

EFFECT OF RICE HUSK ON BULK DENSITY OF SOIL IN MAUTECH AGRICULTURAL FARM, YOLA, NIGERIA

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Abstract

Soil compaction may occur naturally or as a result of working on wet soil, excessive tillage, excessive rainfall and poor drainage causing reduction in infiltration, aeration, crop root growth and consequently crop yield. Determination of the effect of rice husk on bulk density of compacted soils was studied under laboratory condition. Two sets of soils and Rice Husk mixture at 0 and 2000 g level were compacted from 0, 15, 20 and 25 compaction blows. The results show that bulk density of soils decreased with increased rice husk content even when soil depth and compaction increased. The bulk density at zero compaction was found to increase from 0.681 g/cm³ to 0.704 g/cm³ while bulk density at compaction increased from 1.126 g/cm³ to 1.214g/cm³. When rice husk was incorporated to the soil, the Bulk Density decreased from 1.065g/cm³ to 1.006g/cm³ which resulted in high rate of infiltration, aeration, root growth and increase the crop growth, production and higher yield. Statistically, using ANOVA, there was no significant differences between the bulk density of the soil in the study area

Key words: Rice Husk, Bulk Density, Farm, Soil, Compaction, Yola.

1.0 Introduction

Soil is composed of four major components: minerals, organic matter, water and air. The fractions of water and air are contained in the voids between soil particles [1]. Soil compaction is defined as the densification of unsaturated soil due to reduction in air volume without change in mass wetness [2]. During most agricultural practices, mechanized cultivation disturbs the soil, causing fragmentation, compaction and displacement. The intensity of compaction can readily be interpreted with high bulk density of a specific soil type [3]. The effect of changes of structure following tractor wheel passage during cultivation practices on agricultural soils may increase bulk density and soil strength, while reducing aeration and water movement in the root zone. If soil is compacted to the level that plant growth is impaired the compaction must be alleviated to return satisfactory growth condition. One of these measures is the incorporation of organic matter into the soil [4]. Physical properties of soil such as size, shape, texture and structure influence the behavior of soil with regard to plant growth, where the nature and properties of individual particles, their sizes distribution and the arrangement in soil determine the total volume of pore space, as well as the pore sizes, there by impacting on water and air relationships[5].

Rice husk has been shown to be useful as a soil amendment in agriculture. Rice husk is valuable for its roles in increasing soil fertility, through improving soil characteristics by its addition of organic matter to the soil [6, 7] showed that application of rice husk increased total porosity and saturated hydraulic conductivity and mean weight diameter of water stable aggregates significantly by 41.1%, 368.2%, and 155.8%, respectively. The physical properties of soil influence nearly all other soil properties and uses [5]. When Rice Husk is used as incorporated into the soil, it maintains stable soil structure, increase soil fertility and produce crops sustainability [8].

1.1 Soil Bulk Density

Soil bulk density is defined as the ratio of oven-dried mass weight to its bulk volume which depends on the soil particles densities such as sand, silt, clay and organic matter and their packing arrangement. Thus, soil bulk density values are required for converting gravimetric soil water content to volumetric and to calculate soil porosity which is the amount of pore space in the soil [4]. Soil bulk density is a basic soil property influenced by some soil physical and chemical properties [9]. Bulk density is a dynamic property that varies with the structural condition of the soil. This condition can be altered by cultivation, trampling by animals, agricultural machinery, weather, i.e. raindrop impact [10].

Density of soil, which is affected by the mass and volume, depends on the amount of air space in the soil and the type of soil texture. Soil density is also affected by compaction [11]. Increasing the density of soil or compacting the soil appears to have the effect of retarding biodegradation of the organic material by restricting the access of water to the soil [12].

Soil also has different bulk densities depending on their particles sizes which indicate the capability of some soil to withstand some loads due to difference in soil densities which differs in compressibility or compaction level [5]. The soil textures with different bulk densities varies in their particle sizes, and the soil unit weight is essentially determined by the density of the soil aggregate (ordinarily two-third of the total volume) and the amount of air in the mass of the soil [13]. Soil bulk density which is the ratio of the volume of pores (voids) to the total (bulk) volume of a soil [14].

[15] reported that bulk density, an important parameter related to root development was found to decrease, when organic materials were incorporated into the soil, the water holding capacity of the soil increase with the incorporation of organic matter, especially the slower decomposing rice husk. However, the beneficial impact of organic matter in moisture retention declined with time, possibly due to the decomposition of the material in the warm climate of the dry season (mean temperature 32°C) [16].

The importance of mechanizing agriculture, specifically the application of machines in crop production cannot be over emphasized. However, [17] reported that despite the fact that machines offer a considerable contribution to crop production, they present a great damage to the soil structure. The effect of traffic on the soil has been shown to increase bulk density, increase shear strength, reduce porosity, air and water permeability. These damages or problems are caused as a result of compaction of the soil by the trafficking implements or machines. Massive over compaction of soil layers or zones may occur at any depth in the top soil [3]. In addition, [2] observed that soil compaction affects plant growth by causing increased resistance to root, low water use efficiency and loses of nitrogen due to denitrification. Soil compaction typically results in reduced amount and size of pore space and total soil volume, which in turn lead to decreased infiltration capacity and increased surface runoff, standing water, and erosion. Also, [6] stated that this loss of pore space not only restricts movements of air, but create greater resistance to roots and those that penetrate are confirmed to fissure between structures with less clods. These changes represent site degradation and may have a detrimental effect on vegetation and soil resources [5].

Tillage operation is one of the major problems facing modern agriculture and slow speed and tire slippage, excessive rainfall and poor drainage, working on wet soil and low organic matter lead to soil compaction. Modern day farm machinery induced compaction to the soil due to their movement on the field by traction, which is the heavy weight of the machine and the operation cause by the movement of the machine within the field.

Compaction of agricultural soil is thus an escalating problem because compacted soil reduces the rate of root penetration, intake rate (infiltration) to the soil root zone for plant use and aeration which results to poor yield. Hence, determination of the effect of rice husk on bulk density of soil in MAUTECH Agricultural farm will be important in order to reduce soil compaction to enhance optimum use of water, low operational cost and improve crop yield.

2.0 Materials and Methods

2.1 Experimental Site

The research was carried out at the Modibbo Adama University of Technology Yola (MAUTECH) Agricultural Farm located at the extreme end of the University Staff quarters in Girei local Government Area of Adamawa State (Fig.1). The area is located between latitude $9^{\circ}11'$ and $9^{\circ}33'$ N and longitude $12^{\circ}21'$ and $12^{\circ}49'$ East. The climate is broadly divided into wet and rainy season. The rainy season begins in May and reaches its peak in August and ends in November. The area has an average rainfall of 972mm. Temperature within the area varies with season, although the temperature is relatively high which ranges from 27 to 40°C , the coldest month being December and January with mean temperature of 16°C . The hottest periods within the area are April and May with an average temperature of 34°C , the average annual relative humidity is 40.9% and average monthly relative humidity ranges from 15% in February to 68% in August [18].

Soil samples were collected from five different locations in the experimental farm, which represent the entire farm land. Area of one hectare (1ha) was used for the experimental layout, which was divided into five plots size designated as plot 1, 2, 3, 4 and 5 areas (0.2ha). Soil sampling Auger was used to collect the soil sample at different depth from 0- 30cm with interval from 0-10, 10-20 and 20-30cm, respectively. Samples were collected in Randomized complete Block Design (RCBD). Polythene bag was used to collect the soil samples from the field to the laboratory for analysis. Rice Husk was collected from Girei Local rice mill, using polythene bags to convey it to the laboratory for analysis.

2.3 Sample Preparation and Analysis

The soil was allowed to dry and sieved through 2.00mm sieve. An instrument, Mold of 100mm diameter, 127.3mm height and 1869g weight was used; 2000g each of soil was measured from the different depth of sampling for plot 1, 2, 3, 4 and 5, respectively. These samples were compacted using 2.5kg standard proctor for 15, 20, and 25 blows to evaluate the bulk density of soil collected at 0-10, 10-20, and 20-30 cm depth, respectively. 2000g of soil was measured and mixed with 1000g of Rice Husk and was compacted using 15, 20 and 25 blows for different depth of soil (0-10, 10-20, and 20-30) cm to evaluate the Bulk Density of mixed soil and Rice Husk using 2.5kg standard proctor hammer. Observed values and readings were recorded.

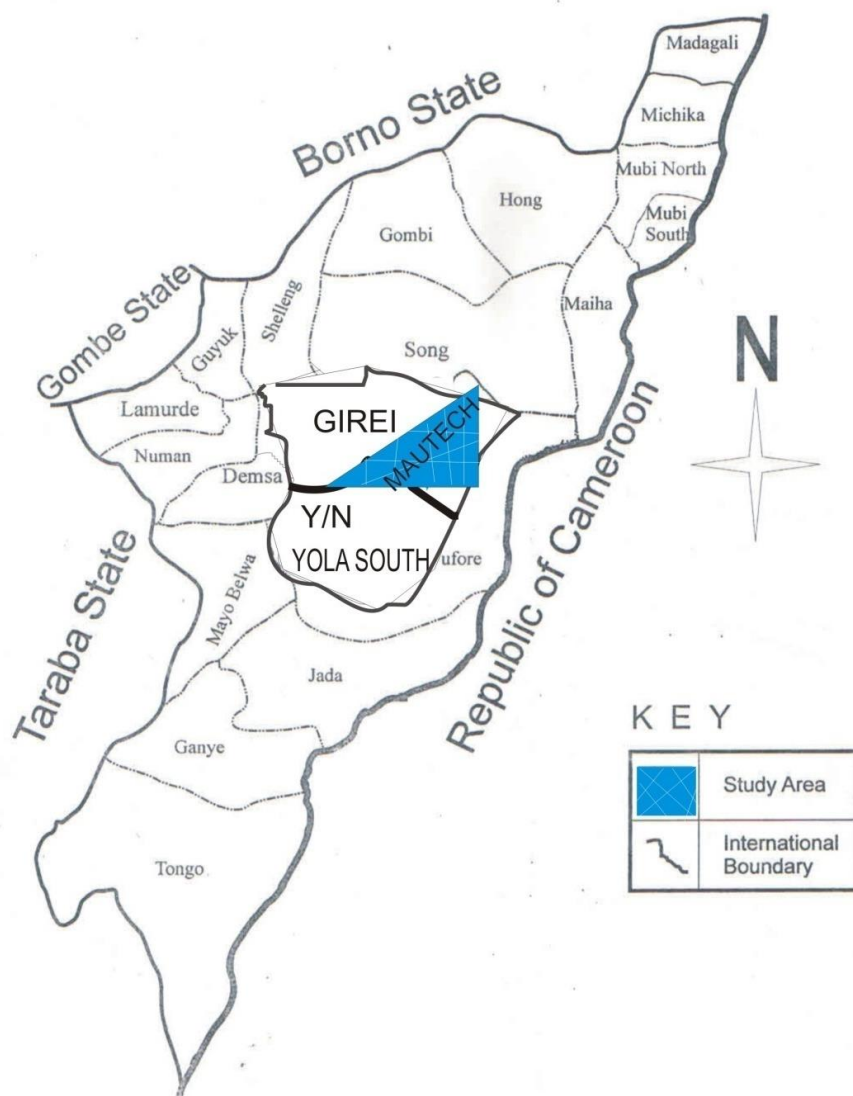


Figure 1: Map of Adamawa State Showing the Study Area

2.4 Sample Collection

2.4.1 Compaction procedure using standard proctor test

2000g air dried soil sample was sieved, measured and recorded for the different soil depth from 100 mm down to 300 mm. Compaction test was carried out using Standard Proctor Test as detailed by [19].

2.4.2 Determination of soil textural classification

Soil samples were taken at incremental depth of 100 mm to 300 mm. Five replications were made during each sampling which was randomized within the five plot units. The soil textural classification was determined using mechanical analysis method as detailed by [19].

2.4.3 Determination of soil bulk density

The bulk density of soil from each of the five locations of soil sample collected was determined using the following relationship [15].

$$BD = \frac{M}{V} \quad (1)$$

Where;

BD=bulk density, g/cm³

M= mass of soil,

$$= m_2 - m_1$$

Where;

m₁= empty weight of mould, g

m₂= mass of compacted soil and mould weight, g

V= volume of the container, cm³

$$= \pi r^2 h$$

Where;

h =height of the mould, cm

r = radius of the mould, cm

Secondly: the bulk density of mix soil and rice husk was calculated using

$$BD = \frac{M}{V} \tag{2}$$

Where;

M = mass of soil, g

$$= m_2 - m_1$$

Where;

m₁= empty weight of mould, g

m₂= mass of compacted mix soil with rice husk and mould weight, g

V= volume of the container, cm³

$$= \pi r^2 h$$

Where;

h =height of the mould, cm

r = radius of the mould, cm

3 Results and Discussion

3.1 Soil Bulk Density

Table 1 Shows, mean bulk density of soil taken from the experimental farm. The result reveals that the soil bulk density increases with increase in compaction and depth. The soil bulk density increases from 0.681g/cm³ to 0.704 g/cm³ at 10-30cm depth (control, no-compaction) which suggested that the soil has a small bulk density that allows infiltration, aeration and crop root growth which is consistence with the result reported by [20] who found an increased in bulk density with increased in depth.

Table 1: Mean of Bulk Density of the Experimental Farm (g/cm³)

Depth (cm)	Number of Blow	Bulk Density of Compacted soil	Bulk Density of rice Husk Compacted	Zero Blow	Compaction soil
0 – 10	15	1.126	1.065	0	0.681
10 – 20	20	1.158	1.025	0	0.690
20 – 30	25	1.214	1.006	0	0.704

Table 1 also indicate that, the soil bulk density increased more from 1.126 g/cm³ to 1.214 g/cm³ as the depth and number of blows increased (independent variable, compaction at 15, 20 and 25 blows) which indicate that soil bulk density increase with increased number of blows which implies that the forces applied to the soil reduce the rate of infiltration, aeration and root growth which is in line with the result obtained in earlier studies by [21]. Also, the

result shows that, the soil bulk density decreases from 1.065 g/cm³ to 1.006 g/cm³ as the depth and number of blows increased. The result shows that incorporating rice husk to the soil reduced the adverse effect of compaction on soils which is consistent with the result of [22]. Statistically using analysis of variance, it was observed that there was no significant difference between the Soil Bulk Density at 5% level of significance for the entire study area.

3.2 Soil Compaction on Bulk Density

Table 2 shows the bulk density on compacted soils. The result indicates that bulk density increases with the depth and number of blows for the entire study area. It was observed that highest bulk density was obtained at the depth of 20-30cm while the lowest Bulk Density was recorded near the soil surface. The result revealed that highest value of soil bulk density 1.225 g/cm³ at 20-30 depth was obtained from plot 3 while plot 1, 3 and 4 recorded the lowest values soil bulk density of 1.119 g/cm³, respectively. Highest mean bulk density of 1.171 g/cm³ and 1.152 g/cm³ were recorded in plot 2 and depth of soil sampling of 10-20 cm, respectively. The results obtained are in line with [11] who observed that bulk density increased with the number of blows applied or forces at different depths. Using analysis of variance, it was observed that bulk density of the compacted soil in the treatments were highly significant at 5% level of significance.

Table 2: Bulk Density on Compacted Soil Test (g/cm³)

Depth of soil sampling (cm)	Number of Blows (g)	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
0-10	15	1.119	1.144	1.119	1.119	1.131	1.126
10-20	20	1.156	1.156	1.150	1.163	1.136	1.152
20-30	25	1.200	1.213	1.225	1.219	1.213	1.214
Mean		1.158	1.171	1.165	1.165	1.160	

3.3 Effect of Rice Husk on Compacted Soil

Table 3 shows the bulk density of compacted mixed soil and rice husk. The result revealed that bulk density decreases as the number of blows and depth of soil increases which was consistent with the result obtained from earlier studies by [22]. It was observed that highest bulk density was obtained at the 15 blows and 0-10cm depth near the soil surface while the lowest mean bulk density was recorded at 20-30cm depth. This result indicate that rice husk has a great influence on bulk density of soil thus, bulk density decrease as the numbers of blow and depth increases.

4.0 Conclusion

The experiment conducted determined the effect of incorporating into soil and subjecting to different compaction levels of rice husk and compaction reveals that great effect was impacted on the soil bulk density by incorporation of rice husk into the soil. The incorporation of rice husk into the soil lowered the soil bulk density from 1.126 g/cm³ to 1.065g/cm³ (at 15 blows and 0-10 depth) and from 1.214 g/cm³ to 1.006 g/cm³ (at 25 blows and 20-30 depth) which indicate a decrease in soil bulk density with increase in levels of compaction. It can be concluded that incorporation of rice husk into the soil will increase the rate of water infiltration, aeration, roots and will enhance shoot growth for higher crop production.

Table 3: Bulk Density of Compacted Soil mixed with Rice Husk Test (g/cm³)

Depth of Soil sampling (cm)	Numbers of blows(g)	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Mean
0 – 10	15	1.038	1.088	1.069	1.075	1.056	1.065
10 – 20	20	1.025	1.031	1.019	1.031	1.019	1.025
20 – 30	25	1.006	1.013	1.000	1.013	1.000	1.006
	Mean	1.023	1.038	1.029	1.040	1.025	

References

1. Patricia, M. Fraser. (2003). Soil Scientist New Zealand Institute for Crop & Food Research (30):23-40.
1. Chan, C. (1992). Tillage induced differences in growth and distribution of wheat roots. Aust. Jr. of Agri. Res. 43 (1) 19 – 28.
2. Goldsmith, W. Silver, M. M. and Fischenich, C. (2001). Determining optimum degree of soil compaction balancing mechanical stability and plant growth capacity, EMRSR-26 Pp45-50.
3. Kushwaha, C.P, Tripathi, S.K. and Singh, K.P. (2001). Soil organic matter and water-stable aggregates under different tillage and residue conditions in a tropical dry land agroeco-system. Appl. Soil Ecol. (16): 229–241.
4. Brady and Wail R. R. (1999). The nature and properties of soil 2nd(Ed) Pp2 4-33.
5. Njoku, C. Mbah, C.N. and Okonkwo, CI. (2011). Effect of rice mill wastes application on selected soil physical properties and maize yield (*Zea mays* L.) on an ultisol in Abakaliki, southeastern Nigeria. J. Soil Sci. Environ. Manage. 2(11):375–383.
6. Oguike P.C, Chukwu G.O. and Njoku C. (2006). Physico-chemical properties of a haplic acrisol in southeastern Nigeria amended with rice mill waste and NPK fertilizer. Umudike, Nigeria, National Root Crops Research Institute.
7. Dick, W. A. and Gregorich, E. G. (2004). Developing and maintaining soil organimatterlevels.In managing soil quality: Challenges in modern agriculture. (P Schjoning et al., eds) CABI, Wallingford, UK Pp103 –120.
8. Arshad, M.A., Lowery, B. and Grossman, B. (1996). Physical tests for monitoring soil quality. In: J.W. Doran and A.J. Jones (eds.) Methods for assessing soil quality, Soil Sci. Soc. Am. Spec. (49):123-142.
9. Akin, M. and Özdemir, N. (2003): Regression models for predicting bulk density from measured soil properties. Tr. J. of Agriculture and Forestry, (20):407-413.
10. Soane, B. D, and Van, Owerkerk, .C. (1994). Soil compaction in crop production Pp66-82

11. Mbah, C.N. (2006). Influence of organic wastes on plant growth parameters and nutrient uptake by maize (*Zea mays* L). *Nigeria J. Soil Sci.* (16):104–108.
12. Muntohar, A. S. (2011). Use of rice husk ash to enhance lime treatment of soil. *Canadian Geotechnical Journal* Vol 1.Pp-843-852.
13. Musa, A. (2008). Potentials of Rice husk ash for stabilization, Technical Report AUJ.T.11 (4) Pp. 246-250.
14. Kuchenbuch, R.O. and Ingram, K.T. (2004). Effects of soil bulk density on seminal and lateral roots of young maize plants (*Zea mays* L) *Journal of Plant Nutrition and Soil Science* (167): 229 – 235.
15. Hartemink, A. E. (2003): Soil fertility decline in the tropics – With case studies on plantations. CAB International. Wallingford, U.K.Pp4-6.
16. Davies D. B, Eagle D. J and Finney J. B. (1993). Soil management, farming press, United Kingdom Pp35-60.
17. Adamawa state Official Diary (2010). Adamawa State Government Yola Ministry of Information Pp 11-20.
18. Satyendra, M. and J.P.Shukla (2012) Soil Testing for Engineers. Sixth Edition, Published by Romesh Chander Khanna for KHANNA PUBLISHERS, 2-B, Nath Market, Nai Sarak, India.Pp: 319.
19. Lowery, B., and R. T. Schuler. (1994). Duration and effects of compaction on soil and plant growth in Wisconsin. *Soil and Tillage Res.* 29(2-3):205-210.
20. Hart, G.E and Lowery, B. (1997): Analysis of the axial-radial influence of crop soil solution in a sandy soil. *Soil Sci, Soc. Am. J* (61):1765-1773.
21. Abubakar, A.S and Abdullah, A.S (2013): Influence of Rice Husk on Bulk Density of Fadama Soil. Agricultural and Bio-Resource Engineering Faculty of Engineering Abubakar Tafawa Balewa University Bauchi. Pp 26-29.