

EFFECT OF SAWDUST AND GROUNDNUT SHELL ON BULK DENSITY OF SANDY LOAM SOIL IN MODIBBO ADAMA UNIVERSITY AGRICULTURAL FARM, YOLA, NIGERIA

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ABSTRACT

Soil compaction may occur naturally as a result of excessive tillage, rainfall, working wet soil, and poor drainage causing reduction in infiltration, aeration, crop root growth and consequently crop yield. Effect of sawdust, groundnut shell and the interaction of saw dust and groundnut shell on bulk density of compacted soil were studied under laboratory conditions. 2000g of soil and 1000g each of sawdust, groundnut shell as soil amendments, respectively were compacted using 15, 20, 25 and 30 blows at incremental depth of 100mm to a depth of 400mm. The result shows that the soil bulk density increases with depth and number of blows. Highest soil bulk density was recorded at the depth of 30 to 40 cm at 30 blows which had mean soil bulk density value of 1.0075g/cm³, and the lowest soil bulk density value of 0.4584 g/cm³ was recorded at the depth of 0-10cm at 15 blows. Incorporation of sawdust into the soil had the lowest mean soil bulk density value of 0.5293 g/cm³ which may result to improving soil porosity and aeration. Incorporation of groundnut shell to the soil resulted in mean soil bulk density of 0.6169 g/cm³ which reduces the soil bulk density, but it's not as pronounced as compared to the sawdust. The incorporation of saw dust and groundnut shell into sandy loam soil improves the rate of infiltration, aeration and roots penetration for higher crop growth and yields. The study only focused on the physical properties (bulk density) of the soil, it is therefore recommended to determine the chemical and other related characteristics of soil on the effect of saw dust and groundnut shell.

Keywords: Sawdust, Groundnut Shell, Bulk Density, Sandy Loam Soil, Compaction, Yola

1 INTRODUCTION

Soil is one of the essential natural resources required for agricultural production; it provides nutrients and anchorage to plants. However, soil degradation has become a pivotal issue in recent times. Soil quality is affected by various factors, including soil bulk density, which is an indication of soil compaction level. Soil compaction affects the soil structure, nutrient availability, water infiltration rate, and oxygen supply to plant roots. Therefore, to maintain healthy soil for agricultural production, it is crucial to reduce soil compaction. One of the possible ways to reduce soil compaction is through the use of organic materials such as sawdust and groundnut shell which improve soil quality by enhancing soil structure, water holding capacity, and nutrient availability. Saw dust is the tiny waste particles obtained from cutting of wood, planing, drilling, chiseling, etc. In Nigeria, great quantity of saw dust are produced and if accumulated, forms a heap which is often burnt off and result to environmental pollution [1]. There are enormous quantities of wood shaving as by products from wood preparation factories and furniture factories. Application of wood chips as an amendment was investigated by some research workers and their results indicated the usefulness of this material in crop production on sandy soils by improving soil fertility status [2]. Groundnut shells on the other hand, are a bulky waste generated in large amounts where significant waste disposal problems are created around the areas. The common methods of handling the

disposal of such groundnut shells are mostly either by incineration or incorporation in soil on dumping land. In developing countries, majority of groundnut hulls are either burned or dumped in forest areas or left to degrade naturally. However, incineration method will emit smoke and particulate matter, which causes air pollution. Incorporation of agricultural waste into soil influences physical, biological and chemical properties of soil [3]. Therefore, it is necessary to develop improved methods of managing the huge amount of waste organic materials, which poses no critical problem in waste management systems and subsequently causes no environmental pollution. Transforming saw dust and groundnut shells into a valuable raw material, ingredient or product would be the better method to utilize them [3, 4, 5]. 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, mainly as a result of compaction of the soil by trafficking implements or machines. Over compaction of layer may cause a greater reduction in percentage pore spaces. This loss of pore space not only restricts movement of air greater resistance to roots and those that penetrate are confirmed to fissure between structures less clod [6]. Advancements in mechanization and increased usage of chemical fertilizers coupled with heavy rains and intensive cropping practices are the main causes of soil compaction, there is therefore the need to determine the effect of sawdust and groundnut shells on bulk density of Sandy Loam soil in Modibbo Adama University Agricultural farm to serve as a decision tool and soil management strategy to the farmer to choose a measure that can alleviate soil compaction and improve soil physical properties of the agricultural land.

2 LITERATURE REVIEW

2.1 Soil

Soil is a complex and dynamic mixture of minerals, organic matter, water, air, and living organisms. It is an essential component of ecosystems, and understanding its composition is important for nutrient management and plant growth [7, 8]. The largest component of soil is the mineral portion, which makes up approximately 45% to 49% by volume. Organic matter makes up about 5% of soil which is composed of dead and decaying plant and animal materials, and it is important for nutrient storage and retention. The soil contains water and air which make up to approximately 2% to 50% of the soil volume and about 20-30% of soil, respectively [7]. Soil is home to a diverse community of living organisms, including bacteria, fungi, insects, worms, and larger animals such as moles and rabbits. These organisms play important roles in nutrient cycling, decomposition, and soil structure formation [8]. Soil organism can change the physical organization of soil by creating burrows, add nutrient to the soil through the breakdown of dead leaves, and help to control the populations of other soil organism [9].

2.2 Soil Bulk Density

The bulk density of soil is the density of a volume of soil as it exists naturally, including air space, organic, and a soil solid [10]. Bulk density is a measure of the mass of a material per unit volume, expressed in grams per cubic centimeter (g/cm^3). It 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. The packing arrangement and 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 [11]. Increase in the density of soil or compaction the soil retards biodegradation of the organic material by restricting access of water to the soil [12]. 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. The bulk density which is the ratio of the volume of pores (voids) to the total (bulk) volume of a soil is the porosity and the porosity may also be determined using the soil bulk density [13]. Researchers often need a bulk density value for models to characterize field conditions, or convert it to volumetric measurements. 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 [14]. Bulk density is naturally higher in sandy soils

than in clayey soils, and it is the main physical factor impacted by crop activities. Bulk density is an important physical property of soil that can impact root growth, soil structure, and crop production [15].

2.3 Soil Amendments

Soil amendments are materials that are added to soil to improve its physical properties and create a better environment for plant roots. There are two broad categories of soil amendments: organic and inorganic. Organic amendments come from something that was alive, such as compost manure, straw, wood chips, and grass clippings. These amendments can improve water retention, permeability, drainage, and structure of the soil [16]. Saw dust as one of the commonly used organic material that can be incorporated into the soil for various purposes, such as improving soil structure, enhancing water retention, and providing nutrients over time as it decomposes. Sawdust is low in readily available plant nutrients when compared to livestock manure which is rich in microbes responsible for rapid decomposition of organic matter and pH of 6.0 to 9.0, which is ideal for microbial activity [17]. Sawdust is a lightweight material that has a low density, and when mixed into the soil, it can increase the pore space, reducing the overall bulk density. This can improve soil aeration and water movement through the soil profile. Sawdust has the ability to absorb and retain water. When incorporated into the soil, it can increase the soil's water-holding capacity, reducing the risk of water logging and improving moisture availability to plants. This can indirectly affect bulk density by altering the water content of the soil [18, 19]. However, other studies have found that sawdust can have negative effects on soil properties, such as reducing soil hydrogen content, increasing soil acidity, and polluting the soil with phenol compounds [20]. It is important to note that the effects of sawdust on soil bulk density can depend on factors such as the amount of sawdust added, the type of soil, and the duration of the trial [19]. The effects of sawdust on soil bulk density can be complex and depend on various factors. It is important to consider the potential positive and negative effects before adding sawdust to soil [21]. Groundnut shells are other organic material that has been found to have positive effects on soil properties, including bulk density. Several studies have shown that the application of groundnut shells to soil increases soil porosity, water holding capacity, soil pH, organic matter, nitrogen, phosphorus, calcium, and decrease soil bulk density [22]. When incorporated into the soil, they can increase the pore space, resulting in a reduction in bulk density. This can improve soil aeration and water movement, which are beneficial for plant growth. Groundnut shells are rich in carbon and can contribute to the organic matter content of the soil. Increased organic matter can improve soil structure and aggregate stability, leading to a decrease in bulk density. Organic matter also enhances nutrient availability and water-holding capacity in the soil. Groundnut shells contain nutrients such as nitrogen, phosphorus, and potassium. As they decompose, these nutrients are gradually released into the soil, contributing to improved soil fertility. Nutrient availability can influence plant growth, root development, and ultimately impact bulk density indirectly [23].

2.4 Soil Compaction

Compaction is the process of expulsion of air from the voids present in the soil. In the construction field, it is process as it improves the engineering properties of soil to a great magnitude. Soil compaction can be associated with majority of field operations that are performed in agriculture which include animal trampling and passage of heavy machinery and equipment which often cause damage to the soil structure [24]. Soil structure is important because it determines the ability of a soil to hold and drain water, nutrients, and air required for plant root activities. Soil compaction occurs when soil particles are pressed together, reducing pore space between them, it changes pore space size and distribution [25]. Soil compaction can be divided into two categories, surface horizon compaction and subsoil compaction. Surface horizon compaction mostly occurs due to wheel trafficking during field operations and surface crusting that occur due to impact of raindrops on weak soil aggregates. Subsoil compaction occur deeper in the soil profile, because of the ground contact pressure or the axle load is very high that the effect attains greater depth [26]. Water movement in soil is important in supporting plant growth. Plants require water, because it acts as a major metabolic agent for growth [27]. Compaction restricts plant ability to absorb water from the soil and this could reduce the yield. Large pores are more effective in soil water movement but compaction causes a reduction in pore space distribution which could result on reduced water infiltration rate. Soil compaction

can influence the concentration and movement of water, oxygen and carbon dioxide which could result in a restricted root development root [28]. [29] stated that one of the functions of plant roots is to maintain the supply of nutrients and water to the plant while the yield is dependent on the root development in the soil profile which determines the capacity for nutrient uptake and water extraction by plants. The potential of plants to obtain water and mineral nutrients from the soil is related to their capacity to develop extensive roots; meanwhile compaction restricts the growth and consequently limits plant access to subsoil water and nutrients. Several studies have investigated the effects of soil compaction on plant growth. A study by [30] shows that compaction at the optimum water content (5%) was the most dramatic for plant growth. However, plant growth was higher for compaction conditions which best owed both a lower soil dry density and hydraulic conductivity.

3 MATERIALS AND METHODS

3.1 The Study Area

This research was carried out at the Modibbo Adama University, Yola (Figure 1), Agricultural Farm located at the extreme end of the University Staff quarters in Girei local Government Area of Adamawa State. The area is located between latitude $9^{\circ}11'$ and $9^{\circ}33'N$ and longitude $12^{\circ}21'$ and $12^{\circ}49'E$. The climate is broadly divided into dry and rainy season. The rainy season begins in May and reaching 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 $40^{\circ}C$ The coldest month being December and January with mean average temperature of $16^{\circ}C$. The hottest periods within the Area are April and May with an average temperature of $34^{\circ}C$, the average annual relative humidity is 40.9% and average monthly relative humidity ranges from 15% in February to 68% in August [31].

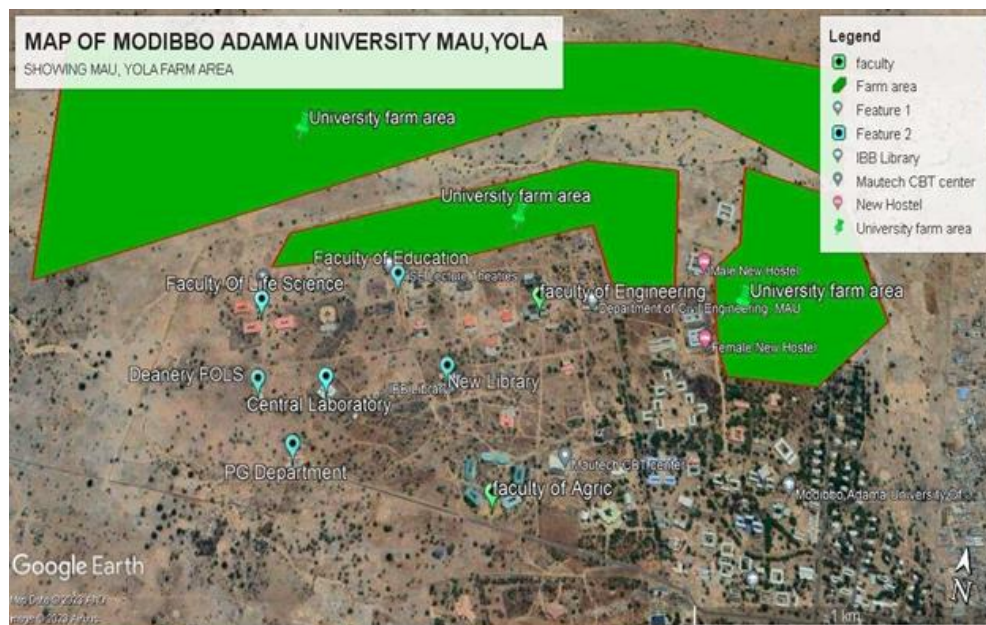


Figure 1. Map of Modibbo Adama University, Yola

3.2 Sample Collection

Soil samples were collected from four 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 four plots size designated as plot A, B, C, and D of 0.25ha each. Soil sampling Auger was used to collect the soil sample at different depth from 0-40cm with interval from 0-10, 10- 20, 20-30 and 30-40cm, respectively. Samples were collected using Randomized complete Block Design (RCBD). Polythene bags

were used to collect the soil samples from the field to the laboratory for analysis. Wood sawdust was obtained from Maitulare, a community in Girei local government and groundnut shells was obtained in Girei as a waste from a household which uses groundnuts for oil making. The shells were packed, cleaned and sun dried and then grinded using rice milling machine to reduce it to sizes conforming to fine aggregates. Polythene bags were used to convey the samples to the laboratory for experimentation in line with [33].

3.3 Laboratory Analysis

The soil was allowed to dry and sieved through 2.00mm sieve in line with [34] in order to have average soil size particles. Mould of 100mm diameter, 127.3mm height and 1869g weight was used; Compaction test was carried out using Standard Proctor Test as detailed by [33]. 2000g each of soil was measured from the different depth of sampling for 0-10, 10-20,20-30 and 30-40cm depth for plot A, B, C and D, respectively and soil bulk densities were determined without compaction (ZC). Also, 2000g each of soil was measured from the different depth of sampling for plot A, B, C and D, respectively. Theses samples were compacted (C) using 2.5kg standard proctor for 15, 20, 25 and 30 blows to evaluate the bulk density of soil depth at 0-10, 10-20, 20-30 and 30-40cm, respectively. Secondly 2000g of soil was measured and mixed with 1000g of Sawdust (SD) and was compacted using 15, 20 25and 30 blows for different depth of soil (0-10, 10-20, 20-30 and 30-40 cm) to evaluate the bulk density of mixed soil and Sawdust using 2.5kg standard proctor. This procedure was repeated for 2000g of soil mixed with1000 of Ground nut shells (GS), 2000g of soil mixed with1000 of Ground nut shells and 1000g of Sawdust (GSSD) to evaluate their bulk densities, respectively.

3.4 Determination of Bulk Density

The bulk density of each of the content was determined using the following relationship [34];

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

Where BD=bulk density, g/cm³, M= mass of soil, = m₂ – m₁, Where; m₁= empty weight of mould, g, m₂= mass of compacted soil and mould weight, g, V= volume of the container, cm³.

$$v = \pi r^2 h \quad (2)$$

Where; h =height of the mould, cm, r = radius of the mould, cm.

4 RESULTS AND DISCUSSION

4.1 Effect of Sawdust and Groundnut shells on Soil Bulk Density of the Farm and soil Compaction

Table 1 shows the values of the soil bulk densities of the farm at the various levels of compaction and soil amendments. The table indicates that the soil bulk density varies in all the farm plots. It was observed that soil bulk density was higher in compacted soils than soil without compaction and those with soil amendments. Soil bulk density was noted to be lower in soil mixed with amendments. Thus, soil bulk density was reduced when incorporated with sawdust which had mean value of 0.5293 g/cm³ which is consisted with the result obtained by [35]. This implies that sawdust incorporated in sandy loam soil will reduce soil bulk density leading to improved porosity and aeration. In addition, it was also observed that the incorporation of groundnut shells to the soil resulted in mean soil bulk density of 0.6169 g/cm³ which reduced the bulk density of the soil, but it's not as pronounced as compared to the sawdust. This reveals that incorporation of groundnut shells decreased soil bulk density, improved aeration and water infiltration. However, the effect is often pronounced less when compared with saw dust due to their higher density and slower decomposition rate. The incorporation of sawdust and groundnut shell in the same proportion in soil resulted in mean soil bulk density of 0.5458 g/cm³ which reduced the soil bulk density as shown in Table 1. The result shows that the incorporation of both soil amendments was found to be more effective when compared with groundnut shells and slightly low for sawdust which is in line with [36] who observed that

a ratio of 1:1 soil amendment offered the best result which significantly reduces soil bulk density, improves water infiltration and promotes crop growth and yield. Statistically, it was observed that the difference between the mean soil bulk densities was highly significant at 5% level of significance for the farm as shown in Table 2.

Table 1. Mean soil bulk density of the Plots in the Farm Incorporated with soil Amendment (g/cm³)

Treatments	Replications				Mean
	Plot A	Plot B	Plot C	Plot D	
ZC	0.6671	0.6215	0.7042	0.6462	0.6598
CS	1.0239	0.9850	0.9676	0.9999	0.9941
SD	0.5144	0.6387	0.3666	0.5975	0.5293
GS	0.5712	0.7013	0.5419	0.6532	0.6169
GSSD	0.5180	0.6774	0.4237	0.5642	0.5458

Note: ZC = zero compaction soil, C = compacted soil, SD = sawdust and soil compaction, GS = groundnut shell and soil compaction, GSSD = groundnut shell, sawdust and soil compaction.

Table 2. ANOVA for mean soil bulk density of the Plots Incorporated with Soil Amendments

Sources of Variance	Degree of freedom	Sum of Squares	Mean Squares	F _{Calculated}	F _{table} 5%
Replication	3	0.042	0.014		
Treatment	4	0.572	0.143	30.43**	3.26
Error	12	0.057	0.005		
Total	19	0.671			

** Highly Significance

4.2 Effect of Sawdust and Groundnut shells on Soil Bulk Density of the Farm, Depth of Sampling and Soil Compaction

Table 3 present the soil mean bulk density of the farm as a result of soil amendments, depth of sampling and compaction. The table indicates that the soil bulk density increases with the depth and number of blows in the study area. Highest soil bulk density was recorded at the depth of 30-40 cm at 30 blows which had value of 1.0075g/cm³, and the lowest soil bulk density value of 0.4584 g/cm³ was recorded at the depth of 0-10cm at 15 blows when sawdust was used which is in line with [13]. The result revealed that the combination of groundnut shells and sawdust at the various level of compaction and depth of sampling recorded lower bulk densities compared to individual application of soil amendment. Table 4 present the analysis of variance for the mean soil bulk density of the farm. It was observed statistically that the difference between the mean soil bulk densities of sandy loam soil in the farm was highly significant at 5% level of significance.

Table 3. Mean soil bulk density of the Farm Incorporated with soil Amendments at various depth of Sampling and Soil Compaction (g/cm³)

Depth of Sampling (cm)	No of Blows	Zero compaction	Compacted soil	Sawdust with compaction	Groundnut shell with compaction	Groundnut shell, Sawdust and compaction
0-10	15	0.6086	0.9669	0.4584	0.5810	0.5011
10-20	20	0.6258	1.0030	0.5034	0.5997	0.5576
20-30	25	0.7038	0.9989	0.5727	0.6311	0.5579
30-40	30	0.7008	1.0075	0.5827	0.6508	0.5667

Table 4. ANOVA of Mean soil bulk density of the Farm Incorporated with soil Amendments at various depth of Sampling and Soil Compaction

Sources of Variance	Degree of Freedom	Sum Mean of Squares	Mean Squares	F _{calculated}	F _{table} 5%
Replication	3	0.0193	0.0064		
Treatments	4	0.5732	0.1433	358.25**	3.26
Error	12	0.0052	0.0004		
Total	19	0.5977			

** Highly Significance

5 CONCLUSIONS

The experiment conducted determined the effect of incorporating Sawdust and Groundnut shells into the soil and subjecting to different compaction levels. The incorporation of sawdust and groundnut shells into the soil decreases the soil bulk density with increase in levels of compaction and depth of sampling. Thus, it can be concluded that sawdust which had the lowest mean soil bulk density value of 0.5293 g/cm³ reduces soil bulk density leading to improved porosity and aeration. Also, incorporation of groundnut shell to the soil resulted in mean soil bulk density of 0.6169 g/cm³ reduces the soil bulk density, but it's not as pronounced as compared to the sawdust. Thus, the incorporation of saw dust and groundnut shells into the soil increase the rate of infiltration, aeration and roots penetration for higher crop growth and yields.

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