Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

# Restorative effects of amendments on artificially degraded soils in the Southern Guinea Savanna of Nigeria.

Adaikwu A. O[1]. , Salako F. K.[2], Busari M. A. [2], and Azeez J. O.[2]

1. *Department of Soil Science, Federal University of Agriculture, P.M.B 2373, Makurdi, Benue. State, Nigeria.*
2. *Department of Soil Science and Land Management Federal University of Agriculture, P.M.B 2240, Abeokuta, Nigeria.*

**ARTICLE INFO**

*Article history:*

*Received February 20, 2020*

*Received in revised form March 2, 2020*

*Accepted March 12, 2020*

*Available online May 20 2020*

***Keywords:***

*Artificial desurfacing*

*Soil amendments*

*Soil productivity*

*Corresponding Author's* E-mail Address:

odigbo2011@yahoo.com+2348052693279

**https://doi.org/10.36265/njss.2020.300115**

ISSN-1597-4488 

**ABSTRACT**

An evaluation of the productivity of degraded alfisols at Makurdi and Otobi, Nigeria, using artificial desurfacing techniques (ADT) was carried out in 2012 and 2013 cropping seasons. The study was a split-split plot experiment arranged in a Randomized Complete Block Design with three replications. The soil was desurfaced at 0 – 5, 0 – 10, 0 – 15, 0 – 20 cm and the undesurfaced soil, 0 cm (control) depths. The restorative amendments were 9 t $ha^{-1}$ of poultry dropping as an organic source of manure, $N:P_2O_5:K_2O$ as an inorganic source of manure and zero application as control. Soybean variety *TGX 1448-2E* and maize variety, Oba super II were used as test crop. Saturated hydraulic conductivity was significantly (P = 0.05) lower at 20 cm (29.08 cm $hr^{-1}$), but did not differ significantly at 0 to 10 cm depths. Soil pH of 5.58 was recorded at 0 cm depth and it decreased to 5.05 at 20 cm depth. Also, organic matter content (1.71 – 1.00 g $kg^{-1}$), total nitrogen (0.12 – 0.08 g $kg^{-1}$) as well as CEC (7.39 – 6.24 cmol $kg^{-1}$) recorded a significant decrease with increase in soil depth from 0 to 20 cm depths. Application of poultry manure increased total porosity and saturated hydraulic conductivity as well as organic matter content across desurfaced depths. Soybean number of leaves was significantly (P = 0.05) reduced at 4, 7, and 10 WAP with increased topsoil removal. The highest grain yield of soybean (1474 kg $ha^{-1}$) was recorded on poultry manure treated plots which were significantly higher (p = 0.05) than other treatments. Application of poultry manure caused 20 % soybean yield reduction at 5 depth, and a 56 % reduction at 20 cm depth.

## 1.0. Introduction

The exacerbating loss of soil productivity due to soil degradation is a significant concern for agriculturists in the Southern Guinea Savanna of Nigeria, particularly in Benue state that is regarded as the food basket of the nation. Agricultural production constraint is associated with soil degradation which is largely responsible for the loss of the productive capacity of the soil as well as the ecological wellbeing. Soil is a non-renewable resource on the human time scale with its vulnerability to degradation depending on a complex interaction among different factors and processes which may be natural or anthropogenic over some time (Lal 2015). The poor soil fertility problem is well recognized as the main constraint to optimum crop yield (Hilhorst *et al*., 2009). Conversion to the use of amendments and strict compliance with recommended conservative practices are restorative measures that could reverse the trend of soil degradation. The target is to reduce erosion to the barest minimum, ensure the buildup of soil organic carbon, and enhance the activity of soil organisms as well as improvement in the aggregate stability of the soil structure (Lal 2015).

Recent studies have provided a roadmap to curb the poor soil fertility challenge, which includes the supply of organic and/or mineral nutrients to the soil. The organic residue is a primary source of plant essential nutrients which provide manure that is a source of energy that influences many biological processes in the soil (Mulins *et al*., 2005). The use of animal manure to improve the physical and chemical properties of the soil as well as enhanced crop productivity has been emphasized by several authors. Poultry manure is considered to have fertilizing properties, intermediate between mineral fertilizers and farmyard manure, and it has an appreciable residual effect (Woomer and Swift, 1994).

Hue (1992) also showed that poultry manure was very effective in raising soil pH. He noted that poultry manure (PM) is an excellent fertilizer containing nitrogen, phosphorus, potassium, and other nutrients. Its application increases the organic matter content of the soil which could improve soil structural stability, aeration as well as soil moisture-holding capacity and infiltration. Ikombo (1984) reported that the application of poultry manure at 8 t $ha^{-1}$ gave high and consistent yield close to that obtained by applying 40 kg N and 17 kg P $ha^{-1}$ to maize and that residual effect was observed in the subsequent seasons. Most small-scale farmers achieve a yield of soybean of about 500 – 1000 kg $ha^{-1}$ with good husbandry practices and recommended varieties (Ajay *et al*., 2011). Low yield of soybean in Nigeria can be attributed to the low level of adoption of technology such as soil fertility management strategies that would improve soybean production. (Adekiya, and Ojeniyi, 2002).

The use of chemical fertilizer greatly ensures food security because of its quick effect on making nutrients available to crops. The nutrient content is higher in fertilizer than organic manures and nutrients and released almost immediately (Reddy, *et al*., 2002). However, farmers commonly report that the long term use of synthetic fertilizers especially anhydrous ammonia leads to soil compaction and poor tilth (Francis *et al.,* 1990). Problems associated use of chemical fertilizer include nutrient imbalance due to nutrients not supplied, lack of technical knowledge of methods of application and high cost for smallholder farmers, and loss of organic matter (Agboola and Corey, 1973, Bationo *et al*., 2006). A severe but often ignored means of acidification of the soil is the application of mineral fertilizers to crops (Ojeniyi, 1995). Nnadi and Arora (1985) reported that virtually all conventional forms of nitrogenous fertilizers including urea reduce soil pH when used continuously on a piece of land. Despite these deficiencies in the use of inorganic fertilizer, their use for crop production to feed the ever-growing population cannot be ruled out because of some very critical roles it performs. According to Omoti (1991), about 60 % of incremental food output achieved in Nigeria in the recent past is attributed to the use of soil amendments introduced into the systems. These amendments have a very significant impact on crop production in Nigeria, to the extent that in some parts of the country crop production is not possible without their uses. Therefore, to sustain food production in most rural communities, the restoration of the productivity of these soils is of great essence. This study was therefore carried out to (I) assess the restorative ability of poultry manure or inorganic fertilizers on an eroded soil and (II) determine the loss in soil productivity due to topsoil removal.

## 2.0. Materials and Methods

### *2.1. The Study area*

Benue State is regarded as the food basket of Nigeria due to its immense agricultural resources. The State is a significant producer of yam, rice, sesame, soybean, sorghum, maize, guinea corn, beans, cassava, groundnuts, and Bambara nuts. Tree crops like oil palm, mango, orange, cashew, etc also thrive very well in the State; and the state is a major supplier of fruits in the country.

The study sites were the Teaching and Research Farm of the University of Agriculture, Makurdi, located between latitude $7^0$40'N to $7^0$53'N and longitude $8^0$22'E to $8^0$35'E at an elevation of 97 m above mean sea level, and the National Root Crop Research Institute outpost, Otobi located between latitude $7^0$ 07'N to $07^0$46'N and longitude $08^0$06'E and $08^0$34'E at an elevation of 143 m above mean sea level. Makurdi site is underlain by Makurdi sandstone while Otobi is underlain by consolidated shales.

### *2.2. Experimental Design and land preparation*

The experimental design was a 5 x 2 x 3 split-split plot laid out in a Randomized Complete Block Design (RCBD), replicated three times. The desurfaced depth constituted the main plots, cropping systems (sole soybean, and maize/soybean intercrop) constituted the subplots. while soil amendments (zero application, inorganic fertilizers (NPK 20:40:20) and poultry manure at the rate of 9 t $ha^{-1}$) constituted the sub-sub plots. The second-year planting was carried out on the old plots.

A total land area of 63 x 37 m (2331 $m^2$) was demarcated and mapped out into net plots of 3 m x 3 m each at the two designated sites. Topsoil loss was simulated by artificially resurfacing the plough layer using spade at four depths (0 – 5 cm, 0 – 10 cm, 0 – 15 cm, and 0 – 20 cm). A fifth plot was left undersurface (0 cm) which served as the control. The plots were later cultivated into ridges using a traditional hoe. The experiment was repeated on the same plot for the following season. Chemical properties of the poultry manure and application of amendments were according to (Adaikwu *et al,* 2017).

### *2.3. Planting of crop*

Soybean variety TGX 1448-2E which served as the test crop was planted as sole crop and also intercrop with maize variety Oba supper II in August for 2012 and 2013 seasons. Soybean seeds were planted by drilling and later thinned to one plant per stand at a spacing of 75 cm x 5 cm after germination. Inorganic fertilizer was applied at the rate of 20:40:20 Kg $ha^{-1}$ ($N:P_2O_5:K_2O$) at 2 weeks after planting (WAP). Weeding was done manually to minimize soil disturbance.

### *2.4. Data collection and analysis*

#### *2.4.1. Soil data*

A composite soil sample was collected from the bare soil each representing the desurfaced depths and the control for routine laboratory analysis before planting. Soil bulk samples were also collected from each plot based on the treatment at harvest for the two cropping season for the same routine analysis. The infiltration rates of the desurfaced depths were measured using the double-ring infiltrometer. while other physical properties of the soils such as the saturated hydraulic conductivity (Ksat), gravimetric water content and porosity were measure using a standard procedure (Udo *et al*., 2009).

#### *2.4.2. Crop data*

Soybean plant height, number of leaves, and number of branches were measured at 4, 7, and 10 weeks after planting (WAP). Nodules biomass was determined at 8 WAP. At harvest number of pods per plant and the net grain yield were determined.

Data collected were analyzed using correlation and analysis of variance test (ANOVA) using SAS Statistical software and significant means were separated using the Ducan Multiple Range Test (DMRT).

## 3.0. Results

### *3.1. Meteorological data at Makurdi*

The meteorological data for Makurdi gave the total annual rainfalls as 1150.60 mm for the year 2011; 1492.80 mm for 2012; 1287.80 mm for 2013 and 1266.60 mm for 2014 (Figure 1.) Whereas the mean annual minimum and maximum temperature for the periods were 21.71 and 33.02 0c (2011); 20.65 and 32.90 0c (2012); 19.78 and 33.16 0c (2013) and 21.44 and 33.10 0c (2014) (Figure 2).

### *3.2. Effects of artificial desurfacing technique on soil properties before planting*

The textural class of the soil at 0 to 20 cm depths before planting in the two locations (Makurdi and Otobi) was sandy loam, soil bulk density increased with increase in the depth of topsoil removal whereas, total porosity decreased with topsoil removal (Adaikwu *et al.*; 2017). Soil chemical properties such as total nitrogen and CEC decreased with depth at the two locations (Adaikwu et al; 2017).

### *3.3. Effect of artificial desurfacing techniques on physical properties*

Topsoil removal, using artificial desurfacing techniques significantly (P = 0.05) affected the physical properties of the soil evaluated (Table 1). Soil total porosity and saturated hydraulic conductivity significantly (P = 0.05) decreased with an increase in topsoil removal. Meanwhile, the gravimetric water content of the soil was significantly higher (26.06 %) at 20 cm depth compared with the lowest value (24.82 %) at 10 cm depth. Saturated hydraulic conductivity of the soil was significantly lower at 20 cm but did not differ significantly at 0 to 10 cm depths. Soil bulk density decreased with an increase in the depth of topsoil removal (Table 1). A pH of 5.58 was recorded at 0 cm depth and it decreased to 5.05 at 20 cm depth. Other chemical properties of the soil such as organic matter content, total nitrogen as well as cation exchange capacity (CEC) recorded a significant decrease as topsoil removal increased from 0 to 20 cm depths. Table 1 further shows the effect of cropping systems, nutrient amendments, and locations as well as cropping seasons on the physicochemical properties of the soil.

Application of poultry manure significantly reduced soil bulk density increased total porosity as well as the saturated hydraulic conductivity compared with the application of inorganic fertilizers. Likewise, the application of poultry manure enhanced soil organic matter content, total nitrogen, and the CEC of the soil compared with the use of inorganic fertilizers (Table 1).

Soil bulk density, gravimetric water content, and saturated hydraulic conductivity were significantly (p = 0.05) higher at Otobi than the values obtained at Makurdi, likewise organic matter content, and CEC (Table 1). The soil total porosity, saturated hydraulic conductivity, and total nitro-

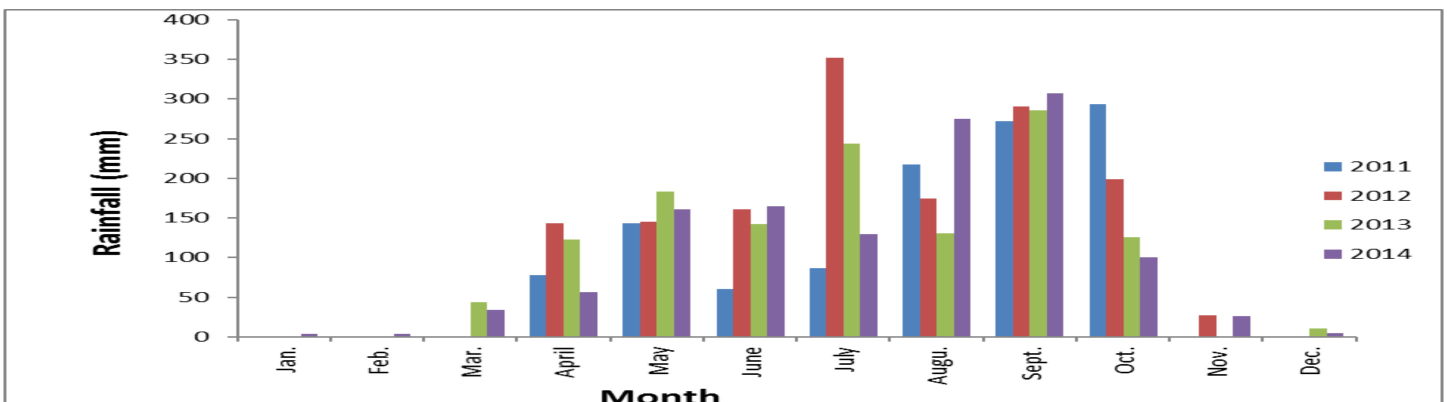


Figure 1. Rainfall data for Makurdi Southern Guinea Savanna of Nigeria for the period of 2011-2014 sources NIMET station airforce base Markurdi

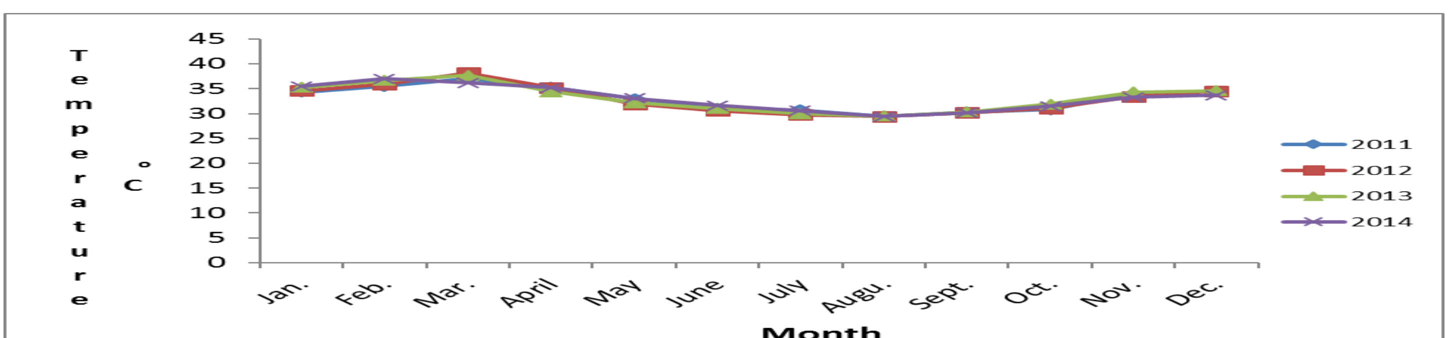


Figure 1. Rainfall data for Makurdi Southern Guinea Savanna of Nigeria for the period of 2011-2014 sources NIMET station airforce base Markurdi

Table 1. Effects of topsoil removal, cropping systems, soil amendments, locations and seasons on physicochemical properties of the soil at harvest

| | Bulk density (g cm$^{-3}$) | Porosity (%) | Gravimetric Water Content (%) | Saturated hydraulic conductivity (cm hr$^{-1}$) | pH (KCl) | OM (kg-1) | N (kg-1) | Avail. P (mg kg$^{-1}$) | CEC (Cmol kg$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| Depth of topsoil removal (cm) | | | | | | | | | |
| 0 | 1.32a | 50.06d | 25.34bc | 40.90c | 5.58e | 1.71e | 0.12c | 5.21e | 7.39d |
| 5 | 1.34b | 49.57c | 25.61cd | 38.87bc | 5.52d | 1.52d | 0.10b | 4.93d | 7.03c |
| 10 | 1.35c | 49.38bc | 24.82a | 41.19c | 5.36c | 1.33c | 0.09b | 4.39c | 6.63b |
| 15 | 1.36c | 49.13b | 25.10ab | 36.04b | 5.26b | 1.16b | 0.09ab | 4.13b | 6.59b |
| 20 | 1.40d | 47.29a | 26.06d | 29.08a | 5.05a | 1.00a | 0.08a | 3.92a | 6.24a |
| Std. Error | 0.00 | 0.13 | 0.16 | 1.29 | 0.02 | 0.02 | 0.00 | 0.06 | 0.06 |
| P. Value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cropping systems | | | | | | | | | |
| SM | 1.37b | 44.69a | 26.16c | 37.35bc | 5.41b | 1.32a | 0.09a | 4.39a | 6.81a |
| SI | 1.35a | 45.38b | 24.8a | 39.55c | 5.29a | 1.31a | 0.10b | 4.41a | 6.76a |
| SS | 1.35a | 45.7b | 25.2b | 34.74a | 5.37b | 1.40b | 0.10b | 4.75b | 6.76a |
| Std. Error | 0.00 | 0.12 | 0.13 | 0.99 | 0.02 | 0.02 | 0.00 | 0.05 | 0.05 |
| P. value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.67 |
| Soil amendments | | | | | | | | | |
| ZA | 1.39c | 44.44a | 25.89b | 34.12a | 5.31a | 1.09a | 0.08a | 4.20a | 6.03a |
| IF | 1.38b | 44.89b | 25.94b | 37.31b | 5.31a | 1.32b | 0.10b | 4.42b | 6.76b |
| PM | 1.30a | 46.44c | 24.33b | 40.21c | 5.45b | 1.62c | 0.11b | 4.93c | 7.54c |
| Std. Error | 0.00 | 0.12 | 0.13 | 1.00 | 0.02 | 0.02 | 0.00 | 0.05 | 0.05 |
| P. value (0.05) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Locations | | | | | | | | | |
| Makurdi | 1.33 | 50.14 | 20.17 | 41.38 | 6.09 | 1.21 | 0.11 | 4.40 | 6.69 |
| Otobi | 1.38 | 48.04 | 23.92 | 45.41 | 6.05 | 1.48 | 0.09 | 4.63 | 6.86 |
| Std. Error | 0.00 | 0.09 | 0.11 | 0.21 | 0.01 | 0.01 | 0.00 | 0.04 | 0.04 |
| P. Value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | NS | 0.00 | 0.00 |
| Seasons | | | | | | | | | |
| 2012 | 1.36 | 49.04 | 23.35 | 43.45 | 6.10 | 1.07 | 0.10 | 4.31 | 6.65 |
| 2013 | 1.35 | 49.14 | 20.73 | 43.34 | 6.05 | 1.62 | 0.10 | 4.73 | 6.91 |
| Std. Error | 0.00 | 0.09 | 0.11 | 0.21 | 0.01 | 0.01 | 0.01 | 0.04 | 0.04 |
| P. Value | 0.00 | NS | 0.00 | NS | 0.00 | 0.00 | NS | 0.00 | 0.00 |

Std. = standard error, P. value=probability value, SM=sole maize, MSI=maize soybean intercrop, SS=sole soybean, ZA=zero application, IF=inorganic fertilizer, PM=poultry manure, NS= not significant.

Mean values in the same column followed by the same letter are not significantly different at P=0.05 (DMRT).

gen did not differ significantly between the two cropping seasons (2012 and 2013), meanwhile, organic matter content, available phosphorus, and CEC were significantly higher in 2013 than in the previous season (Table 1). The interaction between topsoil removal and nutrients amendments had a significant effect on soil physicochemical properties (Figure 3). Application of poultry manure increased total porosity and saturated hydraulic conductivity as well as organic matter content across desurfaced depths. However, the application of either poultry manure or inorganic fertilizer at 15 and 20 cm depths did not improve the organic matter content of the soil than zero application at 0 cm (undersurface) depth, likewise, saturated hydraulic conductivity (Figure 3). Soil bulk density negatively correlated with saturated hydraulic as well as total porosity (Table 2). While bulk density increases with an increase in the depth of topsoil removal, saturated hydraulic conductivity and porosity decreased with increase in topsoil removal.

### *3.4. Treatments effect on soybean growth and yield parameters*

The removal of topsoil caused a significant reduction in the growth parameters of soybean at Makurdi and Otobi. Plant height, number of leaves, number of branches, pods per plant, and nodules biomass per plant significantly decreases with an increase in topsoil loss.

At 7 and 10 WAP, soybean height decreased with an increase in topsoil removal (Table 3). Also, the soybean

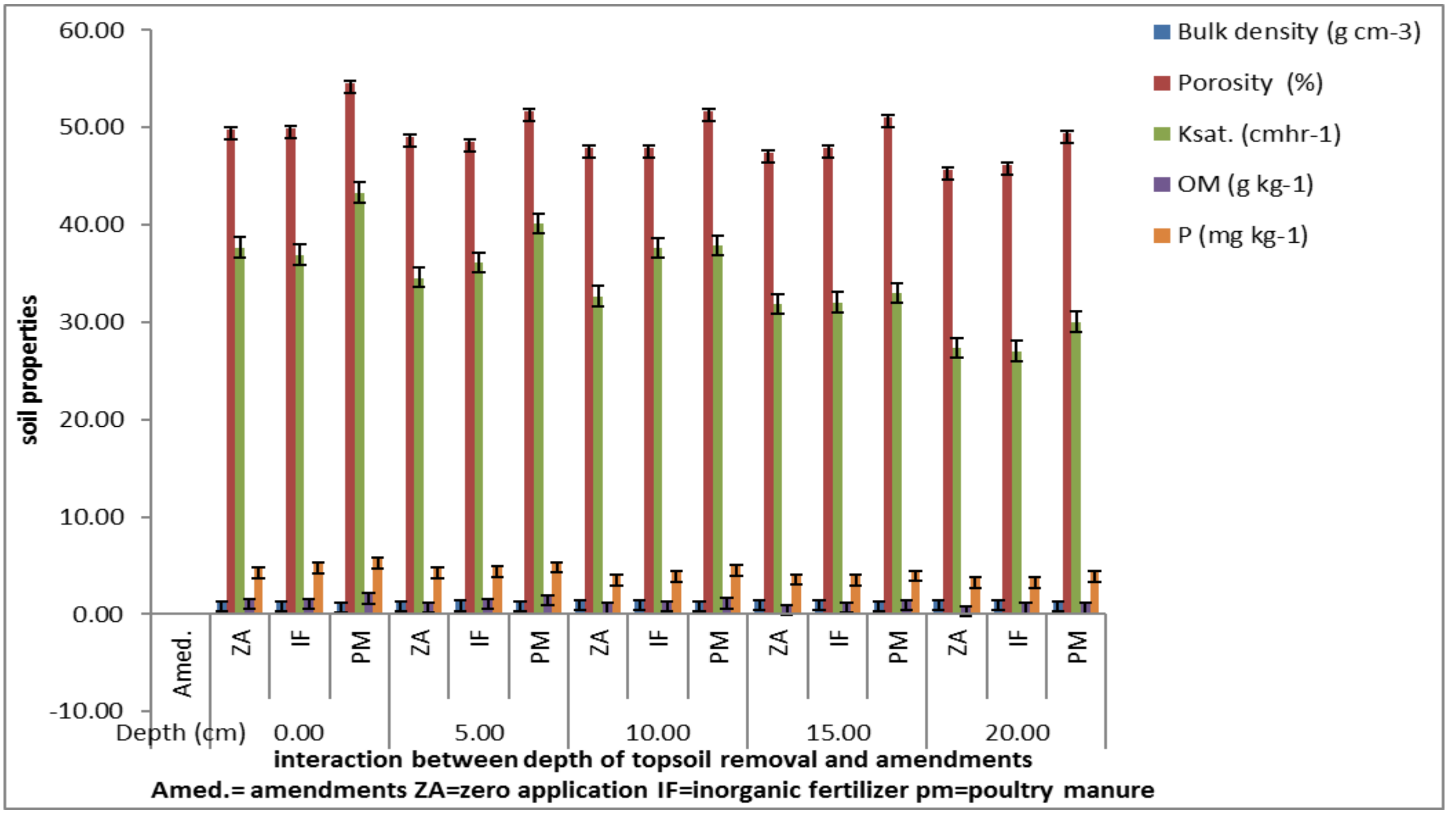


Figure 3 Interaction effects of topsoil removal and nutrient amendments on physicochemical properties of the soil

Table 2 Pearson's correlation matrix of the physical properties of the soil

| | BD 4 WAP | BD 6 WAP | BD 8 WAP | Grv 4 WAP | Grv 6 WAP | Grv 8 WAP | P 4 WAP | P 6 WAP | P 8 WAP | Ksat_4 WAP | Ksat_6 WAP | Ksat_8 WAP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BD 4 WAP | 1 | | | | | | | | | | | |
| BD 6 WAP | 0.567** | 1 | | | | | | | | | | |
| BD 8 WAP | 0.413** | 0.455** | 1 | | | | | | | | | |
| Grv 4 WAP | 0.514** | 0.381** | 0.203** | 1 | | | | | | | | |
| Grv 6 WAP | 0.434** | 0.447** | 0.180** | 0.631** | 1 | | | | | | | |
| Grv 8 WAP | 0.451** | 0.462** | 0.382** | 0.555** | 0.596** | 1 | | | | | | |
| P 4 WAP | -0.855** | -0.554** | -0.372** | -0.527** | -0.450** | -0.465** | 1 | | | | | |
| P 6 WAP | -0.510** | -0.822** | -0.385** | -0.387** | -0.413** | -0.436** | 0.518** | 1 | | | | |
| P 8 WAP | -0.400** | -0.469** | -0.847** | -0.227** | -0.213** | -0.414** | 0.412** | 0.460** | 1 | | | |
| Ksat_4WAP | -0.397** | -0.359** | -0.540** | -0.114** | -0.052 | -0.198** | 0.364** | 0.287** | 0.518** | 1 | | |
| Ksat_6WAP | -0.141** | -0.180** | -0.219** | -0.085* | -0.075 | -0.092* | 0.137** | 0.145** | 0.209** | 0.270** | 1 | |
| Ksat_8WAP | -0.130** | -0.035 | -0.226** | 0.055 | 0.086* | 0.063 | 0.096* | 0.019 | 0.211** | 0.483** | 0.277** | 1 |

Ksat= Saturated Hydraulic conductivity, Grv= Gravimetric water content, P= total Porosity, WAP= weeks after planting

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

number of leaves was significantly (P = 0.05) reduced at 4, 7, and 10 WAP with increased topsoil removal. The highest grain of soybean (1522 kg ha$^{-1}$) was recorded at 0 cm depth and decreased significantly with a depth of topsoil removal (Table 3). Cropping systems had no significant effect on soybean plant height, numbers of pods per plant, and nodules biomass per plant. However, sole soybean plots had a significantly higher grain yield (1071 kg ha$^{-1}$) compared with the intercrop plots (Table 3).

The application of nutrient amendments caused significant changes in the growth and yield parameters of soybean evaluated (Table 4). Plots treated with poultry manure were significantly higher in height, number of leaves per plant as well as numbers of branches per plant. Likewise, the highest grain yield of soybean (1474 kg ha$^{-1}$) was recorded on poultry manure treated significantly higher plots (p = 0.05) than the values obtained from plots treated with inorganic fertilizers and the control (Table 4). Furthermore, at 7 and 10 WAP, soybean plant height was significantly higher at Otobi than at Makurdi, but the numbers of branches and grain yield recorded higher values at Makurdi than at Otobi. For cropping seasons, plant height was not significantly different at 4 and 7 WAP for the 2012 and 2013 cropping seasons likewise the grain yield (Table 6). The number of pod per plant was higher in 2012 (69.89) than in 2013 (57.07) and also the number of leaves at 10 WAP (Table 4).

The interaction effects of topsoil removal and amendments on the overall mean values of soybean grain yield for the two locations (Makurdi and Otobi) and cropping seasons

(2012 and 2013) indicate that application of poultry manure ranged between 2095 – 924 kg ha$^{-1}$ at 0 – 20 cm depths, while inorganic fertilizer ranged between 1495 – 620 kg ha$^{-1}$ at 0 – 20 cm meanwhile, the zero application (control) ranged between 975 – 270 kg ha$^{-1}$ at 0 – 20 cm depth (Figure 4). Furthermore, the interaction effect of topsoil removal and nutrient amendments shows that the application of poultry manure caused 20 % soybean yield reduction at 5 depth, and also 29, 32, 41, and 56 % reduction at 10, 15 and 20 cm depths respectively (Figure 5). Whereas the application of inorganic fertilizer caused soybean yield reduction of 29 % at 5 cm depth as well as 40, 47, and 59 % at 10, 15, and 20 cm depths of topsoil removal. Meanwhile, soybean yield loss on the control plots (zero application) ranged between 41 % at 5 cm to 72 % at 20 cm depth (Figure 5).

Table 3: Comparative mean values of soybean Growth and Yield parameters as affected by the Depth of topsoil removal in the Southern Guinea Savanna of Nigeria

| Depth (cm) | Plant Height (cm) 4 WAP | 7 WAP | 10 WAP | Number of Leaves per Plant 4 WAP | 7 WAP | 10 WAP | No. Brnc/Plt 10 WAP | No. Pods/Plt | NDB/PLT (mg) | Grain Yield kg ha$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 17.30b | 40.65d | 56.24e | 24.40d | 56.60e | 83.65e | 25.50e | 83.72e | 0.86d | 1522e |
| 5 | 17.25b | 37.20c | 50.99d | 25.07d | 52.42d | 74.63d | 21.71d | 76.76d | 0.80d | 1106d |
| 10 | 17.40b | 35.48b | 46.24c | 20.83c | 45.57c | 67.60c | 19.47c | 59.81c | 0.56c | 933c |
| 15 | 16.46b | 35.10b | 43.99b | 19.36b | 41.53b | 63.29b | 16.38b | 52.39b | 0.48b | 769b |
| 20 | 13.94a | 31.04a | 38.87a | 16.44a | 37.33a | 54.60a | 14.36a | 44.74a | 0.27a | 614a |
| Std. Error | 0.32 | 0.5 | 0.58 | 0.39 | 1.24 | 1.13 | 0.38 | 1.81 | 0.02 | 23.95 |
| P. value (.05) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **CRS** | | | | | | | | | | |
| SI | 16.54 | 36.32 | 46.84 | 22.12 | 44.96 | 66.93 | 19.09 | 63.47 | 0.6 | 907.63a |
| SS | 16.4 | 35.47 | 47.69 | 20.33 | 48.42 | 70.57 | 19.87 | 63.49 | 0.58 | 1071b |
| S.E | 0.2 | 0.32 | 0.37 | 0.25 | 0.79 | 0.72 | 0.24 | 1.15 | 0.02 | 15.15 |
| P.value | NS | NS | NS | 0.00 | 0.00 | 0.00 | 0.02 | NS | NS | 0.00 |

N=number of entries, WAP=Weeks after Planting, Brnch/Plt=branches/plant, NDB/Plt= Nodules Biomass/plant. Mean values in the same column followed by the same letter are not significantly different at P=0.05 (DMRT).

Table 4: Comparative mean values of soybean growth and yield parameters as affected by the cropping systems and nutrients amendments in the Southern Guinea Savanna of Nigeria

| | Plant Height (cm) 4 WAP | 7 WAP | 10 WAP | Number of Leaves per Plant 4 WAP | 7 WAP | 10 WAP | No. Brnch/Plt 10 WAP | No. Pods/Plt | NDB/Plt (mg) | Grain Yield kg ha$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| **Soil amendments** | | | | | | | | | | |
| ZA | 14.48a | 27.37a | 33.83a | 15.63a | 32.73a | 45.48a | 10.28a | 32.52a | 0.16a | 516.69a |
| IF | 15.68b | 35.13b | 46.41b | 18.03b | 44.98b | 63.34b | 19.76b | 64.89b | 0.55b | 976.84b |
| PM | 19.25c | 45.18c | 61.55c | 30.01c | 62.35c | 97.43c | 28.41c | 93.04c | 1.06c | 1474.00c |
| Std. Error | 0.25 | 0.39 | 0.45 | 0.3 | 0.96 | 0.88 | 0.3 | 1.41 | 0.02 | 18.55 |
| P. value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Locations** | | | | | | | | | | |
| Makurdi | 16.39 | 32.62 | 45.44 | 23.23 | 46.63 | 67.85 | 21.36 | 64.06 | 0.57 | 1015 |
| Otobi | 16.55 | 39.17 | 49.09 | 19.22 | 46.75 | 69.66 | 17.61 | 62.91 | 0.61 | 963.79 |
| Std. Error | 0.2 | 0.32 | 0.37 | 0.25 | 0.79 | 0.72 | 0.24 | 1.15 | 0.02 | 15.15 |
| P. value | NS | 0.00 | 0.00 | 0.00 | NS | NS | 0.00 | NS | NS | 0.02 |
| **Seasons** | | | | | | | | | | |
| 2012 | 16.26 | 35.58 | 46.34 | 20.86 | 41.35 | 70.84 | 18.67 | 69.89 | 0.77 | 1008 |
| 2013 | 16.68 | 36.21 | 48.19 | 21.58 | 52.03 | 66.66 | 20.3 | 57.07 | 0.41 | 970 |
| Std. Error | 0.20 | 0.32 | 0.37 | 0.25 | 0.79 | 0.72 | 0.24 | 1.15 | 0.02 | 15.15 |
| P-value | NS | NS | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | NS |

CRS= cropping systems, SI=Soybean intercrop, SS=sole Soybean, SE=Standard Error of means, Amnd=Amendments, ZA= Zero application, IF = Inorganic Fertilizer, PM=Poultry Manure, Brnch/Plt=branches/plant, NDB/Plt= Nodules Biomass/plant. Means followed by the same letters within a column are not significantly different at P=0.05 (DMRT).

## 4.0. Discussion

The grain yield response of soybean to soil amendments during this study was in the order of poultry manure higher than inorganic fertilizer greater than zero application. This could be attributed to the ability of poultry manure to improve the physical and chemical properties of the soil. The stabilizing effect of poultry manure on soil physical properties could have accounted for the higher values of saturated hydraulic conductivity and total porosity obtained

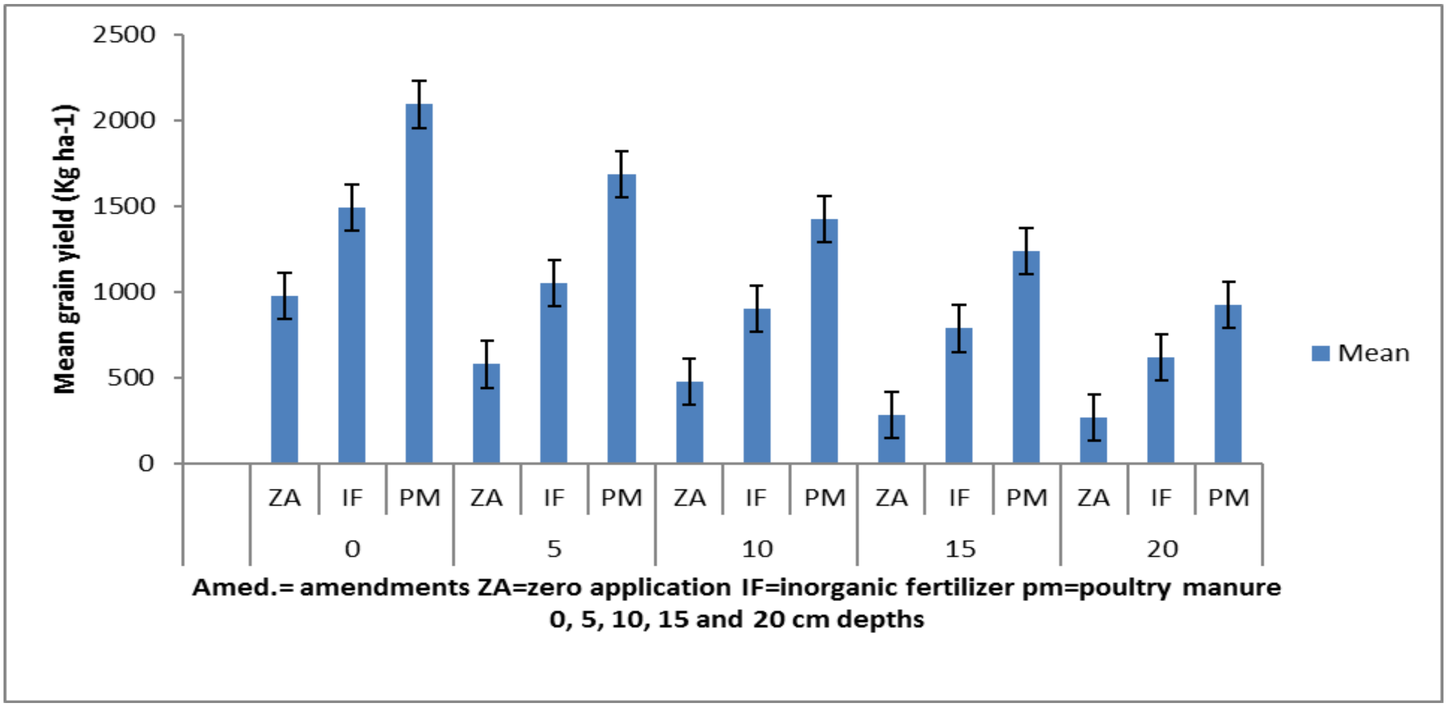


Figure 4. Interaction between topsoil removal and amendments on the overall mean grain yield of soybean for the two locations (Makurdi and Otobi) and cropping seasons (2012 and 2013).

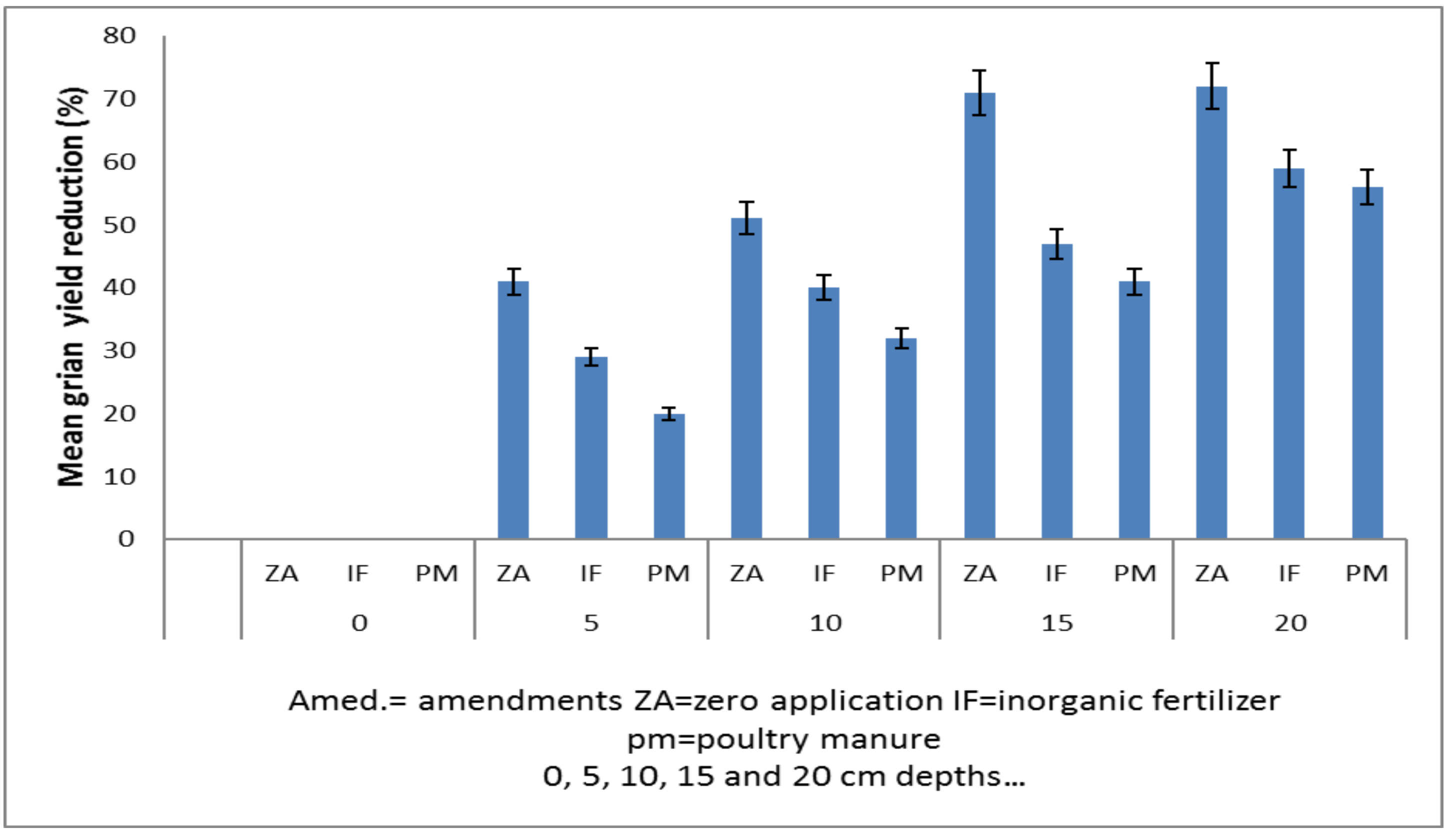


Figure 5: Mean grain yield reduction of soybean due to interaction between topsoil removal and nutrient amendments

with low bulk density compared with other treatments likewise, the increase in soil organic matter content and CEC could have improved the agronomic performance of soybean under poultry manure application compared with other treatments. Several studies have established the advantage of poultry manure over inorganic fertilizer to improve the physical properties of the soil and the agronomic performance of crops and grain yield. Poultry manure applications ranging from 10 to 50 t $ha^{-1}$improved moisture availability in soil and reduced soil bulk density which resulted in improved nutrient availability, growth, and yield of tomato (Rahman, 2000, Ewulo, 2005, Daudu *et al*., 2005). According to Adekiya and Ojeniyi (2002), N, P, K, Ca and Mg uptake by Tomato plant were significantly reduced due to increase in the bulk density of the soil, therefore, application of poultry which caused a reduction in soil bulk density and improvement in other soil physical properties could as well enhance nutrient uptake by the plant.

The decrease in the growth and yield parameters of soybean with an increase in topsoil removal observed in this study could be attributed to the loss of essential soil nutrients such as soil organic matter content, CEC, and exchangeable cations with depth. This may have explained why the 0 cm depth gave higher values of the growth parameters for two seasons at the two locations. And on the contrary, at higher depth of topsoil removal, the high values of soil bulk density and low porosity and saturated hydraulic conductivity increased soil compaction and reduced the size distribution of its pores with a consequent reduction in the growth parameters of the soybean. Low values of bulk density and consequent high values of total porosity and saturated hydraulic conductivity are associated with well-structured soil and contiguous pores as well as high water holding capacity; they allow high infiltration rates and rapid drainage (Marshal *et al.,* 1996). Furthermore, soil hydrologic properties such as infiltration rates and hydraulic conductivity were significantly improved with the application of poultry manure (Diana *et al*., 2008). Jiao et al. (2006) observed increased water-stable aggregate of sandy soil with an application of 30 t $ha^{-1}$ of cow dung. This implied improvement of the soil structure, which might have positive effects on water retention capacity. Mubarak *et al*. (2009) observed that there was a decrease in water movement in sandy soils amended with organic residues. This offers a better chance for crops to absorb water and nutrients instead of nutrients being leached down rapidly.

From the interaction between topsoil removal and nutrient amendments, it is indicative that the application of poultry manure gave lower yield reduction that is, higher yield advantage at each desurfaced depth compared with other treatments. This implies that application 9 tons per hectare of poultry manure could improve the productivity of degraded soils under soybean production than the application of inorganic fertilizer at the rate of NPK 20:40:20.

The grain yield of soybean was significantly ($p = 0.05$) affected by the cropping systems. Growing soybean as sole crop improved its agronomic performance than where it was intercrop with maize. This may be due to more nutrients available to the plant and less interspecific competition under sole cropping compared with higher competing needs of nutrients by the crops in the mixture. The reduction in yield of soybean in the intercrop may be attributed to interspecific competition for resources and depressive effect of maize crop (Nnoko and Doto, 1980; Francis *et al*., 1982, Assefa and Ledin, 2001 Muoneke *et al.,* 2007). Ezuma *et al.,* (1987) reported a 55 % to 61 % and 40 % and 55 % reduction of cowpea yield when intercropped with maize.

## 5.0. Conclusion

This study was carried out to evaluate the restorative ability of artificially desurfaced soil using poultry manure and inorganic fertilizer under soybean production. Soil physical and chemical properties were evaluated before and after planting, growth, and yield parameters of soybean were measured over time.

Application of 9 t $ha^{-1}$ of poultry manure increased soil organic matter content, improved soil physical properties, causing an increase in saturated hydraulic conductivity and total porosity with a consequent reduction in soil bulk density which resulted in improved nutrient availability, growth, and yield of soybean compared with other treatments across the desurfaced depths.

The grain yield response of soybean to soil amendments during this study was in the order of poultry manure higher than inorganic fertilizer higher than zero application.

From the interaction between topsoil removal and nutrient amendments, it is indicative that the application of poultry manure gave lower yield reduction that is, higher yield advantage at each desurfaced depth compared with other treatments. This implies that application 9 tons per hectare of poultry manure has a higher restorative ability on degraded soils under soybean production than the application of inorganic fertilizer at the rate of NPK 20:40:20.

## References

Adaikwu, A. O., Salako, F. K. Azeez, J. O. and Adetunji, M. T. (2017). Effects of topsoil removal and amendments on soil bulk density and maize yield in the Southern Guinea Savanna of Nigeria. Asian Journal of Soil Science and Plant Nutrition1(2): 1-13

Adekiya, A. O. and Ojeniyi, S. O. (2002). Evaluation of tomato growth and soil properties under methods of seedling bed preparation in an Alfisol in the rainforest zone of southwest Nigeria. *Bioresource Technol*. 96: 509-516.

Adeli, A., Sistani, K.R., Rowe, D. E. and Tewolde, H. (2005). Effects of broiler litter on soybean production and soil nitrogen and phosphorus concentration. Agronomy Journal, 97(1): 314 – 321.

Agboola, A. A. and Corey, R. B. (1973). The Relationship between soil pH, Organic matter, available P, exchangeable K and nine elements in the maize tissue. *Soil Science Journal*, 115:367-375.

Assefa, G. and Ledin I. (2001). Effect of variety, soil type and fertilizer on the establishment, growth, forage yield, quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. *Animal feed science and Technology* 92: 95-111.

Bationo, A., Kihara, J. Vanlauwe, B., Waswa, B., and Kimetu, J. (2006). Soil organic carbon dynamics, function and management in West African Agroecosystems. Agricultural Systems volume 94, issue 1. pp13-25.

Chiezey, U. F. and Odunze A. C. (2009). Soybean response to application of poultry manure and phosphorus fertilizer in the Sub-Humid Savanna of Nigeria. Journal of Ecology and Natural Environment Vol. 1(2), pp. 025-031, Dauda, S. N., Aliyu, L. and Chiezey, U. F. (2005). Effect of seedling age at transplanting and poultry manure on fruit yield and nutrients of garden egg (*S. gilo L.*) varieties. J. Trop. Sci. 5: 38–41.

Diana, G., Beni, C.and Marconi, S. (2008). Organic and Mineral Fertilization: Effects on physical characteristics and boron dynamic in an agricultural soil. Commun Soil Sci. Plant Anal. 39: 1332–1351.

Ewulo, B. S. (2005). Effects of poultry dung and cattle manure on chemical properties of clay and sandy clay loam soil. Journal of Animal and Veterinary Advances, 4 (10): 839 - 841.

Ezumah, H. C., Nguyen K. N. and Walker, P. (1987). Maize-cowpea intercropping asaffected by nitrogen fertilization, *Agronomy Journal*, 79: 275-280.

Francis, C, A Cornalia, B. F. and Larry D.K. (1990). Sustainable agriculture in temperate zones. John Wiley and Sons, Inc. New York. 487p.

Gupta, V., Sharma G.L., Sonakiya, V.K., Tiwari, G. (2003). Impact of different levels of FYM and sulphur on morphological indices and productivity of soybean genotypes. JNKVV Research Journal, 37 (2):76 – 78.

Hilhorst T, Muchena F, Defoer T, Hassink J, Jage A, deSmaling E, and Toulmin, C (2009). Managing soil fertility in Africa: Diverse settings and changing practices. In: Nutrients on the move; soil fertility dynamics in Africa farming systems (Hilhorst T, and Muchena F, (Eds). Russell Press, Nottingham, p 1 – 27.

Hue, N.V. (1992). Correcting soil acidity of a highly weathered Ultisol with chicken manure and sewage sludge. Commun. Journal of Soil Science and Plant Analysis, 23:241-264.

Ikombo, J., (1984). Effect of farmyard manure on maize in the semi-arid region of eastern Kenya. East Africa Agric. and Forestry Journal, 44:268-274.

Jiao, Y., Whalen, J. K. and Hendershot, W. H. (2006). No-tillage and manure applications increase aggregation and improve nutrient retention in a sandy-loam soil. Geoderma 134: 24-33.

Lal, R., (2015). Restoring soil quality to mitigate soil degradation. Sustainability ISSN 2071-1050 www.mdpi.com/journal/sustainability.

Marshal, J. I. W. Holmes and C.W. Rose (1996). Soil physics. Third edition. Cambridge University Press, 358 – 376.

Mubarak A.K. Omaima, E.R, A.A and Nemat, E.H. (2009) Short-Term Studies on Use of Organic Amendments for Amelioration of a Sandy Soil. African Journal of Agricultural Research. Vol: 4 (7) 621 – 627.

Muoneke C.O., Ogwuche M.A.O. and Kalu B.A. (2007). Effect of maize planting density on the performance of maize/soybean intercropping systems in guinea savannah agroecosystem. African Journal of Agricultural Research.2 (12): 667-677.

Navale, K.B., Gaikwad, C.B. and Tamboli, B.D. (2000). Effect of integrated nutrient management on yield, nutrient availability and uptake of nutrients by soybean. Journal of Maharashtra Agricultural University, 25(1): 105-107.

Nnadi, L.A. Arora, L (1985). Nitrogen source on crop yield and properties in the savannah. In B.T. Kang and J. Vander Heide (Editor) Nitrogen management in farming systems. Inst. For soil Fertility (IB) Haren Netherlands 223-234.

Nnoko E. N. and Doto A. C. (1980). Intercropping maize and millet with soybean, with particular reference to planting schedules. In: Intercropping in semi-arid areas, morogoro.4-7, Canada, 33-36.

Ojeniyi, S.O. (1995). "That our soil may not die".10$^{th}$ Inaugural lecture of Federal University of Technology, Akure. March 23, 1995. Pp. 5 – 10.

Omoti, U, U., Obatolu, CR. And Fagbenro, J.A. (1991). Organic Fertilizer seminar, Kaduna.Pp. 2 -5.

Rahman, S.A. (2000). The Place of Organic Manure in Sustaining Agricultural Development in Nigeria. Paper presented at Science Technology and Society National Workshop in Lafia, Nasarawa State, 11th July, 2004

Reddy, T. Y. and Reddi, G.H. S (2002). Principles of Agronomy. Kalyani Publishers, New Delhi. Pp. 223-227.