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The Effect of Soil Compaction on Soil Physical Properties Southern Adamawa State Agricultural Soils

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----------ABSTRACT----------
Compaction of Agricultural soil is a concern to many Soil Scientist, Agricultural Engineer, and farmers. The use of agricultural machineries has cause extensive soil degradation, especially in the upper layers of soils. This study was conducted to assess the effect of soil compaction on soil physical properties of some soils in Southern Adamawa. The soil particle analysis ranges from 64.35% sand, 22.50% silt, and 8.15% clay. The models relationship between bulk density and penetration resistance was noted and last strong. The consistency of the soil was recorded with low plastic index of 1.75 and liquid unit of 15.15. As result of compaction, bulk density increases in penetration resistance with significant consequence for crop root development, although there was no definite relationship with penetration resistance.

KEYWORDS: *Soil compaction, soil properties, penetration resistance, bulk density.*

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I. INTRODUCTION

Compaction of agricultural soil is a concern to many soil scientist, Agricultural Engineers and farmers. As farm tractors and field equipment become larger and heavier, there is a growing concern about soil the effect of soil compaction. Soil compaction can be associated with a majority field operation that often performed when the soil are wet. Heavy equipment and tillage implement can cause damage to soil physical properties and structure. Soil structure is very important because it determine the ability of a soil to hold and conduct water, nutrient and air necessary for plant root activity. Soil structure in agriculture is associated with silt which signifies the ability of soil aggregates to withstand pressure from impact of implement, rain drops or run off so that water penetration, aeration and root penetration are maintained at favourable level (Braveret et al. 1990) Ohu et al. reported that continuous manipulation of soil to prepare seed bed for crop growth is associated with problems of soil compaction which include:

1) Increase in bulk density owing to soil particles
2) Reduction in water permeability owing to reduction in pore spaces
3) Increase resistance penetration of water, nutrient, roots and shear strength.

This study was carried out to assess the effect of soil compaction on some soil physical properties in southern Adamawa State, Nigeria.

II. MATERIAL AND METHOD

A laboratory tests were conducted on undisturbed sample of soils collected from the study area in 2004. The soils sample was air dried and passed through 0.02mm batch of screen for particle size distribution. The initial moisture content recorded were 2%, 6%, 8%, 10% and 12%. They were subjected to 5, 10 and 15 blows at different moisture content. Initial 40g soil sample was weighed and used for the analysis. The second equivalent sample was oven dried for 24 hours at 101^0C and the third sample was measured with 600ml cylinder and 150ml of distilled water was added. It was heated for 20 minutes to destroy organic matter. The final process was mixed in 1000ml cylinder with 5ml of 50% Colgon. Subsequent reading of hydrometer was recorded in interval of time as shown in Table 1.

The percentage of sand, silt and clay was computed
$S = R - R_C + r \times 100$ – (1)

Where S = percentage of particle in suspension.
R = hydrometer reading

R_C = Calibration correction
r = Pre-operative correction
w = oven dried weight of soil sample

Saturated Hydraulic Conductivity

The rate of flow of water through a sample in study area was determined in laboratory. A sample of soil was soaked in water for 4 days. After saturation the permeameter cell was connected to stand pipe and filled with water. The water is allowed to flow through the soil sample. Head drops were recorded at interval of 5 minutes. H saturated hydraulic conductivity as computed in Darcy equation.

$$k = aln \frac{L}{At} \frac{H_2}{H_1}$$

Where K = coefficient of permeability (mm/Sec.)
a = Cross-Sectional of standard pipe (m^2)
l = length sample of soil
A = Cross Sectional Area of water (m^2)
H1 & H2 = Hydraulic heads (m)
T = Time in sec.

III. RESULTS AND DISCUSSION

The results of experimental manipulation is obtained from different soil parameters which was summarize in statistical data and presented in tables.

Replications	Agricultural Soils	Percentage %
1.	Sand	64.35
2.	Silt	27.50
3.	Clay	8.15

In Fig1. The type of soil sample was confirmed by textural triangle as a Sandy loam with particle distribution of sand 64.35% Silt 27.50% and clay 8.15%.

Table 2: Soil consistency

Types of soil	Liquid limit	Plastic limit	Plasticity index
Sandy loam	17.00	15.25	1.75

Source: University of Maiduguri, Nigeria faculty of engineering soil laboratory. (2004).

From the result obtained, the liquid limit was interpolated with logarithmic graph. The sample of soil at peak blow was recorded at 17.0 the mean value of plastic limit was recorded at 15.28 affects taking the average values of moisture content in the study area.

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Table 3. The saturated hydraulic conductivity at different moisture content.

Replications	%moisture content percentage	Mean value of saturated hydraulic Conductivity (K) (x 10^{-4} mmls)		
		5 blows	10 blows	15 blows
1.	2	10.45	7.77	6.42
2.	4	8.43	4.84	3.28
3.	6	5.44	4.54	1.99
4.	8	4.83	3.65	1.56
5.	10	3.04	2.61	1.48

Source: University of Maiduguri Nigeria, Faculty of Engineering Laboratory (2004).

Fig 3: Shows the lowest moisture content 2.0% compacted at 5 bows 3, living the highest saturated hydraulic conductivity value of 10.45 x10^{-3} mm ^{3}/5.

The value of K varies in tropical soil within a range covering several orders of magnitude.

Table 4: Mean value of bulk density

Replications	Moisture content %	Mean value of Bulk density ($x\ 10^{-3}\ mg/m^3$)		
		5 blows	10 blows	15 blows
1.	2	1.66	1.76	1.85
2.	4	1.65	1.85	2.04
3.	6	1.76	2.03	2.22
4	8	2.22	2.31	2.32
5.	10	2.10	2.22	2.41
6.	12	1.94	1.94	1.94

Source: University of Maiduguri Nigeria faculty of engineering laboratory (2004)

It was observed that the mean bulk density decreases at highest values of moisture content with the same numbers of compaction in the study zone. In the texture analysis, soil sample has high percentage of sand 64. 25%, silt 27.50, and clay 8.15%. However, the contribution of this process must be limited given low clay content of the soil sample in (Table1) and the high proportion of sand within clay fraction (Briand et al. 2004). The major contributing factor associated with compaction was probably due to lubrication, the planar shipped clay slip against each other. Table 2 shows the value of consistency limit in the study area. It was observed that the value of plasticity index for the soil sample used for experiment was 1.75, owing to the content of clay which is very low 8.15 %. The soil is not easily rolled by hand to standard diameter of 3mm thread.
This, the manifestation of physical forces of cohesion and adhesion from machinery and implement during operation is less in the study area. The blow of the soil towards gravity pressure and pull of farm machinery is below average. The result obtained in Table 3 conformed the observation that compaction decreases the rate of water transmission into soils (Ohu 1985 and Hillel 1971). In the soil, K varies according to development of the macro porosity development rather than to soil texture. Thus, most studies try to relate K to part of the macro porosrity that is called effective porosity as shown in the figure 1.

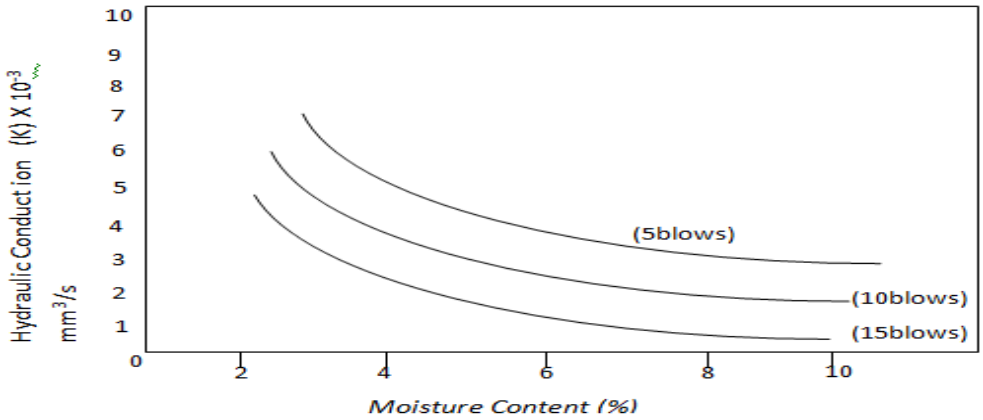

Fig 1: Saturated hydraulic conductivity for Agricultural soil
(Computed after laboratory test I University of Maiduguri, Nigeria, 2004)

In contrast, the compaction curves recorded with the soil in net condition proved that the different numbers of blow moves down wards from 10 blows to 15 blows

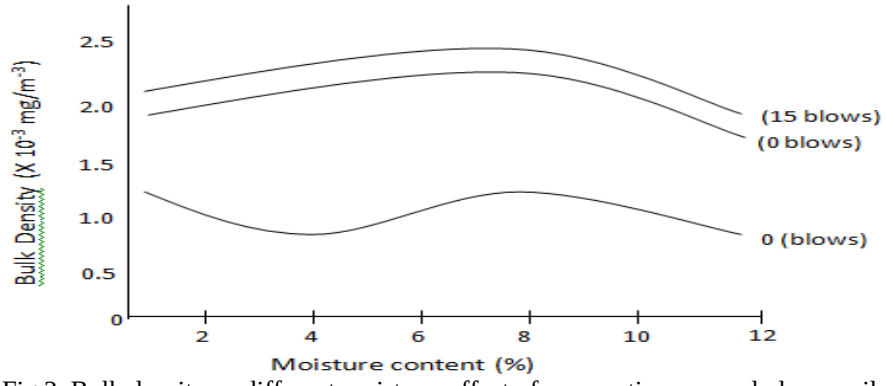

Fig 2. Bulk density vs different moisture, effect of compaction on sandy loam soil.

Figure 2: Shows the increase in bulk density as a result of increase in the penetration resistance with significant consequences for root development, although there is no clear relation with penetration resistance (Mullin et al. 1987)

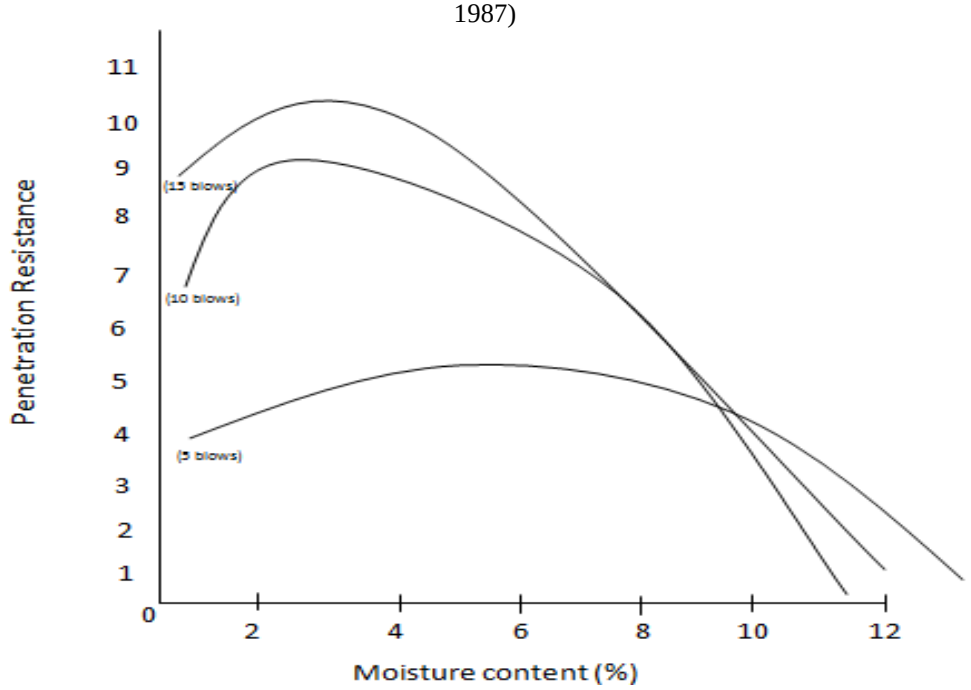

Fig 3: Penetration resistance of prominent soil subjected to three compaction levels computed

In figure 3: Effect of combined deep tillage and controlled traffic on penetration resistance and its consequence for root growth has been studied in several countries. Bruend et al. (2007) recorded a penetration resistance ranging from 0.03 to 0.35 mpa in the subsoil of sandy soil, when water content ranged from 0.03-0.09kg kg. kukal and Aggarwal (2003) measured penetration resistance in sandy loam soil, ranges from 3.0 to 4.5mpa. In the study area, 4.67–7.44mpa penetration resistance value was recorded which was Subjected to three compaction levels in laboratory.

The Consequences of Soil Compaction on Soil Physical Properties

The result of this study showed that compaction has influence on subsoil properties as pressure cause by movement of heavy tractor changes numerical values of bulk density and penetration resistance. Therefore, as can be seen in figure 2 compaction increases bulk density and hence reduces pore space for water and nutrient infiltration.

The Negative Effect of Soil Compaction for Plant Growth

Excessive compacted soil can slow down the rate of seed germination because it will not allow good contact between the seed and soil. It impedes root growth, decreases the plant's ability take up nutrient and water. In dry years, soil compaction can lead to stunted, drought stressed plants due to decrease root growth.

IV. CONCLUSION

The results of this study showed the effect of soil compaction have negative impact on physical properties of soil and plant growth. The average penetration resistance ranges from 4.67–7.44mpa. The influence of compaction on agricultural soils affects seed germination and root development. It impedes nutrients and water infiltration in agricultural productive soils.

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