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Effect of Peasant Farmers Cultivation Practices on Chemical Properties of a Sandy Soil in Sokoto, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors MMS, SAL and ALN designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors IBB and DW managed the literature searches and statistical analyses while authors BSH and SA performed the laboratory analyses. All authors read and approved the final manuscript.

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ABSTRACT

Maximization of agricultural crop production could require continuous cultivation likewise soil protection. Thus, an experiment was carried out in local farmers' farm lands in Usmanu Danfodiyo University Sokoto, Nigeria 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

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(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.

Keywords: Cultivation practices; cultivated soil; uncultivated soil; chemical properties; chemical quality.

1. 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 [1,2,3,4]. However, most deterrent effects on soil chemical properties were found in long term chemically fertilized plots [1,4]. Soil management practices that involved organic fertilization could sustain soil chemical properties at acceptable limits for sustainable agricultural production. In addition, there is dearth of information on 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.

2. MATERIALS AND METHODS

2.1 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 and13°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 mono-model type of rainfall. The rainfall is erratic and scanty in nature throughout the rainy period [5,6]. 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 [7].

2.2 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:

2.2.1 Site 1: Cultivated land

The site comprised of a cultivated land (100 m^2 in size) 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.

2.2.2 Site 2: Uncultivated (Fallow) land

This site comprised of 100 m^2 uncultivated land (left fallow) for a period of 5-8 years. The land was previously cultivated for a period of about 10 years under similar cultivation practices as those of the cultivated land, except that only cow dung manure and sometimes NPK fertilizer are applied to the land. It was later left under natural vegetation (fallow) that comprised of some grasses and scattered *Azadiracta indica* trees for 5-8 years.

2.3 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 (which equals replications). 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 2 mm mesh, and kept for analysis.

2.4 Determination of Soil Chemical Properties

The chemical properties of the soil were determined according to the methods of [8]. 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 [9].

2.5 Statistical Analysis

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

3. RESULTS AND DISCUSSION

3.1 Effect of Cultivation Practices on Chemical Properties of the Soil

3.1.1 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 (0-15 cm) and subsurface (15-30 cm) 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 [10] who reported non-significant effect of cultivation systems on soil pH. Generally, pH values observed in all

Table 1. pH, organic carbon (OC), organic matter, total nitrogen (TN) and available phosphorus as influenced by cultivation practices in semi arid Sokoto, 2014

Treatment	Soil depth	pH (H_2O,1:1)	OC (g/kg)	OM (g/kg)	TN (%)	AP (mg/kg)
	0-15 cm					
Cultivated soil		6.20	7.18	12.41	0.73	1.02
Uncultivated soil		6.18	8.58	14.83	0.74	1.06
SE (±)		0.12	1.27	2.20	0.03	0.05
Significance		Ns	Ns	Ns	Ns	Ns
	15-30 cm					
Cultivated soil		6.56	7.22	12.48	0.60	0.86
Uncultivated soil		6.34	6.94	12.00	0.60	0.94
SE (±)		0.29	1.22	2.12	0.02	0.05
Significance		Ns	Ns	Ns	Ns	Ns

1-OC – organic carbon, OM- organic matter, TN- total nitrogen, AP-available phosphorus
2- Ns - not significant using two-sample t-test at $p < 0.05$

the treatments, across measurement depths are slightly acidic which are suitable for the production of most agricultural crops [11].

3.1.2 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 (0-15 cm) and subsurface (15-30 cm) 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 [3] and [10], 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 turn over 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 [12].

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 [13] and [14] that, cultivation encourages redistribution of soil organic matter, which resulted in higher OM at the subsurface (20-40 cm) soil depth [14].

The results further confirmed that, both treatments have positive effect on OM, OC and TN contents of the soil across measured depths. In addition, values of OM reported are in accord with those reported by [15] which ranges between 10.9 – 14.3 g/kg while those of OC are in line with those reported by [16] ranging from 0.34-0.66% all in a sandy loam soil in Sokoto, northwestern Nigeria.

3.1.3 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 15-30 cm), 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 [17,10]. The AP values observed irrespective of treatment are however lower than those reported by [16] in a sandy loam in Sokoto (4.22 – 4.94 mg/kg), which could be due to less nutrient retention capacity of sandy soil compared to sandy loam soil.

3.1.4 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 presented in Table 2. 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 15-30 cm) 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 [17] and [10], who reported limited influence of tree canopies (uncultivated soils under forest tree canopies) in improving soil exchangeable cations concentration and CEC. In general, the CEC values observed are similar to those reported by [15] in a sandy loam (3.64- 4.98 cmol/kg) in Sokoto, northwestern Nigeria.

Table 2. Exchangeable cations (Ca, Mg, K, Na) and cation exchange capacity (CEC) of the soil as influenced by cultivation practices in semi arid Sokoto, 2014

Treatment	Soil depth	Ca	Mg	K	Na	CEC
		....	....	Cmol/kg	....	....
	0-15 cm					
Cultivated Soil		0.52	0.51	1.36	0.54	4.78
Uncultivated Soil		0.56	0.48	1.41	0.54	4.70
SE (+)		0.03	0.02	0.09	0.05	0.22
Significance		Ns	Ns	Ns	Ns	Ns
	15-30 cm					
Cultivated Soil		0.38	0.38	1.25	0.39	4.19
Uncultivated Soil		0.38	0.40	1.23	0.37	4.15
SE (+)		0.02	0.03	0.03	0.04	0.12
Significance		Ns	Ns	Ns	Ns	Ns

1- Ca-calcium, Mg-Magnesium, K-Potassium, Na-Sodium, CEC-cation exchange capacity
2- Ns - not significant using two-sample t-test at $p < 0.05$

4. CONCLUSION

The study revealed that, the treatments tested (cultivation and no-cultivation) had no significant (P>0.05) effect on the soil chemical properties implying both intensive cultivation and no cultivation could be required for sustainable food production and soil and environmental protection. 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 properties over long-term (20-25 years) intensive agricultural crop production and should therefore be encouraged. It is however recommended that, periodic checking (5-10 years) of chemical fertility of the farms should be encouraged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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