

Agro-ecological Influence on the Nutrient Status and Physico-Chemical Dynamics of the Ultisols of Rural Ehom, Cross River State, Nigeria

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Abstract A study on the agro-ecological influence on nutrient status and physicochemical dynamics of ultisols was conducted in Ehom in Cross River State, Nigeria. The objective was to ascertain the effect of key traditional farming practices on nutrients and physicochemical properties of soils in the area. Soil samples were manually collected for laboratory determination of these properties. Descriptive statistics was used to determine variation in the textural characteristics of soil while Analysis of variance (ANOVA) was used to test variation in soil chemical characteristics. Results proved that traditional bush burning has beneficial effects of adding potassium (K) into the soil while nitrogen (N) and phosphorus (P) were adequately enhanced through the application of artificial fertilizer on one hand and the incorporation of plant's residues into the soil on the other. Tillage and slashed treatments facilitated soil organic carbon and other plant's nutrients absorption but exerted little or no influence on the textural characteristics of soil. The reason is the value of soil textural classes was not statistically different across treatment blocks. Descriptive statistics also proved that all nutrients/chemical properties of soil were altered considerably as mean pH values of 5.32 B/F and 6.62 A/F in burn treatment practice and the soil Organic carbon content also altered considerably from a mean of 2.8 to

4.56. Analysis of variance indicates that there was a significant difference in all nutrients/chemical properties of soil at 0.05 probability level indicating that on farm treatment methods altered soil nutrient and chemical properties considerably. The study recommends adoption of sound agricultural practices taking into consideration the prevailing soil and environmental condition.

Keywords Agricultural Practice, Nutrient Dynamics, Physicochemical Properties, Treatment Blocks

1. Introduction

Productivity is not an absolute measure but rather a reflection of the ratio between inputs and outputs. An agricultural land doubles in productivity and produces double over the previous years may not be an indication of its fertile status. The increase in productivity may be a function of the prevailing management practice. [9] observed that land treatment method has profound influence on soil nutrient status. Thus, to ensure adequate nutrient in the soil, appropriate treatment measures must be adopted [15,13]. The availability of soil nutrient in

required amount is a prerequisite for the attainment of sufficient food production [7].

The most essential nutrient elements required for increased food production are soil dependent. They are obtained from soil for plant growth and development. The availability of soil nutrients in required amount is an important pre-requisite for the attainment of sufficient food production [7,10]. However, the important soil nutrients constraint have been identified to include excessive removal of vegetation, poor agricultural practices and topography [1,8].

In an agro-ecological environment where soil is nutrient deficient, improvement in soil nutrient is required to be replenished [6,4]. Appropriate land treatment methods must also be adopted [15] [13]. It involves various on farm agricultural practices meant to facilitate crop production processes.

Use of manure to improve soil structure, aggregation, infiltration and microbial activity is advocated by [11] and [12]. However, [3, 5] suggested to treat soil with residue to enhances return rate of Nitrogen and Phosphorus. Burning was earlier known to significantly decrease soil nitrate- nitrogen, available phosphorus and sulphur but increase exchangeable calcium (Ca) and available potassium (K) [2].

Nigeria is known for its rich agricultural potentials. Thus from the northern Sahara to the Southern tropical landscape, high agricultural productivity had never been in doubt except in recent times when a sharp decline in soil nutrient is increasingly noticeable. In Cross River State where Ehom is an integral part of the issue of nutrient depletion is becoming a major source of concern. Thus, a search is always there for alternative land treatment method in order to improve land condition. This paper seeks to assess a variety of land treatment methods with a view to ascertaining their effect on soil nutrient status on one hand and the nexus between physicochemical parameters and the various agricultural treatment methods on the other.

2. Materials and Methods

Study Area

The study was conducted in Ehom, Biase Local Government Area of Cross River State. It is located between longitudes $8^{\circ} 08'$ and $8^{\circ} 11'E$ of the Greenwich Meridian and within latitudes $5^{\circ} 27'1''$ and $8^{\circ} 30'1''N$ of the Equator. The landform consists of gentle uniform slope gradient with homogeneous textural characteristics. The landscape can be best described in term of its geospatial characteristics. It is a tropical rainforest soil located within the equatorial climate of $5^{\circ}N$. [17] described soils within this area as tropical rainforest soil having high sunshine, heavy rainfall and considerable moisture content. Such a

condition can encourage rapid decay of plant residue as well as favour the adoption of a variety of farming practices with a view to boosting crop production.

Land preparation

Land preparation was done following the traditional method of clearing. This was so in view of the anthropological activities that has reduced the pristine vegetation to disturb the ecosystem. Four sites were carefully selected to represent the respective treatment blocks *viz*: tillage, fertilizer, burn and residue/slash blocks. Each of these blocks were subsequently demarcated into five plots (sub-blocks) to represent cassava, maize, melon, cocoyam and mixed crop plots respectively. Each block measured 30m x 30m while the demarcated crops plots measured 5m x 30m each with 1m space in-between the plots. The rationale for using crops was to reflect the locally grown crops in the area. Soil samples were collected with the aid of soil auger from a depth of 0-3cm for Laboratory analysis for the physico-chemical properties Before (B/F) and (A/F) treatments were done

3. Result and Discussion

The data in Table 1 reveals the means and ranges of soil physical characteristics in the experimental blocks. Result of the particle distribution of means and ranges obtained from the various treatment blocks did not differ significantly, before and after treatments. For example, a range of 68-69% was obtained (B/F) and 68-69% after (A/F) treatment and a mean of 68.4% and 69.2% of sand were obtained before and after treatment in tillage block. Silt range was 16-20% (B/F) and 15-20% (A/F). While that of clay ranged from 11-16% B/F and 10-16% A/F and mean of 13.6 B/F and 12.8% A/F respectively. Similar result replicated itself across the other treatment blocks. The data in Table 2 reveals the coefficient of variation of particle size distribution. The following variation ranges constituted standard for determination of variation. Variation was low (0-15%) moderate (15-30%) and high (>30%). Thus in all the blocks CVs range for sand was 7.6%, 14.4-16.0% for silt and 15.0-16.99% for clay. The CVs range was within 0-15% meaning that variation of soil in the treatment blocks was apparently low. Table 1&2 are useful in explaining the physical characteristics of soils in the area. The above tables reveal that the soils were homogenous thus various treatment method did not exert significant effect on their physical properties. This is probably because it takes a longer time to alter soil considerably to warrant statistical variability [14]. The data in table 3 are the means and ranges of chemical properties taken before (B/F) and after (A/F). It reveals that pH values were altered in burn treatment block with a mean of 6.62 before and 5.6 after treatment and a range of 6.5-6.8 B/F and 5.4-6.0 A/F treatment. This treatment

proved that plant utilized the burnt plant materials (ash). The total nitrogen (TN) was greatly enhanced in the fertilizer blocks, meaning that the treatment of land with organic fertilizer had contributed immensely by adjusting the mean value from 0.96-1.05 and a range of 0.89-1.02 and 1.0-1.20 indicating positive adjustment. The soil organic carbon (org. C) percent increased indicating

positive adjustment. The soil organic carbon (soc) increased considerably in the slash/residue block where plant parts are allowed to decompose. Here it has concluded that the soc increased from a mean of 2.8% to 4.56% and range of 2.70-2.96 and 3.9-7.0% respectively. Makinde (1996) obtained similar result with different crops.

Table 1. Textural characteristics of soil across treatments

Treatment block	Percentage						Texture
	Sand		Silt		Clay		
	B/F	A/F	B/F	A/F	B/F	A/F	
Residue/Slash							
Mean	62.8	61.9	19.0	19.2	15.4	15.4	SL
Range	58-65	57-65	18-21	19-20	13.17	14.17	
Burn							
Mean	66.4	67.0	15.4	14.6	18.2	17.4	SL
Range	64-70	65-70	14-17	13-17	15-19	15-19	
Fertilizer							
Mean	62.8	61.9 20.2	21.0	15.4	15.4		SL
Range	58-65	57-65	18-21	19-20	13.17	14.17	
Tillage							
Mean	68.4	69.2	18.0	18.0	13.6	12.8	SL
Range	68-69	68-69	16.20	15.20	11-16	10-16	

Blocks indicating means and ranges before after treatment

B/F = before treatment

A/F = after treatment

SL = Sandy Loam

Table 2. Shows coefficient of variation of texture classes (properties)

Treatment Block	Percentage		
	%sand	% self	% clay
Tillage	7.6	14.4	16.9
Fertilizer	8.0	13.9	15.
Residue	2.2	14.2	16.0
Burn	7.8	16.0	15.0
Range	7.6-8.0	13.9-16.0	15.0-16.9

Table 3. Soil chemical parameters taken before (B/F) and after (A/F) treatments

Soil Parameters	Tillage		Fertilizer		Slash		Burn	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
TN%								
Before (B/F)	1.08	1.00-1.2	1.02	1.0-1.06	1.16	1.10-1.20	2.58	2.5-2.7
After (A/F)	1.02	0.0-1.30	0.88	0.8-0.9	1.14	1.00-1.20	0.5	0.3-0.60
Mg (cmol/kg)								
Before (B/F)	1.01	1.0-1.02	0.96-102	0.9-1.2	0.29	0.20-0.40	0.54	0.12-1.16
After (A/F)	0.92	0.8-1.00	0.12-0.14	1.0-1.20	0.29	0.11-0.30	0.46	0.11-0.98
P H								
Before (B/F)	5.02	4.9-5.1	5.08	4.9-5.2	5.32	5.2-5.4	6.62	6.5-6.8
After (A/F)s	5.76	5.4-6.0	4.06	4.8-4.9	5.5	5.1-6.0	5.6	5.4-6.0
Org. C%								
Before (B/F)	1.19	1.18-1.20	1.90	1.89- 90	2.8	2.70-2.96	2.58	2.5-2.7
After (A/F)	2.54	2.00-3.00	2.30	1.69-4.70	4.56	3.9-7.0	1.174	1.6-1.9
A.V.P (%)								
Before(B/F)	3.10	3.0-3.2	2.42	2.19-2.60	3.72	3.69-3.8	3.64	3.6-3.8
After (A/F)	2.82	2.70-3.00	2.48	2.2-2.9	3.57	3.31-3.70	3.34	3.1-3.5
Ca (cmol/kg)								
Before (B/F)	1.70	1.6-1.80	3.29	3.25-3.40	303	3.0-3.1	3.14	3.0-3.8
After (A/F)	1.70	1.50-1.80	3.22	3.0-3.40	3.01	3.0-3.01	2.7	2.6-2.8
Na cmol/kg								
Before (B/F)	0.06	0.6-07	0.08	0.07-0.09	0.09	1.1-1.20		0.05-0.15
After (A/F)	0.06	0.04-0.08	0.08	0.06-0.12	0.10	1.0-1.20		0.09-0.14
K cmol/kg								
Before (B/F)	0.09	0.08-01.0	0.13	0.4-0.5	2.70	0.11-1.16	2.14	2.13-2.17
After (A/F)	0.08	0.06-0.10	1.03	0.45-0.55	0.11	0.09-0.14	1.50	1.12-2.10

Table 4. Soil chemical due to treatment methods

Soil parameters	Sign of squares	DF	Means square	F.cal	Sign
AN.P	9.19621	3	3.0654	132.04	< 001
Ca	14.3558	3	4.7852	365.27	< 001
K	6.6534	3	0.5511	1331.49	< 001
Mg	2.0027	3	0.6675	56.78	< 001
Na	0.0181	3	0.0060	19.69	< 001
Soil Org. C	23.0464	3	7.6821	30.36	< 001
TN	4.0437	3	1.3479	20.71	< 001
PH	6.6960	3	2.2320	43.34	< 001

The exchangeable bases (Ca, Mg, Na and K) were affected by the various treatment methods thus, there was reduction in the mean and ranges of Ca, Mg, Na across blocks while range value of potassium (K) altered positively from 0.12-0.14 to 1.00-1.06 and mean value from 0.13 to 1.03 which indicated an increase in value. Similar result was also obtained in burnt block. The data in Table 4 shows variation in soil chemical properties due to treatment methods. It was evident that there was significant different at 0.05 level of probability implying that land treatment method altered soil nutrient status significantly in the study area.

4. Conclusions

Soil nutrient management is essential for sustainable

agricultural production. Appropriate farming practice is capable of modifying and influencing on soil nutrient status. The efficacy of these nutrients reflects the soil's ability to stimulate growth potentials in crops and enhancement of textural and structural stability of soil through residue enrichment process. In an agro ecological environment where soil inhibiting factors are prevalent, adequate knowledge of nutrients and physicochemical dynamics can doubtless constitute veritable platforms for optimal utilization of agricultural landscape for increased food production. The significance of the study can be viewed from the perspectives of the contributions of various farming practices. For example, traditional bush burning has attendant beneficial effects of adding some amount of potassium into the soil while Nitrogen (N) and phosphorus (P) were adequately enhanced through the

application of fertilizer on one hand and the incorporation of plant's residues into the soil. Tillage and slashed treatments facilitated organic carbon and other plant's nutrients absorption but exerted little or no influence on the textural characteristics of soil.

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