Jewel Journal of Scientific Research (JJSR) 5(1&2): 42–56, 2020
©Federal University of Kashere-Nigeria (Print ISSN: 2384 – 6267, Online ISSN 2756-651X)
jjsr.fukashere.edu.ng

Effects of Spacing, Organic Source and Varieties on the Growth and Yield of Bambara groundnut (*Vigna subterranea* L.) Grown in Gombe State, Nigeria.

[*1]Madina, P., [1]Nazifi, M. I. and [2]Musa, V. H.

[1]Department of Crop Production, College of Agronomy, University of Agriculture, Makurdi, Benue State, Nigeria.

[2]Department of soil science, College of Agronomy, University of Agriculture, Makurdi, Benue State, Nigeria.

*Corresponding Author: madinapaul26@yahoo.com; +2348189945123

Abstract

A field experiment was carried out at Tal, Billiri Local Government area of Gombe State Nigeria at latitude 9^{o} 51^{1} 31.79^{11}N longitude $11^{o}13^{1}$ 18.36^{11}E in Southern Guinea Savannah Agro-ecological zone of Nigeria to investigate the Effects of Spacing, Organic Source and Varieties on the Growth and Yield of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Nigeria. Three spacing were used 15, 20 and 30 cm intra row spacing, the three organic sources were, poultry dropping, cow-dung, goat manure and control, two varieties of DODC-TZ and AS-17 were used for study. The treatment were combined and laid in a randomized complete block design with three replications. During the research, growth characters such as plant height, number of leaves, days of maturity, days of 50% flowering were measured. Other yield and yield related characters like number of pod, number of seed, shelling percentage, 100 seed weight overall yield significantly ($P \leq 0.05$) in both growth and yield related parameters. The use of variety AS-17 was also observed to produce significantly ($P \leq 0.05$) produced taller plant, higher number of leaves, early days of maturity, 50% days of flowering and number of pod, pod weight, 100 seed weight and overall yield. Bambara groundnut farmers in Billiri are therefore advice to grow AS-17 at 20 cm intra row spacing with the application of 250 tonnes of poultry manure for optimum yield.

Keywords: Spacing, Varieties, Organic source, Bambara nut varieties, Organic fertilizer.

Received: 12th Feb., 2020 *Accepted:* 17th June, 2020 *Published Online:* 30th June, 2020

Introduction

Bambara groundnut (*Vigna subterranea* L.) is a legume crop grown by less resource poor farmers mainly in semi-arid parts of African countries Onwubiko *et al.,* (2018). It is an indigenous African crop that has been cultivated for centuries from Senegal to Kenya, and from the Sahara to South Africa and Madagascar, but still remains as underutilized crop. It is a native grain legume south of the Sahara (Kehinde, 1999). It can be regarded as cousin of the groundnut as its outward appearance is same and belongs to the same family. It is a hardy crop due to its drought tolerance, resistance to pests and diseases and ability to yield on poor fertility soils. It is grown either as single crop or as intercrop in mixed cultivation with other crop of semi-arid region Bannayan *et al.,* (2000). It is extensively cultivated in western Africa where about 0.35 million tonne of dry seed

are produced on 0.40 m ha annually. Nigeria, Niger, and Ghana, are the major producers of Bambara groundnuts where it is third in importance only to cowpea and groundnut (Howell, 1994). In south of the Sahara, it is the most widely grown native grain legume second only to the groundnut. The IITA, Nigeria is maintaining nearly 2000 germplasm accessions having variability and yield potentials IITA (2009). Though it is an important legume crop of semi-arid region, its large scale cultivation is restricted in African countries only. However, attempts are being made to popularize the same in many other parts of the world wherever the climate suits for cultivation of the same. The crop has several agronomic values which include: drought tolerant and ability to produce some yield in soils that are too poor for cultivation of other leguminous crops like common beans and groundnut (Anchirinah *et al.,* 2001; Azam-Ali *et al*., 2001). It contributes soil nitrogen for other crops by fixing atmospheric nitrogen through symbiosis with rhizobium bacteria and is therefore beneficial in crop rotation and inter-cropping (Mukurumbira, 1985; Karikari, 1971). Bambara groundnut also has high nutritional value. It serves as an important source of protein in the diet of greater percentage of the African population in Nigeria, Mali, Chad, Ghana, Niger, Burkina Faso, Ivory Coast, Togo, Benin and South Africa (Linnemann and Azam-Ali, 1993). Nutritionally, it contains 17.4% protein, 53.1% carbohydrate, 6.1% fat, 6.1% fibre, 3.4% ash, 0.098% calcium, 0.007% iron, 1.2% potassium and 0.003% sodium (Rowland, 1993; Amarteifio *et al*., 1997). However, despite the importance of Bambara groundnut as a food legume, it is still cultivated in the form of landraces. Several workers reported that the improvement of Bambara groundnut through conventional breeding method is difficult (Ntunda, 1997; Kone *et al.,* 2007). *V. subterranea* is an extreme inbreeder; an autogamous crop with flowers that are cleistogamous in nature (Uguru and Agwatu, 2006), which gives rise to high percentage selfing since the floral structure is perfect resulting in extreme inbreeding. Massawe *et al.,* (2005). The essential elements are assimilated into plant through absorption by root or other plant parts as ions from the soil and like groundnut the bambara groundnut also require all the macro-nutrient (N, P, K, Ca, S and Mg) and micro-nutrients (Fe, Mn, Zn, Cu, B, Mo and Cl). As the pod in bambara groundnut develop both under soil and above ground, the seed nutrition is both directly through pod and from root, shoot and back to the seed. This work intends to come up with the appropriate spacing/ plant population in Bambara groundnut, considering nutrient requirement which the work considered organic source due to its availability and the benefits it gives to soil unlike the chemical fertilizer which is expensive and poses danger to the soil and humans who consume crop grown from them over time, the work also look at some varieties that can be utilized to optimise its potential and yield for food security. The aim of the experiment is to investigate the Effects of spacing, organic source and varieties on the growth and yield of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Nigeria.

Materials and Methods

The experiment was carried out in Tal at (latitude 9^{o} 51^{1} 31.79^{11}N longitude $11^{o}13^{1}$ 18.36^{11}E) Billiri Local Government of Gombe State. Three spacing were used 15, 20 and 30cm intra row spacing, the three organic source were, Poultry dropping, Cow dung, Goat manure and control. The organic source of nutrients had the following content. Cow dung (Dry matter 12%, Organic Material 11%, Total Nitrogen 14.0%, Total Phosphorus 0.3% and Total Potassium 0.6%). Poultry dropping (100% Dry Matter, Organic Material 65%, Total Nitrogen 5.9%, Total Phosphorus 1.41%and Total Potassium 2.72%) and Goat manure (dry matter 45%, Organic material 40%, Total Nitrogen 10.2%, Total Phosphorus 0.5%, Total Potassium 1.46%). All the organic manure where collected from both birds and cattle that where kept under intensive management, where the organic manure where kept/stored to undergo partial decomposition for five months following the

recommendation of (Bello, 2015) with 5 tonnes/ha before incorporation into the soil. Two varieties of DODC-TZ and AS-17 were used for study.

The experiment that was laid in a randomized complete block design (RCBD) with three replicate, a $4m^2$ plot was laid out with 1m between plots and 0.5m between blocks. Three factors were considered thus 3x3x2, there were 18 plots each within a block which gave the total number of 54 plots for the study, Agronomic practice such as weeding was done manually at 2 and 6 weeks after planting to ensure weed free plots, all the data were collected within the net plot of $4m^2$ where a total of 10 plants were tagged for data collection within each net plot.

The parameters recorded were plant height (taken with the aid of measuring tape from the base of the plant to the tip), number for leaves (were counted fortnightly) from 10 plants that was tagged and the average used fortnightly and days of 50% flowering, days of maturity, yield and yield related characters such as number of pod, number of seed per pod, Shelling percentage, pod weight and 100 seed weight was recorded.

Data Analysis

All data collected were subjected to analysis of variance (ANOVA), while least significant difference (LSD) at 5% level of probability was used in separating the means.

Results

Table1 is plant height of Bambara nut grown in Gombe, the result indicate spacing 15 cm had taller plant all through the growing season from 2 to 12 weeks after sowing, followed by spacing 20 cm with spacing 30 having the least in terms of plant height, the result on nutrient source indicate that the application of poultry droppings had teller plants followed by goat manure and cow dung with control having the short plants, variety AS-17 recorded taller plant when compared with DODC-TZ. Table 2 shows the number of leaves of Bambara nut grown in Gombe, same trend was recorded with the treatment used with spacing 15 cm, poultry manure and variety AS-17 having higher number of leaves while spacing 20 cm, control and DODC-TZ having lower number of leaves. Table 3 record number of first flower, 50% flower and maturity days of Bambara nut grown in Gombe, on first flowering spacing 30 cm with 26.09 days had early flower initiation and 15 cm with 26.21 days, while 20 cm had late flower initiation with 27.01 days, on source of nutrient poultry dropping had late flower initiation with 27.21 days followed by goat manure with 27.01 and cow dung with 26.02 days with control having late in term of flower initiation with 26.00 days, on variety AS-17 had late flower initiation with 27.01 days when compared with DODC-TZ who recorded early flower initiation with 26.89 days, 50% flowering spacing 20 cm had early flower initiation with 40.91 days followed by spacing 15 cm with 45.21 days while 30 cm had late 50% flowering with 49.01, on source of nutrient poultry dropping had late flower initiation with 46.21 days followed by goat manure with 43.91 days and control with 41.04 days with cow dung having early in term of 50% flowering with 40.29 days, on variety AS-17 had late 50% flowering with 27.01 days when compared with DODC-TZ who recorded late 50% flowering with 26.89 days. On maturity spacing 20 cm had early maturity, while 30 cm had late maturity, on source of nutrient poultry dropping had late maturity with 140.91 days followed by goat manure with 134.90 days and cow dung with 134.87 days with control having early maturity with 134.45 days, on variety AS-17 had late maturity with 150.83 days when compared with DODC-TZ who recorded early maturity with 134.45 days. Table 4 is yield and yield related character of Bambara nut grown in Gombe. On number of pod per plant spacing 20 cm had higher number of pod with 29.91 pods, followed by 15 cm with 22.21 pods while 30 cm had lower number of pod with 19.02, on source of nutrient poultry dropping had higher number of pod with 28.14 pods followed by goat manure with 20.92 pods and cow dung with 18.12 pods and control having lower number of pod with 15.21 pods, on variety AS-17 had number of pod per plant with 29.12 pods when compared with DODC-TZ who recorded low with 22.67 pods. On shelling percentage spacing 20 cm had shelling percentage, followed by 30 cm

Table 1: Effects of spacing, organic source and varieties on plant height of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Nigeria.

	Plant height (cm) (WAS)					
Spacing (S)	**2**	**4**	**6**	**8**	**10**	**12**
15	6.92[b]	15.62[a]	20.09[a]	27.23[a]	31.01[a]	38.02[a]
20	4.24[c]	10.42[b]	15.92[b]	20.46[b]	27.21[b]	30.21[b]
30	3.99[a]	9.02[c]	14.86[c]	19.89[c]	25.91[c]	29.01[c]
LSD	1.05	2.05	3.03	3.05	3.91	1.05
Nutrient source (N)						
Poultry dropping	6.23[a]	16.26[a]	21.94[a]	28.04[a]	31.28a	39.02a
Cow dung	4.52[c]	12.24[c]	18.91[c]	21.46[c]	26.94c	30.02c
Goat manure	5.09[b]	15.96[b]	20.04[b]	26.04[b]	29.32b	35.49b
Control	3.94[e]	10.89[e]	16.31[e]	19.04[e]	23.42e	28.02e
LSD	1.01	1.05	2.03	2.09	3.03	3.00
Varieties (V)						
DODC-TZ	5.01[b]	15.23[b]	20.91[b]	26.92[b]	29.09[b]	36.97[b]
AS-17	6.81[a]	16.01[a]	21.98[a]	28.32[a]	30.12[a]	38.09[a]
LSD	1.21	1.91	1.01	1.09	1.02	1.05
Interaction						
S X N	**	**	**	**	**	**
N X V	**	**	**	**	**	**
S X V	**	**	**	**	**	**

S= spacing, N= nutrient source, V= varieties, LSD= Least Significant Differences at 5% Level of Probability, ** = 95% level of probability.

Table 2: Effects of spacing, organic source and varieties on number of leaves of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Nigeria.

Spacing (S)	**Number of leaves (WAS)**					
	2	**4**	**6**	**8**	**10**	**12**
15	4.12[a]	10.62[a]	18.09[a]	22.23[a]	27.01[a]	32.02[a]
20	3.24[c]	8.42[b]	15.92[b]	20.46[b]	24.21[b]	37.21[b]
30	3.99[b]	7.02[c]	14.86[c]	19.89[c]	21.91[c]	34.01[c]
LSD	0.09	1.01	2.01	1.01	2.01	1.01
Nutrient source (N)						
Poultry dropping	4.93[a]	12.26[a]	19.94[a]	23.49[a]	28.81[a]	32.72[a]
Cow dung	4.52[b]	9.24[b]	15.91[b]	19.89[c]	24.91[c]	29.42[c]
Goat manure	4.09[c]	11.96[c]	16.04[c]	21.04[b]	26.42[b]	30.19[b]
Control	3.94[d]	8.89[d]	13.31[d]	17.04[d]	22.42[d]	25.02[d]
LSD	0.09	1.03	2.01	1.03	2.05	2.01
Varieties (V)						
DODC-TZ	4.01[b]	10.23[b]	15.91[b]	20.92[b]	26.09[b]	32.97[b]
AS-17	4.81[a]	12.01[a]	19.98[a]	22.32[a]	28.12[a]	33.09[a]
LSD	0.05	1.01	2.09	1.90	1.81	1.05
Interaction						
S X N	**	**	**	**	**	**
N X V	**	**	**	**	**	**
S X V	**	**	**	**	**	**

S= spacing, N= nutrient source, V= varieties, LSD= Least Significant Differences at 5% Level of Probability.

Table 3: Effects of spacing, organic source and varieties on 1st flower, 50% flower and days of maturity of Bambara groundnut (*Vigna subterranea* L.) Grown in Gombe State, Nigeria.

	1st flower, 50% flower and days of maturity (WAS)		
Spacing (S)	**1st Flower**	**50% Flower**	**Maturity**
15	26.21[b]	45.21[b]	134.98[b]
20	27.01[a]	40.91[c]	139.98[a]
30	26.09[c]	49.01[a]	134.01[c]
LSD	0.01	2.63	0.01
	Nutrient source (N)		
Poultry dropping	27.21[a]	46.21[a]	140.91[a]
Cow dung	26.02[c]	40.29[d]	134.87[c]
Goat manure	27.01[b]	43.91[b]	134.90[b]
Control	26.00[d]	41.04[c]	134.45[d]
LSD	0.01	2.10	0.01
	Varieties (V)		
DODC-TZ	26.89[b]	41.98[b]	145.00[b]
AS-17	27.01[a]	44.89[a]	150.83[a]
LSD	0.01	3.08	3.91
	Interaction		
S X N	**	**	**
N X V	**	**	**
S X V	**	**	**

S= spacing, N= nutrient source, V= varieties, LSD= Least Significant Differences at 5% Level of Probability.

Table 4: Effects of spacing, organic source and varieties on the growth and yield and yield related character of Bambara groundnut (*Vigna subterranea* L.) Grown in Gombe State, Nigeria.

Spacing (S)	**Yield and Yield related parameters at harvest**				
	No. of pod/plants	No of seeds per pod	Shelling (%)	100seeds	yield/kg weight (g)
15	22.21[c]	1.01[b]	77.21[b]	29.39[b]	520.84[b]
20	29.91[a]	1.02[a]	80.01[a]	31.39[a]	680.21[a]
30	19.02[b]	1.01[b]	72.91bc	23.31[c]	430.92[c]
LSD	2.00	0.01	2.00	3.00	30.98
		Nutrient source (N)			
Poultry dropping	28.14[a]	1.03a	80.01[a]	30.30[a]	590.01[a]
Cow dung	18.12[c]	1.02[b]	77.00[b]	23.34[c]	410.21[c]
Goat manure	20.92[b]	1.01[c]	75.98[c]	28.21[b]	550.84[b]
Control	15.21[d]	1.00[d]	70.45[d]	20.62[d]	380.46[d]
LSD	2.31	0.01	3.00	2.21	31.01
		Varieties (V)			
DODC-TZ	22.67[b]	1.01[b]	75.92[b]	28.90[b]	550.91[b]
AS-17	29.12[a]	1.02[a]	77.21[a]	31.01[a]	620.90[a]
LSD	3.09	0.01	3.01	2.90	31.09
		Interaction			
S X N	**	**	**	**	**
N X V	**	**	**	**	**
S X V	**	**	**	**	**

S= spacing, N= nutrient source, V= varieties, LSD= Least Significant Differences at 5% Level of Probability

while 15 cm had lower shelling percentage, on source of nutrient poultry dropping had higher shelling percentage with 80.01% followed cow dung with 77.00% and goat manure 75.98% control with having lower shelling percentage with 70.45%, on variety AS-17 had higher shelling percentage with 77.21% when compared with DODC-TZ who recorded low with 75.92%. On 100 seed weight spacing 20 cm had weightier seeds with 31.39 followed by 15 cm with 29.39 while 30 cm recording lower in weight with 23.31, on source of nutrient poultry dropping had weightier 100 seed with 30.20 followed by goat manure with 28.21, cow dung with 23.34 and control having lower number of pod with 20.62, on variety AS-17 had weightier 100 seed with 31.01 when compared with DODC-TZ who recorded low with 28.90. On yield spacing 20 cm yielded more with 680.21 kg/ha, followed by 15 cm with 520.84 kg/ha while 30 cm recording low in yield with 430.92 kg/ha, on source of nutrient poultry dropping recorded higher yield with 590.01 kg/ha followed by goat manure with 550.84 kg/ha and cow dung with 410.21 kg/ha with control having low in term of yield with 380.46 kg/ha, on variety AS-17 had higher yield with 620.90kg/ha when compared with DODC-TZ who recorded low with 550.91 kg/ha.

On interactions, no interaction was recorded between nutrient source and spacing on plant height and number of branches so also no interaction was observed between nutrient source and variety on plant height and number of branches, there was no interaction recorded between nutrient sources and spacing on first flower initiation likewise no interaction between nutrient source and varieties. Table 5 shows a positive interaction was recorded between exist between nutrient source and spacing on 50% flowering where poultry droppings and spacing 20 cm had perfect combination leading to higher 50% flowering with least in the control and 15 cm. Table 6 is another interaction was recorded between nutrient source and variety on 50% flower, where poultry dropping and AS-17 had higher 50% flower with the least in 15cm and DODC-TZ. Positive interaction was recorded (Table 7) between exist between nutrient source and spacing on maturity where poultry droppings and spacing 15 cm had perfect combination leading to late maturity with early maturity in control and 20 cm. Table 8 is another interaction was recorded between nutrient source and variety on maturity, where poultry dropping and AS-17 had late maturity with the early maturity in control and DODC-TZ. Table 9 indicate positive interaction exist between nutrient source and spacing on number of pod per plant where poultry droppings and spacing 20 cm had perfect combination leading to higher number of pods per plant with lower number of pods per plants in control and 15 cm. Table 10 shows another interaction was recorded between nutrient source and variety on number of pods per plant, where poultry dropping and AS-17 had higher number of pods per plants with low number of pods per plant in control and DODC-TZ. Table 11 is a positive interaction was recorded between nutrient source and spacing on 100 seed where poultry droppings and spacing 20 cm had perfect combination leading weightier seeds with less weighty seeds in control and 15cm cm. Table 12 is another interaction was recorded between nutrient source and variety on 100 seeds, where poultry dropping and AS-17 had heavy seeds with the lighter seeds in control and DODC-TZ. Table 13 shows positive interaction exist between nutrient source and spacing on yield where poultry droppings and spacing 15 cm had perfect combination leading higher yield with low yield in control and 15 cm. Table 14 is another interaction was recorded between nutrient source and variety on yield, where poultry dropping and AS-17 had higher yield with low yield in control and DODC-TZ.

Table 5: Effects of spacing, organic source and varieties on plant height of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Nigeria.

Nutrients source	Spacing		
	15	**20**	**30**
Poultry droppings	43.21[a]	45.92[a]	43.91[a]
Cow dung	40.94[c]	42.06[c]	41.24[c]
Goat manure	41.04[b]	43.04[b]	42.67[b]
Control	39.21[d]	40.21[d]	40.32[d]
LSD	0.91	1.01	1.00

Table 6: Interaction between nutrients source and varieties on 50% days of flower of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Varieties	
	DODC-TZ	AS-17
Poultry droppings	43.89a	45.21a
Cow dung	39.21c	40.26c
Goat manure	40.25b	42.32b
Control	37.03d	39.00d
LSD	2.01	2.03

Table 7: Interaction between nutrient source and spacing on days of maturity of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Spacing		
	15	20	30
Poultry droppings	160.81[a]	156.02[a]	159.09[a]
Cow dung	159.56[c]	152.96[c]	156.24[c]
Goat manure	161.74[b]	153.04[b]	158.76[b]
Control	158.21[d]	150.61[d]	157.02[d]
LSD	0.01	1.21	1.00

Table 8: Interaction between nutrients source and varieties on days of maturity of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Varieties	
	DODC-TZ	AS-17
Poultry droppings	145.89[a]	155.41[a]
Cow dung	142.41[c]	150.56[c]
Goat manure	143.25[b]	151.04[b]
Control	141.09[d]	150.00[d]
LSD	1.01	1.03

Table 9: Interaction between nutrient source and spacing on number of pod of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Spacing's		
	15	20	30
Poultry droppings	30.29[a]	33.24[a]	31.21[a]
Cow dung	27.21[c]	30.21[c]	28.24[c]
Goat manure	28.04[b]	31.64[b]	29.07[b]
Control	25.21[d]	28.01[d]	26.24[d]
LSD	2.01	2.04	2.00

Table 10: Interaction between nutrients source and varieties on number of pod of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Varieties	
	DODC-TZ	AS-17
Poultry droppings	30.91[a]	32.21[a]
Cow dung	20.31[c]	21.26[c]
Goat manure	26.25[b]	29.02[b]
Control	17.03[d]	19.21[d]
LSD	2.01	2.03

Table 11: Interaction between nutrient source and spacing on 100 seeds weight of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Spacing		
	15	20	30
Poultry droppings	28.21[a]	29.02[a]	31.21[a]
Cow dung	25.94[c]	26.26[c]	27.04[c]
Goat manure	26.34[b]	27.34[b]	29.47[b]
Control	19.91[d]	20.01[d]	21.32[d]
LSD	2.00	2.01	2.80

Table 12: Interaction between nutrients source and varieties on 100 seeds wieght of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Varieties	
	DODC-TZ	AS-17
Poultry droppings	28.21[a]	30.24[a]
Cow dung	20.01[c]	22.06[c]
Goat manure	25.25[b]	27.21[b]
Control	19.83[d]	20.01[d]
LSD	2.01	2.12

Table 13: Interaction between nutrient source and spacing on yield of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Spacing		
	15	20	30
Poultry droppings	600.21[a]	665.92[a]	593.91[a]
Cow dung	520.94[c]	542.06[c]	510.24[c]
Goat manure	591.04[b]	603.04[b]	562.67[b]
Control	329.21[d]	480.21[d]	320.32[d]
LSD	10.91	`10.01	10.00

Table 14: Interaction between nutrients source and varieties on yield of Bambara groundnut grown in Billiri Gombe.

Nutrients source	Varieties	
	DODC-TZ	AS-17
Poultry droppings	543.89[a]	620.21[a]
Cow dung	390.21[c]	415.96[c]
Goat manure	510.25[b]	530.32[b]
Control	310.03[d]	350.90[d]
LSD	20.01	20.03

Table 15. Physicochemical properties of the experimental site at Gombe in the Rainy Season of 2019.

Soil property	Before	After
% Sand	58.3	57.06
% Silt	14.3	15.54
% Clay	27.4	27.4
Texture	Sandy loam	Sandy loam
Ph	6.11	6.13
Organic carbon (%)	0.76	0.79
Organic matter (%)	1.53	1.61
Total nitrogen (%)	0.28	0.29
P(Bray)ppm	11.02	12.78
CEC (CmolKg-1)	4.81	4.56
EC (CmolKg-1)		
Ca2+	3.32	3.41
Na2+	0.57	0.58
K+	0.24	0.28
Mg2+	0.93	0.94
Base saturation	74.74	76.5

Key; ppm= part per million, CEC= Cation exchange capacity, EC= Exchangeable cation

Discussion

Effects of spacing, organic source and varieties on plant height of Bambara groundnut (*Vigna subterranean* L.) grown in Gombe State. Where significant (0≤05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients on plant height, spacing 15cm had taller plant, this could be as the result of closer spacing making the plant to grow taller to be able to utilized solar radiation for photosynthetic activities, this finding collaborated with the work of Oyige (2010) who reported that closer spacing enhances taller plant for utilization of both climatic and soil resources. On nutrient sources the use of poultry dropping had taller plant when compared with other sources of nutrient used; this is not far from the fact that poultry manure release its nutrients fast when compared with other sources of organic manure Sing *et al*. (2005) lend support to that. On variety, significant difference was observed were AS-17 had taller plant than DODC-TZ which could be attributed to its genetic make-up as supported by the work of Brought *at el.*, (1993). Effects of spacing, organic source and varieties on number of leaves of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients on number of leaves, spacing 15cm had higher number of leaves, closer spacing might lead to higher number of leaves to intercept sun light for photosynthesis it probably may result to

mutual shedding as reported by Kone *et al.*, (2007). On nutrient sources the use of poultry dropping had taller higher number of leaves when compared with other sources of nutrient used, this could be as a result of availability of the nutrient in required quantity influencing leaves initiation for photosynthesis and utilization of assimilate, this was reported by Azam *at el.*, (2001) in his earlier work. On variety significant difference was observed were AS-17 had higher number of leaves than DODC-TZ which could be attributed to its genetic make-up, agronomic practice and adoptability of the crop to its environment as supported by the work of Massawe (2005). Effects of spacing, organic source and varieties on plant height of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients on1st flower, spacing 15 cm produced its flower early. This could be as the result of fast growth, environmental condition, and agronomic activities as reported by Kehinde (1999). On nutrient sources the use of poultry dropping produced its flower early when compared with other sources of nutrient used, this is attributed to the facts that poultry manure produced its nutrients fast and aid to other microbial activities improving the soil status as reported by Linnemann *et al* (1996) On variety significant difference was observed were AS-17 produced its first flower than DODC-TZ which could be attributed to its genetic make-up, acclimatizing to its environment as reported by Massawe (2005). Effects of spacing, organic source and varieties on 50% flower of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients. Spacing 15cm produced 50% of its flower early which could be as a result of competition and climatic condition as reported by. On nutrient sources the use of poultry dropping had produced it 50% flowers when compared with other sources of nutrient used, this could be as a result of fast released of nutrient leading to early flowering and able to reach 50% flower, this finding is in agreement with the work of Brik (1997) On variety significant difference was observed were AS-17 produced its 50% flower early than DODC-TZ which is not far the fact that genetic make-up plays an important role in early flower initiation as reported by the early finding of Hone (1994). Table3. Effects of spacing, organic source and varieties on days of maturity of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients. Spacing 20cm had late maturity days which could be attributed to agronomic practice NRCG (2003) lend support to the present finding. On nutrient sources the use of poultry dropping matured early when compared with other sources of nutrient used, this could be as a result of nutrient availability in needed quantity leading to vegetative growth and extending the maturity days as suggested by Sing (2004) On variety significant difference was observed were AS-17 matured late than DODC-TZ which could be attributed to its genetic make-up, agronomic practice, climatic and edafic conditions as supported by the work of Misari *et al.* (2002) Table 4. Effects of spacing, organic source and varieties on days of number of pod per plant of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients. Spacing 20cm had higher number of pod per plant which could be attributed to appropriate spacing which is agreement with the work of NCRI (2012) who lend support to the present finding. On nutrient sources the use of poultry dropping had higher number of pod when compared with other sources of nutrient used, this could be as a result of nutrient availability in needed quantity leading to vegetative growth hereby leading to pod initiation and increase number of pod per plant as reported by

Linnemann *et al.,* (1993) On variety significant difference was observed were AS-17 had higher number of pod than DODC-TZ which could be attributed to its genetic make-up, agronomic practice, climatic and soil nutrient as supported by the work of Azam-Ali el at (2001). Table4 Effects of spacing, organic source and varieties on days of number of seed per pod of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients. Spacing 20cm had slightly had higher number of seed per pod which could be attributed to agronomic practice Goli (1995) lend support to the present finding stating with an improve agronomic practice and appropriate spacing crop is likely to increase number of seed. On nutrient sources the use of poultry dropping had higher number of seed per pod when compared with other sources of nutrient used, this could be as a result of nutrients availability in needed quantity leading not only to vegetative growth but also may led to increase number of seed per pod, this work is agreement with the findings of Ntunda (1997) who reported that organic manure applications at the required quantity affects and increase seeds positively. On variety significant difference was observed were AS-17 had higher number of pod than DODC-TZ, this might be as a result of the variety genetic make-up and agronomic practice as supported by the work of Uguru (2006) Table4. Effects of spacing, organic source and varieties on 100 seeds weight of Bambara groundnut (Vigna subterranea L.) grown in Gombe State. Where significant (0≤0.05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients. Spacing 20cm had heavier seeds which could be attributed to agronomic practice has reported by Brough and Azam (1992) On nutrient sources the use of poultry dropping 100 seeds weight when compared with other sources of nutrient used, this could be as a result of nutrient availability in needed quantity which is available in poultry dropping leading to heavier seed as reported by Anchinnah *et al*. (2001) On variety significant difference was observed were AS-17 had heavier 100 seeds than DODC-TZ which could be attributed to its genetic make-up, agronomic practice, and probably soil nutritional condition which is collaborated by Rowland (1993). Effects of spacing, organic source and varieties on shelling percentage of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤0.05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients. Spacing 20cm had late had higher shelling percentage which could be attributed to agronomic practice leading to better and qualitative seeds as reported by Onimawa (1999). On nutrient sources the use of poultry dropping had high shelling percentage when compared with other sources of nutrient used; this could be as a result of required nutrient leading to qualitative and quantity seeds as suggested by Alibi (2012). On variety significant difference was observed were AS-17 had higher shelling percentage than DODC-TZ which could be attributed to its genetic make-up and adoptability of the crop to the environment Amarteifio *et al*., (1997). Effects of spacing, organic source and varieties on yield of Bambara groundnut (*Vigna subterranea* L.) grown in Gombe State. Where significant (0≤0.05) difference was recorded which shows effects of spacing and response of plant on organic source of nutrients. Spacing 20cm yielded higher which could be attributed to agronomic practice Marandu and Ntunda (1995) lend support to the present finding. On nutrient sources the use of poultry dropping matured early when compared with other sources of nutrient used, this could be as a result of nutrient availability in needed quantity leading to vegetative growth, extending the maturity and yield related characters leading to overall yield. Is work is in agreement with the findings of NRCG (2005) who reported that organic fertilizer do not affect vegetative growth of plant but also affect positively the overall yield of

crops. On variety significant difference was observed were AS-17 matured late than DODC-TZ which could be attributed to its genetic make-up, agronomic practice, soil and adoptability of the crop to the environmental condition as supported by Amarteifio (1997) in his early finding. The result indicated that there was increment in the soil nutrients which shows that, with the application of organic manure increase in soil nutrient status is obtainable as reported by Fagam (2000).

Interaction between nutrient source and spacing on growth, yield and yield related parameters of Bambara groundnut grown in Billiri Gombe.

There was no interaction between nutrient source and spacing on 1st day of flower. Table 5 shows a perfects interaction was observed between nutrient source and spacing where poultry droppings and spacing 20cm had early days of 50% day of flower, this could be as a result of moderate spacing and ability of poultry manure to produce the needed and available nutrient to prompt the early production of flower with affect yield positively as reported by Dalzeel (2017) There was no interaction between nutrient source and varieties on 1st day of flower production. Table 6 is an interaction between nutrient source and varieties on 50% days of flower production, where DODC-TZ had early days of 50% flower production, this is not far the true that genetic make-up and environmental condition plays a major role as supported by the finding of Masawe (2005). Table 7 is an interaction between nutrient source and spacing on days of maturity. The result indicate control and spacing 15cm had early days of maturity this could be attributed to the facts that insufficient nutrient and competition due to closer spacing might have resulted to that as reported by Mukurumbira (2000) that nutrient deficient and closer spacing due to stress in crop can caused early maturity. Table 8 in an interaction between nutrient source and variety where DODC-TZ and control had early days of maturity, this is very visible that nutrient and variety influence days of maturity as reported by Singh *et al*., (2004) Table 9 is an interaction between nutrient source and spacing, where poultry dropping and spacing 20cm had higher number of pod, this may be due to agronomic practice couple with appropriate plant population as reported earlier by Brik (1997) in his work. Table 10 is an interaction between nutrient source and variety on number per plant, were poultry dropping and DODC-TZ had higher number of pod compared to other treatment used. this is a clear indication that varietal effects and appropriate nutrient not only improve vegetative growth but also yield in terms of increasing the number of pod and seed quality, Basu *et al*., (2004) lend support to this finding. Interaction does not exist between nutrient source and spacing on number of seed per pod, so also there was no interaction between nutrient source and varieties on seed per pod. Interaction between nutrient source and spacing on 100 seed weight, where poultry dropping and spacing 20cm had the heaver seeds where compared with the other sources of nutrient, this is not far from the fact that seeds development is accompanied by available nutrient as reported by Basu *et al*., (2003). There was no interaction between nutrients source and spacing on shelling percentage so also interaction was not recorded between nutrient source and verities on shelling percentage. The interaction between nutrient source and variety on yield, where poultry droppings and spacing 20cm had higher yield to other treatment used, it could be as a result that poultry dropping releases its nutrient fast from the other organic source couple with appropriate plant population, this is not far from the facts that other yield related characters might have contributed to the overall yield such as number of pods and 100 seeds weight. Interaction between nutrient source and varieties on yield were poultry source and DODC-TZ, this could be inherent character couple with environmental changes and having the required quantity of nutrient as reported by Oyiga (2010).

References

Alibi, M.O. (2012). Beniseed Agronomy and Cropping System. In traning manual on beniseed production technology, organised by FADA/NCRI under NAICCP and ARTP. June 4-7-2012. Pg 27-32.

Amarteifio, J.O., Sawula, G. and Gibbons, M.R.D. (1997). Comparison of four landraces of Bambara groundnut. *Trop. Sci*., 37: 143-145.

Anchirinal VM, Yridoe EK, Bennet-lattey SO (2001). Enhancing sustainable production and genetic resources conservation of Bambara groundnut: a survey of indigenous agricultural.28: 98-122.

Anchirnah, D. B., (2010). Analysis of Technical Efficiency of Bambara groundnut Production in Jigawa State. *Savannah Journal of Agriculture,* 5:10-17

Azam-Ali SN, Sesay A, Karikari SK, Massawe FJ, Anguilar-Manjarrez J, Bannayan M, Hampson KJ (2001). Assessing the potential of under-utilised crop – A case study using Bambara groundnut. *Exp. Agric*., 37: 433-472.

Bannayan, M., Collinson, S.T. and Azam Ali S.N. (2000). *Bambara groundnut model user guide*. University of Nottingham. School of Biological Sciences. Division of Agriculture and Horticulture. 43 pp.

Basu, M.S., Udaya Kumar M. and Sheshshyaee, M.S. (2003). Potential of bambara groundnut in stabilizing food legume production in semi-arid tropics of India. In: proceeding of the international symposium on BAMFOOD, held at Botsawana.

Basu, M.S., Basu, S., Udaya Kumar M., Bindu Madhava, H. and Sheshshyaee, M.S. (2004). Potential of Bambara groudnut in stabilizing food legume production in semi-arid tropics of India. Plant Biology. Pp 201-310.

Bello, I.A. (2015). Proximate composition and functional properties of four cultivars of bambara groundnut (*Vigna subterranea*). Plant-Foods-for-Human-Nutrition. 53: 2, 153-158.

Brik, M (1997). Rates of progress towards flowering and podding in bambara groundnut (*Vigna subterranean*) as a function of temperature and photoperiod. *Annals of Botany*. 80: 4, 505-513.

Brough, S.H. and Azam Ali, S.N. 1992. The effect of soil moisture on the proximate composition of bambara groundnut (*Vigna subterranea* L. Verdc). *Journal of the Science of Food and Agriculture*, 60: 197-203.

Brough S.H., Azam Ali S.N. and Taylor A.J. 1993. The potential of bambara groundnut (*Vigna subterranea*) in vegetable milk production and basic protein functionality systems. Food-Chemistry. 1993, 47: 3, 277-283

Dalziel JM (1937). *Vaandzeia* Thou in the useful plants of West Tropical Africa Crown Agents. London, pp. 269-271.

Fagam, I. (2000). Effects of nutrients level on the growth and yield pf maize in Bauchi, Nigeria procedings of the 23rd Annual conference of farm management Sociaty of Nigeria, 14-17th Dec. 2000.

Goli AE (1995). Bibliographical Review of Bambara groundnut in proceedings of the workshop on conservation and improvement of Bambara groundnut, 14-16 November, 1995, Harare, Zimbabwe. pp. 4-10.

Hone, F. N. (1994). The Bambara groundnut (*Voandzeia subterranea*) and Kersting's groundnut (*Kerstingiella geocarpa*) wild in West Africa. *Kew Bull.,* 16: 395-407.

Howell, J. A. (1994). Common names given to Bambara groundnut (*Vigna subterranea*: Fabaceae) in central Madagascar. *Econ. Bot.* 48: 217–221

IITA (2009) Annual report on bambaranut and sesame production in Nigeria. 2: 201-292.

Kehinde O. B. (1999). Flora biology of West African Okra (*Abelmoschus caillei* (A. chev.) Stevels. *Nigerian Journal of Genetics,* 14: 95-97.

Karikari, H. L. (1971). Bambara groundnut intercrop as part improving soil nutrients in Eastern India. Proceedings of the workshop on conservation and improvement of Bambara groundnut, 20-23 Oct. 1971. Pp 21-25.

Kone, M., Patat-Ochatt E. M., Conreux C and Samgwan R. (2007). *In- vitro* morph genesis from cotyledon and epicotyls explants and flow cytometary distinction between landrace of bambara groundnut (*Vigna subterranea* (L.) Verdc) an under-utilizied grain legume. *Plant Cell Tissue Organ Culture*. 88: 61-75.

Linnemann, A. R. and Azam-Ali, S. N. (1993). Bambara groundnut (*Vigna subterranea* (L.) Verdc.) Under-utilised Crop series I. Vegetables and Pulses. Chapman and Hall, London, UK. Pp 209-452.

Linnemann, A. R. (1996). Phenological development in bambara groundnut (*Vigna subterranea*) transferred from 14 to 11 h photoperiods. *Journal of Agricultural Science*. 126(2): 175-182.

Marandu, W. Y. F. and Ntunda, W. H. (1995). The status of underutilized crops in Tanzania. In Anthony K, Haqi N and Clers B (eds). Genetic Resources and Utilization of underutilized Crops in Southern and Eastern Africa. Proc. Of Reg. Workshop held at Nelsprult South Africa. Dynamic AdCc. pp. 116-129.

Massawe, F. J., Mwale, S. S., Azam-Ali, S. N. and Roberts, J. A. (2005). Breeding in Bambara groundnut (*Vigna subterranea* (L.) Verdc.): strategic considerations. *African Journal of Biotechnol*., 4(6): 463-471.

Misari, S. M. and Iwo G. A. (2002) Prospects of beni-seed research and development in Nigeria in genetics and food security in Nigeria. *African Journal of Agronomy*. 4(5):131-156

Mukurumbira, L. M. (1985). Effects of the rate of fertilizer nitrogen and previous grain legume crop on maize yields. *Zimbabwe Agricultural. Journal,* 8(6): 177-179.

Mukurumbira L. M (2000). Effects of single super phosphate on the growth and yields groundnut and Bambara ground nut. *Zimbabwe Agricultural Journal*, 10(3): 11-17.

NCRI (2012) Guide to beniseed production; oilseed research programme, NCRI Badeggi 4pp.

NRCG News Letter (2003). Bambara groundnut, a promising new crop for dry land agriculture in India. Vol II. No 1 March 2003. NRCG News Letter 2003b. Bambara groundnut, a new crop for India. Vol II. No 3 September 2003.

NRCG News Letter (2005). Bambara groundnut, a promising new crop for dry land agriculture in India. Vol III. No 3. NRCG News Letter 2005. Bambara groundnut, a new crop for India. Vol III. No 4 Nov. 2005

Ntunda, W. H. (1997). Tanzania Country Report Bambara groundnut (*Vigna subterranean* L.) Verdc) In Heller J, Begemun F and Mush (eds). Promoting the conservation and use of underutilized and neglected crop of Proc. Of the workshop on conservation and improvement of Bambara groundnut, Nov 14-16, Harare, Zimbabwe, pp. 53-58.

Onimawo, I. A., Momoh, A. H. and Usman A. (1999). Proximate composition and functional properties of four cultivars of bambara groundnut (*Vigna subterranean*). *Plant Foods for Human Nutrition.* 53(2): 153-158.

Onimawa, H. H. (1999) *Rhizobium*-Legume Symbiosis and Nitrogen Fixation under Severe Condition and in an Arid Climate. *Microbiology and Molecular Biology Reviews*, 63: 968-989.

Onwubiko, N. C. M. I. Uguru, A. A. Ngwuta1, E. T. Inyang and O. J. Nnajiemere (2018). Floral biology of Bambara groundnut in Nigeria, (*Vigna subterranea* (L.) Verdc.). Afr. *Journal of Crop Science*. 2: 01-30

Oyiga, B. C., Uguru, M. I. and Aruah, C. B. (2010). Pollen behavior and fertilization impairment in Bambara groundnut (*Vigna subterranea* (L.) Verdc.). *Journal of Agricultural Science*. 2(3):205-239.

Oyige, R.M., (2010). Behaviours of cross fertilization in Bambara groundnut (*Vigna subterranea* (L.) Verdc.). *African Journal of Science*. 2: 207-233.

Rowland, J.R.J. (1993). Bambara groundnut In: Rowland JRJ (ed) Dryland farming in Africa, Macmillan Ltd., London, pp. 278-282.

Singh, A.L., Basu, M.S., Chaudhari, V. and Patel C.B (2004). Phenological requirement of bambara groundnut (*Vigna subterranea* L. Verdc.) for its cultivation in Semi-arid region. In: Proceeding of National Seminar on Plant Physiology held from 27-29th Dec. at Department of Botany, University of Pune, India.

Singh, A.L., Basu, M.S., Chaudhari, V. and Patel C.B (2005). Fertilizer and seasonal requirement of bambara groundnut in India. In Physiological approaches for crop stress management under different environmental conditions-issues and strategies. Proceeding of National Symposium held from 5-7 March 2005 at. WTC, TNAU Coimbatore, India.

Uguru, M.I. and Agwatu, U.K. (2006). Cytogenetic studies on Bambara groundnut (*Vigna subterranea* (L.) Verdc). *Journal of Agriculture. Genet. Breed.*, 60: 100-206.