Ghana Journal of Geography Vol. 18 No. 1 (2026)

Ghana Journal of Geography

journal homepage: https://www.ajol.info/index.php/gjg/ https://journals.ug.edu.gh/index.php/gjg/

Impacts of Agricultural Management Techniques on Selected Soil Physical and Chemical Properties in the Derived Savanna of South West Nigeria.

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http://dx.doi.org/10.4314/gjg.v18i1.2

article info

Article history:
Received 14th November 2025
Accepted 10th February 2026
Published 28th February 2026

Keywords:
Hydraulic conductivity,
manure,
volumetric moisture content,
aggregate stability.

abstract

Land degradation is one of the major threats to food security and natural resources conservation. Fostering sustainable agricultural production systems requires an understanding of how common management approaches affects the physical and chemical characteristics of soil health. This research examined the effect of agricultural management practices on some soil physical and chemical properties at the Teaching and Research Farm of the College of Agriculture, Osun State University, Ejigbo Campus, Ejigbo, Osun State. Agricultural management practices have profound impacts on both soil environment and agricultural productivity. Few of the selected soil physical and chemical properties examined were: Aggregate stability, bulk density, porosity, hydraulic conductivity, moisture content, Organic carbon, and soil pH. The results revealed that Aggregate stability in Organic farm (OF) and Fallow land (FL) were higher than plots managed with synthetic fertilizer (IF) by 24.18 and 26.52 % ($P < 0.05$) respectively. Also, soil managed with manure and (FL) had higher hydraulic conductivity and significantly different from soil that was managed with synthetic fertilizer (IF) by 73.83 and 75.83 % respectively. From soil fertility point of view, long-term organic soil management and fallow practices improve C:N, gravimetric moisture content, organic matter content at the surface layer. In contrast, prolonged in-organic fertilization tends to decrease these crucial properties that can increase and also sustain yield productivity. Lower C:N ratios in IF suggest reduced potential for long-term carbon sequestration compared to OF and FL, which showed improved soil health indicators and carbon storage potential.

1. Introduction

Evaluating soil quality indicators—particularly physical and chemical characteristics in relation to management strategies is a valuable and essential indicator for sustainable agricultural land management. Developing soil management techniques requires an understanding of how these factors affect soil qualities. The information on soil quality can also be used to predict how any future modifications to management techniques will probably affect the characteristics of the soil. Poor soil management can have a detrimental impact on an area's potential uses, which could eventually result in land degradation and decrease productivity. Until better management techniques are used, the soil will continue to deteriorate. Applying soil amendments in the form of manure that contains the three main nutrients: nitrogen, phosphorus, and potassium—is the most often used strategy to remediate soil depletion (Akinbile, 2020). According to Ray et al. (2013), one of the two key elements influencing agricultural productivity is low soil fertility. In order to increase yield in sustainable ways, there is a rising need for researchers to create techniques that would improve the soil management in favour of soil quality in low-fertility areas, improve soil water retention and water usage efficiency. Practices that preserve and enhance the physico-chemical characteristics of the soil and maintaining the highest possible crop production over time are necessary for sustainable soil management in terms of ecosystem service. High physical quality soil must have two essential structural qualities: first, it must be stable in water, and second, its pore size distribution must be suitable for the soil's ability to absorb, store, and release water for plant use (Gate et al., 2004). Additionally, these soils will be more easily penetrated by plant roots and have good aeration state. In sustainable agriculture production systems, environmental deterioration brought on by bad management practices is a major concern in the derived savanna of South West Nigeria. The loss of vegetative cover can promote soil erosion, which in turn exacerbates crop production limits connected to soil. In particular, a thorough comprehension of how land use and management affect soil characteristics offers a chance to assess how sustainable land use systems are (Woldeamlak, 2003). An ecosystem's ability to withstand disruptions brought on by climate change, various management techniques, shifting land use, and other stresses can be significantly influenced by the health of the soil. In the derived savanna regions of Southwest Nigeria, specific agricultural management practices, such as organic farming, fallow, and farming with synthetic fertilizer are usually carried out by farmers. A change in land use and poor soil management can negatively affect the potential use of an area and may ultimately lead to land degradation and loss of productivity. Poor agricultural and soil management can have a detrimental impact on an area's possible uses, which can ultimately result in land degradation and decrease output in the derived savanna regions of Southwest Nigeria. While the general impacts of various agricultural practices on soil properties are known, there is a

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http://dx.doi.org/10.4314/gjg.v18i1.2

paucity of comprehensive, long-term comparative studies specifically evaluating the distinct effects of organic farming, inorganic fertilization, fallow, and natural forest systems on a broad range of physical and chemical soil health indicators within the derived savanna agroecosystem of Southwest Nigeria, The purpose of this study was to assess the effects of different management practices on the physical and chemical properties of soils at the Teaching and Research Farm, Ejigbo, Osun State.

Materials and Methods

Site Description

Field trials were conducted at the Teaching and Research Farm, Osun State University, Ejigbo campus, Osun State, Nigeria**.** The approximate geographical coordinate of research area is 4 º.182864 to 4º.307958 E and 7 º.871924 to 7 º. 874021 N. The research area's soil type was classified as sandy loam by the United States Department of Agriculture (USDA) Table 1. About 50% of the land used in the research region is secondary forest, and 15% of the soils have been constantly treated with manure for more than ten years. 15 % of the soil managed with synthetic fertilizers for 10 years and 20 % Fallow land for 10 years. Due to the homogeneity of the study area, each management practice site was treated as a unit. The rainfall pattern is bimodal, with the first peak occurring between June and July and the second in September, with a brief dry spell in August. About 950 mm of rain falls there each year. The lowest temperature is 20.83 °C, and the highest temperature is 32.80 °C. The study area is roughly 651 meters above sea level, the average relative humidity is 70.30 %, and the majority of people work in business and agriculture (Akinbile et al., 2019). The plant species grown in the study area and their geographic position system is presented in Table 1.

Land management selection

Stratified random sampling was utilized to collect the soil samples after a reconnaissance study was completed to select representative soil sampling locations. The three sites where the study was conducted were chosen because they clearly reflect the main agricultural management practices

The four sites where the study was conducted were chosen because they clearly represent the main agricultural management practices used in the region and the Secondary Forest was chosen as a control in the study area. The four locations selected were:

1. Land that has been managed with manure, an Organic farm (**OF**) for more than 10 years
2. Land that has been managed with in-organic fertilizers In-organic farm (**IF**) for more than 10 years
3. Fallow land, land with more than 10 years fallow, (**FL**)
4. Secondary forest, no agricultural management practices for more than 30 years, (**SF**)

Selected soil properties analysis

The selected soil properties assessed were:

(a) Physical properties of soil, such as bulk density, porosity, aggregate stability, and gravimetric moisture content, Particle size distribution, Cumulative infiltration, and Un-saturated hydraulic conductivity

(b) Chemical characteristics of soil, such as soil pH, organic carbon, available P, cation exchange capacity, and total nitrogen.

Soil sampling and analysis

A Dutch auger was used to collect soil samples at 0–15 cm and 15–30 cm. For the purpose of determining soil physical properties (gravimetric moisture content, volumetric moisture content, and particle size distribution) and chemical soil parameters, composite soil samples at each depth were bulked, completely mixed, and sub-sampled. The soil samples were air dried, crushed using a pestle and mortar and sieved to pass through a 2 mm sieve. The hydrometer method was used to determine the particle size distribution (soil texture) (Bouyoucos 1962) Table 1. The cumulative infiltration (I) values, reported in centimeters, were measured as a function of time using a mini disk infiltrometer. This shows how much water has penetrated the soil's surface overall, according to Philip (1957). Un-saturated hydraulic conductivity (Kun-sat) was determined using the constant head soil core method (Reynolds et al., 2002). After measuring the leachate volume over time until the flow was stable, Equation 2 was used to determine the ultimate rate of flow.

$$K(\mathrm{Un-sat}) = \frac{Q}{AT} \times \frac{L}{\Delta H} \qquad \text{Eq. 1}$$

K un-sat. stands for unsaturated hydraulic conductivity (cm h^{-1}), Q for the volume of water passing through a cross-sectional area (cm^3), A for the cross-sectional area of the core (cm^2), T for time (s), L for length of the core (cm), and ΔH for hydraulic head differential (cm).

The pH of the soil was determined in a 1:2 soil to water suspension using the procedure outlined in Sahelemedhin & Taye (2000). Wet digestion was used to determine the organic carbon content using the Walkley and Black oxidation method (Walkley & Black 1934). Soil organic matter (OM) content was calculated by multiplying the concentration of soil organic carbon by 1.724. The total nitrogen (TN) concentration was determined using the Kjeldahl method (Bremner & Mulvaney 1982) and the Olsen method was used to determine the available phosphorus (Olsen et al. 1962). Following sample extraction using 1 N ammonium acetate, the cation exchange capacity (CEC) was calculated (Chapman 1965). In order to calculate bulk density, which is defined as the amount of oven-dried soil per volume of core, undisturbed soil samples (5 cm long × 5 cm in diameter) were taken from each field that was handled differently at depths of 0-15 cm (Blake & Hartge, 1986). The total porosity of the soil was calculated using the relationship between bulk density and soil particle density (2.6 Mg m-3). Gravimetric moisture content was used to determine the soil's moisture content. Jabro et.al., 2015.

$$\text{Gravimetric water content (\%)} = \frac{(\text{Wet soil weight}) - (\text{Oven dried soil weight})}{\text{Oven dried soil weight}} x\ 100 \qquad \text{Eq. 2}$$

Table 1: Experimental sites and their description

Ecosystem	Longitude	Latitude	Key plant species	Soil texture 0-15 cm	15 – 30 cm
Secondary forest (**SF**) (Not cultivated for the past 20 years)	7 º.874021 N	4 º.30629 E	*Chromolaena odorata* Theobroma cacao, *Kola nitida etc*	Sandy loam	Loam
Organic farm (**OF**) (cultivated land with 10 years organic fertilizer application)	7 º.87170 N	4 º.18286 E	*Musa paradisiaca, Musa sapientum* and under grow bushes	Sandy loam	Sandy loam
In-organic farm (**IF**) (cultivated land with 10 years In- organic fertilizer application)	7 º.87192 N	4 º.30796 E	*Andropogon gayanus,* under grow bushes	Sandy loam	Sandy loam
Fallow land (**FL**) land with more than 10 years fallow	7º.889920 N	4 º.322000 E	*Chromolaena Sp., Andropogon gayanus etc*	Sandy Loam	Sandy Loam

Statistical analyses

The Kolmogorov-Smirnov test was applied to evaluate normality in the distribution of the studied variables. A randomized complete block design (RCBD) was employed to assess treatments effects of different agricultural management practices on selected soil health parameters at two different soil depths for the statistical analysis and the datasets were examined using analysis of variance (ANOVA) (SAS, 2011). The arrangement of the statistical design included four different agricultural management practices as treatments (Secondary Forest (SF), Organic farm (OF), Inorganic farm (IF) and Fallow land FL). A one-way ANOVA was conducted for each soil property at each soil depth to determine the significant effects of agricultural management practices A means comparison was completed using the DMRT at the $p < 0.05$ probability level.

Results and Discussion

The soil texture for both top and subsoil were presented in Table 1. The soil texture for the investigated areas was Sandy loam except for the 15-30 cm soil depth of Secondary Forest; this shows that management practices did not influence particle size distribution in the derived savanna of South West Nigeria.

Effects of different soil management techniques on volumetric moisture content, bulk density and porosity over the two soil depths

The mean percentage gravimetric moisture content values obtained under the different management methods are shown in (Table 2). SF had the highest moisture content (14.40 %) and was significantly different ($p < 0.05$) from experimental plots treated with manure, OF, (5.68 %) and synthetic fertilizer, IF, (3.38 %) by 60.56 and 76.53 % respectively. FL with 8.78 % was the second highest and was higher than OF and IF by 61.50 and 35.31 %. The reasons for higher moisture content in SF and FL could probably be due to the retention of crop residue on the soil surface, reduction of runoff and interception of rainfall as compared to the plot that was continuously managed with synthetic fertilizer, IF, with lower crop residue (Kahlon et al.,2012). According to Wang et al. (2009), another explanation could be a lower evaporation rate in SF and OF due to surface mulch, which positively affected the soil moisture regime by regulating evaporation from the soil surface. Organic materials addition affected the selected four soil quality indicators under consideration as shown in Table 1. The most favourable effect was reported for moisture content, followed by bulk density, porosity and aggregate stability on the sandy loam of the derived savanna agro-ecology. These results are similar to what was reported by Abivenet al. (2009). Mean bulk density (ρb) and porosity at 0 -15 cm were also presented in Table 2. OF and IF had higher bulk densities and significantly higher $p \leq 0.05$ than SF and FL, with lower values. The order of increase in bulk density was IF > OF > FL > SF. Bulk density (ρb) values across all agricultural management soils did not exceed the critical level of 1.40 g/cm^{-3}, suggesting that significant soil compaction was not indicated at this depth (Arshad et al., 1997). Soil ρb was used as an index to evaluate soil compaction under each management practice. In addition, FL and SF had higher total porosity compared to IF were managed with synthetic fertilizers. These observations contradict what was reported by Hajabbasi et al. (2007) who found no significant change in bulk density (ρb) and total porosity as a consequence of agricultural management practices. Higher bulk density and decreased porosity in OF and IF may be caused by farming operations such as planting, weeding, and farmer movement in the field Shittu et al. (2023) reported the same finding. Arshad et al. (1997) and Shittu et al. (2017) reported that high bulk density restricts root exploration of the soil, impedes water and air flow, increases plant root lodging and rotting, reduces crop emergence, and interferes with root development. Aggregate stability in OF and FL were higher than IF by 24.18 and 26.52 % ($p \leq 0.05$) respectively, probably due to the higher value of organic carbon in these areas, Table 4, An et al, (2008) reported similar findings. Soil organic carbon and soil organic matter had a strong positive association with the stability of soil aggregates, which is consistent with the results of An et al. (2008). Higher aggregate stability in OF and FL will make the soil resistant to disintegration, boosting the soil's overall structural stability and long-term carbon sequestration (Ouyang et al. 2013).

Table 2: Effects of different soil management on selected soil physical properties at 0-15 cm soil depth

Treatment	Gravimetric moisture content (%)	Bulk density g cm^{-3}	Porosity (%)	Agg. Stab. (%)
IF	5.68^{bc}	1.20^{a}	55.05^{c}	59.12^{b}
OF	3.38^{c}	1.16^{a}	56.46^{bc}	73.42^{a}
FL	8.78^{b}	1.03^{b}	61.15^{ab}	74.80^{a}
SF	14.40^{a}	0.92^{b}	65.44^{a}	85.25^{a}

Impacts of management techniques on infiltration rate and unsaturated hydraulic at 0–15 cm soil depth

Impacts of management techniques on infiltration rate and unsaturated hydraulic at 0–15 cm soil depth was shown in Figure 1. Soil managed with manure (OF) and FL had higher hydraulic conductivity and significantly $p \leq 0.05$ different from soil that was managed with synthetic fertilizer (IF) by 73.83 and 75.83 % respectively, Figure 1. Additionally, the Unsaturated hydraulic conductivity (Ksat) followed this pattern: FL > OF > IF > SF. The presence of more organic matter may be the cause of the greater hydraulic conductivity seen in OF and FL, Table 4. The buildup of soil organic matter in OF is beneficial from an agricultural perspective because it can enhance water flow through micropores and reduce surface runoff, erosion, and stream pollution (Negassa, 2001). Hydraulic conductivity is crucial for forecasting drainage and water movement within the soil matrix, whether in the form of saturation or vapour transport, according to Shittu et al. (2022).

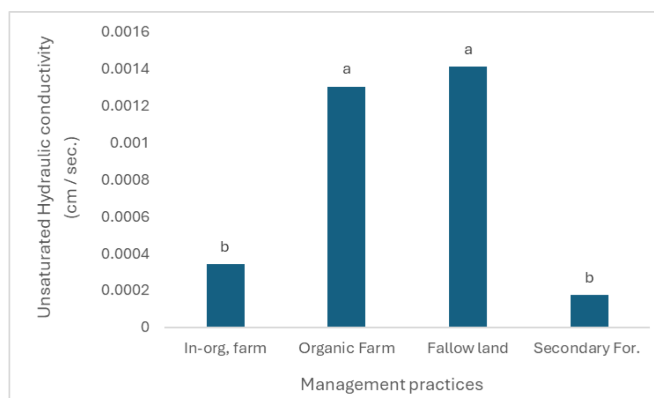

Figure 1: Un-saturated hydraulic conductivity at 0-15 cm soil depth for different agricultural management practices

Effects of agricultural management practices on infiltration rate at 0-15 cm soil depth

From the data gotten from the study, IF had decreased water infiltration rates between 42.52 and 111.09 % relative to OF and FL respectively at top soil (Figure 2). The findings imply that OF and FL can absorb water more quickly than IF. This could be due to the porous nature of the soil (Table 2) as a result of involvements of more micro-organisms in organic materials decomposition which makes the soil to be more loosened than IF (Osanyinpeju et. al., 2018, Schwartz et al., 2010; and Celik, et al, 2011). Higher stability of soil aggregates in FL and OF (Table 2) may be another factor affecting the absorbance rate of rainwater and infiltration rate.

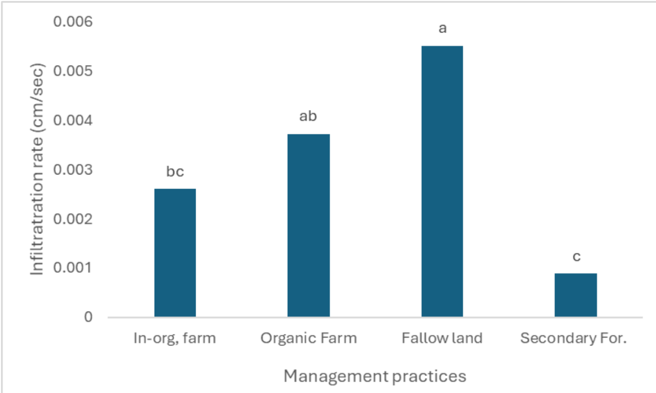

Figure 2: Infiltration rate at 0-15 cm soil depth for different agricultural management practices

Table 3: Effects of Agricultural management techniques on selected soil physical properties at 15-30 cm soil depth

Treatment	Bulk density gcm^{-3}	Porosity (%)	Gravimetric Moisture content (%)
IF	1.04^{a}	60.95^{a}	14.18^{a}
OF	1.05^{a}	60.68^{a}	14.79^{a}
FL	1.06^{a}	59.90^{a}	16.50^{a}
SF	1.18^{a}	55.80^{a}	13.98^{a}

Means within a column (for each treatment factor) not sharing a lowercased italic letter differ significantly at the p < 0.05 level

Impact of Agricultural management techniques **on selected soil physical properties at 15-30 cm soil depth**

Data on the impacts of different agricultural management on selected soil physical properties at sub-soil was presented on Table 3 Agricultural management practices had no effects on selected soil physical properties at the sub-surface soil.

Effects of management practices on Organic carbon, Total Nitrogen, and C: N at 0-15 cm soil depth

The effect of different agricultural management on selected soil chemical properties at 0-15 cm soil depth is presented in Table 4. Agricultural management practices had significant effects P ≤ 0.05 on selected soil chemical properties considered. IF had lower organic matter (2.62 %) while OF had the highest value (3.74 %) and is significantly higher, p ≤ 0.05than others management practices, the pattern is as follows: IF < SF < FL < OF (Table 4). Higher organic matter in OF will lead to lowering the demand for synthetic fertilizer inputs because manure can improve soil health by releasing nutrients gradually as soil microbes and macro-organisms break it down (Soumare et al. 2020; Wittwer & van der Heijden, 2020). They can also inhibit weed growth, stop soil sealing, and lessen erosion if they are applied or kept on the soil's surface (Blanco-Canqui & Lal 2020). Lower level of organic matter on IF might be due to the decrease in C inputs due to few vegetal cover and lower biomass return (Reicosky & Forcella, 1998). Continual cropping and differences in vegetal cover in IF and FL might be the reason for lower level of soil organic matter in the former, this was also reported by (Ashagrie et al., 2007). CEC ranged between 10.45 (SF) and 5.92 cmol /kg (IF), these values were lower and fall below the critical value that was reported by Sobulo & Adepetu, 1987. OF had the least values of Total N (0.15 %) and soil pH, Table 4. Soil pH was generally slightly acidic and ranged between 5.25 and 4.48. OF had the highest C:N (14.46) while IF had the lowest value (7.02), Table 4. From soil fertility point of view, OF and FL had higher C:N, gravimetric moisture content and organic matter content, at the surface layer. In contrast, IF with prolonged in-organic fertilization tends to decrease these crucial properties that can increase and also sustain yield productivity. From the perspective of the environment, C:N is lower in IF compared with OF and FL. The implication of this is that soil managed with manure (14.46) and fallow land (10.86) will sequester more carbon and keep the environment safer compared with the Inorganic farm IF (7.02).

Table 4: Effects of Agricultural management on selected soil chemical properties at 0-15 cm soil depth

Treatment	**Organic carbon %**	**Organic matter %**	**Total Nitrogen %**	**C: N**	**pH**	**CEC** cmol /kg
IF	1.51^{c}	2.62^{c}	0.22^{a}	7.02^{c}	5.29^{b}	5.92^{b}
OF	2.19^{a}	3.74^{a}	0.15^{d}	14.46^{a}	5.25^{b}	8.55^{ab}
FL	2.09^{a}	3.58^{a}	0.19^{b}	10.86^{b}	5.75^{a}	7.61^{ab}
SF	1.75^{b}	3.05^{b}	0.17^{c}	10.37^{b}	5.35^{ab}	10.45^{a}

Means within a column (for each treatment factor) not sharing a lowercased italic letter differ significantly at the p < 0.05 level.

Impacts of Agricultural management practices on soil chemical properties at 15-30 cm soil depth

The Data on impacts of different agricultural management on few soils' physical properties at 15-30 cm soil depth is presented on (Table 5). Management practices also had significant effects P ≤ 0.05 on Organic carbon and soil pH at 15-30 cm soil depth. Unlike the results reported for 0-15 cm soil depth, SF had the highest organic carbon (1.77 %), followed by OF (1.53 %) and FL (1.22 %) had the least value. The FL had the highest soil pH (6.13) that fall within the range that can support the growth of most arable crops (Uponi & Adeoye, 2000), OF had the least value (4.87) (Table 5). FL had the highest C: N (14.46) and statistically different from other plots IF and OF. The order of increase was almost similar with what was observed at the top soil; FL > SF > OF > IF. Soil nitrogen mineralization is often shown by the soil C:N ratio, Shittu et al. 2022. The implication of this is that, IF will have higher soil nitrogen mineralization than FL and OF but lesser carbon sequestration to combat climate change. CEC ranged between 8.21 and 4.35 cmol/kg. with highest value recorded for secondary forest, the CEC is generally low and fall below the critical value of 15 cmol/kg reported by Adepetu, 1990.

Table 5: Effects of Agricultural management on selected soil chemical properties at 15-30 cm soil depth

Treatment	**Organic carbon %**	**Total Nitrogen %**	**C:N**	**pH**	**CEC** cmol/kg
IF	1.59^{b}	0.18^{a}	8.93^{b}	5.45^{b}	4.35^{c}
OF	1.53^{b}	0.17^{a}	9.08^{b}	4.87^{c}	7.81^{a}
FL	1.22^{c}	0.08^{b}	14.60^{a}	6.13^{a}	5.56^{b}
SF	1.77^{a}	0.18^{a}	9.73^{b}	5.40^{b}	8.21^{a}

Means within a column (for each treatment factor) not sharing a lowercased italic letter differ significantly at the p < 0.05 level.

Conclusions

Understanding the variation in soil properties Vis-a-Vis management practices is essential in managing our valuable environment and sustainable crop productivity. The study's findings allowed for the conclusion that different agricultural management practices, had substantial effects on soil health. The research has affirmed that agricultural management practices influence soil quality indicators in various ways. The finding also showed that application of synthetic fertilizer as one of the agricultural management practices for long time had negative effects on the selected soil quality indicators compare to addition of manure (OF) and FL. From the data gotten from the study, IF had decreased in water infiltration rates relative to OF and and FL respectively at topsoil FL, C:N is lower in IF. Aggregate stability in OF and FL are higher than IF by 24.18 and 26.52 % (P < 0.05) respectively. OF and FL land had higher hydraulic conductivity and significantly different from IF by 73.83 and 75.83% respectively. For sustained productivity and soil restoration, the long-term advantages of OF and FL that shield delicate soils from erosion (because of increased aggregate stability and conductivity) and organic matter sources area good investment. It is recommended that farmers should be educated on best management practices for sustainable crop production and soil health.

Conflict of Interest Statement

The author declares no conflicts of interest.

References

Abiven, S., Menasseri, S., & Chenu, C. (2009). The effects of organic inputs over time on soil aggregate stability–A literature analysis. *Soil Biology and Biochemistry*, *41*(1), 1-12.

Adepetu, J.A (1990). Soil-test data interpretation in soil testing programme. Paper presented at workshop on soil testing service for efficient fertilizer use in Nigeria. Moor Plantation, Ibadan.

Akinbile, C.O., Eze, R.C., Yusuf, H., Ewulo, B.S. & Olayanju, A. (2019). Effect of some selected soil properties, moisture content, yield and consumptive water use on two cassava (TMS 0581 and TME 419) varieties. *Journal of Agricultural Engineering,* 919:166-172. doi:10.4081/jae.2019.919

Akinbile, C. O. (2020). Crop water requirements, biomass and grain yields estimation for upland rice using CROPWAT, AQUACROP and CERES simulation models. *Agricultural Engineering International: CIGR Journal*, *22*(2), 1-20.

An, S.S., Huang, Y.M., Zheng, F.L. & Yang, J.G. (2008). Aggregate characteristics during natural revegetation on the Loess Plateau. *Pedosphere* 18, 809–816

Arshad, M. A., Lowery, B., & Grossman, B. (1997). Physical tests for monitoring soil quality. *Methods for assessing soil quality*, *49*, 123-141.

Ashagrie, Y., Zech, W., Guggenberger, G., & Mamo, T. (2007). Soil aggregation, and total and particulate organic matter following conversion of native forests to continuous cultivation in Ethiopia. *Soil and Tillage Research*, *94*(1), 101-108.

Blanco-Canqui, H., & Wortmann, C. S. (2020). Does occasional tillage undo the ecosystem services gained with no-till? A review. *Soil and Tillage Research*, *198*, 104534.

Blake, G. R., & Hartge, K. H. (1986). Bulk density. *Methods of soil analysis: Part 1 Physical and mineralogical methods*, *5*, 363-375.

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analyses of soils *Agronomy journal*, *54*(5), 464-465.

Bremner, J. M, & Mulvaney, C. S. (1982). Total Nitrogen. In: Page AL, Miller RH, Keeney DR (eds) Methods of Soil Analysis. II. Chemical and Microbiological Properties. American Society of Agronomy, *Soil Science Society of America*, pp 595–624

Celik, I., & Ersahin, S. (2011). Evaluation of tillage influence on infiltration characteristics in a clay soil. J. *Food Agric. Environ*., 9, 653–658.

Chapman, H. D. (1965). Cation-exchange capacity. *Methods of soil analysis: Part 2 Chemical and microbiological properties*, *9*, 891-901.

Gaţe, O. P., Czyż, E. A., & Dexter, A. R. (2004). Effects of readily-dispersible clay on soil quality and root growth. *Plant Growth in Relation to Soil Physical Conditions (Eds. J. Lipiec, R. Walczak, G. Józefaciuk)*, 48-56.

Hajabbasi, M. A., Basalatpour, A., & Maleki, A. R. (2007). Effect of shifting rangeland to farmland on some physical and chemical properties of south and southwest soils of Isfahan. *Journal of Scince Technology of Agriculture Natural Resource*, *11*(42), 525-534.

Jabro, J. D., Iversen, W. M., Stevens, W. B., Evans, R. G., Mikha, M. M., & Allen, B. L. (2015). Effect of three tillage depths on sugarbeet response and soil penetrability resistance. *Agronomy Journal*, *107*(4), 1481-1488.

Kahlon, M. S., Fausey, N., & Lal, R. (2012). Effects of long-term tillage on soil moisture dynamics and hydraulic properties. *Journal of Research*, *49*(4), 242-251.

Negassa, W. (2001). Assessment of important physicochemical properties of Nitosols under different management systems in bako area, western Ethiopia. *An MSc thesis Presented to School of Graduate Studies of Haramaya University, Ethiopia*.

Olson, R. E. (1962). The Shear Strength Properties of Calcium-illite for Field Use. J. Terr mechanics 25:287-293.

Ouyang, L., Wang, F., Tang, J., Yu, L., & Zhang, R. (2013). Effects of biochar amendment on soil aggregates and hydraulic properties. *Journal of soil science and plant nutrition*, *13*(4), 991-1002.

Osanyinpeju, K. L., & Dada, P. O. (2018). Soil porosity and water infiltration as influenced by tillage practices on federal university of agriculture Abeokuta, ogun state, Nigeria soil. *Int. J. Latest Technol. Eng. Manag. Appl. Sci*, *7*, 2278-2540.

Philip, J. R. (1957). The theory of infiltration. *Soil Sci*, *84*, 329-339.

Reynolds, W. D., Elick, D. E., Youngs, E. G., Amoozegar, A. and Bootink, N. W. (2002). Saturated and Field-saturated Water Flow Parameters,in Dane, J. H., Topp, G. C. (eds.): Methods of Soil Analysis, Part 4. 797 – 878

Ray, D. K., Mueller, N. D., West, P. C., & Foley, J. A. (2013). Yield trends are insufficient to double global crop production by 2050. *PloS one*, *8*(6), e66428.

Reicosky, D. C., & Forcella, F. (1998). Cover crop and soil quality interactions in agroecosystems. *Journal of Soil and Water Conservation*, *53*(3), 224-229.

Sobulo, R. A., & Adepetu, J. A. (1987). Soil testing and fertilizer formulation for crop production in Nigeria. *Towards Efficient Fertilizer Use and Development in Nigeria*.

SAS, Institute Inc., (2011). The SAS System for Windows, Release 9.2. Statistical Analysis Systems Institute, Cary, NC, USA

Sahlemedhin, S., & Taye, B. (2000). Procedure for soil and plant analysis. National soil research centre, Ethiopian agricultural research organization, Addis Ababa, Ethiopia. *Science Society of America Journal*, *70*, 287.

Schwartz, R. C., Baumhardt, R. L., & Evett, S. R. (2010). Tillage effects on soil water redistribution and bare soil evaporation throughout a season. *Soil and Tillage Research*, *110*(2), 221-229.

Shittu, K. A., Oyedele D. J. & Babatunde, K. M. (2017). The effects of moisture content at tillage on soil strength in maize production, *Egyptian Journal of Basic and Applied Sciences*, 4: 139-142

Shittu, A. K., Nwoke, O. C., Ojeokun, C. O., Akinpelu, M. O., Adisa, K. F., & Afolabi, M. S. (2022). Effects of contrasting agricultural land-use systems on selected soil properties in South-West Nigeria. *Tanzania Journal of Agricultural Sciences*, *21*(2), 204-213.

Shittu, K. A., Adeboye, O. B., Oyedele, D. J., Lamidi, W. A., Babatunde, M. K., & Mosobalaje, A. S. M. (2023). Impact of tillage practices on properties of soil, evapotranspiration and productivity of cowpea in Nigeria. *Tropical and Subtropical Agroecosystems*, *26*(1).

Soumare, A., Diedhiou, A. G., Thuita, M., Hafidi, M., Ouhdouch, Y., Gopalakrishnan, S., & Kouisni, L. (2020). Exploiting biological nitrogen fixation: a route towards a sustainable agriculture. *Plants*, *9*(8), 1011.

Uponi, J. I. & Adeoye, G. O. (2000). Soil Testing and Plant Analysis: Overview, pp177

Walkley, A., & Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, *37*(1), 29-38.

Wang, Y., Xie, Z., Malhi, S. S., Vera, C. L., Zhang, Y., & Wang, J. (2009). Effects of rainfall harvesting and mulching technologies on water use efficiency and crop yield in the semi-arid Loess Plateau, China. *Agricultural water management*, *96*(3), 374-382.

Wittwer, R. A., & van der Heijden, M. G. (2020). Cover crops as a tool to reduce reliance on intensive tillage and nitrogen fertilization in conventional arable cropping systems. *Field Crops Research*, *249*, 107736.

Woldeamlak, B. (2003). Towards Integrated Watershed Management in Highland Ethiopia: the Chemoga watershed case study. *Tropical Resource Management*, Papers 44, Wageningen University