



YIELD ATTRIBUTES OF TWO SORGHUM (*Sorghum bicolor* (L.) Moench) VARIETIES AS AFFECTED BY COW DUNG AND INORGANIC NITROGEN IN SAMARU AND MAIGANA NORTHERN GUINEA SAVANNA ECOLOGICAL ZONE, NIGERIA.

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Abstract

Field experiments were conducted in 2013 and 2014 wet seasons at the Research Farm of the Institute for Agricultural Research, Samaru and Kaduna State Agricultural Project, Maigana to study the growth, yield and malting physical quality of two sorghum varieties as affected by cow dung and inorganic nitrogen fertilizer. The treatments consisted of four rates of nitrogen fertilizer (0, 30, 60 and 90 kg N ha⁻¹) and cow dung (0, 5, 10 and 15 tonnes ha⁻¹) and two sorghum varieties (SAMSORG-17, and SAMSORG 44). Treatments were laid out in a split plot design and replicated three times with nitrogen and cow dung rates assigned in the main plot while the varieties were assigned in the sub-plots. Increase in N rate affected several crop parameters differently but for grain yield, the increase was significant only up to 60 kg N ha⁻¹. Progressive increase in cow dung rate significantly increases grain yield attributes up to 15 t ha⁻¹. Sorghum variety SAMSORG-17 was positively influenced more than SAMSORG-44 with respect to all the yield attributes evaluated. Interaction of 60 kg N ha⁻¹ and 15 t ha⁻¹ cow dung consistently gave the best grain yield but statistically similar with 90 kg N ha⁻¹, therefore it can be recommended for farmers in northern Guinea savannah ecological zone of Nigeria.

Keywords: cow dung, nitrogen and variety.

INTRODUCTION

The population of sub-Saharan Africa (SSA) has increased considerably. It increased from 0.4 billion in 1980 to 1.2 billion in 2020, and is estimated to increase by another billion by 2050. This means that one in four people globally will reside in SSA (World Bank Health Nutrition and Population Statistics 2023). Enhancing agricultural productivity in SSA is extremely important to meeting the escalating food demand. However, the increase in the rate of crop productivity is inconsistent with the population increase in SSA. From 1980 to 2020, cereals crops productivity such as maize and sorghum (yield per unit area) has increased by only 46% and 20%, respectively (FAOSTAT 2023). Lack of soil nutrients is the primary attributing factor for the low productivity (Dimkpa *et al.*, 2023) and the limited use of chemical fertilizers (Dimkpa *et al.*, 2023). The significance of fertilizer application (organic and Inorganic) for improving crop productivity and maintaining soil organic matter has been emphasized (Sande *et al.*, 2024). Nigerian northern Guinea savanna, is in the semi-arid region of west Africa with an annual rainfall between 900- 1500 mm. Being the largest

sorghum-producing country in Africa. Sorghum ranks as the second most important upland crop in Africa after maize (FAOSTAT2023).

Nigeria's annual sorghum production is over six million metric tons (FAO, 2024), which accounts for (35.60 %) on the continent and (12.05%) of the world production. The land area put into cultivation of sorghum in Nigeria was 4.7 m hectares while average yield of the Nigerian farmers was 1.0 tonnes per hectare compared with 2.5 to 4.0 tonnes per hectare obtained under improved management (NAERLS, 2025). It is very hardy and can be grown in areas of the world that are largely too hot or too dry for other crops to thrive successfully. However, the harsh environmental conditions are being ameliorated by the development and use of suitable varieties while the palliative soil fertility measures are best achieved through the management of such soils with the combination of organic manures and inorganic fertilizers.

The use of combinations of organic and inorganic fertilizers among farmers on sorghum is an aged long practice. The need to establish the organic and inorganic fertilizer rates for the commercial short Kaura varieties which has become a dominant and popular variety being used by farmers is therefore essential. Farmers have opted for the production of short Kaura varieties not only for its usual consumption as a staple commodity for thick porridge (*Tuwo*) food but for its relevance as a commercial and industrial commodity. Determining the most appropriate rates of organic manure and inorganic nitrogen fertilizer for a combination that will give the optimum crop yield performances is therefore essential. In Africa, sorghum is predominantly grown for food purposes, while in other places such as the United State of America (USA), Australia, China, etc, it is use as livestock feed and for animal fodder purposes. Unlike most other producing countries, in Nigeria, the production is mainly for the grain and is generally used for household consumption (Feasibility Reports in Nigeria 2025). The sorghum grain is an important raw material in brewing industries with a large number of consumers throughout Africa.

It was in view of this that this research work was carried out to investigate the following aspects under these objectives: a. to assess the comparative grain yield of two short Kaura varieties. b. to determine the effect of cow dung on grain yield of two sorghum varieties. c. to determine the effect of inorganic nitrogen fertilizer on grain yield of two sorghum varieties.

MATERIALS AND METHODS

A two-year field trials were conducted during the 2013 and 2014 rainy seasons. The sites for the trials were Institute for Agricultural Research (I.A.R) Farm, Samaru (11° 11' N 07° 38' E, 686m above sea level) and experimental site of Kaduna Agricultural Development Project (KADP) located at Maigana(11° 39' N; 08° 02' E, 500m above sea level), Soba Local Government Area along Zaria – Jos Road. Both experimental locations are situated in the northern Guinea savanna ecological zone of Nigeria.

The meteorological data of the area (rainfall, temperature, relative humidity and sunshine hour using rain gauge, thermometer, hygrometer and stock- Campbell) were obtained from the Meteorological units of I.A.R, Samaru and Weather Station of the KADA Maigana respectively.

The treatments consisted of two sorghum varieties (SAMSORG-17, and SAMSORG 44), four rates of nitrogen (0, 30, 60 and 90 kg N ha^{-1}) fertilizer and four rates of cow dung (0, 5, 10 and 15 tonnes ha^{-1}). The treatments were laid out in a split plot design and replicated three times with nitrogen and cow dung rates assigned in the main plot while the variety were allocated in the sub-plots. Each sub-plot has a gross size of 6.0m x 4.5m and consisted of six (6) ridges measuring 6m in length out of which the two inner central ridges constituted a net plot of 4.0m x 1.5m. The two varieties were obtained from the Sorghum breeding programme of the Institute for Agricultural Research, Samaru Zaria and have the following characteristics: All the agronomic practices were dully observed.

Observations and Data Collection

Number of panicles per plot

This was done by counting the number of panicles that bore grains and was recorded per net plot.

1000 grains weight (g)

From each net plot a set of five 1000 grains were counted and individually weighed. To obtain the 1000-grain weight, the mean of five sets was determined using mettler Toledo electronic weighing balance P1210 and recorded.

Threshing percentage (%)

Is the ratio of grain weight after threshing to panicle weight (un threshed) multiply by hundred percent. This was determined according to the formula given below as follows:

$$\text{Threshing \%} = \frac{\text{Gw}}{\text{Pw}} \times 100$$

Where Gw = grain weight after threshing, Pw = panicle weight (un threshed) and multiplying by 100 to express as a percentage and the values obtained were recorded.

Harvest index (HI)

It was determined by taking the ratio of grain to the above ground dry plants materials as follows:

$$\text{HI} = \frac{\text{Gw}}{\text{Sdm}}$$

Where Gw was grain weight and Sdm was shoot dry matter weight.

Grain yield (kg ha⁻¹)

This was determined by extrapolating the grain weight per net plot to grain yield per hectare in kilogram (kg ha⁻¹). The data collected were subjected to analysis of variance (ANOVA) the treatment means were compared using Duncan Multiple Range Test (Duncan, 1955) as described by Awadallah (2019). Simple correlation coefficients were calculated from the mean of each parameter as described by Snedecor and Cochran, (1967). Path co-efficient analysis among important parameters were determined using the procedure described by (Little and Hills, 1978) in order to assess the type and magnitude of the cause and effect of relationships among variables. Regression analysis was also conducted to determine the yield response of sorghum cultivars to chemical and organic fertilizers as described by Snedecor and Cochran, (1967).

Threshing percentage (%)

At both locations, years and combined seasons of experimentation each increase of 30 kg N ha⁻¹ in nitrogen rate significantly increased threshing percentage except when the two years data were combined where the increase from 30 to 60 kg N ha⁻¹ gave comparable results (Table 2).

Every 5 t ha⁻¹ increase in cow dung, significantly increased threshing % at both locations and years except the combined years at both locations where the difference in threshing percentage of cow dung rates used were comparable.

SAMSORG-17 variety consistently gave significantly higher value of threshing % than SAMSORG-44 in both years, combined at both locations. There were significant factor



interactions between nitrogen and variety and a highly significant interaction between nitrogen and cowdung in 2013 at Maigana location.

Interaction between N and cow dung rate and N and variety of threshing % at Maigana in 2013 (Table 2.1). Combination of $90 \text{ kg N ha}^{-1} + 10 \text{ t ha}^{-1}$ cow dung gave the highest percent threshed that is statistically similar to $90 \text{ kg N ha}^{-1} + 15 \text{ t ha}^{-1}$ cow dung rate. The least was from the unfertilized plot. Nitrogen x variety interaction on threshing percent was also significant. The result shows that application of 90 kg N ha^{-1} to SAMSORG-17 resulted in the highest threshing percentage while SAMSORG- 44 + 0 kg N ha^{-1} had the least value.



Table 1 Effects of Nitrogen and Cow dung rates on threshing percentage (%) of two sorghum Varieties at Samaru and Maigana during 2013, 2014 and combined rainy seasons.

Treatment	Threshing percent (%)					
	Samaru			Maigana		
	2013	2014	Combined	2013	2014	Combined
Nitrogen (N) rate (kg ha⁻¹)						
0	58.48d	43.31d	50.90c	61.81d	45.93d	53.87c
30	62.90c	51.37c	57.14b	66.10c	54.01c	60.06b
60	65.02b	55.32b	60.17b	67.81b	59.10b	63.45b
90	68.29a	64.37a	66.33a	71.25a	73.06a	72.16a
SE±	0.273	0.610	1.708	0.201	0.700	2.019
Cowdung (C) rate (t ha⁻¹)						
0	61.62d	49.56d	55.59b	64.66d	54.05d	59.35b
5	63.36c	52.97c	58.16ab	66.21c	56.21c	61.21b
10	64.25b	55.04b	59.64a	67.55b	58.74b	63.14ab
15	65.47a	56.81a	61.15a	68.56a	63.09a	65.83a
SE±	0.273	0.610	1.708	0.201	0.700	2.019
Variety (V)						
SAMSORG-17	64.12a	54.38a	59.27a	67.16a	58.91a	63.53a
SAMSORG-44	63.24b	52.80b	58.00b	66.33b	57.14b	61.24b
SE±	0.193	0.432	1.208	0.142	0.495	1.428
Interaction						
N x V	ns	ns	ns	*	ns	ns
N x C	ns	ns	ns	**	ns	ns
C x V	ns	ns	ns	ns	ns	ns
N x C x V	ns	ns	ns	ns	ns	ns

Means followed by the same letter(s) within a treatment group are not statistically different at 5% level of probability, using Duncan Multiple Range Test (DMRT at $p \leq 0.05$)

NS: Not significant, * Significant at 5% and ** significant at 1%

Table 1.1 Interaction between Nitrogen and Cow dung rate and Nitrogen and Variety on threshing percent (%) at Maigana during 2013 rainy season.

Treatment	Nitrogen (N) rate (kg ha ⁻¹)			
	0	30	60	90
Cow dung (C) (t ha⁻¹)				
0	57.01g	65.06e	67.14bcd	69.43b
5	61.78f	65.06e	67.35bc	69.98b
10	63.94e	66.64bcd	67.97bc	72.63a
15	64.51e	66.98bcd	68.78b	72.98a
SE±			0.401	
Variety (V)				
SAMSORG-17	62.70f	66.26ce	67.97c	71.71a
SAMSORG-44	60.92g	65.94ce	67.66c	70.80b
SE±			0.283	

Means followed by the same letter (s) within a treatment group are not statistically different at 5 % level of probability, using Duncan Multiple Range Test (DMRT at $p \leq 0.05$)

1000 Grains Weight (g)

Increase in N rate from 0 up to 90 kg N ha⁻¹ and cow dung from 0 up to 15 t ha⁻¹ significantly increased 1000 grains weights in both 2013, 2014 and locations except the combined at Maigana where the differences in 1000 grains weight among the rates applied were statistically similar (Table 2).

SAMSORG-17 consistently produced heavier 1000 grain weight than SAMSORG-44 at both locations, years and combined.

A highly significant interaction of nitrogen and cow dung on 1000 grains weight was recorded in both years at Samaru only. The interaction between N and cow dung rate on 1000 grains weight at Samaru in 2013 and 2014 (Table 2.1) shows that in all the years of the experimentation, the combination of 90 kg N ha⁻¹ + 15 t ha⁻¹ cow dung gave the highest 1000 grains weight while the least was from the control plot.

Table 2 Effects of nitrogen and cow dung rates on 1000 grains weight (g) of two sorghum varieties at Samaru and Maigana during 2013, 2014 and combined rainy seasons.

Treatment	1000 grains weight (g)					
	Samaru			Maigana		
	2013	2014	Combined	2013	2014	Combined
Nitrogen (N) rate (kg ha⁻¹)						
0	31.13d	30.03d	30.58d	19.38d	27.55d	23.47d
30	33.14c	32.04c	32.59c	24.73c	30.74c	27.73c
60	34.67b	33.57b	34.12b	26.67b	32.27b	29.47b
90	37.73a	36.63a	37.18a	29.73a	35.32a	32.53a
SE±	0.204	0.055	0.189	0.121	0.141	0.841
Cow dung (C) rate (t ha⁻¹)						
0	32.97d	31.87d	32.42d	23.30d	29.64d	26.47c
5	33.87c	32.77c	33.32c	24.62c	31.21c	27.91bc
10	34.52b	33.42b	33.97b	25.68b	32.12b	28.90ab
15	35.32a	34.22a	34.77a	26.90a	32.92a	29.91a
SE±	0.204	0.055	0.189	0.121	0.141	0.841
Variety (V)						
SAMSORG-17	34.42a	33.32a	33.87a	25.48a	31.78a	28.99a
SAMSORG-44	33.92b	32.82b	33.37b	24.78b	31.16b	27.61b
SE±	0.144	0.039	0.133	0.086	0.099	0.595
Interaction						
N x V	Ns	ns	ns	ns	ns	Ns
N x C	**	**	ns	ns	ns	Ns
C x V	Ns	ns	ns	ns	ns	Ns
N x C x V	Ns	ns	ns	ns	ns	Ns

Means followed by the same letter(s) within a treatment group are not statistically different at 5% level of probability, using Duncan Multiple Range Test (DMRT at $p \leq 0.05$)

NS: Not significant, ** significant at 1%

Table 2.1 Interaction between Nitrogen and Cow dung rate on 1000 grains weight of two sorghum varieties at Samaru during 2013 and 2014 rainy seasons.

Treatment	Nitrogen (N) rate (kg ha ⁻¹)			
	0	30	60	90
Cow dung (C) (t ha⁻¹)				
			2013	
0	29.03f	32.57bcd	34.50bc	36.03b
5	31.37b-e	33.00bcd	34.76bc	36.73b
10	31.93b-e	33.33bcd	35.17bc	37.60b
15	32.20bcd	33.67bcd	35.43bc	39.33a
SE±			0.409	
			2014	
0	28.48o	32.02l	33.67h	35.63d
5	30.82n	32.45k	33.95g	36.25c
10	31.38m	32.78j	34.52f	37.17b
15	31.65m	33.12i	34.93e	39.05a
SE±			0.109	

Means followed by the same letter (s) within a treatment group are not statistically different at 5 % level of probability, using Duncan Multiple Range Test (DMRT at $p \leq 0.05$).

Harvest Index (HI)

At both locations, years of experimentation and combined seasons increase in nitrogen rate from 0 to 30 kg N ha⁻¹ significantly increased harvest index except at Samaru in 2014 rainy season and the combined where the increase was observed to be not significant (Table 3). Application of cow dung had resulted in significant increase in harvest index. The highest harvest index mean value recorded was in the plots where 15 t ha⁻¹ was applied but statistically comparable with 5 and 10 t ha⁻¹ except in 2013 at both locations while the least was in the control. However, in 2014 at Maigana, varying the cow dung rate had no significant effect.

SAMSORG-17 consistently recorded higher harvest index values than SAMSORG-44 at both locations, combined at Samaru and in 2013 and combined only at Maigana.



Table 3. Effects of Nitrogen and Cow dung rates on harvest index of two Sorghum Varieties at Samaru and Maigana during 2013 and 2014 rainy seasons.

Treatment	Harvest index (HI)					
	Samaru			Maigana		
	2013	2014	Combined	2013	2014	Combined
Nitrogen (N) rate (kg ha⁻¹)						
0	0.10d	0.22b	0.19c	0.12d	0.11d	0.11d
30	0.16c	0.27ab	0.22bc	0.14c	0.15c	0.14c
60	0.21b	0.28ab	0.27ab	0.19b	0.18b	0.18b
90	0.36a	0.33a	0.29a	0.33a	0.23a	0.26a
SE±	0.008	0.028	0.029	0.004	0.009	0.013
Cow dung (C) rate (t ha⁻¹)						
0	0.16d	0.23b	0.20b	0.15d	0.16	0.16b
5	0.19c	0.25b	0.22ab	0.17c	0.16	0.16b
10	0.22b	0.27ab	0.27a	0.19b	0.17	0.18ab
15	0.26a	0.34a	0.28a	0.24a	0.17	0.20a
SE±	0.008	0.028	0.029	0.004	0.009	0.013
Variety (V)						
SAMSORG-17	0.22a	0.31a	0.26a	0.19a	0.17	0.18
SAMSORG-44	0.20b	0.24b	0.22b	0.18b	0.16	0.17
SE±	0.006	0.019	0.021	0.003	0.006	0.009
Interaction						
N x V	*	ns	ns	ns	ns	ns
N x C	**	ns	ns	ns	ns	ns
C x V	ns	ns	ns	ns	ns	ns
N x C x V	ns	ns	ns	ns	ns	ns

Means followed by the same letter(s) within a treatment group are not statistically different at 5% level of probability, using Duncan Multiple Range Test (DMRT at $p \leq 0.05$)
ns: Not significant, * Significant at 5% and ** significant at 1%.

Significant interaction of nitrogen versus cow dung on harvest index was observed at Samaru in 2013 (Table 3.1). At any given rate of cow dung, increasing nitrogen rate from the control up to the highest rate of 90 kg N ha⁻¹ resulted in increased harvest index except 5 and 10 t ha⁻¹ were statistically similar.

Another interaction is between N rate and variety. Considering the variety, looking at nitrogen rate revealed that the two varieties had no significant difference except at 90 kg N ha⁻¹ that SAMSORG-17 recorded a higher harvest index value than SAMSORG-44.

Table 3.1 Interaction between Nitrogen and Cow dung rate and Nitrogen and Variety on harvest index at Samaru during 2013 rainy season.

Treatment	Nitrogen (N) rate (kg ha ⁻¹)			
	0	30	60	90
Cow dung (C) (t ha⁻¹)				
0	0.06o	0.14k	0.20g	0.28c
5	0.09n	0.15j	0.21f	0.31b
10	0.11m	0.16i	0.22e	0.35b
15	0.13l	0.18h	0.26d	0.46a
SE±			0.017	
Variety (V)				
SAMSORG-17	0.11e	0.16d	0.24c	0.41a
SAMSORG-44	0.10e	0.16d	0.21c	0.23b
SE±			0.012	

Means followed by the same letter (s) within a treatment group are not statistically different at 5 % level of probability, using Duncan Multiple Range Test (DMRT at p≤ 0.05).

Grain yield per hectare (kg ha⁻¹)

In both years of experimentation and the combined at both locations each increase of 30 kg N ha⁻¹ up to 60 kg N ha⁻¹ significantly increased grain yield. However, the increase from 60 to 90 kg N ha⁻¹ significantly increased grain yield in 2014 and the combined at Maigana (Table 4). Every increase of 5 t ha⁻¹ of cow dung significantly increased grain yield in both years and the combined and at both locations.

The SAMSORG-17 variety consistently gave significantly higher grain yield than SAMSORG- 44 variety at both locations and in all the years. SAMSORG-17 was superior to SAMSORG-44 at Samaru by 4.2, 5.0 and 4.7 % in 2013, 2014 and combined respectively. The yield superiority of SAMSORG-17 over SAMSORG-44 at Maigana was 19.2, 8.5 and 14.2% in 2013, 2014 and combined respectively.

A significant interaction between nitrogen and cow dung on grain yield (kg ha^{-1}) was observed at Samaru in both seasons (Table 4.1). It was generally observed that a combination of 60 kg N ha^{-1} and 15 t ha^{-1} cow dung consistently gave the best grain yield but statistically similar with 90 kg N ha^{-1} . Similarly, interaction of 60 kg N ha^{-1} rate at Samaru in 2014 gave the best grain yield levels with both SAMSORG-17 and SAMSORG-44 than all the other rates.

Table 4. Effects of Nitrogen and Cow dung rates on grain yield (kg ha^{-1}) of two Sorghum Varieties at Samaru and Maigana during 2013, 2014 and combined rainy seasons.

Treatment	Grain Yield (Kg ha^{-1})					
	Samaru			Maigana		
	2013	2014	Combine	2013	2014	Combined
Nitrogen (N) rate (kg ha^{-1})						
0	1143c	1285c	1214d	649c	466d	558d
30	2096b	2378b	2237c	1604b	1181c	1373c
60	2571a	2803a	2687a	2103a	1546b	1825b
90	2593a	2886a	2739a	2141a	2142a	2142a
SE $\pm$	27.0	32.0	26.0	38.0	30.0	44.0
Cow dung (C) rate (t ha^{-1})						
0	1831d	2026d	1929d	1368d	1095d	1232d
5	2045c	2199c	2122c	1556c	1262c	1409c
10	2183b	2468b	2326b	1701b	1391b	1546b
15	2343a	2649a	2496a	1871a	1588a	1729a
SE $\pm$	27.0	32.0	26.0	38.0	30.0	44.0
Variety (V)						
SAMSORG-17	2144a	2393a	2269a	1767a	1393a	1580a
SAMSORG-44	2057b	2278b	2167b	1482b	1284b	1383b
SE $\pm$	9.0	14.0	33.0	8.0	12.0	36.0
Interaction						
N x V	Ns	**	ns	ns	ns	Ns
N x C	**	*	ns	ns	ns	Ns
C x V	Ns	ns	ns	ns	ns	Ns
N x C x V	Ns	ns	ns	ns	ns	Ns

Means followed by the same letter(s) within a treatment group are not statistically different at 5% level of probability, using Duncan Multiple Range Test (DMRT at $p \leq 0.05$)

ns: Not significant, * Significant at 5% and ** significant at 1%.

Table 4.1 Interactions between Nitrogen and Cow dung rate and Nitrogen and Variety on grain yield of two Sorghum varieties (kg ha^{-1}) at Samaru during 2013 and 2014 rainy seasons.

Treatment	Nitrogen (N) rate kg ha^{-1}			
	0	30	60	90
2013				
Cow dung (C) (t ha^{-1})				
0	672.0k	1779.0g	2437.0d	2438.0d
5	1101.0j	2047.0f	2517.0c	2517.0c
10	1302.0i	2245.0e	2593.0b	2593.0b
15	1497.0h	2313.0e	2781.0a	2780.0a
SE $\pm$			25.21	
2014				
0	633j	1962.0f	2559.0c	2561.0c
5	1073i	2133.0e	2641.0c	2642.0c
10	1469h	2322.0d	2755.0b	2757.0b
15	1681g	2432.0d	2935.0a	2936.0a
SE $\pm$			39.55	
Variety (V)				
SAMSORG-17	1314d	2314.0b	2734.1a	2726a
SAMSORG-44	1114e	2110.5c	2710.0a	2722a
SE $\pm$			17.82	

Means followed by the same letter (s) within a treatment group are not statistically different at 5 % level of probability, using Duncan Multiple Range Test (DMRT at $p \leq 0.05$).

Discussions

The effects of application of nitrogen and cow dung rates on the productivity of SAMSORG-17 and SAMSORG-44 at both Samaru and Maigana in 2013 and 2014 were evident. However, there was a difference between the years as the results showed better performances in the 2014 season than in the 2013 season. These could be attributed to several factors such as weather conditions as well as a relatively higher nitrogen and organic carbon in the soil of the field in 2014 than in 2013. There was more and evenly distributed rainfall (appendix I and II) during the growing period in 2014 as compared to the erratic rainfall in the 2013 season.

The amount of monthly rainfall received during the two years of the experimentation were consistently higher and more evenly distributed at Samaru than the corresponding months at

Maigana that were lower. The ample rainfall apart from its role of supplying water to meet the crop's requirements for proper growth and development also apparently provided enough moisture for the activities of microorganisms in the soil and consequently aided the aeration, decomposition and mineralization of the cow dung applied for plant use.

Rainfall irregularity can adversely affect yields (Rudolf and Hermann, 2009) especially if such rains fail to arrive during the critical growing stages of the crop's life cycle. There have been corroborative evidences that the organic nitrogen (N) availability for plant use is influenced by the activities of soil microbes in mineralization of organic manure at optimum temperature, soil moisture and soil pH among other factors at their optimum levels (Tulina *et al.* (2009). It is most likely that the temperatures, soil moisture and soil pH similarly had their effects at Samaru location.

The higher monthly rainfall, maximum temperatures, relative humidity and lower mean minimum temperatures at Samaru in contrast to Maigana made the conditions more favourable for grain development than at Maigana. A decrease in the amount and pattern of rainfall reduces the time that crops have to complete their growth cycle and ultimately causes yield losses (Linderholm, 2005).

The higher mean monthly maximum temperatures during the two growing seasons, which were comparably higher at Maigana than Samaru, might have caused the crop to use more energy in respiration for their maintenance and less to support their growth. With a 1⁰C increase in average temperatures, yields of major food and cash crops can decrease by 5 to 10 percent (Hatfield *et al.*, 2015). Higher temperatures induce more rapid completion of plant growing cycle (Hatfield *et al.*, (2015) with less time to reproduce, hence reproductive failures are more likely and this will also lower yields (Craufurd and Wheeler, 2009).

The relative humidity during the two years of the experimentation also indicated higher values at Samaru than Maigana location. The ample air moisture improved crop growth, more dry matter production and consequently yield. Thus, the better performance of sorghum at Samaru could be as a result of the ample air moisture that might have reduced water loss from the soil as well as the crop through excessive evapotranspiration at Samaru compared with Maigana.

Effects of Nitrogen on Growth and Yield of the two Sorghum Varieties

In the study, application of nitrogen significantly increased sorghum grain yield at both locations and seasons. The increase in yield could be attributed to the positive effect of N on dry matter production for grain filling as a result of more photosynthetic apparatus for photosynthesis and hence assimilate production and partitioning to various sinks compared to the control. The significant response of yield parameters such as 1000 grain weight could be attributed to the early enhancement of vegetative growth of sorghum by nitrogen. Adamu *et al.* (2025) independently reported enhanced vegetative growth and yield of sorghum due to application of N.

The high grain yield per hectare obtained at Samaru compared with Maigana could be associated with relatively high rainfall that was more evenly distributed which might have enhanced efficient water and inherent soil nitrogen utilization by the crop at Samaru than Maigana. Increase in yield of sorghum due to nitrogen has been reported by (Adamu *et al.*, 2025).

Effects of Cow dung on Yield of the two Sorghum Varieties

The significant response of yield and yield components such as threshing percent, 1000-grain weight, harvest index and grain yield per hectare could be attributed to the significant role played by cow dung manure in supplying nutrients, organic matter and improving water holding capacity of the soil. These factors might be responsible for improvement in soil water holding capacity and structure as well as soil microbial and biological influence (i.e earthworms, ant and other microbial population as well as their activities in the soil medium) . Application of organic manure to crops is usually based mainly on nutrients content of the organic source, fertility status of the soil as well as the nutrient requirement of the crop. The taller plants and more photosynthetic apparatus observed could be responsible for the interception of solar radiation and production of more assimilate that eventually translated to increased yield. Increases in yield and yield components of sorghum due to application of cow dung was earlier reported by Umeri *et al.* (2025)

The yield of sorghum was better at Samaru compared with Maigana in both years; this could be linked to relatively higher inherent soil nitrogen and organic carbon coupled with better weather elements such as adequate rainfall which was evenly distributed and optimum temperatures received at Samaru than Maigana that might have provided the needed nutrients for plant use.

Varietal response to Nitrogen and Cow dung

Significant variations were observed among the two varieties used at both Samaru and Maigana during 2013 and 2014 years of the experiment. In the present study, sorghum variety SAMSORG-17 was superior with respect to all the yield and yield attributes in both years and locations. Parameters such as 1000-grain weight and grain yield ha^{-1} were observed to be higher for SAMSORG-17 than SAMSORG-44.

The superiority of SAMSORG-17 over SAMSORG-44 could be due to the differences in their tolerance to pest and disease conditions. SAMSORG- 44 is more susceptible to stalk stem borer and spotted stem borer that attacked the crop on the field during the 2013 and 2014 years of the experimentation. The significant variation in yield and yield attributes between the two sorghum varieties in terms of parameters such as 1000 grain weight and grain yield ha^{-1} of SAMSORG-17 is a clear manifestation of better photosynthetic efficiency which is an indication of availability of more photosynthetic apparatus for assimilate production and partitioning that eventually translates into high yield than SAMSORG-44.

The higher grain yield obtained with SAMSORG-17 could be attributed to its higher harvest indices which connote efficiency for partitioning and translocation of assimilate that might have resulted to higher grain yield. The higher grain yield obtained is an indication for high potential of increased dry matter production, longer panicles, heavier 1000-grain weight and higher grain yield. This result is consistent with the findings of Palanisamy *et al.* (2023) who found that high grain yield of sorghum was associated with high dry matter production.

The highest grain yields of 2393 kg ha^{-1} for SAMSORG-17 in 2014 at Samaru and 1767 kg ha^{-1} for the same variety in 2013 at Maigana though low but compared favourably with its potential grain yield range of 1800 – 3000 kg ha^{-1} . The grain yields of SAMSORG-44 of 2278 kg ha^{-1} in 2014 at Samaru and 1482 kg ha^{-1} in 2013 at Maigana also indicated how they compared with the potential grain yield range 2000- 2500 kg ha^{-1} of the variety.

Conclusion

The performance of the two varieties was better in 2014 at both locations which was attributable to the better weather conditions (appendix I and II) as well as a relatively higher nitrogen and organic carbon in the soil of the field in 2014 compared to 2013. Another possible reason could be due to the fact that the benefits of organic manure including cow dung are usually observed in the second year of application because of their slow nutrient release.

Nitrogen fertilization significantly increased the sorghum yield and yield components with each addition of N rate up to the highest rate of 90 kg N ha⁻¹. Significant response of the two sorghum varieties to the rates of nitrogen on yield components which included threshing percentage, harvest index and grain yield ha⁻¹ at both locations and years. The influence of N on yield parameters such as harvest index and grain yield ha⁻¹, at Samaru in 2014 and across the years were worthy of notice as often the significant response was only up to 60 kg N ha⁻¹.

Recommendations

It was generally observed that a combination of 60 kg N ha⁻¹ and 15 t ha⁻¹ cow dung consistently gave the best grain yield but statistically similar with 90 kg N ha⁻¹. Similarly, interaction of 60 kg N ha⁻¹ rate at Samaru in 2014 gave the best grain yield levels with both SAMSORG-17 and SAMSORG-44 than all the other rates and therefore it can be recommended for farmers in northern Guinea savannah ecological zone of Nigeria.

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Appendix I: Meteorological data showing monthly rainfall, temperature, relative humidity and Sunshine hours at Samaru during 2013 and 2014 seasons

Month	Rainfall (m)		Temperatures (°C)				Relative Humidity (%)				Sunshine Ho		Source:
			Maximum		Minimum		2013		2014				
	20	201	201	20	20	20	10:00a.	4:00p	10:00a	4:00p	201	201	
January	0.	0.	32.	33	17	17	21.7	17.	18.6	12.1	8.1	8.	
February	0.	0.	35.	34	1	19	14.9	12.	15.4	12.4	7.	8.	
March	0.	0.	39.	38	22	22	38.1	14.	26.7	19.4	7.	7.	
April	73	141	37.	36	24	24	52.9	24.	54.3	39.5	7.	7.	
May	66	127	35.	33	24	24	64.6	50.	67.3	51.0	7.	6.	
June	16	115	31.	32	13	21	69.6	60.	72.9	61.0	6.	7.	
July	31	115	30.	31	20	20	80.0	67.	78.0	70.0	6.	6.	
August	16	374	30.	30	19	20	83.0	72.	82.0	72.8	7.	5.	
September	23	180	32.	31	18	21	77.0	65.	77.8	70.0	6.	5.	
October	10	9.	34.	33	18	19	54.0	41.	61.0	41.0	7.	8.	
November	0.	0.	34.	30	15	14	24.5	18.	27.0	20.0	9.	8.	
December	0.	0.	29.	26	11	13	19.0	13.	19.6	13.5	8.	8.	
Total	102	106	-	-	-	-	-	-	-	-	-	-	
TRGC	72	798	-	-	-	-	-	-	-	-	-	-	

Metrological Unit of Institute for Agricultural Research (IAR) Samaru, Zaria

Key: TRGC = Total Rainfall during the Growth of the Crop.

* = 10:00 a.m and 4:00 p.m are 09:00 and 15:00 GMT, respectively.

Appendix II: Meteorological data showing monthly rainfall, temperature, relative humidity and Sunshine hours at Maigana during 2013 and 2014 seasons

Month	Rainfall (mm)		Temperatures (°C)				Relative Humidity (%)				Sunshine Hours	
	20	20	Maximum	Minimum	20	20	10:00a.m	4:00p	10:00a	4:00p	20	20
January	4E	4B	NN	L-N	N	L-N	M4B	L-NE	L-NB	L-4B	4E	4B
February	4E	4B	N	L-N	N	L-N	L-NBC	L-NE	L-NB	L-4B	4E	4B
March	4E	4B	NO	M	N	M	NBC	L-NE	MNB	L-OB	4E	4B
April	N	L-M	N	M	N	M	L-B	MN	NB	NB	4E	4B
May	N	L-L	N	M	N	M	NB	N	NB	NB	4E	4B
June	L-M	L-L	NN	M	N	M	NB	N	L-B	NB	4E	4B
July	L-N	L-M	NL	M	N	M	NB	N	NB	NB	4E	4B
August	M	M	NL	M	M	M	NB	N	NB	NB	4E	4B
September	O	L-N	NL	M	M	M	NB	N	NB	NB	4E	4B
October	N	NE	NN	M	N	M	NB	NO	NB	NOE	4E	4B
November	4E	4B	N	L-N	N	L-N	MMB	L-NE	MNB	L-NB	4E	4B
December	4E	4B	N	L-N	N	L-N	L-NB	L-L	L-NB	L-ME	4E	4B
Total	N	OM	-	-	-	-	-	-	-	-	-	-
TRGC	N	N	-	-	-	-	-	-	-	-	-	-

Source: Meteorological Units of Kaduna Agricultural Development Project (KADP)

Key: TRGC = Total rainfall during the Growth of the Crop.

* = 10:00 a.m and 4:00 p.m are 09:00 and 15:00 GMT, respectively.

n.a = Not available.