Abstract

Soil management practices that involved application of organic fertilizers (manures) could sustain soil chemical quality for crop production over longer period of continuous cultivation. Thus, an experiment was carried out in local farmers’ farm lands in Usmanu Danfodiyo University Sokoto, to investigate the effect of different cultivation practices on chemical properties of a sandy soil. The experiment consisted of two treatments (cultivated and uncultivated lands) replicated 5 times. Measurement of chemical properties of the soil such as organic matter (OM), organic carbon (OC), total nitrogen (TN), pH and cation exchange capacity (CEC) were made at 0-15 cm and 15-30 cm soil depths. Data obtained was analyzed using two-sample t-test. The results revealed that, farmers cultivation practices has no significant (p> 0.05) effect on chemical properties of the soil. However, there was a slight deterioration in chemical quality of the soil (at 0-15 cm soil depth) due to long-term continuous cultivation. The study further revealed that, cultivation encourages redistribution of OM contents of the soil within measured depths. From the results, it can be concluded that, the farmers cultivation practice (1 camel traction, 1-2 hand hoe cultivation plus camel or cow dung manure application per year) is still normal soil tillage that is capable of maintaining the soil’s chemical quality for agricultural crop production over longer (20 -25 years) period of cultivation. It is however recommended that, periodic checking (5-10 years) of chemical fertility status of the soil (farms) should be encouraged.

Key words: Cultivation practices, Cultivated soil, Uncultivated soil, Chemical properties, Chemical Quality

Introduction

Soil management practices such as cultivation and fertilization dictates the direction and magnitude of soil changes. Thus, proper soil and land management could be helpful in improving soil productivity, reducing soil degradation, enhancing soil and environmental quality and ensuring agricultural sustainability particularly in fragile coarse textured soils of semi arid environments.

Previous studies on long-term cultivation effects on soil chemical properties showed decreased organic matter (OM), organic carbon (OC), total nitrogen (TN) and other chemical properties due to long-term continuous cultivation (Eghball, 2002; Jiang et al., 2006; Ceyhun and Orhan, 2008; Celik et al., 2010). However, most deterrent effects on soil chemical properties were found in long term chemically fertilized plots
Soil management practices that involved organic fertilization could sustain soil chemical properties at acceptable limits for sustainable agricultural production. In addition, there is a dearth of information on the effect of peasant (local) farmers' cultivation practices on soil chemical properties in many regions of the world. Information on the effect of peasant (local) farmers' long-term cultivation practices on soil chemical properties could help in unveiling best soil management options for sustainable crop production in semi-arid Sokoto, northwestern Nigeria.

In view of the aforementioned, this study therefore was designed to assess the effects of peasant (local) farmers' long-term cultivation practices (involving organic fertilization and tillage) on chemical properties of a coarse-textured soil in Sokoto, Nigeria.

**Materials and Methods**

**The Study Area**

The study was conducted on cultivated and uncultivated peasant (local) farmers' farms around Usmanu Danfodiyo University Sokoto. Sokoto State is located on latitude 15° N and 13° E, 315 m above the sea level and belongs to the Sudan Savanna agro-ecological zone of northwestern Nigeria. The vegetation of Sokoto is characterized by scattered trees and grasses with a mono-model type of rainfall. The rainfall is erratic and scanty in nature throughout the rainy period (Rao, 1983; Singh, 1995). The area experiences two distinct seasons which are wet and dry seasons. The average annual minimum and maximum temperatures are 15°C and 40°C (Arnborg, 1988).
Treatments and Experimental Design

The experiment was established using t-test with two treatments (cultivated and uncultivated: fallowed lands) and five replications. The experimental sites were located around Gumburawa village, adjacent to the livestock farm, Usmanu Danfodiyo University Sokoto. The land use history of the two sites are as follow:

SITE 1: Cultivated Land

The site comprised of a cultivated land that is under local farmers’ management practices for 20-25 years. The commonly grown crops include millet and cowpea or groundnut. Tillage practices on this site involved 1 animal (camel) traction and 1-2 hand hoe cultivation per season (year). Camel or cow dung is the commonly applied organic fertilizer in this site.

SITE 2: Uncultivated (Fallow) Land

This site comprised of an uncultivated land (left fallow) for a period of 5-8 years. The land was left under natural vegetation that comprised of some grasses and scattered Azadiracta indica trees.

Soil Sample Collection and Preparation

Systematic sampling technique was employed for soil sample collection. Each of the 2 experimental sites was systematically divided into 5 segments. Within each segment, 3 random samples were systematically obtained using auger, thoroughly mixed to get a composite sample. The composite samples obtained were then air dried, screened through 2mm mesh, and kept for analysis.
Determination of Soil Chemical Properties

The chemical properties of the soil were determined according to the methods of Page et al. (1982). pH using pH meter, organic carbon (OC) by wet oxidation method, total nitrogen (TN) by micro kjeldahl procedure, available phosphorus (AP) by Bray-1 method, exchangeable bases extracted using 1 M ammonium acetate; sodium (Na) and potassium (K) determined by flame photometer while calcium and magnesium were determined using EDTA titration method. The cation exchange capacity (CEC) of the soil samples was determined using normal neutral ammonium acetate (Davis and Freitas, 1970).

Statistical Analysis

The data obtained was subjected to student two-sample t-test using SAS (2002) analytical software at 5% level of probability.

Results and Discussion

Effect of Cultivation Practices on Chemical Properties of the Soil

Effect of cultivation practices on soil pH

The results of the effect of cultivation practices on soil pH are presented in Table 1. The results revealed that, cultivation systems (cultivated and uncultivated soils) had no significant (P>0.05) effect on pH of the soil, at both surface (0-15cm) and subsurface (15-30cm) soil depths. However, there was a slight reduction on pH of the soil in uncultivated soil, which had lower pH values across the measurement depths compared to the cultivated soils (Table 1).

The non-significant effect of cultivation systems on soil pH could be attribute to the addition of organic manure (in cultivated soils) by farmers, which could have
balanced the pH reduction action of organic matter accumulation (through litter) and
decomposition in the uncultivated soil particularly at the surface soil depth. The results
are similar to the findings of Chiroma et al. (2013) who reported non-significant effect of
cultivation systems on soil pH. Generally, pH values observed in all the treatments,
across measurement depths are slightly acidic which are suitable for the production of
most agricultural crops (Landon, 1991).

**Effect of long-term cultivation on organic matter (OM), organic carbon (OC) and
total nitrogen (TN)**

Results of the effect of long-term cultivation on organic matter (OM), organic
carbon (OC) and total nitrogen (TN) contents of the soil are also presented in Table 1.
The results show that, cultivation systems had no significant (P>0.05) effect on OM, OC
and TN contents of the soil at both surface (0-15cm) and subsurface (15-30cm) soil
depths. However, the uncultivated soil had slightly higher OM, OC and TN content at the
surface soil depth, compared to the cultivated soil (Table 1). This is in accord with the
findings of Ceyhun and Orhan (2008) and Chiroma *et al.* (2013), who reported higher
values of OM, TN and/or OC contents in uncultivated soils compared to the cultivated
ones. The increase in OM, OC and TN contents in the uncultivated soil could be
attributed to higher litter turnover and reduce rate of leaching. Litter materials and other
vegetations upon decomposition, adds OM and OC to the soil, likewise other elements
essential to plant growth. Similar assertions were made by previous workers (Kahl *et al.*, 2009).
### Table 1: Chemical properties of the soil as influenced by cultivation practices in semi arid Sokoto, 2014

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil Depth</th>
<th>pH (H₂O,1:1)</th>
<th>OC (g/kg)</th>
<th>OM (g/kg)</th>
<th>TN (%)</th>
<th>AP (mg/kg)</th>
<th>Ca (g/kg)</th>
<th>Mg (g/kg)</th>
<th>K (g/kg)</th>
<th>Na (g/kg)</th>
<th>CEC (Cmol/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-15cm</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivated Soil</td>
<td></td>
<td>6.20</td>
<td>7.18</td>
<td>12.41</td>
<td>0.73</td>
<td>1.02</td>
<td>0.52</td>
<td>0.51</td>
<td>1.36</td>
<td>0.54</td>
<td>4.78</td>
</tr>
<tr>
<td>Uncultivated Soil</td>
<td></td>
<td>6.18</td>
<td>8.58</td>
<td>14.83</td>
<td>0.74</td>
<td>1.06</td>
<td>0.56</td>
<td>0.48</td>
<td>1.41</td>
<td>0.54</td>
<td>4.70</td>
</tr>
<tr>
<td>SE (±)</td>
<td></td>
<td>0.12</td>
<td>1.27</td>
<td>2.20</td>
<td>0.03</td>
<td>0.05</td>
<td>0.03</td>
<td>0.02</td>
<td>0.09</td>
<td>0.05</td>
<td>0.22</td>
</tr>
<tr>
<td>Significance</td>
<td>Ns</td>
<td>Ns</td>
<td>Ns</td>
<td>Ns</td>
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<td>Ns</td>
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<tr>
<td></td>
<td>15-30cm</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Cultivated Soil</td>
<td></td>
<td>6.56</td>
<td>7.22</td>
<td>12.48</td>
<td>0.60</td>
<td>0.86</td>
<td>0.38</td>
<td>0.38</td>
<td>1.25</td>
<td>0.39</td>
<td>4.19</td>
</tr>
<tr>
<td>Uncultivated Soil</td>
<td></td>
<td>6.34</td>
<td>6.94</td>
<td>12.00</td>
<td>0.60</td>
<td>0.94</td>
<td>0.38</td>
<td>0.40</td>
<td>1.23</td>
<td>0.37</td>
<td>4.15</td>
</tr>
<tr>
<td>SE (±)</td>
<td></td>
<td>0.29</td>
<td>1.22</td>
<td>2.12</td>
<td>0.02</td>
<td>0.05</td>
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<td>0.04</td>
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<tr>
<td>Significance</td>
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<td>Ns</td>
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</tr>
</tbody>
</table>

1-OC – organic carbon, OM- Organic matter, TN total Nitrogen, AP- available phosphorus, Ca-calcium, Mg-Magnesium, Potassium, Na-Sodium, CEC-cation exchange capacity
2- Ns - not significant, using two-sample t-test at p < 0.05.
On the other hand, however, the trend in cultivation systems effects on OM and OC and TN contents of the soil reversed at the subsurface soil depth (Table 1). Cultivated soils recorded higher OM and OC contents, compared to the uncultivated soil. This positive trend in cultivated soil could be attributed to the effect of cultivation that encourages redistribution of soil constituents across soil depths. Cultivation could have helped in burying organic manure applied by the farmers (in cultivated lands) which could have resulted in higher OM and OC contents compare to uncultivated soil. This conforms to the findings of Curtin et al. (2010) and Golchin and Asgari (2008) that, cultivation encourages redistribution of soil organic matter, which resulted in higher OM contents at the subsurface (20-40cm) soil depth (Golchin and Asgari, 2008). The results further confirmed that, both treatments have positive effect on OM, OC and TN contents of the soil across measured depths.

Effect of long-term cultivation on available phosphorus (AP)

Long-term cultivation systems effective on available phosphorus (AP) contents of the soil are presented in Table 1. No significant (P>0.05) effect of cultivation systems on AP content of the soil was observed across measurement depths (0-15 and 15-30cm), although uncultivated soils recorded higher values. The results implied that, the traditional farming system practiced by the local farmers (1 Animal traction, 1-2 hand hoe cultivation and cow dung or camel dung application per season) is good enough to maintain the supply of AP to the soil for sustainable agricultural crop production over longer period (20-25 years) of cultivation. Similar results were earlier reported by number of workers (Gomez-Aparico et al., 2005, Chiroma et al., 2013).
Effect of long-term cultivation on exchangeable cations and cation exchange capacity (CEC)

Result pertaining long-term cultivation systems effect on exchangeable cations and CEC contents of the soil are also presented in Table 1. The results revealed that, there was no significant (P>0.05) differences between treatments tested in exchangeable cations and CEC of the soil. In general, no consistent trend between treatments across sampling depths observed. However, cultivated soils recorded slightly higher CEC values across measurement depths (0-15 and 15-30cm) compared to their uncultivated counterpart. This could also be related to the application of organic manure (cow dung or camel dung) by the farmers, that might have equated the influence of increased organic matter (and hence, CEC) in the uncultivated soils (through the influence of litter accumulation in uncultivated soils). In addition, the limiting influence of no cultivation (uncultivated soil) in improving cations concentrations and CEC of the soil concord with the findings of Gomez-Aparico et al. (2005) and Chiroma et al. (2013), who reported limited influence of tree canopies (uncultivated soils under forest tree canopies) in improving soil exchangeable cations concentration and CEC.

Conclusion

The study revealed that, the treatments tested (cultivation and no-cultivation) had no significant (P>0.05) effect on the soil chemical properties. However, there was a slight deterioration in chemical quality of the soil due to long term cultivation at the surface soil layer (depth) reflected by decreased organic matter, organic carbon and total nitrogen contents. The study further revealed that, cultivation encourages redistribution of organic matter within measured depths. From the results, it can be concluded that, the peasant farmers cultivation
practice (1 camel traction, 1-2 hand hoe cultivation, plus application of cow dung or camel dung per season) had the capacity of maintaining the soil chemical quality at acceptable limits to withstand long-term (20-25 years) intensive agricultural crop production. It is however recommended that, periodic checking (5-10 years) of chemical fertility of the farms should be encouraged.

References


