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FERTILITY EVALUATION OF SOME SOILS IN ADAMAWA STATE, NIGERIA

Hassan, M., Saddiq, A. M. and A. Ibrahim

Department of Soil Science, Modibbo Adama University of Technology, Yola

ABSTRACT

Surface (0-25) and sub-surface (25-80) soil samples were collected from Hong, in Hong Local Government and Chouchi plains, Yola South Local Government with the aim of evaluating their fertility status. The soils were evaluated both in the field and laboratory. Results of the analyses showed that sandy loam soils dominated the upper layers, sandy clay loam to clay loam in the lower horizons in Hong while silt loam dominated the soils of Chouchi both in upper and lower horizons. Soil reaction ranged from slightly acidic to alkaline in both sites (7.5-9.5). Organic carbon content does not have a definite trend in the horizons of Hong soils but higher at the lower horizons in Chouchi plains. Total nitrogen (TN) was generally moderately low to medium while available phosphorus (AVP) ranged from low to medium. Exchangeable bases were generally low except sodium content that was very high in Hong soils. The effective cation exchange capacity (ECEC) and percent base saturation (PBS) of the soils ranged from low to medium. SAR values were generally low in both sites although comparatively higher in Hong soils. Except for total nitrogen (TN) and ESP, the coefficient of variability within the profiles of Chouchi soils were not significant while significant variability was observed in relation to EC, TN and AVP in Hong soils. Organic carbon negatively and significantly correlated with total nitrogen (TN), available phosphorus (AVP), percent base saturation (PBS) and exchangeable sodium percentage (ESP). Highly significant correlation was however observed between TN, AVP, ESP and PBS. This suggests that sustainable productivity of the soils requires careful management of nitrogen fertilizers and salts in Chouchi. Nitrogen, phosphorus and salts need to be monitored and properly managed if the productivity of Hong soils is to be sustained.

INTRODUCTION

Soil fertility is one of the important and essential components of a sustainable agricultural system in the tropical climates. The tropics is faced with a two dimensional problems of declining per capita production and progressive deterioration of the environment. Importantly also, is the high spatial variability in the physico-chemical and morphological characteristics of soils implying that different soils respond differently to management options. Soils in the tropics are much more diversified than in temperate and cold areas due to severe changes under high temperature and heavy rainfall (Varade, 1992). Continuous cultivation and indiscriminate deforestation through the use of fuel wood as source of alternative energy are attributed to be the main source of declining per capita productivity of soils and fertility especially in the Nigerian savannah soils (Lombin, 1987, Rayar, 1988, Singh, 1997). In view of the multidimensional fertility and environmental

challenges of the region, periodic fertility evaluation is not only imperative and important but necessary if the soils are to produce crops on sustainable basis.

Also, if the soil management principles in sustainable agricultural systems as suggested by Greenland (1975), are to be adhered to, chemical nutrients removed by crops must be assessed and replenished. In addition, the physical condition of the soil must be regularly assessed and maintained. All these point towards periodic fertility evaluation of soils.

Soil fertility evaluation encompasses four main components; nutrient deficiency symptoms, plant tissue analysis, biological test and last but most importantly soil analysis. The soil analysis allows for the grouping of soils into their various classes; low, medium and high for the purpose of fertilization as well as amendments of problem soils, prediction of the profitability of getting a profitable response to fertilizer nutrients and amendments application, evaluation of soil fertility status vis-a-vis soil productivity to help monitor both soil fertility and yield sustainability over time and specific soil condition.

There is generally, paucity of soil information in most areas in Nigeria, and soil data bank is often fragmented. In view of that, evaluating some soils in Adamawa State will add to the existing soil information in Nigeria.

MATERIALS AND METHODS

Two locations in two Local Governments; Hong and Yola South respectively, were selected and large agricultural lands were selected and surveyed. Based on the survey and changing soil properties, profile pits were dug. Soils samples were collected and standard laboratory procedures were used to analyse the soils. The Walkley Black method was used to analyse organic carbon (OC), Kjeldahl digestion method was used to analyse the total nitrogen (TN) while Bray-1 and Olsen's methods were used for the analysis of P. Exchangeable bases were extracted using the ammonium acetate extraction procedure while exchangeable acidity was determined by extracting with 1N KCl. Effective cation exchange capacity (ECEC) was determined by summation method) while sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) were calculated using standard formulae. The data generated were analysed using SPSS and Start. 9.1.

RESULTS AND DISCUSSION

Soil Texture

Soils of the Chouchi plains were generally silt loam in texture throughout the soil profile. However, soils analysed from Hong were dominantly sandy loam at the upper layer while other layers down the profile did not show definite trend.

Soil pH (1:2, Soil: water) and Electrical conductivity (EC)

The soil reaction (pH) of both Chouchi plains and Hong were averagely neutral; 6.9 and 7.7 in reaction at the upper layers. The comparatively lower soil pH values in Chouchi plain soils may not be unconnected with the higher exchangeable acidity values of the soils and higher total exchangeable bases at Hong soils. Important also, is the fact that the dominant sandy loam soil at Hong might have allowed for the excess leaching of bases compared to the silt loam of Chouchi plains. The electrical conductivity (EC) of soils of both sites is far below the critical value (4dS/m) to interfere with plant growth (Brady and Weil, 2002).

Organic Carbon (OC), Total Nitrogen (TN) and Available phosphorus (AVP)

The organic matter content in both Chouchi and Hong soils were generally low to medium (< 15 gkg^{-1}). In Chouchi, the organic carbon content was moderate (<15 gkg^{-1}) throughout the profile except in some few instances where it reached up to 30 gkg^{-1}. The soils of Hong

were however generally low in organic carbon content (<10 gkg^{-1}) particularly at the sub-surface layer.

Total nitrogen content in Chouchi soils was generally low (<1.5 gkg^{-1}) except for profile 2 and 4 at the upper layer whose values reached 1.01 gkg^{-1}. In Hong, the total nitrogen content also was generally medium at the surface layer and low at the sub-surface layer except at profile pit 1 with 3.02 gkg^{-1} at the surface layer.

Available phosphorus (AVP) was generally low (<10 $mgkg^{-1}$) but not lacking in both Chouchi and Hong soils. However, Hong soils have comparatively higher available phosphorus values.

Exchangeable Bases Exchangeable Acidity and Base Saturation

The exchangeable bases Ca, Mg, Na and K in both Chouchi and Hong ranged from low to high. In Chouchi soils, calcium content was low (<2 $cmol^{(+)}kg^{-1}$) throughout the horizons while magnesium content was high (>1 $cmol^{(+)}kg^{-1}$). Potassium content was generally high (>0.3 $cmol^{(+)}kg^{-1}$) while sodium content ranged from medium to high (0.1 to >0.3) throughout the profiles. Exchangeable acidity was very high and ranged from 7-13.2 $cmolkg^{-1}$. Percent base saturation was generally low and ranged from 36-72 percent. In Hong soils, all the exchangeable bases were high. Calcium content ranged from 2.1 to 6.5 $cmolkg^{-1}$ while magnesium content ranged from 1.0 to 1.8 cmol $^{(+)}kg^{-1}$. Potassium and sodium content were also high and ranged from 0.63 to 1.46 and 1.07 to 3.6 $cmol^{(+)}kg^{-1}$ for potassium and sodium contents respectively. However, unlike the soils in Chouchi, the exchangeable acidity in Hong soils was generally low (<2 $cmol^{(+)}kg^{-1}$). Similarly, the percent base saturation was moderate to high and ranged from 70 % to >90 %.

Effective Cation Exchange Capacity (ECEC)

Effective cation exchange capacity (ECEC) was generally medium (4-10 $cmolkg^{-1}$) in Chouchi particularly at the surface soils. Hong soils have generally high (>10 $cmolkg^{-1}$) ECEC values especially at the surface.

Sodium Adsorption Ratio (SAR) and Exchangeable Sodium Percentage (ESP)

Sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) have direct bearing on plant growth and microbial activity in soil. Both SAR and ESP values in Chouchi were low. The SAR values were < 1 while ESP values were all < 5 % except at 75-95cm depth in one of the two profiles reaching 8.6%. In the soils of Hong, the SAR values were similarly low (< 5) implying comparatively higher SAR values. Unlike the exchangeable sodium percentage values in Chouchi, the values in Hong soils were generally high >15 %. Reaching up to 34.7 %.

Soil Variability

Studies on the soil's variability showed significant variability of total nitrogen and exchangeable sodium percentage in Chouchi soils. Other soil chemical fertility indices particularly pH, organic carbon, available phosphorus, percent base saturation and sodium adsorption ratio were not significantly different within the profiles. However, in Hong soils, electrical conductivity, total nitrogen and available phosphorus significantly vary within the profiles. Other soil fertility indices such ECEC and TEB were also not significant.

Correlation Studies

Correlation studies of the soils indicated that a highly significant positive correlation was observed between organic carbon (0.694**), exchangeable acidity (0.711**) and electrical conductivity while a highly significant but negative correlation was observed between total nitrogen (-0.694**), available phosphorus (-0.389**), ECEC (-0.636**) and EC.

However, a significant and positive correlation was observed between ECEC (0.500**), percent base saturation (0.711**), exchangeable sodium percentage (0.855**) and total nitrogen. Also, AVP highly and significantly positively correlated with TEB (0.717**), ECEC (0.587**), PBS (0.526**) and ESP (0.489**).

SUMMARY, CONCLUSION AND SUGGESTION

Two Local Governments were chosen in Adamawa state; Hong and Yola South and two locations with high agricultural potentials were deliberately selected and surveyed. Profile pits were sunk and soil samples were collected and analysed using standard laboratory procedures. Results of the selected soil fertility indices studied showed that soil reaction is of wide range (6.2-9.08) in both Chouchi plains and Hong soils. Organic carbon content was generally low in both sites but comparatively higher in the soils of Chouchi plain. Total nitrogen (TN) and available phosphorus ranged low to medium. Exchangeable bases were low in both sites but comparatively higher in Hong soils which was high in sodium content. Unfavourable calcium/magnesium ratios were observed in Chouchi plains. Effective cation exchange capacity (ECEC) of the soils of both sites ranged from low to medium in Chouchi plain and very high in Hong soils. Low exchangeable sodium percentage values were observed in Chouchi plain but high in Hong soils. Sodium adsorption ratio (SAR) values were generally low in both sites but comparatively higher in Hong soils. The coefficient of variability within the different soil profiles showed significant variability in electrical conductivity (EC); 96, 72 and 68 percent for first, second and third profile, total nitrogen; 64, 56 and 68 percent and available phosphorus 48, 65 and 75 percent respectively for Hong soils. Only total nitrogen content and exchangeable sodium percentage values showed significant variability in Chouchi soils. Organic carbon negatively correlated with some important fertility indices notably total nitrogen, available phosphorus and percent base saturation.

The soils of Chouchi plain are therefore of low fertility while Hong soils are of medium fertility. Although there is high percent base saturation in Hong soils, high sodium content of the soils may pose a serious threat of soil dispersion in addition to low organic carbon content. Therefore to produce crops sustainably on these soils, the following are suggested:

(1) The low organic carbon pool in the soils need to be amended through organic residue management and the application of integrated nutrient management (INM)

(2) Gypsum ($CaSO_4$. $2H_2O$) may not only ameliorate the unfavourable calcium/magnesium ratios in the two sites but may also balance some of the high pH values and also adjust high exchangeable acidity values in Chouchi plain. Similarly, it will reduce the high exchangeable sodium percentage values obtained in Hong soils.

(3) Nitrogen fertilizer management is of paramount importance due to its low total nitrogen content and low organic carbon contents. In addition, since the organic carbon contents is negatively correlated with both total nitrogen and available phosphorus perhaps due to some chemical soil peculiarities and interactions in the environment, the inevitability of the use of inorganic fertilizer in form of urea and SSP may be necessary.

(4) Periodic soil tests of both sites are imperative to properly monitor the soil fertility indices and prevent/avert soil fertility decline and degradation.

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