g consisting of 4416 g of sand and 1104 g of soil, with urea fertilizer at the rate of 60kg N/ha, single superphosphate at the rate of 32kg P_2O_5/ha and muriate of potash at the rate of 30 K_2O/ha, using hectare-furrow, slice for calculation. Twenty-four perforated plastic pots of 8cm diameter were used for the experiment. The perforated bases of the plastic pots were plugged with cotton wool for water drainage and then filled with 225g of the sand mixture. 50mg weight of Striga hermonthica seeds collected from sorghum field during the 1987 cropping season were mixed thoroughly with the soil in each pot. The pots were then watered to field

Table 1: Total monthly rainfall, mean temperature, radiation, humidity, sunshine and evaporation during the period of green-house study, February to May 1988 at Institute for Agricultural Research (IAR), Samaru.

Month	Rainfall (mm)	Humidity (%)	Sunshine (hrs)	Evaporation(mm)	Temperature(°C) Max-3	Min-4
February	3.5	14.40	8.30	10.10	31.50	15.70
March	0.00	14.48	7.008	12.90	35.90	20.90
April	34.60	28.10	7.90	10.60	36.10	22.20
May	94.4	60.7	8.00	8.90	34.80	22.50

Source: Meteorological Unit, Institute for Agricultural Research, Samaru - Zaria.

capacity and left overnight. Four viable seeds of sorghum varieties were sown at a depth of about 1.0cm covered with soil lightly and watered, using perforated milk tin in order for uniform application into the pots. Equal volume of water was added to each pot which had petri-dishes under it to collect the excess water that drained from the pots. The drained water was added to the corresponding pot, each morning before fresh water was added. This was done to ensure that the exudates from sorghum roots are not lost through leaching.

3.1.2 Treatment and experimental design

The pots in the green-house experiment were arranged on the benches of the greenhouse in completely randomized design in three replicates. The treatments evaluated were six sorghum varieties namely ICSV 1002, ICSV 1005, ICSV 1007, L.187, S.35 and SK 5912 for their reactions to Striga hermonthica.

3.1.3 Observations

The following observations were made:

Stand count - Stand count was done 10 days after sowing (DAS) by counting the number of emerged sorghum seedlings per pot.

Crop vigour score - Crop vigour score was taken at 8 weeks after sowing (WAS), using a scale of 0-5 where 5 represents individual plant with the most vigorous growth and 0 for completely killed plant. Each plant was scored separately in each pot.

Striga count - The number of Striga hermonthica seedlings which were attached to the roots of sorghum plants were counted, 11 WAS. This was done by carefully washing the roots of the sorghum plants with water to remove the soil particle from the sorghum.

3.2 Field Trials

3.2.1 Description of experimental site

The two field trials were conducted during 1988 wet season on the commercial farm of Ahmadu Bello University, Mokwa (09°11'N, 5° 4'E) in the Southern Guinea Savanna ecological zone. The site of these two field trials has been reported to have high infestation of Striga hermonthica when cropped with maize in the previous years. Apart from S.hermonthica, other common weeds found at the site are contained in Table 2.

The soil at the site of the two field trials was a sandy loam Details of the physico-chemical composition of the soil are in Table 3.

A total of 708.8mm rainfall was received during the period of crop growth. Details of the distribution of rainfall and temperature during the crop growth at Mokwa are shown in Table 4.

3.2.2 Cultural practices

Land preparation and fertilizer application - The experimental fields was ploughed and then harrowed twi e two weeks later. Basal application of NPK (15:15:15) at the rate of 45kg/ha each of N, P_2O_5, and K_2O mixed thoroughly with the appropriate additional nitrogen fertilizer treatment using urea as source to give three levels of 60, 90 and 120 kg N/ha in the first trial and 60kg N/ha for the second trial. All applications in both trials were done a week after sowing (WAS).

Varietal characteristics - Four of the six varieties evaluated were obtained from International Crop Research Institute for Semi-arid Tropics (ICRISAT) while the remaining two varieties were those of Institute for Agricultural Research (IAR), Samaru, Nigeria.

Table 2: Physico-chemical properties of the soil of experimental site at Mokwa, collected up to a depth of 30cm

Soil Properties	Characteristic level Depth 0-30cm
Physical properties (%)	
Sand	79.00
Silt	16.00
Clay	5.00
Textural class - sandy loam	
Chemical properties	
pH in H_2O	5.80
Organic carbon (%)	0.52
Available phosphorus (ppm)	3.21
Exchangeable cations (meq/100g soil)	
Ca	2.04
Mg	0.34
K	0.10
Total N (%)	0.03

Table 3: Total rainfall and mean temperature at ten days interval during the period of the trial, 1988 wet season at Mokwa

Month	Date	Rainfall (mm)	Temperature (°C) Max[2]	Min[3]
June	21-30	68.40	28.40	23.40
July	1-10	50.80	31.5	23.5
	11-20	100.4	30.6	23.3
	21-31	59.90	32.9	25.5
August	1-10	13.60	33.2	23.7
	11-20	36.50	32.50	23.2
	21-31	61.8	35.54	25.4
September	1-10	199.5	30.5	22.6
	11-20	40.2	31.1	23.3
	21-30	29.1	30.6	22.4
October	1-10	56.60	31.1	23.2
	11-20	Nil	33.5	23.3
	21-30	Nil	37.7	25.7
November	1-10	Nil	34.5	19.1
	11-20	Nil	34.9	18.5
	21-30	Nil	35.3	20.5

[1]millimeter

[2]maximum

[3]minimum

Source: Meteorological Unit, Institute for Agricultural Research, Samaru-Zaria.

Table 4: List of common weed species at experimental site, Mokwa, 1988 wet season

Type of Weeds	Level of infestations
Broadleaved weeds	
Striga hermonthica (Del) Benth	***
Veronica galamensis (Cass) Less	*
Spermacoce ventiallate (L)	*
Spermacoce rutellice (L)	*
Portulaca Oleracea (Linn)	*
Mitracanpus villosus	*
Commelina benghalensis (L)	**
Grassy weeds	
Panicum meximum (Jacq)	*
Rottebollia conchinchinensis (Lour) Clayton	**
Rottebollia exaltata (L)	**
Axonopus compressus (SW) P. Beauv	*
Brachiaria deflexa (Schumacl) C.E.H ex Robyns	*
Bracharia lata (Fig & De Not) Stapf.	*
Cynodon dactylon (L) Pers	*

* Low infestation

** Moderate infestation

*** High infestation

i) L.187: This is a long season variety reaching a height of about 180cm. It is very robust with excellent standability in the field and large drooping leaves. It heads about 126 days and matures at 160 days. The semi-compact and large head is bent into peduncle. The seeds are very bold, yellow and surrounded with straw-coloured glumes. It has been previously classified as Striga resistant variety.

ii) SK 5912: It is a long season semi-dwarf improved local variety reaching a height of about 261cm. It heads in about 130 days and matures between 160 and 165 days. The head is compact and elliptical with bold yellow grains surrounded with brown small glumes. The high yields and the low shedding of seeds at harves due to the structure of the head make this a preferred variety.

iii) ICSV 1002: This is one of the four varieties from ICRISAT. It is a good grain yielder, semi-dwarf reaching a height of about 130cm. Under moderate level of Striga infestation, it is very moderately resistant and tolerant under heavy Striga infestation. The ability of ICSV 1002 to both produce high grain yield and resist/ tolerate Striga hermonthica might have not been unconnected with the two parent stocks used in developing it. One of the parent stocks, E.35-1, an Ethiopian variety, is a good grain yielder while the other parent stock Framida is a Striga resistant variety. The grain are medium sized and creamy in colour. it is an early maturing variety.

iv) ICSV 1005: This is another variety developed by ICRISAT. The seeds are creamy in colour and bold. It is also a semi-dwarf variety reaching a height of about 180cm. It is an early maturing variety. It combines the ability of one of its parent stock Framida

which is Striga resistant to tolerate low level of Striga infestation.

v) ICSV 1007: It is an early maturing variety developed by ICRISAT. It is a semi-dwarf reaching a height of about 150cm. The seeds are less bold. It combines two different resistance mechanism of its parents. 148 (mechanical barriers) and Framida (low stimulant production plus moderate levels of root cell wall thickening). It resists lodging it It heads at about 72 days.

vi) S.35: This is ICRISAT variety developed in Samaru, Nigeria. It is semi-dwarf early maturing variety which exhibits good degree of resistance to Striga hermonthica combined with good grain yield. The seeds are bold and creamy in colour.

3.2.3 Planting and spacings

In the two trials, four seeds of sorghum were sown at a depth of 3cm on the flat at 25cm and 75cm intra-row and inter-row spacing respectively. The crop was later thinned to one plant per stand 3 WAS. Sorghum was planted in the herbicide evaluation trial and the first date of sowing, in sowing date x nitrogen x variety trial on June 23, 1988. Sowing of the second sowing date was done 14 July, 1988.

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3.2.4 Treatments and experimental designs

In the trial on evaluation of the effect of sowing dates and nitrogen levels on the reaction of sorghum varieties to Striga hermonthica the treatments were laid out in a split-split plot design with sowing dates, nitrogen levels and sorghum varieties as the main plot, sub-plot and sub-sub plot treatments respectively. The gross and net plot sizes were 4.0m x 3.75m (15.0m^2) and 4.0m x 0.75m (3.0m^2) respectively. The main plot treatment consisted

of three levels of nitrogen (60, 90 and 120kg N/ha) and six varieties of sorghum, namely, ICSV 1002, ICSV 1005, ICSV 1007, L.187, S.35 and SK 5912.

The treatments of the trial on herbicide evaluation for Striga hermonthica control were laid out in a randomized complete block design (RCBD). The gross and net plots sizes were 4.0m x 3.75m (($15m^2$) and (4.0m x 0.75m ($3.0m^2$) respectively. In this trial, only sorghum variety SK 5912 was tested. There were eighteen Striga hermonthica control treatments consisting of three pre-emergence herbicide treatment mixture of either atrazine plus diflufenican at 1.0 + 0.3kg a.i/ha, atrazine + diflufenican at 1.0 + 0.4kg a.i/ha, atrazine + diflufenican at 1.0 + 0.4kg a.i/ha or atrazine plus terbutrylazine at 1.25 + 1.25kg a.i/ha followed as post-emergence treatments viz hoe-weeding, 2,4-D plus diflufenican at 1.5 + 0.3kg a.i/ha, bromoxynil/MCPA at 2.0kg a.i/ha or bromoxynil/MCPA plus diflufenican at 1.0 + 0.3kg a.i/ha. All herbicide treatments were compared with two hoe-weedings and unweeded controls (Table 5).

3.3 Herbicide Application

Pre-emergence herbicide treatments were applied one day after sowing, while post-emergence treatments except 2,4-D plus diflufenican at 1.5 + 0.3kg a.i/ha were applied at twelve weeks after sowing, when 50% of the field was infested. 2,4-D plus diflufenican at 1.5 + 0.3kg a.i/ha was applied 10 WAS when Striga symptoms were observed on the crop.

For general weed control, atrazine plus terbuthylazine at 1.25 + 1.25kg a.i/ha was also done a day after sowing in trial involving the evaluation of the effect of sowing dates, nitrogen levels on the reaction of sorghum varieties to Striga hermonthica for general weed control. This was later supplemented with one hoe-weeding at 8 WAS.

Table 5: Herbicides treatments for the control of Striga in sorghum

Code	Pre-emergence herbicide mixture	Rate kg a.i/ha	Post-emergence herbicide mixture	Rate kg a.i/ha
T_1	Diflufenican + atrazine	0.3+1.0	-	-
T_2	Diflufenican + atrazine	0.3+1.0	fb.Diflufenican +2,4-D*	0.3+1.5
T_3	Diflufenican + atrazine	0.3+1.0	fb.Dimethametryn+ Diflufenican	1.0+0.3
T_4	Diflufenican + atrazine	0.3+1.0	Hoe-wooding	-
T_5	Diflufenican + atrazine	0.3+1.0	fb. Bromoxynil/ MCPA	2.0
T_6	Diflufenican + atrazine	0.3+1.0	fb. Bromoxynil/ MCPA +Diflufenican	1.0+0.3
T_7	Diflufenican + atrazine	0.4+1.0	-	-
T_8	Diflufenican + atrazine	0.4+1.0	fb. Diflufenican + 2, 4-D*	0.3+1.5
T_9	Diflufenican + atrazine	0.4+1.0	fb.Dimethametryne+ Diflufenican	1.0+0.3
T_{10}	Diflufenican + atrazine	0.4+1.0	fb. Hoe-weeding	-
T_{11}	Diflufenican + atrazine	0.4+1.0	Bronoxynil/MCPA	1.0
T_{12}	Diflufenican + atrazine	0.4+1.0	fb.Bronoxynil/MCPA +Diflufenican	1.0+0.3
T_{13}	Atrazine + terbuthylazine	1.25+1.25	-	-
T_{14}	Atrazine + terbuthylazine	1.25+1.25	fb.Diflufenican + 2, 4 - D*	0.3+1.5

Table 5 cont'd

Code	Pre-emergence herbicide mixture	Rate kg a.i/ha	Post-emergence herbicide mixture	Rate kg a.i/ha
T_{15}	Atrazine + terbuthylazine	1.25+1.25	fb.Dimethametryne +Diflufenican	1.0+0.3
T_{16}	Atrazine + terbuthylazine	1.25+1.25	fb. Hoe-weeding	-
T_{17}	Atrazine + terbuthlazine	1.25+1.25	fb.Bronoxynil/MCPA	2.0
T_{18}	Atrazine+ terbuthlazine	1.25+1.25	fb. Bronoxynil/ MCPA+Diflufenican	1.0+0.3
T_{19}	Unweeded	-	-	-
T_{20}	Hoe-weeded	-	-	-

- = No herbicide application

* = followed by post-emergence treatment at 10 weeks after planting (WAP).

All herbicides were applied with Copper Peggler knapsack sprayer in about 240L/ha spray liquid volume at a pressure of 2.1 kg/cm^2 using a deflector nozzle.

3.4 Crop Protection

Weeding operations were carried out with hand-hoe according to the treatments. The crop was sprayed against aphids at 10 WAS with cypermethrin plus dimethoate at the rate of 0.25 + 1.0kg a.i/ha using a formulated mixture Shepa plus EC.

3.5 Observation and Data Collection

3.5.1 Weed weight

In the herbicide evaluation study, weed samples were taken from 0.75cm^2 quadrat per plot at 4, 6 and 12 WAS to assess the effectiveness of the pre-emergence herbicide treatments on various categories of weeds including S.hermonthica. The samples were cleansed free of soil oven-dried at 70°C to constant weight and weighed for dry matter determination.

3.5.2 Herbicide injury score

Herbicide injury score was done 10 days after pre-emergence herbicide treatment application and at one week after post-emergence treatment application representing 10 DAS, 11 and 13 WAS respectively. Scale of 0 to 5 was used where 0 represented no injury and 5 represented seriously injured plant.

3.5.3 Striga symptoms

Striga symptoms as represented by the number of scorched plants, chlorotic plants and stunted plants per 3m^2 were taken at 10 and 12 WAS while the number of dead plants and percentage of Striga infested sorghum plant per 3 m^2 were taken at harvest in both trials. Striga score was also done in both trial at harvest using a scale of 0 to 5,

where 0 represented no Striga infestation and 5 represented completely Striga infested plots.

3.5.4 Striga counts

The number of emerged Striga shoots was counted per 3 m^2 at 12 and 16 WAS and at harvest in the herbicide evaluation trial and at 10 and 12 WAS at harvest in the trial involving the evaluation of the effect of sowing date, nitrogen level on the reaction of sorghum varieties to Striga hermonthica.

3.5.5 Crop growth parameters

Crop stand count - Crop stand count was taken at 10 WAS, 4 WAS and at harvest in order to assess the effect of treatments on the crop establishment.

Leaf area - All the fourth sorghum plants of the four outer rows were tagged for leaf area measurement. Leaf area per plant was calculated by measuring the length and multiplied by width (at the widest point of the leaf) and multiplied by 0.747 as described by Krishmurthy et al. (1974). In all, four plants were measured and the average for each plot was recorded at 4 and 8 WAS.

Crop height - Crop height measurement was done at 4 and 8 WAS and at harvest. Every 10th plant of four outer rows were tagged for height measurement. Measurement of the crop height was by measuring from the ground level to the tip of the flag leaf of the crop. Four crops were measured and the average for each plot was recorded.

Crop dry matter production - Using systematic sampling, plants were removed from each plot oven dried at 70°C to a constant weight for the determination of dry matter production at 4 and 6 WAS. At harvest the plants in each net plot were cut down and sun-dried before the weight was taken.

Harvesting - Each variety was harvested at full maturity, after the development of black layer at the base of the kernels (Chiezy, 1981). The four early maturing varieties, viz: ICSV 1002, ICSV 1005, ICSV 1007 and S.35 were harvested at 105 days after planting in both sowing dates. The two late maturing varieties of SK5912 and L.137 were harvested at 154 days after planting in the first and the second sowing dates since both were photosensitive. Harvesting of the herbicide evaluation trial was also done at 154 days after planting.

Harvesting was done by cutting the sorghum heads using sharp knife. The weight of sorghum heads per net plot was taken before threshing while the weight of the grain yield and the weight of 1000 seeds were taken after the heads were threshed and winnowed.

3.6 Data Analysis

All data collected were subjected to analysis of variance and the treatment means compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1955). Coefficient of correlation (r) between sorghum grain yield and other parameters were also determined.

CHAPTER 4

RESULTS

4.1 Reactions of Varieties of Sorghum to Striga hermonthica

The preliminary results on the reactions of varieties of sorghum to S.hermonthica as reflected in sorghum vigour and number of S.hermonthica attachment to sorghum plant roots in the green house are presented in Table 6.

VArieties of sorghum differed significantly in crop vigour score at 10 WAS in response to the attack of S.hermonthica. Varieties E.35 and ICSV 1007 had the highest crop vigour while SK 5912 had the lowest. L.187 also had comparable crop vigour score to SK 5912 at 10 WAS.

Siginificant differences were observed between the six varieties of sorghum in the green house on the number of S.hermonthica seedlings attached to the roots of sorghum at 11 WAS. Variety SK 5912 had the highest number of Striga attachment of 19.5 to the roots per pot while ICSV 1007 had none.

4.2 Effects of Sowing Date, Nitrogen Level and Variety of Sorghum on the Growth Parameters of Sorghum

The effects of sowing date, nitrogen level and variety of sorghum on the growth parameters of sorghum viz: crop height, leaf area and dry matter production of sorghum are shown in Tables 7 to 14.

4.2.1 Crop height

Sowing date significantly affected crop height at harvest, while varieties of sorghum differed significantly in crop height at 4 and 6 WAS (Tables,7 and 9).

At harvest sorghum plants sown on June 23 1988 were taller than those of the plants sown on July 14 1988 at harvest. Variety

Table 6 Reaction of varieties of sorghum to Striga hermonthica in the green house, I.A.R/A.B.U. Zaria, February to May 1988.

Treatment	Crop vigour score at 10WAS[1]	Striga count at 11 WAS	
		x	$\sqrt{x+1}$
Variety			
ICSV1002	3.75ab[2]	1.50	1.40bc
ICSV1005	3.38b	2.25	1.70bc
ICSV1007	4.25ab	0.00	1.00c
L. 187	2.88bc	3.75	1.82b
S. 35	4.38a	2.25	1.67bc
SK5912	2.25c	19.5	4.27a
SE (±)	0.28		0.53

1 Weeks after sowing

2 Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability (DMRT).

Table 7 The effect of sowing date, nitrogen level and sorghum variety in crop height, leaf area and dry matter yield at Mokwa, 1988 wet season.

Treatment	Crop height (m) at			Leaf area(dm^2) per plant at		Crop dry matter production g/plant at		(t/ha) at
	4 WAS	6 WAS	Harvest	4 WAS	8 WAS[2]	4 WAS	8 WAS	Harvest
Sowing Date								
23 June	0.43	1.13	1.70a[1]	4.67	37.42a	1.21	21.77	7.48
14 July	0.40	0.99	1.35b	3.65	28.72b	0.69	20.27	5.31
SE (±)	0.02	0.05	0.03	0.32	1.07	0.16	4.04	0.69
	NS	NS	**	NS	**	NS	NS	NS
Nitrogen (kg/ha)(N)								
60	0.39	1.06	1.42	4.20	32.16b	1.05	22.34	5.92
90	0.45	1.09	1.54	4.42	36.13a	0.95	19.50	6.25
120	0.40	1.03	1.62	3.86	30.92b	0.86	21.21	7.01
SE (±)	0.01	0.04	0.08	0.15	0.98	0.08	1.27	0.36
	NS	NS	NS	NS	*	NS	NS	NS
Variety(V)								
ICSV1002	0.42a	1.17a	1.35	4.06	38.88a	1.07	20.74	6.35b
ICSV1005	0.42a	1.03b	1.48	4.82	27.09b	0.82	21.50	4.77c
ICSV1007	0.35b	1.03b	1.40	3.56	29,84b	1.14	24.60	5.37bc
L. 187	0.42a	0.99b	1.59	4.01	37.6)a	0.97	15.54	8.30a
S. 35	0.41a	1.12a	1.50	4.05	28.08b	0.85	21.04	4.50c
SK5912	0.45a	1.03b	1.64	4.46	36.92a	0.87	22.70	9.09a
SE (±)	0.02	0.03	0.06	0.43	1.81	0.10	2.27	0.44
	**	**	NS	NS	**	NS	NS	**
Interactions								
S x N	**	NS	NS	**	NS	NS	NS	NS
S x V	NS	NS	**	NS	*	*	NS	NS
N x V	NS	NS	NS	NS	*	*	NS	NS
S x N x V	NS	NS	NS	NS	**	NS	NS	NS

NS Not significant

*/** Significant at 5%/1% levels of probability

1 Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability (DMRT).

2 Weeks after sowing

ICSV 1007 had shorter sorghum plants than all the other five varieties at 4 WAS, while only plants of ICSV 1002 and S.35 were taller than those of other varieties at 6 WAS (Table 7).

The interaction of sowing date and nitrogen on crop height was significant at 4 WAS (Table 8), while that of sowing date and variety was significant at harvest (Table 9). Plants of sorghum sown on 23 June 1988 and given 120 kgN/ha were taller than those of the crops sown on 14 July 1988 given the same rate of nitrogen. However at 4 WAS, crop sown on 14 July 1988 had taller plants than those sown on 23 June 1988 where 60kgN/ha was applied at 4 WAS. Irrespective of sowing dates, varieties ICSV 1005 and ICSV 1002 did not differ significantly in height at harvest, while the other five varieties had shorter plants when sown on 14 July 1988, compared with the earlier sowing on 23 June 1988. Varieties of SK 5912 and L.187 were significantly taller than the others were sown on June 23, while ICSV 1002 plants were tallest in July sown crop.

4.2.2 Leaf Area

Sowing date, nitrogen level and variety significantly affected leaf area of sorghum plants at 8 WAS (Table 7).

Sorghum plants sown on 23 June 1988 had higher leaf area per plant at 8 WAS than those of plants sown on 14 July 1988. All sorghum plants that received 90kgN/ha gave higher leaf area per plants at 8WAS than those plants that received 60kg N/ha. Varieties ICSV 1002 SK 5912 and L.187 had identical but higher leaf area per plant at 8 WAS than the three other varieties.

The interaction of sowing date and nitrogen was significant at 4 WAS (Table 10), while that of sowing date and variety and second order interaction of nitrogen sowing and date and variety were

Table 8 Interaction of sowing date and nitrogen on crop height at Mokwa, 1988 wet season.

Nitrogen(kg/ha)(N)	Crop plant height(m)/sorghum plant at 4 WAS[1] 23 June	14 July
60	0.37b[1](a)	0.41ab(a)
90	0.46ab (a)	0.44ab(a)
120	0.47a(a)	0.34b(b)

SE (±) for comparison between sowing dates and nitrogen levels 0.02
SE (±) for comparison between sowing dates for a nitrogen level = 0.06

Table 9 The interaction of sowing date and sorghum variety on crop height at Mokwa, 1988 wet season.

Sorghum variety	Crop plant height (m) at harvest 23 June	14 July
ICSV1002	1.58c(a)	1.53d(a)
ICSV1005	1.54cd(a)	1.41e(a)
ICSV1007	1.49de(a)	1.30f(b)
L. 187	1.93b(a)	1.24f(b)
S. 35	1.58c(a)	1.41e(b)
SK5912	2.06a(a)	1.23f(b)

SE (±) for comparison between sowing dates and varieties = 0.03
SE (±) for comparison between sowing dates for a variety = 0.08

1 Weeks after sowing

2 Means followed by the same letter(s) within nitrogen level sowing date, variety and interaction means are not significantly different at 5% level of probability (DNRT).

Significant at 8 WAS (Tables 11 and 12). Although leaf area increased non-significantly as nitrogen level increases with 23 June sowing, significantly lower value was obtained with 120kgN/ha compared with lower rates in the 14 July sown crop. Leaf area with all rates of nitrogen in the 14 July sown crop were significantly lower than that of 23 June sown crop given 120kgN/ha. At 8 WAS when sorghum varieties were sown on 23 June, varieties ICSV 1002 and L.187 had higher leaf area per plant than the other four varieties where as when sowing was delayed until 14 July 1988 varieties SK 5912 had higher leaf area per plant than the others except L.187 (Table 11). Except for varieties ICSV 1007 and L.187 which had lower leaf area per plant at 8WAS, all other varieties had higher leaf area per plant at 90kgN/ha than at either 60 or 120kgN/ha. Varieties ICSV 1005 and S.35 had lower leaf area per plant at 60kgN/ha than at either 90 or 120kgN/ha. Also variety ICSV 1007 had lower leaf area per plant at 90kgN/ha than at 60kgN/ha at 8 WAS (Table 12). The highest leaf area was obtained with SK 5912 given 90kgN/ha, ICSV 1002 given the same rate of nitrogen and L.187 given 120kgN/ha were however comparable.

4.2.3 Crop dry matter production

Varieties of sorghum differed significantly in dry matter production at harvest. Varieties L.187 and Sk 5912 had the highest dry matter production at harvest, while varieties ICSV 1005 and S.35 gave the lowest dry matter production (Table 7).

The interaction of sowing date and variety as well as that of nitrogen and variety were significant on dry matter production at 4 WAS (Table 13, 14). With early sowing, crop dry matter production of varieties ICSV 1002 and ICSV 1007 were comparable but higher than

Table 10 Interaction between sowing date and nitrogen on leaf area per plant at Mokwa, 1988 wet season.

Nitrogen(kg/ha)(N)	Leaf area (dm^2)/sorghum plant at 4 WAS[1] 23 June	14 July
60	4.30ab[2](a)	4.10b(a)
90	4.75ab(a)	4.09b(a)
120	4.90a(a)	2.76c(a)

SE (±) for comparison between sowing dates and nitrogen level = 0.22

SE (±) for comparison between sowing dates for a nitrogen level = 1.05

Table 11 Interaction of sowing date and variety on leaf area per plant at Mokwa, 1988 wet season.

Sorghum variety	Leaf area (dm^2)/sorghum plant at 8 WAS[1] 23 June	14 July
ICSV 1002	48.64a[2](a)	29.13c(b)
ICSV 1005	32.13bc(a)	22.05c(b)
ICSV 1007	32.51bc(a)	27.18c(a)
L. 187	45.57a(a)	29.63(bc(b)
S. 35	28.69c(a)	27.48c(a)
SK 5912	36.99b(a)	36.84b(a)

SE (±) for comparison between sowing dates for a variety = 2.58

SE (±) for comparison between sowing dates for a variety = 2.56

1 Weeks after sowing

2 Means followed by the same letter(s) within nitrogen level sowing date, variety and interaction means are not significantly different at 5% level of probability (DMRT).

Table 12 Interaction between nitrogen and sorghum variety on Leaf area/plant at Mokwa, 1988 wet season.

	Leaf area (dm^2)/sorghum plant at 8 WAS[1]		
	Kg N/ha		
Sorghum variety	60	90	120
ICSV1002	39.42bc(b)	44.62ab(a)	32.64cde(c)
ICSV1005	20.82f(b)	38.80bc(a)	29.64c-f(a)
ICSV1007	38.82f(a)	23.24f(b)	27.f0def(b)
L. 187	39.32bc(a)	33.78cde(b)	39,88abc(a)
S. 35	20.70f(c)	37.16bcd(a)	26.40ef(b)
SK 5912	34.58b-e(b)	49.20a(a)	19.98c-f(c)

SE (±) for comparison between nitrogn levels for a variety = 0.76

SE (±) for comparison between nitrogen levels and varieties = 3.13

Table 13 Interaction between sowing date and sorghum variety on crop dry matter production at Mokwa 1988, wet season.

	Crop dry matter production (g/plant) at 4 WAS	
Sorghum variety	23 June	14 July
ICSV1002	1.56a[2](a)	0.57c(b)
ICSV1005	0.86b(a)	0.78bc(a)
ICSV1007	1.58a(a)	0.69bc(b)
L. 187	1.24ab(a)	0.70bc(b)
S. 35	1.08b(a)	0.62c(a)
SK 5912	0.93bc(a)	0.82bc(a)

SE (±) for comparison between sowing date for a variety = 0.20

SE (±) for comparison between sowing dates and varieties = 0.14

1 Weeks after sowing

2 Means followed by the same letter(s) within nitrogen level. Sowing date sorghum variety and interaction means are not significantly different at 5% level of probability (DMRT).

those of the other varieties and those of all varieties sown late in July at 4 WAS (Table 13). Higher crop dry matter production was obtained with L.187 and ICSV 1007 given 60kgN/ha; ICSV 1002, ICSV 1007 and SK 5912 given 90kgN/ha and ICSV 1005 given 120kgN/ha than other varieties af the same rate respectively. Except for variety L.187 which had higher dry matter production at 60kgN/ha than at 90 or 120kgN/ha at 4 WAS, none of the varieties was significantly affected by different rates of nitrogen (Table 14).

4.3 Effect of sowing date, nitrogen level and variety on striga symptoms and score percentage of striga infested sorghum plant and striga count

The effect of sowing date nitrogen level and variety on Striga symptoms viz: chlorotic plants, scorched plants and percentage of striga infested plants are presented in Tables 15 to 20.

4.3.1 Chlorotic plants

Sowing date and variety significantly affected the number of chlorotic plants at 12 WAS (Tables 15 & 16). Plants of sorghum sown in 23 June 1988 had higher number of chlorotic plants than those of plants sown on 14 July 1988. Varieties L.187 and SK 5912 had lower number of chlorotic plants than the other four varieties at 12 WAS.

The interaction of sowing date and variety was significant at 12 WAS. Except for varieties L.187 and SK 5912 which were not significantly affected by the differences in sowing date, other four varieties had lower number of chlorotic plants at July sowing than at June sown (Table 16).

4.3.2 Scorched plants

Varieties of sorghum significantly differed in the number of scorched plants at 12 WAS (Tables 15, 16). Varieties L.187 and SK 5912 had

Table 14 Interaction between nitrogen and sorghum variety on crop dry matter production at Mokwa 1988 wet season.

	Crop dry matter production(g/plant) at 4 WAS[1]		
	Kg N/ha		
Sorghum variety	60	90	120
ICSV1002	0.99b[2](a)	1.34ab(a)	0.87b(a)
ICSV1005	0.78b(a)	0.63b(a)	1.05ab(a)
ICSV1007	1.28ab(a)	1.25ab(a)	0.93b(a)
L. 187	1.44a(a)	0.[illegible]Cb(b)	0.86b(b)
S. 35	0.96b(a)	0.84(a)	0.75b(a)
SK 5912	0.89b(a)	1.06ab(a)	0.67b(a)

SE (±) for comparison between nitrogen levels for a variety = 0.18

SE (±) for comparison between nitrogen levels and varieties = 0.18

1 Weeks after sowing

2 Means followed by the same letter(s) within nitrogen level variety and interaction mean are not significantly different at 5% level of probability (DMRT).

lower number of scorched plants at 12 WAS.

The interaction of sowing date and variety was significant at 12 WAS. Except for varieties L.187 and SK 5912 which were not significantly affected by differences in sowing date, all other four varieties had higher number of scorched plant when the crop were sown on 23 June, than sowing on 14 July, 1988 (Table 17).

4.3.3 Striga score

Varieties of sorghum differed significantly in Striga score at harvest. Variety ICSV 1007 had a lower Striga score than the other five varieties. Among the other varieties only S.35 had comparable score to ICSV 1007 (Table 15).

The interaction of sowing date and variety was significant on Striga score at harvest. Variety ICSV 1007 consistently had lower Striga score at both sowing dates. The variety and ICSV 1002 had singificantly lower Striga score compared with the maximum with ICSV 1002 in the early sown crop while with S.35 and ICSV 1005 it resulted in lower score than the maximum of ICSV 1002 in the late sow sowing. In the late sown crop, varieties ICSV 1002 and SK 5912 had comparable Striga score to variety L.187 but higher than the other three varieties. While early sowing resulted in significantly lower Striga score in varieties ICSV 1002 and SK 5912, it led to increased Striga score in variety ICSV 1005 (Table 16).

4.3.4 Striga count

Varieties of sorghum differed significantly in Striga count at harvest. Only variety ICSV 1007 had singificantly lower Striga count than varieties SK 5912 and L.187. No significant differences were observed between the other five varieties. Varieties ICSV 1002, ICSV 1005 and S.35 were also comparable to ICSV 1007 in Striga

Table 15 The effects of sowing dates, nitrogen levels and sorghum varieties on Striga symptoms and score, and percentage of infested plants in sorghum at Mokwa, 1988 wet season.

Treatments	Chlorotic plants at 12 WAS[1]	Scorched plants at 12 WAS	Striga score at harvest	% Striga infested sorghum plant at harvest
Sowing date(s)				
23 June	28.52a[2]	12.44	2.60	22.76
14 July	21.93b	5.04	2.60	22.42
SE (±)	0.37	1.66	0.72	7.15
	**	NS	NS	NS
Nitrogen (kg/ha) (N)				
60	24.67	9.39	2.62	21.10
90	25.36	8.58	2.66	24.10
120	25.64	8.25	2.50	19.57
SE (±)	0.91	0.48	0.18	4.43
Variety (V)				
ICSV 1002	31.33a	10.39a	2.88a	22.70ab
ICSV 1005	29.39a	10.49a	2.18a	23.60ab
ICSV 1007	30.44a	11.33a	1.34b	10.83b
L. 187	14.78b	5.06b	2.88a	22.57ab
S. 35	30.33a	10.33a	2.34ab	18.66ab
SK 5912	15.06b	4.89b	3.34a	31.17a
SE (±)	1.37	0.98	0.36	4.70
	**	**	**	*
Interactions				
SxN	NS	NS	NS	NS
SxV	*	**	*	NS
NxV	NS	NS	NS	NS
SxNxV	NS	NS	NS	NS

1 Weeks after sowing

2 Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability (DMRT).

*/** Significant at 5% level and 1% level of probability

NS Not significant.

Table 16 Interaction of sowing date and sorghum variety on number of chlorotic plants at Mokwa, 1988 wet season.

Sorghum variety	Number of chlorotic plant at 12 WAS[1]	
	23 June	14 July
ICSV1002	36.11a[2](a)	26.56b(b)
ICSV1005	34.11a(a)	24.44b(b)
ICSV1007	34.44a(a)	26.44a(b)
L. 187	15.33ac(a)	14.22c(a)
S. 35	35.56a(a)	25.11b(b)
SK 5912	15.56c(a)	14.56c(a)

SE (±) for comparison between sowing dates for a variety = 1.88

SE (±) for comparison between sowing dates and varieties

1 Weeks after sowing

2 Means followed by the same letter(s) within date, variety and interaction mean are not significantly sowing different at 5% level of probability (DMRT).

Table 17 Interaction of sowing date and variety on the number of scorched plants at Mokwa 1988, wet season.

Sorghum variety	Number of scorched plants at 12 WAS[1]	
	23 June	14 July ±
ICSV1002	16.22(a)[2]	4.56(b)
ICSV1005	16.11(a)	4.78(b)
ICSV1007	15.78(a)	6.89(b)
L. 187	5.89(a)	4.22(a)
S. 35	14.89(a)	5.78(b)
SK 5912	5.78(a)	4.00(a)

SE (±) for comparison between sowing dates and varieties = 1.38

SE (±) for comparison between sowing dates for a variety = 2.09

Table 18 Interaction of sowing date and sorghum variety on Striga score at Mokwa 1988 wet season.

Sorghum variety	Striga score at harvest		
	23 June	14 July	Mean(±) 0.36
ICSV1002	2.22b(b)	3.56a(a)	2.88a
ICSV1005	3.56a(a)	2.00b(b)	2.78a
ICSV1007	1.56b(a)	1.00b(a)	1.34b
L. 187	2.88ab(a)	2.88ab(a)	2.88a
S. 35	2.44ab(a)	2.22b(a)	2.34ab
SK 5912	2.88ab(b)	3.78a(a)	3.34a
	2.60	2.60	

Mean (±) 0.72

SE (±) for comparison between sowing dates varieties = 0.52

SE (±) for comparison between sowing dates for a variety=0.43

1 Weeks after sowing

2 Means followed by the same letter(s) within a variety, sowing date & interaction means are not significantly different at 5% level of probability (DMRT).

count. Striga count with varieties ICSV1007 and S.35 were lower by 85.40 and 57.1% respectively compared with maximum obtained with SK5912 at harvest (Table,19).

The interaction of sowing date and nitrogen was significant on Striga count at harvest. With early sowing, Striga count was significantly higher with 90kgN/ha compared with the other rates, while with late sowing, the highest count was obtained with 120kgN/ha (Table, 20).

4.3.5 Percentage of Striga infested - sorghum plants

Varieties of sorghum difered significantly in the percentage of Striga infested sorghum plant at harvest. Only variety ICSV1007 had lower percentage of Striga infested sorghum plants than variety SK5912. There was no significant differences between the other five varieties (Table, 15).

4.4 Effects of sowing date nitrogen level and variety of sorghum on sorghum yield at harvest

The effects of sowing date, nitrogen and variety of sorghum are presented in Tables 21 to 24.

4.4.1 Head weight

Sowing date and variety of sorghum significantly affected sorghum head weight. Sorghum plant sown on 23 June 1988 produced higher head weight than those sown on 14 July, 1988. Variety ICSV1002 had the highest head weight while varieties L.187 and SK5912 both had the lowest head weight(Table, 21). S.35 was next to ICSV1002 in head weight.

The interaction of sowing date and variety was significant on head weight. While variety ICSV1002 had the highest head weight at 23 June 1988 sowing variety S.35 had the highest head weight at 14 July 1988 sowing (Table, 22).

Table 19 The effect of sowing date, nitrogen level and sorghum variety on Striga count, Mokwa, 1988 wet season.

Treatment	Striga count at 10 WAS[1]	12WAS	Harvest
Sowing date(s)			
23 June	0.37	4.33	9.28
14 July	0.06	2.09	5.20
SE (±)	0.17	2.13	3.97
Nitrogen (kg/ha)(N)			
60	0.33	3.83	7.33
90	0.11	3.42	10.53
120	0.19	2.39	9.86
SE (±)	0.71	0.79	0.98
Variety (V)			
ICSV1002	0.33	2.56	9.44ab[2]
ICSV1005	0.28	4.89	9.72ab
ICSV1007	0.00	0.50	2.28b
L. 187	0.22	4.06	11.61a
S. 35	0.17	3.00	6.72ab
SK 5912	0.28	4.28	15.67a
SE (±)	0.16	1.90	3.12
	NS	NS	*
Interactions			
SxN	NS	NS	*
SxV	NS	NS	NS
NxV	NS	NS	NS
SxNxV	NS	NS	NS

1 Weeks after sowing

2 Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability (DMRT).

*/** Significant at 5% / 1% level of probability.

NS not significant.

Table 20 Interaction of sowing date and nitrogen on shoot count of Striga hermonthica at Mokwa 1988 wet season.

Nitrogen (kg/ha)(N)	Shoot count of Striga hermonthica at harvest. 23 June	14 July
60	7.56b[1](a)	7.11b(a)
90	13.44a(a)	7.61b(a)
120	6.83b(a)	12.89a(a)

SE (±) for comparison between sowing dates and nitrogen levels = 1.38

SE (±) for comparison between sowing dates for a variety = 10.11

1 Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (DMRT).

4.4.2 Grain yield

Sowing date, nitrogen and variety of sorghum significantly affected sorghum grain yield. Grain yield of sorghum sown on June 23 was 68.1% higher than the July sown crop.

Increasing the nitrogen level from 60kgN/ha to 90kgN/ha significantly increased the grain yield by 21.7% while further increase to 120kgN/ha did not cause any significant increase compared with 90kgN/ha. Variety S.35 produced the highest grain yield which was 75.12% and 76.53% higher than those of SK 5912 and L.187, respectively. Yields of other varieties followed the order ICSV 1002 > ICSV 1005 > ICSV 1007 > SK 5912 > L.187.

The interactions of sowing date and variety, nitrogen and variety and that of second order interaction between sowing date, nitrogen and variety of sorghum were significant. Irrespective of sowing date variety S.35 had the highest grain yield (Table, 23). Grain yield of late sown S.35 was comparable to early sown ICSV 1007. Varieties ICSV 1007 and S.35 gave higher grain yield at 90kgN/ha than when either 60kgN/ha or 120kgN/ha was applied. Highest grain yield was produced by variety SK 5912 also at 90kgN/ha. Varieties ICSV1002 and S.35 consistently had highest grain yield irrespective of the level of nitrogen. At 60kgN/ha, highest yield was obtained with ICSV 1002 and S.35 while at 90 and 120kgN/ha S.35 produced highest yield (Table, 24).

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4.4.3 Weight of 1000 Seeds

Early sown sorghum produced bigger grains than the late sown crops sorghum differed significantly in grain size. Varieties, L.187, S.35, and SK 5912 had higher grain size than the other three varieties. Neither the effect of sowing date nor nitrogen significantly affected the grain size in the trial (Table, 21).

4.5.C Correlations

Grain yield was positively correlated with leaf area per plant at 8 WAS ($r = 0.22^{*}$), crop height at harvest ($r=0.23^{*}$), number of chlorotic plants at 12 WAS ($r= 0.50^{**}$), number of scorched plants at 12 WAS ($r = 0.45^{**}$), number of scorched plants at 12 WAS ($r = 0.45^{**}$) weight of 1000 seeds ($r = 0.28^{**}$), and head weight ($r = 0.28^{**}$). Negative correlation was also observed between grain yield and Striga count at harvest ($r=0.28^{**}$). Percentage of Striga - infested sorghum plant was negatively correlated with crop height at harvest ($r = 0.23^{*}$) but was positively correlated with Striga count at 12 WAS ($r = 0.52^{**}$) at harvest ($r = 0.73^{**}$) and Striga score at harvest ($r = 0.73^{**}$).

4.6 Effects of Striga control treatments on weed dry matter production, Striga score and count

The effect of herbicide treatments on weed drymatter production, Striga score and Striga count are presented in Table 25.

Table 21 Effect of sowing date, nitrogen and sorghum variety on sorghum yield at Mokwa, 1988 wet season.

Treatments	Head weight (kg/ha)	Grain yield (t/ha)	Weight of 1000 seeds (g)
Sowing date(s)			
23 June	3.50a[1]	1.69a	27.65
14 July	1.23b	0.53b	23.88
SE (±)	0.11	0.05	0.98
	*	*	NS
Nitrogen (kg/ha)(N)			
60	2.06	0.87b	25.95
90	2.36	1.23a	24.91
120	2.63	1.20a	26.45
SE (±)	0.05	0.02	0.85
	NS	**	NS
Variety (V)			
ICSV1002	3.76a	1.53b	21.04b
ICSV1005	2.16c	1.10c	20.81b
ICSV1007	2.23c	0.83d	20.22b
L. 187	1.57d	0.50e	31.10a
S. 35	3.03b	2.13a	31.61a
SK 5912	1.40d	0.53e	29.83a
SE (±)	0.06	0.03	1.34
	**	**	**
Interaction			
SxN	NS	NS	NS
SxV	**	**	NS
NxV	NS	*	NS
SxNxV	NS	**	NS

1 Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability (DMRT).

*/** Significant at 5%/1% level of probability.

NS not significant

Table 22 Interaction of sowing date and sorghum variety on sorghum head weight at Mokwa 1988 wet season.

Sorghum variety	Sorghum head weight (t/ha)	
	23 June	14 July
ICSV1002	6.03[1](a)	1.50f(b)
ICSV1005	3.26c(a)	1.07g(b)
ICSV1007	3.23c(a)	1.27fg(b)
L. 187	2.13d(a)	1.00g(b)
S. 35	4.20b(a)	1.83e(b)
SK5912	2.10de(a)	0.67h(b)

SE(±) for comparison between sowing dates and varieties

SE (±) for comparison between sowing dates for a variety = 0.14

Table 23 Interaction of sowing date and sorghum variety on sorghum grain yield at Mokwa, 1988 wet season.

Sorghum variety	Sorghum Grain yield (t/ha)	
	23 June	14 July
ICSV1002	2.50b[1](a)	0.57g(b)
ICSV1005	1.70c (a)	0.53g(b)
ICSV1007	1.23 (a)	0.43gh(b)
L. 187	0.73f(a)	0.27h(b)
S. 35	2.93a(a)	1.37d(b)
SK 5912	0.90e(a)	0.17h(b)

SE (±) for comparison between sowing dates for a variety = 0.07

SE (±) for comparison between sowing dates and varieties.

1 Mean followed by the same letter(s) within variety, sowing date and interaction means are not significantly different at 5% level of probability (DMRT).

Table 24: Interaction of nitrogen and sorghum variety on sorghum grain yield at Mokwa 1988 wet season.

Sorghum variety	Sorghum Grain yield (t/ha) kg N/ha 60	90	120
ICSV 1002	1.47cd(a)	1.56c(a)	1.54c(a)
ICSV 1005	0.72gh(b)	1.22ef(a)	1.32def(a)
ICSV 1007	0.54hij(c)	1.17f(a)	0.79g(b)
L.187	0.57hij(a)	0.42j(a)	0.57hij(a)
S. 35	1.39cde(c)	2.69a(a)	2.35b(b)
SK 5912	0.50ij(a)	0.40j(a)	0.68gh(a)

SE (±) for comparison between nitrogen levels and varieties =0.06

SE (±) for comparison between nitrogen levels for a variety= 0.06

1 Means followed by the same letter(s) within nitrogen level, sorghum variety and interaction means are not significantly different at 5% level of probability (DMRT).

Table 25 Correlations between sorghum grain yield and various parameters in the effect of sowing dates, nitrogen levels and sorghum varieties at Mokwa 1988 wet season.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.29**													
2	0.50**	0.49**												
3	0.02	-0.07	-0.20*											
4	0.12	0.03	-0.06	0.70**										
5	0.12	0.06	0.06	-0.10	-0.02									
6	0.25**	-0.14	-0.15	0.10	0.12	0.30**								
7	0.04	-0.10	-0.11	0.07	0.18	0.04	0.03							
8	0.03	-0.26**	-0.03	-0.12	-0.07	0.01	-0.02	0.59**						
9	0.04	-0.21*	-0.06	-0.08	-0.03	0.03	0.01	0.65**	0.92**					
10	0.04	-0.23*	-0.07	-0.07	-0.03	0.01	0.03	0.52**	0.73**	0.73**				
11	0.37**	0.32**	0.27**	0.50**	0.47**	-0.23*	-0.03	-0.09	-0.19*	-0.15	-0.13			
12	0.22*	0.23*	0.09	0.50**	0.45**	-0.11	-0.02	-0.06	-0.20*	-0.12	-0.10	0.86**		
13	-0.18	0.32	-0.41	-0.26**	-0.13	0.06	-0.19*	-0.02	-0.11	-0.68	-0.12	0.14	0.28**	
14	-0.02	-0.11	-0.12	0.20**	0.31**	0.18	0.24*	-0.91	0.00	0.02	-0.03	-0.07	-0.07	-0.09

*Significant at 5% level of probability (r=0.19)
**Significant at 1% level of probability (r=0.25)

1 Crop height at harvest
2 Dry matter yield at harvest
3 Chloretic plant at 12 WAS
4 Scorched plant at 12 WAS
5 Crop height at 4 WAS
6 Crop height at 6 WAS
7 Striga control at 12 WAS
8 Striga count at harvest
9 Striga score at harvest
10 % Striga infested sorghum plants at harvest
11 dead weight (t/ha)
12 Grain yield ($t/_{ha}$)
13 Weight of 1000 seeds
14 Crop dry matter (t/ha) at 6 WAP

4.6.1 Weed dry matter production

The effect of Striga control treatments in sorghum differs significantly on weed dry matter production at 4,6 and 12 WAS (Table, 26). There was no significant differ nces among all the pre-emergence treatments at 4 WAS. At 6 WAS and 12 WAS the pre-emergence herbicide treatments and hoe-weeding caused significantly lower weed dry matter production than the unweeded control.

4.6.2 Striga score and count

Herbicide treatments had significant effect on Striga count at 16WAS and at harvest but not on Striga score (Table, 26). At 16 WAS, plot that with pre-emergence a plication of diflufencion plus atrazine 0.4 + 1.0 kg a.i/ha followed by post-emergence application of bromoxynil/MCPA mixture plus diflufenican the rate of 1.00 + 0.30kg a.i/ha had the least Striga count but comparable to diflufenican plus atrazine at 0.30 + 1.0 kg a.i/ha followed by post-emergence application of bromoxynil/MCPA at 2.0kg a.i/ha, pre-emergence application of diflucnican plus atrazine at the rate of 0.40 + 1.00kg a.i/ha and unweeded control. At 16 WAS and harvest the highest number of emerged Striga plants was observed on the plots that received pre-emergence application of diflufenican plus atrazine at the rate of 0.40 + 1.00 kg a.i/ha followed by a hoe weeding both at 16 WAS and at harvest. Supplementary hoe weeding resulted in higher number of emerged Striga plants when it followed pre-emergence application of diflucnican plus atrazine either at the rate of 0.30 + 1.00 or 0.40 + 1.00 kg a.i/ha (Table, 26).

4.7.0 Effect of herbicide treatments in sorghum on herbicide injury score, stand count and percentage of Striga - infested sorghum plants

The effects of Striga control treatment in sorghum on herbicide injury score, stand count and percentage of Striga infested sorghum plants are presented in Table 27.

4.7.1 Herbicide injury score

The effect of herbicide treatments on sorghum differed significantly at 10 DAS, 11 WAS and at 13 WAS. Plots treated with pre-emergence difluencian plus atrzine at the rate of 0.3 + 1.0 and 0.4 + 1.0 kg a.i/ha exhibited some varying degrees of phytotoxicity at 10 DAS. There was no phytotoxicity effects on plots treated with pre-emergence atrazine plus terbuthylazine at 1.25 + 1.25 kg a.i/ha at 11 WAS or at 13 WAS, a week after post-emergence treatments. All the plots that received diflufenican as part of their mixture also exhibited some blenching on their lower leaves a week after post-emergence treatment (Table, 27).

4.7.2 Stand count

The effect of herbicide treatments, did not differ significantly on sorghum stand count at harvest (Table, 27).

4.7.3 Percentage of Striga-infested sorghum plants

The effect of herbicide treatments was significant on the percentage of Striga-infested sorghum plant at harvest. Pre-emergence application of diflufenican plus atrazine at the rate of 0.40 + 1.00 kg a.i/ha resulted in the lowest percentage of Striga-infested plant at harvest. Supplementary hoe-weeding resulted in the highest number of Striga-infested plant at harvest when it followed all the pre-emergence treatments (Table, 27).

Table 26 Effects of herbicide treatments in sorghum on weed dry matter production Striga score and count at Mokwa, 1988 wet season.

Pre-emergence herbicide mixtures	Rate kg a.i/ha	Post-emergence herbicide mixtures	Rate kg a.i/ha	Weed dry matter production at			Striga score at	Striga count at		
				4 WAS	6 WAS	12 WAS	harvest	12 WAS[1]	16 WAS	Harvest
Diflufenican+Atrazine	0.30+1.00	-	-	2.27c[2]	14.72b	95.49b	2.00	1.33	5.00b-d[2]	8.00bc
"	0.30+1.00	fb Diflufenican+2,4-D	0.30+1.50	1.57c	11.37b	76.52b	1.67	0.00	2.67cd	10.33bc
"	0.30+1.00	fb Dimethametryn+ Diflufenican	1.00+0.30	3.38bc	19.10b	80.87b	2.33	19.00	10.33bc	23.67b
"	0.30+1.00	Hoe-weeding	-	1.20c	6.98b	126.97b	2.67	0.33	10.67b	16.67bc
"	0.30+1.00	fb Bromoxynil/MCPA	2.00	1.53c	22.76b	116.81b	1.67	1.00	4.00bcd	5.33c
"	0.30+1.00	fb Bromoxynil/MCPA+ Diflufenican	1.00+0.30	1.10c	28.60b	54.15b	1.00	0.67	1.67d	2.00c
"	0.40+1.00	-	-	2.07c	21.65b	131.46b	1.33	1.00	1.67d	1.67c
"	0.40+1.00	fb Diflufenican+2,4-D	0.30+1.50	0.80c	23.30b	117.43b	2.00	0.00	10.33bc	15.33bc
"	0.40+1.00	fb Dimethametryn+ Diflufenican	1.00+0.30	0.38c	24.46b	63.56b	1.67	3.00	4.67bcd	2.67c
"	0.40+1.00	Hoe-weeding	-	4.53bc	40.35b	103.16b	4.00	7.33	23.00a	58.67a
"	0.40+1.00	fb Bromoxynil/MCPA	2.00	0.38c	19.82b	72.37b	2.33	3.67	6.00bcd	6.33c
"	0.40+1.00	fb Bromoxynil/MCPA+ Diflufenican	1.00+0.30	2.69c	20.28b	73.36b	1.33	7.33	1.33d	6.33c
Atrazine+Terbuthylazine	1.25+1.25	-	-	0.78c	11.82b	127.14b	2.00	2.33	7.33bcd	10.33bc
"	1.25+1.25	fb Diflufenican+2,4-D	0.30+1.50	2.63c	20.57b	88.62b	1.00	1.33	6.33bcd	6.33c
"	1.25+1.25	fb Dimethametryn+ Diflufenican	1.00+0.30	1.06c	18.04b	85.50b	2.00	0.00	3.00bcd	4.67c
"	1.25+1.25	Hoe-weeding	-	0.61c	20.20b	55.84b	2.33	1.00	8.67bcd	14.33bc
"	1.25+1.25	fb Bromoxynil/MCPA	2.00	1.01c	13.43b	138.79b	1.67	6.67	8.33bcd	7.67bc
"	1.25+1.25	fb Bromoxynil/MCPA+ Diflufenican	1.00+0.30	2.13c	23.05b	146.06b	1.33	1.33	2.33cd	4.67c
Unweeded	-	-	-	9.45b	71.83a	314.17a	2.33	0.00	2.00d	4.33c
Hoe-weeded	-	-	-	21.99a	11.73b	23.83b	3.00	3.33	8.67bcd	7.00c
SE (±)				2.14	7.98	41.29	0.78	3.39	2.38	0.24
				*	*	*	NS	NS	**	**

1 Weeks after sowing.
2 Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability(DMRT).
*/** Significant at 5%/1% level of probability.
NS = Not significant.

Table 27 Effects of herbicide treatments in sorghum on herbicide injury score, stand count and percentage of Striga infested sorghum plant at Mokwa in 1988 wet season.

Pre-emergence herbicide mixtures	Rate kg a.i/ha	Post-emergence herbicide mixtures	Rate kg a.i/ha	Herbicide injury score at 10 WAS[2]	Herbicide injury score at 13 WAS[3]	Stand count at harvest	% of infested plant at harvest
Diflufenican+atrazine	0.30+1.00	-	-	2.33a	0.00d	28.00	18.90bc[1]
"	0.30+1.00	fb Diflufenican+2,4-D	0.30+1.50	2.00ab	2.67a	27.67	12.69c
"	0.30+1.00	fb Dimethametryn+diflufenican	1.00+0.30	1.00b	1.67b	26.67	36.23ab
"	0.30+1.00	Hoe-weeding	-	2.67a	0.00d	22.67	34.93ab
"	0.30+1.00	fb Bromoxynil/MCPA+	2.00	3.00a	1.00c	24.33	7.43c
"	0.30+1.00	fb Bromoxynil/MCPA+diflufenican	1.00+0.31	1.67b	1.67b	24.33	6.50
"	0.40+1.00	-	-	3.00a	0.00d	29.33	3.50
"	0.40+1.00	fb Diflufenican+2,4-D	0.30+1.50	0.67b	2.33ab	30.67	17.40bc
"	0.40+1.00	fb Dimethametryne+Diflufenican	1.00+0.30	3.33a	1.00c	29.67	10.57c
"	0.40+1.00	Hoe-weeding	-	2.67a	0.00d	26.67	47.53a
"	0.40+1.00	fb Bromoxynil/MCPA	2.00	3.33a	1.00c	30.00	17.90bc
"	0.40+1.00	fb Bromoxynil/MCPA+Diflufenican	1.00+0.30	2.00ab	1.00c	28.33	10.30c
Atrazine+terbuthylazine	1.25+1.25	-	-	0.33c	0.00d	27.67	19.03bc
"	1.25+1.25	fb Diflufenican+2,4-D	0.30+1.50	0.00c	2.33ab	28.00	10.00c
"	1.25+1.25	fb Dimethametryn+diflufenican	1.00+0.30	0.00c	1.33c	28.67	13.33c
"	1.25+1.25	Hoe-weeding	-	0.00c	0.00d	28.67	24.10bc
"	1.25+1.25	fb Bromoxynil/MCPA	2.00	0.00c	1.33c	28.33	16.50bc
"	1.25+1.25	fb Bromoxynil/MCPA+Diflufenican	1.00+0.30	0.00c	1.33c	27.67	9.53c
Unweeded	-	-	-	0.00c	0.00d	27.67	9.83c
Hoe-weeded	-	-	-	0.00c	0.00d	30.67	10.57bc
SE (±)				0.49[c]	0.28	1.68	5.27
				*	**	NS	*

1 Means followed by the same letter(s) within the same column and treatment are not significant at 5% level of probability (DMRT).
2 Days after sowing
3 Weeks after sowing

NS Not significant
*/** Significant at 5%/1% levels of probability

4.8.0 Effects of Striga control treatments in sorghum on sorghum yield and yield components

The effect of herbicide treatments on sorghum yield are presented in Table 28.

4.8.1 Head weight

The effect of Striga control treatments was significant on sorghum head weight. All the herbicide treatments resulted in comparable head weight to two hoe-weedings. Amongs the herbicide treatments the bigest head weight was obtained from atrazine plus terbuthylazine at the rare of 1.25+1.25kg a.i/ha applied pre-emergent alone. Unweeded plots had the least head weight (Table 28).

4.8.2 Grain yield

The herbicide treatments significantly affected sorghum grain yield. The best herbicide in the trial with resulting in highest grain yield. Yield with the treatment was higher than the unweeded control by 76.7%

Two hoe-weeding also resulted in 65.2% higher grain yield than the unweeded control. Except for pre - emergence application of diflufenican plus atrazine at the rate of 0.3+1.0kg a.i/ha followed by either diflufenican plus 2, 4 - D amine at 0.30+1.50kg a.i/ha, dimethametryne diflufenican at 1.00+0.30kg a.i/ha or bromoxynil/MCPA at 1.0+1.0kg a.i/ha and pre-emergence application of diflufenican plus atrazine at the rate of 0.4+1.0kg a.i/ha followed by dimethametryne plus diflufenican at the rate of 1.0+0.30kg a.i/ha or bromoxynil + MCPA at the rate of 1.00+1.00kg a.i/ha or bromoxynil+ MCPA at the rate of 1.00+1.00kg a.i/ha which caused lower grain production all the other herbicide treatements resulted in significantly higher or comparable grain yield with two hoe-weeding (Table 28).

4.8.3 Weight of 1,000 seeds

The herbicide treatments did not have any effect on the weight of 1,000 seeds in the Trial (Table 27).

4.9 Correlation

Grain yield was positively correlated with head weight (r=0.95**), and weight of 1000 seeds (r=0.52***). Grain yield was negatively correlated with number of chlorotic plants (r=0.46**), Striga count at 16 WAS (r=0.026*) and percentage of Striga infested sorghum plants at harvest(r=-0.32*) (Table 29).

Table 28 Effects of herbicide treatments in sorghum on sorghum yield at Mokwa 1988 wet season.

Pre-emergence herbicide mixtures	Rate kg a.i./ha	Post-emergence herbicide mixture	Rate kg a.i./ha	Head weight(t/ha)	Grain yield (t/ha)	Wt of 1,000 seeds(g)
Diflufenican+Atrazine	0.30+1.00	-	-	2.89abc[1]	1.00a-d	35.10
"	0.30+1.00 fb	Diflufenican+2,4-D	0.30+1.50	1.94c	0.95bcd	33.30
"	0.30+1.00 fb	Dimethametryn+Diflufenican	1.00+0.30	1.89c	0.82bcd	35.25
"	0.30+1.00 fb	Hoe-weeding	-	2.45bc	1.31abc	33.27
"	0.30+1.00 fb	Bromoxynil/MCPA	2.00	3.01abc	0.95bcd	36.57
"	0.30+1.00 fb	Bromoxynil/MCPA+Diflufenican	1.00+0.30	3.31a	1.43abc	34.33
"	0.40+1.00	-	-	3.21ab	1.62ab	37.97
"	0.40+1.00 fb	Diflufenican + 2,4-D	0.30+1.50	2.84abc	1.33abc	34.83
"	0.40+1.00 fb	Dimethametryn+Diflufenican	1.00+0.30	2.73abc	0.84bcd	32.37
"	0.40+1.00 fb	Hoe-weeding	-	2.38bc	0.70cd	34.27
"	0.40+1.00 fb	Bromoxynil/MCPA	2.00	2.06c	0.77bcd	33.32
"	0.40+1.00 fb	Bromoxynil/MCPA+Diflufenican	1.00+0.30	2.78abc	1.30abc	34.40
Atrazine + Terbuthylazine	1.25+1.25 fb	-	-	3.57a	1.80a	35.03
"	1.25+1.25 fb	Bromoxynil+2,4-D	0.30+1.50	2.02c	0.92bcd	36.27
"	1.25+1.25 fb	Dimethametryn+Diflufenican	1.00+0.30	2.05c	1.19a-d	32.63
"	1.25+1.25 fb	Hoe-weeding	-	3.24ab	1.44abc	35.93
"	1.25+1.25 fb	Bromoxynil/MCPA	2.00	2.38bc	1.21a-d	34.43
"	1.25+1.25 fb	Bromoxynil/MCPA+Diflufenican	1.00+0.30	3.31ab	1.58ab	35.53
Unweeded	-	-	-	1.68d	0.42e	32.77
Hoe-weeded	-	-	-	2.58abc	1.21a-d	34.30
SE (±)				0.35	0.24	1.61
				**	*	NS

1 Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability (DMRT).

*/** Significant at 5%/1% level of probability.

Table 29 Correlation of various parameters and sorghum grain yield in the effect of herbicide treatments for the control of Striga in sorghum trial.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	-0.02														
2	0.08	0.08													
3	0.15	0.15	-0.25												
4	-0.31*	-0.31*	0.02	0.14											
5	-0.16	-0.16	-0.04	0.03	-0.07	[illegible]									
6	-0.33**	-0.33**	-0.27*	0.23	0.59	-0.07									
7	0.07	0.07	-0.20	-0.10	-0.83**	0.07	0.45**								
8	-0.02	0.02	-0.10	-0.11	0.23	-0.08	0.33**	0.64**							
9	-0.03	-0.03	-0.14	-0.17	0.17	0.05	0.25*	0.60**	0.77**						
10	-0.08	0.68	0.36**	0.22	-0.51**	0.03	-0.67**	0.22	-0.24	-0.16					
11	0.11	-0.11	0.32*	0.26*	-0.56**	0.01	-0.69**	0.23	-0.25*	0.19	0.98**				
12	-0.06	-0.06	0.19	0.02	-0.47**	0.02	-0.58**	-0.18	-0.25*	-0.11	0.95**	0.92**			
13	-0.15	-0.15	0.16	0.01	-0.40**	0.04	-0.45**	0.11	-0.18	-0.11	0.90**	0.88**	0.97**		
14	-0.01	0.01	0.23	0.10	-0.18	-0.02	-0.33	-0.08	10.18	-0.13	0.54**	0.50**	0.52**	0.57**	
15	-0.06	0.06	-0.18	-0.13	-0.21	0.05	0.36**	0.57*	0.87**	0.79**	-0.37**	-0.34**	-0.32*	-0.31*	-0.32*

* Significant at 5% level of probability (r=0.25); ** Significant at 1% level of probability (r=0.33)

1 Herbicide injury score at 12 WAS
2 Sorghum dry matter yield (t/ha) at harvest
3 Sorghum dry matter yield/plant at harvest
4 Chlorotic plants at 10 WAS
5 Stunted plants at harvest
6 Dead plants at harvest
7 Striga count at 12 WAS
8 Striga count at 16 WAS
9 Striga count at harvest
10 Head weight (t/ha)
11 (Head weight/plant
12 Grain yield (t/ha)
13 Grain weight/head
14 Weight of 1000 seeds
15 % Striga infested sorghum plant at harvest

Chapter 5

DISCUSSION

The higher grain yield of 1.69 t/ha. and 1.80 t/ha. obtained in the two field trials conducted in this study are lower than 2.24 t/ha. and 2.30 t/ha earlier reported by Chiezey (1981) and Choudhary and Lagoke (1980) for the same crop. High Striga infestation on the site of the trials and low yield potential of the Striga - resistant tolerant sorghum varieties tested were probably responsible for the low yields of sorghum obtained in these trials. In the herbicide trial where Striga infestation was reduced by pre-emergence herbicide, the delay in the sowing of the medium maturing variety SK 5912 used in the study until late June might have also contributed to the low yield. Low sorghum grain yield of 1.30 t/ha and 1.25 t/ha have also been reported by Carson (1986) and ICRISAT (1988) in Striga infested fields. The reliance of Striga hermonthica on his host for both nutrient, water and manufactured food including carbohydrates and some amino acid, the alteration of hormonal balance with consequent distruption of physiological process in the host and the production of toxin in the host plant have been reported responsible for depression in the yield of sorghum by the parasite (Doggest, 1965, Dronna and El-Hiwewise, 1979; Shah and Stewart, 1987, Lagoke and Adesoun, 1989).

5.1 Effect of sowing date on sorghum and Striga hermonthica

Delayed sowing until 14th July reduced crop height at harvest, leaf area at 8 WAS, head weight and grain yield drastically compared with early sowing on June 23, 1988. The response of the crop to early sowing may be attributed to exposure to longer rainfall period within the season resulting in enhanced growth and utilization of available resources including nutrients. Although similar observation was made by Lawal, (1989) at Samaru, reports on the effect of sowing date on grain yield of sorghum have however not been consistent, Curtis (1965), Andrew (1975) and Ogunlela (1983) have similarly reported higher grain yield with early sowing date. Assis et al., (1978) however reported increase in grain yield of sorghum with delay up to July.

Remaiah (1983) reported that delayed sowing reduced both the number of emerged Striga shoot in sorghum and crop grain yield. Early sowing favour early emergence of Striga compared with late sowing when moisture is limiting (Andrew, 1945, Ramaiah, 1987,) Parker (1978) and Ogborn (1975) reported that main emergence of Striga hermonthica occured in late August and September.

5.2 Effect of Nitrogen on Sorghum and Striga hermonthica

The significant higher grain yield obtained with 90kgN/ha compared with 60kgN/ha inspite of non-significant increased in Striga shoot count at harvest suggests that increased nitrogen level merely improved the crop tolerance to Striga in this study as was earlier proposed by Lagoke et al (1988).

In fact nitrogen did not have significant effect on all the Striga parameters measured in this study, while it was apparent that 90kgN/ha was adequate for good sorghum grain yield. Babawi (1981) had earlier reported that there was no consistent evidence that host response to N - fertilizer would invariably depress Striga infestation. Pieterse (1985) also reported that the effect of nitrogen is not always apparent and that high levels are needed to suppress Striga. Ogborn (1984) also suggested that higher concentration of N in the host root would inhibit Striga parasitism in sorghum. In this study, even at 120kgN/ha Striga parameters where not significantly reduced while slight depression in growth and yield parameters of the crop was observed.

5.3 Reaction of Varieties of Sorghum to Striga hermonthica:

Varieties of sorghum defered significantly in their reaction to S. hermonthica both in the greenhouse and in the field. Variety ICSV 1007 consistently had the lowest number of Striga attack in the greenhouse and supported the least Striga number under field condition. Other parameters measured in the field such as Striga score and percentage of Striga infested- sorghum plant, all at Sorghum harvest, were lowest in variety ICSV 1007 acmpared with other five varieties. Ramaiah (1988) reported that high level of resistance in ICSV 1007 was as a result of combination of low stimulant production and mechanical barrier mainly derived from Franda - very resistant variety.

The finding from this study agrees with that of Lagoke (1987) and Lagoke (1989) who reported that variety ICSV1007 exhibited high level of resistance under field condition at Mokwa in Nigeria and Garona in Cameroon. The bigger grain size produced by variety S.35 and its tolerant to the weed as reflected in Striga score and the number of Striga shoots at sorghum harvest was responsible for higher grain yield production by the variety compared with ICSV1002 which also produced high head weight. The higher head weight and grain yield of ICSV1002 compared with ICSV1005, L.187 and SK 5912 inspite of comparable number of emerged Striga shoots, Striga score and percentage of Striga infested-sorghum plant, confirms the tolerance of ICSV1002 to Striga as earlier reported by Carson (1985, 1986, 1989) and Ramaiah (1985, 1986). The head weight and grain yields of varieties SK5912 and L.187 were the lowest due to their susceptibility to Striga even though they produced higher leaf area at 8WAS than S.35, ICSV1005 and ICSV1007. Although variety ICSV1007 was the most resistant as reflected in all the Striga parameters taken, its yield was lower than those of ICSV 1002, ICSV 1005 and S.35. Pierterse (1985) has reported that based on many genes conditioning yield, resistance to Striga is generally associated with low grain yield and quality. The lowest grain yield produced by variety L.187 as a result of its susceptibility to Striga attack was at variance with an earlier suggestion that it was resistant to Striga (Obilana, 1983[b].) Similarly, Lagoke et al (1990) have reported the high susceptibility of L.187 to S. hermonthica irrespective of sowing date and nitrogen level.

5.4 Effect of herbicide treatments on sorghum and Striga hermonthica:

The non-significant differences between the Striga control treatments on stand count at harvest may be attributed to the fact that Striga infestation started late in the season when the crop had established on the field. Consequently, the parasitic effect of Striga on the crop in plots where Striga was not effectively controlled later in the season was more pronounced on grain yield, whose development coincided with the period of rapid emergence and active growth of the weed. It has been observed that Striga emerges late in variety SK 5912 (Lagoke Pers. comm). Some degree of leaf bleaching was observed during the first two weeks of emergence on sorghum plants of all the plots that received diflufenican as part of their herbicide mixture. This was as a result of interference of diflufenican with the production of plytoene, a chlorophyll precursor in the plant. However, all the crops recovered about three weeks, after application.

The plots treated with pre-emergence application of diflufenican plus atrazine at 0.40 + 1.0kg a.i/ha alone consistently had the lowest percentage of Striga infested plant at harvest and number of emerged Striga shoot both at 16 WAS and at harvest. The effectiveness of low rate of atrazine was improved by diflufenican since low rate has been observed ineffective for the control of Striga in sorghum (Hamdoun, 1969, Babawi and Farah, 1981b).

The inability of post-emergence herbicide treatment to effectively suppress Striga population at 16 WAS and at harvest could be due to the time of application. Diflufenican plus 2.4 - D amine at 0.30 + 1.50kg a.i/ha was applied 10 WAS when Striga symptoms were observed on the crop while the other post emergence treatment were applied 12 WAS when 30% of the field was infested with Striga. In effect, the emerged Striga and other weeds were killed by post-emergence herbicide but this did not prevent further emergence to allow the crop escape parasitism (Mbaa, 1988).

The significantly higher head weight and grain yield obtained from plots treated with only pre-emergence application of atrazine plus terbuthylazine at 1.25kg a.i/ha and diflufenican plus atrazine at 0.40 + 1.00kg a.i/ha alone was due to the rate used and their efficacy in preventing or delaying Striga emergence and possible damages through hoe-weeding and phytotoxicity of post-emergence herbicide were avoided. Similar efficacy of diflufenican in delaying/preventing Striga emergence has been reported in Nigeria and Cameroon by Lagoke et al (1988) and Parkinson et al (1988), respectively.

The depression in head weight and grain yield recorded in the plots treated with pre-emergence application of diflufenican plus atrazine at 0.30 + 1.00kg a.i/ha or at 0.40 + 1.00kg a.i/ha followed by post-emergence dimethametryn plus at 1.00 + 0.30kg diflufenican a.i/ha or supplementary hoe-weeding was as a result of Striga parasitism as reflected in the numb r of emerged Striga shoot both at 16WAS and at harvest. The highest number of emerged Striga shoot observed in the plots that received supplementary hoe-weeding was due to breaking of apical

dominance of the parasite through hoeing which in effect stimulated the sprouting of subterranean lateral buds, hence shoot emergence.

5.5 INTERACTIONS

5.5.1 Sowing date and nitrogen

The interactions between sowing date and nitrogen on leaf area and crop height both at 4WAS show that the effect of nitrogen was more pronounced at the early stage of growth. The progressive increase in leaf area and crop height as the nitrogen level was increased from 60 to 120kgN/ha at 23 June sowing, and decrease at the 14 July sowing indicated that with early sowing the crop was more efficient in the use of higher nitrogen level applied because of adequate rainfall. Rainfall enhanced dissolution of applied nitrogen and hence rapid uptake and growth early sown crops (Lawal, 1989).

5.5.2 Sowing date and Variety:

The interaction between sowing date and variety on crop height at harvest, dry matter at 4 WAS, leaf areas at 8WAS, *Striga* score at harvest, head weight and grain yield show that varieties of sorghum tested reacted differently to sowing date possibly because of the individual response to moisture regime. This was evidently reflected in the *Striga* score at harvest. While *Striga* score was lower with the July sowing in variety ICSV 1005, it was higher in varieties ICSV1C02 and SK 5912; the other varieties had comparable *Striga* score irrespective of the sowing date.

5.5.3 Nitrogen and Variety:

The significant interactions between nitrogen level and variety on leaf area at 8 WAS and grain yield indicated that the amount of nitrogen needed to suppress Striga varies with cultivars tested. While variety S.35 consistently had the highest grain yield both at 90 and 120kgN/ha and comparable grain yield with variety ICSV1002 at 60kgN/ha, varieties SK5912 and L.187 consistently had the lowest grain yield irrespective of the nitrogen level applied.

The low grain yield of varieties SK5912 and L.187 was due to their susceptibility to Striga despite high nitrogen applic tion. Deke (1988) has reported that susceptible varieties such as SK 5912 and L. 187 needed to exhibit some level of resistance before they can make good use of higher level of nitrogen.

5.6 Correlations

The negative correlations between grain yield and Striga count and other Striga parameters measured in the two trials indicated that Striga parasitism on sorghum reduces grain yield seriously. Similar observation has been reported reported by Ramaiah (1983), Deke (1988) and Orinkhi (1988).

The positive correlation observed between the grain yield and the number of chlorotic and scorched plants at 12WAS in the evaluation of date of sowing, nitrogen level on the reaction of variety of sorghum to Striga trial was due to the time of data collection.

These parameters may not however be a strong indication of Striga parasitism in sorghum contrary to earlier observation by Parkinson (1988) in maize.

The high positive correlations between grain yield and leaf area, grain yield, head weight and the weight of 1000 seeds revealed these as important yield component and critical determinants of sorghum grain yield. The result conforms with finding of Chizoy (1981) who also observed positive correlation between grain yield and leaf area and other yield components.

Chapter 6

SUMMARY AND CONCLUSION

A green House experiment was conducted at the Institute for Agricultural Research, A.B.U., Samaru-Zaria (11 10' N°7 35'E) in the Northern Guinea Savanna ecological zone and two field trials during the 1988 wet season on the commercial farm of Ahmadu Bello University, Mokwa (09 18'N 5°4'E) in the southern Guinea Savanna ecological zone to evaluate the effects of sowing dates, nitrogen levels, varieties of sorghum and herbicides on Striga hermonthica in the crop.

The experiment in the greenhouse was arranged in a completely randomized design having six varieties as treatments and repeated three times. In the field, the effects of sowing dates, nitrogen levels and varieties of sorghum trial were evaluated in split-split plot design with sowing date, nitrogen level and variety as main plot, sub-plot and sub-sub-plot treatments respectively and replicated three times. Eighteen pre-emergence and post-emergence herbicide applications for the control of Stria hermonthica in sorghum varieties SK5912 trial, were compared with two hoe-weedings and unweeded check in a randomized complete block design and replicated three times.

The results obtained indicate that sorghum variety ICSV 1007 consistently exhibited the highest level of resistance both in the greenhouse and in the field but its yield was lower than that of ICSV1005, ICSV 1002 and S.35 in the field.

Sorghum plant sown on 23 June, 1988 had significantly higher leaf area and number of chlorotic plants than those of plants sown on 14 July, 1988. Conversely, sorghum head weight and grain yield were higher at 23 June sowing by 68.6% and 64.2% respectively. The effect of nitrogen was not significant on all the Striga paranetors studied but increasing the nitrogen level from 60kgN/ha to 90kgN/ha significantly increased the grain yield by 21.7% while further increase to 120kgN/ha did not cause any significant increase compared to 90kgN/ha. variety S.35 was the best in terms of tolerance to Striga and grain yield with 76.6% yield increase over the least grain yielder L. 187.

Significant interaction between sowing date and nitrogen on crop height, leaf area, Striga count; between sowing date and variety on crop height and Striga score the number of chlorotic and scorched plants, head weight and grain yeidl; between nitrogen and variety on leaf area and grain yield and second order interaction between sowing date x nitrogen level x variety on leaf area and grain yield. Grain yield was negatively correlated with Striga count.

In the herbicide evaluation trial, the two outstanding herbicide treatments in terms of percentage of Striga infested plant, head weight and grain yield were atrazine plus terbuthylazine at 1.25 + 1.25kg a.i/ha and diflufenican plus atrazine at 0.40 + 1.00kg a.i/ha both applied alone without supplementary hoe-weeding or post-emergence herbicide treatments which had 76.7% and 74.1% grain yield increase respectively over the unweeded control.

Supplementary hoe-weeding resulted in higher number of emerged Striga plants and the percentage of Striga-infested plant when it followed pre-emergence application of diflufenican plus atrazine either at 0.30 + 1.00 or at 0.40 + 1.00kg a.i/ha. Grain yield was negatively correlated with Striga counts, and the percentage of Striga infested plants.

In conclusion, results from these studies suggest that:-

1. Sowing early when adequate rainfall prevails is advisable for better sorghum grain yield than late sowing when rainfall is limiting eventhough Striga emergence may be less in the late sown.

2. For tolerante/resistant variety 90kgN/ha is quite adequate for sorghum to produce economic grain yield in the presence of Striga.

3. Based on their reaction to Striga hermonthica, the six varieties can be classed as follows:
   a. Resistant - ICSV 1007,
   b. Tolerant - S. 35; ICSV 1002, ICSV 1005,
   c. Susceptible - SK5912, L. 187.

• Soil persistent herbicides could be effective in delaying/preventing Striga infestation and increase sorghum grain yield in Striga infested field.

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Appendix 1: Means squares from analysis of variance for crop vigour and Striga count as affected by varieties of sorghum in the green house.

Source of variation	DF	Crop vigour score at 10 WAS	Striga Count at 11 WAS
Treatment	5	2.69**	5.37**
Error	18	0.32	1.12
Total	23		

** Significant at 1% level of probability

WAS = Week after sowing.

Appendix 2: Mean squares from analysis of variance for crop height as affected by sowing date, nitrogen and variety at Mokwa, 1988 wet season.

Source of variation	DF	Crop heights at 4WAS	6WAS	Harvest
Replication	2	0.08	0.172	0.36
Sowing date	1	0.03	0.510	3.17**
Error (a)	2	0.02	0.120	0.04
Nitrogen	2	0.04	0.026	0.35*
Nitrogen x sowing date	2	0.07*	0.035	0.07
Error (b)	8	0.007	0.047	0.04
Variety	5	0.02*	0.084	0.14
Variety x sowing date	5	0.008	0.036	0.48**
Variety x nitrogen	10	0.01	0.014	0.09
Variety x nitrogen x sowing date	10	0.009	0.012	0.04
Error (c)	60	0.007	0.019	0.07
Total	107			

** significant at 5/1% level of probability

Appendix 3: Mean squares from analysis of variance for leaf area per plant as affected by sowing date, nitrogen and variety at Mokwa, 1988 wet season.

		Leaf area per plant $(dm)^2$ at	
Source of variation	DF	4WAS	8WAS
Replication	2	18.105	22.431
Sowing date	1	28.060	2043.50**
Error (a)	2	5.601	62.132
Nitrogen	2	2.855	266.36*
Nitrogen x sowing date	2	9.853**	292.88*
Error (b)	8	.860	34.298
Variety	5	3.327	504.345**
Variety x sowing date	5	2.334	240.520**
Variety x nitrogen	10	2.982	27.715**
Variety x nitrogen x sowing date	10	5.651	227.25**
Error (c)	60	3.301	58.927
Total	107		

*/** Significant at 5/1% level of probability

Appendix 4: Mean squares from analysis of variance for crop dry matter production as affected by sowing date nitrogen and variety at Mokwa, 1988 wet season.

Source of variation	DF	Crop dry matter at 4WAS	6WAS	Harvest
Replication	2	2.34	203.27	9.06
Sowing date	1	7.15	60.59	127.14
Error (a)	2	1.33	882.41	25.99
Nitrogen	2	0.34	72.50	11.36
Nitrogen x sowing date	2	0.78	78.94	1.36
Error (b)	8	0.26	58.01	4.72
Variety	5	0.30	165.80	65.40**
Variety x sowing date	5	0.65**	103.52	8.45
Variety x nitrogen	10	0.38*	141.05	2.96
Variety x nitrogen x sowing date	10	0.25	132.94	2.42
Error (c)	60	0.19	92.14	3.45
Total	107			

1 Week after sowing

* Significant at 5% level of probability

** Significant at 1% level of probability.

Appendix 5: Mean squares from analysis of variance for Striga symptoms viz: Chlorotic plants sourced plant and percent infested plant as affected by sowing date nitrogen and variety at Mokwa, 1988 wet season.

		Scorched plant	Chlorotic plant	% infested
		at	at	Plant at
Source of variation	DF	12WAS	12WAS	Harvest
Replication	2	419.59	1197.00	2355.00
Sowing date	1	1481.50	1173.50**	148.59
Error (a)	2	149.50	7.26	1382.00
Nitrogen	2	12.34	9.03	191.43
Nitrogen x sowing date	2	4.4.29	73.45	568.06
Error (b)	8	8.45	29.63	708.35
Variety	5	155.86**	1154.00**	800.60**
Variety and sowing date	5	92.97**	85.55*	545.71
Variety x nitrogen	10	13.11	30.04	228.14
Variety x nitrogen x sowing date	10	10.88	52.02	236.73
Error (c)	60	17.17	33.61	397.52
Total	107			

1 Weed after sowing */** significant at 5/1% level of probability.

Appendix 6: Mean squares from analysis of variance for Striga count and Striga score as affected by sowing date nitrogen and variety of 1988 wet season.

Source of variation	DF	Striga count at 10WAS	Striga count at 12WAS	Striga score at Harvest	Striga score at Harvest
Replication	2	0.898	111.81	698.51	2.926
Sowing date	1	2.676	135.56	0.145	0.331
Error (a)	2	1.509	245.48	850.18	7.000
Nitrogen	2	0.454	19.90	102.23	0.065
Nitrogen x sowing date	2	0.898	33.95	318.98**	0.528
Error (b)	8	0.426	22.51	34.77	0.269
Variety	5	0.254	44.97	367.24**	2.170**
Variety x sowing date	5	0.298	51.32	148.24	1.178*
Variety x nitrogen	10	0.376	55.97	81.24	0.887
Variety x nitrogen x sowing date	10	0.487	69.24	197.92	0.572
Error (c)	60	0.452	65.11	175.01	0.600
Total	107				

1 Week after sowing

*/** significant at 5/1% level of probability.

Appendix 7: Mean squares from analysis of variance for sorghum yield as affected by sowing date, nitrogen and variety at Mokwa, 1988 wet season

Source of Variation	DF	Head weight (t/ha)	Grain yield (t/ha)	Weight of 1000 Seeds (g)
Replication	2	0.016	0.160	65.433
Sowing date	1	12.546*	3.020*	384.010
Error (a)	2	0.674	0.140	54.158
Nitrogen	2	0.268	0.138**	22.302
Nitrogen x sowing date	2	0.065	0.007	28.143
Error (b)	8	0.095	0.012	25.940
Variety	5	1.307**	0.658**	564.10**
Variety x sowing date	5	0.583**	0.126**	25.500
Variety x nitrogen	10	0.061	0.0429	18.792
Variety x nitrogen x sowing date	10	0.087	0.050*	22.323
Error (c)	60	0.075	0.022	32.513
Total	107			

*/** significant at 5/1% level of probability.

Appendix 8: Mean square from analysis of variance for general weed dry matter production and stand count as affected by harbicide treatments for the control of S. hermonthica in sorghum

		Weed dry matter production at			Stand count at
Source of variation	DF	4WAS	6WAS	12WAS	Harvest
Replication	3	37.651	211.156	445.031	65.400
Treatment	19	71.888 *	565.705**	10391.900*	12.873
Residual	38	13.714	191.111	5114.58	8.47
Total	59				

Appendix 9: Mean square from analysis of variance for Striga symptoms as affected herbicide treatments for the control of S. hermonthica in sorghum.

		Scorched plant at	Chlorotic plant at	Stunted plant at	Dead plant at
Source of variation	DF	10WAS	10WAS	Harvest	Harvest
Replication	3	0.517	81.450	0.267	253.217
Treatment	19	0.453	4.242	1.067	16.561
Error	38	0.376	3.028	0.635	18.795
Total	59				

*/** significant at 5/1% level of probability.

WAS = Week after sowing.

Appendix 10: Mean square from analysis of variance for percent Striga infested sorghum plants, Striga score and counts as affected by herbicide treatments for the control of S. hermathica in sorghum.

		Striga hermonthica counts at		Striga score at	%infested plant at	
Source of variation	DF	12WAS	16WAS	Harvest	Harvest	Harvest
Replication	2	245.45	53.52	44.820	0.317	65.310
Treatment	19	59.85	84.77**	47.160**	1.645	359.560**
Error	38	61.85	16.98	71.980	1.807	107.030
Total	59					

Appendix 11: Mean square from analysis of variance for sorghum yield as affected by herbicide treatments for the control of S. hermonthica in sorghum.

		Head weight	Grainyield	Weight of 1000 seeds
Source of variation	DF	(t/ha)	(t/ha)	(g)
Replication	2	6.120	2.850	68.301
Treatment	19	0.960**	0.360*	6.000
Error	38	0.360	0.180	7.724
Total	59			

*/** significant at 5/1% level of probability.

Appendix 12: Mean squares from analysis of variance of herbicide injury score as affected by herbicide treatments for the control of S. hermonthica in sorghum Mokwa, 1988 wet season.

Source of variation	DF	Herbicide injury score at 10DAYS	13WAS
Replication	3	1.250	0.417
Treatment	19	5.214**	2.968**
Error	38	0.706	0.223
Total	59		

DAS = Days after sowing
WAS = Week after sowing
*/** = Significant at 5%/1% level of probability.

Appendix 13. Common chemical and trade names, LD. 50 and solubility of the herbicide mentioned in

COMMON NAME	CHEMICAL NAME	TRADE NAME	LD 50	SOLUBILITY
Atrazine	2-chloro-6-ethylamion 4-150 propylamino 1,3, 5-triazine.	Gesaprim	3,080mg/kg	70ppm
Bromoxynil	3,5, dibromo-4hydroxybenzo nitrite 4-cycro-2, 6 - dinitrophenol.	Buctril	440mg/kg	
2,4-Damine	2, 4-dichlorophenoxyl acetic acid.	Difenine		
Diflufenican	2,' 4'- difluro-2 (, , -trifluro - - tolylozy)	Difluforicon	2000mg/kg	0.05ppm
Dimethianetryne	2-(1,2 dimethl - propylamino) -4-ethyl-amino-6-methyl-thro- 1,3,5-triazine	Dimepex	3,000mg/kg	50mg/l
MCPA	((4-chbro-O-tolyl) oxy) acetic acid.	Methoxon		
Terbuthlazine	2-tert-butylamino- 4-chloro 6-ethyl-amino - 1,2,3,5-trizine.	Gadopril	2,150mg	

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N.Y.S.C. FARM, YOLA	SENIOR FARM SUPERVISOR (CRO1)	1986	1987

AWARD

1989 CAPL - WSSN POST GRADUATE AWARD FOR THE BEST PAPER PRESENTATION AT 17TH ANNUAL CONFERENCE OF THE WEED SCIENCE SOCIETY OF NIGERIA HELD IN LAGOS, NIGERIA.

YEAR OF ADMISSIONAL FOR POST GRADUATE STUDIES: 1988.
REGISTRATION NUMBER: M.Sc/AGRIC/1026 - 1987 - 88.