# A COMPARATIVE ANALYSIS OF SOIL CHARACTERISTICS UNDER MIXED CROPPING, CROP ROTATION AND FALLOW IN BAMA LOCAL GOVERNMENT AREA OF BORNO STATE

**M.B Shehu[1] and H.K Ayuba[2]**

[1]Department of Geography, collage of Education PMB 16 Bama, Borno State;
[2]Department of Geography, University of Maiduguri,
NIGERIA.

mbshehu66@gmail.com

## ABSTRACT

*This study focuses on the comparative analysis of the nutrient status of loamy soil under management systems of mixed crop, cropping rotation and fallow, where selected soil fertility parameters measured and analysed. The composite soil samples taken in the field were analysed in the soil laboratory for organic carbon; total nitrogen while C:N ratio and Cation Exchange Capacity (CEC) were both calculated. Organic carbon and total nitrogen were measured using titrimeter method of Walkey and Black and distillation method of Kjeldahl respectively. Generally both organic carbon and total nitrogen were lacking in the area. Total nitrogen and CEC showed significant difference ($P<0.01$) among the management systems examined both in the topsoil and subsoil. Organic matter showed significant difference ($P<0.01$) only at the topsoil, this could be attributed to high demand of this element by most arable crops. There are no significant association ($P>0.05$) between organic matter and CEC both in the topsoil and subsoil. This could be largely due to low level of organic matter content in the soil. Despite its short coming, the research encourages fallow type of agriculture, because of its sustainability. Research must be concentrated on the development of ways to restore the soil nutrient status.*

**Keywords:** Mixed crop, cropping rotation and fallow, Organic carbon

## INTRODUCTION

The use of soil requires careful planning and management in order to derive maximum benefit from it and to conserve it for future generation. Most of the soils have constraints such as low fertility, high acidity, poor structure, low water holding capacity and low organic matter content. These can be improved through improvement of soil structure, increase water infiltration, erosion control and organic matter maintenance (Ofori, 1993). These can achieve through sustainable agriculture. An agricultural system is sustainable only when the soil quality is maintained or improved. As a result of rapid population growth in the area, pushes man in to less productive and more fragile land. Over exploitation gives rise to degradation of vegetation, soil and water. In the area traditional fallow period has been shortened, which results in a progressive decline of soil fertility. This study compared some selected soil characteristics under management regimes of mixed cropping, crop rotation and fallow.

Fada and Rayar (1988) state that, the rapid depletion of soil fertility and soil deterioration in the arid and semi-arid regions is the result of several factors notably the cultivation of row crops such as sorghum, millet, maize and so on, as well as ecological factors like wind, water erosion and crop management strategies such as lack of use of manure and fertilizer.

There is urgent need to promote careful management of the soil. Unless soils are conserved and their fertility improved, present and future options for intensive agriculture will not be achieved. If no serious attention is paid to soil fertility management, it will be impossible to



ISSN: 2223-9944, e ISSN: 2223-9553

stop land degradation, crop yield reduction, poverty and communal dispute. Ayuba (1992), asserted that as the nutrient status of most savannah soils is naturally low, the establishment of high productivity system of agriculture required initial build up of soil fertility.

With the current concern about sustaining soil productivity, information from long term plots is needed to predict the impact of various soil management practices on the soil properties and to provide essential information for assessing sustainability and environmental impact. (Lopez-Bellido et al, 1997). Farmers are usually frustrated by the poor yield of various crops due to lack of adequate knowledge of our soils. The research therefore aims at examining mixed cropping, crop rotation and fallow soil management strategies in Bama area of Borno state.

The study intends to achieve the following objectives: -

i) To assess the nutrient status of the soil at different depth under three management regimes.

ii) To examine the difference among the management systems at the same depth levels (0 – 30cm) or (30 – 60cm).

iii) To study the difference in the nutrients status under the same management system at different depth levels (0 – 30cm) and (30 – 60cm).

## METHODOLOGY

Bama Local Government Area is located between Latitude $11^{0}00^{1}$N and $12^{0}\ 00^{1}$ N and Longitude $13^{0}\ 15^{1}$E and $14^{0}\ 45^{1}$E. Composite soil samples were taken in the loamy soil region under management system of mixed cropping (MC), cropping rotation (CR) both practiced for more than ten years and composite soil sample were also taken from a control site (C), that is land under fallow. The soil samples were taken from 0-30cm (topsoil) and 30-60cm (subsoil), to ascertain the soil nutrient status of the loamy soil, under three management systems (MC, CR, and C). From the management systems, five (5) plot measuring 100m by 100m were delineated for soil sample survey in each management systems. Five (5) soil samples were collected and mixed to form a composite sample. In all, fifteen composite samples were collected for the topsoil and subsoil (30-60cm) soil depths. These composite soil samples were analyzed for organic carbon using titrimeter method by Walkey and Black; total nitrgen using distillation method by Kjeldahl and carbon nitrogen ratio C: N ratio and Cation Exchange Capacity (CEC) were calculated. Mean, standard error, variance, t-test and chi square of the selected soil fertility parameters measured in the laboratory were analyzed. Variance and t-test (to assess difference among the managements and difference between the topsoil and subsoil were and chi-square to assess the association between one variable and another.

## RESULTS

Comparative Analysis of Selected Soil Properties under Mixed Cropping (Mc), Crop Rotation (Cr) And Land Under Fallow (C) Organic Matter (Om)

The table 1 shows the organic matter content of the loamy soil under management system of mixed cropping, crop rotation and fallow. The minimum and maximum mean of organic matter content values are 0.33% and 1.40% determined under crop rotation and fallow respectively. This could be due largely to the high microbial activities under fallow regime. There are significance differences ($p<0.01$) in the organic matter content in the topsoil and no significance difference ($p>0.01$) in the subsoil among the management systems examined. Under the same management system however, shown significance difference ($p<0.01$) under



ISSN: 2223-9944, e ISSN: 2223-9553

crop rotation and fallow regimes, while no significance difference (p>0.01) under mixed cropping.

**Table 1. Organic Matter (OM) Content of soil under mixed cropping, crop rotation and fallow in the topsoil (0-30cm) and subsoil (30-60cm).**

| Number of sampled plots | MC OM (%) 0-30cm | MC OM (%) 30-60cm | CR OM (%) 0-30cm | CR OM (%) 30-60cm | C OM (%) 0-30cm | C OM (%) 30-60cm |
|---|---|---|---|---|---|---|
| 1 | 0.92 | 0.91 | 0.84 | 0.41 | 1.66 | 0.44 |
| 2 | 0.62 | 0.54 | 0.66 | 0.25 | 1.45 | 0.91 |
| 3 | 0.74 | 0.43 | 0.62 | 0.33 | 1.25 | 0.35 |
| 4 | 0.54 | 0.32 | 0.60 | 0.30 | 1.42 | 0.41 |
| 5 | 0.62 | 0.30 | 0.52 | 0.35 | 1.23 | 0.92 |
| **Mean X** | **0.69** | **0.50** | **0.65** | **0.33** | **1.40** | **0.61** |
| **Standard Error (SE)** | **0.07** | **0.11** | **0.05** | **0.03** | **0.08** | **0.13** |

*MC – mixed Cropping, CR – Crop rotation, C – Control (fallow)

There are no significant association (P>0.05) between organic matter and cation exchange capacity both in the t opsoil and subsoil. This could be largely due to low level of organic matter content in the soil.

This is one of the vital soil nutrients resulting from dead and decaying of plants and animal materials. Organic carbon can be converted to organic matter by multiplying by a factor of 1.254 (Ayuba, 1992). Fada and Raya (1998) viewed that the presence of organic matter in the soil is fundamental in maintaining the soil fertility. Kumar and Rowland (1993) stated that the low level of organic matter content of the tropical soils generally results to unstable soil structure, easily damaged by heavy rain or over cultivation. Nair (1984) asserted that crop residues serve as major source of organic matter in the area.

**Table 2.** Total Nitrogen (TN) content of soil under mixed cropping, crop rotation and fallow in the topsoil (0-30cm) and subsoil (30-60cm)

| Number of sampled plots | MC TN (%) 0-30cm | MC TN (%) 30-60cm | CR TN (%) 0-30cm | CR TN (%) 30-60cm | C TN (%) 0-30cm | C TN (%) 30-60cm |
|---|---|---|---|---|---|---|
| 1 | 0.25 | 0.24 | 0.24 | 0.20 | 0.30 | 0.29 |
| 2 | 0.21 | 0.20 | 0.21 | 0.18 | 0.31 | 0.24 |
| 3 | 0.27 | 0.21 | 0.19 | 0.18 | 0.35 | 0.21 |
| 4 | 0.21 | 0.18 | 0.25 | 0.22 | 0.36 | 0.30 |
| 5 | 0.29 | 0.19 | 0.28 | 0.24 | 0.36 | 0.32 |
| **Mean (X)** | **0.25** | **0.20** | **0.23** | **0.20** | **0.34** | **0.27** |
| **Standard Error (SE)** | **0.02** | **0.01** | **0.02** | **0.01** | **0.01** | **0.02** |

*MC – mixed Cropping CR – Crop Rotation C – Control (Fallow)

The mean minimum total nitrogen contents were measured under mixed cropping and crop rotation and the maximum was measured under fallow. There are significant difference (P<0.01) in the total nitrogen content among the management systems both in the topsoil and subsoil. The difference between topsoil and subsoil of the same management shown no significant difference (P>0.01), this could be due largely to the fairly equal distribution of total nitrogen within the depth levels examined.



ISSN: 2223-9944, e ISSN: 2223-9553

This is one of the most important of plant nutrients, occurring in the soil mainly as ammonium compounds and nitrates. It is important in the production of plant proteins. It also regulates the efficient use of phosphorus and potassium (Sachs, 1999). The total nitrogen content of the soil varies from trace 0.18% to 0.366%. Kaigama and Omeje (1994) observed that the farmer himself can supply the nitrogen by strategic using leguminous plants in the cropping system and sequence (herbaceous forage, legumes, grain legumes and so on). Nitrogen fixation can be considerable and substantial nitrogen transfers from leguminous crops to the subsequent cereal grown in the plots have been reported in north east arid zone of Nigeria.

**Carbon Nitrogen Ratio (C:N Ratio)**

Table 3 shows the Carbon nitrogen ratio of the loamy soil under management systems of mixed cropping, crop rotation and fallow in the topsoil (0 – 30cm) an subsoil (30 – 60cm) depth levels. The mean minimum and maximum values of carbon/nitrogen ratio are 1.62 and 4.21 under management systems of crop rotation and fallow respectively. There are no significant difference (P>0.01) among the management systems both in the topsoil and subsoil. This could be largely due to fairly equal distribution of the organic carbon and total nitrogen in the soil examined. The difference between the topsoil and subsoil of the same management system show significant difference (P<0.01) under crop rotation only. This could be relatively higher level of organic matter at the topsoil.

**Table 3.** Carbon/Nitrogen ratio (C:N ratio) under mixed cropping, crop rotation and fallow for the topsoil (0 – 30cm) and subsoil (30 – 60cm).

| Number of sampled plots | MC C:N ratio 0-30cm | MC C:N ratio 30-60cm | CR C:N ratio 0-30cm | CR C:N ratio 30-60cm | C C:N ratio 0-30cm | C C:N ratio 30-60cm |
|---|---|---|---|---|---|---|
| 1 | 3.68 | 3.79 | 3.50 | 2.05 | 5.53 | 1.52 |
| 2 | 2.95 | 2.70 | 3.14 | 1.39 | 4.68 | 3.79 |
| 3 | 2.74 | 2.05 | 3.16 | 1.83 | 3.57 | 1.67 |
| 4 | 2.57 | 1.77 | 2.40 | 1.36 | 3.94 | 1.37 |
| 5 | 2.14 | 1.58 | 1.86 | 1.46 | 3.35 | 2.88 |
| **Mean (X)** | **2.82** | **2.38** | **2.83** | **1.62** | **4.21** | **2.25** |
| **Standard Error (SE)** | **0.25** | **0.40** | **0.31** | **0.14** | **0.40** | **0.47** |

MC – Mixed Cropping CR – Crop Rotation C – Control (Fallow)

**Cation Exchange Capacity** (CEC)

Table 4 show cation exchange capacity level of the loamy soil under management systems of MC, CR and C. the mean minimum and maximum value of CEC are 2.88 Cmol/kg and 8.57 Cmol/kg under management systems of crop rotation and fallow respectively. There are highly significant difference (P<0.01) in the cation exchange capacity levels both in the topsoil (0 – 30cm) and subsoil (30 – 60cm). This could be largely due to the difference in the clay content, organic matter content and exchangeable bases. There are significant difference (P<0.01) between topsoil and subsoil of management systems of crop rotation and fallow.

Any element with a positive charge is called Cation. It is also basic Cations. These elements are calcium ($Ca^{+}$), magnesium (Mg), Potassium (K) and Sodium (Na) and the acidic cations are hydrogen (H) and aluminum (Al). The CEC refers to the total amount of these positive charged elements that a soil can hold. The CEC is expressed in centimol per kilogram (Cmol/kg) of soil. The larger this number, the more cations the soil can hold (Sachs, 1999). Kessler 2000 viewed CEC as the organic materials from soil react with clay particles to form organic – clay complexes. There is vital need to conserve and increase soil organic matter content.



ISSN: 2223-9944, e ISSN: 2223-9553

**Table 4** Cation Exchange Capacity (CEC) of the soil under mixed cropping, crop rotation and fallow in the topsoil and subsoil.

| Number of sampled plots | MC Cmol/kg 0-30cm | MC Cmol/kg 30-60cm | CR Cmol/kg 0-30cm | CR Cmol/kg 30-60cm | C Cmol/kg 0-30cm | C Cmol/kg 30-60cm |
|---|---|---|---|---|---|---|
| 1 | 4.96 | 4.20 | 4.39 | 3.49 | 8.42 | 9.74 |
| 2 | 5.71 | 4.71 | 5.05 | 2.58 | 7.55 | 6.94 |
| 3 | 6.20 | 4.53 | 4.31 | 2.77 | 9.46 | 6.59 |
| 4 | 5.09 | 4.00 | 3.88 | 2.28 | 8.40 | 6.74 |
| 5 | 4.03 | 3.69 | 5.18 | 3.29 | 9.36 | 7.03 |
| **Mean (X)** | **5.20** | **4.43** | **4.66** | **2.88** | **8.57** | **7.01** |
| **Standard Error (SE)** | **0.37** | **0.18** | **0.25** | **0.22** | **0.41** | **0.20** |

*MC – mixed Cropping CR – Crop Rotation C – Control (Fallow)

## SUMMARY

The research compared the management strategies of mixed cropping (MC), crop rotation (CR) and Fallow as control (C). Their fertility status at surface (0-30cm) and subsoil (30-60cm) soil depths were examined. From the three management regimes (MC, CR and C), 5 samples plots each measuring 100m by 100m were delineated for soil sample survey. Soil samples were collected for the topsoil (0-30cm) and subsoil (30-60cm). in each plot, 5 soil samples were collected and mixed to form a composite sample.In all, 15 composite samples were collected from the 3 management regimes (5 in each) for the topsoil and another 15 composite samples for the subsoil. They were taken to the laboratory for the routine analysis.

These samples were analyzed in the laboratory for selected soil fertility parameters. These are organic carbon, total nitrogen and Cation Exchange Capacity (CEC) and C:N ratio were calculated. Result showed that, total nitrogen and Cation Exchange Capacity showed significant difference ($P<0.01$) among the management systems of mixed cropping, crop roattion and fallow, both in the topsoil and subsoil. While organic matter show significant difference ($P<0.01$), only at the topsoil, this could be attributed to high demand for this element by most arable crops.

## CONCLUSION

The research encourages fallow, however, with the rapid population growth in the recent years made this system uncommon, however, this research encourages farmers to allow their lands for fallow with intensive addition of manure and household refuse. Where there is abandon land, research encourages long fallow period. Farms should be manage with crops by-products such as legumes haulms, sorghum and millet straw as well as other farm waste.

## RECOMMENDATION

1. Research must be concentrated on the development of ways to restore the soil fertility status.
2. The research also encourages Universities and Agricultural research institutes to raise more nitrogen fixing such as Acacia to improved soil nitrogen and organic matter.
3. Over grazing, over cultivation and bush burning should be discouraged.
4. Soil fertility regeneration should be considered as major focus toward attaining food security in the area and state at large.



ISSN: 2223-9944, e ISSN: 2223-9553

## REFERENCES

[1]. Ayuba, H.K. (1992). *Effect of continue Cultivation on Soil and Vegetation in Konduga L.G.A of Borno State*. Unpublished M.Sc dissertation presented to the Department of Geography, University of Ibadan.

[2]. Fada, B and Rayar (1988). Agricultural Management Strategies in an Arid Environment. *Journal of Agriculture,* 1(1), pp 1 University of Maiduguri Press.– 21.

[3]. Kaigama, B.K and Omeje, M.U (1994)" Soil Fertility and Water Conservation management Practices in Fadama". In Kolowale, A; Scoones, 1; Awogbade, M.O and Voh, J. P (eds) *Strategies for Sustainable Use of Fadama lands in Northern Nigeia.* (SER) IIED. Zaria. pp 133.

[4]. Kumar, V. and Rowland, J. (1993)." The Dry land Farming Environment". In Rowland, JRJ (ed) *Dry Land Farming in Africa*. Accra: Macmillan Press.

[5]. Lopez – Bellido, L; Lopez – Gerriudo, F.J; Fuentes, M; Castillo, J.E and Fernandez, E.J (1997) "Influence of Tillage, Crop Rotation and Nitrogen Fertilization on Soil Organic Matter and Nitrogen under Rain fed Mediterranean condition" *Soil and Tillage Research, 43* pp 277 – 293.

[6]. Ofori, C.S (1993). Towards the Development and Technology Transfer of Soil Management Practices for Increased Agricultural Productivity in Africa". In Ahenkorah, Y; Owusu. Bennoah, E and Dawuona, G.N.N (eds). *Sustaining Soil Productivity in Intensive African Agriculture.* Seminar proceeding 15 – 19 November,, Accra pp 22-23.

[7]. Sachs. P.D (1999). Edaphos: Dynamics of a Natural Soil System Biomass, pp152 – 153.

[8]. Ressler, J.J (2000). Low External input and Sustaining Agriculture. *Natural Strategies for Integrated Soil Fertility Management in Africa, 16(*1) AB Leusden the Netherland. P 26.

[9]. Nair, P.K.P (1984). *"Soil Productivity aspect of Agro – Forestry".* IITA. Ibadan.



ISSN: 2223-9944, e ISSN: 2223-9553