EFFECT OF TRACTOR, TRAFFIC COMPACTION ON INFILTRATION RATE OF AGRICULTURAL SOIL IN FEDERAL POLYTECHNIC, MUBI IN ADAMAWA STATE

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ABSTRACT

The effect of tractor, traffic compaction on infiltration rate of agricultural soils was examined on the field. The implements chosen for the experiment was Massey Ferguson four wheel drive model M.F. 435 with weight 3951kgt. The plough used was disc plough of weight 470kgt. Field sizes (4m wide and 20m long) were measured and marked out using tape and pegs. The tractor was driven to the marked edge of the field and was engaged in gear two. The speed of the tractor was 5km/h which was maintained throughout the practical by using the hand throttle. The tractor was driven along the length of the field. The number of passes of the tractor was varied (1, 2, 3, 4 and 5). For each number of passes the bulk density of the soil and infiltration rate where the tires of the tractor passed was measured. The result revealed that bulk density increased as the number of tractor passes increased, while infiltration rate decreased with increase in bulk density. A simple linear regression analysis of infiltration on bulk density was performed using computer soft ware which yielded equations. For a given bulk density of soil the infiltration rate can be calculated from the derived equations.

Key words: Tractor, Field Compaction, infiltration.

INTRODUCTION

Water is applied to the surface of land either directly by rain or through irrigation (except sub-surface irrigation) where it subsequently enters the soil and is stored for later use by plants. Thus rate of entry of water into soil under field condition is of fundamental importance, unless sufficient water enters the soil and is store there in, crop growth is significantly reduced. Infiltration is the process by which water enters the soil (young 1955). Infiltration rate is the soil characteristics determining the mass rate at which water can enter the soil under specific condition factors such as soil structure, texture, porosity and bulk density affect infiltration rate of a soil (Iya and Umar 1999). Dusa (2007) reported that infiltration rate of a soil decrease with increase in bulk density. The bulk density of a soil changes with natural and artificial processes in the field. Changes in the volume of soil in a field are primarily by natural processes such as shrinkage with drying, consolidation with drainage, swelling with infiltration and with artificial procedures such as traffic compaction and tillage (Iya and Umar 1999). The use of heavy machinery such as tractor leads to compaction of soil. If soils are worked when the moisture content is about a friable range and into the plastic state they are more readily compacted to form impermeable layers and pans. The smearing caused by implements or spinning of tractor wheels seals off the soils interconnecting system of pores. The seals reduce infiltration rate of the soil resulting to run off (Goyal 1980 and Nelson 2003). Compactions produced by heavy machinery are frequently the cause of slow infiltration of a soil leading to pounding of water and excessive runoff.

Dowkins (1983) reported 28% reduction in yield of cowpea due to soil compaction by tractor traffic. Compaction causes low infiltration of water into soil pores resulting in erosion of top soil and nutrients, formation of gulley and flooding. Several researchers (Ohu 1985, Allmaras 1996, Iya and Umar 1999, Dusa and Yaduma 2003 and Dusa 2007) have worked on infiltration and saturated hydraulic conductivity in different places.

Agriculture happens to be the prominent occupation of the people of Mubi North and South Local Government areas. At the time of study there was no statistical data evidence of farm machinery traffic. The area however, falls in the region where many individuals owns and uses tractors in addition to the state tractor hiring unit operations. Over use of farm machinery on a given pieces of land with time will constitute a serious compaction leading to low soil infiltration and consequently low crop yield. Therefore this study was carried out to evaluate the effect of tractor traffic compaction on infiltration rate of the soil in the area of study with the view to make some recommendations regarding the use of machine in order to increase crop yield.

MATERIAL AND METHOD

The study area is Federal Polytechnic; Mubi which is located on latitude 10° 16′ N and latitude 13° 17′ E, field experiment was conducted within Federal Polytechnic, Mubi campus at the following locations: irrigation farm, project farm, Demonstration farm, departmental farm and plot near animal farm. The selected locations have been under cultivation for at least the previous five years using disc plough as an implement for primary tillage. These locations were selected because they represent the common five soil type: sand, sand loam, sandy clay, Clay loam and clay respectively as shown by the result of the particle size distribution analysis table (Table 1). The implements chosen for the experiment was Massey Ferguson 4 wheel drive model M.F 435 with weight 3951kgt. The plough used was disc plough of weight 470kgt. Fields of sizes (4m wide a 20m long) were measured and marked out using tape and pegs. The tractor was driven to the marked edge of the field and was engaged in gear two (the usual gear used by the operators in this area during ploughing).

The speed of the tractor was 5km/h which was maintend throughout the practical by using the hand throttle. The tractor was driven along the length (20m) of the field. The numbers of passes of the tractor were varied (1, 2, 3, 4 and 5). For each number of pass, the bulk density of the soil and infiltration rate where the tires of the tractor passed was measured. Also before the commencement of the experiment, the bulk density, infiltration rate, moisture content and organic matter content of the soil at the five locations were measured. The infiltration rate of the soil was measured using double ring infiltrometer as directed by Richard (1989). While the bulk density was determined using core sample method as adopted by Lambe and Robert (1979). The organic matter content (OM) was determined by following the Potassium dichromate method (Steven 1965). The soil moisture content on dry bases was measured by oven dry method as stated by Blake (1965). While the particle size distribution was obtained by hydrometer method following the procedure of Lambe (1951). These tests were performed three times at each number of passes at the five locations.

The average infiltration rate of the three tests were determined and plotted against corresponding soil bulk density values. A simple linear regression analysis of infiltration on bulk density was performed using computer soft ware which yields equations estimating infiltration rate of the soil types based on their bulk density.

RESULT

The results of the particle size analysis for the five soils were presented in Table 1. While the results of the bulk density, infiltration rate and moisture content of the soils before experiments were shown in Table 2. The summary of the simple linear regression of infiltration on soil dry bulk density for the five soil types were presented in Table 3.Table 4 contain the regression equation for predicting infiltration for the five soil type s. Figure 1 shows the relationship between tractor passes and bulk density. While Figure 2 indicates relationship between bulk density and infiltration rate for the five soil types.

Table 1: Particle Size Analysis for the Five Soil Samples.

Location	Soil Type	Sand (%w/w)	Clay (%w/w)	Silt (%w/w)	Organic matter (%w/w)
Irrigation farm	Sandy	89	6	5	0.72
Project farm	Sandy loam	76	15	9	0.82
Demonstration Farm	Sandy clay	47	49	4	0.37
Dep'tal farm	Clay loam	37	41	22	0.37
Animal farm Area	Clay	5	60	35	0.63

Table 2: Bulk Density, Infiltration Rate and Moisture Content of the Soils before Experiment.

Soil type	Dry bulk density (gcm^{-3})	Infiltration (Mm/h)	Soil moisture content (%w/w)
Sand	1.01	35.01	6.7
Sandy loam	1.02	34.1	6.9
Sandy clay	1.1	34.01	7.1
Clay loam	1.01	35.1	7.00
Clay	1.11	31.21	7.2

Table 3: Summary of the Simple Linear Regression of Infiltration Rate (I) on Dry Bulk Density (B) for the Various Soil Types.

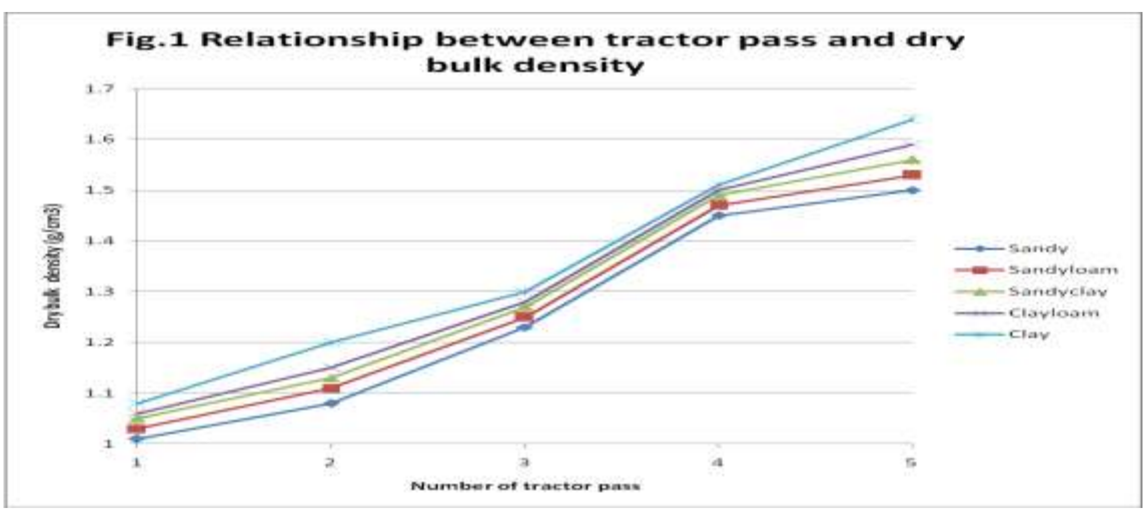
Soil type	Function	C	B	R
Sand	1=C+BX	47.41	-12.76	0.98
Sandy loam	1=C+BX	44.63	-11.95	0.95
Sandy clay	1=C+BX	46.78	-13.41	0.99
Clay loam	1=C+BX	43.72	-10.93	0.92
Clay	1=C+BX	45.31	-12.33	0.95

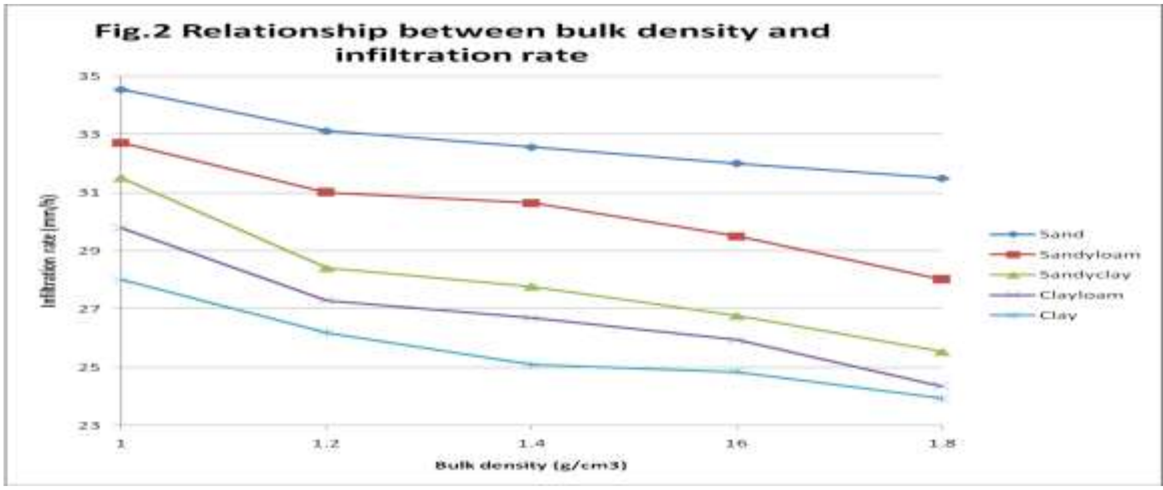
C" and B" are regression coefficient
R" is correlation coefficient
X" is the dry bulk density
I" is the infiltration rate.

Table 4: Regression Equations for Predicting Infiltration Rate for the Five Soil Types.

Soil type	Regression equations	R
Sand	1=47.41 - 12.76X	0.98*
Sandy loam	1=44.63 - 11.95X	0.95*
Sandy clay	1=46.78 - 13.41X	0.99*
Clay loam	1=43.72 - 10.93X	0.92
Clay	1=45.12 - 12.33X	0.95*

I - Infiltration rate
X -Dry bulk density (g cm^{-3})
* - All values are significant at 0.05 levels.





DISCUSSION

It will be observed that the soil represent different texture classification ranging from sand to Sandy clay and Clay (table1). The Sand to Sand clay soils are classified as "Typic ustipsamments" while the clay soils are classified as vertisol (FAO/UNESCO 1974. Soil Survey Staff, 1975). All the soils studied exhibited a similar behavior; as the number of tractor passes increased the bulk density increased. While the infiltration rate decreased with increase in bulk density (Figures 1 and 2). Farmers and agronomist should therefore reduce the number of tractor passes as much as possible during field operation. By combining other farm operations such as planting and fertilizer application in one pass and also by choosing turning patterns that will not involve back and forth movement of the farm machine in the same place. For a given bulk density sand has the highest infiltration rate followed by sandy loam, sandy clay, clay loam and lastly clay (Fiure2). Similar typical behavior of infiltration rate with bulk density has been reported by Dusa (2007) and Richard (1989).

The trend of results so obtained could be due to the reduction of the micro pores with corresponding increase in bulk density by tractor traffic compaction which automatically kept in changing the structural pattern of the soil. The effect of organic matter and moisture content of the soil before experiment on infiltration rate of the soils were not significant (at $p < 0.05$ level of significance). As could be observed in Table 2 the soils exhibited inconsistent and low level of organic matter and moisture content from one type to the other. Hence the effect of organic matter and moisture content before the experiment in this study can be said to be negligible. Following the procedure of simple regression as described by Gomez and Gomez (1996) the data fitted reasonably well according to straight line equation, $I = BX + C$. Where,

I - Infiltration rate (mm/h)
B - Slopes of the line
X - Dry bulk density
C - Constant.

The infiltration rate and dry bulk density values of all soils used in this study at all number of tractor passes were used to generate expressions for predicting infiltration rate values for a given dry bulk density. The summary of the analysis was presented in Table 3. This exercise produced a linear regression equation (see Table 4). The equation would be useful in quick estimation of infiltration rate of a given soil texture when the dry bulk density is known. Consequently field experiment involving ring infiltrometer and tractor will be avoided especially in areas where such equipments are not readily available.

CONCLUSION

The result from this study revealed that bulk density and infiltration rates are influenced significantly by number of tractor passes and dry bulk density of the soil respectively. Bulk density increased with increase in number of tractor passes while infiltration rate decreased with increase in soil field bulk density. Also the relation between infiltration rate and bulk density established in this study can be used for quick estimation of infiltration rate for a given soil texture when its dry bulk density is known.

REFERENCE

Blake L.G. 1965.Soil analysis part 1 *Am Soc. Of Agronomy* Academic Pres Inc. 374 – 390.

Dusa A.A. 2007. Field determination of soil infiltration of some selected area in Hong locality. *Journal of engineering and Environmental Technology Vol. 3, 18 – 21.*

Dusa A.A. and P.S. Yaduma .2003. Relasionship between bulk density and saturated hydraulic conductivity of Agricultural soil in Adamawa state *Journal of league of Researchers in Nigeria Vol. 4 (1): 83 – 90.*

Dawkins T.C.K. 1993. Crop reaction to compaction *Journal of soil & water 7:25.*

FAO/UNESCO .1974. *Soil mao Pt the world* 1: 5,000,000 Vol. 1 legend sheet and memoirs Paris pp. 59.

Goyal .1980.*A study on soil crusting*; BSc project. Silsoe College Cran field Institute of Technology; England.

Iya S.A. and A. M.Abubakar.1999. Evaluation and Effect of hardpan formation on the physical and organic soil properties and seedling Emergency in Song and Girei Local Government Areas of Adamawa State. *Journal of Applied Science and management Vol. 3, 70 – 76.*

Lambe T.W. 1951. Soil testing for Engineering John Willey and Sons, New York N.Y. p: 72 – 83.

Lambe .W. and W.V. Robert .1979. *Soil Mechanics*. John Willey & Sons Inc. New York N.Y. p: 62 – 78.

Nelson H.Y. 2003. Determination of the hydraulic conductivity of some soil samples in Mubi Locality.*Journal of science and management* Vol. 7: 60 – 63.

Ohu, J.O V.S.G; Reghavan and E. Mckyes .1985. Peatmoss effect on th physical and hydraulic characteristics of compacted soils Trans. *Am Soc. Agric Engineering.* 28 (2): 420 – 424.

Richard H.C .1989. New York pp. 120 – 135.

Stevenson J.F. 1965. Method of soil analysis part 2. *American Society Agronomy Inc.* Madison. USA p. 1409 – 1421.

Soil Survey Staff .1975. *Soil taxonomy: A basic system for making and interpreting Soil Survey USDA SCS Agric*. Hand book 436. US Government printing office Washington D.C p. 754.

Youngs E.G. 1995. Development in the physical of infiltration*. Soil science Soc. Am.J.* 54: 629 636.