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EFFECT OF NUTRIENT SOURCES AND VARIETY ON GROWTH AND YIELD OF SORGHUM (*Sorghum bicolor* (L.) Moench) IN BAUCHI STATE, NIGERIA.

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ABSTRACT

A field experiment was conducted at the Bauchi State College of Agriculture Research Farm during the 2018 and 2019 rainy seasons, to study the effect of nutrient sources and variety on the growth and yield of sorghum (Sorghum bicolor (L.) Moench). The treatments consisted of five nutrient sources (Poultry

Introduction

Sorghum {*Sorghum bicolor (L.)Moench*} is the 5th most important cereal crop in the world after rice (*Oryza sativa L.*) wheat (*Triticum aestivum L.*), maize (*Zea mays L.*) and barley (*Hordeum vulgare L.*) (Musa, *et al*.,2011). It is used for food in Africa and many parts of Asia, cattle feed, bio-energy, thatch making, roofing of houses, brewing beer and for the manufacture of starch (Reda *et al*., 2005).

It is adapted to the hot, semi-arid tropical and dry temperate areas of the world (Blum, 2004). Sorghum is better suited to high temperature and moisture stress conditions bio-chemically and physiologically than rice, wheat and barley. It can give useful yields in areas unfavourable to other cereal crops like rice, wheat and barley (Dowens,1992).

Sorghum is adapted to a wide range of environmental conditions, particularly drought.

manure, Cow dung, Mineral Fertilizer, Chicken Feather, Municipal waste) a Control and two sorghum varieties namely, CSR-01 and SK-5912. These were factorially combined to give 12 treatments and laid out in a Randomized Complete Block Design (RCBD) and replicated three times. Data was collected at bi-weekly interval on plant height, number of leaves, leaf area, stem girth, days to 50% flowering and days to physiological maturity. Others are panicle length, number of spike/panicle, 1000 grain weight and grain yield. All data collected were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was used to separate the means. The result of the experiment revealed a significant difference among the treatments used throughout the study period. The result further indicated that, poultry manure proved to be significantly better than the other nutrient sources used in all the characters observed and all the nutrient sources were better than the control. Varieties on the other hand, except grain yield where no significant difference was observed, CRS-01 was found to be statistically better than SK 5912 in all the characters observed. Based on the result of this study, it is recommended that farmers should adopt the use of poultry manure or chicken feather at the rate of 2t/ha or mineral fertilizer at the rate of 60 kg N, 30 kg P & K/ha. It is also recommended that CSR-01 variety should be grown for higher yield. Further studies are recommended with other varieties and higher rates of nutrient sources to explore more inference on sorghum.

Keywords: Effect, Nutrient, Growth, Yield, Sorghum.

Hence, it is widely grown in different ecological zones of Nigeria (Showemimo *et al.*, 2000). It has a number of morphological and physiological characteristics that contribute to its adaptation to dry conditions. These include an extensive root system, waxy bloom on the leaves that reduces water loss, ability to stop growth in period of drought

and resumes when conditions are favorable and tolerance to water logging (FAO,2011). The crop also grows on a wide range of soils: sand, loam, sandy-loam, saline and alkaline soils with a p^H range of 4.0-8.5 (Aba *et al*., 2004).

Global sorghum production is estimated at about 65.6 million metric tons on a cultivated area of 43.8 million hectares in 2020. United States is the leading producer of sorghum in the world having produced 9.74 million metric tons in 2020. This is followed by Nigeria with 6.57 million metric tons, India and Mexico 5.0 million metric tons, Ethiopia 4.5 million metric tons and China 3.5 million metric tons. (Shahbaudeh, 2021). Now sorghum has reached the second position as feedstock for grain based ethanol after maize (Musa *et al.*,2011). As the global population and fresh water demand is continuously increasing, dry land farming and sorghum crop are gaining importance. (Bado *et al,*. 2011).

About 50% of the total area devoted to cereal crops is Nigeria is occupied by sorghum. The area estimated at 6.86 million hectares extends north-ward from latitude 8°N and latitude 14° N (Aba et al.,2004). In 2020, the total sorghum production in Nigeria was estimated at 6.57 million tons (Shahbaudeh, 2021).Consequently, Nigeria became the largest sorghum producer in the West African sub-region accounting for 71% of regional total sorghum output. Globally also, Nigeria leads in sorghum production for human consumption and has risen from its fifth position in 1995 (Clara, *et al*., 2019) to be the third largest sorghum producer in the world after USA and India where more than 90% of their sorghum harvest is used for animal feed (Shuaibu, *et. al.*, 2018).

In terms of production, Bauchi State is among the leading states following Kaduna and Borno states with a total production of 453,000 metric tonnes in 2017 (FMOA & RD, 2018).

Statement of the Problem

In West African savannah, the intensification of agricultural system has resulted in declining nutrient availability, soil acidification and build-up of pests and diseases leading to decline in crop yield. Declining soil fertility due to nutrient mining, erosion and desertification are the major threat to food

production in Nigeria. The problem of soil fertility in the Northern States of Nigeria like most of sub-Saharan African countries is driven by a wide range of factors. The rapid increase in population growth impose more pressure on the land leading to cutting down of trees for shelter, fuel and farmland. This exposes the soil to adverse climatic factors and increases the rate of nutrient depletion with little or no commensurate increase in the amount of fertilizing elements in form of organic or inorganic fertilizers being added to the soil. Under continuous crop cultivation common in the savannah zone, the drain in soil nutrients is very high and the occurrence of nutrient deficiency becomes widespread. The high cost of inorganic fertilizers coupled with its poor distribution system and the low incomes of our peasant farmers who constitute about 75% of the population has made its widespread use difficult. This necessitates the use of other nutrient sources as a means of soil fertility restoration in order to determine the one that gives optimum growth and yield of sorghum in the study area.

Justification of the Study

Sorghum is an important cereal crop that is used for food in many parts of Africa and Asia, as cattle feed, bio-energy, brewing bear and for the manufacture of starch (Reda *et al*.,2005). Savannah soils are known to be inherently low in fertility due to continuous cropping leading to the depletion of the available nutrients in the soil. This poor or low fertility status is seen as one of the most limiting factor for cereal production in this ecological zone. The traditional system of low cropping intensity practiced several decades in West African savannah involves the use of fallow as a means of soil fertility restoration. However, the increase in population growth leading to increasing pressure on the land has led to continuous cropping at the expense of soil fertility management. This has resulted in rapid nutrient depletion and soil structure deterioration over the years (Graham, 1981). Nitrogen has been identified to be a major constraint to increased sorghum production in the savannah zone of Nigeria (Singh, 1989). Analysis has shown that organic fertilizers, especially those of animal origin, besides the supply of major nutrients (NPK), also provides calcium,

magnesium as well as micro-nutrients to the soil (Lombin and Abdullahi, 1997). The use of organic fertilizers also helps to reduce the problem of soil compaction, increases easy penetration of air and water and improve the soil physical properties. (Watmann et al.,2013).

Therefore, the use of different organic sources of fertilization and inorganic fertilizer will have a positive impact towards reducing the problem of nutrient supply of the soil and consequently improve/increase the growth and yield of sorghum in the study area.

Objectives of the Study

The objectives of this study are:

1. To study the effect of different nutrient sources on the growth and yield of sorghum in the study area.
2. To identify the best among the varieties tested for the growth and yield of sorghum in the study area.

METHODOLOGY

Experimental Site

The experiment was conducted at the Bauchi State College of Agriculture School Farm, located at 10°25'N and 9°51'E, during the 2018 and 2019 rainy seasons. The research was carried out to study the effect of nutrient sources and variety on growth and yield of sorghum (*Sorghum bicolor* (L) moench) in the northern guinea savanna agro-ecological zone of Nigeria.

The climatic condition of the study area (Bauchi) is characterized by two main seasons; the rainy season spanning from April to October and dry season from November to March. The mean annual rainfall is 1000mm with a mean daily maximum temperature of 26°C (Kowal and Knabe, 1972). According to Lombin (1983), the soil of the experimental site is sandy loam with p^H range of 6.30-6.78.

Experimental Materials and their Sources.

The materials used for the research consisted of poultry manure, cow dung, municipal waste, mineral fertilizer (NPK 15:15:15), and chicken feather. The

sorghum varieties used for the experiment were SK-5912 and CSR-01 all obtained from seed multiplication unit, BSADP Bauchi.

Treatments and Experimental Design

The treatments consisted of two varieties of sorghum (SK-5912 and CSR-01) and five nutrient sources (poultry manure, cow dung, municipal waste, mineral fertilizer, chicken feather) and control. These were factorially combined to give 12 treatments combination and laid out in a randomized complete block design (RCBD) and replicated three times. A plot size of $4m^2$ was adopted, 0.5m was left as a border row between the plots and 1.0m was left as a walk way between replications.

Data Collection

Data was collected from ten randomly tagged plants from the net plot at bi-weekly interval on plant height, number of leaves, leaf area, leaf area index, days to 50% flowering, days to physiological maturity, panicle length, 1000 grain weight and grain yield (kg/ha).

Data Analysis

All data collected during the experiment were subjected to Analysis of Variance (ANOVA) using SPSS version 20 to determine the significant difference between treatments and the mean performance of each treatment. However, the treatment means were separated using Duncan's Multiple Range Test (DMRT) .

Results and Discussion

Plant height (cm)

Table 1 showed the effect of nutrient sources and variety on plant height (cm) of sorghum during 2018 and 2019 rainy seasons. The result revealed a significant ($P \leq 0.05$) difference on plant height among the various treatments used throughout the study period. The result further indicated that application of poultry manure at the rate of 2t/ha produced significantly ($P \leq 0.05$) taller plants followed by mineral fertilizer, chicken feather, cow

dung and municipal waste. The control on the other hand produced the shortest plants compared to other nutrient sources in both seasons. Moreover, variety CSR-01 was found to significantly (P≤ 0.05) produced taller plants than the other variety (SK-5912) in both 2018 and 2019 rainy seasons. On the interactive effect of nutrient sources and variety, it has been observed that the application of 2t/ha poultry manure on CSR-01 variety produced taller plants than the other treatments except at 4WAE and 10WAE of 2018 where the two varieties were statistically the same. The increase in plant height could be as a result of increase in optimum efficiency of fertilizer used. This agrees with the findings of Ismaeil *et al*. (2012) who reported that, by using chicken manure, taller plants can be obtained and that growth attributes (plant density, height, number of leaves, stem diameter and Leaf Area Index) of sorghum increases with increased rate of poultry manure. Amir *et al.* (2020) also reported that maximum plant height (130.35cm) was noted when poultry manure with dose 4t/ha was applied on sorghum. The result is also in conformity with the findings of Agbede, *et al*. (2008) who said that poultry manure has significant impact on growth and yield of crops because of its high content of N, P, K and S.

Table 1: Effect of Nutrient Sources and Variety on Plant Height (cm) of Sorghum in 2018 and 2019 Rainy Seasons

	WAE											
	2			4		6		8		10	AT HARVEST	
Treatments	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Nutrient sor												
Control	11.68^{f}	11.75^{f}	20.51^{e}	20.58^{e}	54.18^{f}	56.85^{f}	83.95^{f}	86.21^{f}	11.61^{f}	118.95^{f}	130.08^{f}	133.15^{e}
CD	16.36^{d}	16.52^{d}	36.57^{d}	36.75^{d}	94.80^{d}	96.01^{d}	146.23^{d}	150.34^{d}	158.39^{e}	160.80^{e}	198.62^{e}	201.67^{c}
CF	17.59^{c}	17.82^{c}	40.41^{c}	40.45^{c}	100.18^{c}	102.53^{c}	156.25^{c}	158.81^{c}	172.22^{c}	175.19^{c}	253.19^{c}	256.90^{b}
MF	20.14^{b}	20.39^{b}	42.96^{b}	43.27^{b}	102.80^{b}	107.34^{b}	161.60^{b}	169.38^{b}	188.62^{b}	189.48^{b}	266.84^{b}	268.55^{b}

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MW	15.08[e]	15.22[e]	36.37[d]	36.46[d]	82.85[e]	87.14[e]	97.95[e]	100.13[e]	134.85[d]	134.85[d]	175.43[d]	178.42[d]
PM	24.62[a]	24.77[a]	49.79[a]	49.84[a]	118.52[a]	121.19[a]	170.57[a]	177.19[a]	219.25[a]	222.16[a]	274.33[a]	279.36[a]
LS	**	**	**	**	**	**	**	**	**	**	**	**
SE±	0.279	0.335	0.176	0.184	0.906	0.957	0.422	0.451	0.832	0.851	1.04	1.07
Variety												
CSR-01	18.64[a]	18.78[a]	37.68[a]	37.76[a]	57.52[a]	58.01[a]	75.39[a]	75.46[a]	82.19[a]	86.33[a]	215.97[a]	225.17[a]
SK-5912	16.63[b]	16.71[b]	37.93[a]	38.02[a]	55.06[b]	55.11[b]	70.48[b]	70.60[b]	79.42[a]	82.59[b]	206.31[b]	210.85[b]
LS	**	**	NS	NS	**	**	**	**	NS	**	**	**
SE±	0.928	0.194	0.590	0.106	0.819	0.552	0.410	0.260	0.734	0.491	1.065	1.860
Interaction												
N × V	**	**	NS	**	**	**	**	**	NS	**	**	**

LS= Level of significance, NS= Not significant, SE= standard error *=significant at 0.05 **= significant at 0.01. means followed by the same letter within the same column are not statistically different following DMRT. CD = Cowdung, CF = Chicken feather, MF = Mineral fertilizer, MW = Municipal waste, PM = Poultry manure

Table 2 showed the result of effect of nutrient sources and variety on number of leaves of sorghum in 2018 and 2019 rainy seasons. From the result, it revealed that there is significant (P≤ 0.05) difference among various treatments used in both 2018 and 2019 rainy seasons. The result further indicated that, application of 2t/ha poultry manure had significantly (P≤ 0.05) produced higher number of leaves than the other sources of nutrient used in both 2018 and 2019 rainy seasons. This is followed by application of mineral fertilizer, chicken feather, cow dung and municipal waste. The control however recorded the lowest number of leaves. The result also indicated that CSR-01 variety significantly (P≤ 0.05) produced higher number of leaves than SK-5912 variety throughout the study period. This is an indication that poultry manure has influence on the number of

leaves of sorghum. The result is in agreement with the findings of Olayinka, *et al.* (2007) where he reported that organic materials especially poultry droppings have been identified as good sources of soil amendment and can be used to increase the growth of sorghum plant and subsequently improve production. It also supports the findings of Abdullahi *et al.*(2019) who depicted that number of leaves, leaf area, plant height and stem girth were increased when 5t/ha poultry manure was applied at the time of sowing.

Table 2: Effect of Nutrient Sources and Variety on Number of Leaves of Sorghum in 2018 and 2019 Rainy Seasons

	WAE									
		2		4		6		8		10
Treatment	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Nutrient Source										
Control	2.43^{f}	2.56^{f}	3.048^{f}	3.59^{f}	4.61f	4.65^{f}	6.82^{f}	6.86^{f}	8.49^{f}	8.53^{f}
CD	2.96^{d}	3.04^{d}	4.51^{d}	4.54^{d}	5.55^{d}	5.59^{d}	8.46^{d}	8.51^{d}	9.79^{d}	9.88^{d}
CF	3.18^{c}	3.27^{c}	4.80^{c}	4.85^{c}	6.18^{c}	6.29^{c}	9.02^{c}	9.08^{c}	10.10^{c}	10.22^{c}
MF	3.59^{b}	3.65^{b}	5.23^{b}	5.29^{b}	6.90^{b}	6.95^{b}	9.49^{b}	9.54^{b}	10.61^{b}	10.65^{b}
MW	2.73^{e}	2.80^{e}	3.96^{e}	4.03^{e}	5.11^{e}	5.11^{e}	7.51^{e}	7.56^{e}	9.28^{e}	9.32^{e}
PM	4.01^{a}	4.13^{a}	6.01^{a}	6.06^{a}	7.88^{a}	7.97^{a}	10.38^{a}	10.41^{a}	11.49^{a}	11.60^{a}
LS	**	**	**	**	**	**	**	**	**	**
SE±	0.029	0.035	0.016	0.017	0.081	0.099	0.029	0.031	0.211	0.240
Variety										
CSR-01	2.26^{a}	2.29^{a}	8.78^{a}	3.81^{a}	5.21^{a}	5.27^{a}	7.68^{a}	7.73^{a}	9.11^{a}	9.20^{a}
SR-5912	2.19^{b}	2.20^{b}	3.60^{b}	3.63^{b}	3.90^{b}	4.93^{b}	5.55^{b}	5.59^{b}	8.80^{b}	8.86^{b}
LS	**	**	**	**	**	**	**	**	**	**
SE±	0.170	0.020	0.016`	0.010	0.041	0.057	0.123	0.018	0.009	0.014
Interaction										
N X V	*	*	**	**		NS		NS		NS

LS= level of significance, NS= Not significant, SE= standard error *=significant at 0.05 **= significant at 0.01. Means followed by the same letter within the same column are not statistically different following DMRT.

CD = Cowdung, CF = Chicken feather, MF = Mineral fertilizer, MW = Municipal waste, PM = Poultry manure

Leaf area (cm^2)

The effect of nutrient sources and variety on leaf area (cm^2) of sorghum in 2018 and 2019 rainy seasons is presented in Table 3. The result in Table 7 showed that, there is a significant ($P \leq 0.05$) difference among the various treatments where application of poultry manure at the rate of 2t/ha produced significantly ($P \leq 0.05$) higher leaf area than the other nutrient sources used throughout the study period. The result further indicated that, except at 10 WAE where statistically ($P \leq 0.05$) the varieties appeared to be same, CSR-01 variety produced statistically ($P \leq 0.05$) higher leaf area than SK-5912 in both 2018 and 2019 rainy seasons. This may be due to the fact that, apart from the supply of major nutrient elements N, P and K, poultry manure is found to contain other essential such as S, Mg and Fe that are usually lacking in various chemical fertilizers. This result is in agreement with the findings of Buah *et al*., (2012) who reported that sorghum fertilized with poultry manure produced higher leaf area than those that were not fertilized. The result is also in line with the findings of Ismaeil *et al*., (2012) who reported that application of poultry manure significantly increased growth attributes of sorghum such as plant height, density, number of leaves, stem diameter and leaf area index.

Table 3: Effect of Nutrient Source and Variety on Leaf Area of Sorghum in 2018 and 2019 rainy seasons

	WAE							
	4		6		8		10	
Treatments	2018	2019	2018	2019	2018	2019	2018	2019
Nutrient Source								
Control	26.18^{f}	26.37^{f}	43.89^{f}	44.50^{f}	200.66^{f}	202.81^{f}	308.81^{d}	310.18^{d}
CD	59.06^{d}	58.19^{d}	89.79^{d}	90.06d	341.28^{d}	343.24^{d}	423.73^{c}	425.21^{c}
CF	21.95^{c}	72.06^{c}	104.16^{c}	105.52^{c}	376.84^{c}	378.17^{c}	460.01^{bc}	461.09^{bc}
MF	87.64^{b}	87.94^{b}	135.14^{b}	136.77^{b}	414.45^{b}	416.62^{b}	511.69^{ab}	513.29^{ab}

MW	47.28^{e}	47.35^{e}	72.04^{e}	72.24^{e}	266.13^{e}	267.96^{e}	323.26^{d}	326.30^{d}
PM	100.68^{a}	101.95^{a}	193.37^{a}	194.78^{a}	455.98^{a}	458.45^{a}	565.45^{a}	568.99^{a}
LS	**	**	**	**	**	**	**	**
SE±	0.91	1.02	2.92	3.86	2.19	2.59	22.79	24.66
Variety								
CSR-01	67.03^{a}	67.38^{a}	109.74^{a}	111.78^{a}	350.04^{a}	351.99^{a}	430.19^{a}	432.87^{a}
SK-5912	63.69^{b}	63.91^{b}	102.05^{b}	102.83^{b}	333.19^{b}	337.09^{b}	433.77^{a}	435.48^{a}
LS	**	**	**	**	**	**	NS	NS
SE±	0.55	0.59	2.19	2.23	1.39	1.50	14.21	14.24
Interaction								
N X V	NS	NS	NS	NS	NS	NS	NS	NS

LS= level of significance, NS= Not significant, SE= standard error *=significant at 0.05 **= significant at 0.01. mean followed by the same letter within the same whumn are not statistically different following DMRT. CD = Cowdung, CF = Chicken feather, MF = Mineral fertilizer, MW = Municipal waste, PM = Poultry manure.

Stem girth (cm)

Table 4 showed result of the effect of nutrient sources and variety on stem girth of sorghum in 2018 and 2019 rainy seasons. From the result, it indicated that there is a significant (P≤ 0.05) difference among the various treatments used throughout the study period. The further indicated that, application of poultry manure at the rate of 2t/ha produced significantly (P≤ 0.05) thicker stems followed by mineral fertilizer than the other nutrient sources used in both seasons. This could be as a result of soil improvement as a result of nutrient supply ability of organic matter leading to better accumulation of food, contributing to healthy plant and sturdy stem which ultimately enhanced stem diameter. This agrees with the findings of Arunah, *et al*., (2006) who reported that application of poultry manure ameliorated soil degradation and had positive cumulative effect by continuously adding organic carbon and nutrients. This is further supported by Amir *et al.,* (2020) who reported significant effect of poultry manure application on stem diameter of sorghum.

Table 4: Effect of Nutrient Source and Variety on Stem Girth (cm) of Sorghum in 2018 and 2019 Rainy Seasons

	WAE							
	4		6		8		10	
Treatments	2018	2019	2018	2019	2018	2019	2018	2019
Nutrient Source								
Control	1.65^{c}	1.67^{c}	2.45^{f}	2.47^{f}	3.84^{f}	3.86^{f}	5.52^{d}	5.56^{d}
CD	2.16^{ab}	2.19^{ab}	3.42^{d}	346^{d}	4.84^{d}	4.86^{d}	7.39^{a}	7.45^{a}
CF	2.49^{ab}	2.57^{ab}	4.01^{c}	4.08^{c}	5.25^{c}	5.30^{c}	8.09^{b}	8.14^{b}
MF	2.71^{ab}	2.78^{ab}	4.42^{b}	4.47^{b}	6.38^{b}	6.42^{b}	8.46^{b}	8.50^{b}
MW	1.90^{bc}	1.92^{bc}	3.00^{e}	3.04^{e}	4.35^{e}	4.36^{e}	7.18^{c}	7.21^{c}
PM	3.20^{a}	3.19^{a}	4.98^{a}	5.00^{a}	6.86^{a}	6.90^{a}	9.30	9.34^{a}
LS	**	**	**	**	**	**	**	**
SE±	0.33	0.36	0.02	0.02	0.01	0.01	0.20	0.21
Variety								
CSR-01	2.39^{a}	2.42^{a}	3.81^{a}	3.84^{a}	5.33^{a}	5.35^{a}	7.78^{a}	7.85^{a}
SK-5912	2.30^{b}	2.33^{b}	3.62^{b}	3.66^{c}	5.19^{b}	5.21^{b}	7.50^{a}	7.55^{a}
LS	**		**		**		NS	
SE±	0.01	0.02	0.01	0.01	0.01	0.01	0.11	0.12
Interaction								
N X V	NS	NS	**	**	**	**	NS	NS

LS= level of significance, NS= Not significant, SE= standard error *=significant at 0.05 **= significant at 0.01. means followed by the same letter within the same whumn are not statistically different following DMRT. CD = Cowdung, CF = Chicken feather, MF = Mineral fertilizer, MW = Municipal waste, PM = Poultry manure.

Flag leaf area (cm²)

The effect of nutrient sources and variety on flag leaf area of sorghum in 2018 and 2019 rainy seasons is presented in Table 5. The result showed that, application of poultry manure at the rate of 2t/ha significantly (P≤ 0.05)

produced higher flag leaf area than all other nutrient sources used. Furthermore, the result indicated that CSR-01 variety produced statistically (P≤ 0.05) larger flag leaf area than SK-5912 variety in the two growing seasons. The result is in line with the findings of Ismaeil *et al*., (2012) who reported that application of poultry manure significantly increased growth attributes of sorghum such as plant height, density, number of leaves, stem diameter and leaf area index. Arunah, *et al*., (2006) also buttressed this point where he opined that application of poultry manure increases the physical and chemical properties of the soil which in turn increases growth characters and grain yield of sorghum.

Days to physiological maturity

Table 5 also showed result of the effect of nutrient sources and variety on days to physiological maturity of sorghum in 2018 and 2019 rainy seasons. The result revealed a significant (P≤ 0.05) difference among the various treatments used. The result further indicated that, control matured earlier than all other treatments in the two growing seasons. This is followed by municipal wastes and cow dung treated plot. Poultry manure matured later than all the treatments considered. Study on variety showed that, SK-5912 variety matured statistically (P≤ 0.05) earlier than CSR-01 in both 2018 and 2019 growing seasons. This shows the importance of fertilizer as a basic component of many physiological processes in plants. The present findings is in agreement with the report of Marschner (2005) who stated that, nitrogen is a basic constituent of many compounds of physiological importance to plant metabolism. The reduction in days to physiological maturity with the application of poultry manure can also be attributed the fact that nutrients released from poultry manure had direct effect on growth and grain yield of sorghum. Blankenau et al. (2002) agreed with the result of this study where he stated that proper rate and time of poultry manure application are critical for meeting crop needs, and considerable opportunities exist for growth and yield improvement

Days to 50% flowering

The effect of nutrient sources and variety on days to 50% flowering of sorghum in 2018 and 2019 growing seasons is also presented in Table 5. The result revealed that, there is a significant (P≤ 0.05) difference among the treatments used where control plot was observed to have flowered earlier than all the treatments. Poultry manure on the other hand flowered later than the other nutrient sources used. The result further indicated that, the two varieties (CSR-01 and SK-5912) were statistically (P≤ 0.05) the same with respect to days to 50% flowering. This might be as a result of increase in growth rate of the crop due to the addition of fertilizers. The reduction in number of days to 50% flowering as a result of application of poultry manure revealed the importance of poultry manure in sorghum production. This is in agreement with the findings of Mahama, *et al.*, (2014) who reported that application of poultry manure (7.5 ton/ha) significantly increased a number of growth and yield attributes of sorghum cultivar, than the control. This further agrees with the report of Ismaeil, *et al.*, (2012) who reported that poultry manure resulted in an increase in growth attributes as well as grain yield of sorghum more than the control.

Panicle length (cm)

Table 5 showed the effect of nutrient sources and variety on panicle length (cm) of sorghum in 2018 and 2019 rainy seasons. The result showed that, there is a significant (P≤ 0.05) difference among the treatments where application of poultry manure at the rate of 2 t/ha was found to significantly (P≤ 0.05) produced longer panicles in both the seasons under study. This is followed by mineral fertilizer while control produced the shortest panicles. In addition, the result showed that, CSR-01 variety significantly (P≤ 0.05) produced longer panicle than SK-5912 variety throughout the two growing seasons. This is an indication that organic fertilizers especially poultry manure are very important for crop production. Increase in panicle length subsequently translates to increase in the yield of sorghum. This result is in agreement with the findings of Shuaibu *et al.*, (2018) who reported a significant increase in panicle length as a result of application of poultry

manure based compost. This is further confirmed by Arunah *et al*., (2006) and Mohammad and Solaiman (2012) who reported that panicle length, number of spikes per panicle and grains per panicle increase with increased level of fertilizer and manure application.

Table 5: Effect of Nutrient Sources and Variety on Flag Leaf Area, Days to Physiological Maturity Days to 50% Flowering and Panicle Length of sorghum

Parameter								
	FLA		DPM		DF50%		PL	
Treatment	2018	2019	2018	2019	2018	2019	2018	2019
Nutrient S.								
Control	352.88^{f}	360.18^{f}	111.26^{a}	110.99^{a}	78.22^{a}	77.04^{a}	19.19^{f}	19.62^{f}
CD	468.62^{d}	475.09^{d}	102.18^{b}	106.77^{c}	71.86^{c}	71.04^{c}	37.87^{d}	38.08^{d}
CF	500.01^{c}	502.82^{c}	105.02^{c}	105.41^{d}	69.05^{c}	68.98^{c}	30.16^{d}	30.44^{d}
MF	555.84^{b}	563.29^{b}	105.00^{c}	104.25^{e}	67.11^{c}	67.26^{e}	32.98^{c}	33.58^{c}
MW	428.52^{e}	433.83^{e}	107.95^{b}	107.83^{b}	72.10^{b}	72.47^{b}	22.78^{e}	24.02^{e}
PM	62.76^{a}	619.01^{a}	101.04^{d}	101.26^{f}	63.42^{d}	63.09^{d}	36.14^{b}	36.93^{b}
LS	**		**		**		**	
SE±	4.49	4.63	0.28	0.31	0.72	0.76	0.13	0.15
Variety								
CSR-01	489.76^{a}	499.56^{a}	105.86^{a}	105.74^{a}	70.69^{a}	70.07^{a}	29.65^{a}	29.35^{a}
SK-5912	478.33^{b}	485.18^{b}	106.66^{b}	106.44^{b}	70.04^{b}	69.86^{b}	28.36^{b}	28.21^{b}
LS	**	**	**	**	**	**	**	**
SE±	2.38	2.67	0.16	0.18	0.40	0.44	0.07	0.09
Interaction								
NXV	NS	NS	NS	NS	NS	NS	NS	NS

LS= level of significance, NS= Not significant, SE= standard error *=significant at 0.05 **= significant at 0.01. mean followed by the same letter within the same whumn are not statistically different following DMRT.

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CD = Cowdung, CF = Chicken feather, MF = Mineral fertilizer, MW = Municipal waste, PM = Poultry manure

Number of spikes/panicle

The result in Table 6 showed the effect of nutrient sources and variety on number of spikes/panicle in 2018 and 2019 rainy seasons. The result revealed a significant (P≤ 0.05) difference among the treatments used throughout the study period. The result further indicated that, application of poultry manure was found to have significantly (P≤ 0.05) higher number of spikes than the other nutrient sources and all the nutrient sources were better than the control. This could be attributed to the fact that growth characters in sorghum mostly translate to yield components. This result agrees with the findings of Buah *et al*., (2012) who reported that increases in sorghum grain yield were mainly associated with improving panicle number, number of spikes per panicle, and grain weight. It further concurs with the report of Asghari, et al. (2016), who observed that application of N up to 150 kg/ ha increased grain number, grain yield, and harvest index in sorghum. Variety on the other hand, the result also showed that CSR-01 variety produced statistically (P≤ 0.05) higher number of spikes than SK-5912 variety in both the seasons under study.

1000 Grain weight (g)

Table 6 also presented result on the effect of nutrient sources and variety on 1000 grain weight (g) of sorghum in 2018 and 2019 rainy seasons. The result revealed that there is a significant (P≤ 0.05) difference in 1000 grain weight among the treatments used. It further indicated that, application of poultry manure was proved to be significantly (P≤ 0.05) better in terms of 1000 grain weight than the other nutrient sources while the control produced the least 1000 grain weight. Study on variety showed that, CSR-01 variety produced statistically (P≤ 0.05) heavier grain than SK-5912 variety throughout the study period. It may also be connected to the increase in the supply of essential nutrients which are important in the determination of yield components. This finding is consistent with the results obtained by

Asghari *et al*., (2016) who reported that an increase in poultry manure rates significantly increased 1000 kernel weight. It also agrees with the findings of Arunah and Ibrahim (2004) who stated that poultry manure when applied alone or in combination with Urea-N exerted more beneficial effect on the growth and yield of sorghum compared to a single application of urea-N. Buah *et al*., (2012) also reported that increases in sorghum grain yield were mainly associated with improving panicle number, number of spikes per panicle, and grain weight. It further concurs with the report of Agbede, *et al*. (2008), who observed that application of N up to 150 kg/ ha increased grain number, grain yield, and harvest index in sorghum.

Grain yield (kg/ha)

The effect of nutrient sources and variety on grain yield (kg/ha) of sorghum in 2018 and 2019 rainy seasons is presented in Table 6. The result showed that, there exists a significant (P≤ 0.05) difference among the treatments in both the seasons under study. The result further indicated that, application of 2 t/ha poultry manure and mineral fertilizer were found to produced significantly (P≤ 0.05) higher grain yield than the other treatments throughout the period of study. Control on the other hand, produced the least grain yield compared to other nutrient sources considered. The result also revealed that, no significant (P≤ 0.05) difference was observed between the varieties (CSR-01 and SK-5912) as they produced statistically (P≤ 0.05) the same grain yield per hectare in both 2018 and 2019 rainy seasons. This could be attributed to the increase in organic matter content of the soil due to application of poultry manure which in turn improved its physical and chemical characteristics. It is also a clear indication of the importance of organic fertilizers in improving the yield and yield components of sorghum. This agrees with the findings of Arunah, *et al*.,(2006) who stated that factors associated to crop yield as the positive and strong correlation between growth and yield parameters and soil physical and chemical properties. This is supported by Garko, *et al*., (2020) who reported that all the growth and yield characters measured contribute positively and significantly to grain yield. The higher grain yield recorded

could also be attributed to other yield components. This is in conformity with the reports of Arunah *et al.*,,(2006) and Mohammed, *et al.*, (2008) who stated that poultry manure significantly increased growth and yield of sorghum which is attributable to improved soil physical and chemical properties. The result is also similar to the findings by Abdullahi *et al.*, (2019) who reported that application of organic manure to the soil would help to improve the growth and development of plant as well as yield performance.

Table 6: Effect of Nutrient Source and Variety on Number of Spikes Per panicle, 1000gram Weight (g) and Grain Yield per hectare (kg)

Treatment	Parameters NSP 2018	2019	GW 1000 (g) 2018	2019	GYH (kg/ha) 2018	2019
Nutrient sources						
Control	30.36^{f}	31.13^{f}	19.16^{f}	19.84^{f}	493.01	496.27^{c}
Cow dung	45.88^{d}	47.01^{d}	30.94^{d}	31.36^{d}	1047.45	1051.87^{b}
Chicken feather	57.96^{c}	59.04^{c}	34.62^{c}	35.03^{c}	1031.85	1033.52^{b}
Mineral fertilizer	69.02^{b}	69.97^{b}	38.99^{b}	40.04^{b}	1449.12	1453.96^{a}
Municipal waste	39.14^{e}	39.88^{e}	27.10^{e}	27.35^{e}	950.08	952.69^{b}
Poultry manure	68.95^{a}	73.10^{a}	44.15^{a}	44.92^{a}	1655.35	1660.41^{a}
LS	**	**	**	**	**	**
SE±	0.75	0.79	0.26	0.28	73.99	74.86
Variety						
CSR-01	54.28^{a}	54.85^{a}	33.14^{a}	33.55^{a}	1084.33	1087.03
SK-5912	51.62^{a}	57.86	32.20^{b}	32.62^{b}	1126.28	1129.21

LS	**	**	**	**	NS	NS
SE±	0.41	0.46	0.14	0.16	42.87	43.22
Interaction						
N X V	NS	NS	NS	NS	NS	NS

LS= level of significance, NS= Not significant, SE= standard error *=significant at 0.05 **= significant at 0.01. mean followed by the same letter within the same whumn are not statistically different following DMRT.

Conclusion

From the results, it became clear that the application of nutrient sources especially poultry manure and mineral fertilizer had an influence on the growth and yield of sorghum. Even though, these organic sources had almost similar influence on the crop, the potentials of the poultry products as an organic source may not be overemphasized. The higher cost coupled with harzardous nature to the environment associated with mineral fertilizer is of great global concern. Therefore, in search of a more environmentally friendly organic source, this could serve as good news to sorghum growers in the study area. Sorghum variety CRS-01 was superior to SK5912 in growth and yield components, even though they gave similar yield.

Recommendations

Based on the results of this study, the following recommendations were made;

1. Application of poultry manure or chicken feather at the rate of 2 tons/ha or mineral fertilizer at the rate of 60 kg N, 30 kg P & K/ha should be adopted by farmers in the study area for profitable sorghum production.
2. CRS-01 variety should be grown for good yield of sorghum.
3. Continues application of organic manure in order to enhance soil fertility should be adhered to by farmers in the study area.

4. Further studies are recommended with other varieties and higher rates of nutrient sources to explore more inference on sorghum.

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