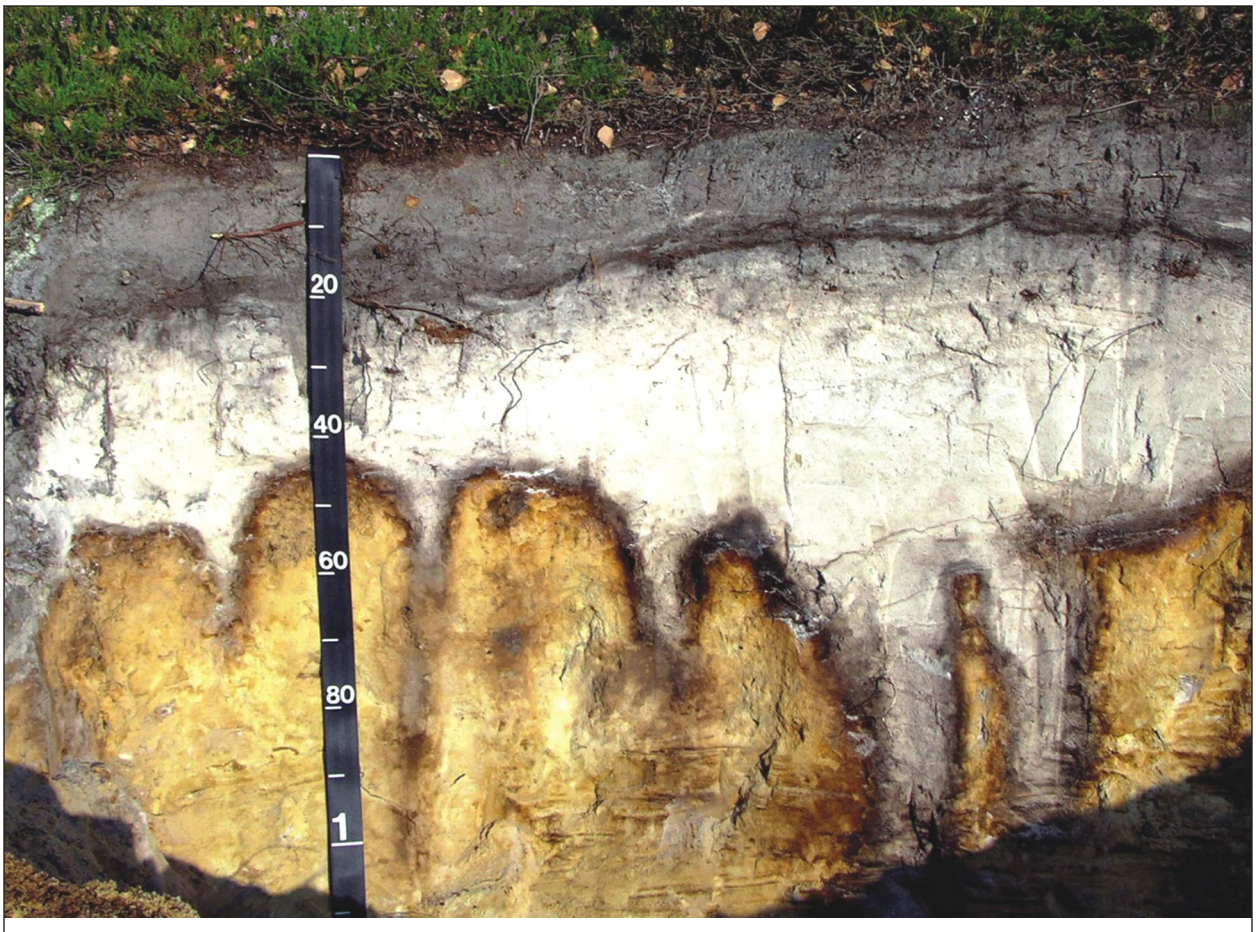


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# Physico-Chemical Properties and Fertility Status of Some Haplic Plinthaquults in Bauchi Local Government Area of Bauchi State, Nigeria

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**Abstract:** Studies were conducted to evaluate some physico-chemical properties of some fadama soils in Bauchi Local Government Area (LGA), Bauchi State, Nigeria. A total of fifty composite soils, comprising five each from the surface 0-15 and 15-30 cm depths were collected from each of fadama lands in Bayara, Luda, Liman Katagum, Zungur and Mun locations. The soil samples were analysed for some physico-chemical properties using standard procedures. Results obtained show that the soils were mostly clay-loams in texture and slightly acidic (mean pH in water = 5.55). The soils ranged from low in exchangeable acidity (0.17-0.48 cmol (+) $kg^{-1}$) and electrical conductivity (0.02-0.18 dS $m^{-1}$) to low-medium in total nitrogen (0.07-0.21 g $kg^{-1}$), available phosphorus (3.6-15.2 mg $kg^{-1}$) and organic carbon (1.78-12.97 g $kg^{-1}$). The CEC (8.52-23.7 cmol (+) $kg^{-1}$ was generally medium to high. The results also indicate that soil depth and location significantly ($p = 0.05$) influenced the silt and CEC distribution in the study area; which are, for now, free from salinity and sodicity problems. The application of organic matter, complimented by split application of inorganic fertilizers is recommended for sustainable crop production in the study areas.

**Key words:** Properties, fertility status, haplic Plinthaquult

## INTRODUCTION

Fadama is a wetland in dry land that was described by Armborg (1988) as a garden, a little paradise in the semi-arid northern Nigeria. It is usually a site of busy agricultural activities throughout the year owing to its characteristic residual and underground moisture retention within the rhizosphere for most part of the year and the understanding that they are more fertile than their upland counterparts (Mustapha *et al*., 2005; Singh and Babaji, 1990).

In Nigeria today, owing to the rapid increase in population and the realization of the need to feed the ever-increasing human and animal populations, attention is now focused on the utilization of fadama lands that were hitherto neglected. This is evidenced in the Federal Government's Projects such as the National Fadama Development Project, Fadama 1 and Fadama 2 Projects. The sustainable exploitation of the fadama lands is, however, currently hindered by the lack of site-specific information on these soils (Mustapha and Loks, 2005) thereby rendering them prone to abuse and mismanagement. Consequent upon this and in order to achieve Nigeria's goal of food sufficiency through scientific agriculture, the proper understanding of the physico-chemical properties of these soils becomes imperative (Mustapha *et al*., 2005). This will, amongst others, create an understanding of the soils in terms of their outstanding characteristics and constraints, thus ensuring their more rational and economic utilization and guaranteeing greater productivity and sustainability (Mustapha and Fagam, 2007).

This study was therefore conducted with the objective of evaluating the physico-chemical properties of some fadama soils in Bauchi Local Government Area (LGA), Bauchi State, Nigeria as a pre-requisite to their sustainable utilization.

## MATERIALS AND METHODS

### The Study Area

The study was conducted between February and October, 2006 at the fadama areas at Luda, Mun, Bayara, Zungur and Liman Katagum, all in Bauchi LGA, Bauchi State, Nigeria. Bauchi LGA is located between longitudes 9° 00' and 10° 30' N and latitudes 9° 30' and 10° 30'E. It is situated in the northern guinea savanna ecological zone of Nigeria. The climate is characterized by high temperature and seasonal rainfall. The mean minimum temperature ranges between 10-12°C in December/January, while the mean maximum is about 30-32°C in March-May. The rainfall (1000-1250 mm per annum) is unimodal and lasts from June to October while the dry season starts from late October to May. The soils of the fadama areas studied had earlier been classified as Haplic Plinthaquults by Mustapha *et al*. (2003a).

### Soil Sampling and Handling

Five composite fadama soil samples each from surface 0-15 and subsurface 15-30 cm depths were collected from Luda, Mun, Bayara, Zungur Liman Katagum; making a total of 50 soil samples. Each sample was a composite of five sub-samples collected about 50 m apart. The soil samples were collected and separately stored in polythene bags.

In the laboratory, each sample was separately air-dried and then ground using a porcelain pestle and mortar and sieved through a 2 mm sieve. The fine earth fraction was used for all laboratory analyses.

### Laboratory Analyses

Soil samples were analysed using standard procedures as outlined by Page *et al*. (1982). Particle-size distribution was determined by the hydrometer method (Bouyoucous, 1951). The pH (in water) was determined potentiometrically using a glass electrode pH meter in a 1:1 soil:water suspension while organic carbon was determined by the dichromate wet oxidation method (Walkley and Black, 1934). Available P was extracted using the Bray-1 method (Bray and Kurtz, 1945) and determined colorimetrically with a spectrophotometer.

### Data Analyses

The data obtained were subjected to simple descriptive statistics including coefficient of variation (CV) to test the dispersion of the data (Harry and Steven, 1995).

## RESULTS AND DISCUSSION

### Particle-Size, pH and Exchangeable Acidity

Results in Table 1 indicate that the range, respectively, for sand, silt and clay in the soils were 23.3-69.5 (mean = 43.4), 15.8-42.4 (mean = 27.4) and 14.9-35.9 (mean = 28.3)%; indicating a generally clay loam texture. Of the soil fractions, only the silt fraction was significantly ($p<0.05$) influenced by both depth and location. This corroborates earlier reports by Voncir *et al*. (2006) for soils in Bauchi State and Jauro *et al*. (2006) for some fadama soils elsewhere in Nigeria. It is probable that the predominance of the silt in most of the surface soils is due to its annual deposition through seasonal flooding. Between the fadama lands studied, the various soil fractions were more or less uniformly distributed (CV<12%) indicating a fairly similar flooding phenomenon in all the areas studied.

The soil pH (in water) ranged from 4.80-6.56 (mean = 5.55) and in $CaCl_2$ 4.0-5.3 (mean = 4.65). The negative delta pH values (pH in $CaCl_2$ minus pH in water) obtained indicates that the soils are negatively charged (Mustapha *et al*., 2003a). The fairly large delta pH values are, however, associated with low exchangeable Al levels which ranged from 0.01-0.18 (mean = 0.13) cmol (+) $kg^{-1}$ indicating

Table 1: Distribution of particle-size fractions and pH in some fadama soils in Bauchi LGA, Bauchi State

| Locations | Depth (cm) | Sand | Silt (%) | Clay | Textural class | Organic C. (g $kg^{-1}$) | Total N (g $kg^{-1}$) | Avail. P (mg $kg^{-1}$) | pH (in $CaCl_2$) |
|---|---|---|---|---|---|---|---|---|---|
| Luda | 0-15 | 23.3 | 40.7 | 36.1 | Clay loam | 7.38 | 0.07 | 3.60 | 5.26 |
| | 15-30 | 39.4 | 32.7 | 27.9 | Clay loam | 2.79 | 0.07 | 8.60 | 4.00 |
| Bayara | 0-15 | 43.4 | 32.0 | 24.8 | Clay loam | 9.18 | 0.14 | 5.60 | 5.13 |
| | 15-30 | 39.3 | 39.3 | 35.9 | Clay loam | 12.97 | 0.11 | 9.30 | 4.92 |
| Mun | 0-15 | 44.6 | 24.0 | 31.4 | Clay loam | 3.99 | 0.18 | 5.80 | 4.90 |
| | 15-30 | 69.5 | 15.8 | 14.9 | Sandy loam | 1.79 | 0.07 | 7.30 | 4.30 |
| L/Katagum | 0-15 | 69.4 | 23.1 | 34.1 | Clay loam | 4.78 | 0.11 | 9.90 | 4.10 |
| | 15-30 | 40.6 | 10.7 | 19.8 | Sandy clay loam | 1.99 | 0.11 | 4.20 | 4.86 |
| Zungur | 0-15 | 69.4 | 42.4 | 17.0 | Loam | 5.19 | 0.14 | 6.80 | 4.54 |
| | 15-30 | 33.5 | 41.4 | 25.1 | Clay loam | 2.45 | 0.04 | 15.20 | 4.43 |
| Mean | 0-15 | 39.0 | 30.0 | 28.6 | Clay loam | 6.10 | 0.13 | 6.34 | 4.79 |
| | 15-30 | 47.8 | 24.7 | 28.0 | Sandy clay loam | 4.40 | 0.08 | 8.92 | 4.50 |
| Grand mean | | 43.4 | 27.4 | 28.3 | Clay loam | 5.25 | 0.11 | 7.63 | 4.65 |
| CV (%) | | 11.8 | 11.3 | 9.1 | | 19.68 | 14.02 | 14.88 | 2.95 |

that the soils possess a poor buffering capacity (Agboola *et al*., 1998). This also points to the soils' tenderness and fragility; implying that they could be adversely affected even with slight mismanagement (Mustapha *et al*., 2001).

**Exchangeable Bases and CEC**

The results obtained, compared against the rating scale given by Esu (1991) in Table 4, show that Na and Ca in the fadama soils studied were low; K was medium, while Mg was high. The relatively medium to high contents of K and Mg in the soils could be as a result of the presence in reasonable quantities, high amounts of K and Mg-bearing minerals such as muscovite ($KAl_2(AlSi_2O_{10})(OH_3)_2$) and biotite ($(K(Mg,Fe)_3(AlSiO_{10})(OH)_2$), micas and the orthoclase and microcline ($KAlSi_3O_8$) feldspars as was also observed by Mustapha *et al*. (2003a) (Table 2).

The CEC (range = 8.52-23.70 cmol (+) $kg^{-1}$) was medium to high. As the soils were generally low in organic carbon contents, it is probable that the CEC obtained could be as a result of the presence of high activity montmorillonitic 2:1 clays.

**Soil Fertility Status**

Organic carbon in the soils was generally low (Table 1). It ranged from 1.99 to 12.97 (mean = 5.25) g $kg^{-1}$. The distribution between the fadamas was fairly not uniform (CV = 19.68%) even though their differences were not statistically significant ($p>0.05$). similarly, even though the organic carbon contents in the top 0-15 cm soils in the fadamas was higher (mean = 5.19 g $kg^{-1}$) than that in the lower 15-30 cm (mean = 2.45 g $kg^{-1}$), the contents are all rated low (Esu, 1991). This corroborates earlier reports by Mustapha *et al*. (2005) for the fadama soils in the area and elsewhere in Bauchi State (Mustapha *et al*., 2001, 2003b).

**Total N**

Total N was low (Table 1) in all the soils considered (range = 0.04-0.18; mean = 0.11 g $kg^{-1}$). It was more or less uniformly low (CV = 14.02%) and did not significantly ($p>0.05$) vary with either location or depth. The result conforms to earlier reports by Mustapha *et al*. (2005) for soils in similar agroecology and in some fadamas elsewhere (Singh, 1999) in Nigeria. The low N contents may be because of impeded nitrogen mineralization under anaerobic condition; which does not pass the ammonia stage and, thus, is subsequently lost as a gas to the atmosphere (Brady and Weil, 1999).

**Available P**

The available P in the soils studied ranged from 3.6-15.2 (mean = 7.63) mg $kg^{-1}$ and are, according to the rating by Esu (1991) shown in Table 4, rated low to medium. The results also show that

Table 2: Distribution of some exchangeable characteristics (in cmol (+) $kg^{-1}$) in some fadama soils in Bauchi LGA, Bauchi State

| Locations | Depth | Na | K | Mg | Ca | $Al^{3+}$ | $H^{+}$ | TEA | CEC |
|---|---|---|---|---|---|---|---|---|---|
| Luda | 0-15 | 0.092 | 0.23 | 1.61 | 1.63 | 0.18 | 0.18 | 0.36 | 11.02 |
| | 15-30 | 0.086 | 0.25 | 1.54 | 1.23 | 0.09 | 0.09 | 0.18 | 10.34 |
| Bayara | 0-15 | 0.086 | 0.41 | 1.58 | 1.41 | 0.10 | 0.10 | 0.20 | 13.69 |
| | 15-30 | 0.088 | 0.42 | 1.43 | 1.23 | 0.13 | 0.13 | 0.26 | 13.48 |
| Mun | 0-15 | 0.084 | 0.21 | 1.60 | 1.91 | 0.10 | 0.10 | 0.20 | 15.36 |
| | 15-30 | 0.088 | 0.31 | 1.48 | 1.01 | 0.10 | 0.10 | 0.20 | 10.02 |
| L/Katagum | 0-15 | 0.088 | 0.25 | 1.60 | 2.10 | 0.16 | 0.10 | 0.26 | 13.78 |
| | 15-30 | 0.088 | 0.24 | 1.43 | 1.87 | 0.12 | 0.10 | 0.22 | 8.52 |
| Zungur | 0-15 | 0.084 | 0.26 | 1.59 | 1.79 | 0.14 | 0.10 | 0.24 | 23.70 |
| | 15-30 | 0.089 | 0.29 | 1.50 | 1.53 | 0.12 | 0.01 | 0.13 | 21.51 |
| Mean | 0-15 | 0.087 | 0.27 | 1.60 | 1.77 | 0.14 | 0.12 | 0.25 | 15.51 |
| | 15-30 | 0.088 | 0.30 | 1.48 | 1.37 | 0.11 | 0.09 | 0.20 | 12.77 |
| Grand mean | | 0.088 | 0.29 | 1.54 | 1.57 | 0.13 | 0.11 | 0.23 | 14.14 |
| CV (%) | | 2.780 | 25.51 | 4.62 | 2.92 | 44.24 | 44.59 | 44.37 | 11.50 |

Table 3: Salinity/sodicity parameters used in assessing the *fadama* soils in Bauchi LGA, BauchiState

| Locations | Depth (cm) | pH (in water) | Ec (d $Sm^{-1}$) | ESP (%) |
|---|---|---|---|---|
| Luda | 0-15 | 5.83 | 0.18 | 8.40 |
| | 15-30 | 5.99 | 0.05 | 8.30 |
| Bayara | 0-15 | 5.13 | 0.10 | 6.30 |
| | 15-30 | 5.21 | 0.18 | 6.50 |
| Mun | 0-15 | 6.56 | 0.73 | 5.50 |
| | 15-30 | 6.33 | 0.12 | 8.80 |
| L/katagum | 0-15 | 4.80 | 0.06 | 6.60 |
| | 15-30 | 5.29 | 0.05 | 10.30 |
| Zungur | 0-15 | 5.33 | 0.05 | 3.60 |
| | 15-30 | 5.03 | 0.02 | 4.10 |
| Mean | 0-15 | 5.53 | 0.22 | 6.08 |
| | 15-30 | 5.57 | 0.08 | 7.60 |
| Grand mean | | 5.55 | 0.15 | 6.84 |
| CV (%) | | 2.99 | 20.68 | 31.07 |

Table 4: Ratings for soil fertility classes in the Nigerian savanna

| | Rating | | |
|---|---|---|---|
| Parameters | Low | Medium | High |
| Organic C (g $kg^{-1}$). | <10 | 10-15 | >15 |
| Total N (g $kg^{-1}$). | <1.5 | 1.5-2.0 | >2.0 |
| Available P (mg $kg^{-1}$). | <10 | 10-20 | >20 |
| Available K (cmol(+)$kg^{-1}$) | <0.15 | 0.15-0.30 | >0.30 |
| Exch. Ca (cmol(+)$kg^{-1}$) | <2 | 2-5 | >5 |
| Exch. Mg (cmol(+)$kg^{-1}$) | <0.3 | 0.3-1.0 | >1.0 |
| CEC (cmol(+)$kg^{-1}$) | <6 | 6-12 | >12 |

P fraction in the soils was not significantly ($p>0.05$) affected by either depth or location. With a CV of 14.9%, it was observed that available P varied within narrow limits in the soils studied.

The results obtained corroborate the findings of Mustapha *et al*. (2003b) for fadama soils in Bauchi State, but fell below the reported values of 80 mg $kg^{-1}$ obtained elsewhere in Borno State, Nigeria (Rayar and Haruna, 1985). The overall low values of available P in the fadama soils indicate the need for application to the soils for optimum crop production, especially in areas rated low.

**Salinity/Sodicity Status**

The salinity and/or sodicity status of the fadama soils studied was assessed using the parameters shown in Table 3. The results show that the pH values ranged from 4.80-6.56 (mean = 5.55), the Ec (in $dSm^{-1}$) from 0.02-0.73 (mean = 0.15) the ESP ranged from 3.6-10.3 (mean = 6.84)%.

Salinity and/or sodicity of the soils were assessed using the criteria for classifying salt affected soils set (Anonymous, 1954). A soil with Ec> 4 m $Sm^{-1}$, ESP<15 and pH<8.5 is saline, that with Ec>4 $mSm^{-1}$, ESP>15 and pH<8.5 is saline-sodic that with Ec<4 $mSm^{-1}$, ESP>15 and pH>8.5 is sodic. Results of the present study show that the Ec, ESP and pH values for the fadama soils are less than the critical values given in Table 3. Consequently, they could be said to be free from salinity and sodicity problems, for now.

## CONCLUSION

From the results obtained in this study it can be concluded that the fadama soils in the study area are dominantly clay loams, low in total N, Na, Ca and organic carbon, low to medium in available P medium to high in K, Mg and CEC. The fadama soils are, for now, neither saline nor sodic. Split application of especially N fertilizers is recommended.

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