EFFECT OF SOWING DATE AND TIME OF NITROGEN FERTILIZER APPLICATION ON YIELD AND YIELD COMPONENTS OF SORGHUM (Sorqhufr bicolor (L.) Moench) VA&IElTIES

BY

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A thesis submitted to the Postgraduate School, Ahmadu Bella 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 publication for a higher degree. All quotations are indicated and the sources of information are specifically knowledged by means of references.

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CERTIFICATION

This thesis titled "EFFECT OF SOWING DATE AND TIME OF NITROGEN FERTILIZER APPLICATION ON YIELD AND YIELD COMPONENTS OF SORGHUM (Sorghum bicolor (L.) Moench) VARIETIES" by Lawal Mohmed Ila 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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DEDICATION

This thesis is dedicated to my mother and late father.

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ABSTRACT

A field experiment was conducted during the wet season of 1987 on the Institute for Agricultural Research (I.A.R.) farm at Samaru, Zaria, to study the effect of sowing date and time of nitrogen application on yield and yield components of sorghum (Sorghum bicolor (L.) Moench) varieties, samsorg 17 and samsorg 5.

Early sowing (June 24) significantly increased stover yield, shoot height, number of days to 50% flowering, 1000-grain weight and percentage bird damage. Sowing on July 15 resulted in higher grain weight per panicle and grain yield kg/ha. However, sowing date had no significant effect on percentage nitrogen and crude protein content of the grain, number of panicles per unit area, panicle length and number of seeds per panicle.

Time of nitrogen application had significant effect on stover yield at 6 weeks after sowing, but no significant effect was observed in other parameters measured. However, application of nitrogen in two equal splits at sowing and at six weeks after sowing resulted in slightly longer panicles, more number of days to 50% flowering, number of panicles per unit area, higher grain weight per panicle, 1000-grain weight number of seeds per panicle and grain yield. On the other hand, signle application at sowing resulted in taller plants and higher nitrogen and crude protein content of the grain.

With regard to variety, significantly higher number of panicles per unit area, number of seeds per panicle, and grain yield was obtained from samsorg 5, whereas, samsorg 17 was superior in shoot height, panicle length, grain weight per panicle and 1000-grain weight.

For the attainment of higher grain yield, samsorg 17 should be sown early (June 24), while sowing of samsorg 5 should be delayed to July 15. Nitrogen should be applied in equal splits, half at sowing and remaining half at six weeks after sowing.

Coefficient of correlation (r) showed that growth and yield components such as number of panicles per unit area (r=0.605**), number of seed per panicle (r=0.45**), panicle length (r=0.330*) and grain weight per panicle (r=0.29*) were positively and significantly correlated with grain yield.

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LIST OF ABBREVIATIONS

Abbreviation	Full Meaning
F.A.O.	Food and Agricultural Organisation of the United Nation.
N	Nitrogen
P (P_2O_5)	Phosphorus (Phosphorus pentoxide)
K (K_2O)	Potassium (Potassium Oxide)
Na	Sodium
Ca	Calcium
Mg	Magnesium
Meq	Milliequivalent
PPM	Parts Per Million
CEC	Cation Exchange Capacity
kg/ha	Kilogram per hectare
t/ha	Tonne per hectare
Ml	Millilitre
L	Litre
MM	Millimetre
CM	Centimeter
M	Metre
0^{C}	Degree Centigrade
WAS	Weeks After Sowing
LSD	Least Significant Difference
SE	Standard Error
No	Number
Wt	Weight
Ht	Height
I.A.R.	Institute for Agricultural Research.

Chapter 1

INTRODUCTION

Grain sorghum (Sorghum bicolor (L.) Moench) also called guinea corn, is extensively cultivated in the tropics, subtropics and temperate zones, sorghum ranks fourth in importance among the world's cereals after wheat, rice and maize (Doggett, 1970).

Sorghum, unlike other cereals tolerates hot and dry conditions. It grows well on light soils and perform satisfactorily on heavy soils, even when subjected to temporary water-logging (Kramer and Ross, 1970). Sorghum tolerates salinity and alkalinity fairly well.

World production is currently estimated to be 90.6 million tonnes (Anonymous, 1980). In Nigeria, sorghum occupies about 46% of the total land area devoted to cereal production and accounts for 50% of the total cereal production (Saleko, 1986). In 1977, about 4.8 million tonnes of sorghum grains were produced from about 6.6 million hectares, mainly in northern Nigeria.

Sorghum has been a potential source of food, feed and industrial raw material. It is mostly grown as a staple food crop in Africa and Asia and for livestock feed and industrial purposes in U.S.A. and Europe. In Nigeria, different parts of the sorghum plant are put to various uses. The stalks are used for fencing, thatching, mats, baskets, window and door blinds and fuel. The pith of the stalk is used for making toys for small children. The dry leaves and stalks are used for livestock feed (Oyeleke, 1981). The grains can be cooked and eaten as rice or used in making couscous (Leaky and Wills, 1977). In the industries sorghum grain can be used for making beer, flour, starch, wax, sugar and automobile fuel (Richard et al., 1974).

Sorghum production varies from place to place dur to variation in climate and agronomic practices. The maximum potential yield of sorghum have not been achieved. Yield on farmers field is about .633 ton/ha (Elemo and Obilana, 1985), whereas, yield of up to 5.5 ton/ha have been reported with commercial hybrids elsewhere (Picket and Oswalt, 1971). The low yields are as a result of limited amount of rainfall and poor distribution, lack of proper fertilization and poor pest and disease control practices coupled with habit of planting sorghum late. The optimum sowing date for sorghum is between May-June, at the establishment of the rainy season and delay in sowing was reported to decrease yield (Kowal and Kassam, 1975). Whereas, early sowing of the short season variety was observed to decrease yield (Anonymous, 1977).

The appropriate time to apply nitrogen fertilizer on sorghum depends on the climate, soil and crop variety. The response of improved varieties to time of nitrogen application varies with that of the local varieties (Wyne and Marlove, 1979). Research work by Sharma et al. (1980) showed that different times of nitrogen application had no significant influence on grain yield of sorghum. Kaigama (1978) reported higher grain yield from split application of nitrogen, half at sowing and half at 8 weeks after sowing. However, Tarfa (1987) observed that split application with half dose at 3 weeks after sowing and half at 8 weeks after sowing gave higher grain yield.

Several studies have been done on the effect of sowing date and time of nitrogen application on samsorg 17, but published research on the effect of sowing date and time of nitrogen application on samsorg 5 is rather limited. Therefore, the need to collect more information coupled with the increasing importance of sorghum in the industries, that the present investigations are carried out with the following objectives:-

1. To evaluate the effect of sowing date and time of nitrogen application on yield and yield components of sorghum varieties.

2. To determine the interactions between sowing date and time of nitrogen application on yield and yield components of sorghum.

Chapter 2

LITERATURE REVIEW

2.1 Effect of Weather on Sowing Date

A seed is a miniature plant with a well defined genotype and yield potential. The expressed characteristics of the final plant are, however, subject to modification by the type of environment in which the seeds are grown. The climatic constraint to sorghum production in the tropics is primarily water, this is as a result of variability on the onset of rains from year to year and from place to place.

In tropical climates, length of maturity of a variety and problems of infection by diseases and attack by pests determine the sowing date. Doggett (1970) observed that in most African countries, the optimum date of sowing is at the onset of rain showers. Early sowing results in utilization of the dry season nitrogen build up released as a flush of nitrate on the first rains (Birch, 1958). In an experiment to establish the optimum sowing date for early and late maturing sorghum varieties during the 1974 growing season, Anon. (1974) found that the short-season variety when planted early, the grains matured during the rains which cause moulding of the heads. The long-season variety when planted late were difficult to establish and did not head. He further observed that plants sown late were weak, and had poor growth. Russel

(1963) stated that planting delayed for 2 - 3 weeks can cause a 50% reduction in yield. A delay in planting often results in severe shootfly damage and midge infestation late in the season. Other workers who gave similar reports include (Firk and Kadam, 1979; Rao and Paul, 1979; Jotwani et al., 1976 and Summers et al., 1978).

2.2 Effect of Variety on Sorghum Plant Growth

Differences in growth and drymatter yield among sorghum varieties have been reported by various workers. Chiezey (1981) at Samaru, while working on physiological and morphological determinants of grain yield in sorghum reported significant differences in plant height among the cultivars. He further reported that stover yield, plant height, and length of panicle were influenced by cultivar. Onyibe (1987) working with three sorghum varieties, samsorg 17, samsorg 28 and samsorg 31, noted that, samsorg 17 produced taller plants.

2.3 Effect of Variety on Yield and Yield Components of Grain Sorghum

The yield of sorghum crop can be influenced by cultural practices, environmental factors and crop variety. Elemo and Obilana (1985) reported an average grain yield of 2.24 ton/ha with open-pollinated sorghum varieties, while yields of up to 4 ton/ha with improved cultivars have been reported by Goldsworthy (1970). Yield superiority of improved sorghum varieties have also been reported by Clegg et al. (1973), Onyibe (1987) and Dalton (1967). However, Obilana and El-Rouby (1978) while determing comparative performance of improved sorghum varieties, reported that the local variety yielded as much as the improved varities. Number of heads per square meter and number of grains per head also varies with cultiver.

2.4 Effect of Variety on Chemical Composition of Grain Sorghum

There is very little data as regards varietal effect on chemical composition of sorghum grains. However, Doggett (1970) reported lower protein content in the improved sorghum varieties. Rooney (1970) in an experiment with three sorghum hybrids to determine the influence of environment on the protein concent observed that the lower yielding hybrid (Martin variety) was significantly higher in crude protein content. He further stated that available soil nutrients, and the variety play an important role in influencing level of the protein in the grain.

2.5 Effect of Sowing Date on Sorghum Plant Growth

The growth and development of crops can be influenced by agronomic practices. Sowing date is one of these agronomic practices that can effect growth of sorghum. Kudasomannavar *et al.* (1984) working with two sorghum cultivars reported that total stover per plant and rate of stover production were not affected by late sowing up to Novembe1 16. However, Mirhadi et al. (1979) working with sorghum sown at 15 days interval (from May 1 to July 15) found that delay in sowing to May 15 increased the dry weight of the stem. Arkel (1980) using sorghum and maize in the high lands of Kenya reported losses in stover with delay in sowing. He further stated that early sowing proved more important for grain than for forage yield. Similar results were also reported by Han et al. (1985), and Andrews (1973). Kassam and Andrews (1975) compared the performance of samsorg 17 (SK 5912) a photosensitive Nigerian sorghum at Samaru in 10 sowings. They observed that growth generally decreased with delay in sowing, but there was little difference in crop growth in the first three sowings of May 7, 14 and 21. Ogunlela (1982) at Samaru in trial with two sorghum varieties, samsorg 20 (L187) and samsorg 2 (HP3) sown on 6 dates reported a significant reduction in stover yield with delay in sowing. Total number of leaves and plant height were reported to decrease with delay in sowing (Kassam and Andrews, 1975). Ogunlela (1985) roted reduction in stover yield with late sowing of sorghum.

2.6 Effect of Sowing Date on Yield of Grain Sorghum

A reliable estimate of the start of the rainy season is very important in tropical agriculture. The estiblishment of the crops early in the season means higher yields (stanton and Wiebe, 1953; and Andrews, 1975). Late planting results in low yields because of the limited period the crop gets for its vegetative growth. Working with ten sorghum hybrids sown on nine dates from September 21st to January 18, Assis et al., (1979) found that grain yields were highest in seven hybrids at the earliest sowing date and in the other three hybrids at the third sowing date. Singh (1976) while studying the effect of sowing date on the performance of grain sorghum in India, pointed out that after the onset of the monsoon, every delay in sowing resulted in substantial yield reduction which range from 37 to 318.8kg grain/ha/day. Decrease in grain yield with delay in sowing was also reported by Pacheco et al. (1984) and Pretorious and Human (1983).

Kassam and Andrews (1975) observed a decline in grain yield with delay in sowing at Samaru, but stated that date of heading and initiation were little affected by sowing date. In an experiment with sorghum varieties (samsorg 2 and Bauchi local) at Kano, Nigeria, samsorg 2 was observed to give its highest grain yield with the second sowing date, though the differences in grain yield between the first and second sowing date was not significant, Bauchi local gave its highest yield with the first sowing date (Anonymous, 1987). He further observed that successive sowing of Bauchi local from June 21, resulted in decrease in grain yield by about 20%. Ogunlela (1983) at Samaru and Mokwa, using samsorg 2, 20, 17 and 35 each sown on six different dates, found that delay in sowing after June 19 reduced grain yield by 44%. Kassam and Andrews (1975) reported a decrease in total grain weight at a rate of 360kg/ha/week with delay in sowing after May 26. They further observed that each week's delay in sowing after May 12 shortened the total growth cycle by 5.9 and 6.0 days. Trials with Samsorg 2 and Samsorg 20 sown at five dates (June 3 to July 24) was observed to reduced both grain and straw yield of Samsorg 20, whereas, late sown Samsorg 2 yielded more grains than when sown early (Ogunlela, 1985). He further reported that grain yield varied from 825 to 1625 kg/ha in Samsorg 2 and from 679 to 2476 kg/ha in Samsorg 20. He attributed the yield losses to shootfly attack and low soil moisture when the crops are sown late.

2.7 Effect of Sowing Date on Yield Components of Grain Sorghum

The yield of sorghum crop can be broken down into several components such as number of heads per plant, number of seeds per head, seed weight and 1000-grain weight. At a given population number of seeds per head is usually the most important component of yield (Kambal and Webster, 1966). Sigh (1982) reported that, the sorghum variety (CSH-5) produced best quqlity seed in terms of seedling vigour and higher 1000-grain weight when sown early than when sown late. Ogunlela (1982) working at Samaru, observed a significant reduction in number of grains per head as sowing was delayed. Kassam and Andrews (1972) also at Samaru, noted a decrease in grain weight and number of grains per head with every week delay in sowing, but harvested index increased from the first to the second sowings and thereafter decreased sharply. Ogunlela

(1985) in an experiment with Samsorg 2 and 20, reported that late sowing reduced panicle weight, grain number and grain weight of Samsorg 20, but increased grain number of Samsorg 2.

2.8 Effect of Time of Nitrogen Application on Sorghum Plant Growth

Time of fertilizer application depends on climate, the crop, soil and also on the mobility of the particular nutrient to be applied. Potassium and phosphate fertilizers which were hardly leached are often applied at once during land preparation or at sowing. On the other hand, nitrogen fertilizers which are generally susceptible to leaching, are applied at different times during the growing season or at different stages of growth and development of the crop (Mengel and Kikby, 1982). In India, Nagur and Ramo (1967) suggested an initial application of nitrogen to be followed by a top dressing after one month for maximum growth of sorghum. Split application of the total nitrogen dose in two or more splits was suggested by Mengel and Kikby (1982).

Basal application of nitrogen followed by top dressing was reported to increased stover yields from 6.29 to 7.83 tonnes/ha (Itnal et al. (1980). Split application of nitrogen with 50% of the dose at sowing and 50% at boot stage was observed to shorten growth cycle of sorghum (Rosolem et al., 1981). Tarfa (1987) observed that single application of the nitrogen at emergence resulted in greater plant height, but this reduced the stem diameter.

Hussain and Rao (1968) observed the highest grain and stover yield with nitrogen application as a single dose at planting followed by split application of equal doses of half at sowing and half at Knee hight stage. They further reported that single application at sowing induced sorghum to flower early. Ismaila and Ali (1986) while studying effect of nitrogen rate and time of application on sorghum noted that split application increased time taken to reach 50% flowering while plant height was not affected.

2.9 Effect of Time of Nitrogen Application on Grain Yield of Sorghum

Time of nitrogen application has been reported to significantly influenced grain yield of sorghum (Anon. 1972 and 1974). Sharma et al. (1980) reported that different times of nitrogen application did not significantly affect grain yield of sorghum. When nitrogen rates of 50 kg/ha and 90 kg/ha were applied in split doses before and 20 days after sowing or applied singly at or just prior to sowing no yield advantage was noted (Doughton 1971). Similar results were also reported by Nagre and Khedekar (1984). However, Pererira and Fontes (1979) working with sorghum in Brazil reported that single nitrogen application increased grain production but split nitrogen application regardless of the amount reduced grain yield in one of the trials. Rosolem et al.

(1985) noted highest yields when all the nitrogen was applied at planting and there was no yield advantage in splitting the nitrogen. Ogunlela and Egharevba (1981) reported 10 - 15 per cent increased in yield when nitrogen was applied at 0 WAS than application at 4, and 10 WAS. Egharevba (1970) stated that even though no one time of nitrogen application proved superior over the other, however, split application might be beneficial over single application. Doggett (1970) reported that there is often yield advantage from split nitrogen dressing at seed bed preparation and top dressing 1 - 2 weeks before floral initiation.

Stomoyor and Lugo (1970) working on the effect of the rate and time of nitrogen application on yield nutrient uptake and other characteristics on sorghum in Puerto Rico, observed that yields were higher with split application of nitrogen than with single application. An average of 2.09 to 3.36 tonnes per hectare of grain yield was observed when basal nitrogen dressing was followed by a top dressing (Ismaila and Ali, 1980). Boonampol et al. (1975) working with maize and sorghum, reported that split nitrogen application was more effective producing the best yields than single application in the ratio 1:3 at sowing and 2:3 at 30 days after sowing. Turkhede et al. (1970) and Basavaraju (1982) also obtained higher yields with split application of nitrogen.

At Samaru, a sorghum hybrid Samsorg 27 (SSH-1) was observed to give highest yields when nitrogen was applied in two split dressings at sowing and as top dressing or in three split dressings (Anon., 1970). Kaigama (1970) working with two sorghum varieties (Samsorg 2 and Bauchi local) to determine the best time to apply nitrogen using four dates of nitrogen application (4, 6, 8 and 10 WAS) noted that split application at seed bed and at 8 WAS gave highest grain yield which was 10-15% higher than the yields of other times of nitrogen application. In an experiment with Samsorg 16 (FFBL) and Samsorg 17 using nitrogen rate of 50kg/ha which was applied at different times, it was observed that for Samsorg 16 the highest grain yield was recorded when half the rate was applied at sowing and the other half at one month after sowing. While for the other variety highest yield was obtained when half the nitrogen rate was applied at sowing and the other half at two months after sowing (Anonymous, 1976). Yusuf and Egharevba (1978) in an experiment with farafara and Samsorg 17 using nitrochalk as source of nitrogen applied at the rate of 80 kg/ha in split doses, found that the best timing was half dose at sowing and the remaining half at 6-8 WAS. Tarfa (1987) while determining the effects of rate, time and method of nitrogen application on the performance of sorghum, observed that split application of nitrogen with half dose at 3 WAS and half at 8 WAS gave higher grain yield than single application at emergence, at 3 WAS and at 6 WAS.

2.10 Effect of Time of Nitrogen Application on Yield Components of Sorghum

Application of nitrogen affect both morphological characteristics and yield components of sorghum. Nitrogen application was reported to increased panicle length, number of grains per panicle and leaf area index (Oteze, 1981). Roselem and Machado (1980) noted that application of nitrogen at sowing and 25 days after emergence increased the number of grains per head, while application at a later date induced sorghum to produce heavier grains without increasing yield. Carvalho and Fontes (1980) stated that nitrogen increased number of grains per panicle but reduced the average weight of the grains. Working with tall and dwarf sorghum varieties at Samaru, Anonymous (1976) reported that the tall variety produced the greatest number of heads when half the nitrogen dose was applied at sowing and half at one month after sowing, whereas, the dwarf variety produced more number of heads when half the nitrogen dose was applied at sowing and half at two months after sowing. Tarfa (1987) observed that split application of the nitrogen dose resulted in heavier grains per panicle, and higher number of grains per panicle.

2.11 Effect of time of Nitrogen Application on Chemical Composition

Not much have been reported on the effect of time of nitrogen application on chemical composition of sorghum grain.

However, Doggett (1970) reported reduction in protein content of grain with low soil nitrogen. Increase in protein content with single application of nitrogen was reported (Pereira and Fontes 1979). Stomoyor and Lugo (1978) while working on the effect of the rate and time of nitrogen application on sorghum, observed that crude protein levels in the grains were higher with split application of nitrogen than with single application. Rooney (1970) observed that protein content of sorghum grain was negatively related with yield and that any factor which increases grain yield will cause decrease in protein content. Dechev (1976) reported that split application of nitrogen before sowing and at first hoeing increased the crude protein and ash content of the sorghum grain. Tarfa (1987) reported increase in nitrogen and crude protein content with single application of nitrogen at 6 WAS.

2.12 Correlation of Yield of Sorghum and Other Yield Components

Yield is the intergrated expression of complex relationships between a number of plant characters. These relationships are conveniently and mathematically expressed as correlations. It has been shown that there is a positive correlation between different growth characters, yield components and grain yield of sorghum.

Chiezey (1981) reported that seed yield was positively correlated with grain number per head and that, the high yielding cultivars were found to have more grains on the head than the lower yielding cultivars. This relationship had earlier been reported by Ogunlela (1979), who observed significant positive correlation between grain and harvest index. Graham (1967) while studying the effects of height on yield and yield components of sorghum reported that a significant positive correlation existed between total yield and all characters except number of tillers per plot which was negative. He further reported a significant positive correlation between plant height, main stalk yield and total yield. Eckebil (1974) also reported that number of heads per plant and number of tillers were negatively correlated with grain yield. However, Chiezey (1981) observed that height was negatively correlated with grain yield and that, the shorter plants showed their superiority in yield over the taller ones. In an experiment with short season sorghum varieties grain number per panicle was observed to be significantly and positively correlated with grain yield (Anonymous 1974). He further stated that, 1000-grain weight was positively but not significantly correlated with grain yield. Doggett (1970) reported similar results. Ogunlela (1979) observed a significant negative correlation between seed number and seed weight. Chiezey (1981) stated that, 1000-grain weight had little or no effect or even negative effect on grain yield. He observed that a sorghum variety (Samsorg 27) with the heaviest grains yielded poorly. Rooney (1970) reported a negative correlation between grain yield and percentage nitrogen and crude protein content of sorghum grain. Eckebil (1974) also reported similar results.

Chapter 3

MATERIALS AND METHODS

3.1 Experimental Location

The experiment was conducted during the 1987 cropping season at the Institute of Agricultural Research (I.A.R.) farm of Ahmadu Bello University, Samaru ($11^{\circ}11'$N and $07^{\circ}38'$E). Samaru is located at the Northern Guinea Savanna ecological zone of Nigeria with average annual rainfall of 1100mm.

The soil at the trial area is sandy-loam. A composite soil sample taken from 0-15cm and 15-30cm depths were analysed and the physical and chemical properties of the area are presented in Table 3.1.

The meteorogical data including temperature, rainfall, sun-shine hours and relative humidity during the period of experimentation are presented in Table 3.2.

3.2 Crop Varieties

The sorghum varieties used were Samsorg 17 (SK 5912) which is a late maturing variety, about 2.2m tall with cream grains. The other was Samsorg 5 (KSV II) which is an early maturing variety, about 1.2m tall with white grains.

3.3 Treatments

The treatments were made up of three factors: two

Table 3.1 Physical and chemical properties of the soil of the experimental site at the University Farm, Samaru.

Soil Properties	Characteristic Level Depth (cm) 0-15	15 - 30
Physical Properties		
% day	15.0	16.2
% silt	31.0	30.5
% Sand	53.8	52.7
Textural Class: Sandy loam		
Chemical Properties		
pH (H_2O 1:1)	6.1	5.8
pH (1:1.25 0.01m $Cacl_2$)	5.6	5.2
Organic Carbon %	0.42	0.34
Available - P (ppm)	7.7	6.5
Total - N(0.048N.H_2SO_4)	0.035	0.029
Exchangeable cations (meq/100g soil)		
ca	3.10	2.02
mg	0.79	0.84
k	0.23	0.24
Na	0.04	0.03
Cation exchange capacity	5.60	5.40

Table 3.2 Total Rainfall, mean temperature, Relative humidity and sun-shine hours at ten-days interval during 1987 wet season.

			Mean Temperature		Relative Humidity		Sun-shine hour
Month	Days	Rainfall	Max	Min	AM	PM	
May	1-10	Nil	38.7	21.3	36.0	18.7	9.9
	11-20	Nil	38.6	23.4	47.7	16.8	8.1
	21-31	12.3	33.4	22.0	66.6	45.6	8.5
June	1-10	8.5	29.8	20.6	81.5	6.5	6.4
	11-20	1.68	32.1	21.8	71.2	53.8	8.9
	21-30	4.5	30.1	21.0	76.7	68.2	7.5
July	1-10	5.2	30.5	20.6	77.6	61.7	8.4
	11-20	10.6	30.6	20.3	78.9	64.3	7.9
	21-31	10.7	29.2	19.7	82.6	68.6	6.8
August	1-10	10.5	29.9	19.9	83.0	67.7	7.0
	11-20	7.6	28.5	19.2	86.6	76.6	5.1
	21-31	8.0	29.2	20.4	86.5	72.8	6.1
September	1-10	3.3	29.9	20.4	78.7	64.8	8.0
	11-20	5.7	30.4	20.4	75.9	65.6	7.1
	21-30	1.2	31.0	20.3	73.2	59.1	8.9
October	1-10	4.3	30.8	20.0	73.4	57.1	8.0
	11-20	Nil	31.4	18.7	62.6	47.3	9.4
	21-31	Nil	30.9	14.1	20.4	20.8	8.3
November	1-10	Nil	31.2	11.4	22.0	19.0	9.4
	11-20	Nil	31.3	12.8	23.7	19.7	9.2
	21-30	Nil	33.0	13.0	23.3	18.1	10.0
December	1-10	Nil	32.5	12.7	24.5	18.9	8.5
	11-20	Nil	29.5	11.6	20.9	16.7	8.9
	21-31	Nil	28.5	13.5	27.3	21.6	7.4

Source: Meteorological Unit, IAR-ABU, Samaru, Zaria.

varieties (Samsorg 17 and Samsorg 5), three sowing dates (at three weeks intervals) and three times of nitrogen fertilizer application. (All nitrogen dose applied at sowing, half nitrogen applied at sowing and half at 6 WAS and half nitrogen dose applied at 3 WAS and half at 6 WAS.

3.4 Experimental Design

The experiment was laid out in a randomised complete block design (CB) with 18 treatments. The factorial arrangement was replicated four times giving a total of 72 plots.

3.5 Gross Plot Size

The gross plot consisted of 6 ridges 0.75m apart, 5m long with an area of 22.5m^2. Yield data were collected from net plots measuring 0.75m x 4 5m with an area of 15m^2.

3.6 Agronomic Practices

3.6.1 Land preparation

The experimental area was ploughed once, harrowed twice and ridged at 75cm apart.

3.6.2 Sowing

Four to five seeds per hole were sown at a spacing of 75cm x 25cm at three weeks intervals starting from 24th June, 1987. Thinning to two plants per stand was done two weeks after sowing. The total plant population used was 54,000 plants per hectare.

3.6.3 Fertilizer management

Single super phosphate fertilizer (18% P_2O_5) at the rate of 32kg/ha was applied at the time of sowing. Calcium ammonium nitrate (CAN) containing 26% N used as source of nitrogen at the rate of 64kg/ha was applied in groove at three different times.

3.6.4 Weed and pest control

Three hoe-weedings were done at 3, 7 and 10 weeks after sowing. Observed stemborer and head smuts were controlled by weekly spray of carbaryl (Vetex 85) at the rate of 2.2kg/ha and by hand pulling out the affected heads, respectively. A boy was employed to scare away birds.

3.6.5 Harvesting and threshing

Harvesting, threshing and cleaning of seeds were done manually. The harvesting was done at full physiological maturity, after the appearance of a dark layer at the placental region of the grains (Table 3.3). The panicles were threshed after two weeks of continuous sun-drying.

3.7 Measurements and Observations

3.7.1 Percentage stand establishment

The number of stand per plot were counted at three weeks after sowing.

Table 3.3 Date of sowing, maturity, harvesting and duration of the crop in the field.

Variety	Date of Sowing	Date of Maturity	Date of Harvesting	Duration (Days)
Samsorg 5	June 24, 1987	Oct. 2, 1987	Oct. 16, 1987	102
	July 15, 1987	Oct.11, 1987	Oct. 16, 1987	93
	Aug. 6, 1987	Nov. 1, 1987	Nov. 5, 1987	91
Samsorg 17	June 24, 1987	Nov.20, 1987	Dec.10, 1987	172
	July 15, 1987	Nov. 8, 1987	Dec.23, 1987	161
	Aug. 6, 1987	Nov.21, 1987	Jan.3, 1987	152

3.7.2 Number of days to 50% flowering

The date of 50% flowering for each plot was determined from the date of sowing to when 50% of the plants in a plot had flowered, this was scored by counting.

3.7.3 Stover yield

Using systematic sampling, three plants were removed from each plot at 3, 6. 9, 12 and 15 weeks after sowing, cleaned and oven dried for 48 hours at 60^{o}C to constant weight to determine the stover yield.

3.7.4 Shoot height

A sample of 5 randomly selected plants were taken and their heights from ground level to the tip of the panicle were measured. An average plant height was later calculated.

3.7.5 Number of panicles per unit area

The number of panicles per unit area at physiological maturity were counted.

3.7.6 Length of panicle

Five plants were randomly selected and the length of their panicles measured. For the tall variety, length of panicle was taken after harvest.

3.7.7 Weight of grains per panicle

The weight of grains per panicle was obtained from 5 plants which were seperately and carefully threshed. Average weight of grains per panicle was calculated.

3.7.8 Number of grains per panicle

The number of grains of three plants randomly selected from each plot was recorded.

3.7.9 A thousand grain weight

From the samples of 5 plants, 1000 grain weight (grams) was recorded.

3.8 Grain Yield/Hectare

The grain yield was obtained after threshing and cleaning.

The seeds harvested from each plot were weighed separately and from these the grain yield/ha was calculated at 14% moisture.

3.8.1 Pest and disease score

The number of plants attacked by diseases and pests were recorded.

3.8.2 Percentage crude protein and nitrogen content

Fifty grams of the grains were taken from each plot, clean, grounded and percentage of nitrogen content determined using Micro-Kjedahl method. Percentage of crude protein content was obtained by multiplying with the factor 6.025.

3.9 Statistical Analysis

All data collected were subjected to statistical analysis of varience and were "F" test showed significant difference, the means of such treatments were then compared using Duncan's multiple range test (Duncan, 1955). Correlation analysis between growth characters, yield components and grain yields of sorghum was also done to determine their relationships.

Chapter 4

RESULTS

4.1 Effect of Sowing Date, Time of Nitrogen Application and Variety on Growth of Grain Sorghum

4.1.1 Percentage stand establishment

Results of the effect of variety sowing date and time of nitrogen application on percentage stand establishment is presented in Table 4.1. Percentage stand establishment was significantly affected by sowing date. Sowing on July 15 gave the highest stand establishment, followed by sowings of August 6 and June 24, respectively. No significant interaction effect was observed on percentage stand establishment.

4.1.2 Number of days to 50% flowering

Number of days to 50% flowering was significantly affected by variety and sowing date (Table 4.1). Samsorg 5 attained 50% flowering earlier than Samsorg 17. 50% flowering occured earlier with late sowing on August 6. Earlier sowing dates (June 24) and (July 15) increased the number of days to 50% flowering.

Time of nitrogen application had no significant effect on number of days to 50% flowering, however, 50% flowering occured earlier when all the nitrogen dose was applied at sowing. Interaction effect between sowing date by variety,

Table 4.1: Effect of variety, time of nitrogen application and sowing date on percentage stand establishment, number of days to 50% flowering and shoot height (cm) of sorghum plant at Samaru in 1907.

	% Stant Establishment	No. days to 50% flowering	Shoot height (cm)
Variety			
Samsorg 17	76.50a	101.61a	176.79a
Samsorg 5	75.06a	73.89b	110.12b
(SE±)	1.70	0.47	2.75
Time of N application			
All dose at sowing	70.25a	07.00a	149.53a
½ dose at sowing + ½ at 6 WAS	75.07a	00.25a	139.50a
½ dose at 3 WAS + ½ at 6 WAS	73.67a	00.00a	141.94a
(SE±)	2.00	0.50	3.36
Sowing date			
June 24	70.33b	95.17a	160.42a
July 15	79.75a	80.96b	145.52b
August 6	77.71ab	79.13c	116.42c
(SE±)	0.08	0.58	3.36

* Means followed by the same letter(s) within a column are not significantly different at 5% level of significance using DMRT.

and sowing date by time of nitrogen application were significant on number of days to 50% flowering (Table 4.2 and 4.3). Interaction between variety by time of nitrogen application was not significant on number of days to 50% flowering.

4.1.3 Shoot height

The effect of sorghum variety, sowing date and time of nitrogen application on plant height is shown in Table 4.1. Samsorg 17 was significantly taller than Samsorg 5. The none split application of the nitrogen dose at sowing was observed to produce the tallest sorghum plants, but this was not significantly different from split application of the nitrogen.

Earliest sowing date of June 24 produced significantly taller sorghum plants than the other two dates of sowing. The last sowing on August 6, resulted in significantly shorter plants than that of July 15, sowing date. There was significant interaction effect between variety by sowing date on shoot height (Table 4.4). All other interaction effects were not statistically significant.

4.1.4 Stover yield

Stover yield per plant was significantly affected by variety, sowing date and time of nitrogen application (Table 4.5). The variety Samsorg 17, had significantly higher stover yield at 6 and 9 WAS. Whereas, at 12 and 15 WAS, Samsorg 5

Table 4.2: Interaction between sowing date and variety on number of days to 50% flowering of sorghum plant at Samaru, in 1907.

	Sowing date		
Variety	June 24	July 15	August 6
Samsorg 17	114.83a	103.00b	07.00c
Samsorg 5	75.50d	74.92d	71.25d
SE ± (interaction)		0.82	

Table 4.3: Interaction between sowing date and time of N application on number of days to 50% flowering of sorghum plant at Samaru, in 1907.

	Sowing date		
Time of N Application	June 24*	July 15	August 6
All dose at sowing	96.00a	00.75b	76.24d
½ dose at sowing + ½ at 6 WAS	95.00a	00.00b	00.80c
½ dose at 3 WAS + ½ at 6 WAS	94.50a	09.25b	00.25c
SE ± (interaction)		1.00	

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

Table 4;4: Interaction between variety and sowing date on shoot height (cm) of sorghum plant at Samaru, in 1907.

	Sowing date		
Variety	June 24	July 15	August 6*
Samsorg 17	220.03a	100.72b	129.63c
Samsorg 5	116.02c	110.32c	103.2[illegible]
SE ± (Interaction)		4.7b	

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

Table 4.5: Effect of variety, time of nitrogen application and sowing date on stover yield per sorghum plant (g) at Samaru, in 1987.

Treatment	Weeks after sowing (WAS)				
	3	6	9	12	15
Variety					
Samsorg 17	3.20a	22.84a	58.84a	94.42b	110.13b
Samsorg 5	3.09a	19.39b	50.37b	101.72a	119.55a
(SE ±)	0.17	0.60	1.82	2.59	2.45
Time of Nitrogen Application					
All dose at sowing	3.14a	20.70ab	51.95ab	88.12a	102.03a
½ dose at sowing + ½ at 6 WAS	3.59a	22.33a	59.64a	95.22a	113.90a
½ dose at 3 WAS + ½ at 6 WAS	2.37a	17.24b	45.23b	85.37a	101.51a
(SE ±)	0.21	0.83	2.23	3.10	3.00
Sowing date					
June 24	3.76a	28.36a	76.02a	120.56a	140.99a
July 15	3.74a	19.66b	48.55b	85.96b	103.32b
August 6	1.93b	12.34c	33.25c	54.19c	67.19c
(SE ±)	0.21	0.83	2.23	3.10	3.00

* Means followed by the same letter(s) within a column are not significantly different at 5% level of significance using DMRT.

gave higher stover yield. With regard to time of nitrogen application, split application of half the nitrogen dose at sowing and half at 6 WAS gave highest stover yield per plant throughout the sampling period. However, this was not significantly different with that of whole application of the nitrogen dose at sowing. Significant difference in stover yield between split application of nitrogen (half at sowing and half at 6 WAS) and split application of nitrogen (half at 3 WAS and half at 6 WAS) was obtained at 6 and 9 WAS only.

Significantly highest stover yield was obtained with the earliest sowing date of June 24. Delay in sowing from June 24 to July 15 had higher significant stover yield throughout the sampling period than further delay in sowing to August 6. The interaction effect between variety by sowing date, variety by time of nitrogen application and sowing date by time of nitrogen application were statistically significant at the 6th sampling only (Tables 4.6, 4.7 and 4.8). All other interactions were not significant on stover yield.

4.2 Yield and Yield Components of Grain Sorghum

4.2.1 Grain yield/hectare

Results of the effect of variety, sowing date and time of nitrogen application on grain yield (kg/ha) is shown in Table 4.9. Samsorg 5 gave a significantly higher grain yield and this was 17.85% higher than grain yield of

Table 4.6: Interaction between variety and sowing date on stover yield per sorghum plant (g) at 6 WAS at Samaru, in 1987.

	Sowing date		
Variety	June 24	July 15	August 6*
Samsorg 17	32.93a	22.71bc	12.09d
Samsorg 5	23.79b	16.61cd	11.70d
SE ± (Interaction)		1.17	

Table 4.7: Interaction between sowing date and time of nitrogen application on stover yield per sorghum plant (g) at 6 WAS at Samaru, in 1987.

	Sowing date		
Time of nitrogen application	June 24	July 15	August 6
All dose at sowing	30.60a	20.47bc	11.37d
½ dose at sowing + ½ at 6 WAS	31.29a	22.24b	13.44cd
½ dose at 3 WAS + ½ at 6 WAS	23.10b	16.26cd	12.37cd
SE ± (Interaction)		1.43	

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

Table 4.0: Interaction between variety and time of nitrogen application on stover yield per sorghum plant (g) at 6 WAS at Samaru, in 1987.

Variety	Time of Nitrogen Application		
	All dose at sowing	½ dose at sowing + ½ at 6 WAS	½ dose at 3 WAS + ½ at 6 WAS
Samsorg 17	23.69ab	26.59a	18.24bc
Samsorg 5	17.07bc	18.06bc	16.25c
Se ± (Interaction)		1.17	

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

Samsorg 17. Split and single application of the nitrogen dose had no significant grain yield advantage, but application of half the nitrogen dose at sowing and half at 6 WAS produced higher grain yield, similarly, single application of the nitrogen dose at sowing gave better grain yield than splitting the nitrogen half at 3 WAS and the remaining half at 6 WAS.

Sowing date of July 15 resulted in higher grain yield, but this was not significantly different with that of June 24 sowing. However, sowing of August 6 gave a significantly lower grain yield than the two earlier sowing dates (June 24 and July 15). Interaction between variety by sowing date significantly influenced grain yield (Table 4.10). Grain yield of Samsorg 17 gradually declined with delayed sowings, while that of Samsorg 5 was highest with delayed sowing on July 15, this was followed by earlier sowing on June 24 and late sowing on August 6, respectively. Time of nitrogen application by variety and all other interactions had no significant effect on grain yield per hectare.

4.2.2 <u>One thousand grain weight</u>

Variety and sowing date significantly affected 1000-grain weight (Table 4.9). Higher 1000-grain weight was obtained from Samsorg 17. Time of nitrogen application had no statistical significance on 1000-grain weight, but application of half the dose at 3 WAS and half at 6 WAS gave

Table 4.9: Effect of variety, time of nitrogen application and sowing date on 1000-grain weight (g) and grain yield per hectare (kg) of sorghum plant at Samaru, in 1987.

Treatment	1000-grain wt (g)	Grain yield kg/ha
Variety		
Samsorg 17	35.90a	1912.36b
Samsorg 5	22.77b	2327.70a
(SE ±)	0.66	69.99
Time of nitrogen application		
All dose at sowing	28.65a	2154.76a
½ dose at sowing + ½ at 6 WAS	28.70a	2190.93a
½ dose at 3 WAS + ½ at 6 WAS	26.00a	2006.52a
(SE ±)	0.81	85.73
Sowing date		
June 24	30.10a	2051.90a
July 15	29.73a	2415.94a
August 6	23.72b	1892.34b
(SE ±)	0.81	85.73

* Means followed by the same letter(s) within a column are not significantly different at 5% level of significance, using DMRT.

Table 4.10: Interaction between variety and sowing date on grain yield (kg/ha) of sorghum plant at Samaru, in 1987.

Variety	Sowing date June 24	July 15	August 6
Samsorg 17	2463.57ab	1954.51bc	1341.12c
Samsorg 5	1662.41c	2857.36a	2441.46ab
SE ± (Interaction)		121.23	

Table 4.11: Interaction between variety and sowing date on 1000-grain weight (g) of sorghum plant at Samaru, in 1987.

Variety	Sowing date June 24	July 15	August 6
Samsorg 17	40.24	36.60ab	31.07b
Samsorg 5*	20.16c	22.70c	16.37c
SE ± (Interaction)		1.14	

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

the least 1000-grain weight. Sowing on June 24 and July 15 had no significant difference on 1000-grain weight, delaying sowing to a later date significantly reduced 1000-grain weight. Results of interaction of variety by sowing date on 1000-grain weight is shown in Table 4.11 early and late sowing of Samsorg 5 gave similar results while samsorg 17 sown early had significantly higher 1000-grain weight over the late sowing date. No significant interaction was obtained between time of nitrogen application by variety and time of nitrogen application by sowing date.

4.2.3 Number of panicles per unit area

Sowing date and time of nitrogen application had no significant effect on number of panicles per unit area. Single or split application of nitrogen had no significant difference on this variable (Table 4.12). Variety significantly influenced number of panicles per unit area at harvest. Samsorg 5 produced higher number of panicles than Samsorg 17, All interactions had no significant effect on number of panicles per unit area.

4.2.4 Length of panicle

The length of the sorghum panicle was significantly affected by variety (Table 4.12). Samsorg 17 had longer panicles than Samsorg 5. Time of nitrogen application and sowing date had no significant effect on length of panicle. However, split application of half the nitrogen dose at

Table 4.12: Effect of variety, sowing date and time of nitrogen application on number of panicles per unit area, length of panicle (cm), number of seeds per panicle and grain weight per panicle (g) of sorghum plant at Samaru, in 1987.

Treatment	No. of panicles per unit area ($15m^2$)	Panicle length (cm)	No. of seeds/ panicle	Grain wt/ panicle(g)
<u>Variety</u>				
Samsorg 17	71.47b	32.50a	2603.47b	89.07a
Samsorg 5	90.47a	23.39b	2965.92a	69.94b
(SE $\pm$)	2.65	0.29	92.49	3.02
<u>Time of nitrogen application</u>				
All dose at sowing	80.92a	28.01a	2840.21a	82.60a
½ dose at sowing + ½ at 6 WAS	81.96a	28.14a	2841.96a	86.21a
½ dose at 3 WAS + ½ at 6 WAS	80.04a	27.60a	2671.92a	78.65a
(SE $\pm$)	3.25	0.35	113.27	3.70
<u>Sowing date</u>				
June 24	82.03a	28.30a	2843.46a	86.40a
July 15	82.00a	28.13a	2879.04a	90.62a
August 6	78.00a	27.40a	2631.50a	61.44b
(SE $\pm$)	3.25	0.35	113.27	3.70

* Means followed by the same letter(s) within a column are not significantly different at 5% level of significance using DMRT.

sowing and half at 6 WAS, and early sowing of June 24 showed similar trend by slightly increasing the panicle length. Interaction between variety by sowing date, variety by time of nitrogen application and sowing date by time of nitrogen application were not significant.

4.2.5 Number of seeds per panicle

Table 4.12 shows the effect of variety, sowing date and time of nitrogen application on number of seeds per panicle. These parameters did not significantly influence number of seeds per panicle. However, Samsorg 5 produced higher number of seeds per panicle. While split application of nitrogen half at sowing and half at 6 WAS resulted in slightly higher number of seeds per panicle. Least number of seeds per panicle was obtained with split application of the nitrogen dose (half at 3 WAS and half at 6 WAS). Delayed sowing from June 24 to July 15 gave slightly more seeds per panicle than the earlier or later sowing dates. All interactions had no significant influence on seed number per panicle.

4.2.6 Grain weight per panicle

Grain weight per panicle was significantly affected by variety and sowing date (Table 4.12). Grain weight per panicle of Samsorg 17 was significantly higher than that of Samsorg 5. Delay in sowing up to July 15 gave highest grain weight per panicle and this was followed by the sowing on

June 24, while sowing on August 6 reduced the grain weight by about 32%. Time of nitrogen application had no significant effect on grain weight per panicle, however, split application of half the nitrogen dose at sowing and half at 6 WAS resulted in slightly heavier grains per panicle, this was followed by single nitrogen application at sowing. Interaction between variety by sowing date was statistically significant (Table 4.13). Variety by time of nitrogen application and sowing date by time of nitrogen application were not significant statistically.

Table 4.13: Interaction between variety by sowing date on grain weight/panicle (g) of sorghum plant at Samaru, in 1987.

		Sowing date	
Variety	June 24	July 15	August 6
Samsorg 17	101.27a	94.77a	71.18b
Samsorg 5	71.69b	86.48a	59.70c
SE ± (Interaction)		5.23	

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

4.3 Chemical Composition of Sorghum Grain

4.3.1 Percentage of nitrogen content

All parameters considered in the present studies had no significant effect on percentage nitrogen content of sorghum grain (Table 4.14). However, Samsorg 17 had slightly higher nitrogen content than Samsorg 5. Single application of the nitrogen dose at sowing resulted in higher percentage nitrogen content than split application of nitrogen. The later the sowing date the higher the nitrogen content. All interactions were not statistically significant with regard to percentage of nitrogen content.

4.3.2 Percentage crude protein content

Percentage crude protein content of sorghum grain showed same trend with per cent of nitrogen content of sorghum grain as regard the effect of variety, sowing date and time of nitrogen application. Variety, sowing date, time of nitrogen application and all their interaction effect were not significant on percentage crude protein content (Table 4.14).

4.4 Pest and Disease Score

4.4.1 Perxentage bird damage

Variety and sowing date had no significant influence on percentage bird damage (Table 4.15). Samsorg 5 suffered

Table 4.14: Effect of variety, time of nitrogen application and sowing date on percentage nitrogen and crude protein content of sorghum greins at Samaru, in 1987.

Treatment	% Nitrogen content*	% Crude protein content*
<u>Variety</u>		
Samsorg 17	1.43a	0.62a
Samsorg 5	1.34a	0.53a
(SE ±)	2.72	0.22
<u>Time of nitrogen application</u>		
All dose at sowing	1.40a	0.85a
½ dose at sowing + ½ at 6 WAS	1.27a	0.24a
½ dose at 6 WAS + ½ at 6 WAS	1.34a	0.63a
(SE ±)	3.33	0.62
<u>Sowing date</u>		
June 24	1.30a	0.07a
July 15	1.39a	0.65a
August 6	1.40a	9.00a
(SE ±)	3.33	0.62

* Means followed by same letter(s) within a column are not significantly different at 5% level of significance using DMRT.

more damage by birds than Samsorg 17. Highest damage by birds was observed with the earliest sowing on June 24. The later the sowing, the less percentage bird damage. All interactions with the exception of variety by sowing date (Table 4.14) were not significant statistically.

4.4.2 Stemborer infestation

Variety, sowing date and time of nitrogen application were not significant with respect to stemborer attack on sorghum plant (Table 4.15). Higher rate of infestation by stemborer was observed on Samsorg 5 than Samsorg 17. While least infestation was recorded with single application of the nitrogen at sowing than the other times of nitrogen application. Late sowing on July 15 had higher rate of attack by stemborer. None of the interactions were significant on rate of stemborer attack.

4.4.3 Head smut infection

No significant effect of variety, sowing date, time of nitrogen application and all their interactions was obtained with respect to smut infection on sorghum plant. But slightly higher infection was observed on Samsorg 5 than Samsorg 17 (Table 4.15).

Table 4.15: Effect of variety, time of nitrogen application and sowing date on percentage bird damage to grains and disease score at harvest of sorghum at Samaru in 1987.

Treatment	% Birds damage	Stemborer	Head smut
<u>Variety</u>			
Samsorg 17	0.00b	0.20a	0.39a
Samsorg 5	0.03a	3.19b	0.50a
(SE ±)	0.94	0.90	1.22
<u>Time of nitrogen application</u>*			
All dose at sowing	4.04a	0.67a	0.46a
½ dose at sowing + ½ at 6 WAS	4.00a	2.42a	0.13a
½ dose at 3 WAS + ½ at 6 WAS	3.92a	1.92a	0.71a
(SE ±)	1.15	0.71	1.49
<u>Sowing date</u>			
June 24	7.17a	2.30a	0.33a
July 15	4.04ab	2.73a	0.20a
August 6	0.03b	0.00b	0.33a
(SE ±)	1.15	0.71	1.49

* Means followed by the same letter(s) within a column are not significantly different at 5% level of significance using DMRT.

Table 4.16: Interaction between variety and sowing date on percentage bird damage to grains (at harvest) of sorghum at Samaru in 1987.

Variety	Sowing date June 24	July 15	August 6
Samsorg 17	0.00c	00.00c	0.00c
Samsorg 5	14.33a	7.00b	1.67c
SE ± (Interaction)		1.01	

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

4.5 Correlation

Correlation analysis between different growth characters, yield components and grain yield of sorghum was done to determine relationships (Table 4.17). A highly significant (P=0.1) positive correlation was observed between grain yield and number of panicles per unit area and number of seeds per panicle. Similarly, there was a significant (P=.0.05) positive correlation between grain yield and grain weight per panicle. However, grain yield was significantly but negatively correlated with number of days to 50% flowering, panicle length, shoot height, percentage nitrogen and crude protein content of the grain.

Stover yield, shoot height, number of days to 50% flowering, panicle length and grain weight per panicle were highly significantly and positively correlated with 1000-grain weight. Shoot height was also highly significantly and positively correlated with number of days to 50% flowering, panicle length and grain weight per panicle.

A highly significant but negative correlation was observed between number of panicles per unit area and panicle length. Yield components such as number of panicles per unit area, number of seeds per panicle and grain weight per panicle were significantly and negatively correlated with percentage crude protein content of the grain. Percentage stand establishment did not correlate with any of the growth, yield and yield component parameters.

Table 4.17: Correlation of various parameters and sorghum grain yield in the sowing date and time of nitrogen application studies at Samaru, 1987.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	.600**	1										
3	.009	-.430**	1									
4	.636**	.092**	-.243	1								
5	.330*	.760**	-.510**	.660**	1							
6	.055	-.200	.630**	-.110	-.213	1						
7	.470**	.509**	.176	.506**	.421**	.312*	1					
8	.497**	.050**	-.260	.030**	.794**	.105	.652**	1				
9	.119	-.331*	.605**	-.303*	-.330*	.450**	.290*	.024	1			
10	-.203*	-.445**	-.032	-.444**	-.146	-.162	-.267	-.297*	-.260	1		
11	-.201	-.230	-.319*	-.249	-.045	-.329*	-.274*	-.101	-.300*	.660**	1	
12	-.142	-.101	-.165	-.065	-.074	-.047	-.001	-.072	.052	.004	.049	1

1=Stover yield
2=No. of days to 50% flowering
3=No. of panicles/unit area
4=Shoot height
5=Panicle length
6=No.of seeds/panicle
7=Grain wt/panicle.
8=1000-grain weight.
9=Grain yield kg/ha.
10=% Nitrogen content.
11= % crude protein content
12= % stand establishment.

* Significant at 5% level of probability (r=0.27)

** Significant at 1% level of probability (r=0.35).

Chapter 5

DISCUSSION

5.1 Effect of Variety

The ability of any seed to germinate depends on the viability of the seed, favourable edaphic and climatic factors. The two sorghum varieties did not show any significant varietal advantages as regards percentage stand establishment. The slightly higher stand establishment of 76.50% recorded for Samsorg 17 as compared with 75.06% for Samsorg 5 may probably be as a result of better seed viability of Samsorg 17 and higher rate of water absorption. The two varieties showed the same pattern of stover accumulation. Samsorg 17 gave a significant higher stover yield at 6 and 9 WAS. However, at 12 and 15 WAS, Samsorg 5 produced significantly higher stover yield over Samsorg 17. The initial advantage on stover yield shown by Samsorg 17 may be due to possession of more number of nodes, longer internodes, more leaves and, therefore, higher capacity for stover yield. The production of higher stover by late maturing sorghum varieties has been reported by Chiezey (1981), Enyi (1987) and Kassam (1975). The ability of the early maturing variety to give higher stover yield at the later stage (12 and 15 WAS) was attributed to the formation of reproductive structures (panicles) at 12 and 15 WAS and these combined with the vegetative parts resulted in higher stover yield.

Variety significantly affected number of days to 50%

flowering. Samsorg 5 reached 50% flowering about 20 days earlier than Samsorg 17. These results are in line with the reports of Kassam and Andrews (1975) who observed 90 days from sowing to heading of Samsorg 17 and less number of days for the short season varieties. The time of flowering in sorghum is controlled by genes and modified by the environment. Samsorg 5 being a short season crop have shorter growing period than Samsorg 17. Therefore, when ever these two varieties are grown in the same environment with similar cultural practices, Samsorg 5 will flower and mature earlier than Samsorg 17. There was significant difference in shoot hight and panicle length among the two varieties. Samsorg 17 was taller with a mean height of 176.79cm compared with 110.12cm recorded for Samsorg 5. Various workers (Andrews 1975, Doggett 1970 and Chiezey 1981) reported height differences among different sorghum cultivars. The superiority in height of Samsorg 17 may be explained by its longer internodes, and longer panicles. There were significant differences in 1000-grain weight, number of panicles per unit area and number of grains per panicle. Higher number of panicles per unit area and number of seeds per panicle were obtained from Samsorg 5, whereas, Samsorg 17 has heavier 1000-grain weight. The large and plump seeds of Samsorg 17 may have resulted in higher seed weight; secondly the longer period required for grain filling period in the late maturing variety (Samsorg 17) may have contributed to the heavier seeds. The ability of Samsorg 5 to produce tillers may be the cause for its higher number of panicles per unit area, while its efficiency in mobilizing more assimilates for grain formation resulted in more number of seeds per panicle.

The most important character for predicting grain yield are: number of heads per plot, number of seeds per panicle, 1000-grain weight and effective grain filling duration. No significant difference in grain yield was observed between the two varieties, however, Samsorg 5 has higher grain yield which was 17.05% over that of Samsorg 17. This supports the findings of Onyibe (1987) who reported yield superiority of the sorghum varieties Samsorg 20 and Samsorg 31 over Samsorg 17 by margins of 22.2% and 17.3%, respectively. Other workers who gave similar reports include (Chiezey 1981; Goldsworthy 1970; and Krishnamurthy 1973). The yield advantage of Samsorg 5 can be explained with the views of Dalton (1967) who pointed out that grain yield of late maturing sorghum varieties may be significantly lower than those of early maturing varieties especially were there are limiting factors of the environment. Clegg et al. (1973) observed that early maturing sorghum varieties have grain yield superiority over late maturing varieties because moisture became limiting at the latter part of the growing season. The low yield of Samsorg 17 suggests that a good proportion of the assimilates synthesized are not translocatdd to the head for grain formation but rather are translocated to other parts of the plant. The capacity of Samsorg 5 to produce tillers and its compact head that contained more grains per unit length might have also contributed to its higher grain yield. The differences in percentage nitrogen and crude protein content of the grain between the two varieties were not significant. However, Samsorg 17 has slightly higher percentage of nitrogen and crude protein content of grain. The chemical composition of plant is genetically controlled and is only modified by the environment and cultural practices. Rooney (1979) and Doggett (1970) reported that high yielding sorghum varieties have less nitrogen and protein content than the low yielding unimproved varieties. The low nitrogen and crude protein content of Samsorg 5 might be attributed to its ability to utilize nitrogen in increasing grain yield rather than increasing protein content.

Damage caused to the grains by birds (Quela quela)was not significant between the two varieties. No bird damage score was obtained for Samsorg 17. The confined damage to Samsorg 5 may be attributed to its small and soft seeds that do not have any protective features. The short growing cycle of Samsorg 5 also made it became the only matured standing crop in the field thus attracts birds. The higher but non significant stemborer (Busseola fusca, sesamiasp) attack on Samsorg 5 may be as a result of the growth habit and stem characteristics that rendered it more susceptible to attack by stemborer.

5.2 Effect of Sowing Date

Sowing date significantly affected percentage stand establishment. Least number of plants emerged and survive at the first sowing date (June 24). The second sowing date (July 15) has the highest percentage stand establishment, but this was not significantly different from that of the third sowing date (August 6). This might be due to optimum soil moisture conditions at the time the second and third sowing dates were planted compared to the first sowing date. Low moisture coupled with very high temperature towards the end of June (Table 2) resulted in low rate of establishment. Some of the seeds and seedlings of the first sowing date were also destroyed by birds. Results obtained in the experiment showed that delaying sowing from June 24 to July 15 and August 6 decreased the shoot height by 13.59% and 30.00%, respectively. Variations in temperature, sun-shine hours and relative humidity were reported to accelerate or retard plant growth (Hassam and Andrews, 1975). The decrease in shoot height with late sowing was as a result of low moisture and less hours of sun-shine available to the late sown crops. Secondly, the early sown crops might have had advantage of utilizing the first initial flush of the soil nitrates which encouraged vigorous growth and, therefore, formation of taller plants.

Generally, delaying planting resulted in decrease in stover yield. The highest stover yield was obtained with the first sowing of June 24 and this was followed by the sowings of July 15 and August 6, respectively. This is in agreement with Ogunlela (1975) who observed a significant reduction in stover yield in sorghum with delay in planting. Other workers who obtained similar observation are Andrews (1975), Kassam and Andrews (1975) and Arkel (1980). Sowing early means longer growing period and, therefore, longer vegetative phase and this is likely to result in more number of leaves, and larger plants, whereas, sowing late will reduce the length of the vegetative phase and the direct effect of this is that shoot height, leaf number and area, and total dryweight per unit area are all proportionately lower.

Panicle length and number of panicles per unit area were not affected by early or late sowing of sorghum. The effect of sowing date to time of 50% flowering, number of seeds per panicle, 1000-grain weight and grain weight per panicle varied considerably with changes in sowing dates. Number of days to 50% flowering were significantly reduced by about 6 and 16 days, respectively, when sowing was delayed from June 24 to July 15 and August 6. This ability of the late sown crop to flower early can be explained with the views of Kassam and Andrews (1975) who reported that late sowing of Samsorg 17 reduced the number of days required for flowering through reduction in the length of the vegetative phase with the length of reproductive phase only slightly altered. Severe water stress late in the growing season might have also resulted in the hastening the on set of the reproductive phase in sorghum plants. Delaying sowing from June 24 to July 14 slightly increased the number of seeds per panicle by 1.24%, while further delay to August 6 reduced the seed number by 0.6%.

Similar trend was observed in respect of grain weight per panicle with an increase of 4.57% when sown on July 15 and a further lateness in sowing decreased the grain weight per panicle by 30.2%. The 1000-grain weight showed a gradual decrease of 1.50% and 21.40% when sowing was delayed to July 15 and August 6, respectively. Earlier studies by Ogunlela (1982), Ogunlela (1985), Kassam and Andrews (1975) and Mirhadi *et al.* (1979) on sowing date effect on yield and yield components of sorghum reported decrease in number of seeds per panicle with successive delays in sowing. The non significant increase in number of seeds per panicle obtained in the present experiment was attributed to poor pollination of the first sown crops especially the early maturing variety. This resulted in reduction of the number of effective flowers that will have developed and form seeds. The decrease in number of seeds per panicle, grain weight per panicle with delay in sowing after July 15 and the gradual decrease of 1000-grain weight with late sowing from June 24 may be explained by the fact that flower initiation and grain filling might have occured under moisture stressed condition late in the growing season. At Samaru, the reins ceased for more than two weeks before the late sown crops (August 6) enter the maturity phase, it is thus possible that moisture stress may have started developing at the time which probably affected its grain weight per panicle seed number per panicle and seed weight per panicle.

Grain yield is a complex character and a product of interacting factors such as number of seeds per panicle, 1000-grain weight, variety and other factors. Changing sowing date influences these factors in one way or the other. Some of the common features of these influences was in the second sowing date giving higher grain yields than the other sowing dates. Sowing on July 15 resulted in 15.06% higher grain yield than the sowing of June 24, the two earlier sowing dates (June 24 and July 15) out-yielded the third sowing of August 6 by 7.70% and 21.67%, respectively. Reports of the effect of sowing date on grain yield of sorghum by various workers have not been consistent. Working with sorghum at Kano, Samsorg 2 (NF3) was observed to give its maximum yield from the second sowing date (Anonymous, 1977). Assis <u>et al</u>. (1979) and Anonymous (1976).also reported increased in grain yield with delay in sowing up to the end of July. However, this result varies with that of (Ogunlela 1983, Kassam and Andrews 1975, Curtis 1960a and Andrews 1975) who reported higher grain yields with the earliest sowing date. The differences between the grain yields of the first and second sowing dates may be as a result of the higher percentage stand establishment and low rate of damage to grains by birds in the second sowing. While the low yields recorded in late sowing of August 6 might be attributed to reduction in the length of the growing season as reported by Andrews (1975) and stanton and wiebe (1973). The earlier sowing date enjoyed longer growing period which resulted in bigger and vigorous plants with better developed yield components. In addition, the earlier sown crops had favourable photoperiod during vegetative stage and available moisture during flowering and grain filling period. Because the rains end by October 10, when the third sowing of August 6 was flowering and producing grains, moisture stress at this time caused decreased in number of flowers, some of the panicles became rudimentry and did not form seeds. Whereas, seeds that has already been formed during this period failed to mature.

Sowing date had no significant influence on percentage nitrogen and crude protein content of grains, however, late sowings gradually increased the nitrogen and crude protein content of the grains. This supports the findings of Han et al. (1985) who reported increase in protein content with delay in sowing. Rooney (1970) pointed out that any factor that increases grain yield will cause decrease in protein content of the grain. Therefore, the higher percentage nitrogen and crude protein content observed in the present experiment with late sowing may be as a result of moisture stress effect. Accumulation of nitrogen as a result of lower yield might have also been the cause for higher protein content of the grains with late sowing.

Sowing date had significant effect on percentage bird damage to grains. The highest rate of damage was obtained with the earliest sowing date of June 24. This is in line with the reports of Bruggers and Jaegar (1982) who observed high incidence of bird damage to early maturing variety that has been sown early in the growing season.

Stemborer attack and smuts infection were not significantly affected by sowing date. But the late sown crops were more infested than the early sown crops. Similar observation was reported by Firk and Kadam (1979). Rao and Paul (1979) Jotwani et al. (1976) and Summers et al. (1978). Kassam (1975) also reported that damage due to stemborer (Buseola fusca), shootfuly (Altherigoma saccota) and sorghum midge (contarinia were relatively unimportant when sowing was done early.

5.3 Effect of Time of Nitrogen Fertilizer Application

Time of nitrogen application had significant effect on stover yield, however, all other growth parameters, yield and yield components, chemical composition of the grains, infestation and infection considered in the present studies were not significantly affected. Highest stover yield was obtained with split application of nitrogen half at sowing and half at 6 WAS. This was followed by single application of nitrogen at sowing and split application of nitrogen half at 3 WAS and half at 6 WAS, respectively. Previous studies on the effect of time of nitrogen application on stover yield by (Mengel and Kikby 1982, Itnal et al., 1980, Hussain and Rao 1968 and Nagur and Ramo 1967) were reported to obtain higher stover yield with split application of nitrogen on sorghum. Other workers (Anonymous 1974, and Tarfa 1987) observed highest stover yield with single dose application of nitrogen on sorghum. The higher stover yield obtained with split application of nitrogen (half at sowing and half at 6 WAS) may be attributed to the first half, applied at sowing acting as a starter nitrogen utilized at seedling stage for better establishment of the seedling, while the other half applied at 6 WAS might have concided with period of rapid vegetative growth of the sorghum plant.

Though time of nitrogen application had no significant influence on shoot height, taller plants were obtained with single application of the nitrogen at sowing, this suggests development of longer internodes at the expense of stem diameter. This supports the observation of Tarfa (1987) who reported that application of nitrogen to sorghum as a single dose at emergence increased shoot hight at the same time reducing stem diameter.

Split application of nitrogen with half dose at sowing and half at 6 WAS resulted in slightly higher number of panicles per unit area, grain number per panicle, grain weight per panicle, 1000-grain weight and grain yield per hectare than the other times of nitrogen application. Various studies have been carried out on the effect of time of nitrogen application on sorghum. But there are differences of opinion as regards the effect of time of nitrogen application on sorghum. Doggett (1970), Egharevba (1979), Kaigama (1970), Yusuf and Egharevba (1970). Boom-ampol et al., (1975) Ismail and Ali (1986) and Turkheed and Prasad (1970) reported superiority of split nitrogen application over single application at sowing. Different reports by Rosolem et al. (1985), Doughton (1971), and Sharma et al. (1980) observed no yield advantage between split and single application of nitrogen on sorghum. Whereas, higher grain yield were noted by Anonymous (1974), Tarfa (1987) and Pereira and Fontes (1979) when nitrogen was applied as a single dose at sowing or after emergence. The high percentage of nitrogen content of the soil at the University farm might have been responsible for the non-significant response to the time of nitrogen application.

Time of nitrogen application had no significant effect on percentage nitrogen and crude protein content of the grain. However, single application at sowing resulted in slightly higher percentage of nitrogen and crude protein content. This was followed by split application of nitrogen half at 3 WAS and half at 6 WAS and split application of half at sowing and half at 6 WAS, respectively. The higher percentage obtained with single application suggests preferential translocation of the applied nitrogen to the developing grains, whereas, the low value with split application of half at sowing and half at 6 WAS was attributed to the utilization of the applied first half for vegetative growth and the later application of the second half to increase in grain yield rather than increasing nitrogen and crude protein content of the grains. This observation is in agreement with that of Roomey (1970) who reported that protein content of sorghum grain is negetively related to grain yield. However, Tarfa (1987), Stomoyor and Lugo (1970) and Dechev (1976) observed higher nitrogen and protein content with split application of nitrogen on sorghum. Difference in cultural practices and environmental resources, especially rainfall and solar radiation may have accounted for the variations. Varietal differences may also be very important.

5.4 Effect of Interactions

Interaction between variety and sowing date had significant effect on stover yield at 6 WAS, number of days to 50% flowering shoot height, 1000-grain weight, grain yield per hectare and percentage bird damage. On stover yield, both varieties had significant reduction in stover yield with delay in sowing. Tallest plants and heavier 1000-seed weight were obtained with the earliest sowing date than the subsequent late sowings. The decrease in rainfall and sun-shine hours with late sowing might have resulted in decrease in shoot height. The two varieties when sown late flowered earlier than the earliest sowing date of June 24. At all the sowing dates tested the decrease in number of days to 50% flowering was more for Samsorg 17 than Samsorg 5. This may be explained by the variations in the length of maturity between the two varieties. Samsorg 17 being a late maturing variety and photosensitive had more number of days to 50% flowering reduced with late sowings.

The effect of late sowing on grain yield varied considerably between the two varieties. Samsorg 17 had its grain yield gradually reduced by 20.66% and 45.56%, respectively, when sowing was delayed to July 15 and August 6. Samsorg 5 gave its highest grain yield with late sowing of July 15, early and late sowing than this date (June 24 and August 6) decreased grain yield by

41.02 and 14.56%, respectively. The high grain yield reduction of Samsorg 5 with the earliest sowing of June 24 was attributed to the bird damage to the grains. While the gradual yield reduction of Samsorg 17 and that of Samsorg 5 sown on August 6 were as a result of stressed conditions late in the growing season. This is in line with the views of Kassam and Andrews (1975) who observed that late sown crops had their yield reduced due to moisture stress late in the growing season. Variety by sowing date interaction showed that bird damage to grain was less obvious on Samsorg 17 than Samsorg 5. This suggests that date of sowing made no difference with regards to their menace on Samsorg 17. This may be as a result of late maturing of Samsorg 17 even when sown early, therefore, it is not the only matured standing crop on the fields, hence, birds have alternative grains to feed on. The large and hard seeds of Samsorg 17 might have also prevented birds from feeding on them. Highest damaged by birds on Samsorg 5 was recorded at the earliest sowing (June 24), no significant effect was observed at the later sowings.

Time of nitrogen application by sowing date interaction significantly affected stover yield at 6 WAS and number of days to 50% flowering. When sowing was delayed from June 24 to July 15 and August 6, split application of the nitrogen was found to be more beneficial on stover yield. This may be explained by the higher rain fall recorded during July 15 and August 6 sowings, therefore, the sole applied nitrogen might have been leached. Even though sole application of nitrogen at sowing on June 24 gave the highest number of days to 50% flowering, least number of days to 50% flowering was obtained with sole application of the nitrogen at the later sowing dates of July 15 and August 6.

Interaction effect between variety and time of nitrogen application had no significant effect on all the growth and yield attributes considered in the present study, with the exception of stover yield at 6 WAS. For both varieties, highest stover yield was obtained with spilt application of nitrogen (half at sowing and half at 6 WAS). Among the growth and yield and yield components considered in this experiment, it was observed that percentage stand establishment, panicle length, number of panicles per unit area, grain weight per panicle and percentage nitrogen and crude protein content were not significantly affected by any of the interactions. This suggests that variety, sowing date and time of nitrogen application might be acting independent of each other with respect to these attributes. All the second order interactions between variety, sowing date and time of nitrogen application were not significant.

5.5 Correlation

Sorghum grain yield is shown to have strong association in positive direction with number of panicles per unit area (r=.605**), number of seeds per panicle (r=.450**), and grain weight per panicle (r=.290*). This indicates that these yield component parameters are critical determinants of sorghum grain yield. Therefore, for higher yields the number of panicles per unit crea and number of seeds per panicle must be sufficiently high. Chiezey (1981) and Eckebil (1974) reported similar results. The negative correlations between shoot height (r=.303*) panicle length (r=-.338*) and number of days to 50% flowering (r=-.331*) with grain yield reveals that grain yield was limited by the supply of assimilates. Whereas, the negative correlation between grain yield on the one hand and number of days to 50% flowering on the other in the present study probably suggests that the longer the time to maturity the lower the yield.

The highly significant and positive correlation between shoot height (r=-.636**), panicle length (r=.330*), and number of days to 50% flowering (r=.600**) with stover yield may be attributed to the fact that these growth characters directly determined the amount of photosynthetes available for stover accumulation. This supports the findings of Graham (1967) who observed a significant positive correlation between plant height and main stalk yield.

The negative correlation between grain yield (r=.300*), number of panicles per unit area (r=-.309*) and number of seeds per panicle (r=-.329) with percentage crude protein content indicates that for high crude protein content to be obtained, the yield components should be few in number. Rooney (1970) observed similar results.

The results of the correlation analysis, therefore, indicates that number of panicles per unit area, number of seeds/panicle, shoot height, and number of days to 50% flowering were critical in the overall performance of the two sorghum varieties.

Chapter 6

SUMMARY AND CONCLUSION

A field experiment was conducted on the farm of Institute for Agricultural Research (I.A.R.), Ahmadu Bello University, Samaru ($11^{o}11'$N and $7^{o}38'$E. 606m. above sea level), during the 1987 wet season to investigate the effect of sowing date, time of nitrogen fertilizer application on yield and yield components of sorghum varieties (Sorghum bicolor (L.) Moench). The treatment consisted of two sorghum varieties, namely, Samsorg 17 and Samsorg 5. Three sowing dates at three weekly interval (June 24, July 15 and August 6) and three times of nitrogen application (T= all N dose at planting, T2 = half dose at sowing and half at 6 WAS and T3 = half dose at 3 WAS and half at 6 WAS)were used. The treatments were replicated four times in a Randomised Complete Block Design (RCBD) in factorial arrangement.

The results showed that sowing date had significant effect on growth characters, yield and yield components and percentage damage by birds to sorghum grain. Among the sowing dates tested, higher stover yield, shoot height, number of days to 50% flowering, percentage bird damage and 1000-grain weight were obtained with the first sowing date of June 24. At the second sowing date of July 15, higher number of seeds per panicle, grain weight per panicle and grain yield (kg/ha) were obtained. Late sowing on August 6 gave the least stover yield, number of days to 50% flowering, shoot height, number of panicles per unit area, number of seeds per panicle, grain weight per panicle, 1000-grain weight, percentage bird damage and low disease score. However, the highest percentage of nitrogen and crude protein content resulted from this late sowing.

Time of nitrogen application significantly influenced stover yield at 6 WAS, but had no significant effect on the other parameters considered. Application of nitrogen in two equal split at sowing and at 6 WAS resulted in higher stover yield, grain weight per panicle, grain yield per hectare and slightly higher number of panicles per unit area, panicle length, number of seeds per panicles, 1000-grain weight, number of days to 50% flowering and stemborer attack. Whereas, single dose application of the nitrogen at sowing resulted in taller plants. Higher percentage of nitrogen and crude protein content were obtained when nitrogen was split in equal doses half at 3 WAS and half at 6 WAS.

Variety significantly influenced growth parameters, yield and yield components and percentage bird damage. Samsorg 5 excelled Samsorg 17 in many parameters considered such as less number of days to 50% flowering, higher number of panicles per unit area and number of seeds per panicle.

Variety by sowing date interaction affected most of the growth characters, and yield and yield component attributes. With the exception of stover yield at 6 WAS and number of days to 50% flowering, time of nitrogen application by sowing date had no effect on any of the parameters studied. While significant effect of variety by time of nitrogen application was only on stover yield at 6 WAS. No second order interaction was significant.

Correlation analysis between grain yield and growth, and yield components of the two sorghum varieties, revealed that number of panicles per unit area, number of seeds per panicle, grain weight per panicle and shoot height, respectively, were responsible for the observed grain yield response.

It is concluded from the present study that for the attainment of high yield in sorghum varieties, late maturing varieties such as Samsorg 17 should be planted early when the rains became established. Whereas, early maturing varieties such as Samsorg 5 should be sown late at the middle of July after establishment of the rains so as to avoid mouldness of the grains and bird damage to grains. Even though split application of nitrogen with half at sowing and half at 6 WAS has a potential for increasing sorghum production, it cannot be recommended because the grain yield advantage over single dose application was rather low to justify the extra cost of application. Also for the attainment of high nitrogen and crude protein in sorghum, nitrogen fertilizer should be applied as a single dose at sowing.

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