East African Scholars Journal of Agriculture and Life Sciences
Abbreviated Key Title: East African Scholars J Agri Life Sci
ISSN 2617-4472 (Print) | ISSN 2617-7277 (Online) |
Published By East African Scholars Publisher, Kenya

OPEN ACCESS

Volume-2 | Issue-8 | Aug-2019 |

Research Article

Comparison between the Bulk Density of Fallowed and Continuously Cultivated Lands: A Case Study of Kogi State University Research Farm

Aina, O.A[1], Agboola, K[1], Owoeye, M[1] and Ayodele, F.G[2]
[1]Faculty of Agriculture Department of soil and Environmental Management, Kogi State University Anyigba Nigeria
[2]College of Agriculture (A.B.U) Kabba

*Corresponding Author
Aina, O.A

Abstract: This study investigated the influence of the two land use types namely fallowed and continuously cultivated, on the bulk density, soil quality and soil degradation. Bulk density was determined using core method for both fallowed and continuously cultivated lands at two soil depths (0-10cm and 10-20cm) with bulk samples collected at five locations each from the two land use types. Bulk density of continuously cultivated land was higher than that of fallowed land with an average of 1.59g/cm^3 and 1.41g/cm^3 for continuously cultivated land and fallowed land respectively. Bulk density increases with increasing soil depth for the two land use types with an average of 1.37g/cm^3 for 0-10cm depth and 1.44g/cm^3 for 10-20cm depth (for fallowed land). And 1.56g/cm^3 for 0-10cm depth and 1.61g/cm^3 for 10-20cm depth (for continuously cultivated land***).***
Keywords: Bulk density, soil aeration, land use types, agricultural production, crop growth.

INTRODUCTION

In agricultural term, the bulk density of the soil can be used to give an indication of the porosity and structure of the soil which will govern oxygen (O_2) and water (H_2O) movement in the soil. It is also a measure of the degree of compaction of the soil. One of the most important factor agriculturally in terms of bulk density is plant growth.Bulk density is a measure of a soil mass per unit volume of soil. It is measured in gram per cubic centimetre (g/cm^3). It can be used to calculate soil wetness (volumetric water content) and porosity. Factors that influence the measurement include organic matter content, the porosity of the soil and the soil structure (Grossman and Reinsch, 2002). A soil that has a well-developed structure will become less dense, increase in porosity results in decreased bulk density. Soils which show massive structure and less porosity will show higher bulk densities. Decrease in organic matter content results in increased bulk density. This explains why bulk densities of soils increase with soil depth since organic matter of soil decreases with soil depth. If the soil has a high bulk density (compaction), the seed will be restricted in emergence and root growth which will affect the total plant growth and yield. The use of tractors will directly affect the soil bulk density causing extreme compaction especially if the soil is wet. Apart from root growth restriction, high bulk density can also lead to reduced infiltration rate which may result in generation of run-off, reduction in aeration, poor drainage etc.

However, effect of soil compaction need not be negative it depends on the type of soil, the amount of humus in the soil and regenerative power of the soil as to whether the soil is able to eliminate compaction and recover. It was discovered that a certain level of soil compaction is not always detrimental, it can have positive effects. It helps retain higher content of soil water for a longer period, which is of vital importance especially in lower precipitation areas (Badalikova and Hruby, 1998). Also, slightly compacted soils can speed up the rate of seed germination because it promotes good contact between the seed and soil. The major ways of determining the bulk density of the soil are:- core method, clod method, excavation method and radiation method.The choice of the method to be used depends on the physical nature of the soil. For example, the core method is not suitable for soil with abundance of stones and very loose soils but the excavation method could be used for such soils. For this research work, the core

Quick Response Code

Journal homepage:
http://www.easpublisher.com/easjals/

Article History
Received: 15.07.2019
Accepted: 25.08.2019
Published: 29.08.2019

DOI: 10.36349/easjals.2019.v02i08.002

method will be used because of the availability of the apparatus needed and the suitability of the method with respect to the physical characteristics of the research area.

THE CORE METHOD

In this method, a core sampler (usually a metal cylinder open at both ends, sharpened at one end, usually 5cm in diameter and 5cm in height) is used. The sharpened end is pressed into the soil to obtain an undisturbed sample whose volume is the same as the internal volume of the metal cylinder. The sample would then be dried in an oven and the oven dry weight of the sample is determined. The bulk density of the sample is then calculated using the equation. Bulk density (e_b) = mass of oven dry soil (g)/volume of the soil (cm^3).

This study is important because it enables us to calculate the related soil moisture content and the porosity of the soil. It also helps us to understand the concept of soil-plant-water relationship. The objectives of this project work were to enable us give a proper definition and qualitative importance of bulk density as an indicator of soil quality, to enable us properly compare the bulk density of fallowed and continuously cultivated lands so as to know the importance of fallow period in bulk density and soil quality improvement and to examine the effect of land use type on the soil physical and chemical characteristics.

MATERIALS AND METHODS

Soil sample were taken from the demonstration and research farm of the Faculty of Agriculture, Kogi State University, Anyigba. Anyigba is located between latitudes 7^0 15' and 7^0 29'N of the equator and longitude 7^0 11' and 7^0 32'E of the Greenwich Meridian (Ifatimehin *etal.*, 2009) which is situated in the southern Guinea savannah agroecological zone of Nigeria. The average annual temperature of Anyigba is 27^0 C with an average annual rainfall of about 1260mm. Anyigba has a high relative humidity between the range of 60% to 65% and a mean relative humidity of 60.5% per annum (KSARDA, 1996).

Samples Collection

Samples were collected with core samples from both fallow and continuously cultivated lands on the University research farm. Sampleswere collected from depth of 0-10cm and 10-20cm from each of the fallow and continuously cultivated lands and taken to the laboratory forbulk density determination.Soil samples analyzed for physicochemical properties were collected using the soil auger from the two land use types and also from depths of 0-10cm and 10-20cm.

Bulk density determination (The core method).

Apparatus

- Core sampler which is used to sample the soil
- Knife or spatula to trim the soil on the sampler.
- Hammer used in driving the core sampler into the ground.
- Measuring scale.
- Oven used for drying the soil samples.

Procedure

- The core samplers were weighed empty.
- The diameter (d) and the height (h) of the core sampler were determined.
- -Hammer was used to press the sharpened end of the samplers into the soil to obtain anundisturbed soil samples
- The samplers were gently withdrawn from the ground ensuring that core samplers were filled with soil samples
- Knife was used to trim the soils extending beyond the edges of the inner cylinder.
- The soil samples were brought to the laboratory and dried in an oven (at105^{0}C) to a constant weight based on the procedure of gravimetric moisture content method.
- The core samplers plus the oven dry soils were weighed. The weights of the oven dry soils were obtained by subtracting the weights of the samplers from the weights of the samplers plus oven dry soils.
- The volume of the inner cylinder was calculated using the formula.

$$V=\pi r^2 h$$

Where,

V = volume of the cylinder.
h = height of the cylinder
r = radius
But r = d/2

Where, d =diameter of the core sampler
Therefore, bulk density (e_b) equals

$$\frac{\text{Mass of oven dry soil (g)}}{\text{Volume of the soil (cm}^3\text{)}}$$

$$e_b = \frac{X_1 - X_2}{\pi r^2 h}$$

Where,

X_1 = mass of the dry soil+ cylinder.
X_2 = mass of the empty cylinder

It should be noted that the volume of the soil is equivalent to the volume of the cylinder.

Laboratory analysis

Soil samples were air-dried, ground and sieved through a 2 mm Sieve. Materials that are larger than 2 mm in diameter were then set aside while the samples that passed through the 2 mm sieve were used for the physical and chemical analysis as outlined below.

Particle size distribution

The particle size distribution was determined by hydrometer method (Gee and Or, 2002). The textural class of the soil was determined using the textural triangle.

pHdetermination

Soil pH was determine using 1:2.5 soil liquid (water) ratio (Thomas, 1996)

Organic carbon

Organic carbon was determined using dichromate wet digestion method (Nelson and Sommers, 1996). The value obtained for organic carbon was then multiplied by a constant 1.724 to obtain the value of the organic matter content of the samples.

Available phosphorus

Available phosphorus was determined using Bray-2 extractant method (Olsen and Sommers, 1982).

Exchangeable bases

Exchangeable bases (Ca, Mg, K and Na) were extracted in NH_4-OAC buffered at pH 7.0 (Thomas,1982). The Ca and Mg were determined using Atomic Absorption Spectrophotometer and K and Na were estimated using FlamePhotometer.

Exchangeable acidity (Al^{3+}, H^+)

These were extracted with concentrated KCl (Thomas, 1982) and determined by titration with 0.05M NaOH using phenolphthalein as an indicator.

Effective cation exchangeable capacity (ECEC)

The summation method was used to determine the ECEC (Carter, 1993). This was obtained by summing total exchangeable bases (Mg, Ca, K, Na) and the total exchangeable acidity (H, Al). ECEC=TEB+TEA.

Percentage base saturation

This was calculated by multiplying the quotient of TEB to ECEC by 100

$$\%\text{exchangeable} \; \frac{Ca + Mg + K + Na}{ECEC} \times \frac{100}{1}$$

Total nitrogen

This was determined using Macrokjeldahl digestion method (Bremner and Mulvaney, 1982).

RESULTS AND DISCUSSION

Soil physical and chemical properties

The average of results of soil physical and chemical properties in the 0-10 cm and 10-20 cm depths of both fallowed and continuously cultivated lands are given in Table 1.

TABLE 1: Average of the Results of the Chysical/Chemical Properties of both Fallowed and Continuously Cultivated Lands

S/N	Site Description	Depth (cm)	Particle Size Distribution			pH	Organic Matter (%)	Total Nitrogen (%)	Available Phosphorus (ppm)	CEC (Cmol/kg)	EA	%BS	ECEC
			% Sand	% Silt	% Clay								
1	Fallowed land	0 – 10	89.52	0.78	9.7	5.95	1.035	0.03	6.92	7.12	1.06	87.04	8.18
		10 – 20	86.02	2.78	11.2	6.4	0.89	0.025	5.92	7.12	1.01	87.62	8.13
2	Continuously cultivated land												
		0 – 10	88.10	2.78	9.12	5.8	0.72	0.02	7.49	7.19	0.99	87.89	8.18
		10 – 20	87.02	2.28	10.7	6.00	0.53	0.015	7.48	6.65	0.865	87.45	7.52

Particle Size Distribution

The results from Table 1 show that the percentage of sand in both continuously cultivated land and fallowed land is very high. The sand fraction of both soils decreases slightly with depth (with an average value from 88.1% to 87.02% and 89.52% to 86.02%) for continuously cultivated land and fallowed land respectively. While the clay fraction increases slightly with depth (with an average value from 9.12% to 10.7% and 9.7% to 11.2%) for continuously cultivated land and fallowed land respectively.The texture of the soils ranged from sand, loamy sand to sandy loam. The soil texture reflected the nature of the parent material from which the soils were developed and the drainage pattern of the area. Sandiness of the soils suggests low CEC (Cation Exchange Capacity), high infiltration rate and observable low moisture content of the soils. It also encourages rapid leaching of nutrients from the soils beyond the rooting zones of crops. The coarse nature of soils of the studied area can encourage soil erodibility on exposure to high rainfall through reduced fallow period leading to soil degradation.The low clay content of the surface horizons could be due to sorting of soil materials by biological and/or agricultural activities, clay migration or surface erosion by runoff or combination of these (Malgwi *etal*.,2000). Chikezie *etal (*2009) and Idoga and Azagaku, (2005) reviewed that increase in clay content of soils with depth may be the consequence of eluviation- illuviation processes as well as contributions of the underlying geology through weathering.

Organic matter

Organic matter content of the fallowed land was slightly higher than that of continuously cultivated land. Organic matter content of fallowed land ranged from 0.81% to 1.05% while that of continuously cultivated land ranges from 0.43% to 0.81%.. This is in agreement with the report of Akamigbo (1999). The low organic matter content in continuously cultivated land may be due to the intensive land use without fallow or crop rotation, annual bush burning which prevents organic matter accumulation on the soil surface, removal of plant materials for various uses, among other factors. The higher organic content in fallowed land may be due to the fact that soils under this land use system are always covered with vegetation and had not been subjected to intense degradation.From the result of the soil analysis, it can also be seen that organic matter content of the two land use systems considered decreases with depth. Higher organic matter content were recorded in surface soils (0-10 cm) than in the depth of 10-20 cm. This may be due to the fact that most of the organic residues in both continuously cultivated and fallowed lands and even virgin soils are deposited on the surface.

Available phosphorus

Available phosphorus was generally low in the two land use systems, an average of 6.42 mg/kg for fallowed land and 6.88 mg/kg for continuously cultivated land. The slight higher value of available phosphorus in continuously cultivated land may be as a result of the frequent use of phosphorus fertilizer on the soil.

Cation Exchange Capacity (CEC)

The CEC of the experimental sites are generally low to moderate with an average of 6.92 Cmol/kg and 7.12 Cmol/kg for continuously cultivated land and fallowed land respectively. This may be due to the sandiness of the soils and the low organic matter contents of the soils. The CEC of the soils are dominated by Ca^{2+},Mg^{2+} andK^{+} with Ca and Mg having values above the critical levels of 2.00 Cmol/kg and 1.2 Cmol/kg respectively. The slight higher average CEC value of fallowed land may be as a result of higher organic matter content compared to continuously cultivated land since organic matter is the major exchange site for the basic cations in most low activity clay of the tropical soils.

Total Nitrogen

The total nitrogen content in both fallowed and continuously cultivated lands are generally low, ranging from 0.01% to 0.03%. Total nitrogen content is slightly higher in fallowed land than in continuously cultivated land. The higher level in fallowed land may be attributed to higher organic matter content and soil cover that prevents soil erosion. The lower total nitrogen content recorded in continuously cultivated land may be attributed to the intense cultivation of the soils which normally increase the rate of mineralization of organic matter (Senjobi and Ogunkunle, 2011).The general low total nitrogen level of the experimental sites can also be as a result of sandiness of the sites which is associated with leaching loss of nutrients. Organic carbon was also generally low in both fallowed and continuously cultivated lands and slightly higher in fallowed land than in continuously cultivated land.

Bulk Density of Experimental Sites

In the study conducted, the bulk density of the experimental sites which include both fallowed and continuously cultivated lands at different depths varies from one depth to another. The bulk densities ranged from 1.33 g/cm^3 to 1.65 g/cm^3 on the sites. As seen in Tables 2, and 3, the bulk density of continuously cultivated land is higher than that of fallowed land. This may be a reflection of frequent cultivation of land that results in soil compaction and low granulation of soil. This degradative process results in depletion of soil organic matter, thus weakening soil structure. The frequent use of agricultural implements, machineries and intensive ploughing of the continuously cultivated lands also degrade soil particles, making them more compacted. The vegetation cover of the fallowed land reduces natural soil erosion rates, thereby slowing down the rate of mineral surface soil removal. As a result, soils under fallow are richer in organic matter and hence lower bulk densities.Also from Tables 2 and 3, it can be seen that bulk densities of the two land use types increases with depth. At a depth of 0 – 10 cm, the average bulk density is 1.37 g/cm^3 and 1.44 g/cm^3 at a depth of 10 – 20 cm for fallowed land. For continuously cultivated land, the average bulk density at depth 0 – 10 cm is 1.56 g/cm^3 while it is 1.61 g/cm^3 at depth 10-20 cm. This agrees with the report of Onweremadu *et al* (2009).

TABLE 2: Bulk densities (g/cm^3) of top and subsoil of fallowed land

S/N		Bulk Density (g/cm^3) Depth = 0.10cm	Bulk Density (g/cm^3) Depth = 10-20cm
1		1.38	1.51
2		1.39	1.43
3		1.33	1.39
4		1.40	1.44
5		1.36	1.42
	Mean	1.37	1.44
	S	0.03	0.04
	CV (%)	2.03	3.09

S = Standard deviation, CV=Coefficient of variation.

TABLE 3: Bulk densities (g/cm^3) of top and subsoil of continuously cultivated land

S/N		Bulk Density (g/cm^3) Depth = 0.10cm	Bulk Density (g/cm^3) Depth = 10-20cm
1		1.54	1.64
2		1.52	1.65
3		1.56	1.59
4		1.57	1.57
5		1.61	1.62
	Mean	1.56	1.61
	S	0.03	0.05
	CV (%)	2.18	3.71

S = Standard deviation, CV=Coefficient of variation

The higher bulk density in subsoil may be a reflection of lower organic matter content and less aggregation. Since tractors are used for farm operations in the experimental sites, the higher bulk density recorded in continuously cultivated land and in the sub-surface layer may be due to surface and sub-surface compaction caused by the weight of the tractor and the wheel traffic it creates which causes severe compaction.The standard deviation for soil bulk densities of the fallowed land is 0.03 and the coefficient off variation (CV) is 2.03% for depth of 0-10 cm and the standard deviation and coefficient of variation for the depth of 10 – 20 cm are 0.04 and 3.09% respectively. For cultivated land, the standard deviation and coefficient of variation for the depth 0 – 10 cm are 0.03 and 2.18% respectively while the standard deviation and coefficient of variation for the depth of 10-20 cm are 0.05 and 3.71% respectively.

It is however worthy of note that the bulk densities of the experimental sites (both the fallowed land and continuously cultivated land) were less than the critical limits for root restriction (1.75 – 1.85 g/cm^3) reported by soil survey staff in 1996. But management practices that will reduce the bulk density of the sites (especially the continuously cultivated land) and prevent it from rising to the critical limits for root restriction should be embarked upon in order to sustain the productivity of the land.

AND RECOMMENDATIONS

Continuous cultivation of land led to changes in soil properties. The decline of these qualities is attributed to intensive cultivation of crops, use of inorganic fertilizers, poor water and soil conservation measures employed by the farmers e.t.c. Land management practices such as fallowing, conservative tillage and agro-forestry practices that boost soil quality should be up-scaled to cover wider area to promote sustainability of soil productivity. Farming without adequate conservation measures should be discouraged.Organic matter is obviously one of the most (if not the most) important parameter in judging soil quality. It is also the major exchange site for the basic cations in tropical soils. In view of these, steps should be taken to increase the organic matter content of the soil, so as to improve soil quality and reduce soil degradation. This can be achieved through appropriate land use type and use of organic residues to conserve, maintain favorable soil temperature and encourage biological activities of soil organisms.The sandy nature of the soils of the experimental sites calls for split-application of nitrogen fertilizers to avoid leaching loss.

Based on the report of Michael (1978) that bulk density within the range of 1.0g/cm^3 to 1.6g/cm^3 is required for agricultural production, the experimental sites can be said to be good for agricultural production. However, the slight higher bulk density values in continuously cultivated land suggest the need to allow the farm land to fallow for some years so as to reduce its bulk density and improve its productivity.

REFERENCES

1. Akamigbo, F.O.R. (1999). Influence of land use on soil properties of the humid tropical agro-ecology of southern Nigeria. Niger Agric J.30:59-76.
2. Badalikova, B., & Hruby, J. (1998). Physical soil properties at different systems of sugar beet cultivation in:proc: soil cultivation and crop production Godollo; Hungary pp 83-85.
3. Bremner, J. M., & Mulvaney, C. S. (1982). Total Nitrogen In: Methods of soil analysis, Part 2. A. L page R.H. Mille and Dr. Kecney (eds). American Society of Agronomy Madison, W1 pp 595 – 624.
4. Carter, M.R. (1993). Soil Sampling and Methods of Analysis. Lews Publishers, London pp.23.
5. Chikezie, A., Eswaran, H., Asawalam, D.O., & Ano, A. O. (2009). Characterization of the benchmark soils of contrasting parent materials in Abia State, Southeastern Nigeria. Global Jorunal of pure and applied sciences. 16(1), 23 – 29.
6. Gee, G.W., & Or, (2002). Particle size analysis. In:J.H Dane and G.C Topp(eds). Methods of soil analysis, Part 4. Physical methods soil science society of America. No.5, ASA and SSA Madison W1, PP:255-293.
7. Grossman, R.B., & Reinch, T.G. (2002). Bulk density and linear extensibility in: Methods of soil analysis part 4. Physical methods. Dane, J.H and G. C Topp (eds) Soil Science Society of America No. 5 ASA and SSA Madison, W1, pp:201-228.
8. Idoga, S., & Azagaku, D.E. (2005). Characterization and Classification of soils of Janta area, Plateau State of Nigeria. Journal of Soil Science 15, 116-122.

9. Ifatimelehin, O.O., Musa, S.D., & Adeyemi, J.O. (2009). An analysis of the changing land use and its impact on the environment of Anyigba. Journal of sustainable development in Africa. 10(4), 357-364.
10. Kogi State Agricultural and Rural Development Agency-KSARDA (1996).
11. Malgwi, W.B., Ojanuga, A.G., Chude, D.O., Kparmwag, T., & Raji, B.A. (2000). Morphological and Physical properties of some soils Research. 1, 58-64.
12. Michael, A.M. (1978). Irrigation Theory and Practice. Vikes Publishing house put Ltd.
13. Nelson, D.W., & Sommers, L.E. (1996). Total Carbon, Organic Carbon and Organic matter, In: method of soil analysis Part 3. Chemical methods. Soil science society of America. Book series.
14. Olsen, R.S., & Sommer, L.E. (1982). Phosphorus in: Methris of soil analysis Part 2 (ed. Page, A.L, Miller, R.H and Keeney, D.R). American Society of Agronomy. Madison, Wisconsin pp 15 – 72.
15. Onweramadu, E. U., Ndukwu, B.N., & Ohiri, K.U. (2009). Variability in particle size distribution of soils as affected by crude oil spillage Int. J. soil science 1(1), 104 – 109.
16. Senjobi, B. A., & Ogunkunle, A.O. (2011). Effect of different land use types and their implications on land degradation and production in Ogun state, Nigeria. Journal of Agric. Biotech and Sustainable Development 3(1) 7 – 18.
17. Thomas, G.W. (1982). Cation in A.L page, R.H. Miller and D.R. Keeney (eds) method of Soil Analysis part 2. 2nd Edition. Am., Soc of Agronomy. Madison pp157-164.
18. Thomas, G.W. (1996). Soil pH and soil Acidity. In: Methods of soil Analysis, part 3, chemical methods. L.D. Sparks (Ed). SSA Book Series No. %