NSUK Journal of Science & Technology, Vol. 6: No. 2. 2016. pp. 85 - 90 ISSN: 1597- 5527

EVALUATION OF APPLICATION METHODS AND RATES OF GOAT MANURE ON THE GROWTH AND POD CHARACTERISTICS OF OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) IN THE SOUTHERN GUINEA SAVANNAH OF NIGERIA

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ABSTRACT

A Field experiment was conducted at Mokwa (Latitude 09 08''N and longitude 05^0 04''E) and Lapai (Latitude 9^0 02` N and Longitude $06^0$ 34`E) of the Equator, Southern Guinea Savannah ecology. The experiment was laid in 3 x 4 factorial in a completely randomized block design (CRBD). There were three (3) levels of goat manure application methods (single row application, double row application and ring application) and four (4) levels of goat manure rates (0, 5, 10 and 15 t ha^{-1}). Collected data included plant height/plant, number of leaves/plant and leaf area/plant at 4, 8 and 12 weeks after planting (WAP). Flowering and pod characteristics data included days to first flowering, days to 50% flowering, days to first fruiting, days to 50% fruiting, pod length/plant, pod diameter/plant, number of pods/plot and pod cumulative yield/ ton/ha. Data were subjected to Analysis of Variance (ANOVA). Means were separated using Least Significant differences (LSD) at 5% probability level. The results indicated that okra growth parameters were not significantly affected by the goat manure rates at 4WAP. However, at 8 and 12 WAP, okra plant height/plant, number of leaves/plant and leaf area were significantly affected by goat manure method of application and its rates. The ring method of goat manure application and 15 t ha^{-1} significantly produced taller okra plant, larger number of leaves/plant and widest leaf area/plant at $P<0.05$ at Mokwa and Lapai in Southern Guinea Savannah in 2015 cropping season. It also supported longest pod/plant (cm), widest pod diameter/plant (cm), largest number of pods/plot and highest cumulative pod yield t ha^{-1}.

Keywords: Goat manure, Application methods, Pod Characteristics, Single row, Double rows, Ring methods

INTRODUCTION

Abelmoschus *esculentus* L. Moench, is a member of the family Malvaceae (Charrier 1984)). It was domesticated in West and Central Africa (Cobley and Steele, 1976) and widely known as 'okra' in the Anglophone African countries as a fast growing common annual vegetable widely consumed in Africa (Schippers, 2000). It is one of the numerous vegetable crops cultivated in Nigeria where a total of 1 – 2 million hectares annually are under cultivation (Anonymous, 1986). Okra is a leading fruit vegetable in the Nigerian market on the basis of land area, production and value. It has a great demand in tropical countries.

The importance of okra in our diet cannot be over-emphasized. It serves as an important source of dietary fibre (Siemonsma and Kouamé, 2004) and source of vitamin A, B and C as well as calcium, phosphorous, iron and iodine (Purseglove, 1987). Okra is important in neutralizing the acid substance produced in the course of digestion of meats and other foods. It contains roughages that promotes digestion and prevents constipation and other gastronomic disorders.

Organic manure plays a great role in crop production. The addition of organic manure to the soil influence many physical, chemical and biological properties of the soil (Palm and Sanchez, 1995; Reeves, 1997). These include increased infiltration rate, reduced bulk density, aggregate stability, cation exchange capacity (CEC) and biological activities. Organic manure also serves as a slow-release reservoir for plant macronutrients, aids in plants micronutrient nutrition and facilitates water and air infiltration. It increases water retention by the soil and is important in maintaining soil tilth (www.sfc.ucdavis.edu 2011). Ball *et al.* (2005) noted that organic fertilizers are also responsible for the formation of soil aggregates. This is because organic matter is known to form bonds between adjacent soil particles.

Goat manure is second to poultry manure in its plant nutritional values (Amanullah *et al.*, 2010) and to some extent, it has some other benefits over the poultry manure. The manure can help gardeners produce healthier plants and higher crop yields. Goats not only produce neater pelletized droppings, but their manure does not typically attract insects or burn plants as does manure from cows, horses or even poultry manure. Goat manure is odourless and is beneficial for the soil. It contains adequate amounts of nutrients that plants need for optimal growth. The use of goat manure in vegetable gardens is one of the best ways to enrich the soil. Its pelleted state makes it suitable for direct applications to vegetable gardens.

Animal manures are cheap sources of valuable nutrients for crop growth and they contribute significantly to the long-term fertility of the soil. However, much of the nutrients contained in animal manures can be lost by incorrect handling and method of application. Applying rates that are too low can lead to nutrient deficiency and low yields. On the other hand, the application of a higher rate can lead to nitrate leaching, phosphorus runoff, accelerated eutrophication of lakes and excessive vegetative growth of some crops (Allah-Bakhsh *et al.*, (2013). Therefore, it is very important to use appropriate method(s) of application in addition to the application of the quantity required by the plant.

Several research works have been reported on the effects of manure rates on the growth and development of many crops. However, there is a paucity of information on the appropriate methods of application and the rates of goat manure on the growth and yield of okra at Lapai and Mokwa, southern Guinea savannah. Thus, the objective of this research work is to evaluate the effects of goat manure rate and application methods on the growth and fruiting characteristics of okra at Mokwa and Lapai, Southern Guinea Savannah.

MATERIALS AND METHODS

The experiment was conducted at .at the Research Farm of the Niger State College of Agriculture, Mokwa (Latitude 09 08''N and Longitude 05^0 04''E) and the Teaching and Research Farm of Ibrahim Badamasi Babangida University, Lapai, (Latitude 9^0 02` N and Longitude $06^0$ 34`E) of the Equator in Southern Savannah of Niger state. The two locations have an average temperature of 23-34.4^{o}C and minimum rainfall of 107.3mm. The experiment was conducted between 10th of July to 10th November, 2015.

Prior to land preparation, pre-planting soil samples were randomly collected from the two experimental locations using soil auger within 0–30 cm depth at the beginning of the experiment. Soil samples were air dried ground and sieved to pass through a 2-mm sieve and then digested for physical and chemical analysis.

Goat manure used for the study was obtained from the livestock unit of the Niger State College of Agriculture, Mokwa and the Teaching and Research Farms of Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria. Prior to the experiment, random sample of the goat manure was collected for chemical analysis to determine the following chemical components: Total N (g kg^{-1}), Available P (mg kg^{-1}), K (cmol kg^{-1}), Ca (cmol kg^{-1}), Mg (cmol kg^{-1}) , Na (mg kg^{-1}), Mn (mg kg^{-1}), Fe (mg kg^{-1}), Cu (mg kg^{-1}), Zn (mg kg^{-1}).

The experimental fields were properly cleared of debris and stumped. The land was ploughed, harrowed and ridged, then divided into plots (12 plots per block) with three replicates. Each plot was made up of four (4) ridges (75 cm apart) of 3 meters length.

The "*Jokoso"* variety of okra was used as test crop and it was sourced from The National Institute for Horticultural Research (NIHORT) Ibadan. The seeds were planted directly on well ploughed, harrowed and ridges beds. The ridges were 75 cm apart, four (4) ridges per treatment and the length of each plot was 4 m. Each plots and blocks were separated with alley ways of 1 and 1.5 m alley ways respectively.

The experiment was laid out in a 3 x 4 factorial in a randomized completely block design (RCBD). The treatments consists of three (3) levels of goat manure application methods (single row banding, double row banding and ring methods of application) and four (4) levels of goat manure application rate (0 t ha^{-1}, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}) replicated three (3) times.

First weeding was carried out two (2) weeks after planting and subsequent weeding was carried out as situation demand. Pests and diseases were controlled using the mixture of karate (Lambdhacyhalotrin) and Cypermethrin.

Soil and manure samples were analysed using standard laboratory methods: soil pH (soil: water ratio of 1:1); organic carbon; total nitrogen, available P (using Bray-1 method), exchangeable basic cations; exchangeable acidity and effective cation exchange capacity (by summation method) (Okalebo, 2002). Particle size analysis was determined on the soil using Bouyoucos method (Bouyoucos, 1962).

The following growth and yield parameters were also evaluated:

- Plant height was measure with measuring tape from base to the tip of the main shoots
- Number of Leaves was measured by counting the number of leaves on the shoot
- Leaf area (cm^2) was measured by multiplying the leaf length and leaf breath then multiplied by a constant. Length X Breath X Constant
- Days to first flowering and days to 50% flowering
- Days to first podding and days to 50% podding
- Pod length and pod diameter
- Number of pods/plant/plot and /ha
- Cumulative fruit yield tons/ha

Data Analysis

All data collected were subjected to analysis of variance (ANOVA), using Genstat 2014 software package, significant means were separated using least significant differences $LSD_{\infty 0.05}$

RESULTS

1. Soil and goat manure analysis

Soils properties of the two locations are similar in their inherent plant nutrient content. The soils were very poor nutritionally. The soils of the two locations were suitable for the cultivation of okra due to their weak acidic nature. However, the nitrogen, available phosphorus, potassium as well as organic matter contents were very low as shown in Table 1.

The goat manure applied in the two location are rich in nitrogen, potassium and organic matter content. This showed the beneficial effects of the manure that plant can benefit from their application Table 2.

2. Okra growth Characteristic

Goat manure methods of application significantly affect the okra growth. Okra growth parameters (okra plant height/plant, number of leaves/plant and leaf area/plant) were significantly affected by goat manure application at 8 and 12 weeks after planting at Mokwa and Lapai in 2015 cropping season. The ring method of application significantly produced tallest okra plant, highest number of leaves/plant and widest leaf area/plant which were significantly difference from double row and single row application ($P < 0.05$) at Mokwa and Lapai, southern guinea savannah in 2015 cropping season. The shortest plant, least number of leaves and narrow leaf area/plant were produced by the single row application as shown in table 1, 2 and 3.

Goat manure rates significantly affect okra growth (plant height, number of leaves and leaf area) of okra at 8 and 12 WAP ($P < 0.05$) at Mokwa and Lapai in 2015 cropping season. The 15 t ha^{-1} of goat manure significantly supported tallest okra plant, highest number of leaves/plant and widest leaf area / plant at 8 and 12WAP which was significantly different from 10, 5 t ha^{-1} and the control at Mokwa and Lapai in the 2015 cropping season. Although, the 5 and 10 t ha^{-1} were not significantly different from each other, the least okra growth was obtained from the control, as shown in the Tables 1, 2 and 3.

Table 1. Physico-chemical analysis of the experimental field soil at the beginning of the field experiment

Parameters	Mokwa	Lapai
pH 1:1 H_2O	6.65	6.62
Organic carbon g kg^{-1}	300	302
Total Ng Kg^{-1}	110	80
Available P mg kg^{-1}	2.75	2.76
K cmolkg^{-1}	0.15	0.19
Na cmolkg^{-1}	0.24	0.23
Cacmolkg^{-1}	8.90	9.33
Mg cmolkg^{-1}	4.05	4.03
Total acidity cmolkg^{-1}	0.85	0.82
CEC cmolkg^{-1}	14.80	14.58
Sand %	80.85	82.60
Silt %	9.25	7.40
Clay %	9.90	10.00
Texture	Loamy sand	Loamy sand

Table 2: Chemical Analysis of Goat Manure from the Mokwa and Lapai in 2015 cropping season

Element	Mokwa	Lapai
pH	7.8	7.6
N. $g.kg^{-1}$	20.22	19.25
Organic matter $g.kg^{-1}$	468	465
Available P mg. kg^{-1}	1980.10	2002.5
K $cm.kg^{-1}$	4315	4325
Ca. $cm.kg^{-1}$	2005	2000
Mg $cm.kg^{-1}$	565	561
Na Mg kg^{-1}	0.20	0.20
Mn Mg kg^{-1}	0.52	0.48
Fe Mg kg^{-1}	355.00	356.00
Cu Mg kg^{-1}	0.032	0.022
Zn Mg kg^{-1}	0.92	0.101

Key: N= Nitrogen, P =Phosphorus, K= Potassium, Ca= Calcium, Mg= Magnesium, Na = Sodium, Mn= Manganese, Fe= Iron, Cu= copper, Zn= Zinc

Table 3. Effects of goat manure rates and application methods on the okra height at Mokwa and Lapai in 2015 cropping season

	Okra Height (cm)					
	4WAP		8WAP		12WAP	
Locaton	Mokwa	Lapai	Mokwa	Lapai	Mokwa	Lapai
Methods of Application						
Single Row App.	28.12	27.98	42.27b	42.20b	55.40b	57.30b
Double Row App.	28.48	28.20	45.64b	45.58b	58.28b	58.53b
Ring Method App.	28.97	28.82	56.69a	55.48a	70.24a	69.60a
Rates						
0 t ha^{-1}	27.83	27.62	42.21c	42.20c	60.80c	63.30c
5 t ha^{-1}	28.49	28.30	43.36bc	42.80bc	65.22bc	64.85bc
10 t ha^{-1}	28.82	28.51	50.25b	50.10b	66.23b	65.50b
15 t ha^{-1}	28.94	28.90	59.56a	59.25a	78.50a	76.95a

Means followed by the same letter(s) are not significantly different at 5% probability level

Table 4. Effects of goat manure rates and application methods on the okra number of leaves at Mokwa and Lapai in 2015 cropping season

	Number of Leaves					
	4WAP		8WAP		12WAP	
Locaton	Mokwa	Lapai	Mokwa	Lapai	Mokwa	Lapai
Methods of Application						
Single Row App.	7.20	7.05	13.89b	13.72b	15.16b	15.25b
Double Row App.	7.38	7.32	14.95b	14.87b	18.56b	18.18b
Ring Method App.	8.92	8.80	20.37a	20.28a	27.90a	27.50a
Rates						
0 t ha^{-1}	6.34	6.18	11.74c	11.68c	17.50c	16.58c
5 t ha^{-1}	6.38	6.24	14.48bc	13.98bc	21.84bc	19.40bc
10 t ha^{-1}	6.99	6.80	16.76b	16.72b	22.26b	20.85b
15 t ha^{-1}	8.27	8.15	21.57a	21.45a	28.35a	27.33a

Means followed by the same letter(s) are not significantly different at 5% probability level

3. Okra flowering and pod Characteristics

The flowering of okra was not significantly affected by the goat manure application. However, the pod characteristics of okra were significantly affected by the goat manure application methods and the rate of manure ($P < 0.05$) at Mokwa and Lapai in the southern guinea savannah of Nigeria in 2015 cropping season.

With respect to goat manure application method, the ring application method significantly supported longest pod length/plant and widest pod diameter, largest number of pods/plot and cumulative pod yield ($P < 0.05$) at Mokwa and Lapai, southern guinea savannah in 2015 cropping season as shown in Table 7.

In another vein, goat manure rate had significant effect on pod length/plant, pod diameter, number of pods/plot and cumulative. 15 t ha^{-1} application rates significantly out-performed other goat manure rates by supporting longest pod length/plant and widest pod diameter, largest number

of pods/plot and cumulative pod yield ((P < 0.05) at Mokwa and Lapai, southern guinea savannah in 2015 cropping season. The trend is as followed in ascending order; 15 < 10 = 5 < 0 tha^{-1}

DISCUSSION

The significant differences recorded by ring method of application among the three methods of goat manure application methods with respect to okra growth and pod characteristics could be attributed to the ability of the okra plant to spread its root well in the soil and obtain the nutrient from every direction. This aids the nutrient absorption by the okra plant. Unlike the single row and double row application in which the nutrients can only be absorbed from the direction where nutrients are available. This result coincides with Awe *et al.,* (2011) who reported the superiority of band application method of poultry manure application over broadcasting method. Furthermore, since ring method of application made organic nutrients available around the plant, it is even more better than band placement that provide organic nutrient in only one spot around the plant.

The okra positive significant response to goat manure application rates (15 t ha^{-1}) agrees with the earlier findings of Ayoola and Adeniyan (2006) and El- Shakweer *et al*. (1998) who reported an increase in plant growth and yield with increase in organic manure applied. Organic manure generally supply plant nutrient elements to the soil, improves the soil physical properties which enhance crop growth and development (Mbagwu and Ekwealor, 1990) and (Stevenson and Ardakani, 1972). It was reported that crops respond well to manure application in soil with low fertility (Tisdale and Nelson 1975). This is line with Uwah and Eyo (2014) who reported the positive response of soils with low fertility to the application of 15 and 20 t $ha^{-1}$of goat manure. This applies to the present study since the soil analysis revealed that the soil is low in fertility.

The superior growth and pod yield attributes obtained from the application of high rate of goat manure (15 t ha^{-1}) can be due to increased availability of nutrients supplied by goat manure which resulted in enhanced growth and pod yield of okra. This have been reported by other researchers (Ojeniyi and Adegboyega, 2003; Odedina *et al.,* 2011; Nweke *et al.,* 2013).Thus, the present advocacy for organic farming which provides quality and safe products as an alternative to conventional farming system which involved the use of inorganic fertilizers and other agrochemicals that are responsible for a number of environmental degradation problems. Suddhiyan *et al.,* (2009) observed that inorganic fertilizers do not produce higher yield than organic fertilizers. Hence, organic fertilizers are a better alternative to inorganic fertilizers if the proper method and adequate rates are used for their application.

CONCLUSIONS

Ring method of goat manure application and 15 t ha^{-1} are among the important agronomic practices that can improve the growth and pod yield of okra. It is therefore, very essential to follow strictly the recommendation in order to obtain higher yield from our crop. This will enable us to feed continually increasing world population.

Table 5: Effect of goat manure rates and application methods on leaf area (cm^2) of *Abelmoscus esculentus* in 2015 cropping season

Parameters	**Okra leaf area (cm^2)**					
	4WAP		**8WAP**		**12WAP**	
Locations	**Mokwa**	**Lapai**	**Mokwa**	**Lapai**	**Mokwa**	**Lapai**
Methods of Application						
Single Row App.	21.30	20.16	62.35b	61.25b	93.25b	90.85b
Double Row App.	21.82	20.72	65.92b	63.89b	98.75b	97.50b
Ring Method App.	23.55	22.89	72.55a	70.35a	120.55a	115.65a
Rates						
0 t ha^{-1}	20.15	20.22	62.80c	61.65c	79.85c	78.30c
5 t ha^{-1}	21.64	20.35	68.20bc	63.02bc	89.62bc	87.25bc
10 t ha^{-1}	22.72	20.95	69.05b	64.50b	95.20b	92.65b
15 t ha^{-1}	22.79	22.50	75.25a	70.35a	124.35a	118.75a

Means followed by the same letter(s) are not significantly different at 5% probability level

Table 6: Effect of goat manure rates and application methods on flowering and Pod characteristics of *Abelmoscus esculentus* at Mokwa and Lapai in 2015 cropping season

	Flowering and pod characteristics of okra							
Parameters	Days to First flowering		Days to 50% flowering		Days to First pod		Days to 50% pod	
Locations	Mokwa	Lapai	Mokwa	Lapai	Mokwa	Lapai	Mokwa	Lapai
Methods of Application								
Single Row App.	58	59	63	64	70	62	77	75
Double Row App.	52	56	58	61	68	60	72	72
Ring Method Appl.	50	54	60	60	66	58	71	69
Rates								
0 t ha^{-1}	56	54	64	65	63	57	70	65
5 t ha^{-1}	55	55	62	63	64	59	68	68
10 t ha^{-1}	52	53	59	62	60	63	65	70
15 t ha^{-1}	50	53	56	61	55	62	62	71
Interaction	ns	ns	ns	ns	ns	ns	ns	ns

Mean followed with the same letter(s) are not significantly different at 5% probability level

Table 7: Effect of goat manure rates and application methods on Pod characteristics of *Abelmoscus esculentus* at Mokwa and Lapai in 2015 cropping season

Parameters	Pod characteristics of okra							
	Pod length/plant (cm)		Pod diameter/plant (cm)		Number of pods/plot		Pod cumulative yield/ ton/ha	
Locations	Mokwa	Lapai	Mokwa	Lapai	Mokwa	Lapai	Mokwa	Lapai
Methods of App.								
Single Row App.	5.25b	5.73b	4.65b	4.14b	32.00c	30.00c	3.30c	3.15c
Double Row App.	6.43b	6.21b	6.02b	5.85b	43.00b	39.00b	5.25b	5.10b
Ring Method App.	8.40a	8.18a	8.23a	8.27a	55.00a	50.00a	7.25a	7.00a
Rates								
0 t ha^{-1}	4.55c	4.27c	3.80c	3.42c	24.00c	23.00c	2.25c	2.20c
5 t ha^{-1}	7.15b	6.84b	5.75b	5.48b	35.00b	34.00b	4.10b	3.92b
10 t ha^{-1}	7.60b	6.92b	6.55b	6.25b	37.00b	36.00b	4.80b	4.38b
15 t ha^{-1}	10.20a	9.25a	8.52a	8.55a	51.00a	49.00a	6.85a	6.55a
Interaction	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Mean followed with the same letter(s) are not significantly different at 5% probability level

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