



Effect of Cropping Practice on Fertility Status of the Northern Guinea Savannah Soil of the National Open University of Nigeria (NOUN) Research Farm in Rigachikun, Kaduna State Nigeria

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ABSTRACT

This study investigated the impact of cropping systems on soil fertility status at the NOUN Research Farm, Kaduna State, Nigeria. Two sites within the farm were utilized for monocropping and mixed cropping, while a fallow land served as the control. Sixty soil samples were collected from the three sites at a depth of 0–20 cm and analyzed for chemical properties in the laboratory. The analysis revealed that the mean values of soil chemical properties decreased from fallow land to monocropping and mixed cropping systems. This decline in nutrient content under the two cropping systems, compared to the fallow land, led to a significant reduction in crop output. These findings indicate that cropping systems influence soil elements, fertility status, and ultimately agricultural productivity. To address these challenges, the study recommends adopting appropriate environmental soil management techniques to enhance soil fertility and ensure sustainable food production.

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INTRODUCTION

Soil is a natural body and formed under various ecosystems with the help of various factors. It is the end product of the combined influence of natural processes controlled by climate, topography, organisms, parent material and climate. Mineral soils hardly contain 1-2% organic matter. Most of the soil materials are inorganic aluminum-silicates. Yet the soil is considered as a living body since it helps survival of numerous micro- and macro-organisms through physical and nutritional support. Many scientists believe that there are more species in existence below the soil surface than above it. Some organisms are plant and human pathogens and most of them are innocuous and benign. Soil is a complex mixture of minerals, organic matter, liquids, gases, and microorganisms that all work together to support life. It is the top layer of the earth's surface made up of organic remains, clay, and rock materials on which plants grow. It promotes plant growth and life. It is constantly

evolving due to a variety of physical, chemical, and biological processes such as Weathering and erosion. Soil responds to improvement or deterioration in properties and fertility status due to human impacts. Man affects his environment as he responds to the changing conditions set by the environment and the environment's response to human manipulation, thereby creating a state of dynamic equilibrium that continues to adjust and re-adjust in space with time (Olofin, 2000). Man's activities in his immediate environment often led to a number of problems whose consequences may be positive or negative. Modification in soil properties within a region or agricultural zone due to human-induced practices had been noted. For example, Oriola (2004), in a study on Irrigation farming practice reported that some soil chemical elements were translocated when water was applied to the field.

The physical, chemical, and biological properties of soil are paramount to crop yield. Absence of any of these acts as limiting factor and

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crop as a whole suffer (Dutta, 1986). The soil chemical properties (organic carbon, total nitrogen, phosphorus, cation exchangeable capacity and exchangeable bases) are in particular associated with the colloid fraction and affect nutrients availability, biota growing conditions, and in some cases, soil physical properties (Yakub, 2012).

Study Area

The study area is located on the Latitudes $10^{\circ} 36'$ and $10^{\circ} 60' N$ and Longitudes $7^{\circ} 25'$ and $7^{\circ} 40' E$ respectively and in the north western Nigeria. It has been characterized as a region where the rainfall is unimodal in pattern and between 900 – 1300 mm per annum (Uyovbisere and Lombin 1998). The region also has a wave-like but relatively plain relief, with general elevation from about 450 to 700 m, dominated by mostly sandy soils, which are usually very low in organic matter, may degrade rapidly under conditions of very high rainfall. The region is also known for its high annual average temperature ($28-32^{\circ}C$), short wet season and long dry season (6-9 months). Generally, soil moisture and temperature regimes in the area are inferred to be ustic and isohyperthermic respectively. During the rainy season however, mean temperature drops to $25^{\circ}C - 28^{\circ}C$ (June to September) and decreases to less than $20^{\circ}C$ in the months between December and February (Gabasawa et al., 2017). Tree cover varies from open woodland to light forest which has been reduced to bare land due to uncontrolled tree felling for fuel as well as farming activities (Carsky et al., 1998) while abundant short grasses (<2 m) are also available (Swami & Akintola, 2010).

MATERIAL AND METHODS

Soil Sample Collection

Soil samples were taken using soil Augur for the determination of chemical properties of soils for within the research Farm for both mono cropping and mixed cropping systems and fallow land to serve as the control. Twenty (20) Soil samples were collected from each of the three sampling areas. A total of sixty (60) soil samples were taken at 0 – 20cm depth.

Laboratory Analysis

The collected soil samples were taken to the laboratory analyses to determine essential soil chemical parameters using standard laboratory analytical methods. Soil organic matter (OM) was determined based on the chromate wet oxidation method (Walkey – Black 1934); Total Nitrogen (N) was determined using Macro – Kjeldhal digestion distillation (Bremner, 1965); Available Phosphorus (P) was analyzed using Bray No. 1 method (Olsen and Dean, 1965) and Exchangeable bases (K, Na, Ca, and Mg) were extracted using neutral ammonium acetate. While potassium (K) and sodium (Na) were determined using the flame photometry method (Chapman, 1965), calcium (Ca) and magnesium (Mg) concentration were determined by the use of Atomic Absorption Spectrophotometer (Chapman, 1965). The Cation Exchange Capacity (CEC) was determined using ammonium acetate extraction method while the percentage Base saturation was derived through the addition of the exchangeable cations' values divided by the CEC value and multiply by 100 $[EC/CEC (100)]$.

Statistical Analysis

Both descriptive and inferential statistics were used to summarize and draw inferences from the results. Co-efficient of Variation was employed to measure the variation in the means of the element within the data sets, ANOVA was used to establish significant differences among the means of soil properties of the mono cropping farmland, mixed cropping farmland and fallow land while New Duncan Multiple Range test was used to identify soil chemical properties that are significantly different from one another in the sampled land uses.

RESULTS AND DISCUSSION

The result of soil chemical properties for the two-cropping system and fallow land considered is presented in table 1. The mean values of soil chemical properties are highest in the fallow land and reduce through mono cropping system while mixed cropping system has the least mean value.

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Organic matter content decreases from a mean of 1.43% in fallow land site through 1.25% to 1.10% in mono cropping and mixed cropping farmlands respectively. The high-level content of Organic matter observed in the fallow area can be due to the accumulated humus as a result of falling leaves and dead plant decay. The mean value of organic matter content observed in fallow area corresponds with that of Yakubu (2012). Differences observed between the fallow area and

the two cropping systems may reflect the differences in vegetation cover, turnover of organic matter and the degree and frequency of soil disturbance (Jaiyeoba, 1995). The relatively low organic matter seen in mixed cropping system may be attributed to their lost through extensive cultivation and multi-cropping.

Table 1: Soil Chemical Properties analyzed

S/N.	SOIL PROPERTIES	FALLOW LAND			MONO CROPPING			MIXED CROPPING		
		X	S.D.	C.V.	X	S.D.	C.V.	X	S.D.	C.V.
1.	pH H ₂ O	6.81	0.55	8.07	5.85	0.38	6.49	6.06	0.59	9.74
2.	Nitrogen%	0.65	0.28	29.1	0.40	0.16	8.16	0.30	0.10	31.25
3	OC%	0.94	0.23	24.47	0.795	0.17	21.38	0.62	0.13	20.96
4.	OM%	1.43	0.39	24.07	1.25	0.299	21.51	1.10	0.23	21.29
5.	Ca ²⁺ cmol/kg	2.03	0.65	21.38	1.50	0.56	28.43	1.20	0.43	27.92
6.	Mg ²⁺ cmol/kg	1.20	0.59	39.07	0.75	0.43	44.33	0.51	0.30	35.29
7.	Na ⁺ cmol/kg	0.71	0.12	13.19	0.43	0.129	21.86	0.31	0.10	23.26
8.	K ⁺ cmol/kg	2.15	0.81	7.66	1.55	0.12	6.98	1.20	0.20	16.26
9.	EA cmol/kg	0.064	0.015	33.43	0.087	0.026	29.88	0.152	3.80	25.00
10.	CEC cmol/kg	6.50	0.93	11.92	5.10	0.71	13.45	4.01	0.66	12.96
11.	Base stn %	70.00	0.87	0.87	69.33	0.57	0.57	61.20	1.46	1.52
12.	Available P(mg/kg)	3.41	0.68	18.04	1.42	0.44	25.58	0.70	0.23	23.95

x=means, SD= Standard deviation, C.V =Coefficient of variation, (*significant C. V > 33%)

Total Nitrogen decreases from a mean of 0.65% in fallow land site through 0.40% to 0.30% in mono cropping and mixed cropping farmlands. The higher value over the fallow land can be explained in terms of symbiotic relationship of the dense herbaceous undergrowth that releases or fixed nitrogen and rapid humification. The relatively lower mean values in mono and mixed cropping may be attributed to inadequate application of nitrogen based chemical fertilizers, increasing immobilization by plants as well as leaching and volatilization which is common to most mineral soils (Jones and Weld 1975; Brady and Weil, 2002).

The mean values of exchangeable cations (Ca, Mg, Na and K) in table 1 show that the fallow land is very rich in the base elements with exchangeable calcium being the most abundant cation in the soil. Calcium content decreases from a mean of 2.03cmol/kg in fallow

land through 1.50cmol/kg to 1.20cmol/kg in both mono cropping and mixed cropping. These base elements are generally low in both mono-cropping and mixed cropping. The variation in the base elements across the three areas will be reflected in the growth rate as well as the translocation and storage of carbohydrates and proteins into seed and tubers. The comparatively low values for the two cropping systems may be due to reflection of losses through leaching, cultivation or harvesting (Wilson and Kang, 1983; Jaiyeoba, 1995). Magnesium which also plays important role in photosynthesis varied significantly in the three areas. The magnesium content decreases from a mean of 1.20cmol/kg in fallow land through 0.75cmol/kg to 0.51cmol/kg in mono cropping and mixed cropping. Sodium content decreases from mean value of 0.71cmol/kg in fallow area through 0.43cmol/kg to 0.31cmol/kg in the mono and mixed cropping areas. Potassium equally

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decreases from a mean of 2.15cmol/kg in fallow land through 1.55cmol/kg to 1.20cmol/kg in mono cropping and mixed cropping areas. This reduction delays plants growth and hence variation in crop yields is bound to occur between the cropping systems.

Available Phosphorous (P) which increases plant resistance to disease decreases from a mean of 3.41mg/kg in fallow land through 1.42mg/kg to 0.70mg/kg in mono cropping and mixed cropping farmlands respectively. The phosphorous content on fallow land is basically high. This also goes with high organic matter content obtained on fallow area. This agrees with the work of Adamu and Dawaki (2008) that Phosphorus content in soil is also another factor that agrees with the organic matter content.

The mean value of CEC is high in the fallow area 6.50 and reduces to 5.10 in mono and 4.01 in mixed cropping areas. The pattern of CEC over the three sampled sites is similar to that of organic matter content. This may be attributed to the fact that organic matter and clay are the principal soil colloids materials upon which the phenomenal of CEC processes rests (Fitzpatrick, 1980). The observed variation in CEC over the

three areas agreed with the findings of Asadu et al., (2001).

The result shows that % base saturation is higher for fallow area and mono cropping system. The mean values range between 70% in fallow to 69% in mono cropping and 61% for mixed cropping. This implies that the soil under fallow and mono cropping are more fertile because soil with a high % base saturation contain greater amount of the essential plant nutrients cations of (K^+ , Ca^{2+} and Mg^{2+}) for use by plants. The PH revealed that the soils of the three sampling plots were slightly acidic with mean values of 6.81 in fallow, 5.58 in mono cropping and 6.06 in mixed cropping. This implies that most nutrients needed by plants will dissolve easily for proper uptake by roots.

Analysis of Variance

The result of the analysis of variance (ANOVA) contained in table 2 confirmed the differences in the means of the soil chemical elements in the three sampled areas. It revealed that all soil properties selected for investigation were found to be significantly different from each other at $p=0.05$ level of significant.

Table 2: ANOVA Statistical Test Performed on the Sampled Sites

Source of variation	Sum of Square	Df	Mean of Square	F	p-value	F-crit
Between	9.536	2	4.678	6.0799E-03	.994	3.288
Error	2.5392+04	33	769.5			
Total	2.5401E+04	35				

It shows that $F(2, 33) = 6.08$ at P-value of 0.99. Since the $F_{obs} = 6.08$ is greater than the $F_{crit} = 3.29$, this implies that the means of soil chemical properties are significantly different for fallow, mixed cropping and mono cropping systems. It was generally observed that soil of the fallow land is much richer in fertility than the two cropping systems. It should however be noted that the fallow area here have undergone a long fallow period. Despite the fact that fallowing is an important way of restoring soil fertility, the ability of fallow vegetation to cause significant changes in soil condition varies considerable from one

bioclimatic environment to another. Areola et al. (1982) observed in south-western Nigeria that the built up in most of the nutrient elements in some fallow soils have by the 8th fallow years come close to equilibrium.

CONCLUSION AND RECOMMENDATIONS

Generally, the study revealed that the contents of the soil chemical elements vary as cropping system changes, hence the production level of soil in the study area will vary from one cropping systems to another. It can be concluded from this study that the fertility status of soil under

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mono cropping system is higher than that of mixed cropping. This is due to relatively higher values of chemical properties obtained on mono cropping area. This is an indication to and a pointer that cultivation and cropping systems cause reduction in most soil chemical properties that are important indicator of soil quality and fertility. These properties are paramount to crop growth and increased productivity. It is therefore recommended that appropriate soil management practice suitable for these cropping systems be apply to enhance soil fertility and sustain food production in general.

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