The Impact of Cropping Systems on Fertility Status of Soil in Babanla Rural Area, Nigeria

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ABSTRACT

This study was carried out to examine the impact of cropping systems on fertility status of soil in Babanla rural community of Kwara State, Nigeria. Two farms sites of mono cropping and mixed cropping and a fallow land (control) within the same ecological zone were used for the study. Sixty soil samples were collected from the three sites at 0-20cm depth from a 25m x 25m quadrat. Soil samples collected were subjected to laboratory analysis for essential soil chemical properties that are paramount to soil fertility. The results of the analysis revealed that the means values of the chemical properties decreases through fallow land to mono cropping and mixed cropping system. As a result of the reduction in the nutrient contents of the soils under the two cropping systems, when compared with the contents on fallow land, a significant variation in crop output is inevitable. This means that the cropping systems have effects on soil elements, fertility status and has implications for agricultural productivity. It is recommended that appropriate environmentally friendly soil management techniques suitable for each cropping system should be adopted by farmer to enhance soil fertility and sustain food production in the study area and Nigeria in general.

Keywords: Cropping system, soil, fertility status, chemical properties, babanla, rural area

INTRODUCTION

The soil constitutes a natural resource base for sustainable agriculture. Soil as a component of landscape occupies a central position in the landscape balance due to its diverse functions. It constitutes a dynamic system within which a series of changes (Addition, losses, modification and alterations) constantly occur. These changes directly affect the composition, properties and productive potentials of the soils (Akinbode, 1986: Oriola and Hammed 2012).

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 lead 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 trans-located when water was applied to the field. Similarly Adamu and Maharaz (2014) in their comparative study of the changes in soil fertility under two farming practices reported that soil under mixed cropping have higher levels of chemical properties than sole cropped plot. Goudie (1993) and Morenikeji (1993) also observed that exploitation of the soil through farming activities (cropping) has been found to induce changes in the soil.

The physical, chemical, and biological properties of soil are paramount to crop yield. Absence of any of these acts as limiting factor and crop as a whole suffer (Dutta, 1986). The soil chemical

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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). For example, organic matter content is an indicator for soil quality and its fertility and may be lost through continuous cultivation (Lombin, 1999; Brandy and Weil, 2002). The resultant effects of the changes in soil properties are manifested in the fertility status which can either increase or reduce crop productivity. A good understanding of the effect of different cropping system on soil elements and fertility status is thus essential to enhance agricultural productivity. This research work aims to achieve this in Babanla farming community of Kwara State. The objectives are to:

1. Determine the soil chemical properties of the fallow land and the two cropping systems
2. Make a comparison between the three sites with a view of knowing deterioration in fertility status across them.

THE STUDY AREA

Babanla is a rural farming community located in Ilere district of Ifelodun Local Government Area of Kwara State. It is situated on latitude $08^0\ 33^{\prime}$ N and $08^0\ 40^{\prime}$ N, and Longitude $05^o 11^{\prime}$ and $05^o\ 17^{\prime}$ E (figure 1). It is about 123km from Ilorin, the kwara state capital. The geology is of crystalline pre- Cambrian basement complex rocks. The study area is 273m above sea level and the land is mainly drained by River Oro. Other rivers are Awere, Onikunin and Tapa. The vegetation of Babanla is derived savanna. The climate has two distinct seasons, very wet and short dry seasons. The rainfall according to Alex (2000) ranges between 1000mm and 1500mm and temperature also ranges between 68^0F and 86^0F. This climatic condition supports woodland vegetation.

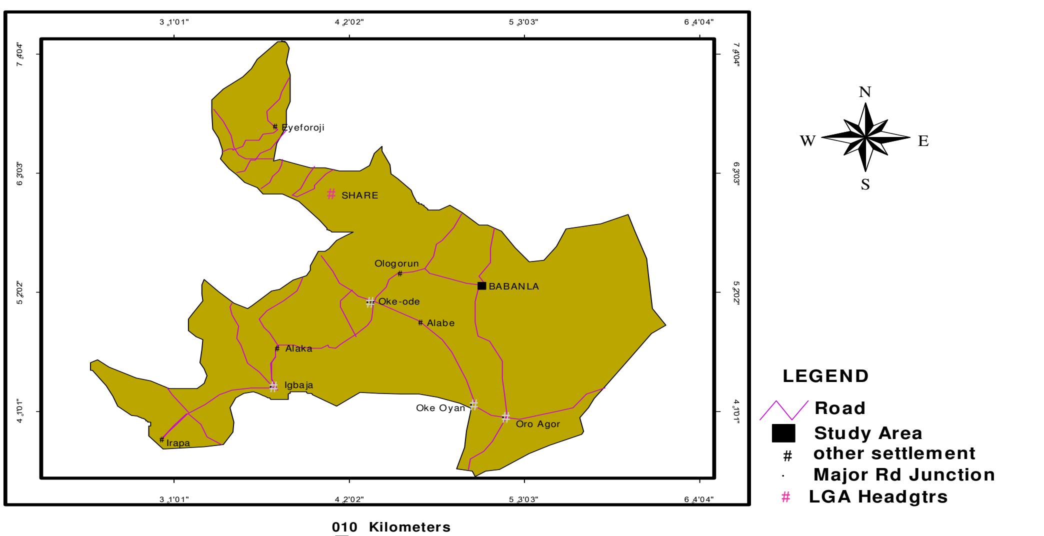

Figure 1. Map of Ifelodun L.G.A. Showing the Study Area; Source: Adapted from Kwara State Diary (2003)

The zone is covered by ferruginous tropical soil on crystalline acid rocks. The soil is considered naturally fertile because of the climate and presence of trees (Agboola 1979). However, intensive cultivation, past use of fire to clear vegetation and traditional management practices had led to the degradation of land in general. The economy of Babanla is based on agrarian and commercial activities. The inhabitants of this community are predominantly farmers who grow crops like cassava (Manihot Utlissima), yam (Dioscorea Spp), maize (Zea Mays), guinea corn (Sorgum Spp).

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MATERIAL AND METHODS

Soil Sample Collection

Soil samples were taken with a hand trowel for the determination of chemical properties of soils under two large farms operating on mono cropping and mixed cropping systems, and an adjacent fallow land to serve as the control. Twenty (20) Soil samples were collected from each of the three sampling plots on a demarcated site of 25m by 25m quadrant. In all, a total of sixty (60) soil samples were taken at 0 – 20cm depth to represent the average plough layer.

Laboratory Analysis

The collected soil samples were taken to the laboratory and subjected to analyses to determine essential soil chemical parameters using standard laboratory analytical methods as discussed here. Soil organic matter (OM) was determined based on the chromate wet oxidation method (Walkey – Black 1934); Total Nitrogen (N) was determined using Macro – Kjedhal 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 made known 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.

Organic Matter

Organic matter content decreases from a mean of 1.62% in fallow land site through 1.39% to 1.8% in mono cropping and mixed cropping farmlands respectively. The fairly high level of Organic matter observed in the fallow site can be due to the humus formed by fallen leafs and dead plant decaying on the surface. The mean value of organic matter content observed here in fallow land corresponds with that of Yakubu (2012) in his analysis of changes in soil chemical properties due to different land uses. Differences between the fallow land 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 in mixed cropping system may be attributed to their lost through extensive cultivation and multi-cropping.

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Table 1. Summary of 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_20	6.81	0.55	8.07	5.85	0.38	6.49	6.06	0.59	9.74
2	Nitrogen %	0.96	0.28	29.16	0.51	0.16	8.16	0.32	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 %	1.62	0.39	24.07	1.39	0.299	21.51	1.08	0.23	21.29
5	Ca^{2+} cmol/kg	3.04	0.65	21.38	1.97	0.56	28.43	1.54	0.43	27.92
6	Mg^{2+} cmol/kg	1.51	0.59	39.07*	0.91	0.43	44.33*	0.85	0.30	35.29*
7	Na^+ cmol/kg	0.91	0.12	13.19	0.59	0.129	21.86	0.43	0.10	23.26
8	K^+ cmol/kg	2.35	0.18	7.66	1.76	0.12	6.98	1.23	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	7.80	0.93	11.92	5.28	0.71	13.45	4.04	0.66	12.96
11	Base saturation %	71.01	0.87	0.87	70.33	0.57	0.57	62.23	1.46	1.52
12	Available P. (mg/kg)	3.77	0.68	18.04	1.72	0.44	25.58	0.96	0.23	23.95

X= mean, S.D = Standard Deviation, C.V = Co-efficient of variation, (*significant C.V > 33%)

Nitrogen Content

Total Nitrogen decreases from a mean of 0.96% in fallow land site through 0.51% to 0.32% 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 volatization which is common to most mineral soils (Jones and Weld 1975; Brady and Weil, 2002).

Exchangeable Cation

The mean values of exchangeable cations (Ca, Mg, Na and K) as revealed in table 1 show that the fallow land (control) 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 3.04cmol/kg in fallow land through 1.97cmol/kg to 1.54cmol/kg in mono cropping and mixed cropping respectively. These base elements are generally low for mono-cropping and mixed cropping but mono-cropping has a slight higher value than that of mixed cropping. The variation in the base elements across the three sites 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 a 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 sites. The magnesium content decreases from a mean of 1.51cmol/kg in fallow land through 0.97cmol/kg to 0.85cmol/kg in mono cropping and mixed cropping respectively. Potassium equally decreases from a mean of 2.35cmol/kg in fallow land through 1.76cmol/kg to 1.23cmol/kg in mono cropping and mixed cropping farmlands

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respectively. This reduction delays plants growth and hence variation in crop yields is bound to occur between the cropping systems.

Available Phosphorous

Available Phosphorous (P) which increases plant resistance to disease decreases from a mean of 3.77mg/kg in fallow land through 1.72mg/kg to 0.96mg/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 land. It is therefore in accordance with Adamu and Dawaki (2008) that the P content in the soil is also another factor that agrees with the organic matter content.

Cation Exchange Capacity (CEC)

The mean value of CEC is high for fallow land (7.80) and reduces to 5.28 and 4.04 for mono cropping and mixed cropping respectively. 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 sites was in agreement with the findings of Asadu et al., (2001).

Base Saturation and Soil PH

The result shows that % base saturation is higher for fallow land and mono cropping system. The mean values ranges between (71%) in fallow to (70%) in mono cropping and (62%) 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 (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 sites. 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. Summary of the ANOVA Statistical Test Performed on the Three 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	2.5392E+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, the null hypothesis is rejected and this implies that the means of soil chemical properties are significantly different for fallow, mixed cropping and mono cropping systems.

The New Duncan's multiple range tests was also used to identify the means that are different as shown in Table 3. From the result as shown in table 3, all the soil properties were found to be significantly different from one another at p= 0.05 level of significant.

The New Duncan's multiple range tests in table 3 revealed that all the chemical properties except Exchangeable Acidity, Magnesium and Base saturation are statistically different from one

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another. Magnesium content of the two cropping systems is similar but differs from that of fallow land. Similarly Exchangeable acidity and base saturation of fallow land and mono cropping farmland are similar but different from the mixed cropping farmland.

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 land considered here must 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 8^{th} fallow years come close to equilibrium whereas Abubakar (1995) observed that in Kabomo basin of Katsina State north-western Nigeria, changes in most of the properties under 2, 5, 10 and 15^{th} fallow years were only effective at about the 15^{th} fallow years.

Table 3. Mean Values of Soil Parameters Selected for Investigation

Soil Parameters	*Fallow Land*	*Mono Cropping*	*Mixed Cropping*	*S. E. of Mean*
PH	6.81a	5.85c	6.06b	0.067
Nitrogen%	0.96a	0.51b	0.32c	0.039
Organic carbon%	0.94a	0.79b	0.62c	0.038
Organic Matter%	1.62a	1.39b	1.08c	0.660
Ca^{2+}cmol/kg	3.04a	1.97b	1.54c	0.123
Mg^{2+}mol/kg	1.51a	0.91b	0.85b	0.102
Na^{2+}cmol/kg	0.91a	0.59b	0.43c	0.024
Kc^{2+}mol/kg	2.35a	1.76b	1.23c	0.041
Available P(mg/kg))	3.77a	1.72b	0.956c	0.103
CEC cmol/kg	7.80a	5.28b	4.04c	0.175
EA cmol/kg	0.064b	0.087b	0.152a	0.008

Note: values in the same row followed by the same letter(s) are not significantly different at P=0.5

IMPLICATIONS OF THE STUDY

As a result of general reduction in the contents of the soil chemical properties under the two cropping systems, a significant variation in crop output is expected. The analysis of variance revealed that the mean of the soil parameters were significantly different from one another in the three sampled sites. This implies that the cropping systems constitute a threat to soil fertility and agricultural productivity. It also implies that different cropping systems effect changes in the content of the soil elements and the rate of nutrient immobilization. This will therefore require different management strategies to sustain soil fertility in this area.

CONCLUSION/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 the other. It can be inferred from this study that the fertility status of soil under mono

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cropping system is higher than that of mixed cropping. This is due to relatively higher values of chemical properties obtained on mono cropping plot.

It serves as a strong pointer to the fact that cultivation and cropping systems cause reduction in most soil chemical properties that are important indicator of soil quality and fertility. These properties are equally paramount to crop growth and increased productivity. It is therefore recommended that the State government should employ and empower Agricultural Extension Workers to assist these rural farmers in appropriate soil management practice suitable for each cropping system in order to enhance soil fertility and sustain food production in the rural farming community of Babanla, Kwara state and Nigeria in general.

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