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Soil Management Methods under Rice Cultivation in Ndokwa Grassland Soils of Delta State, Nigeria

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Abstract

The study examines the soil management methods under rice cultivation in Ndokwa grassland soils with the aim of determining the most effective soil management measures for rice cultivation. Soil samples were collected at three locations where rice is presently cultivated in the area. Five plots of 20m x 20m were randomly selected from each location for assessment, both for cultivated and uncultivated plots. Soil samples were collected and analyzed for physical, chemical and heavy metals properties in the soil using the most probable instruments and analytical methods. The yield of rice harvested was measured in tons per hectares (He). The results revealed that the application of soil management techniques has enhanced rice yields by 23.45tons/He. The combination of slash and burn, tillage and soil amendment indicates the best soil management techniques that enhanced the yield of rice in the area. The result of the multiple regression analysis showed an r value of 0.996, indicating that soil improvement methods *contributed over 99% to soil fertility status of the Ndokwa grassland. The study therefore recommends the adoption of the combination of slash and burn, tillage and soil amendment as the best soil improvement method on rice yied in the Ndokwa grassland soil.*

Keywords: Soil, Management methods, Ndokwa, Grassland

Introduction

Soil is a major component of the environment; it's a major resource of the earth with a lot of potentials, and it was described by Ahn (1970) as the basis of human civilization. The role of soil as a medium for food production cannot be over emphasized. It is in recognition of this fact that Ashaye (1978) described soil as the great provider of food which in turn is the bedrock of civilization. Areola, (1990) asserted that no nation can be stronger than its agriculture". But agricultural development depends, more than anything else, on the ability of a nation to conserve and exploit fully the potential productivity of its soils. Thus, soil management is based not only on soil agricultural productivity but equally importantly on these other critical roles that it plays in man's total environment. Therefore, proper soil management is imperative in order to eliminate or at least minimize the loss of soil fertility on which all forms of life intricately depend. The need to improve and sustain soil productivity at reasonably high level necessitate a well planned soil conservation scheme whose primary objective is the prevention of the deterioration of man's biological environment (Akinbode, 2002)

Farming is the most important occupation in Ndokwa area. The natives, who are mainly farmers, cultivate rice in the grassland soils, and the soil management methods adopted by the farmers in the cultivation of rice in the Ndokwa grassland are long fallow system, slash and burn technique, tillage system and the use of soil amendments. The rice farmers adopt these techniques without knowing the most suitable one at the right time, and the fallow only takes four years, while most of them use planted fallow, very few use natural fallow because of scare land availability and adopts continuous cropping system with occasional planted fallow. But according Salako et al , (2001) soil characteristics of degraded soil could not been easily restored using planted fallow of either tree or herbaceous legumes within 4 years but do for natural fallow, he however concludes that the performance of planted fallow is as good as natural fallow. Hulugalle (1994) has earlier clarified this issue that improvement often found for short planted fallow on degraded soils

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are short lived as soon as the soil is cultivated. It was observed by the farmers that despite these soil management practice, there is still a steady decline in soil fertility even with the application of fertilizer. The questions that agitate their mind is that which is the best soil management techniques that can be adopted in this grassland to enhance rice productivity, thus the study is aimed at assessing the soil characteristics under different soil management techniques in Ndokwa grassland in order to determine the best soil management measures in the area.

Study area

The study area is located in the South – Eastern part of Delta State in the South South Zone of Nigeria. It lies between latitude 5^0 45' N to 6^0 01N and longitude 6^0 06'E to 5^0 45' N to 6^0 01N and longitude 6^0 20'E. It is bounded by river Niger on the East, Isoko North Local Government Area in the South, Ughelli North and Ethiope West and Ika North and South, Aniocha South and Oshimili South Local Government Areas to the North. Ndokwa lies in the coastal plain of Southern Nigeria (see fig 1). The grassland is gently undulating plain without even a single hill rising above the general land surface. The mean elevation of the area is generally below 50 meters above sea level (Okpor, 2002)

The study area is part of Niger Delta and it is underlain by sedimentary rocks, consisting mainly of yellow and white sand with pebbles. Clay and sandy clay occur in lenses (Reyment, 1964). Three geological formations of Benin, Agbada and Akata formations occur in the area and they lie one below the other. The soil is deeply weathered, severely leached, friable, and they lack distinct and well defined horizons. The soils have low silt and clay content, low catio exchange capacity and consequently low pH (Okpor, 2002). The annual mean temperatures is about 27^0C, and mean annual rainfall is 2540mm with September being the wettest month (485.39mm) and January is the direst month (33.27mm). Relative humidity of the air is high throughout the year. During the wet season, it is about 80%, and 60% - 70% during the dry season (Okpor, 2002).

The natural vegetation of Ndokwa is the tropical rainforest. The plant community is basically of evergreen species that yield hardwood *e.g. Entaudrphragma spp, melicia excelsa Khaya ivorensis, Lovoa Trichiliodes etc.* but because of anthropogenic activities there is the emergence of grassland vegetation in many areas in Ndokwa, mainly in patches. This grassland has encouraged practice of rice cultivation in Ndokwa area of Delta State Nigeria.

Materials and methods

Soil samples were collected from rice farms under different soil management measures, and other sets of soil samples were collected from rice farms not under any soil management measure. Soil samples were collected before and after application of soil management techniques, the difference in the soil characteristics gives the soil improvement attributed to soil improvement, soil amendment (NPK 20 20 20 fertilizer) was applied through broadcasting, after fermenting the rice were planted. The three locations of grassland patches in the study area were each divided into five divisions for the purpose of sample selections. In each of the divisions, samples were selected randomly in a quadrat of 20m x 20m at an equidistance point of 10 meters within a predetermined depth of 0 – 10cm, 10-20cm from the top soil, being the threshold of rice cultivation (Omoruyi et al, 2003). The mean of these soil samples were determined and used for the study. The study is based on results of 4 years investigation of three cultivated locations in Ndokwa grassland. The samples collected were placed in a polythene bag and labeled before taken to the laboratory for further processing and analysis.

Soil bulk density was estimated from samples collected from the cultivated and uncultivated plots and was determined on cores (Black, 1965) collected separately, also from the 0 – 10cm layer from the top soil, from each of the divisions in a quadrat of 20m x 20m. The soil samples were immediately weighed before transportation to the laboratory for oven drying at 105^{0c} for 24 hours and re – weighed. Bulk density was then calculated as oven – dry mass (mg) per volume (m3). Total porosity values were calculated from the bulk density figures using an assumed particle density value of $2.65cm^3$ (Vomocil, 1965). With the exception of soil samples collected for density determination, all the other soil samples were air – dried at room temperature, passed through a 2mm sieve and analyzed for particle size composition by hydrometer method (Bouyoucos, 1926). Organic carbon by chromic acid digestion method (Walkley and Black, 1934) total nitrogen by regular micro-kjeldahl method, and available phosphorus by Bray P1 method. Soil pH was determined potentiometrically in distilled water using a soil ratio of 1:1 (Bates, 1964). The yield of rice harvested was weighed in Kilogram per plots (20m x 20m) and were expressed in tons per hectares (He) of rice farm harvested in the grassland.

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Multiple regression analysis was adopted to ascertain if the different soil management techniques adopted over the years has significant improvement on the nutrients status of the cultivated soil of the Ndokwa grassland; this was done with the view of determining the most effective soil management *measure in the grassland.*

Results and Discussion

Data collected are presented in table 1- 3 and discussed below. Table 1 showed that the application soil management measures have improved the fertility of the soil of the Ndokwa grassland soil. For instance Soil pH in water, Organic Carbon, Total Nitrogen, Available Phosphorous and CEC, has improved by 0.3, 1.20%, 0.17%, and 2.74ug/g and 1.6me/g respectively (see table 1 and 2), these improvement are significant at 0.05 (P >.0.06). On the other hand there are reduction in Bulk Density and lead by 0.16g/cm^3 and 0.002mg/l respectively, and these indicate an improvement in the soil characteristics. This corroborated the view of Asadu, Ezeaku and Nnaji (2004) that application of soil management measures enhanced soil fertility in sub Sahara African countries.

The soil fertility indicator of pH, organic carbon, Phosphorous, nitrogen, and cation exchange capacity (CEC) has increased with the introduction of soil management measure in the grassland soil. For instance CEC span 2.96me/g in soil under slash and burn to 6.82(me/g) in soil under the combination of slash and burn, tillage and soil amendment with a mean of 4.80me/g, which is higher than the 3.2me/g in soil before the application of soil improvement measures (see table 2). Similarly after the application of soil management measures, Organic carbon, total nitrogen and available phosphorous recorded mean values of 2.74%, 0.38% and 8.71(ug/g) respectively, which are generally higher than those before the introduction of soil management (see table 2). A critical examination of the individual improvement of these soil management measures revealed that soil under long and planted fallow had 22-23% organic carbon, 0.26-0.27% total nitrogen , 7.28(ug/g) available phosphorous and 4.87me/g CEC, which are higher those in soil before the introduction of soil management measures. Nye and Greenland (1960), categorized the fallow system as shifting cultivation (short fallow) and continuous (no fallow). More, specifically, Asadu and Nweke (1999) described long fallow as less than 10 or more years of cultivation with less than one year of fallow between crops. Nye and

Greenland (1960) noted that an ecological balance of nutrients and soil organic matter (SOM) can be achieved with this system. While the disadvantage of the system lies in its in ability to sustain an increasing population.

Soil under slash and burn improvement measures had a general increased in organic carbon, total nitrogen available phosphorous and CEC over those without soil improvement measures (see table 2). In slash and burn, the farmers use it to incorporate into the soil some of the materials accumulated in the vegetative cover during fallow. The plant ash resulting from the slash and burn technique, improve the soils and also control weeds, insects and pathogens population (Asadu and Nweke, 1999). Also Areola, (1990) opiend that annual bush burning results in most of nitrogen, sulphur and carbon being lost as gases, and also compound the problem of soil deterioration.

Lal (1974) defined tillage as physical, chemical or biological soil manipulation to optimize conditions for seed germination, emergence and seedling establishment. Soil tillage has also showed increased improvement in soil nutrient , as organic carbon, total nitrogen available phosphorous and CEC concentration in soil were generally more than those without soil improvement measures (see table 2). The purpose of tillage is to create a soil environment favorable to plant growth. It also help to minimize nutrient loss (Aina and Egolum,1980). Lal, (1974) noted that organic carbon decreases less when no tillage were used than when the soil were ploughed.

The use of soil amendment considered here are mineral and organic fertilizers as well as lime. Aina and Egolum (1980) illustrated how high doses of N and P were able to restore the original top soil. They also showed that a combination of NPK fertilizer alone can improve soil productivity. While Asadu and Nweke (1999) noted that fertilizers may not necessary result in increased soil content of the fertilizer element especially after the crop has been removed. Over the years, the yield from rice has been decreasing. This low yield has been attributed to poor soil management by some farmers in the area. But with the introduction of soil amendment and organic residues it enhanced the soil fertility status of the grassland soil (see table 2). The highest soil fertility improvement were generally observed in soil under the combination of slash and burn, tillage and soil amendment, which had an increased of 1.84%, organic carbon 0.58%.total nitrogen, 6.69ug/ available phosphorous and 3.62me/g CEC over those soil without soil improvement

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The introduction of soil management techniques has improved the yield of rice cultivated in the Ndokwa grassland soil which is indicated in the yields of rice harvested from the farms under different soil management measures (see table 3). The application of soil management techniques has enhanced the yields of rice by 23.45tons/He, indicating over 200% increase in rice yields. Table 3 showed that the highest and lowest yields of rice were harvested from farms under the combination of slash and burn, tillage and soil amendment (66.32 tons/He) and slash and burn (11.72 tons/He), and indicate that the combination of slash and burn, tillage and soil amendment is the best soil management techniques that enhances the yield of rice in Ndokwa grassland soil of Nigeria.

The zero order correlation showed that the soil management measure adopted by the farmers has positive relationship to soil fertility status of the grassland soil (see table 4 and 5). The joint contribution of these soil improvement methods recorded 0.996 r value (see table 5), this is significant at P>0.05 confidence level (see table 6).

Thus, the addition of soil improvement methods to the soil of the Ndokwa grassland has contributed 99% to the soil fertility status of the Ndokwa grassland soil. The t values are significant at P>0.05 confidence levels (see table 6).

Conclusion

This study has examined the various soil management methods under rice cultivation in Ndokwa grassland soils. The study revealed that the various soil management techniques adopted over the years by the farmers has a significant improvement on the nutrient status of the soil of the grassland. With the improvement been more in rice farms under the combination of slash and burn, tillage and soil amendment; and lowest in those farms under slash and burn alone. use of soil amendment, tillage system, fallow system, and the slash and burn technique. And similarly, the introduction of other soil management measures like, the use of organic residue, use of cover crops, liming, etc will help in enhancing the fertility of the soil.

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Table 1: Mean soil properties before and after Application of soil management techniques

Soil Properties	Before soil management	After soil management	Improvement
Sand (%)	85.63 ± 78.2 – 90.2	83.45 ± 75.1-88.2	-2.18
Silt (%)	7.25 ± 3.5 - 12.4	7.54 ± 5.1 – 10.4	0.29
Clay (%)	7.12 ± 2.4 – 10.4	6.38 ± 4.3 – 10.4	0.74
Bulk Density (g/cm^3)	**1.02 ± 0.94 – 1.02**	0.86 ± 0.79 – 1. 07	-0.16
Total Porosity (%)	**61.56 ± 58.5 – 62.34**	63.20 ± 60.40 – 69.91	1.64
Soil pH (in water)	**4.3 ± 3.8 - 5.2**	4.6 ± 4.0 – 6.5	0.3*
Organic Carbon (%)	**1.54 ± 0.16 – 3.47**	2.74 ± 2.16 – 4.14	1.20*
Total Nitrogen (%)	**0.21 ± 0.12 – 0.3**	0.38 ± 0.26 – 0.76	0.17*
Available Phos (ug/g)	**5.97 ± 2.20 – 7.28**	8.71 ± 6.90 – 12.65	2.74*
CEC (me/g)	**3.2 ± 0.84 – 6.36**	4.80 ± 2.86 – 6.82	1.6*
Lead (mg/1)	**0.009 ± 0.005 – 0.011**	0.0068 ± 0.002 – 0.008	-0.002

*r = 0.999 (P>0.05)

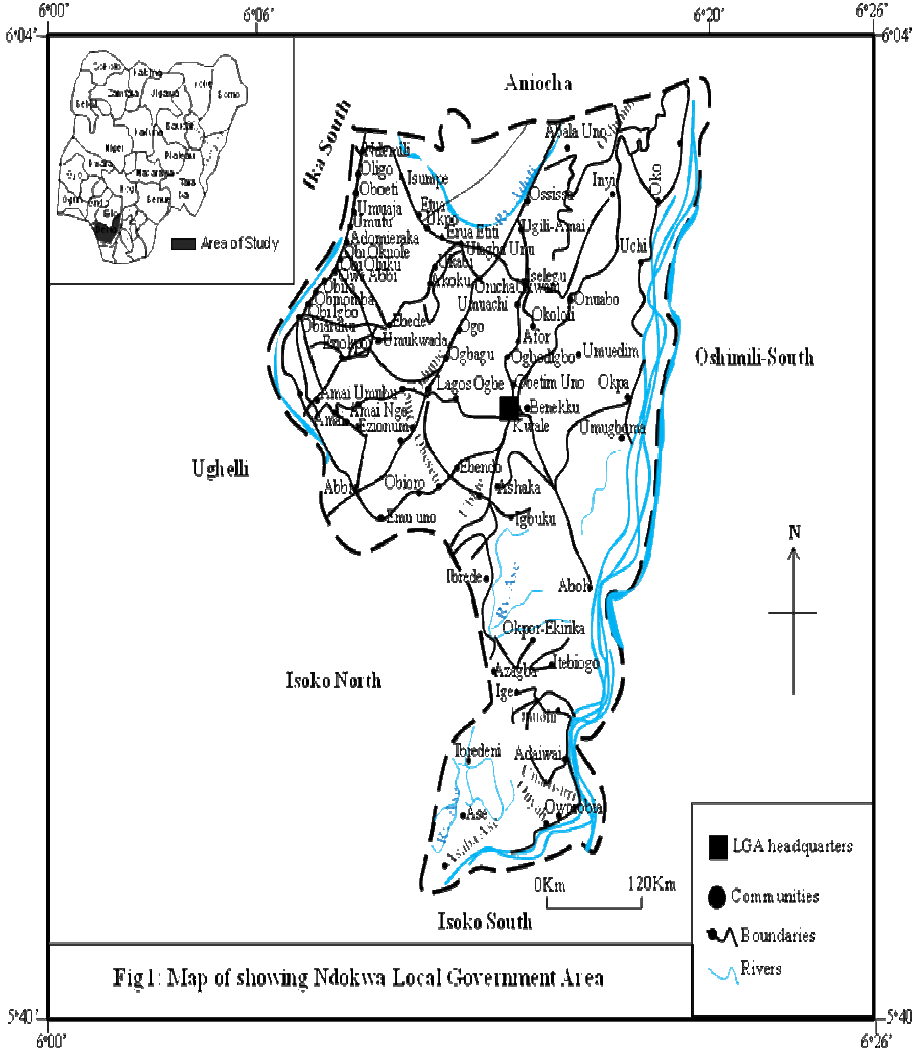

Fig 1: Map of showing Ndokwa Local Government Area

Table 2: Mean soil properties under different soil management techniques

Soil Properties	No Soil Mgt	Long Fallow System	Planted Fallow	Slash & Burn	Tillage System	Soil Amend	Slash & Burn + soil amend	Organic Residue	Mean
Sand	81.2	86.2	85.4	84.2	79.2	88.2	75.1	88.1	83.45
Silt (%)	8.2	5.2	5.1	9.4	10.4	7.4	7.0	7.5	7.54
Clay (%)	7.9	6.2	6.0	6.4	10.4	4.4	5.4	4.3	6.38
Bulk Density	0.79	0.98	0.99	1.03	0.07	0.99	1.07	0.99	0.86
Total Porosity	69.91	63.02	63.02	61.13	63.40	62.64	60.40	62.04	63.20
Soil pH	4.9	4.5	4.5	3.9	4.4	4.1	6.5	4.0	4.6
Organic Carbon (%)	1.33	2.23	2.22	2.20	2.16	3.17	4.14	3.07	2.74
Total Nitrogen (%)	0.18	0.27	0.26	0.27	0.32	0.45	0.76	0.35	0.38
Available Phosphorus (ug/g)	5.96	7.28	7.28	6.90	8.45	9.80	12.65	8.60	8.71
CEC (me/g)	3.2	4.87	4.80	2.86	4.82	4.84	6.82	4.60	4.80
Lead	0.003	0.007	0.007	0.011	0.008	0.008	0.002	0.008	0.006 8

Source: Field Survey, 2007.

Table 3: Mean Yield of Rice (Tons/He) under different Soil Management Techniques in Ndokwa Grassland

Locations	Rice Yield Before Soil Mgt	Fallow System	Planted Fallow	Slash & Burn	Tillage System	Soil Amend	Slash & Burn, Tillage and soil amend	Organic Residue	Mean Yield of Rice under Soil Mgt
Ogbe Ogume	3.05	8.02	6.12	4.26	17.39	14.01	23.09	14.00	12.41
Utagbe-Uno	3.00	8.01	6.00	4.08	13.67	13.08	23.00	13.21	11.58
Ossissa	2.45	6.02	5.01	3.38	-	10.06	20.23	11.04	7.96
Total	**8.5**	**22.05**	**17.13**	**11.72**	**31.06**	**37.15**	**66.32**	**38.25**	**31.95**

Table 4: Zero order correlation analysis of soil management methods on soil nutrient status

Soil Mgt methods	No mgt	fallow	Plant fallow	Slash burn	tillage	Soil amend	Slash/ burn, tillage soil amend	Organic residue
No mgt	1.000	.995	996	.995	.997	.994	.995	.993
Nat fallow	.992	1.000	1.000	.998	.996	.998	.996	.998
Planted fallow	.992	1.000	1.000	.998	.996	.998	.996	.998
Slash /burn	.993	.998	.998	1.00 0	.997	.999	.993	.999
Tillage	.994	.996	.996	.997	1.000	.994	.995	.994
Soil amend	.995	.998	.998	.999	.994	1.000	.993	1.000
Slash/burn, tillage, soil amend	.997	.996	.996	.993	.995	.993	1.000	.992
Organic	.994	.998	.998	.999	.994	1.000	.992	1.000

Table 5: Summary of regression Analysis of Soil Management Methods on Soil Nutrient Status

Model	R	R Square	Adjusted R. Square	Std. Error of the Estimate	Durbin-Waston
1	.998 (a)	.996	.992	2.65664	1.302

(a) Predictors: (Constant), organic, slash/burn, tillage and soil amend, tillage, fallow, slash burn

(b) Dependent Variable: soil under no management method

Table 6: Standardized Beta Coefficients of Soil Management Methods on Soil Nutrient Status

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	Lower Bound	Upper Bound
(Constant)	.300	1.530		.196	.857
Long fallow	-4.608	2.173	-4.659	-2.121	.124
Planted fallow	6.083	2.479	6.085	2.454	.091
Slash and burn	2.667	1.460	2.601	1.827	.165
Tillage system	-.597	.807	-.565	-.739	.513
Slash & burn, tillage and soil amendment	.549	.823	.489	.668	.552
Organic residue	-2.945	.947	-2.967	-3.111	.053

a Dependent Variable: nomgt