DOI: https://doi.org/10.67042/njss.2011.x4mivmic

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

IMPROVING THE PHYSICAL PROPERTIES OF A DEGRADED ALFISOL IN NIGERIA USING ORGANIC AMENDMENTS FOR PROFITABLE OKRA PRODUCTION

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ABSTRACT

Experiments were conducted between 2007 and 2008 to determine the optimum rate of organic fertilizer (OF) for okra production and to evaluate residual effects of OF on soil physical properties. Six different rates of OF; 0 kg N ha^{-1}, 60 kg N ha^{-1}, 80 kg N ha^{-1}, 100 kg N ha^{-1}, 120 kg N ha^{-1} and 140 kg N ha^{-1} were replicated five times in a Randomized Complete Block Design on an Alfisol in the sub humid region of Southern Nigeria. Plots that received OF at the rates of 100, 120 and 140 kg Nha^{-1} were significantly ($P< 0.05$) lower in bulk density values than control. Fresh pod weight obtained from 100 kg Nha^{-1} plots was higher than 120 and 140 kg Nha^{-1} plots by 13.56 and 11.44%, respectively. The increase in net profit over control by OF applied at the rates of 100, 120 and 140 kg Nha^{-1} was 35.3%, 20.7% and 19.9%, respectively; suggesting that break-even was achieved when 100 kg Nha^{-1} was applied.

Keywords: Physical properties, Organic fertilizer, Optimum rate, Crop yield, Economics.

INTRODUCTION

Nigerian soils are being degraded at an alarming rate through continuous cultivation, deforestation and inappropriate farming practices. Consequently, the potential capacity of the soil to support healthy and nutrition yield of crop to meet the demand of the ever increasing human population is hindered. Continuous cultivation of crops on the same piece of land is practiced in Africa due to rapid growth in population coupled with urbanization and industrialization (Isokrari, 1995). This practice results in low organic matter content that makes the fragile soils collapse readily under the impact of raindrops leaving the soil more prone to compaction and erosion (Aiyelari and Oshunsanya, 2008). To rejuvenate degraded soil under cultivation demands for soil science and skill (Adeniyan and Ojeniyi, 2003), to incorporate nutrients into the soil for sustainable crop production.

The use of organic fertilizer (OF) has been adopted as a cultural means of solving soil fertility problems over the years because the use of chemical fertilizer in Nigeria is limited by its high costs and scarcity. AdeOluwa and Oshunsanya (2009), observed that inorganic fertilizer did not improve soil physical condition in terms of soil bulk density, porosity, soil available water and macro porosity. Hence, many countries began to explore the fertilizer value of organic wastes to supply crop nutrients. OF improves the physical condition of soil to support good

growth and development of crop under continuous cultivation. In Nigeria, okra (*Abelmoschus esculentus*) is a popular vegetable crop which is very rich in vitamin A and C, and has traces of vitamin B, calcium, phosphorous, iron and sodium. However, one major constraint to growing this crop is the demand for large quantity of fertilizer (Schippers, 2000)

The use of OF and organic agriculture is being advocated worldwide because of the shortfall of inorganic fertilizers which have made many state and public companies to be bagging and commercializing organic fertilizers with minimum guarantee. This work investigated the effect and optimum rate of OF for okra production and the effect of OF on soil physical properties and the cost benefit analysis of the treatments.

MATERIALS AND METHODS

The study was conducted at the University of Ibadan Teaching and Research Farm. Ibadan extends from latitude 7° 24'N to longitude 3°54'E. Ibadan is characterized by average rainfall of 1229 mm per annum with a bimodal distribution that peaks in June and September, respectively. The soil is Oxic Paleustalf (Alfisol) according to the USDA classification and by the local classification; the soil belongs to Iwo series.

Six different rates of fertilizer were imposed with five replications in Randomized Complete Block Design. The treatments were: 0 kg N ha^{-1}, 60 kg N ha^{-1}, 80 kg N ha^{-1}, 100 kgN ha^{-1}, 120 kg N ha^{-1} and 140 kg N ha^{-1} of OF corresponding to 0 kg ha^{-1}, 1714.3 kg ha^{-1}, 2285.7 kg ha^{-1}, 2857 kg ha^{-1}, 3428 kg ha^{-1} and 4000 kg ha^{-1} quantities of organic fertilizer respectively. The chemical analysis for the OF is provided in table 1. Experimental plot was 2m × 2m. Organic fertilizer was broadcast and incorporated into the soil to a depth of 15cm. Application was made two weeks before planting to give room for mineralization. Okra was used as a test crop. Okra seeds were sown 50 cm between row and 50 cm within rows for three growing seasons in 2007 and 2008.
Some physical properties of soil on the experimental site were determined. Before planting, soil samples were randomly collected to ascertain the base line properties. At the end of the third growing season, another set of soil samples were collected from each plot at 0-15cm and 15-30 cm soil depths. Particle size analysis and bulk density were determined as described by Smith and Mullins (1991).

Yield and yield parameters were estimated for the three inner rows of plants. Harvesting of pods was done at 3-4 days after flowering on each plot. The harvesting was done over a period of five weeks. The yield parameters taken include number of fresh pods, weight of fresh pods and weight of dry pods. Fresh pods were oven dried at temperature of 65°C to a constant weight. Statistical analyses were carried out using ANOVA to test levels of significance due to treatments.

The yield of fresh pod weight was also subjected to economical analysis on the basis of marginal analysis for net benefit of return keeping in view 100% minimum rate of return should (CIMMYT, 1988)

RESULTS AND DISCUSSION

Soil properties

The soil of the experimental site before fertilizer application was loamy sand and sandy texture, for 0-15cm and 15-30 cm depths respectively. Corresponding values of organic carbon were 11.8 and 7.1g kg. Total N, available P and K values were 1.2g $kg^{-`1}$, 18.3g mg^{-1} and 0.1cmol kg^{-1} for 0-15cm soil depth and 0.7g kg^{-1}, 3.6g mg^{-1} and 0.2cmol kg^{-1} for 15-30cm soil depth respectively. These nutrient values were very low according to nutrient rating for soil fertility classes in Nigeria (Obigbesan, 2000). Low soil fertility class according to Obigbesan (2000) implies that cropping without fertilizer is uneconomical. Therefore, fertilizer was applied to degraded soil to enable farmers to crop successfully and economically.

Table 2 shows some specific physical characteristics of soil amenable to changes by the treatments imposed. At the end of the third growing season, treatments influenced significantly ($P< 0.05$) the mean soil bulk density at 0-15cm soil depth. OF applied at the rates of 100, 120 and 140 kg N ha^{-1} gave significantly lower bulk density values than the control, suggesting better soil physical condition. Among these three rates, there were no significant difference in bulk density values which implies that farmers should apply OF at the rate of 100 kg N ha^{-1} to improve soil physical condition of a degraded soil for economic reasons. Similarly, plots that receive OF at 100, 120 and 140 kg N ha^{-1} were higher in clay than at other levels of fertilizer but highest clay content (62.0 g kg^{-1}) was obtained from 100 kg N ha^{-1} plot. This again shows that organic fertilizer applied at 100 kg N ha^{-1} will provide fine particles necessary for nutrients and water retention for crop production. This is consistent with the observation of Mbagwu (1992), that organic manure reduced soil bulk density and improved water retention of degraded soils. There was no significant difference among the values of sand, silt, clay and bulk density from treatment with different levels of fertilizer at 15-30 cm soil depth after the three growing seasons.

Okra yields and economic analysis

Differences in okra yields is attributable to better physical conditions of the soil as induced by OF. Table 3 indicates definite beneficial and significant effects of OF on fresh and dry pod weight of okra compared with the control (without OF). Okra fresh pod weight obtained from 60 and 80 kg N ha^{-1} plots were not significantly different from the control during the first and second growing seasons. Higher application of OF ranging from 100 to 140 kg N ha^{-1} significantly ($P<0.05$) performed better than lower rates for both first and second seasons with best from 100 kg N ha^{-1} plot. Any practice that improves soil physical conditions will also enhance crop yield (Salako, 2008). In this work significant correlation coefficient was recorded between bulk density (0-15cm soil depth) and fresh pod weight for both first and second seasons as ($r = -0.61$; $Y = 7.6x- 3.4$) and ($r = -0.92$; $Y = 14.6x-7.8$), respectively. An increase in application rates of OF resulted in decrease in bulk density. Although, no significant difference was observed among the values of fresh pod weight during the third season, highest okra pods were recorded for 100 kg N ha^{-1} plot. On average basis, fresh pod weight from 100 kg N ha^{-1} plot was higher than 120 and 140 kg N ha^{-1} plots by 13.56 and 11.44%, respectively suggesting that applying OF beyond 100 kg N ha^{-1} is not only uneconomic but also detrimental to okra performance. It is clear from economic analysis of the data (Table 4) that maximum average net profit was obtained from 100 kg N ha^{-1} of OF followed by 120 kg N ha^{-1} and 140 kg N ha^{-1}. The increase in net profit over control by OF applied at rates of 100, 120 and 140 kg N ha^{-1} was 35.3%, 20.7% and 19.9%, respectively; suggesting that break-even is achieved when 100 kg N ha^{-1} was applied. The OF applied at rates of 60 and 80 kg N ha^{-1} was lower in average net profit than control by 2% and 8%, respectively. This implies that application of OF below the optimum rate for okra production is non-profitable.

CONCLUSION

On average basis, marketable fresh pod weight from 100 kg N ha^{-1} was higher than 120 and 140 kg N ha^{-1} plots by 13.56 and 11.44 %, respectively. The increase in net profit over control by organic fertilizer applied at the rates of 100, 120 and 140 kg N ha^{-1} was 35.3 %, 20.7 % and 19.9 %, respectively; suggesting that break-even is achieved when 100 kg N ha^{-1} was applied. Resource poor farmers, who cannot afford the cost of applying inorganic fertilizers at every season should apply OF at the rates of 100 kg N ha^{-1} as this rate gave maximum profit at minimum cost.

Table 1: Chemical analysis for organic fertilizer (OF)

Nutrient element	Value
Total nitrogen (%)	3.5
Available P (%)	1.0
Exchangeable K (%)	1.2

Source: *Soil analysis laboratory, Department of Agronomy, University of Ibadan (2007).*

Table 2: Residual effects of organic fertilizer application on soil physical properties after three growing seasons in 2009

Treatment kgNha^{-1}	Sand(gkg^{1})*	Silt (g kg^{-1})*	Clay(gkg^{1})*	Bulk density(gcm^{-3})
		0 - 15 cm soil depth		
Ouma,0(control)	854	92	54	1.73a
60	846	112	54	1.67ab
80	832	112	54	1.66ab
100	829	108	62	1.59b
120	831	112	60	1.56b
140	846	93	60	1.52b
		15 - 30 cm soil depth		
0(control)	869	80	50	1.62a
60	862	84	54	1.63a
80	858	92	52	1.62a
100	846	108	55	1.61a
120	848	98	54	1.63a
140	842	104	54	1.63a

* no significant difference at p = 0.05. Means with the same letters in the same column are not significantly different from each other at P= 0.05 using DMRT.

Table 3: Effect of different rates of organic fertilizer on fresh pod weight (t ha^{-1}) and dry pod weight (t ha^{-1}) as at 14 WAP

Treatment Kg N	Early 2008	Late 2008	Early 2009	Mean
		Fresh pod weight (t ha^{-1})		
0(control)	1.67b	1.24a	1.11a	1.34
60	1.98ab	1.35a	1.15a	1.49
80	1.86b	1.40a	1.14a	1.47
100	2.92a	2.59b	1.58a	2.36
120	2.12ab	2.55b	1.46a	2.04
140	2.26ab	2.50b	1.52a	2.09
		Dry pod weight (t ha^{-1})		
0(control)	0.24a	0.18a	0.12a	0.18
60	0.30a	0.26a	0.14a	0.23
80	0.30a	0.27a	0.13a	0.23
100	0.45b	0.42b	0.33a	0.40
120	0.31ab	0.40b	0.28a	0.33
140	0.31ab	0.41b	0.32a	0.34

Means with the same letters in the same column are not significantly different from each other at P= 0.05 using DMRT.

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Table 4: Economic analysis for response of organic fertilizer levels

Variables	Control	60	80	100	120	140
Variable cost			105			
Fertilizer /bag	0	34	46	57	69	80
Price / bag (₦)	0	51,000	69,000	85,500	103,500	120,000
Transportation of bags(₦)	0	1,240	1,250	1,260	1,280	1,400
Application cost(₦)	0	1,000	1,000	1,000	1,000	1,000
Total variable cost	0	53,240	71,250	87,760	105,780	122,400
Fresh yield (tha^{-1}) early 2008	1.67	1.98	1.86	2.92	2.12	2.26
Gross profit(₦)	167,000	198,000	186,000	292,000	212,000	226,000
Net profit(₦)	167,000	144,760	114,750	204,240	106,220	97,600
Fresh yield (tha^{-1}) late 2008	1.24	1.35	1.40	2.59	2.55	2.50
net profit(₦)	124,000	135,000	140,000	259,000	255,000	250,000
Fresh yield (tha^{-1}) early 2009	1.11	1.15	1.14	1.58	1.46	1.52
Net profit(₦)	111,000	115,000	114,000	158,000	146,000	152,000
Total net profit	402,000	394,760	368,750	621,240	507,220	501,600
Average net profit	134,000	131,586	122,916	207,080	169,073	167,200

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