THE EFFECT OF NITROGEN LEVELS AND SOURCES ON YIELD, YIELD COMPONENTS AND OTHER AGRONOMIC CHARACTERS OF TWO SORGHUM (Sorghum bicolor (L) Moench) VARIETIES.

By

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

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DECLARATION

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

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CERTIFICATION

This thesis entitled 'THE EFFECT OF NITROGEN LEVEL AND SOURCE ON YIELD, YIELD COMPONENTS AND OTHER AGRONOMIC CHARACTERS OF TWO SORGHUM VARIETIES. (Sorghum bicolor (L) Moench)' by Ahmed Ibrahim meets the regulations governing the degree of Master of Science of Ahmadu Bello University Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my Father, Alhaji Ibrahim M. Bello (Sarkin Kudun Gombe) and my Mother Hajiya Maryam Umar Danfulani for their patience, endurance and guidance.

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ABSTRACT

A field experiment was conducted in 1992 wet season, on the farm of Institute for Agricultural Research Samaru(ll° 11' N 07° 38' E),to evalute the effect of level and sources of nitrogen on yield, yield components and other agronomic characters of two sorghum varieties.

The result of the trial, indicated a significant response to different level of nitrogen but not to the sources of nitrogen applied. Irrespective of the nitrogen source, the rate of 60kg N/ha appeared to be the optimum rate for the two sorghum varieties evaluated. Variety SAMSORG 17 (SK 5912) was found to out-yielded SAMSORG 16 by 14.8%, even though this difference was not significant. There was no significant effect of nitrogen source on either the yield or yield components and other agronomic characters of the two sorghum varieties.

A correlation studies showed that leaf area per plant, leaf area index, stem and leaf dry weight, plant height all at 10 WAS panicle weight, stover weight and 1000 grain weight were all possitively correlated with the grain yield of the sorghum varieties. Grain crude protein percentage was however, found to be negatively associated with the grain yield of sorghum. A regression analysis was carried out to see the effect of different levels of nitrogen applied to grain yield of the sorghum varieties. The result of the analysis is fitted to a quadratic response which is represented by an equation $y = 298.4 + 9.31x - 0.039x^2$. The curve of the regression analysis indicated a maximum level of nitrogen for highest grain yield to be 119.35 Kg N/ha.

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LIST OF ABBREVIATION

ABBREVIATION	FULL MEANING
ai	Active ingredient
Ca	Calcium
CAN	Calcium ammonium nitrate
CEC	Cation exchange capacity
CM	Centimeter
DAS	Days after sowing
FYM	Farm yard manure
g	Gram
ha	Hectare
$K(K_2O)$	Potassium (Potassium Oxide)
kg/ha	kilogram per hectare
m	metre
meq	Milli equivalent
Mg	Magnesium
N	Nitrogen
Na	Sodium
NS	Not significant
$P(P_2O_5)$	Phosphorus (Phosphorus Pentoxide)
ppm	Parts per million
Sig	Significance
SE	Standard error
t/ha	Tonne/hectare
WAS	Weeks after sowing
Zn_4O_5	Zinc Oxide

CHAPTER ONE

INTRODUCTION

Sorghum, adapts to many environments, requiring 90 to 150 days to mature. Highest yields are usually obtained from varieties maturing in 100 to 120 days. Such grain sorghum usually has a grain to straw ratio of about 1:1. Varieties maturing earlier may not yield quite as much because of the reduced growing period; Late maturing varieties tend to put on foliage and make less grain (the grain to straw ratio may run as high as 1:5). Yields of such late varieties commonly average 1500 to 2000 kg/ha, compared with 4000 to 5000 kg/ha or more for 100 to 120 day types (House, 1985).

Sorghum was produced on about 4.8 million hectares in 1991, this account for about 42 percent of total hectarage devouted to cereal crops production. As much as 90 percent of the area put under sorghum cultivation was in the savanna ecological zone of Nigeria. Annual production of sorghum in 1991 was 4.8 million metric tonnes (Anon, 1991), accounting for about 55.5 percent of the total cereal production in the country. Although total annual production of sorghum is experiencing an upward trend, this can be primarily attributed to increasing total hectarage put to sorghum cultivation rather than from an increase in yield per unit area accomplished through the adoption of improved technology. Average yield of local varieties under traditional farmers' practice is about 643 kg/ha (Anon, 1984) while the yield potential of sorghum under improved crop management practice is about 3.5 to 4.5 tonnes per hectare (Kassam, et al, 1976). Yields of 8.5 to 10.0 tonnes per hectare have been recorded with commercial hybrids elsewhere (Pickett and Oswalt, 1971). Similarly yield of up to 14 tonnes per hectare have been reported by Goldsworthy (1970). A recent report has shown that a yield of 1000 kg/ha can be obtained in most fields in Nigeria (Anon, 1991).

Sorghum grain is used for human food and as feed for animals, the plant stem and foliage are used for green-stover, hay, silage and pasture. In some areas, the stem is used as building materials and stover may be used for fuel. An unleavened bread prepared with flour ground from the grain is one of the most common food items made of sorghum, sometimes the dough is fermented before the bread is prepared. Sorghum is also boiled into a porridge or gruel. Beer is commonly made of the grain in many parts of Africa, often with grain of various colours. There are "specialty" sorghums, such as pop sorghum and sweet sorghum, that can be parched and eaten (House, 1985).

The deficiency of nitrogen and phosphorus in most soils of Nigeria is one of the main causes of low yields. Application of nitrogen and phosphate fertilizers produces significant yield responses from almost all crops. Cereals and cotton will respond to additions of nitrogen if phosphorus fertilizer has been applied (Goldsworthy, 1967).

As a result of mounting economic pressure, there has been a fierce competition on the demand for grain sorghum for human food, livestock feed and as raw material for industries. Fertilizer has the potential to increase agricultural production especially when coupled with the use of improved adapted varieties. In general, the intensive agriculture with short or no fallowing has drastically reduced native soil fertility to such an extent that the addition of fertilizer becomes inevitable if yield is to be increased or even be maintained.

Nitrogen which is the main plant nutrient can occur in the form of straight or compound fertilizer which are both inorganic forms as against the organic forms. In some cereal crops, for example rice, the source of nitrogen applied is of paramount importance in determining the yield of the crop. It is important to note that each nitrogen source, be it in the form of compound or straight fertilizer has certain qualities that make it different from the other sources. This can be in terms of cost, relative availability, ease of use and uptake by the plant, etc. A lot of work has been done on the response of sorghum to nitrogen but little has been done on how the response will be when different sources of nitrogen are used.

The objective of the study therefore is:-

To evaluate the effect of level and sources of nitrogen on the performance of two varieties of sorghum.

CHAPTER TWO

LITERATURE REVIEW

2.1 Effect of Fertilizers on Sorghum

Fertilizer response studies in industrialized countries where crop yield and crop response to fertilizer are high include high levels of applied nutrients. For example, in the United States of America 100.35 kg of N/ha has been found to increase grain yield from 2.5 to 4.5 t/ha as reported by Golsworthy (1967) who cited Burtleson et al (1956), Rahaja and Krantz (1958), Herron and Ephart (1960). Hartley and Greenwood (1933) found out that in Northern Nigeria, dressing of one tonne per acre of pen manure gave a considerable increase in yield of sorghum although a comparable effect could not be obtained with inorganic fertilizers. Subsequently, yield increases as great as or greater than those obtained with orgnaic manure were produced with inorganic nitrogen, phosphorus and potassium (Goldsworthy, 1967).

Improved varieties and hybrids of sorghum responded to N-rates ranging from 60 - 150 kg N/ha, whereas a response to P-application was observed upto 40 kg P/ha. Although a response to K-application had been inconsistent, an increase in grain yield was recorded by applying 33 kg K/ha. A balanced fertilizer schedule consisting of 120 kg N/ha, 26 kg P/ha, 33 kg K/ha and 15-25 kg Zn_4O_5/ha is recommended for improved productivity of grain sorghum in India (Pal et al, 1982). An enhancement in flowering and maturity stages brought about by N-application had been reported by Pal et al (1983). This also resulted in increased grain weight, translocation coefficient, grain yield per plant and grain yield per hectare, with some differences in response by different varieties.

Earlier, fertilizer trials by Goldsworthy (1967) indicated that 11 kg/ha of P was optimum rate of phosphorus fertilization in the savanna zone of Nigeria. But recent experiments have shown that improved varieties respond to upto 33 kg P/ha (Mokwunye, 1979). However, a latest fertilizer P recommendation is 21 kg/ha (Ogunlela, et al. 1983).

Pal et al (1983) in a field trial conducted during three wet seasons at Pantnagar, India found out that application of upto 160 kg N/ha to newly developed hybrids and varieties of grain sorghum hastened flowering and maturity and increased growth rates, translocation coefficient, grain yield and N-uptake. Goudreddy et al. (1989) in a two-year irrigated trial with sorghum cultivar CSH - 8R in India, applied 0, 60 and 120 kg N/ha, obtained an average grain yield of 4.42, 5.79 and 6.46 t/ha respectively. Yield increased from 5.29 to

5.81 t/ha by applying 5 of FYM/ha.

Dakore and Mungikar (1991) reported that sorghum CV CSH-5 grown for fodder at Marathwada University in 1982 and 1983 given no fertilizer, 150 kg N/ha or with 60 kg P_2O_5 and/or K_2O/ha produced dry matter yields of 1.19 t/ha without fertilizers and 5.02 - 6.65 t in fertilized crops; the highest yield was from sorghum given N only.

2.2 Effect of Nitrogen levels on yield and yield components of sorghum

Ogunlela (1988) reported that grain and stem yields and yield components were enhanced by nitrogen application in two out of three years of an experiment conducted at Samaru. The findings also indicated that optimum rate of grain yield was 60 kg N/ha while straw yield increased upto 120 kg N/ha. The optimum rate of K from dryland sorghum was 11 kg/ha. Both N and P were found to enhance grain weight per head, grain number, test weight and flag leaf area. Dry matter production was increased by N-fertilization but not by P. Increase in grain yield was also reported by Ogunlela and Okoh (1989) with the application of 60 kg N/ha which is the optimum rate of N. This response was associated with variation in grain weight per panicle, panicle weight and grain number.

Jagtap and Pharande (1982) recorded a significant increase in the panicle characters, grain yield and the protein content with higher doses of nitrogen and organic matter. Applications of N fertilizer increased plant height, leaf area index, panicle length, number of grains per panicle, stover and grain yield (Escasinas et al., 1981). Karikanthimath and Palamiappan (1984) observed that N had no significant effect on plant height and that increasing N rate significantly decreased the number of days to 50 percent flowering. Nitrogen significantly increased the apparent leaf area per plant and 1000 grain weight. But the method of N application had no effect on the yield components. Rajput et al., (1983) revealed that nitrogenous fertilizers significantly affected plant height, ear head length, weight of earhead and grain yield per plot.

A lot of work has been done on the effect of N-rate on sorghum. Derasenapathy and Subburayalu (1986) reported that application of 60-90kg N/ha increased the N, P and K uptake in sorghum during different growth stages and at harvest. Gupta et al. (1986) observed that increasing N-rate from 0-90 kg/ha increased grain yield from, 1.12 to 2.54 t/ha and stover yield from 6.28 - 11.88 t/ha. Raut and Ali (1987) also reported an increase in plant height, leaf area, fresh fodder and DM yields of sorghum with the application of 50 - 60kg N and

30kg P_2O_5/ha. Similarly, in a trial involving six cultivars of fodder sorghum, Bahl et al (1988) reported that given 0, 30 and 60 kg N/ha cultivar J-6 gave the highest grain yield of 1.41 t/ha with 60 kg N. Jayakumar et al. (1987) also reported that application of 60 or 90 kg N/ha and in two equal split dressing gave highest grain yields of 5.84 - 5.87 t/ha compared to 3.98t without N. Increasing N-rate from 0-50, 100-150 kg/ha has been reported to increase the average fodder yield from 16.15 - 20.11, 21.62 and 22.58 kg/ha respectively (Bainade et al, 1988). Howard and Lessman (1989) had also reported an increase in grain yield with increasing application of N-rate from 0, 30, 60, 90 and 120 kg N/ha.

2.3 Effect of Nitrogen source on sorghum

Nangare and Khedekar (1984) found out that application of 60kg N/ha to rainfed sorghum significantly increased its yield but further increase in yield with 120 kg N/ha was not significant. The report also indicated that the effectiveness of N as urea, ammonium sulphate, calcium ammonium nitrate was similar in the first year of trial, but urea was superior in another year.

In a series of trials carried out at IAR Samaru from 1964 to 1966, to compare the efficiency of various N-sources in the Nigerian semi-arid zone little difference between ammonium sulphate, calcium ammonium nitrate and urea was recorded in terms of immediate N supplying power and crop yield (Jones, 1974). In a study of crop response to sulphur-coated urea and other N-carriers in sandy soils of Saudi-Arabia, Hamdallah et al. (1985) reported that dry matter yields were greater with sulphur-coated urea fertilizer than with other sources applied single or split particularly in the loamy sand. Murtadha et al (1988) in a trial conducted in Nebraska to study calcium deficiency in sorgum grown in controlled environments in relation to nitrate/ammonium ratio and nitrogen source, reported that when comparing N-sources, plants grown with nitrate or urea as the sole source of N generally had the best growth and highest calcium concentration. Howard and Lessman (1989) reported that N source had no effect on yield but in 1984 and 1985, 60 or 90 lb as ammonium nitrate at sowing gave considerably greater yield than 60 or 90 lb N as urea. Ssali (1989) studied the effect of two N-sources (ammonium nitrate and urea) on sorghum. The crop showed significant response to applied N but the difference between the sources used were not significant. Similarly, Barber (1991) in an experiment on the effect of ammonium and nitrate nitrogen source on grain hybrid sorghum conducted in Kansas (USA) found that, N source did not affect grain yield.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Experimental Site

The trial was conducted during the 1992 wet season on the Farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria (11° 12'N 7° 37' E) 686m above sea level. Samaru is located in the Northern Guinea Savanna ecological zone of Nigeria. The soil type is loam and the land was left fallow for six years. The details of the physico-chemical analysis of the soil and meteorological records collected are shown in tables 3.1 and 3.2 respectively. The rain started late, therefore late planting in the month of July when the rainy season was established was done.

3.2 Treatments, Experimental Design and plot size

Treatments consisting of factorial combination of two sorghum varieties (SAMSORG 16 and SAMSORG 17) four levels of nitrogen (0, 30, 60 and 90 kg/ha) and two sources of nitrogen (Calcium ammonium nitrate 26% N and Urea 46% N) were arranged in a split plot design with three replications. Sorghum varieties and nitrogen levels were alloted to main plots while sources of nitrogen was placed as the sub-plot. Main plot and sub-plot size were $30m^2$ and $15m^2$ respectively. Nitrogen was applied in two equal split doses, half at planting and the second half at six weeks after sowing. A uniform dose of P_2O_5 and K_2O were applied as basal dressing before harrowing.

3.3 Sorghum Varieties

The two sorghum varieties evaluated are SAMSORG 16 formerly known as SSV2 (FFBL) - is a sorghum of the guinea race (Curtis, 1966) and is important locally. When sown in May to early June, it flowers in about 130 days which can extend to up to 150 days, it reaches a height of about 450 - 500 cm. The panicle is loose with large white grains. The second variety SAMSORG 17 formerly SSVB or (SK 5912) is also a late maturing variety. It belongs to the Kaura race and flowers in about 135 days when sown in early June at Samaru. It grows to a height of about 170 - 250 cm, the panicle is compact with round yellow grains (Goldsworthy, 1969).

3.4 Soil Sampling

Soil samples were taken at the depth of 0-15 and 15-30 cm before land preparation. Composite samples were made and analysed for their physical and chemical properties. The details of this is presented in table 3.1. This indicated that the soil is loam, moderately acidic, low in organic carbon, moderate total nitrogen

Table 3.1: Physico-chemical properties of the soil sample collected at 0-15cm and 15 - 30 cm soil depths from the Experimental site, at Samaru 1992 set season.

Soil	Soil Depth	
	0-15cm	15-30cm
1. <u>Physical property</u>		
Clay (%)	13	13
Sand (%)	41	43
Silt (%)	46	44
Textural class	Loam	Loam
2. <u>Chemical property</u>		
pH in water	5.50	5.30
pH in 0.01M CaC^{T}_{2}	4.80	4.60
Organic Carbon (%)	0.50	0.40
Total nitrogen (%)	0.07	0.04
Available phosphorus(ppm)	11.65	8.06
3. <u>Exchargeable bases</u> (meq/100g soil)		
Ca	2.87	3.10
K	0.20	0.18
Mg	1.05	1.15
Na	0.14	0.14
CEC	4.70	5.00
Exchangeable Acidity (meq/100gsoil	0.20	0.35

Table 3.2: Total rainfall, minimum and maximum temperature, relative humidity and sunshine hours at monthly interval during the period of the experiment at Samaru 1992 wet season.

MONTH	RAINFALL (mm)	TEMPRETURE (°C) MIN	MAX	REL.HUMIDITY % 10.00am	4.00pm	SUNSHINE Hours.
JULY.						
1-10	74.3	19.5	16.0	81.5	70.0	6.0
11-20	130.9	28.1	19.9	84.9	56.2	6.0
21-31	38.4	28.4	20.0	73.9	71.2	6.5
AUG.						
1-10	1507	27.8	19.8	81.8	60.5	5.3
11-20	1521	29.0	19.3	79.9	66.7	1.6
21-31	326	28.0	17.7	65.6	51.7	2.1
SEPT.						
1-10	729	28.6	19.9	83.8	71.7	5.3
11-20	562	27.6	20.4	80.7	73.3	5.4
21-30	804	29.8	21.8	94.7	83.3	4.7
OCT.						
1-10	4.7	30.8	18.8	67.1	54.2	8.1
11-20	20.2	31.5	19.4	70.7	46.8	9.5
21-31	15.0	32.2	15.2	46.9	29.7	9.5
NOV.						
1-10	2.6	32.4	12.2	45.1	47.8	7.8
11-20	0	30.6	13.9	25.8	32.0	9.3
21-30	0	26.2	14.6	27.4	25.1	2.8
DEC.						
1-10	0	30.0	12.8	30.4	23.0	7.9
11-20	0	29.9	12.8	20.0	32.0	8.8
21-31	0	29.0	11.4	24.9	19.4	7.8

Source; Meteorological Unit, Institute for Agricultural Research, Samaru, Zaria, Nigeria.

and high in available phosphorus.

3.5 Land Preparation and Sowing

The experimental site was disc-ploughed and harrowed once, ridges were made at a distance of 75 cm apart. Two to three seeds were sown per hill, after two weeks the plants were thinned down to a single plant per stand.

3.6 Weed Control

Manual hoe weedings were done carefully at three, six and nine weeks after sowing.

3.7 Pest Control

Stemborer was controlled by weekly spray of Vetox 85 at the rate of 2.2 kg ai/ha from three weeks after sowing to ten weeks, after sowing while birds were controlled by employing boys to scare them away.

3.8 Harvesting and Threshing

Harvesting was done after the sorghum had attained full physiological maturity, when there is a dark layer at the placental region of the grain. The stalks were cut as close to the ground level as possible and the panicles were severed at their base (neck node) from the plant. The panicles were counted, bagged, sun-dried until they attain constant weight and their final weights recorded. Threshing was done using wooden mortar and pestle. Threshed grains were cleaned by winnowing, weighed and bagged.

3.9 Observations

3.9.1 Seeds Germination Test

This was carried out in the laboratory, ten seeds were selected at random placed in petri-dishes and a soaked cotton wool was placed on them and covered, after one week the seeds were checked and percentage germination was calculated.

3.9.2 Percent Emergence

The number of emerged plants were counted at 10 days after sowing in each plot.

3.9.3 Number of Leaves per Plant

The number of leaves were counted at six, eight and ten weeks after sowing. Five plants were sampled at random and their means recorded.

3.9.4 Leaf Area/Plant

Leaf area per plant was measured at six, eight and ten weeks after sowing using Stickler et al (1961) method, in which the length of the lamina was multiplied by the greatest width and multiplied by a factor (0.747) and expressed in dm^2.

3.9.5 Leaf area index (LAI)

Leaf area index is the ratio of leaf area per plant to the unit area of land covered by the plant. This was calculated at six, eight and ten weeks after sowing.

3.9.6 Leaf dry weight per plant

Five plants were sampled at random, their leaves were separated from the other plants parts and oven dried at a temperature of 70°C until constant weight was obtained. This process was carried out at six, eight and ten weeks after sowing.

3.9.7 Stem dry weight per plant

Stem dry weight was obtained by weighing the oven dried stems until constant weight was recorded. This was carried out at six, eight and ten weeks after sowing.

3.9.8 Plant height

Five plants were tagged randomly in each plot and their height were recorded at six, eight and ten weeks after sowing and at harvest.

3.9.9 Tiller Number per Plant

Five plants were sampled for tiller number at random in each plot at 12 weeks after sowing. Their means were worked out therefrom.

3.9.10 Panicle length per plant

Five panicles were harvested randomly per plot to record their length and their means calculated.

3.9.11 Weight of panicles per plot

The panicles of net plot was weighed at harvest.

3.9.12 Stand Count

Individual stand count after harvest was recorded in each sub plot.

3.9.13 Dry Stover weight per plant

Plants were randomly selected in each sub-plot and sun dried until constant weight is obtained, their means was then worked out.

3.9.14 Grain yield

The grain yield of each sub-plot was recorded after threshing and cleaning. The yield was projected and expressed in kg/ha.

3.9.15 Crude protein percentage of grains

The grain of each sub-plot was sampled ground into powder and subjected to kjeldahl digestion. This gave the total nitrogen content of the grain. This was then multiplied by a factor (6.25) to give the crude protein percentage.

3.9.16 1000 grain weight

Grains from each sub-plot were sampled and 250 grains were counted in three different places, then weighed, their means was then recorded and used to estimate the 1000 grain weight.

3.10 Statistical Analysis

The data collected were subjected to analysis of variance as described by Cochran and Cox (1967) and significant differences among the treatments means were evaluated using Duncan's Multiple Range Test (DMRT) Duncan (1955).

CHAPTER FOUR

RESULTS

4.1 Seed Germination Test

Seed germination test in the laboratory was carried out and as high as 97 percent germination was observed.

4.2 Percent Emergence

Analysis of the data on emergence at 10 days after sowing indicated no signiicant effect of variety, level of nitrogen applied and the source of nitrogen used. The first and second order of interactions were also found to be insignificant. For both varieties, a percent emergence of over 96% was recored (Table 4.1).

4.3 Number of leaves per plant

There was no significant difference in the number of leaves per plant at six weeks after sowing among all the treatment combinations and their interactions. Similarly at eight and ten weeks after sowing (WAS) no significant difference was observed within the varieties, sources of nitrogen, first and second order interactions in the number of leaves per plant. However, there was a significant response to the application of different levels of nitrogen at (P = 0.05 and 0.01) in eight and

Table 4.1 Seed emergence (%)/plot at 10 DAS and number of leaves per plant of sorghum varieties as affected by level and source of nitrogen fertilizer at Samaru, 1992 wet season

Treatment	%Emergence 10 DAS	Number of leaves per plant 6	8 (WAS)	10
Variety				
SAMSORG 16	97.87	6.158	7.58	9.56
SAMSORG 17	96.61	6.383	7.47	9.39
SE ±	0.98	0.14	0.21	0.17
N Level (kg/ha)				
0	97.68	5.91	6.53b	8.36c
30	96.72	6.27	7.64a	9.30b
60	95.44	6.36	8.05a	10.03a
90	99.13	6.54	7.76a	10.19a
SE ±	1.24	0.19	0.15	0.25a
N Source				
CAN	96.99	6.29	7.62	9.61
Urea	97.49	6.25	7.37	9.33
SE ±	0.61	0.13	0.15	0.21
Interaction				
V x N	NS	NS	NS	NS
V x S	NS	NS	NS	NS
N x S	NS	NS	NS	NS
V x N x S	NS	NS	NS	NS

Means in a column within set of treatment followed by unlike letter are significantly different at 5% level of significance using DMRT.

NS = Not significant
WAS = Weeks after sowing
DAS = Days after sowing

ten weeks after sowing respectively. Plants that received 30kg N/ha were found to have higher number of leaves than those in the control, however, they were found to be similar with those plants that received 60 and 90 kg N/ha at six WAS. At ten WAS plants that received 30 kg N/ha were found to have higher number of leaves than those in the control. Plants that received 60 and 90 kg N/ha were found to be similar with one another but superior to those that received 30 kg N/ha and those in the control (Table 4.2).

4.4 Leaf Area per plant

The difference between varietal means, means of sources of nitrogen, first and second orders of interaction were all found to be non significant in all the weeks of sampling. A highly significant difference in the leaf area per plant was recorded however, with different levels of nitrogen applied. At six WAS plants that received 60 and 90 kg N/ha had statistically similar leaf area per plant but significantly higher than the other two nitrogen treatments which were themselves not significantly different. At 8 WAS increasing N levels from 0-30 significally increased the leaf area. A further increase of nitrogen either to 60 or 90 kg/ha did not however affect the leaf area significantly. At 10 WAS plants that received 30 kg N/ha were significantly

Table 4.2 Leaf area per plant (dm^2) of sorghum varieties as affected by level and source of nitrogen fertilizer at Samaru, 1992 wet season.

Treatment	Leaf area/Plant (dm^2) WAS		
	6	**8**	**10**
<u>Variety</u>			
SAMSORG 16	33.9	142.3	316
SAMSORG 17	33.0	156.0	337
SE ±	2.81	14.79	16.26
<u>N-Level (kg/ha)</u>			
0	20.7b	82.1b	216c
30	26.3b	155.1a	317b
60	42.2a	182.4a	381a
90	44.6a	177.0a	397a
SE ±	3.97	20.92	22.98
<u>N - Source</u>			
CAN	29.5	137.2	313
Urea	29.5	161.1	342
SE ±	3.04	12.72	20.29
<u>Interactions</u>			
V x N	NS	NS	NS
V x S	NS	NS	NS
N x S	NS	NS	NS
V x N x S	NS	NS	NS

Means in a column within a set of treatment followed by unlike letter are significantly different at 5% level of significance using DMRT.
NS = Not significant
WAS = Weeks after sowing

higher than the control. Increasing the nitrogen level to 60 and 90 kg N/ha which are at par, also resulted in a highly significant increase in the leaf area when compared to those plants that received 30 and 0 kg N/ha (Table 4.2).

4.5 Leaf area index (LAI)

The trend of leaf area index followed exactly the same pattern to that of leaf area per plant (Table 4.3). Means between varieties, source of nitrogen used and all the means of first and second order interactions were found to be non significant. However, application of nitrogen gave a highly significant difference in leaf area index at six, eight and ten WAS respectively. At six WAS increasing the N level from 0 to 30 kg/ha did not produce any significant difference in the leaf area index, however a further increase to 60 and 90 kg N/ha gave a significant increase in the leaf area index which are themselves at par with one another. At eight WAS all nitrogen treated plants were found to be similar with one another but statistically having higher leaf area index than the control. At ten WAS plants that received 30 kg N/ha were having higher LAI than the control. increasing the nitrogen level to 60 and 90 kg/ha gave a higher LAI than the plants that received 30 kg N/ha but they are however similar with one another (Table 4.3).

Table 4.3: Leaf area index (LAI) Per plant of sorghum varieties affected by level and source nitrogen fertilizer at Samaru, 1992 wet season.

Treatment		Leaf area index/plant WAS 6	8	10
Varieties				
SAMSORG	16	0.147	0.693	1.508
SAMSORG	17	0.150	0.631	1.406
SE	±	0.01	0.07	0.07
N-Level (kg/ha)				
	0	0.092b	0.364b	0.959c
	30	0.117b	0.687a	1.414b
	60	0.187a	0.811a	1.694a
	90	0.198a	0.781a	1.762a
	SE±	0.02	0.09	0.10
N-Source				
	CAN	0.166	0.716	1.393
	Urea	0.131	0.608	1.521
	SE±	0.01	0.06	0.09
Interaction				
	VxN	NS	NS	NS
	VxS	NS	NS	NS
	NxS	NS	NS	NS
	VxNxS	NS	NS	NS

Means in a column of any set of treatment followed by unlike letter are significantly different at 5% level of significance using DMRT.

NS = Not significant
WAS = Weeks after sowing

4.6 Leaf dry weight per plant

Varietal means in all the weeks of sampling, means of nitrogen sources at 8 and 10 WAS first and second order of interaction were found to give a non significant difference in the leaf dry weight per plant. At six WAS however, Calcium ammonium nitrate gave a higher leaf dry weight than Urea. There was a highly significant difference in leaf dry weight per plant in all the weeks of sampling with the application of nitrogen. At 6 WAS increase the N level from 0 to 30 kg/ha did not give any significant increase in leaf dry weight. But a further increase of 60 to 90 kg N/ha produced heavier leaf dry weight when compared with the other two nitrogen treatments, but the 60 and 90 kg N/ha are similar to one another. At 8 WAS increasing the N level from 0 to 30 kg/ha led to a significant increase in leaf dry weight per plant. A further increase to 60 and 90 kg N/ha also gave a higher leaf dry weight. The 60 and 90 kg N/ha treatment were similar with one another, however the difference between 90 and 30 kg N/ha was not significant. At 10 WAS plants that received 30 kg N/ha have higher leaf dry weight when compared with the control. A further increase to 60 and 90 kg N/ha produced heavier leaf dry weight when compared to the other two fertilizer treatments. The 60 and 90 kg treatments were however similar with one another (Table 4.4).

Table 4.4: Leaf dry weight (g) per plant of sorghum varieties at 6, 8, and 10 WAS as affected by level and source of nitrogen fertilizer at Samaru, 1992 wet season.

Treatment		Leaf dry weight/plant WAS		
		6	8	10
Variety				
SAMSORG	16	1.11	6.31	16.49
SAMSORG	17	1.10	6.10	15.35
	SE±	0.11	0.63	1.07
N-Level (kg/ha)				
	0	0.64b	3.03c	10.06c
	30	0.87b	5.94b	14.72b
	60	1.39a	8.01a	18.93a
	90	1.15a	7.75ab	19.98a
	SE±	0.15	0.90	1.51
N-Source				
	CAN	1.25a	6.37	16.71
	Urea	0.96b	5.66	15.14
	SE±	0.11	0.54	1.15
Interaction				
VxN		NS	NS	NS
VxS		NS	NS	NS
NxS		NS	NS	NS
VxNxS		NS	NS	NS

Means in a column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant
WAS = Weeks after sowing.

4.7 Stem dry weight per plant

Varietal means at 6 and 8 WAS, means of source of nitrogen, first and second order interactions means were also found to give insigificant difference in the stem dry weight per plant. At ten WAS variety SAMSORG 16 was found to have heavier stem dry weight than SAMSORG 17 (Table 4.5).

Increasing application of nitrogen was observed to have significant increase in stem dry weight per plant. At 6 WAS the application of 30 kg N/ha was found to give a similar stem dry weight with plants at the control. A further increase to 60 and 90 kg N/ha gave statistically heavier stem dry weight than the other two fertilizer treatments. However, the difference between 60 and 90 kg N/ha was not significant. At 8 and 10 WAS plants that received 30 kg N/ha had higher stem dry weight per plant when compared to the plants under control. A further increase to 60 and 90 kg N/ha also gave higher stem dry weight per plant than the other two fertilizer treatments, however the difference between 60 and 90 kg N/ha was not significant (Table 4.5).

4.8 Plant height

The varietal means at 6 WAS was not significantly different with one another but at 8, 10 WAS and at harvest a highly significant difference was recorded

Table 4.5: Stem dry weight (g)/plant of sorghum varieties as affected by level and source of nitrogen fertlizer at Samaru, 1992 wet season.

Treatment	Stem dry weight/plant (g) WAS		
	6	8	10
Variety			
SAMSORG 16	0.68	4.89	24.8a
SAMSORG 17	0.67	4.16	16.0b
SE ±	0.08	0.53	1.94
N-Level (kg/ha)			
0	0.38b	1.87c	9.5c
30	0.46b	3.86b	19.9b
60	0.94a	6.11a	26.3a
90	0.93a	6.26a	25.9a
SE±	0.11	0.75	2.60
N-Source			
CAN	0.81a	5.11	21.90
Urea	0.54b	3.94	18.90
SE±	0.08	0.47	1.73
Interaction			
VxN	NS	NS	NS
VxS	NS	NS	NS
NxS	NS	NS	NS
VxNxS	NS	NS	NS

Means in a column of any set of treatment followed by unlike letter are significantly different at 5% level of significance using DMRT.

NS = Not significant
WAS = Weeks after sowing.

between the two varieties. Variety SAMSORG 16 was found to have taller plants than SAMSORG 17 (Table 4.6).

At 6 WAS there was a highly significant difference in plant height among the different levels of nitrogen applied. Increasing N levels from 0 to 30 kg/ha however gave no significant increase in plant height, but a further increase to 60 and 90 kg N/ha produces plant that are taller than those at the other two fertilizer treatment. The difference between 60 and 90 kg N/ha was also not significant. At 8, 10 WAS and at harvest plants that received 30 kg N/ha all produced taller plants than those of the control. A further increase in N level to 60 and 90 kg N/ha results in taller plants than at 30 and 0 kg N/ha. However, at 10 WAS and at harvest plants that received 90 kg N/ha and 60kg N/ha respectively were found to be at par with plants that received only 30 kg N/ha. The difference between 60 and 90 kg N/ha were found to be non significant (Table 4.6)

A significant difference observed in the plant height when different source of nitrogen was used only at 8 WAS. Plant that received nitrogen as calcium ammonium nitrate (CAN) produced significantly taller plants. This was however not significant at 6, 10 WAS and at harvest. The first and second orders of interaction were all found to be non significant (Table 4.6).

Table 4.6: Plant height (cm) of sorghum varieties as affected by level and source of nitrogen fertilizer at Samaru, 1992 wet season.

Treatment		Plant height (cm) WAS 6	8	10	At Harvest
Variety					
SAMSORG	16	12.16	28.34a	61.30a	297.0a
SAMSORG	17	11.35	24.69b	39.60b	155.2b
SE±		0.51	1.32	3.09	5.27
N-Level (kg/ha)					
	0	10.00b	18.72c	33.40c	204.3c
	30	10.48b	25.92b	47.70b	222.7b
	60	13.52a	31.04a	62.10a	231.8ab
	90	13.02a	30.40a	56.70ab	245.7a
	SE±	0.73	1.87	4.37	7.45
N-Source					
	CAN	12.41	28.22a	53.80	230.80
	Urea	11.10	24.82b	47.10	221.50
	SE±	0.50	1.13	3.01	4.51
Interaction					
VxN		NS	NS	NS	NS
VxS		NS	NS	NS	NS
NxS		NS	NS	NS	NS
VxNxS		NS	NS	NS	NS

Means in a column of any set of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant
WAS = Weeks after sowing.

4.9 Tiller number per plant

The tiller number was not significantly affected by variety, level and source of nitrogen used. Similarly, first and second order interactions of the treatment combination were not significant (Table 4.7).

4.10 Panicle length per plant

The difference in the panicle length per plant between varieties was found to be highly significant. SAMSORG 16 produced longer panicles than SAMSORG 16. When the means of N level were compared, it was observed that increasing levels either to 30 or 60 kg/ha did not increase the panicle length. However, when the highest level of 90 kg was applied, this resulted in significantly longer panicles than other treatments under trial. The source of nitrogen, first and second order interactions of the treatment combination did not affect the panicle length significantly (Table 4.7).

4.11 Weight of panicles of net plot

The means between variety and source of nitrogen used were all found to be non significant. However, a highly significant difference in panicle weight was recorded when different levels of nitrogen were applied. When their means were compared, increasing N level from 0 to 30 kg/ha gave a similar panicle weight, but a

Table 4.7: Tiller number and panicle length (cm) of sorghum varieties as affected by level and source of nitrogen fertilizer at Samaru, 1992 wet season.

Treatment	No. of tillers (12WAS)	Panicle Length (cm)
Variety		
SAMSORG 16	2.29	33.81a
SAMSORG 17	2.29	24.18b
SE±	0.18	0.46
N-Level (kg/ha)		
0	2.25	27.60b
30	2.17	27.97b
60	2.25	29.02b
90	2.50	31.40a
SE±	0.26	0.65
N-Source		
CAN	2.25	29.14
Urea	2.33	28.85
SE±	0.16	0.45
Interaction		
VxN	NS	**NS**
VxS	NS	**NS**
NxS	NS	**NS**
VxNxS	NS	**NS**

Means followed by the same letter are statistically the same at 5% level of significance using DMRT.

NS = Not Significant
WAS = Weeks after sowing

further increase to 60 and 90 kg N/ha gave higher panicle weight when compared with the other two N treatments. The difference between 60 and 90 kg N/ha was not significant (Table 4.8). The means of different source of N and interactions of VxS, NxS and VxNxS were all found to be non significant. However, an interaction between variety and nitrogen level was found to be highly significant (Table 4.8).

4.12 Interaction

Interaction between variety and N level was found to be highly significant (Table 4.9). When the same variety was compared at varying levels of N, SAMSORG 17 produced heavier panicles at the highest N rate of 90 kg N/ha when compared with the other three levels. It was followed by 60 kg N/ha which was also heavier than 0 and 30 kg N/ha. The difference between 0 and 30 kg N/ha was non significant. There was a progressive increase in the panicle weight as the level of nitrogen increases from 0 - 60 kg N/ha. A further increase of N to 90 kg/ha however reduced the panicle weight which was statistically similar both with 30 and 60 kg N/ha. When the same fertilizer level was examined for the two varieties, the difference was non significant at 0 and 60 kg N/ha. In the case of 30 kg N/ha SAMSORG 16 produced heavier panicle weight than SAMSORG 17. However, the

Table 4.8: Panicles weight/plot (g) and stand count/ha of sorghum varieties as affected by level and source of nitrogen at Samaru, 1992 wet season.

Treatment	Panicle weight/plot(g)	Stand Count/ha
Variety		
SAMSORG 16	1054	35,806.67
SAMSORG 17	1044	35,086.67
SE ±	58.41	106.67
N-Level (kg/ha)		
0	677b	35,720.00
30	801b	35,333.33
60	1308a	34,780.00
90	1410a	36,220.00
SE±	82.59	580.00
N-Source		
CAN	1052	35,386.67
Urea	1047	35,640.00
SE ±	48.58	260.00
Interactions		
VxN	**	NS
VxS	NS	NS
NxS	NS	NS
VxNxS	NS	NS

Means followed by the same letter are statistically the same at 5% level of significance using DMRT.

NS = Not significant
** = Highly significant

Table 4.9: Interaction of variety and nitrogen levels on panicle weight (g) per plot of two sorghum varieties at Samaru, 1992 wet season.

N-Level (kg/ha)		0	30	60	90
<u>Variety</u>					
SAMSORG	16	781d	1034c	1317b	1084bc
SAMSORG	17	573d	568d	1300b	1736a
SE	±	116.81			

Means followed by the same letter(s) are statistically the same at 5% level of significant using DMRT.

response was reversed at 90 kg N/ha, whereas SAMSORG 17 yielded higher panicle weight than SAMSORG 16 (Table 4.9).

4.13 Stand count per plot

There was no significant difference in stand count per plot at harvest between varieties, nitrogen levels, sources of nitrogen used, first and second orders of interaction of the treatment combinations (Table 4.8).

4.14 Dry stover weight per plant

The means between varieties indicated a highly significant difference in stover weight per plant. SAMSORG 16 was found to have heavier stover weight than SAMSORG 17. Similarly, a highly significant difference was recorded with different level of N. Plants that received 0 and 30 kg N/ha were found to be statistically at par with one another. Increasing the N level to 60 and 90 kg/ha was found to give heavier stover dry weight than the other two N treatments. However, the diffference between 60 and 90 kg N/ha was not significant. Means of N source, first and second orders of interaction were all found to be non significant (Table 4.10).

Table 4.10: Stover weight per plant (g) and Grain yield (kg/ha) of sorghum varieties as affected by levels and source of nitrogen at Samaru, 1992 wet season.

Treatment		Stover weight (g)	Grain yield (kg/ha)
<u>Variety</u>			
SAMSORG	16	207.5a	557
SAMSORG	17	155.0b	654
SE	±	14.24	57.70
<u>N-Level (kg/ha)</u>			
	0	132.5b	355b
	30	147.5b	435b
	60	217.5a	861a
	90	727.5a	772a
	SE±	20.0	81.60
<u>N-Source</u>			
	CAN	181.7	607
	Urea	180.8	604
	SE±	4.72	30.90
<u>Interactions</u>			
VxN		NS	NS
VxS		NS	NS
NxS		NS	NS
VxNxS		NS	NS

Means followed by the same letter are statistically the same at 5% level of significance using DMRT.

NS = Not significant

4.15 Grain yield

Means between varieties, sources of nitrogen first and second orders of interaction were all non significant. There was a highly significant difference in yield, however, among the different levels of nitrogen under trial. Increasing N level from 0 to 30 kg/ha did not give any significant difference in the sorghum grain yield, however, further increase to 60 and 90 kg N/ha gave significantly higher grain yield than 0 and 30 kg N/ha. The difference between 60 and 90 kg N/ha was not significant (Table 4.10).

4.16 1000 - Grain weight

A highly significant difference in 1000 - grain weight was recorded between the two varieties under trial. SAMSORG 16 was found to have heavier 1000-grain than SAMSORG 17. Means of nitrogen levels, sources, first and second orders of the treatments combination were all found to give a non significant difference in 1000-grain weight (Table 4.11).

4.17 Grain crude protein

The means of varieties, levels of nitrogen and source all indicated a non significant difference in the grains crude protein content. Similarly, all the interactions except that of nitrogen level and source, are nonsigificant (table 4.11).

4.18 Interaction

The first order interaction between level and source of nitrogen was found to be significant at (P = 0.05). When the same level of N was examined for different sources, there was no significant difference observed for the two N sources. However, when the same source was examined for the varying level of N, control produced significantly less crude protein than the other three levels of N, for both N sources. The differences within the three applied levels of N however were found to be nonsignifcant (Table 4.12).

4.19 Correlation and regression

The coefficient of correlation between yield and number of leaves, leaf area per plant, leaf area index and stem dry weight all at 10 WAS, was found to be highly significant. Similarly, the correlation coefficient were highly significant between yield and weight of panicles per plot and dry stover per plant. The other correlation coefficient were found to be nonsignificant and are even negative between yield and grain crude protein content (Table 4.13).

Table 4.11: *1000 grain weight (g) and grain crude protein* percentage of sorghum varieties as affected by level and source of nitrogen fertilizer at Samaru, 1992 wet season.

Treatment	1000grain wt(g)	Crude Protein(%)
Variety		
SAMSORG 16	38.33a	13.47
SAMSORG 17	34.13b	12.38
SE ±	0.89	0.54
N-Level (kg/ha)		
0	35.67	11.92
30	34.17	12.67
60	36.67	13.23
90	38.42	13.67
SE±	1.26	0.77
N-Source		
CAN	36.67	12.89
Urea	35.79	12.96
SE±	0.68	0.24
Interactions		
VxN	NS	NS
VxS	NS	NS
NxS	NS	*
VxNxS	NS	NS

Means followed by the same letter are statistically the same.

NS = Not significant
* = Significant at 5% level of probability.

Table 4.12: Interaction of nitrogen level and sources on grain crude protein (%) of two sorghum varieties at Samaru, 1992 wet season.

N-Level (kg/ha)	N-Source	
	CAN	UREA
0	12.32b	11.23b
30	12.54a	13.20a
60	12.61a	13.27a
90	14.07a	14.14a
SE ± 0.84		

Means followed by same letter are statistically the same at 5% level of significance

Table 4.13: Correlation matrix of yield and other parameters of sorghum as influence by different levels and sources of nitrogen, at Samaru, 1992 wet season (means of two varieties)

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000											
2	0.9368**	1.000										
3	0.9362**	0.999**	1.000									
4	0.5851**	0.640**	0.6405**	1.000								
5	0.8546**	0.877**	0.8770**	0.6269**	1.000							
6	0.3211*	0.351*	0.3506*	0.2705ns	0.6043**	1.000						
7	0.3054*	0.313*	0.3112*	0.1983ns	0.4932**	0.8822**	1.000					
8	0.6411**	0.672**	0.6707**	0.5681**	0.5509**	0.2064ns	0.1605ns	1.000				
9	0.4709**	0.552**	0.5510**	0.3682**	0.5527**	0.5350**	0.5266**	0.5610**	1.000			
10	-0.2711	-0.192	-0.1920	-0.0484	-0.1012	0.1633ns	0.1469ns	-0.3255	-0.1105	1.000		
11	0.2698ns	0.306*	0.3081*	0.4583**	0.3751**	0.5226**	0.4946**	0.4257**	0.4596**	0.0308ns	1.000	
12	0.5055**	0.566**	0.5613**	0.5424**	0.4051**	0.0488ns	0.0103ns	0.7350**	0.7350**	-0.1606	0.138	1.00

NS = Not significant
* = Significant at 5% level of probability (R = 0.285)
** = Significant at 1% level of probability (R = 0.368)
WAS = Weeks after sowing

(1) Number of leaves 10 WAS (2) Leaf area per plant 10 WAS (3) Leaf area index 10 WAS (4) Leaf dry weight 10 WAS (5) Step dry weight 10 WAS (6) Plant height at harvest (7) Length of panicle (8) net weight of panicles per plot (9) Stover weight per plant (10) Crude Protein percentage of grains (11) 1000 grains weight (12) Yield in kg/ha.

Sorghum grain yield was regressed on level of nitrogen. The observed and estimated grain yield gave a quadratic response which fit in the equation $\hat{Y} = 298.4 + 9.31X - 0.039X^2$ with an R^2 value of 0.38. The curve of the regression analysis (Fig. 4.1) indicated a maximum level of nitrogen for highest yield to be 119.35 kg/ha which is approximately 120 kg N/ha using the equation.

$$X_{max} = -b/2c$$

Where X max = Maximum N level at maximum grain yield

b = slope

c = coefficient of the quadratic regression curve.

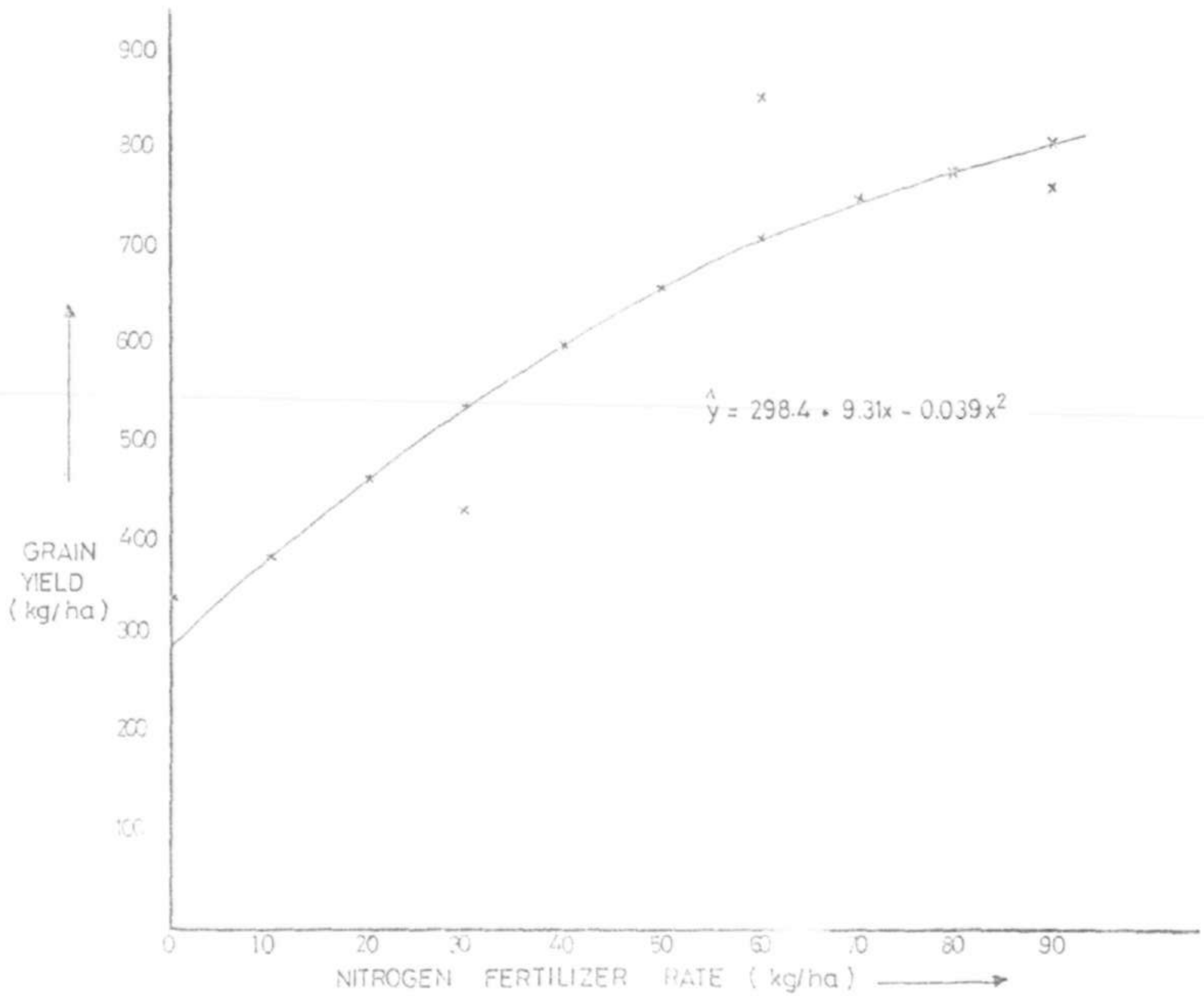

Fig. 4.1 Regression of Sorghum grain yield (estimated) on Nitrogen level at Samaru 1992 wet season.

CHAPTER FIVE

DISCUSSION

5.1 Effect of nitrogen application on growth and development of sorghum

The growth and development of cereal crops can be adversely affected by a deficient or excessive supply of any one of a series of essential macro nutrients (Russel, 1963, Hay, 1981b) as cited by Hay and Walker (1989). Nitrogen plays a central role in plant biochemistry as an essential constituent of cell wall, cytoplasmic proteins, nucleic acids, chlorophyll and a vast array of other cell components, consequently a deficiency in the supply of nitrogen has a profound influence upon crop growth and can lead to a total loss of grain yield in extreme cases. The following growth parameters were found to be significantly affected by nitrogen application. Number of leaves per plant, leaf area, leaf area index (LAI), leaf and stem dry weights per plant, plant height, panicle length and weight and stover weight.

Nitrogen application was however found to have no significant effect on sorghum emergence percentage, number of tillers per plant, stand count at harvest, grain crude protein percentage and 1000 - grain weight. Nitrogen application may not have likely affected crop emergence because the germination of seed is mainly dependent upon viability of seeds, and other environmental factors that favours germination such as temperature and moisture status of the soil. As high as 97% emergence was recorded this could be attributed to the quality of seeds used that was obtained from National Seed Service.

Tillering was not affected by nitrogen application because the extent of tillering in a given crop is largely determined by management and, in particular, by the choice of species or cultivar and by plant population. This finding is however in conflict with that of Ogunlela (1988) who reported that application of nitrogen and phosphorus enhanced grain weight and tillering significantly. The tillering ability in sorghum is not as pronounced as in millet, but some cultivars of sorghum do produce a few tillers. Chiezey (1981) had reported that there is no significant difference in the number of tillers produced by SK5912 and FFBL.

The application of 30, 60 and 90 kg N/ha was found to cause an increase of 11.6, 20 and 21.9% respectively, in the number of leaves per plant at 10 WAS, when compared to plants that were not treated with any amount of nitrogen. Increase in the number of leaves will result in an increase in the leaf area for photosynthesis, this will then result in the production of more assimilates that will be translocated into the grain. The leaf area per plant at 10 WAS was also found to increase with the application of 30, 60 and 90 kg N/ha by 46.8, 76.4 and 83% respectively when compared with no fertilizer treatments (20.7 dm^2). Many workers have reported a similar finding (Karve, 1965, Choudhari, 1967 and Raghunattan et al, 1973). The response of leaf area index to the application of nitrogen follows a similar trend with that of leaf area. Escaninas et al (1981) had reported an increase in the leaf area index with the application of N fertilizer.

Leaf and stem dry weights were also significantly affected by the application of nitrogen. At 10 WAS a percentage response of 46.3, 88.2 and 98.6% was recorded for leaf dry weight with the application of 30, 60 and 90 kg N/ha respectively. Similarly as high as 176.8% increase in stem dry weight was recorded with 60 kg N/ha at 10 WAS. These increases can be attributed to the leaf expansion due to enhanced nutrition by fertlizer N that influence the growth and improve the manufacture of assimilate in the crop thereby increasing the dry matter production. Warsi and Wright (1973), and El-Sabaaie (1979) and Mulikat (1987) all reported an increase in total dry matter production with increase application of nitrogen.

Increasing the rate of nitrogen application from 0 - 90 kg N/ha was found to increase plant height significantly. There was however an insignificant difference in plant height between plants that received 30 kg N/ha and those that did not receive any fertilizer at 6 WAS. This may be attributed to the utilization of the food reserved in the seed and to some extent by the contribution of the relatively high nitrogen percentage (0.07% N) of the experimental site. At 10 WAS the application of 30, 60 and 90 kg N/ha gave a percentage increase in plant height of 9, 13.5 and 20.3% respectively. Tarfa (1987) reported a similar response of plant height to application of nitrogen, with 30 to 60 kg N/ha, but was unable to observe further increase with higher rates.

5.2 Effect of nitrogen application on yield and yield components of sorghum

Sorghum grain yield was significantly increased with the application of nitrogen. The result indicated a percentage increase of 22.5, 142.5 and 117.5% respectively when compared to the plants that were not supplied with nitrogen. This finding is in agreement with the work of Tarfa (1987), Ogunlela (1988), Anon. (1988), Ogunlela and Okoh (1989) reported increases in grain yield of sorghum with increase in nitrogen rate.

There was however no significant difference in yield between the varieties used, even though SAMSORG 17 is believed to be more responsive to fertilizer. SAMSORG 17 had out-yielded SAMSORG 16 by 17.4%. When comparing the average yields of the two varieties SAMSORG 17 (654 kg/ha) and SAMSORG 16 (557 kg/ha), it will be seen that the yields are low. This can be attributed mainly to the effect of the season in which most crop yields were low may be due to poor distribution of rainfall (Anon, 1993). Another reason probably due to delay in sowing. Rusell (1964) cited by Doggett, 1970) reported that a delay in planting by two or three weeks will cause yield reduction of upto fifty percent. The reduction in yield could be due to moisture stress late in the growing season.

Grain yield is a complex character which is influenced by a number of factors such as number of seeds per panicle, 1000-grain weight, variety and other factors. Sowing date has some effect on these factors in one way or the other. Ila (1989) reported that sowing on June 24, and July 15 out-yielded sowing on August 6 by 7.78% and 21.67% respectively. Many workers had reported higher grain yields with early sowing date (Ogunlela, 1983, Kassam and Andrews, 1985). Looking at the rainfall distribution of 1992 wet season, it could be realized that only 42.5mm was received by the crop after September. The crop was harvested in December, there was every likelihood that the crop was subjected to moisture stress at the crucial time of grain filling. This had resulted in decrease in number of florets, some panicles were rudimentary and did not form seeds, some seeds that were formed failed to mature.

The major yield component under this study is 1000-grain weight. This was found not to be significantly affected by the rate of nitrogen application even though a significant difference was observed between the two varieties. The lack of response to different N rates may not be unconnected to the high initial N percentage (0.07 %) in the experimental site when compared to the (0.04% N) which is the average in most savanna soils.

Length of panicle and the panicle weight were found to have responded significantly to increased nitrogen application. An increase in panicle length of 13.8% was recorded with the highest N-rate (90 kg N/ha). The difference in panicle length was also significant among varieties used. SAMSORG 16 (FFBL) had an average panicle length of 33.8 cm as against SAMSORG 17 (SK 5912) which has 24.18 cm. This difference may be attributed to the genetic make up of the two varieties. A similar result was obtained by Ila (1989) who reported a significant difference between the panicle length of SAMSORG 17 and SAMSORG 5 in which the former was longer. The addition of 30, 60 and 90 kg N/ha gave an increase of 18.3, 93.2

and 108.3% in the panicle weight per plot respectively. This was similar to the finding of many workers, Tatwawadi and Choudhary (1976), Powar and Narkhede (1981), Ogunlela (1983) and Mulikat (1989).

Plant stand count at harvest which determines the number of panicles in a unit area was found not to be significantly affected by nitrogen application or varietal differences.

5.3 Effect of variety

There was a significant difference in plant height, panicle length, stover weight and 1000-grain weight between the two varieties. SAMSORG 16 (Farafara) was found to be taller than SAMSORG 17 with an average height of 297cm as against 155.2 cm. Many workers had reported height difference among different sorghum cultivars (Doggett 1970, Andrews, 1975, and Chiezey, 1981). SAMSORG 16 had an average panicle length of 33.81 cm as against 24.18 cm of SAMSORG 17. This difference can be attributed mainly to the genetic make up of the two different varieties. The stover weight of SAMSORG 16 which had an average of 207.5 g was higher than that of SAMSORG 17. This can be attributed to the height differential among the two varieties. SAMSORG 16 was also found to have heavier 1000-grains with a mean of 38.33 g as against 34.13g of SAMSORG 17. The large and plump seeds of SAMSORG 16 may have resulted in heavier seed weight.

5.4 Effect of nitrogen source on sorghum

There was no significant difference in the growth characteristics and grain yield between urea and calcium ammonium nitrate. This could be due to their similarity in terms of efficiency to supply the required amount of N. Ssali (1989) had reported a no significant difference in the grain yield of sorghum when the two sources were used. Similarly Barber (1991) and Barber et al (1991) reported a no significant response in sorghum grain yield with the two sources of N. Uyovbisere et al (1990) has reported a no significant difference in response of maize to different sources of nitrogen. However, Bationo et al. (1985) reported that Calcium ammonium nitrate tended to perform better than urea when applied on millet in Niger Republic.

5.5 Effect of nitrogen rate and source on grain protein content

Application of nitrogen had been found to increase total protein content of grain sorghum by many workers. Welch et al (1966), Gaya (1975) and Veeranna and Patil (1978). Dechev (1970), Warsi and Wright (1973) Armero and Brambila (1977) and Mirhadi et al (1979). The results of this study however indicated a no significant difference in protein content of the grains between the control and even with the highest rate of nitrogen (90 kg N/ha). There was however an increase of 12.8% on the crude protein content of grain with the application of 90 kg N/ha when compared to that of plants that were not supplied with any amount of nitrogen. This finding can be attributed to the inherent soil nitrogen of the site which was relatively high (0.07%N) as against (0.04% N) which is the average in most savanna soils. The high N content of the site was as a result of long fallow period. Ogunlela and Okoh (1989) had reported that soil fertility level is an important factor on the chemical composition of plant tissue including that of the grain. Another reason could be due to early application of nitrogen. The two splits doses were applied first at sowing and the second doses was applied at six WAS. For this reason, most of the nitrogen applied might have been used up during the vegetative growth phase of the crop development. Hay and Walker (1989) had reported that late/or heavy nitrogen application can result in the production of grains with high nitrogen content in barley which made it unacceptable to malting industry. SAMSORG 16 seems to have higher grain crude protein percent of (2.16%) as against (1.96%) of SAMSORG 17. However, this difference was not significant.

Campbell and Pickett (1968) had reported a significant difference among fertility levels and among genotypes in regard to protein content on sorghum. The non significant difference in grain protein content in the two varieties conforms to the finding of Ogunlela and Okoh (1989) who reported that the crude protein contents in grains of varieties SK 5912 and FFBL were similar.

The total crude protein content of grains indicated that urea seems to contribute more to the grain protein percentage than calcium ammonium nitrate (CAN). However, the difference between the two sources were not significant. The edge that Urea has over CAN may not be unconnected to its high analysis (46% N) as against CAN (26% N).

5.6 Effect of interactions

Interaction between variety and level of nitrogen applied was found to be significant in regard to panicle weight per plot. SAMSORG 17 gave the heaviest panicle weight per plot (1736 g) with the highest rate of 90 kg N/ha at the same time it gave the least weight of (573 g) with no fertilizer. This finding suggest that SAMSORG 17 is more responsive to fertilizer treatment than SAMSORG 16. And SAMSORG 16 will yield better when no fertilizer is applied. The difference in panicle weight may be attributed to the varietal differences and yield potential of the two varieties.

Another interaction was observed between nitrogen level and source. This was found to have affected grain protein content significantly. The highest rate of 90 kg N/ha was found to give the highest grain crude protein content and Urea tend to have an edge over CAN in contribution to grain crude protein content. This could be due to the high analysis of N in Urea (46% N) as against CAN (26% N). Many workers had reported an increase in grain crude protein content Welch et al (1966), Roy and wright (1973), Gaya (1976) and Veerenna and Patil (1978).

5.7 Correlation

Sorghum grain yield is shown to have strong positive association with number of leaves per plant, leaf area per plant (r=0.566**), leaf area index (r=0.5613**), leaf dry weight (r=0.5424**) stem dry weight (r=0.4051**), net weight of panicle/plot (r=0.7350**) stover weight per plant (r=0.4506**). This indicates that these growth and yield components parameters are critical determinants of sorghum yield. Chiezey (1981), Elkebil (1974), and Ila (1989) reported a similar result for one or more of the parameters indicated above. The highly significant and positive correlation between leaf area per plant, leaf area index, leaf and stem dry weight, with grain yield support that these growth characters determined the amount of photosynthates that will be available for grain filling.

Sorghum stover yield was also found to be highly significant and positvely correlated to number of leaves, leaf area per plant, leaf area index, leaf, stem dry weights, plant height at harvest. This may be attributed to the direct effect of translocation of assimilates to the stover by these growth parameters. This supports the findings of William (1967) who observed a significant positive correlation between plant height and main stalk yield.

A negative correlation between grain yield and crude protein percentage of grain (r= -0.1606) indicates that as the crude protein content increases the grain yield decreases probably due to reduction of the number of yield components. Rooney (1970) observed a similar result.

CHAPTER SIX

SUMMARY AND CONCLUSION

A field trial was conducted during the wet season of 1992 to study the effect of nitrogen level and source on yield, yield components and other agronomic characters of two sorghum varieties, at the Institute for Agricultural Research (IAR) Farm, Ahmadu Bello University, Samaru, Zaria. The varieties used were SAMSORG 16 (FFBL) and SAMSORG 17 (SK 5912), four different levels of nitrogen were applied (0, 30, 60 and 90 kg N/ha), while calcium ammonium nitrate (CAN) and urea were used as sources of nitrogen. The treatments were replicated three times in a split plot design in a factorial arrangement. Seeds were sown on 9th July, 1992.

The result indicated a 142.5% increase in sorghum grain yield with the application of 60 kg N/ha, when compared to plants that were not treated with nitrogen. The application of 90 kg N/ha was however found to give no significant increase in grain yield when compared to 60 kg N/ha. Similarly, there was a significant response to nitrogen level with up to 60 kg N/ha by different parameters under observations, such as number of leaves per plant, leaf area, leaf area index (LAI), leaf and stem dry weights per plant, plant height, panicle length and weight and the stover weight.

The response of the two sorghum varieties to the different sources of nitrogen was found to be nonsignificant. But urea appears to have an edge over calcium ammonium nitrate (CAN) in terms of increase in total crude protein content of the grains. This could be due to the high analysis of N in urea.

The choice of the either source of nitrogen depends partly on availability, price charged for 1 kg of nitrogen, the efficiency of each fertilizer for particular crop and soil, ease of storage, handling and distribution and whether the fertilizer causes a loss of lime from the soil.

In this study, the rate of 60 kg N/ha appears to be the optimum rate of nitrogen for sorghum. However, regression analysis indicates a maximum N level of 119.35 kg/ha, which approximately 120 kg/ha can be used to obtain highest grain yield. Most early work on N rates were done with local varieties. With the introduction of hybrid sorghum and other improved varieties, it would be necessary to re-evaluate the optimum rate of nitrogen in a savanna environment that is already low in nitrogen.

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