EFFECT OF DIFFERENT TRACTOR TRAFFICS ON PHYSICAL PROPERTIES OF SOIL (A Report)

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ABSTRACT: *The field experiment was performed to find out the impacts of tractor traffic on soil physical properties conducted at Latif Experimental Farm of Sindh Agriculture University Tandojam. The operations performed were, Controlled Traffic with Cultivator (T_1), Random Traffic with Cultivator (T_2) and Random Traffic with Disc Harrow (T_3). Experiment was laid down on nine plots and samples were taken at a depth of 10, 20, 30 cm. The parameters to be determined were soil texture, bulk density, moisture content, penetration resistance, soil aggregation, effective plowing depth and effective plowing width. The experimental result revealed that soil texture was found to be clay loam; moisture content for T_1, T_2 and T_3 was 26.64%, 25.1% and 25.8% respectively. Bulk density, soil compactness and soil aggregation was less in T_1 as compared to T_2 and T_3. The abstraction appropriate that controlled traffic is suitable for tillage practices for clay loam soils.*

Keywords: Controlled traffic, random traffic, soil texture, bulk density, moisture content, penetration resistance, soil aggregation effective plowing depth and width.

INTRODUCTION

Tillage has been an important aspect of technological development particularly in food production. It is one of the most critical operations conducted on a farm each season and it aims to place the soil in the best physical condition for the crop to be grown including seedbed preparation (grounding), water and soil conservation and weed control. It is necessary to study the effect of deep and shallow tillage practices on soil properties, crop growth and yield [4]. Vehicular traffic and puddling resulted in formation of compacted subsoil layer in the root zone at 10-40 cm depth that restricts the root growth and root density of plants. The reduction in root growth and density further decreases nutrient uptake and ultimately crop yield [7]. Change in the structure of soil caused by numerous tillage tools and their impacts on growth of plant which vary from one region to another, as well as soil to soil. A field experiment was conducted to appraise the effects on the bulk density and infiltration rate of loamy sand soil caused by tractor wheel compaction. Among various treatments 4-passes of tractor caused 69% fall in infiltration rate of soil whereas utmost compaction up to 77% was observed with 8-passes of tractor [2]. Physical effects, i.e aggregate stability, infiltration rate of soil and water conservation directly effects soil productivity and sustainability. Barken L. A. *et al.* conducted an experiment where denitrification rate, structure of soil and wheat yield were to be determined. Tractor traffic reduced pore volume, increased (almost doubled) the percentage of large aggregates and minimized wheat productivity by 25% [3]. Effects of tillage on some main physical parameters such as soil aggregation, temperature, water infiltration and retention have been reported in large scale. It is affirmed by researchers that soil compaction with farm machinery resulted a decrease in hydraulic conductivity; one and four passes gave lowest values with 1.5 and 0.08 mm hr^{-1}, respectively [8, 10]. An experiment was conducted by Mari G. R. and Changying J. They stated that the penetration resistance and bulk density resulted a positive relationship between them while penetration resistances showed a negative relationship [9]. The most common causes for soil compaction are agricultural machines such as tractors, harvesters and various other cultivation implements, as wheels travelling over moist and loose soils [1]. Experimental data have been published on the large capacity in a variety of climatic conditions, agro-ecological conditions, soil, crops and crop residue management systems on tillage affects. An experiment was placed to examine the effects of conservation tillage on soil aggregate characteristics. Cyclotiller with three tillage systems was used with speed of 150, 200 and 250 rpm at depth of 200mm. It resulted that bulk density and cone index significantly increased with increasing speed of cyclotiller, passes of tractor and appropriate blade speed cyclotiller used in all three mentioned depths and can determinately decrease the potatoes yield, [6]. A thick compacted layer builds up in the root zone as a consequence of poor tillage practices, primarily as a result of the farmer failing to vary the depth of ploughing over several years [12]. Tillage before planting in the soil can achieve a good rate of return for which the soil is the most essential natural resource. There is no substitute for soil as a plant growth medium; therefore it is necessary to study the soil. Tillage on a variety (physically, chemically and biologically) affects both beneficial and degrading to soil, subjected to whether appropriate or otherwise used methods. The soil not only provides bed for holding plants, but also supplies nutrients, moisture, organic matter, etc. to plants during their growth. To obtain the better yield and best performance it is all-important to study the physical properties of soil in relation to the implementation of the performance of the tractor. Plant growth is affected by increasing resistance to root penetration and in result a decrease in uptake of water and ions [11]. Tilling the soil is the most intense of all process involving the production of crops. These effects are compressed more by repetition of segments of agricultural machinery during the production of crops. In continuation of tractors over farmland, it not only compresses the plow layer, but also has a significant effect on crop growth and productivity. Problems related to water, air, temperate regime, mobilization of nutrients and costs can be resolved by implementing right tools for preparation of primary and secondary bed for soil.

MATERIAL AND METHODS

The field experiment was performed to find out the impact of tractor traffic on soil physical properties with controlled and random traffics. The experiment was conducted at Latif Farm of Sindh Agriculture University Tandojam. The operations performed were, controlled traffic with cultivator (T_1), random traffic with cultivator (T_2) and random traffic with disc harrow (T_3). The experimental design was randomized complete block design (RCBD) and was laid down on nine plots with size of sub plots of 25m x 09m. Samples were taken at the depth of 10, 20 and 30cm.

Soil Texture

Soil texture was determined by hydrometer method. Collected soil samples were dried in open air. 1/3 of water was filled and 10 ml of sodium hexameta phosphate was added to the dispersion cup. Dispersion machine for 5-10 minutes was used for dispersing the material and readings were taken after two hours.

Bulk Density

Samples were collected randomly in different places at a depth of 10, 20 and 30 cm respectively with the core sampler of 2cm diameter. Collected samples were weighed and placed in oven for drying at a temperature of 105 ^{O}C for 24 hours.

$$B = \frac{Wd}{V} = \frac{4Wd}{3.14d^2 L}$$

Moisture Content

Core sampler of 2cm was used to collect soil samples at different depths. Collected samples were weighed and placed in oven for drying at a temperature of 105 ^{O}C for 24 hours and was calculated as follow,

$$M.C = \frac{Mw}{Md} \times 100$$

Penetration Resistance (Soil Strength)

Penetration resistance was measured directly using CN-973 cone penetrometer, which consists of 30^{O} cone, square inch base area, extension rod (18 inch), ring dial indicator and a handle. When the cone is forced into the ground, the amount of force required to move the cone into the ground, is indicated on the dial inside the ring.

Soil Aggregation

Soil aggregation and pulverization were evaluated using the group of ten sieves which were of mesh (75mm, 63mm, 50mm, 37.5mm, 31.5mm, 25mm, 15.60mm, 12.50mm, 8mm, 2.36mm). For determination of soil aggregation on the basis of mean weight diameter of soil clods, twelve samples were randomly taken.

$$\text{Mean soil clod diameter} = \frac{ZwD}{Zw}$$

Effective Plowing Width and Depths

Measuring tape was used to measure the working width and depth of cultivator and disk harrow.

RESULTS AND DISCUSSION

Soil Texture

Soil was found to be clay loam. Textural class was clay at 10 cm with 30.5% sand, 24.1% silt and 45.8% clay. At the depth of 10-20cm texture class was clay loam with 22.6% sand, 36.6% silt and 40.8% clay. Similarly at the depth of 20-30cm the textural class was same clay loam with 32.6% sand, 31.6% silt and 35.8 % clay.

Moisture Content

The soil moisture content for controlled tractor traffic (T_1), uncontrolled tractor traffic cultivator (T_2) and uncontrolled tractor traffic disk harrow (T_3) were 26.64%, 25.1% and 25.8% respectively and is shown in figure 1.

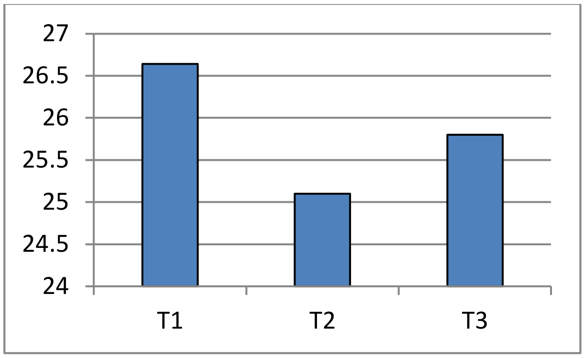

Figure.1. Moisture content at different operations (T_1, T_2 & T_3)

Bulk Density

The result for bulk density is shown in figure 2. Bulk density at 0-10cm depth was 0.93, 1.01 and 1.11 gm/cm^3 for T_1, T_2 and T_3 respectively. Bulk density at 10-20cm depth was 1.04, 1.07 and 1.13 gm/cm^3 for T_1, T_2 and T_3 respectively. Bulk density at 20-30cm depth was 1.27, 1.31 and 1.28 gm/cm^3 for T_1, T_2 and T_3 respectively.

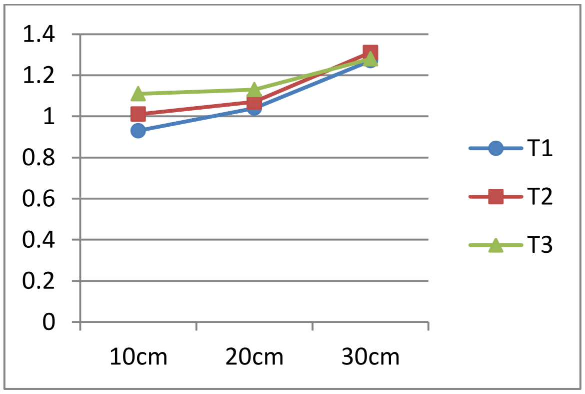

Figure.2. Bulk density at different depths of operations T_1, T_2 & T_3

The regression equation of the relationship between bulk density (B) and depth of soil are given as,

$$B_{T1} = 0.017D + 0.74$$
$$B_{T2} = 0.015D + 0.83$$
$$B_{T3} = 0.008D + 1.003$$

The coefficients of determination (R^2) obtained were 0.960, 0.892 and 0.836 for T_1, T_2 and T_3, respectively.

Penetration Resistance (Soil Strength)

The result for penetration resistance is shown in figure 3. Penetration resistance at top of soil was 264.66, 291.33 and 472.33 KN/m^2 for T_1, T_2 and T_3 respectively. Penetration resistance at depth of 10cm of soil was 297.66, 327.33 and 521 KN/m^2 for T_1, T_2 and T_3 respectively. Penetration resistance at depth of 20cm of soil was 504.11, 522.88 and 607.22 KN/m^2 for T_1, T_2 and T_3 respectively.

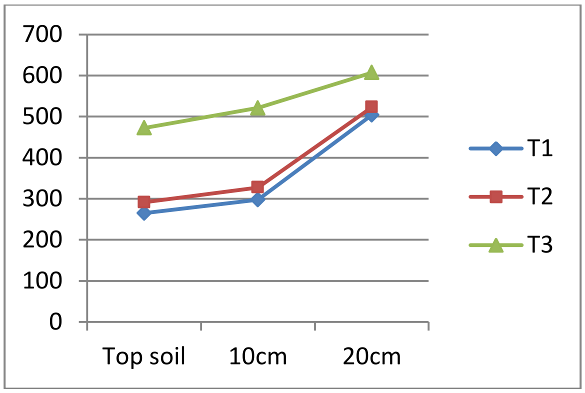

Figure.3. Penetration resistance at different depths of operations T_1, T_2 & T_3

The regression equation of the relationship between penetration resistance (P) and depth of soil are given as,

$$P_{T1} = 11.97D + 116.0$$
$$P_{T2} = 11.57D + 148.9$$
$$P_{T3} = 6.744D + 398.6$$

The coefficients of determination (R^2) obtained were 0.851, 0.863 and 0.974 for T_1, T_2 and T_3, respectively.

Soil Aggregation

The result for soil aggregation is shown in figure 4. Soil passing the sieve of 37.5mm was weighted to be 0.66, 1.52 and 1.63 kg for T_1, T_2 and T_3 respectively. Soil passing the sieve of 31.5mm was weighted to be 0.45, 0.32 and 0.26 kg for T_1, T_2 and T_3 respectively. Soil passing the sieve of 25mm was weighted to be 0.34, 0.25 and 0.35 kg for T_1, T_2 and T_3 respectively. Soil passing the sieve of 15.6mm was weighted to be 0.91, 1 and 1.06 kg for T_1, T_2 and T_3 respectively. Soil passing the sieve of 12.5mm was weighted to be 0.54, 0.55 and 0.74 kg for T_1, T_2 and T_3 respectively. Soil passing the sieve of 8mm was weighted to be 1.23, 1.75 and 1.27kg for T_1, T_2 and T_3 respectively. Soil passing the sieve of 2.36mm was weighted to be 2.61, 3.27 and 2.95 kg for T_1, T_2 and T_3 respectively.The data related to Sum of weight of soil clods or weight of soil held by a particular sieve was 12.51, 13.01 and 14.65 for T_1, T_2 and T_3 respectively.

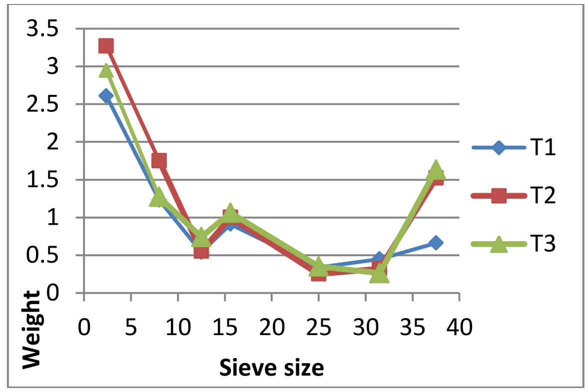

Figure.4. Soil aggregation at different operations (T_1, T_2 & T_3)

The regression equation of the relationship weight of soil retained (W) and sieve size are given as,

$$W_{T1} = -0.043S + 1.791$$
$$W_{T2} = -0.047S + 2.126$$
$$W_{T3} = -0.035S + 1.857$$

The coefficients of determination (R^2) obtained were 0.509, 0.319 and 0.248 for T_1, T_2 and T_3, respectively.

Effective Plowing Width and depth

The result for effective plowing width and depth is shown in figure 5. Effective plowing width observed was 2.8, 1.73 and 1.64m for T_1, T_2 and T_3 respectively. Effective plowing depth observed was 0.16, 0.15 and 0.13m for T_1, T_2 and T_3 respectively.

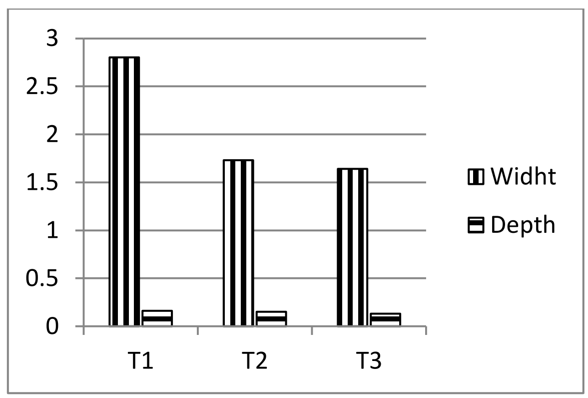

Figure.5. Effective Plowing Width and depth of different operations (T_1, T_2 & T_3)

CONCLUSION

It is concluded that higher moisture content retained minimum bulk density, reduced penetration, and good soil pulverization under controlled traffic with cultivator as compared to random traffic with cultivator and disc harrow. While no significant difference was observed in terms of effective plowing width and depth.

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