Productivity of okra (*Abelmoschus esculentus*) in response to rate and method of cattle manure application in the northern guinea savanna of Nigeria.

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ABSTRACT

Two field trials were conducted at the experimental farm of the Institute for Agricultural Research farm (IAR), Samaru in the 2009 and 2010 rainy season to study the effect of four rates of cattle manure (0, 5, 10 and 15 t h-1) and two methods of application (broadcasting and stand to stand placement) on growth, yield and yield components of okra. The experiment was laid out in a complete randomized block design and replicated four times. Application of cattle manure significantly increased both green pod yield, weight of seeds per pod, height to first pod, average pod length and days to 50% flowering up to the 10 t ha-1 rate which increased pod yield by 29.8%, the average weight per green pod showed significantly greater effect in terms of yield for manured plots than the untreated control in both trails. Number of seeds per pod, number of pod per plant, average pod diameter and 100-seed weight were unaffected by rates or methods of cattle manure application. However, the best manure rate was influenced by adequate and well distributed rainfall in both years and manure quality by the application of 10 t ha-1 rate as early as possible in the season though there were no significant differences amongst the different methods of manure application. This indicates that either of the two methods of manure application could be adopted as treatment for okra production at Samaru in the northern guinea savanna agro - ecological zone of Nigeria.

Key words: Cattle manure, okra, growth and yield components

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INTRODUCTION

The total world production of okra (*Abelmoschus esculentus* L. Moench) is estimated at 4.1million tones of which developing countries produce about 3.1million tones (Grubben, 1977). It is an important vegetable valued for its mucilaginous characteristics and cultivated for its edible tender leaves and especially green pod yield. In Nigeria, where it is cooked as soup and relished when cooked with fish or meat to go with any carbohydrate or cereal food; its production is exclusively by small-scale farmers, while its economic importance lies in internal trade. Unfortunately, as with most local vegetables, okra has so far received only very little research attention using both inorganic and organic fertilizers combination in the country and the use of organic manure purely have been neglected.

The exclusive use of inorganic fertilizers to improve crop production most of the time has negative effect on the soil, inversely, the practice of fallow system as a means of allowing the soil to rest and naturally regain its fertility is increasingly becoming impossible due to population explosion, urbanization and industrialization. Development of alternative strategies for improving and sustaining satisfactory okra production is therefore imperative. The adoption of the use of organic fertilizers in form of cattle manure is advantageous as source of crop nutrients as it has long-term favourable effect on soil physical and chemical properties and their ability to supply macro, micro and trace elements which are not contained in the inorganic fertilizers resulting from their slow release of nutrients, improvement of aggregate stabilities and preventing the depletion of soil organic matter by many agricultural practices. As a result of the low-input system commonly adopted for okra production, green pod production yields in most cases have been relatively modest. Even in cases where high yielding cultivars have been cultivated, the inherently low native fertility status of the soils of northern guinea savanna coupled with minimal application of inorganic fertilizers remains the principal limiting factor to okra production; and by and large on food security in Nigeria.

Research work on the differential fruit yield response of two okra varieties to cattle manure application has been reported in Zimbabwe (Ogunlela *et al.* 2004) and the effect of nitrogen and phosphorus in the northern guinea savanna of Nigeria (Majanbu *et al.* 1985). Cattle manure is readily available within farmsteads and ranches. Norman *et al.* (1982) and Agyemang *et al.* (1993) observed that farmers keeping livestock, especially cattle, produce higher cereal crop yields than those who do not keep livestock; had larger farms, were more likely to accept new innovations and faced less drudgery on farms. Therefore, the awareness and potentials for improving and sustaining the productive capacity of the soil using organic manure for the production of

cereal crops already exist. What is lacking is the capacity to improve upon the ways and means of accomplishing these potentials in the production of vegetable such as okra and the ability of small-scale farmers to acquire such initiatives through further research. However, there has been no research work on the effect of cattle manure rate and method of application on okra performance at Samaru Nigeria.

The objective of this study therefore was to determine the optimum rate and best method of cattle manure application for green pod yield of okra at Samaru in the northern guinea savanna ecological zone of Nigeria.

MATERIALS AND METHODS

Field trials were conducted during two cropping seasons (2009 and 2010) at the IAR's experimental farms, Samaru (Lat. 11°11'N, Long. 07°38'E; 686m above sea level) in the northern guinea savanna agro-ecological zone of Nigeria with a unimodal annual rainfall of 750-1000mm (Table 5), has a semi-arid and sub-tropical climate.

The soils of the 2009 and 2010 trials were analyzed to determine their physical and chemical characteristics (Table 6). The cattle manure used in both trials was sourced from the Division of Agricultural Colleges, Ahmadu Bello University, College of Agriculture, Samaru cattle pens. Manure used in the trials was also analyzed to determine its chemical contents (Table 7). Experimental cultivar was Jokoso which is a very popular, dwarf and high yielding okra variety grown mostly amongst the Yorubas in the western part of Nigeria. The treatments were factorial combinations of four rates of cattle manure (0, 5, 10 and 15 t ha^{-1}) and two methods of application (broadcasting and stand to stand placement). The experimental design was a randomized complete block design with four replicates. The gross plot size was 3.4 x 6.0m (21.0m^2) and the net plot size was 2.1 x 5.5m (11.44m^2). The trials were sown 70cm inter-rows with 40 cm intra-row spacing.

Plants were thinned to 2 plants per stand at 4 weeks after sowing (WAS). The cattle manure application was carried out according to treatment at 4 WAS immediately after the first hoe weeding as weed control was carried out by hand hoe weeding at 4, 8 and 12 WAS to keep the plots clean. Plots were scored for weed infestation at 8 WAS and weeds were therefore collected using a 1 m2 quadrant and after taken weed fresh weight; they were dried to constant weight in an oven at 70°C for 48 hours. Crop protection measures were taken against aphids, podadrica spp. and fungal infection.

Data collection commenced 8 WAS, plant samples were collected from the border rows using ten plants per plot for growth determining components

and from the net plots for yield determining components. The samples were separated into leaves, pods and stalks which were weighed and later dried in an oven at 70ºC for 48hrs. the dried samples were also weighed before grinding with a milling machine and then analyzed for nutrient contents of N, P, K, Ca and Mg. Total nitrogen was determined by the micro-Kjeldahl method (Bremner, 1965) after digestion with concentrated sulphuric acid. P concentration was determined by the vanado-molybdate yellow method (Olsen *et al.* 1982) after digesting with 2.4% perchloric acid. After extraction with mixture of 25% hydrochloric acid and 55% nitric acid, Ca and Mg concentration in the plant tissues were determined by atomic absorption and K concentration by using the curcumin method (Johnson *et al.* 1959).

Green pods were harvested at regular intervals to derive cumulative green pod yield and yield components such as plant height, days to 50% flowering, height to first pod, number of pods per plant. Ten plants were sampled per plot to determine average pod length, average pod diameter and average weight per green pod. Five dry pods were sampled for assessment of number of seeds per pod, weight of seeds per pod and 100-seed weight with their means recorded for analysis.

Data collected were subjected to statistical analysis system (SAS) (1990) and the treatment means were separated using the least significant difference at 5% level of probability. The data were analyzed separately for each year and where the F-test was significant, the means were separated using the Duncan's multiple range test (Duncan, 1965).

RESULTS AND DISCUSSION

Plant height of okra did not increase significantly with the rates of manure application in both years (Table 1). In the 2009 trial, there was significant difference between the rates of manure application on days to 50% flowering, as the highest number of days to 50% flowering was recorded by the manure application of 10 t ha $^{-1}$ when compared to the untreated control. The manure application of 5 and 15 t ha $^{-1}$ produced the lowest days to 50% flowering which were statistically at par; while for 2010, there were no significant differences between the different rates of manure application on days to 50% flowering. The different methods of cattle manure application had no significant effect on plant height and days to 50% flowering for both.

Table 1: Effect of rate and method of cattle manure application on plant height, days to 50% flowering, height to 1st pod and number of pod per plant in okra at Samaru (2010 and 2011)

Treatment	Plant height (cm)		Days to 50% flowering		Height to 1st pod (cm)		No of pod/plant	
	2009	2010	2009	2010	2009	2010	2009	2010
Manure rate (t ha^{-1})								
0	130.6	131.8	69.0b	69.0	29.6	22.5ab	8.4	8.2
5	132.1	133,2	68.4c	69.0	29.9	29.3b	8.8	8.6
10	137.1	138.2	69.6a	69.2	32.0	34.9a	10.2	9.1
15	135.8	134.6	68.3c	68.0	28.6	28.8b	9.4	9.0
SE+	3.16	3.25	1.04	0.03	1.23	1.44	1.32	1,30
Method of manure application								
Broadcasting	133.9	134.31.	68.8b	68.9	30.9	31.0	8.6	8.6
Stand to stand placement	133.8	134.1	68.8b	68.8	29.1	31.8	8.9	8.8
SE+	2.24	2.32	0.04	0.04	0.87	1.02	1.28	1.26
Mean	133.9	134.5	48.09	48.08	30.0	31.4	15.2	15.0
CV (%)	6.7	6.9	5.4	5.6	11.6	13.0	12.5	12.8

Means followed by the same letter(s) in a column of any set of treatments are not significantly different at 5% level of significance using the Duncan Multiple Range Test.

Height to first pod of okra in the 2009 trial and number of pod per plant for both years were not significantly influenced by the different rates of manure application. The different methods of manure application also had no significant effect on height to first pod and number of pod per plant in okra. However, the highest height to first pod in okra in 2010 trial was recorded by the application of 10 t ha $^{-1}$ when compared to the untreated control; while the manure application of 5 and 15 t ha $^{-1}$ produced the lowest height to first pod that were statistically similar to the zero manure plots. The different methods of manure application had no significant influence on height to first pod in okra (Table 1).

Two of the green pod components were influenced by manure application rate in one or both years but none of them responded to different methods of manure application (Table 2).

Table 2: Effect of rate and method of cattle manure application on average pods length, average pod weight and average weight per green pod in okra at Samaru (2009 and 2010)

Treatment	Ave.pod length (cm)		Ave. pod diameter (cm)		Ave. wt / pod (g)	
	2009	2010	2009	2010	2009	2010
Manure rate (t ha^{-1})						
0	8.12	9.02b	4.06	3.63	9.69b	16.07b
5	8.13	9.13ab	4.16	3.83	11.02ab	16.46ab
10	8.34	9.38a	4.20	3.79	11.52a	16.86a
15	8.47	9.41a	4.24	3.84	11.69a	16.87a
SE+	0.168	0.171	0.142	0.124	0.240	0.221
Method of manure application						
Broadcasting	8.23	9.21	4.11	3.74	13.45	12.17
Stand to stand placement	8.25	9.23	4.19	3.79	13.76	12.17
SE+	0.121	0.124	0.103	0.133	0.101	0.132
Mean	8.13	8.25	4.18	3.77	13.60	12.09
CV (%)	4.5	5.3	7.0	4.7	3.8	4.6

Means followed by the same letter(s) in a column of any set of treatments are not significantly different at 5% level of significance using the Duncan Multiple Range Test.

Average pod length in 2009 and average pod diameter in both trials were not significantly increased by increase in rate of manure application up to 15t ha $^{-1}$. There were only modest differences between the lowest and the highest values for these two components. Average pod length responded to manure rate in 2010; the values for 10 and 15 t ha $^{-1}$ manure rates recorded statistically similar average pod length that were significantly higher when compared to the untreated control; while the application of manure rate of 5 t ha $^{-1}$ produced the lowest average pod length that was significantly higher when compared to the untreated control. Average weight per green pod for the two trials were influenced significantly by manure application rate but none of the different methods of manure application had significant influence on average weight per green pod.

In 2009 trial, application rates of 10 and 15 t ha $^{-1}$ produced statistically similar average weight per green pod that were significantly higher than the untreated control; while application of 5 t ha $^{-1}$ recorded the lowest average weight per green pod. Likewise, in 2010, application rates of 10 and 15 t ha $^{-1}$ recorded the highest average weight per green pod that were statistically at par but significantly higher than the untreated control while the application of manure rate of 5 t ha $^{-1}$ gave the lowest average weight per green pod when compared to 10 and 15 t ha $^{-1}$ but was statistically higher when compared to the untreated control in okra. There was no significant difference among the different methods of cattle manure application on average weight per green

pod.

Table 3 shows the effect of rate and method of cattle manure application on number of seeds per pod, weight of seeds per pod, 100-seed weight and green pod yield in okra in 2009 and 2010.The number of seeds per pod and 100-seed weight were not significantly influenced by manure application rate in both trials. There was no significant difference among the methods of cattle manure application with respect to number of seeds per pod and 100-seed weight. Weight of seeds per pod had only modest difference between the lowest and the highest values for the two years as the application rate of 10 t ha $^{-1}$ recorded the highest weight of seeds per pod which was significantly higher than the untreated control while the application rates of 5 and 15 t ha $^{-1}$ produced weight of seeds per pod that were statistically at par but significantly lower than the manure application rate of 10 t ha $^{-1}$. There was no significant difference among the methods of manure application for weight of seeds per pod in both trials respectively. The highest green pod yield was from 10 t ha $^{-1}$ manure application rate, although the rate of 5 and 15 t ha $^{-1}$ gave green pod yield that were statistically at par but significantly higher when compared to the untreated plots, indicating that further increase in manure application rate up to 15 t ha $^{-1}$ had little or no significant effect in increasing green pod yield in okra. There was no significant response between the different methods of cattle manure application with respect to their effect on green pod yield (Table 3). Although not statistically significant, the 10 t ha $^{-1}$ manure rate had the lowest weed dry mass (Table 4). The dominant weed species in the two trials were *Bidens pilosa, Cyperus esculentus, Cyperus rotundus, Nicandra physaloides and Ipomoea involucrate.*

Table 3: Effect of rate and method of cattle manure application on number of seeds per pod, weight of seeds per pod, 100-seed weight and green pod yield in okra at Samaru (2010 and 2011)

Treatment	No of seeds/pod		Wt of seeds/pod(g)		100-seed wt (g)		Green pod yield (t ha-1)	
	2009	2010	2009	2010	2009	2010	2009	2010
Manure rate (t ha-1)								
0	60.2	60.0	3.5b	3.50ab	11.80	11.86	8.98b	9.97b
5	62.4	62.2	4.09ab	4.08ab	13.68	11.94	10.97a	11.32ab
10	65.6	64.8	4.49a	4.47a	11.84	11.86	11.05a	12.26a
15	67.2	65.4	3.84ab	3.68ab	12.55	12.34	10.80a	11.36ab
SE+	2.48	2.54	0.287	0.242	1.05	1.01	0.455	0.550
Method of manure application								
Broadcasting	62.42	63.1	5.98	5.84	12.24	12.10	10.40	11.13
Stand to stand placement	63.32	63.2	5.90	5.82	12.44	12.12	19.50	12.36
SE+	2.024	2.038	0.087	0.081	0.046	0.024	0.322	0.379
Mean	62.48	62.28	5.94	5.81	12.34	12.13	10.45	11.22
CV (%)	12.6	12.9	5.9	5.6	12.49	11.45	17.40	13.4

Means followed by the same letter(s) in a column of any set of treatments are not significantly different at 5% level of significance using the Duncan Multiple Range Test.

Table 4: Effect of Rate and Method of Cattle Manure Application on Fresh Weed Weight and Weed Dry Mass (gm2) in Okra at Samaru (2010 and 2011)

Treatment	Fresh Weed Weight (gm2)		Dry Weed Weight (gm2)	
	2009	2010	2009	2010
Manure rate(t ha-1)				
0	81.2a	80.4a	47.1a	45.7a
5	62.4ab	60.5ab	40.6a	41.1a
10	56.1b	53.4b	27.4b	25.2c
15	58.5b	59.2ab	39.05a	37.1b
SE+	13.42	13.65	12.21	12.48
Method of manure application				
Broadcasting	51.2	52.4	31.9	31.1
Stand to stand placement	54.5	53.8	33.7	33.1
SE+	10.90	11.10	10.43	11.41
Mean	56.1	54.2	34.2	35.0
CV (%)	20.6	21.4	25.0	27.6

Means followed by the same letter(s) in a column of any set of treatments are not significantly different at 5% level of significance using the Duncan Multiple Range Test.

Table 5: Meteorological data of rainfall, temperature, relative humidity and sunshine hours at Samaru, Nigeria in 2009 and 2010 rainy seasons

Months	Rainfall		Air Temperature(°C)				Relative humidity (%)		Sunshine (hr)	
	2009	2010	2009		2010		2009	2010	2009	2010
			Min	Max	Min	Max				
April	20.3	52.4	23.1	38.4	22.7	38.4	39.9	31.7	8.2	8.4
May	85.1	92.9	22.2	35.4	22.7	35.3	53.1	61.8	8.2	8.5
June	89.5	158.3	21.0	33.2	20.6	32.5	62.5	69.2	8.0	7.9
July	285.0	216.8	20.0	31.2	19.3	30.2	69.7	75.9	6.9	7.1
August	439.7	313.4	20.4	29.9	20.0	29.7	74.3	77.5	5.5	5.7
September	206.7	218.5	20.0	31.8	20.9	31.1	68.9	73.0	6.7	6.8
October	151.7	82.3	20.2	32.7	20.6	32.6	66.8	69.6	6.4	6.4
November	0.0	0.0	14.8	32.3	16.2	33.6	68.5	27.8	8.1	8.2
December	0.0	0.0	13.2	33.4	12.6	31.8	16.6	15.6	8.8	8.8

Collected from meteorological unit of the Institute for Agricultural Research, Samaru, Zaria, Nigeria

Table 6: Physical and chemical characteristics of soil taken from the experimental sites at Samaru, Nigeria in 2009 and 2010.

Soil Properties	**Soil Depth 0 – 15cm**	
Particle Size Distribution (%)	**2009**	**2010**
Sand	56	52
Silt	32	32
Clay	12	16
Textural Class	Sandy Loam	Sandy Loam
Chemical Properties		
pH in Water	5.4	5.3
pH in 0.1m CaCl	5.1	4.5
Organic Carbon g/kg	0.98	1.0
Total Nitrogen	0.18	0.20
Available P (ppm)	7.4	8.1
Exchange Cation (Cmol/kg)		
K	0.2	0.08
Mg	1.25	0.33
Ca	2.5	2.4
Na	0.25	0.35
CEC	6.2	5.2

Analyzed at the soil science laboratory of the Institute for Agricultural Research (IAR), Samaru, Zaria, Nigeria.

Table 7: Chemical Content of the Cattle Manure used in the Two Experiments

Chemical Properties	
Total Nitrogen (N) (g/Kg)	26.4
Available Phosphorus (P) (g/Kg)	17.20
Potassium (K) (g/Kg)	3.39
Calcium (Ca) (g/Kg)	2.521
Magnesium (Mg) (g/Kg)	3.100
Organic Carbon (g/Kg)	45.23
Sand Content (%)	35.10

Analyzed at the soil science laboratory of the Institute for Agricultural Research (IAR), Samaru, Zaria, Nigeria.

The survival level of plant stands was lowest under the untreated control due to inherent low native soil fertility; however, mild burning was observed on the younger and susceptible okra plants due to the highest rate of cattle manure application (15 t ha $^{-1}$) by both methods of manure application because of ammonia and uric acid levels in the manure rate used. This calls for some measures of caution when applying manure at high rates to young vegetable crops in spite of its obvious benefits (Mbagwu and Ekwealor, 1990). Ogunlela *et.al.;* (2004) had opinioned that when organic amendment above agronomic levels is applied, there might be a release of phytotoxic quantities of NH_3, NO_3 and other salts into the soil that could affect the plant. Okra plant mortality can occur depending on the type of organic amendment used (Aliyu, 2000) especially at high levels.

The effect of cattle manure on plant height was generally not significant in cases where manure was applied by the three rates of application than when compared to the zero manure treatment and there were no significant differences in most instances between different methods of manure application. This conforms to the reports of Palevitch *et. al.;* (1965) who reported similar results for winter tomatoes in the Western Negev, Israel, as animal manure application did not produce significant growth increase in tomatoes.

The application of 10 t ha $^{-1}$ rate of manure had the most days to 50% flowering which were more than those for plants in the untreated control plots. This is in agreement with the finding of (Myanmer, 1996) who reported that 35-60 days after emergence, okra plants begins to flower, especially when land was tilled and manure applied at the rate of 20 t ha $^{-1}$ worked into the soil at land preparation. However, the various yield contributing characters such as weight of seed per pod and green pod yield; were generally slightly higher in cases where manure was applied than when not applied. In virtually every instance, there were no significant differences between the first manure increment and the highest application. Oikeh and Asiegbu, (1993) reported similar results for tomatoes in Southern part of Nigeria, as manure did not produce significant differences in 100-seed weight and number of fruits per plant.

The overall green pod weight reflected greater effect in terms of okra green pod yield for manured plots than for the untreated control. Average green pod weight is therefore an important yield determining component in okra. This is in support with that reported for pepper by Aliyu, (2000) that FYM rates 0-30 t ha $^{-1}$ were statistically similar but higher than the untreated control. Number of seeds per pod and 100-seed weight (seed size) did not respond to rates and methods of cattle manure application. Similar findings was reported by Katung *et.al*, (1996) from their study on okra at Samaru, Nigeria; who

indicated that number of seeds per plant, seed dry weight per plant and okra seed yield per hectare were not influenced by FYM rate ranging from 0 to 10 t ha $^{-1}$; but 20 t ha $^{-1}$ rate even depressed the yield parameters. This was attributed to slow release of plant nutrients from organic manure. This also explains why in this trial, cattle manure which was applied at 0-15 t ha $^{-1}$ to okra failed to indicate any significant increase between applying manure at 0 t ha -1 up to 15 t ha $^{-1}$. Considering that much of the nutrients in cattle manure will be in organic form, therefore, some reasonable length of time would be required for these to be converted to their mineral forms and made available for up take by the plants in close relation with plant nutrient demand.

Aside the dynamic nature of mineral composition of okra plant tissue, phonological changes may radically affect tissue composition. Jokso, the okra variety used in this study might have been an important factor. Majanbu *et.al*; (1985) demonstrated through their study in the semi-arid Nigeria; varietal influence on nutrient accumulation in okra plants; they reported that nitrogen, and magnesium concentrations in the okra pod and calcium in the leaves were observed to be higher at 6 t ha $^{-1}$ than at 12 t ha^{-1} manure rate; since such quantities of manure had the advantage of time for mineralization and translocation of nutrients to the pods with rainfall establishing adequately at this growth period. Okra leaf is a better accumulator of N and Ca than the pod (Fatokun *et al.* 1981). This finding is in support of the explanation given by Russell, (1973) that cation concentrations in most plant tissues such as actively functioning leaves and fruits are not only characteristics of the crop but also fairly dependent of the soil fertility status or applied plant nutrients.

Applying high amounts of cattle manure to okra under a low-input system such as the small scale cropping system in Nigeria will be economical and sustainable. The 10 t ha $^{-1}$ rate particularly in the context of a low-input system, represents a better return for labour, a major limitation in any farming system (Gibberd, 1995.) even from the perspective of availability of cattle manure from ranches and farmstead animal kraals, availability of large quantity of animal manure for use on local vegetables may be realistic due to small farm sizes cropped by farmers.

Effect of cattle manure on weed interference was observed when the untreated control gave the highest weed cover score, fresh weed weight and dry weed weight (table 4); while the other rates of application were not affected, which suggests that increasing manure rates did not increase weediness. This is indicative of the management given to the cattle manure prior to its application. Question about cattle manure being a source of weed introduction and dissemination has often been raised. Baig *et.al;* (2001) asserted from their study with different organic sources, that organic manure had seed bank of

different weed species in viable conditions and acted as a major source of weed infestation within crop fields. The result of this study refutes their finding but lends further credence to the findings of Ogunlela *et. al*.; (2004) indicating that the degree of plot weediness was not increased by manure application, suggesting that proper curing of cattle manure by heaping and allowing it to rot down and cure for about six weeks before application as treatment, is capable of drastically reducing weed seed viability and thus reducing plot weediness.

CONCLUSION

This investigation has revealed that in order to maximize the yield of okra in Samaru, a semi-arid subtropical environment in the northern guinea savanna of Nigeria under the low external input system and continue to maintain soil fertility, aggregate stability and consequently increase general crop productivity; an early application of well rotted and cured cattle manure at the optimum rate of 10 t ha $^{-1}$ by either of the two methods of manure application will be appropriate for good production of okra at Samaru agro-climatic zone, since there was no significant difference between the two methods of manure application.

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