The Effect of Continuous Crop Cultivation on Soil Condition in Funtua, Nigeria

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Abstract: This study involves the collection soil samples from six demarcated plots. Texture, pH, organic matter, total nitrogen, available phosphorus, exchangeable cations (EC), cation exchange capacity (CEC) and base saturation were assessed. Results show that the continuous cultivation of the soil and application of chemicals and fertilizers further eliminates and/or alters soil vital properties and natural habitat. Introduction of leguminous species such as beans maintain comparatively better soil condition than monocropping, or even woodland fallow plots. Consequently, more intensive use of organic manure, mulch or compost to compliment inorganic fertilizer can help in improving the condition of the soils such as: soil structure or tilth, increases the water-holding capacity of coarse-textured sandy soils, improves drainage in fine-textured clay soils, provides a source of slow release nutrients, reduces wind and water erosion, and promotes growth of earthworms and other beneficial soil organisms

Key Words: Continuous cultivation; Soil properties; fallow plots; leguminous crops; Funtua-Nigeria.

1. Introduction:

Soil is basic to life and it is the primary means of food production, directly supporting the livelihood of most living organisms. It is an essential component of terrestrial ecosystems, sustaining their primary producers and decomposers while providing major sinks for heat energy, nutrients, water and gases (Wild, 1993). However, the stress of continuous cultivation of food and cash crops on the soil has created impacts and sometimes hindered further cultivation of crops on the same land, thereby affecting crop yield (Jaiyeoba, 2003 and Bello et al., 2010). Continuous cultivation-induced changes are found to be a major contributor to soil degradation and decline in relevant yield (Tivet et al., 2013). For example, Bueno and Ladha, (2009) found that the extensive use of inorganic fertilizer, although contains some valuable soil nutritional elements has failed to replenish the nutritional requirement for rice-wheat soils in the Philippines. This is because continuous cultivation persistently exposes the soil to the direct impact of rain, wind and temperature, and reduces the biodiversity of affected area (Rosen and Bierman, 2005; Nunes, et al., 2000); a processes leading to soil degradation such as: accelerated erosion, increased wetness and poor drainage, lateralization, salinization, nutrient imbalance, decline in organic matter level and reduction in activities and diversity of soil flora and fauna (Lal *et al*, 1989 and Millington, 1992). A sustainable land cultivation with a view to enhance the protection of natural resources, preserve soil and water quality (Abba et al., 2013), enhance food production with reduced risk was reported to be the focus of agricultural and soil experts for long (Flieβbach et al., 2007). Many areas of northern Nigeria are now under severe threat of land degradation as a result of unchecked human activities (Birnin-Yauri and Aliero, 2008). Soil fertility in this region has for long been maintained by the system of bush fallow and application of Farm Yard Manure (FYM). The Bush fallow system involves the cultivation of a piece of land for about three or four years and its subsequent abandonment to rest in fallow for a much longer number of years. It has been observed that the increase in population and its persistent pressure on land and market expansion have shortened the traditional bush fallow practices (Leows and Gardiner, 1982; Jaiyeoba, 1983; Bello, 1986 and Abubakar, 1995[b]). Thus in many areas, shifting cultivation is no longer practiced as lands are now scarce and pressure on existing ones is very high. Consequently, permanent land cultivation is currently practiced; thus replacing the bush fallow system. Although a number of studies have been carried out on the changes in properties of soils under continuous cultivation and other land uses in the savanna area (Abubakar, 1995[b]; Jaiyeoba, 2003), few attempts were recorded to monitor such effect under small-holder conditions as many of these researches were conducted on researchers' experimental farms. To effectively tackle soil degradation problem, data on changes in relevant soil properties from continuous cultivation practices is needed for soil conservation and management.

In Funtua Nigeria, land is used intensively to cultivate a variety of crops, mainly; cotton, maize and rice. This has made the soils more sandy and low in organic matter and basic nutrients like exchangeable cations, phosphorous and nitrogen. As such, the farmers have resorted to the use of animal, and farm manure, urban waste ash as well as inorganic fertilizer in creating good condition for crop growth on their farmlands. It is envisaged that over time changes in soil condition in Funtua area will result as continuous cultivation persist. The extent to which such soil condition is affected remains largely unknown due to inadequate research coverage. The need for such information constitutes the problem of interest which this study seeks to examine.

1.1 Study area and scope:

The study area (Funtua) is located about 150 km SW of Katsina town at 7^{0}43' – 7^{0}44' East of longitude and 11^{0} 50' - 11^{0} 52' North of latitude in northern Nigeria. It is a home to some 100,000 full time farmers. The scope of the study is limited to examination of selected plots under continuous cultivation and natural vegetation/long standing bush fallow in the area. Funtua falls within the tropical savanna climate with distinctive wet and dry seasons. The climate is hot and dry for most of the year and maximum daily temperature of about 100^{0}F (38^{0}C) and minimum daily temperature of about 55^{0}F (22^{0}C) are common. Relative humidity falls considerably during the Harmattan It never exceeds 20 to 25% because of the effect of the two air masses (Dry Tropical Continental (CT) air mass of Northern origin from the Sahara desert and the moist, cool tropical maritime (Mt) air mass of the Southern origin of the Atlantic Ocean). Average total rainfall is about 750-800mm per annum with rainfall duration of 5-6 months. August is the month of the year when the highest rainfall is recorded. The atmospheric humidity over the area is the lowest in the dry season as low as 15% and is highest in the wet season above 60% for most of time of the day. Evaporation is higher in the dry season and lower in the wet season.

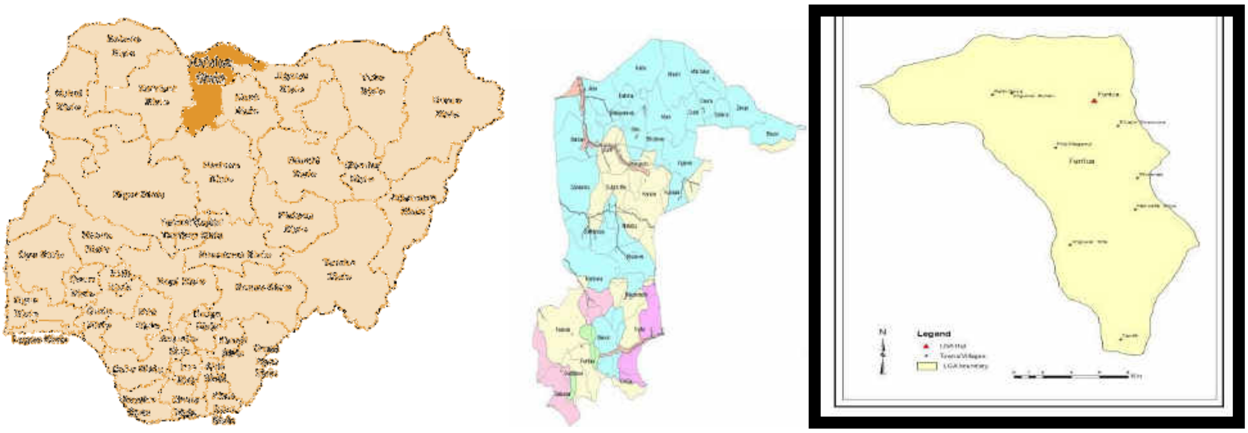

Figure 1: Location of Funtua in Funtua LGA of Katsina State, Nigeria
(Source, KTSCSDP, 2012)

1.2 Soil and Vegetation:

Soil and vegetation are two important constituents in any cropping wellbeing (Arnhold et al., 2014). For example, research indicates that soil fauna play an important role in litter decomposition, it largely controls decomposition processes through the breakdown of litter, digestion and stimulation of microbial activities (Jiang et al., 2013); a process that facilitates the healthy growth of crops. The soils of the study area are basically derived from the basement rocks and deposits (Lews, 1962; Malgwi, 1979; Smith and Whalley, 1981). The parent materials are weathered rock and sand drift in nature which render the soil porous and susceptible to erosion. The sand drift soils are more coarse, tend, less water retention and of low or medium fertility that make them only convenient for the growth of less fertile soil, crops such as millet, groundnut and beans over large areas (Oguntoyinbo, 1979). The soils are generally leached ferruginous tropical soils (Kowal and Omolokun, 1971) and as ferruginous tropical soils on sandy parent material and on crystalline acid rocks. Klinkenberg (1970) identified some general characteristics of the soils of the area as follows: The lower parts of the profiles are usually derived in situ from the underlying weathered rocks, particularly the gneisses, granites and meta sediments (schists and quartzites), while the upper parts are composed of a mixture of the same materials and Aeolian drift. The Federal Department of Agricultural Land Resource, (1990) described the soils as very deeply drained, with sandy loam surfaces, and the clay fraction predominantly Kaolinite. However, the soils pattern of the area, according to Klinkenberg (1970) and McCurry (1970) are further subdivided into (I) Fadama Soils. These are soils which occur in the bottoms of extensive wide valley systems. They are generally classified as hydromorphic (Ipinmidun, 1972). Fadama soils are mostly dark gray clays with poor to very poor drainage, most of which have been formed from alluvial based materials, (II) Soils developed on Meta sediments (Schists and Quartzites). As a result of the widespread occurrence of elongated quartzite ridges to the west of the study area, the soils are shallow and stony in the inter-fluve crests. However, in the middle and lower slopes, their profiles are deeper, reddish-gray in color, exhibit signs of clay accumulation, and hard iron concretions found.

Earlier research indicates that the vegetation is typical of woodland type and deciduous, shedding their leaves annually during the dry season in order to conserve water (Hopkins, 1965). They develop some adaptive features such as thick cuticle and thick young twigs to enable them to survive the high evapotranspiration and the annual bush burning. The dominant tree species include: *Isoberlinia Doka, Bridelia, Terminalia aficionados, Acacia, Combretum binderianum, Parkia clappertoniana, Piliostigma thonningii, Vitrex domino*. The natural vegetation has long been disturbed (except the economic and shade providing species) as a result of a long history of settlement and occupation. The forest reserves of the area include the following species: Acacia; *Combretum; piliostigina* while the cultivated fields are colonized by grasses such as *Andropogon Spp* and protected trees such as *Adansonia digitata***.** Birnin-Yauri and Aliero (2008) and Rains (1963) showed that nearly all the vegetation of Northern Nigeria has been subjected to interference by fire, grazing by domestic stock or cultivated in many places. This practice has affected the seasonal precipitation. Thus down pours are basically only enough to provide moisture for growth of grassland with scattered trees of no great height, either growing single or in group or sometimes occurring as woodland (Jaiyeoba, 2003).

1.3 Land use:

The economic base of most cities in Northern Nigeria is basically agrarian as about 80% of its population engaged in agriculture (rain-fed farming, irrigation and animal rearing) as the main occupation. Funtua serves as an important market centre for inter-regional trade in agricultural produce between northern and southern parts of the country. Farming in the area is of small-scale type relying on hand hoe operation tillage system under rain-fed mixed farming of cereal and cover crops (Jaiyeoba, 2003). Rain-fed agriculture takes place in the rainy season on the upland fields supporting such crops as millet (*Pennisetum americanum*), guinea corn (*sorghum bicolor*), maize (*Zeamays L.*), groundnuts (*Arachis hypogaea*), cotton (*Gossypium spp*), Soyabeans (*Glycine max*). Irrigation activities on the other hand, take place on the low land field and support labor intensive higher value crops such as sugar cane, onion, tomatoes, pepper, spinach and watermelon.

2. Methodology:

Two major approaches are available for assessing soil change under specific land use type. One is to establish plot for such land use type over which soil could be monitored for a period of time (Bello et al., 2010; Jaiyeoba, 2003). This approach is perhaps the most desirable because it results in the generation of the much desired time series data. Its practicality is, however constrained by time and specific cost factors. The second approach is to sample soil simultaneously under a land use type and a control plot. It is an inferential approach which involves side by side comparison of soil properties under different land uses and control land portion (Jaiyeoba, 2003; Birnin-Yauri and Aliero 2008). This is the method adopted in this study. To control the possible effect of soil nutrient loss through erosion, soil specimens were taken on relatively flat sites where the slope angle will not exceed two degrees (Jaiyeoba, 2003). Since all the sites are within a confined geographical area, all of them can be assumed to be experiencing the same climatic condition. However, the approach adopted in sampling and analyzing the soils conformed to the general methodology reported by Bello et al. (2010) and Jaiyeoba, 2003. A reconnaissance survey was conducted across eight main communities of the Funtua area with established records of intensive crop farming. The aim was to obtain a historical data on farming practices in the locality. Following the survey, a substantive site was located at funtua town where six land use plots that appropriately fit the working objectives of this study were found. Five plots under different continuous cultivation practices were selected. They included arable Maize mono-cropping, Cowpea (Beans) Mono-cropping, Maize and Cowpea mixed cropping, Cotton mono-cropping, Sorghum (Guinea Corn) mono-cropping and Sorghum and Cowpea mixed cropping. The sixth one is a land under longstanding bush fallow chosen to serve as the control on the basis of whose condition the changes in fertility level of the five cultivated plots were compared.

2.1 Soil Sampling:

The various plots selected vary in size between 0.5 and 2.0 hectares (ha) in size. To ensure uniformity in soil sampling, a 0.5 ha sub-sample plot was selected from each of the six plots. For the purpose of soil sampling, each of the sub-sampled plots was sub-divided into sixteen quadrants (4m x 4m) and numbered accordingly. At midpoint of every quadrant, soil samples were taken at two standard depths, namely 0–15cm (topsoil) and 20–30cm (sub-soil). These depths were chosen here based on the understanding that 0 – 15cm represents the average plough layer while 20 – 30cm represents the layer with maximum clay accumulation in the area. At each depth, two categories of samples were taken. The first (undisturbed) was collected with the aid of a bulk density ring of known height and diameter (undisturbed sample) and the second (disturbed) was taken with a hand trowel. The former was used for bulk density and moisture content determinations and the later for other soil properties. The collected samples were inserted into soil bags, adequately labelled and marked after the plot and depth of the collection and transported to the Soil Science Laboratory of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria and analyzed as follows: The soil's properties considered amongst others, include: texture, pH, organic matter, total nitrogen, available phosphorus, exchangeable cations (EC), cation exchange capacity (CEC) and base saturation. Their selection is based on the understanding that they are the key determinants of soil fertility (chemical, biological or physical fertility) (Young, 1976).

2.2 Particle Sizes Distribution:

Pipette method: collected soil samples were air-dried and a sub-sample of 50g was taken and crushed gently in a mortar. Using a 2mm sieve, the gravel fractions were removed from the crushed soil sample and from that, a 25g sub-sample was again taken. To ensure that the various particle sizes are in separate forms, each of the 25g sub-sampler was treated with sodium hexametephosphate (Calgon) and left for some hours to react completely with the soil samples. The suspension was then poured into a measuring 1000ml cylinder and some distilled water added to make it to 1000ml mark. This was then stirred for 30 seconds to ensure proper and thorough dispersion. It was then allowed to settle for 3 minutes, 30 seconds. With the aid of a pipette the representative fractions of clay and silt were computed at different depths and time using Stroke's law. The sucked mixtures were then poured into an evaporating dish and oven-dried at 105^{o}C after which the weight of silt and clay fraction and their percentages were determined as follows:

$$\% \ SiltClay = \frac{W^z e}{Wa} x \frac{1000}{25} x \frac{100}{1} = \frac{W^z ex4000}{Wa}$$

$$\% \ Clay = \frac{We}{Wa} x \frac{1000}{25} x \frac{100}{1} = \frac{Wax4000}{Wa}$$

% Silt = (% Silt + % Clay) - % Clay

where, W^{z}e = Weight of Silt and clay, We = Weight of clay and Wa = weight of air-dried sub-sample (25g). The remaining suspension in the measuring cylinders was then carefully poured into an evaporating dish and then oven dried. Using appropriate sieve, the fraction of sand was then separated into coarse and fine sand. The fractions of each of the sub-faction (coarse and fine sand) were then estimated as follows:

$$\% Finesand (0.5 - 0.05mm) = \frac{Wfs}{Ws} x \frac{100}{1}$$

$$\% Coarsesand (2.00 - 0.50mm) = \frac{W^e s}{Wa} x \frac{100}{1}$$

Where, *Wfs = Weight of fine sand* and *W^{e}s = weight of coarse sand*

2.3 Bulk Density and Moisture Content:

The Bulk Density (BD) ring containing the collected soil sample as weighed and then oven-dried at 105^{o}C for 12 hours after which it was re-weighed. Bulk density value was then determined as follows:

$$BD(g / cm^3 = \frac{weightofth esoil}{volumeofthesoil}$$

where, Weight of the soil (g) = Weight of the ring plus the Bulk sample after oven-drying

Minus weight of the ring.

Volume of the soil = Volume of the ring = Πr^{2}h (cm^3)

Moisture content was determined as: $WC = \frac{Ws1 - Ws2}{Dw - Vs1}$

where, WC = Water Content (g/cm3), WS1 = Weight of the soil before over-drying, WS2 = Weight of the soil after over-drying, S1 = Volume of the soil and Dw = Density of the water in the sample

2.4 Porosity:

Porosity is related to bulk density. It refers to the volume of pore spaces within the soil, and is expressed as the percentage of the soil volume occupied by voids. It is assessed by measuring the bulk density of the soil and the average specific gravity (G.S) of the soil particles. It is expressed by the relationship:

$$P\% = \left(I - \frac{BD}{GS} \right) X \frac{100}{1}$$

where, D = Bulk Density, GS = Specific gravity or particle density of quartz which is $2.65 g/cm^{-3}$

Specific gravity of quartz is used because it is generally acknowledged that sandy soils and soils with little or no organic matter have specific gravity of $2.65 g/cm^3$ (Briggs, 1977, Brandy, 1999).

***2.5 Water Stable Aggregates* (> 0.5mm):**

To determine water stable aggregates greater than 0.50mm, water stable aggregates were prepared by crushing a moistured bulk sample on a 8.00mm sieve. From that, an air dried sub-sample of 50g was taken from the amount retained on the sieve. The sub-sample was then spread evenly over a 0.50mm sieve and was then immersed in water for one minute. After that, the wet sieving was raised and lowered through 3cm at the rate of 30 times in 2 minutes to ensure that all the aggregates which are less than 0.50mm were sieved. Then the proportion retained on the 0.50mm sieve was oven-dried and weighed. After this, the percentage of water stable aggregates greater than 0.50mm was calculated using the formula:

$$WSA(\%) = \frac{Wx}{Wt} x \frac{100}{1}$$

where, WSA = Water stable aggregates, WX = Weight of the retained soil aggregate on 0.05mm sieve

and Wt = Weight of the Sub-sample (50g).

2.6 Soil Organic Matter:

This was determined using Walkey-Black digestion method. A representative sample was taken, grinded and passed through a 0.50mm sieve. 10g sub-sample was then taken in a 250ml conical flask and 10ml of potassium dichromate (K_2Cr0_7) solution was then pipetted into 200ml and 500ml conical flasks and swirled gently to disperse the soil. Then 20ml concentrated sulphuric acid was rapidly added from a measuring cylinder. The flasks were then immediately swirled gently until the soil and the reagents were mixed. Next, the mixtures were swirled more vigorously for one minute. Each flask was then rotated gently again and then allowed to stand on a sheet of asbestos for 30 minutes to cool the mixture. Then, 100ml of distilled water was added after the cooling and then the mixture was allowed to cool again. Following this, four drops of indicator were added onto the mixture and titrated with 0.5N ferrous sulphate ($FeSO_4$) solution on a white background. Thereafter, a blank determination was then made in the same way, but without the soil with a view to standardize the dichromate. Percentage Carbon was then calculated using the formula:

$$PC = \frac{Blanktitre - Actualtitr\, ex0.2xmxf}{Weightofai\, rdriedsoilused} x \frac{100}{1}$$

where, PC = percent Carbon, M = Concentration of $FeSO_4$ and F = Correction factor (1.33).

Organic matter (0m) % was then calculated using the formula:

(1 - S / B) x 10 x 0.68 = organic matter (%) of sample (Mylavarapu, 2009)

where, S = Volume of Ferrous Sulfate solution required to titrate the sample, in mL.

B = Average Volume of Ferrous Sulfate solution required to titrate the two blanks, in Ml, 10 = onversion factor for units, 0.68 = a factor derived from the conversion of % organic carbon to % organic matter.

2.7 Total Nitrogen:

This was determined using the regular macro Kjeidah method. Here, 20g of soil was weighed into Kjeidah flask and 20ml of distilled water was added and the flask was swirled for 5 minutes and allowed to stand for 30 minutes. Then 3g of catalyst (copper based) and 20ml of concentrated sulphuric acid (H_2SO_4) were added. The mixture was then continually heated slowly until the water was removed and frothing has ceased. The mixture was then heated for 5 hours during which the heat was regulated so that the H_2SO_4 condensed half way up the neck of the flask. The flask was then allowed to cool. The digest was carefully transferred into another clean flask. The sand particles were retained in the original digestion so as to prevent the particles from causing bumping during distillation. Next, the sand residue was washed with 50ml of distilled water for about four times and made to mark with distilled water. 10ml of boric acid solution was then added into a 500ml Erlenmeyer flask which was then placed under the condenser of the distillation apparatus with the end of the condenser placed 4cm above the surface of the boric acid solution. 10ml of 4% sodium hydroxide (NaOH) was slowly added into 10ml of the digest which was attached to the distillation apparatus. The mixture was then heated until boiling point. Sufficient water was allowed to flow through the condenser to allow it to cool (below 30^oC). When about 50% of the distillate was collected, the distillation is stopped. Ammonia, which is liberated from the H_2SO_4, is titrated and three drops of indicator were added until the color changes from green to pink. A blank determination was then run without the soil sample. The percent Nitrogen (PN) is then calculated using the formula (Barbano and Clark, 1990).

$$PN = \frac{0.014xNxTVxVDx100}{Weightofso\,ildriedxAD}$$

where, PN = Percent Nitrogen, VD = Volume of Digest, N = Normality of acid, TV = Titre volume and AD = Aliquot of digest

2.8 Available Phosphorus:

This was determined using the Bray No1 method. Here, 1g of air dried soil was weighed into a 15ml centrifuge tube and 7ml of extracting solution was added and the mixture was shaken for 1 minute on a mechanical shaker. The suspension was then centrifuged at 2,000 rounds per minute for 15 minutes and was then decanted into an acid washed volumetric flask. The phosphorus in the extract was then determined using ascorbic molybdate blue method. This was done by pipetting 3ml of the soil extract into a 25ml volumetric flask and about 10ml of distilled water was then added to it. Next, a 4ml of 0.5N hydrochloric acid was added and the mixture allowed to stand for 15 minutes for the color to develop. The phosphorus content was then determined in the extract on a spectrophotometer using spectronic 70, 50, 20 at 882 May by percent transmittance. A set of standard P solutions containing 0, 0.1, 0.2, 0.4, 0.6, 0.8 and 1.0 PPm respectively were prepared and used for blank determination to aid in reading off the ppm of P for the soil solution prepared.

2.9 Soil pH:

To determine soil pH, 20g of air-dried soil sample was taken into a beaker of 20ml of distilled water. The suspension was then stirred several times for 30 minutes with a glass rod and allowed to stand for 30 minutes to enable the suspended clay settle down. Electrodes of pH meter were then inserted into the partly settled suspension and the pH was then measured.

2.10 Cation Exchange Capacity (CEC):

The CEC was determined using ammonium acetate extraction method. 10g of air-dried 2mm sieved soil sample was weighed into a 500ml Erlenmeyer flask and 40ml of neutral 1N ammonia acetate (NH_4 OAC) was added. The flask was then shaken thoroughly and allowed to stand overnight. The soil was filtered with light sunction using a 55mm buckner funnel. Then the soil was leached with the neutral 1N NH_4 OAC reagent until no evidence of Calcium can be obtained in the affluent solution. The leacheate was then preserved for the determination of exchangeable bases. Next, the soil was again leached four times with 250ml each of 1N ammonium Chloride (NH_4cl) and once with 250ml of 0.25N NH4cl. The electrolyte was then washed out with 200ml of 99N ethyl alcohol. When the chloride in the leachate (which was tested using 0.10 N silver nitrate) became negligible, the soil was allowed to drain thoroughly and filtered into 50ml Kjeidah flask with 250ml of distilled water was added. Few drops of liquid paraffin, pumice beads (to prevent fuming and bumping) and 10ml of 1N NAOH were added. About 60ml of the solution was then distilled into 50ml of 2% borate acid solutions which was measured into a 250ml Erlenmeyer flask. 10 drops of bromocresol green-methyl – red mixed indicator were added and ammonium boreto was titrated (produced with standard 0.02 N sulphuric acid solutions). The CEC was then calculated using the formula:

$$\text{CEC (me/100g)} = \frac{\text{T-BxNx100}}{\text{Wt}}$$

where, N = Normalty of the acid used, B = Blank titre volume used, T = Titre volume of the acid used in titration and Wt = Weight of the sub-sample used.

2.11 Exchangeable Cations (EC):

The leachate which was preserved during the CEC determination was used to determine the EC (namely Ca, Mg, K and Na). Standard readings were used for different concentration of each cation to plot a graph absorbance Vs concentration (ppm) of each base. Ca and Mg were determined using atomic absorption spectrophotometer while K and Na were determined using flame emission method. The me/100g of each base was then calculated using the formula.

$$\text{Me/100g} = \frac{\text{ppm graph} \times \text{VE} \times \text{DF} \times 100}{100 \times \text{W} \times \text{Equivalent weight of the element}}$$

where, VE = Volume of extractant, DF = Dilution factor, W = Weight of soil sample.

3. Results and discussion:

Tables 1 and 2 present the values of properties for topsoil and subsoil soils samples considered for the analysis. Tables 3 on the other hand present the performance of the topsoil, subsoil and fallow soils t-test for significance to indicate the difference between mean values of every soil property for pairs of the studied plots.

3.1 Texture:

In the topsoil, mean values of sand particles are significantly higher over the maize, cowpea, cotton and sorghum cropping plots than the control, indicating that the four practices have promoted significant increases in soil sand particle levels (Table 1). In the sub soil, however, only maize and sorghum crops promoted significant increases in sand particle levels (Table 2). In the case of silt practices, maize cowpea and sorghum cropping practices in the topsoil and cowpea, sorghum and cowpea practices in the subsoil have values that are significantly higher than the control and are hence crops that promoted significant increases in mean values of the property.

For clay particles on the other hand, all the cropping practices with the exception of maize+cowpea maintain values that are significantly higher than those of the controls. In the subsoil, cowpea and sorghum+cowpea are the only ones that are not having mean values that are significantly higher than those of the controls. It could therefore be observed from the above that the mixed cropping practices in general maintain significantly lower sand, but higher silt and clay fractions than the control which implies that the practices have promoted conservation (rather than deterioration) of a soil textural condition. Compared to other single cropping practices, the mixed cropping practices provide greater crop cover to the soils. Usually, the greater such a cover is, the less the rate of removal of fine soil fractions (silt and clay) in soil wash processes (Lal, 1976).

Table 1**:** Mean Values of Topsoil Properties for the Various Plots

Soil Property	Mean and Standard Error of the Mean Values for the Plots Under Various Cropping/Management Types						
	Maize	Maize + Cowpea	Cowpea	Cotton	Sorghum	Sorghum+ Cowpea	Woodland Fallow
Sand (%)	69.1** +3.7	51.4 + 4.3	61.3* +4.2	59.6* + 8.9	64.2* + 5.6	54.5 + 6.7	49.6 +8.9
Silt (%)	19.2 +1.3	25.1 + 2.1	18.4* +0.45	19.6 +0.42	20.3 +1.13	25.6* +1.42	23.7 +0.78
Clay (%)	11.7** +4.8	23.5 +1.2	20.3* +6.7 .	20.8 +4.1	15.5** +3.2	19.9* +3.5	26.7 +5.2
Organic Matter (%)	0.73 +0.25	0.67* +0.18	0.54** +0.14	0.69* +0.25	0.89 +0.12	1.39** +0.44	0.78 +0.32
Total Nitrogen (%)	0.11 + 0.10	0.34* +0.22	0.36* +0.15	0.13 +0.02	0.19 +0.05	0.32* +0.03	0.22 +0.04
Available Phosphorus (ppm)	4.63* + 0.7	4.72* +1.52	3.97* +0.52	3.18* +0.82	4.52** +0.98	4.16* +0.71	3.75 +0.71
CEC. (Me/ 100g)	5.43 +1.12	5.91* +0.90	6.12* +0.36	6.09* +0.76	5.45 +0.14	6.82* +0.52	5.34 +0.29
pH (H2O) (1 :2.5)	5.42* +0.12	5.29* +0.10	6.72 +0.17	5.49* +0.37	6.51 +0.28	6.10 +0.32	6.54 +0.29
PH (CaCI2) (1 :2.5)	5.23 +0.04	5.72 +0.09	6.28* +0.05	5.29 +0.12	6.28* +0.03	5.22 +0.17	5.52 +0.30
Exchangeable Calcium (Me/100g)	1.91** +0.11	2.37** +0.42	2.67* +0.40	3.28* +0.34	4.22 +0.12	4.30 +0.56	4.14 +1.13
Exchangeable Magnesium (Me/ 100g)	0.32 +0.04	0.32 +0.05	0.87** +0.12	0.72** +0.03	0.22 +0.04	0.51** +0.05	0.27 +0.03
Exchangeable Potassium (Me/ 100g)	0.33** +0.02	0.24* +0.09	0.22* +0.05	0.28* +0.03	0.28* +0.07	0.26* +0.04	0.16 + 0:05
Exchangeable Sodium (Me/100g)	0.18** +0.04	0.12* +0.04	0.04 +0.02	0.10* +0.04	0.15** +0.02	0.12* +0.04	0.05 + 0.02

Note: The asterisk denote the mean value for the various cropping practices plots that are significantly different from those of the woodland fallow (control) plot; as revealed by t-test statistics

* Difference significant at 0.05 probability level

**Difference significant at 0.01 probability level

3.2 Organic Matter:

In the topsoil, only maize and sorghum mono cropping practices maintain organic matter levels that are not significantly higher than those of the controls. In the subsoil, the trend is almost the same as the cotton mono cropping is the practice with organic matter, content not significantly higher than that of the control. Intercropping plots maintain the best organic matter level in the area, with guinea corn + beans being the most efficient in this regard (Table 1). Obatolu and Agboola. (1993) made similar observations. A possible explanation to this is the comparatively longer period guinea corn crop takes before it matures and gets harvested, which means more time is taken over which the build-up process of organic matter in the soil.

Table 2: Mean Values of Subsoil Properties for the Various Plots

Soil Property	Mean and Standard Error of the Mean Values for the Plots Under Various Cropping/Management Types						
	Maize	*Maize + Cowpea*	*Cowpea*	*Cotton*	*Sorghum*	*Sorghum+ Cowpea*	*Woodland Fallow*
Sand (%)	56.5* +1.9	52.3 +7.1	51.3 +3.9	49.5 +4.6	60.5* +5.6	51.2 +5.1	46.7 +4.7
Silt (%)	17.1 +1.9	19.4 + 2.7	17.6 +0.8	22.4* +2.0	20.1 +3.4	22.2* +3.1	17.6 +3.2
Clay (%)	26.4* +5.2	28.3* +4.4	31.1 +3.7	28.1* +2.5	19.4** +4.2	26.6 +3.8	35.7 +6.2
Organic Matter (%)	0.41* +0.14	0.48* +0.4	0.36** +0.1	0.60 +0.8	0.42* +0.4	1.40** +0.3	0.63 +0.2
Total Nitrogen (%)	0.12 +0.01	0.28** +0.02	0.26** +0.13	0.05** +0.02	0.09 +0.04	0.21* +0.09	0.13 +0.03
Available Phosphorus (ppm)	3.74* +0.71	2.72 +0.32	3.42 +0.52	2.91 +0.61	3.26 +0.42	2.96 +0.16	3.14 +0.42
CEC. (Me/ 100g)	5.40** +1.12	4.63* + 0.94	3.16* +0.76	4.16** +1.13	2.52* +0.72	4.80* +0.76	3.70 +0.76
pH (H_2O) (1 :2.5)	5.42 +0.46	6.17* +0.09	5.15 +0.16	5.08 +0.09	5.52 +0.42	6.00* +0.52	5.30 +0.42
PH ($CaCl_2$) (1 :2.5)	5.20* +0.08	5.43* +0.26	5.86 +0.13	5.42* +0.46	6.17 +0.09	5.15* +0.16	6.10 +0.22
Exchangeable Calcium (Me/100g)	2.01** +0.83	2.16** +0.72	1.98** +0.46	3.26* +1.02	4.16 +0.94	4.26 +1.14	4.11 +0.76
Exchangeable Magnesium (Me/ 100g)	0.12* +0.02	0.16* +0.01	0.02** +0.01	0.11** +0.03	0.15* +0.02	0.58** +0.11	0.22 +0.06
Exchangeable Potassium (Me/ 100g)	0.13 +0.02	0.07* +0.04	0.21 +0.06	0.28 +0.07	0.15 +0.03	0.20 +0.02	0.17 +0.03
Exchangeable Sodium (Me/100g)	0.15* +0.02	0.18** +0.11	0.22** +0.06	0.11 +0.03	0.17* +0.02	0.09 +0.04	0.08 +0.03

Note: The asterisk denote the mean value for the various cropping practices plots that are significantly different from those of the woodland fallow (control) plot; as revealed by t-test statistics

* Difference significant at 0.05 probability level

**Difference significant at 0.01 probability level

3.3 Other soil nutrients:

As might be expected, the cropping practices involving the use of beans (a leguminous crop) generally maintained significantly higher total nitrogen levels than other plots. In fact, in the soil layers beans, maize + beans and sorghum + beans plots maintain significantly higher levels of nitrogen than the control. On the other hand, however, the level of this property under the cropping plots not involving cowpea cultivation are lower than those of the controls, with those under cotton cropping much significantly lower (Table 1). This means that leguminous species help greatly in nitrogen build-up in soils. This finding further indicates that intercropping with beans in the area can help raise total soil nitrogen even above that of savanna woodland fallow.

All the six cropping practices maintain significantly higher mean phosphorous levels than the control. In the subsoil however, maize cropping is the only practice that exhibits this trend. These results seem to suggest that phosphorous build up in the topsoil is occurring under the six cropping practices. A possible reason for this is due to the annual compound (NPK) fertilizer is used by the farmers in dressing up the soil so as to enhance crop yield. In a related study, Abubakar (1995[a]) has also made a similar observation.

In both topsoil and subsoil, the trends of cation exchange capacity (CEC) under the six cropping plots are almost the same as those exhibited by organic matter. This similarity in pattern between organic matter and CEC is not surprising as organic matter plays very important role in influencing soil CEC levels. In low activity tropical soils (such as those of the study area), organic matter is considered as the main source of fixing CEC (Sanchez, 1976).

The six cropping practices maintain mean levels of exchangeable potassium (K) that are significantly higher than those of the controls. In the subsoil however, the values of the exchangeable cations are comparatively lower than those of the controls. This also suggests that the practices are promoting K build up in the topsoil. This may be a reflection of annual dressing up of the soil with compound (NPK) fertilizer. In a previous study, Abubakar (1995[a]) has also observed that due to NPK fertilizer application in a continuously cultivated maize plot in a Kabomo area of Katsina state exchangeable potassium level has been raised. In all the topsoils and subsoils, the six cropping practices main mean levels of exchangeable CA, Mg, and Na are generally lower than those of the controls. This suggests that the practices have promoted loses of the three base elements from the soils. This may be a reflection of loses through accelerated run off with continuous cropping that does not have adequate erosion control.

Mean values of both pH (H_2O) and pH ($CaCl_2$) in the topsoil and subsoil under the six cropping plots are slightly lower than those of the controls. This trend may be a reflection of generally lower levels of the base elements under the cultivated plots since the elements largely define the acidity or alkalinity levels of soils.

3.4 Soil degradation and rehabilitation by the six cropping practices:

Continuous cropping practices generally promote soil degradation. This has forced farmers to realize the need to rehabilitate the fertility of their farmland soils and adoption of practices (most of the time indigenous) to help conserve the fertility of those soils. In Table 3, the aggregated percentages of the various soil properties are considered. For soil rehabilitation to occur, mean values are supposed to increase. Generally, the higher the mean values of clay, organic matter, total nitrogen, available P, pH and excahgeable Ca, Mg, K and Na, the better the fertility of a soil. Consequently, the percentage of these properties under each of the six cropping practices compared to those of the controls as shown in Table 1 and 2. Table 3, an extract from the two previous tables compares the degradation and/or rehabilitation of the soils of the area.

Table 3: Percentage of mean values of soil fertility parameters under the six cropping practices that are significantly different from those of the controls

Soil Depth	Extent of the Difference	Maize	Maize +Cowpea	Cowpea	Cotton	Sorghum	Sorghum+ Cowpea
Topsoil	Significantly Higher than control	8	12	23	30	30	46
	Significantly Lower than the control	38	38	38	30	15	8
	Same with the Control	54	50	49	40	45	43
Subsoil	Significantly Higher than control	30	23	23	24	23	38
	Significantly Lower than the control	38	46	23	22	30	15
	Same with the Control	32	31	54	54	47	47

Table 3 reveals the following trends in terms of soil rehabilitative capabilities of the six cropping practices:

Topsoil: Sorghum+cowpea > Sorghum > Cotton > Cowpea > Maize+cowpea > Maize

Subsoil: Sorghum+cowpea > Maize > Cotton > Cowpea > Sorghum > Maize+cowpea

The above trend indicates that sorghum+cowpea intercropping in general maintain the best and maize+cowpea the least soil rehabilitation condition in the area. This is partly expected given that maize crop is typically associate 1 leads in most cases to nutrient mining unless where adequate soil amendments are incorporated.

4. Conclusions:

On the basis of the results obtained in this study, it can be concluded that no single cropping/management practice has maintained a consistently favorable response to all the nutrient elements in the area. However, it is apparent that multiple cropping with fertilizer applications and use of leguminous species such as beans maintain comparatively better soil condition than monocropping, or even woodland fallow plots. Since beans usually have a shorter maturity period than some cereals (such as maize and guinea come) it is probable, however, that where leguminous species with a longer maturity period are used, more benefits are to be obtained. For instance, leucaenae, which has been widely acclaimed as the best leguminous specie, takes comparatively longer period of maturity to develop. It is thus possible that where such specie is used on farm lands under multiple cropping in the area, the favorable soil conditions as observed here could be further improved. It should be borne in mind that, continuous tampering/cultivation of the soil and application of chemicals and fertilizers further eliminates and/or alters soil vital properties and natural habitat (Bello et al., 2010). Consequently, more intensive use of organic manure, mulch or compost to compliment inorganic fertilizer can help in improving the condition of the soils such as: soil structure or tilth, increases the water-holding capacity of coarse-textured sandy soils, improves drainage in fine-textured clay soils, provides a source of slow release nutrients, reduces wind and water erosion, and promotes growth of earthworms and other beneficial soil organisms (Rosen and Bierman, 2005). Further research investigations are therefore necessary on whether such an improvement could be made possible.

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