



Evaluation Of Some Soil Chemical Properties As Influenced By Cowpea (*Vigna Unguiculata* Walp) Cultivation In An Entisol Of Sokoto Sudan Savannah Agroecological Zone Of Nigeria

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ABSTRACT

Cultivation of Legumes in rotation improves soil fertility resulting in high and sustainable productivity of succeeding crop. A study was therefore conducted to evaluate some soil chemical properties as influenced by cowpea (*Vigna unguiculata* Walp) cultivation in an Entisol of Sokoto Sudan savanna agroecological zone. Treatments imposed were five cowpea varieties [IT 88D-867-11, IT 89KD-288, IT 90K-1372-1-2, IT 90K – 82-2 and Bahausha (local)] and a fallow. The decrease in soil pH prior to the following year's cropping compared with at cowpea harvest did not alter the strongly acid class of the soil. Mean values of soil exchangeable Calcium (Ca) and Magnesium (Mg), Effective Cation Exchange Capacity (ECEC), Cation Exchange Capacity (CEC) and Base Saturation (BS) recorded were significantly ($P < 0.05$) higher prior to planting of subsequent crop than at cowpea harvest. However, only the mean value obtained in CEC was higher than the initial value. The lowest depletion of these parameters and highest CEC value were observed in IT89KD-288 variety. It is therefore suggested that IT 89D-288 be included in the farming systems of Sudan savanna agroecological zone.

Keywords: Cowpea cultivation, chemical properties, Entisol, Sudan savanna

INTRODUCTION

It was reported by Singh (2004) that bulk of the soils in the Sudan Savanna are predominantly low in soil fertility. They have low levels of soil nutrient, sorption, cation exchange capacities, water holding capacities and sometimes potassium (K).

Grain legumes particularly cowpea occur widely in traditional cropping systems, but there are few signs of deliberate use of legumes for fertility management by African farmers (McDonagh and Hillyer, 2003). Legume/cereal rotations have been suggested as an effective means to increase soil productivity. In addition to improving soil physical and chemical properties, it decreases pest and disease incidence and addition of growth promoting substances (Giller, 2001).

Apart from its nutritional value, grain legumes were reported to improve soil nutrient supply, availability and or improvement in soil water holding capacity. Moreover, legumes offer other benefits such as providing cover to reduce soil erosion, maintenance and

improvement of soil physical properties, Cation Exchange Capacity (CEC) and reduction in soil temperature and weed suppression (Abayomi *et al.*, 2001). Enhanced infection of cereal roots with arbuscular micorrhizal infection, decreased nematode infection and beneficial changes in the soil bacterial community status were also observed by Alvey *et al.* (2001). Also, the study carried out by Promsakha *et al.* (2005) showed that, complete removal of legume residue gave 2786 and 1169 kg ha⁻¹ grain and stover yields of maize, respectively.

According to Promsakha *et al.* (2005), grain legumes are generally thought to make a substantial contribution to soil fertility in crop rotation systems. However, studies carried out by Usman (2006), Adeboye *et al.* (2006), Ibrahim (2007) and Okonji *et al.* (2011) were

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focused on effects of legume residues (above and below ground) on food crops immediately sown after the legume crop. While in many tropical countries with a prolonged dry season such as Sokoto Sudan savanna ecological zone, there is a large gap (lag period) before planting the next crop.

Cowpeas are found on farmer's field across the entire savanna agro-ecological zone (Yusuf *et al.*, 2006) but more in the semi arid where it is better adapted. The need to evaluate and compare the chemical properties of soils at cowpea harvest and prior to planting of millet is therefore imperative. Millet is the most cultivated cereal crop in the Sokoto Sudan savanna zone of Nigeria. It is a very important crop, because it is the most dependable source of food (usually consumed as stiff porridge (Tuwo), (kunu, ogi or akamu, fura and masa) for large number of people in this environments for which it has special adaptation (Gwadi *et al.*, 2004). Millet fodder and stover are also used as livestock feed.

This work is therefore conducted to evaluate some soil chemical properties as influenced by cowpea (*Vigna unguiculata* Walp) cultivation in an Entisol of Sokoto sudan savannah agroecological zone of Nigeria

METHODOLOGY

Site Description

Sokoto, the capital of Sokoto state is located between latitude $11^{\circ} 30' - 13^{\circ} 55' N$ and longitude $4^{\circ} 07' - 6^{\circ} 56' E$ situated in Sudan savanna zone. The region enjoys the Sudan savanna type of vegetation with few scattered trees and numerous shrubs sandwiched by grasses and herbs in isolated places. The On-Station research was carried out at Dabagi Farm Usmanu Danfodiyo University, Sokoto in 2008 through 2010 cropping seasons. Dabagi Farm lies on latitude $12^{\circ} 46' N$ and longitude $05^{\circ} 26' E$ and is about 40 Km south - east of Sokoto metropolis. The mean average annual rainfall of Sokoto State is 565 mm (it occurs between May-October) and the temperature averages $27^{\circ} C$ with peak at $40^{\circ} C$ (April) and $15^{\circ} C$ (December – January). Taxonomic classification using the USDA Soil Taxonomy classified the soil unit as *Typic Dystrustepts*. The soil order is an Entisol (Sakaba, 2011). A ten-year cropping history showed that, except for 1998, 2003 and 2007

that the experimental site was left fallow, either millet or sorghum was cultivated at the site in the remaining years.

Treatments and Experimental Design

Five cowpea cultivars {IT88D-867-11 (early maturity), 89D-288 (medium maturity), IT90K-82-2 (early maturity), IT90K-372-1-2 (medium maturity) [obtained from IITA, Kano sub – station]} and Bahaushen wake {local} (medium maturity) (obtained from a local farmer in Sokoto) were grown to maturity. Fallow treatment was included in the study. The experiment was laid out in a randomized complete block design replicated three times. Each experimental plot measured 16 m by 7.5 m large enough to contain 10 ridges of 0.75 m apart. The intra row spacing for cowpea was 0.25. A starter dose of 20 Kg ha⁻¹ NPK 15:15:15 was applied by single banding about 5 cm deep made along the ridges 5 – 10 cm away from the plant stand to cowpea at two weeks after planting (WAP). Four (4) cowpea seeds were sown per hole and later thinned to 2 plants per stand at 2 WAP. Weeding was carried out in all the plots at 2 and 4 WAP.

Soil Sampling and Analysis

Twenty core samples (0 – 20 cm) were initially taken at random within the experimental sites before ridges for planting cowpea were made in each of the cropping years (2008 and 2009) for routine physical and chemical properties (Table 1). At cowpea harvest in 2008 and 2009 cropping seasons, ten (10) soil samples from each plot were taken. In 2009 and 2010 another ten (10) soil samples were taken from 0 – 20 cm depth from each treatment plots. This was carried out before ridges for planting the subsequent crop were made in the following cropping seasons (2009 and 2010). Soil samples in each plot were bulked accordingly to form a composite sample. A sub – sample of the composite soil obtained through coning and quartering were sieved through a 2 mm sieve and subjected to routine soil analysis. Soil reaction (pH), exchangeable bases [Calcium (Ca), Magnesium (Mg), Potassium (K) and Sodium (Na)], Cation Exchange Capacity (CEC), effective CEC, Exchangeable Acidity and Base Saturation (BS) were analyzed using standard methods described by Anderson and Ingram (1993) and International Institute of Tropical Agriculture (IITA) (1989).

Statistical analysis

Data obtained was subjected to analysis of variance (ANOVA) using General Linear Model procedure of SAS (Statistical Analysis System Inst., 1999). Means separation was done using Duncan Multiple Range test, tested at 5% probability level.

RESULTS AND DISCUSSION

Initial Soil Physical and Chemical Properties of experimental site

Soil chemical and physical properties at the experimental site are presented in Table 1.

Except for pH in water that recorded significantly higher value in 2008 than that of 2009, other chemical parameters determined statistically at par. The soils at the study area were strongly to moderately acidic and belong to the sandy loam textural class. Organic Carbon, total nitrogen, available Phosphorus, CEC and percentage base saturation were generally low (Table 1) according to the ratings of Esu (1991).

Soil reaction and exchangeable acidity

The effect of growing cowpea on some chemical properties of the soil at cowpea harvest and prior to sowing of subsequent crop [after about 9 months (i.e. June – October) of lag period] are presented in Tables 2 through 9. Soil pH and exchangeable acidity at cowpea harvest and prior to planting the following crop are presented in Tables 2 and 3.

At cowpea harvest, pH (H₂O) and pH (CaCl₂) ranged from 5.36 to 5.53 and 5.08 to 5.13, respectively in 2008, 2009 and two years combined (Table 2). These values (5.36 to 5.53 and 5.08 to 5.13) were significantly ($P \leq 0.05$) lower than those of initials and combined analysis. The pH values that ranged between 5.36 – 5.43 in H₂O and 5.08 – 5.15 in CaCl₂ were recorded prior to subsequent cropping in both years and combined (Table 3).

Only the value of pH in water differed statistically ($P < 0.05$) in 2010 among treatments (Table 3). Pooled analysis of values obtained in both sampling periods (cowpea harvest and prior to subsequent cropping) as shown in Table 4 revealed that significantly ($P \leq 0.05$) highest pH values were observed in IT 89D- 288 (pH in H₂O = 5.44 and pH in CaCl₂ = 5.13) and Bahaushe

(local) (pH in H₂O=5.43 and pH in CaCl₂ = 5.13) plots. Table 5 showed that irrespective of varietal treatments pH in H₂O and CaCl₂ at cowpea harvest and prior to following year's cropping had values that differed only marginally. The pH ranges obtained in this work indicated that the soil was moderately acidic according to Victor *et al.* (2005) criteria. Generally, pH values observed during the sampling periods were lower than the initial indicating that the cowpea varieties grown and fallow increased acidity of the soil (Mohammed, 2001). Increased acidity was however, generally highest in fallow plots. The findings of Kamh *et al.* (1999) revealed that legumes have acidifying effect on the soils due to nitrogen fixation. Variations observed in the values of pH among treatments could be attributed to the differentials in their genotypes. This corroborates the assertions of Tebebe *et al.* (1995) and Sanginga *et al.* (2000). These researchers explained that plant genotypes influence the effect of phosphorus on nodulation and hence the amount of nitrogen fixed in the soil, which in turn causes variation in their effect on soil pH where they are grown. Except for IT 89D-288 that had exchangeable acidity value of 0.14 cmolkg⁻¹ in 2009 which was similar to that of the initial, all the values obtained in other treatments and combined were significantly higher than those of the initial at cowpea harvest (Table 2). Prior to sowing of subsequent crop, IT 89D- 288 recorded significantly the lowest values of 0.16 and 0.12 cmolkg⁻¹ exchangeable acidity in 2009 and 2010 respectively followed by Bahaushe (local) among treatments (Table 3). The IT 89D-288 consistently had significantly the lowest value of 0.14 cmolkg⁻¹ in the combined, while fallow plots recorded significantly the highest value of 0.22 cmolkg⁻¹. Table 4 showed that, irrespective of sampling periods IT 90K-82-2 recorded the highest exchangeable acidity value of 0.21 cmolkg⁻¹ and the lowest value was observed in IT 89D-288 (0.15 cmolkg⁻¹) among cowpea varieties. Fallow was only marginally higher than the 0.21 cmolkg⁻¹ obtained in IT 90K-82-2. On the whole, exchangeable acidity at cowpea harvest and before sowing of subsequent crop were similar (Table 5).

Table 1. Selected chemical and physical properties of soil (0-20cm) at the experimental site prior to cowpea cropping in 2008 and 2009

Soil parameter	2008	2009	S. E.
pH (H ₂ O) in 1:1 ratio	5.73 ^a	5.41 ^b	0.044
pH (CaCl ₂) in 1:2 ratio	5.44 ^a	5.12 ^a	0.061
Org. C (g kg ⁻¹)	1.32 ^a	1.30 ^a	0.059
Org. M (g kg ⁻¹)	2.28 ^a	2.24 ^a	0.101
Total N (g kg ⁻¹)	0.22 ^a	0.22 ^a	0.017
Available P (mg kg ⁻¹)	2.73 ^a	2.71 ^a	0.014
Exchangeable cations (cmol kg ⁻¹)			
Ca	1.77 ^a	1.74 ^a	0.032
Mg	0.26 ^a	0.23 ^a	0.004
K	0.12 ^a	0.12 ^a	0.004
Na	0.20 ^a	0.19 ^a	0.004
Exchangeable acidity (cmol kg ⁻¹)	0.13 ^a	0.14 ^a	0.015
Effective CEC	2.48 ^a	2.42 ^a	0.023
Cation exchange capacity(cmol kg ⁻¹)	5.64 ^a	5.61 ^a	0.011
Base saturation (%)	44 ^a	43 ^a	0.325
Particle size distribution			
Sand (g kg ⁻¹)	792.0	792.0	
Silt (g kg ⁻¹)	183.0	183.0	
Clay (g kg ⁻¹)	25.0	25.0	
Textural class	Sandy Loam	Sandy Loam	

Means in a column and treatment group followed by same letters are not significantly different.
S. E. = Standard Error.

Table 2. Effect of growing cowpea on soil pH and exchangeable acidity at cowpea harvest in 2008 and 2009

Treatment	pH (H ₂ O)			pH (CaCl ₂)			Exch. Acidity (Al ³⁺ + H ⁺) (cmolkg ⁻¹)		
	2008	2009	Combined	2008	2009	Combined	2008	2009	Combined
Initial	5.73 ^a	5.41	5.57 ^a	5.44 ^a	5.12 ^a	5.28 ^a	0.13 ^c	0.14 ^c	0.14 ^d
IT 88D- 867-11	5.43 ^b	5.37	5.40 ^b	5.11 ^b	5.09 ^a	5.10 ^b	0.19 ^{ab}	0.17 ^{abc}	0.18 ^{bc}
IT 89D- 288	5.53 ^b	5.40	5.47 ^b	5.12 ^b	5.13 ^a	5.13 ^b	0.18 ^b	0.14 ^c	0.16 ^{cd}
IT 90K- 372- 1 -2	5.40 ^b	5.36	5.38 ^b	5.11 ^b	5.10 ^a	5.11 ^b	0.19 ^{ab}	0.20 ^{ab}	0.20 ^{ab}
IT 90K-82-2	5.41 ^b	5.39	5.40 ^b	5.10 ^b	5.08 ^a	5.09 ^b	0.20 ^{ab}	0.21 ^{ab}	0.21 ^{ab}
Bahaushe (local)	5.50 ^b	5.39	5.44 ^b	5.12 ^b	5.11 ^a	5.12 ^b	0.19 ^{ab}	0.17 ^{bc}	0.18 ^{bc}
Fallow	5.38 ^b	5.38	5.38 ^b	5.09 ^b	5.09 ^a	5.09 ^b	0.21 ^a	0.22 ^a	0.22 ^a
S. E.	0.06	0.04	0.05	0.03	0.04	0.04	0.01	0.02	0.01

Means in a column and treatment group followed by same letters are not significantly different using DMRT at 5 % level.

Table 3. Residual effects of growing cowpea on soil pH and exchangeable acidity prior to subsequent year's cropping in 2009 and 2010

Treatment plots	pH (H ₂ O)			pH (CaCl ₂)			Exch. Acidity (Al ³⁺ + H ⁺) (cmolkg ⁻¹)		
	2009	2010	Combined	2009	2010	Combined	2009	2010	Combined
IT 88D- 867-11	5.36	5.41 ^a	5.39 ^{ab}	5.08 ^a	5.10 ^a	5.09 ^a	0.22 ^a	0.18 ^b	0.20 ^{bc}
IT 89D- 288	5.41	5.42 ^a	5.41 ^a	5.13 ^a	5.13 ^a	5.13 ^a	0.16 ^c	0.12 ^d	0.14 ^e
IT 90K- 372- 1 -2	5.40	5.42 ^a	5.40 ^{ab}	5.11 ^a	5.12 ^a	5.12 ^a	0.18 ^{bc}	0.19 ^b	0.19 ^c
IT 90K-82-2	5.35	5.40 ^a	5.38 ^{ab}	5.08 ^a	5.10 ^a	5.09 ^a	0.22 ^a	0.19 ^b	0.21 ^{ab}
Bahaushe (local)	5.41	5.43 ^a	5.42 ^a	5.13 ^a	5.15 ^a	5.14 ^a	0.18 ^{bc}	0.15 ^c	0.17 ^d
Fallow	5.37	5.34 ^b	5.36 ^b	5.09 ^a	5.08 ^a	5.09 ^a	0.20 ^{ab}	0.24 ^a	0.22 ^a
S. E.	0.03	0.02	0.02	0.03	0.03	0.02	0.01	0.01	0.02

Means in a column and treatment group followed by same letters are not significantly different using DMRT at 5 % level.

At cowpea harvest, pH (H₂O) and pH (CaCl₂) ranged from 5.36 to 5.53 and 5.08 to 5.13, respectively in 2008, 2009 and two years combined (Table 2). These values (5.36 to 5.53 and 5.08 to 5.13) were significantly ($P \leq 0.05$) lower than those of initials and combined analysis. The pH values that ranged between 5.36 – 5.43 in H₂O and 5.08 – 5.15 in CaCl₂ were recorded prior to subsequent cropping in both years and combined (Table 3).

Only the value of pH in water differed statistically ($P < 0.05$) in 2010 among treatments (Table 3). Pooled analysis of values obtained in both sampling periods (cowpea harvest and prior to subsequent cropping) as shown in Table 4 revealed that significantly ($P \leq 0.05$) highest pH values were observed in IT 89D- 288 (pH in H₂O = 5.44 and pH in CaCl₂ = 5.13) and Bahaushe (local) (pH in H₂O=5.43 and pH in CaCl₂ = 5.13) plots. Table 5 showed that irrespective of varietal treatments pH in H₂O and CaCl₂ at cowpea harvest and prior to following year's cropping had values that differed only marginally. The pH ranges obtained in this work indicated that the soil was moderately acidic according to Victor *et al.* (2005) criteria. Generally, pH values observed during the sampling periods were lower than the initial indicating that the cowpea varieties grown and fallow increased acidity of the soil (Mohammed, 2001). Increased acidity was however, generally highest in fallow plots. The findings of Kamh *et al.* (1999) revealed that legumes have acidifying effect on the soils due to nitrogen fixation. Variations observed in the values of pH among treatments could be attributed to the differentials in their genotypes. This corroborates the assertions of Tebebe *et al.* (1995) and Sanginga *et al.* (2000). These researchers explained that plant genotypes influence the effect of phosphorus on nodulation and hence the amount of nitrogen fixed in the soil, which in turn causes variation in their effect on soil pH where they are grown. Except for IT 89D-288 that had exchangeable acidity value of 0.14 cmolkg⁻¹ in 2009 which was similar to that of the initial, all the values obtained in other treatments and combined were significantly higher than those of the initial at cowpea harvest (Table 2). Prior to sowing of subsequent crop, IT 89D- 288 recorded significantly the lowest values of 0.16 and

0.12 cmolkg⁻¹ exchangeable acidity in 2009 and 2010 respectively followed by Bahaushe (local) among treatments (Table 3). The IT 89D-288 consistently had significantly the lowest value of 0.14 cmolkg⁻¹ in the combined, while fallow plots recorded significantly the highest value of 0.22 cmolkg⁻¹. Table 4 showed that, irrespective of sampling periods IT 90K-82-2 recorded the highest exchangeable acidity value of 0.21 cmolkg⁻¹ and the lowest value was observed in IT 89D-288 (0.15 cmolkg⁻¹) among cowpea varieties. Fallow was only marginally higher than the 0.21 cmolkg⁻¹ obtained in IT 90K-82-2. On the whole, exchangeable acidity at cowpea harvest and before sowing of subsequent crop were similar (Table 5).

Generally, it shows that exchangeable acidity values obtained in all the treatment plots were generally higher than those of the initial. This cannot be unconnected with the increased acidity recorded in the treatment plots over those of the control. The upper limit of 0.12 to 0.24 cmolkg⁻¹ range (Tables 2 and 3) observed in this study was very much below the 1.00 cmolkg⁻¹ critical level for soils to have acidity problem according to Odunze *et al.* (1992).

Exchangeable bases and effective cation exchange capacity (ECEC)

Presented in Tables 4, 5, 6, 7, 8 and 9 are the results of soil exchangeable bases and ECEC. All the mean values obtained in the cowpea and fallow treatment plots for Ca, Mg, K, Na and ECEC at cowpea harvest in 2008 and 2009 and combined were significantly ($P < 0.05$) different (Table 6 and 8). The mean values that ranged from 0.88 – 1.48, 0.12 – 0.19, 0.06 – 0.10 and 0.11 – 0.16 cmol kg⁻¹ were obtained for Ca, Mg, K and Na respectively in both years and combined (Table 6). The ECEC on the other hand, recorded values that ranged between 1.41 and 2.06 cmol kg⁻¹ in 2008 and 2009 and combined (Table 8). Both cowpea and fallow treatment plots significantly decreased the mean values of exchangeable bases and ECEC over those of the initial at cowpea harvest in the two years and combined (Tables 6 and 8).

Generally, the largest decreases were observed with IT 90K-82-2 and IT 88D- 867-11, while the lowest was with IT 89D- 288 followed by Bahaushe (local).

Prior to subsequent year's cropping, values recorded for Ca, Mg, K, Na and ECEC were between 0.91 – 1.54, 0.14 – 0.19, 0.08 – 0.10, 0.11 – 0.13 and 1.46 – 2.11 cmolkg^{-1} , respectively in the combined analysis (Table 7 and 9). These values and those of 2009 and 2010 differed significantly ($P < 0.05$). The only exception was that of Na in 2009. The values recorded in this sampling period were also lower than the initial value (Tables 6 and 8). The trend of decrease was similar to that of sampling at cowpea harvest (Table 7). Table 5 shows the comparison between sampling at cowpea harvest and prior to subsequent year's planting irrespective of cowpea and fallow treatments. Three trends of result were obtained. They include; (i) soil Ca and Mg contents significantly higher ($P < 0.05$) prior to sowing of millet than at cowpea harvest (ii) Na contents significantly ($P < 0.05$) higher at cowpea harvest than prior to sowing of crop the following year and (iii) the non significance ($P < 0.05$) of K contents and ECEC between sampling periods.

Irrespective of sampling periods, exchangeable bases and ECEC ranged from 1.03 – 1.51, 0.15 – 0.19, 0.06 – 0.10, 0.13 – 0.13 and 1.56 – 2.08 cmolkg^{-1} among cowpea varieties (Table 4). Significantly the highest soil exchangeable base and ECEC were observed in IT 89D- 288. However, these values did not differ significantly from those of K in Bahausha (local) and Na in IT 90K- 372- 1 -2 and Bahausha (local). The values obtained in exchangeable bases and ECEC irrespective of sampling periods (Table 4) were below those of the initials (Tables 6 and 8). This implies that the crops used in this study depleted the soil exchangeable bases. This is in agreement with the findings of Promsakha *et al.* (2005) and Osundare (2008). They reported decrease in soil K and Ca contents in legumes grown plots. Only Na had mean value that was rated medium, Ca, Mg and K were rated low according to the rating of Esu (1991).

Cation exchange capacity (CEC) and percentage base saturation (PBS)

Results of cation exchange capacity (CEC) and percentage base saturation (PBS) are shown in Tables 4, 5, 8 and 9. The values obtained at cowpea harvest varied significantly in 2008 and 2009 and combined (Table 8). In the combined analysis, CEC and PBS ranged from 5.55 (fallow) to 5.77 (IT 89D- 288) cmolkg^{-1}

and 25.86 (fallow) to 35.48 (IT 89D- 288) % respectively (Table 8). Significantly ($P < 0.05$) the highest CEC was consistently observed with IT 89D- 288 in 2008 and 2009 and combined. Values obtained in the combined analysis for other cowpea treatments did not differ statistically. Except for the fallow plots that decreased CEC, all the cowpea treated plots increased CEC over those of the initial values. The increased organic carbon (OC) content probably led to the increased CEC. On the contrary, all the treatments decreased percentage base saturation (PBS) in relation to the initial value (Table 8). This could be as a result of the general decrease in soil pH and exchangeable bases, and increased exchangeable acidity (Tables 2 and 6). The largest decrease among cowpea treatments was in IT 88D- 867-11 which was statistically the same with IT 90K-82-2. IT 89D- 288 consistently recorded the lowest decrease in 2008 and 2009 and combined (Table 8). Percentage BS ranged from 25.35 to 36.07 % in 2008 and 2009 and combined (Table 8).

Table 9 also revealed that CEC values obtained prior to planting in 2009 and 2010 and combined were higher than those of the initials. Significantly ($P < 0.05$) largest increase in CEC value (5.78 cmolkg^{-1}) was with IT 89D- 288 and the lowest with IT 90K-82-2 (5.67 cmolkg^{-1}) and in the combined analysis (Table 9). In the combined, the highest percentage BS was recorded in IT 89D- 288 followed by Bahausha (local) and IT 90K-372- 1 -2 which did not differ statistically ($P > 0.05$). The IT 88D- 867-11 had the lowest percentage BS and was not significantly different from that of IT 90K-82-2 (Table 9). The 5.68 cmolkg^{-1} and 31.22 % values obtained for CEC and PBS respectively, prior to planting in the subsequent year were significantly higher than that observed at cowpea harvest (Table 9). In the pooled analysis presented in Table 4, CEC and percentage BS values were significant. CEC ranged between 5.65 cmolkg^{-1} in IT 90K-82-2 and 5.77 cmolkg^{-1} in IT 89D- 288 among cowpea treatments. The lowest value of this range (5.65 cmolkg^{-1}) was higher than the initial values averaged (5.63 cmolkg^{-1}) (Table 8). The IT 89D- 288 consistently recorded the highest percentage BS irrespective of the sampling periods (Table 4) but was below the value obtained in the initial (Table 8).

The values of CEC and percent BS recorded in this study fall within the low rating category (CEC of $> 6 \text{ cmolkg}^{-1}$ and PBS of $> 50 \%$) of Esu (1991).

Table 4 . Pooled analysis of soil pH, Exchangeable bases and acidity, ECEC, CEC and Base saturation at both cowpea harvest in 2008 and 2009 and before subsequent crop planting in 2009 and 2010 as influenced by cowpea variety

Treatment Plot	pH (H ₂ O)	pH (CaCl ₂)	Ca (cmolkg^{-1})	Mg (cmolkg^{-1})	K (cmolkg^{-1})	Na (cmolkg^{-1})	Exch. Acidity (Al ³⁺ +H ⁺) (cmolkg^{-1})	ECEC (cmolkg^{-1})	CEC (cmolkg^{-1})	BS (%)
IT 88D- 867-11	5.39 ^{ab}	5.10 ^{ab}	1.03 ^c	0.16 ^c	0.07 ^{bc}	0.11 ^b	0.19 ^b	1.56 ^d	5.66 ^c	27.5 6 ^c
IT 89D- 288	5.44 ^a	5.13 ^a	1.51 ^a	0.19 ^a	0.10 ^a	0.13 ^a	0.15 ^d	2.08 ^a	5.77 ^a	35.9 6 ^a
IT 90K- 372- 1 -2	5.40 ^{ab}	5.11 ^{ab}	1.35 ^b	0.17 ^b	0.08 ^b	0.12 ^{ab}	0.18 ^{bc}	1.90 ^c	5.68 ^{bc}	33.3 5 ^b
IT 90K-82-2	5.40 ^{ab}	5.09 ^{ab}	1.04 ^c	0.15 ^c	0.06 ^c	0.11 ^b	0.21 ^{ab}	1.57 ^d	5.65 ^c	27.7 6 ^c
Bahaushe (local)	5.43 ^a	5.13 ^a	1.38 ^b	0.17 ^b	0.10 ^a	0.13 ^a	0.17 ^c	1.95 ^b	5.70 ^b	34.0 6 ^b
Fallow	5.37 ^b	5.08 ^b	0.91 ^d	0.13 ^d	0.07 ^{bc}	0.11 ^b	0.22 ^a	1.45 ^e	5.56 ^d	25.9 9 ^d
S. E.	0.02	0.01	0.02	0.01	0.004	0.01	0.01	0.02	0.01	0.33

Means in a column and treatment group followed by same letters are not significantly different using DMRT at 5 % level.

Table 5. Soil pH, Exchangeable bases and acidity, CEC and Base saturation (BS) at cowpea harvest and before planting in the subsequent compared

Sampling period	pH (H ₂ O)	pH (CaCl ₂)	Ca (cmolkg^{-1})	Mg (cmolkg^{-1})	K (cmolkg^{-1})	Na (cmolkg^{-1})	Exch. Acidity (Al ³⁺ +H ⁺) (cmolkg^{-1})	ECEC (cmolkg^{-1})	CEC (cmolkg^{-1})	BS (%)
At cowpea harvest	5.41	5.10	1.18 ^b	0.16 ^b	0.08	0.12 ^a	0.19	1.72 ^b	5.66 ^b	30.34 ^b
Before planting millet	5.39	5.11	1.23 ^a	0.17 ^a	0.08	0.11 ^b	0.19	1.78 ^a	5.68 ^a	31.22 ^a
S. E.	0.01	0.01	0.01	0.003	0.003	0.004	0.004	0.01	0.01	0.19

Means in a column and treatment group followed by same letters are not significantly different.

Table 6. Soil exchangeable bases at cowpea harvest as affected by growing cowpea varieties in 2008 and 2009 cropping seasons

Parameter	Ca (cmolkg ⁻¹)			Mg (cmolkg ⁻¹)			K (cmolkg ⁻¹)			Na (cmolkg ⁻¹)		
	2008	2009	Combined	2008	2009	Combined	2008	2009	Combined	2008	2009	Combined
Initial Treatment	1.77 ^a	1.74 ^a	1.76 ^a	0.26 ^a	0.23 ^a	0.25 ^a	0.12 ^a	0.12 ^a	0.12 ^a	0.20 ^a	0.19 ^a	0.20 ^a
IT 88D- 867-11	0.92 ^{de}	1.08 ^d	1.00 ^d	0.15 ^{bc}	0.15 ^{cd}	0.15 ^c	0.08 ^{bc}	0.07 ^c	0.08 ^{cd}	0.13 ^b	0.11 ^c	0.12 ^b
IT 89D- 288	1.48 ^b	1.47 ^b	1.48 ^b	0.18 ^b	0.19 ^b	0.19 ^b	0.09 ^{bc}	0.10 ^{ab}	0.10 ^b	0.10 ^b	0.16 ^b	0.13 ^b
IT 90K- 372- 1 -2	1.31 ^c	1.31 ^c	1.31 ^c	0.17 ^b	0.16 ^{bc}	0.17 ^{bc}	0.09 ^{bc}	0.08 ^{bc}	0.09 ^{bc}	0.12 ^b	0.13 ^c	0.13 ^b
IT 90K-82-2	0.96 ^d	1.02 ^{de}	0.99 ^d	0.15 ^{bc}	0.14 ^{cd}	0.16 ^c	0.08 ^{bc}	0.07 ^c	0.08 ^{cd}	0.12 ^b	0.12 ^c	0.12 ^b
Bahaushe (local)	1.36 ^c	1.36 ^c	1.36 ^c	0.17 ^b	0.16 ^{bc}	0.17 ^{bc}	0.10 ^{ab}	0.10 ^{ab}	0.10 ^b	0.11 ^b	0.16 ^b	0.14 ^b
Fallow	0.88 ^e	0.95 ^e	0.92 ^e	0.13 ^c	0.12 ^d	0.13 ^d	0.07 ^c	0.06 ^c	0.07 ^d	0.12 ^b	0.11 ^c	0.12 ^b
S. E.	0.02	0.03	0.03	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01

Means in a column and treatment group followed by same letters are not significantly different using DMRT at 5 % level.

Table 8. Effect of cowpea varieties on soil ECEC, CEC and BS at cowpea harvest in 2008 and 2009 cropping seasons

Treatment	ECEC (cmolkg ⁻¹)			CEC (cmolkg ⁻¹)			BS (%)		
	2008	2009	Combined	2008	2009	Combined	2008	2009	Combined
Initial	2.48 ^a	2.42 ^a	2.45 ^a	5.64 ^b	5.61 ^b	5.63 ^c	43.98 ^a	43.14 ^a	43.56 ^a
IT 88D- 867-11	1.47 ^d	1.58 ^d	1.53 ^e	5.68 ^b	5.63 ^b	5.66 ^{bc}	25.89 ^d	28.13 ^d	27.01 ^d
IT 89D- 288	2.03 ^b	2.06 ^b	2.05 ^b	5.82 ^a	5.71 ^a	5.77 ^a	34.89 ^b	36.07 ^b	35.48 ^b
IT 90K- 372- 1 -2	1.82 ^c	1.88 ^c	1.85 ^d	5.68 ^b	5.64 ^b	5.66 ^{bc}	32.04 ^c	33.34 ^c	32.69 ^c
IT 90K-82-2	1.51 ^d	1.56 ^d	1.54 ^e	5.66 ^b	5.63 ^b	5.66 ^{bc}	26.68 ^d	27.70 ^{de}	27.19 ^d
Bahaushe (local)	1.93 ^b	1.95 ^c	1.94 ^c	5.68 ^b	5.68 ^{ab}	5.68 ^b	33.32 ^{bc}	34.33 ^c	33.83 ^c
Fallow	1.41 ^d	1.46 ^e	1.44 ^f	5.56 ^c	5.54 ^c	5.55 ^d	25.36 ^d	26.35 ^e	25.86 ^d
S. E.	0.04	0.03	0.04	0.02	0.02	0.03	0.69	0.53	0.60

Means in a column and treatment group followed by same letters are not significantly different using DMRT at 5 % level.

Table 9 . Cowpea varieties effect on soil ECEC, CEC and BS before planting in 2009 and 2010

Treatment plots	ECEC (cmolk ⁻¹)			CEC (cmolk ⁻¹)			BS (%)		
	2009	2010	Combined	2009	2010	Combined	2009	2010	Combined
IT 88D- 867-11	1.46 ^d	1.73 ^c	1.60 ^c	5.68 ^{bc}	5.67 ^c	5.68 ^c	25.71 ^c	30.51 ^c	28.11 ^c
IT 89D- 288	2.05 ^a	2.16 ^a	2.11 ^a	5.85 ^a	5.71 ^{ab}	5.78 ^a	35.04 ^a	37.83 ^a	34.44 ^a
IT 90K- 372- 1 -2	1.87 ^c	2.01 ^b	1.94 ^b	5.71 ^b	5.69 ^b	5.70 ^b	32.72 ^b	35.32 ^b	34.02 ^b
IT 90K-82-2	1.50 ^d	1.71 ^c	1.61 ^c	5.67 ^c	5.66 ^{bc}	5.67 ^c	26.46 ^c	30.21 ^c	28.34 ^c
Bahaushe (local)	1.95 ^b	1.97 ^c	1.96 ^b	5.70 ^{bc}	5.73 ^a	5.72 ^b	34.21 ^a	34.39 ^b	34.30 ^b
Fallow	1.34 ^e	1.57 ^d	1.46 ^d	5.56 ^d	5.58 ^d	5.57 ^d	24.10 ^d	28.14 ^d	26.12 ^d
S. E.	0.03	0.03	0.04	0.01	0.01	0.01	0.43	0.44	0.41

Means in a column and treatment group followed by same letters are not significantly different using DMRT at 5 % level.

Conclusion

Cultivation of cowpea reduced soil pH value prior to subsequent year's planting compared with at cowpea harvest which did not alter the strongly acid class of the soil. Mean values of soil exchangeable Ca and Mg, ECEC, CEC and BS recorded were significantly ($P < 0.05$) higher prior to planting of subsequent year's crop than at cowpea harvest. However, only the mean value obtained in CEC was higher than the initial value. The lowest depletion of these parameters and highest CEC value were observed in IT89KD-288 variety. It is therefore suggested that IT 89D-288 be included in the farming systems of Sudan savanna agro-ecological zone.

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