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Impact of Farm Machinery (Tractor) uses in Various Physical Properties of Soil

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Abstract—*Today is the age of farm mechanization. The engineering and technological improvements in world agriculture since mid-sixties have brought about revolutionary increase in agricultural production. There has been increase in the use of farm machinery in agriculture as it contributed to the increase in output due to timeliness of operations and increasing precision in input application. A research was conducted in Chitrakoot region of Madhya Pradesh, India to find the impact of farm machinery (tractor) uses on soil physical properties. Three numbers of fields, A, B and C were taken as the experiment area and the results were compared accordingly. Field A, B and C has no tractor passage, has minimum tractor passage and has maximum capability of tractor passage, respectively. The soil samples from all the three fields were collected on random basis with the help of soil core cutter. Different soil physical properties were analyzed like moisture content, density, specific gravity, porosity, void ratio and infiltration rate before cultivation. The result analysis of soil revealed that the average moisture content, density, specific gravity, porosity, void ratio and infiltration rate was 3.3%, 0.00143 g/cc, 2.62, 0.46, 0.877 and 23.5 mm/hr., respectively for field A; 2.2%, 0.00154 g/cc, 2.57, 0.40, 0.692 and 11.4, mm/hr., respectively for field B; 1.5%, 0.00163 g/cc, 2.29, 0.28, 0.43 and 1.28 mm/hr., respectively for field C. The result concluded*
that field A have a very good retention ability of the physical properties of soil as compared to the other fields. The conclusion have been made by this research that the agricultural machinery(tractor) results in more compaction to the soil and have a great impact on the physical properties of soil.

Keywords*: Agriculture, farm machinery, mechanization, soil physical properties and tractor.*

1. INTRODUCTION

Today is the age of farm mechanization in world scenario. The population is continuously increased since last few decades, so it is very difficult to achieve high yield by using traditional methods of agriculture. The use of farm machinery brings new revolution in agriculture production since last 50 years**.** The current technologies of crop cultivation imply multiple passages of agricultural vehicles on the field. Soil compaction under the effect of tractors and other vehicles deteriorates the physical properties of the soil, decreases its fertility, and reduces the yield of the agricultural crops [1, 2]. Soil compaction is a major environmental problem in modern agriculture. The overuse of machinery has been identified as the main reason for soil compaction [7,12] that is, decrease in pore space. Such compaction is one of the most important factors responsible for soil physical degradation [4]. The work of tractors and other agricultural vehicles in fields is accompanied by their vibrations, which deteriorate the soil fertility because of the increase of the compacting impact on the soil [5]. Soil compaction due to field machinery traffic is observed as shrinkage at the surface, which is the cumulative effect of deformation beneath the Surface [6,7].

A following research study was conducted to find the impact of farm machinery (tractor) uses on soil physical properties. Three cultivated fields, A, B and C were taken as the experiment area and the results were compared accordingly. Field A, B and C has no tractor passage, has minimum tractor passage and has maximum capability of tractor passage, respectively. The soil samples from all the three fields were collected on random basis with the help of soil core cutter. Different soil physical properties were analyzed like moisture content, density, specific gravity, porosity, void ratio and infiltration rate before cultivation. The objective of research was to find out the impact of tractor on the soil physical property and compression between the all the three fields.

2. MATERIAL AND METHODS

2.1 Experimental site

The investigation site was located at near the MGCG University campus of Chitrakoot (MP) India. This location was selected because large no of cultivation is performed by the tractor and plough. In this region generally the sandy loam soil is found. There are three field were under investigation A, B and C, respectively. The study for farm machinery impact on soil physical properties was done in the month of april-june 2014.

2.2 Experimental plan

The experiment was carried out on different soil physical properties of Sandy loam soil and they were analyzed in this research work like moisture content, density, specific gravity and infiltration rate. The soil samples were taken for study between depths of 10-25 cm. There are different apparatus and methods were used for the determination of the physical properties of soil.

2.2.1 Moisture Content

Moisture content of soil is determined by the rapid moisture meter or calcium carbide method. This test is done to determine the water content in soil by calcium carbide method as per IS: 2720 (Part II) – 1973. It is a method for rapid determination of water content from the gas pressure developed by the reaction of calcium carbide with the free water of the soil. From the calibrated scale of the pressure gauge the percentage of water on total mass of wet soil is obtained and the same is converted to water content on dry mass of soil. The apparatus and material is used for this experiment is Rapid moisture meter, electronic weigh, spatula, steel ball, absorbent and soil sample.

2.2.2 Density

The density of soil is determined by the Core Cutter method. Apparatus that are used for the density determination are cylindrical core cutter, Steel rammer, Steel dolly, Electronic Balance, Scale, spatula. For determination of the density of the soil, the cutter is pressed into the soil mass so that it is filled with the soil. The cutter filled with the soil is lifted up. The mass of the soil in the cutter is determined. The dry density is obtained as

$$\rho = \frac{\gamma}{1+W} = \frac{M/V}{1+W} \ldots\ldots (1)$$

Where

M= mass of the wet soil in the cutter (g)

V= internal volume of the cutter (cm^3)

w= water content

2.2.3 Specific gravity (G)

The specific gravity is determined by the pycnometer method.

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)} \ldots\ldots (2)$$

Where

M_1=mass of empty Pycnometer. (g)

M_2= mass of the Pycnometer with dry soil (g)

M_3= mass of the Pycnometer and soil and water. (g)

M_4 = mass of Pycnometer filled with water only. (g)

G= Specific gravity of solids

2.2.4 Infiltration rate

There are many methods are available for finding the infiltration rate on the field but in this study the double ring infiltrometer is used having the inner and outer ring diameter 18 inch and 24 inch respectively.

Insert the both rings with minimum disturbing the soil profile up to 5 cm in field. By Placing the measuring bridge on top of the ring and by filling the water and takes a reading after s time intervals of 5 mints to 3 hours.

3. RESULT AND DISCUSSION

The objective was set for this study is to find out the impact of farm machinery on soil physical properties. Under this the first result was the moisture content of fields A, B and C was 3.3%, 2.2% and 1.5% respectively. There is a huge difference between the all three fields (fig 1) A has good moisture retention whereas the C has minimum amount of moisture retention which shows that tractor disturb the water holding capacity of soil.

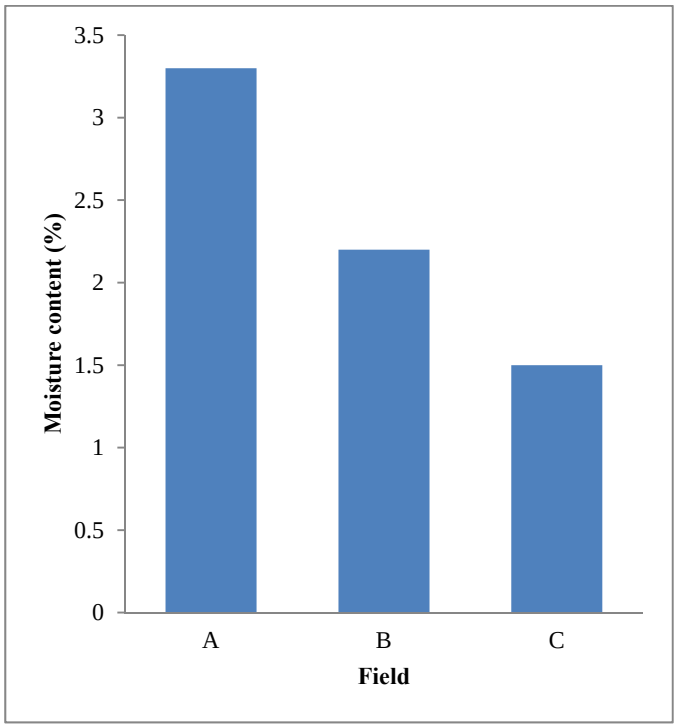

Fig. 1: Moisture content variation observed in fields.

The density of the fields A, B and C was 0.00143 g/cm^3, 0.00154 g/cm^3 and 0.00163 g/cm^3, respectively. Density of all three fields is also very different form each other (fig 2) field C was found denser compare to the field A.

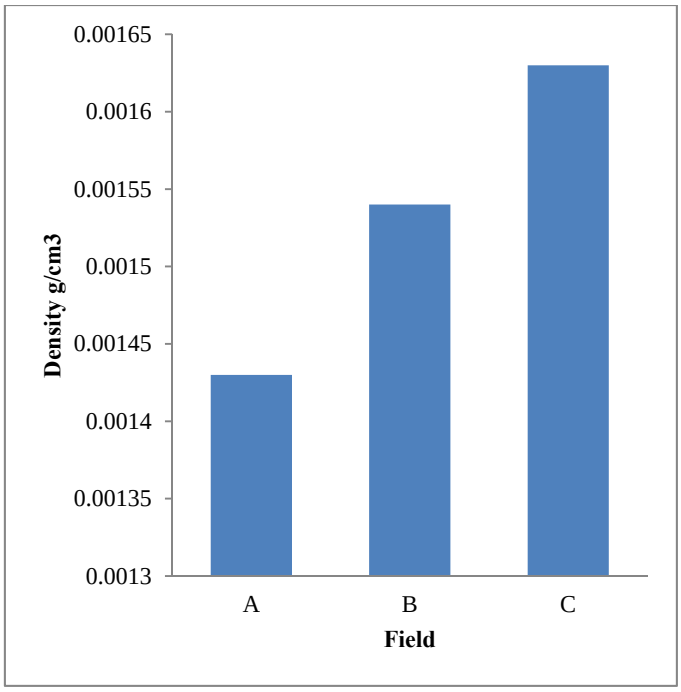

Fig.2: Density variations observed in fields.

Specific gravity of is also an important soil physical property. The value of specific gravity (fig 3) of field A, B and C was very between 2.62, 2.5 and 2.29, respectively. This result shows that the impact of farm machinery cannot bring much change in the specific gravity of the soil.

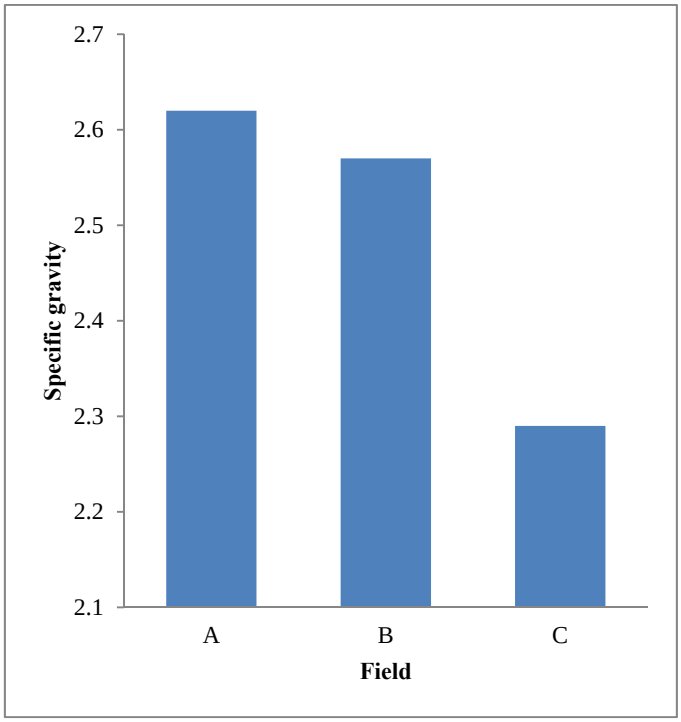

Fig. 3: Specific gravity variations observed of fields.

Infiltration is the main soil physical factor that has huge variation among all three fields (fig 4). Because of the high soil compaction the infiltration rate is low which shows that the field C is much compacted then the field A. The result of field A, B and C was 23.52 mm/hr., 11.4 mm/hr. and 1.3mm/hr., respectively. The rate of downward movement of soil is decreased, that result in poor crop yield.

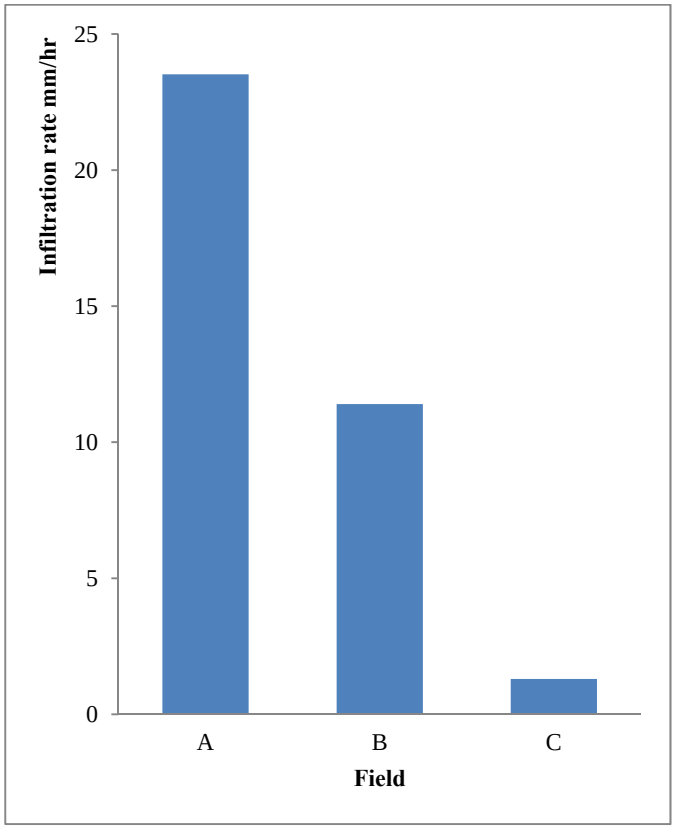

Fig. 4: Infiltration rate variations observed in fields.

Table 1: Different variations of soil physical properties observed in all fields.

Properties↓/Field→	A	B	C
Moisture content (%)	3.3	2.2	1.5
Bulk density (gm./cm3)	1.43*10-3	1.54*10-3	1.63*10-3
Dry density (gm./cm3)	0.62*10-3	1.54*10-3	1.63*10-3
Specific gravity	2.62	2.57	2.29
Infiltration (mm/hr.)	23.52	11.4	1.3
Wet unit mass (g/cm2)	1.414	1.52	1.61
Wet unit wet (kN/m3)	13.87	14.91	15.8
Dry unit wet	13.87	14.91	15.8
Unit mass of solid	1.396	1.52	1.609
Volume of solids	0.533	0.63	0.71
Volume of voids	0.466	0.41	0.264
Void ratio	0.877	0.692	0.432
Porosity	0.466	0.40	0.28

After determining these soils physical properties the following table is obtained of some other properties can be made. Variations is found (table 1) which shows the soil of field is was found batter compare to From all the field and laboratory experiments we conclude that the field(A) which is cultivated only by the animals having less compaction ,higher infiltration rate , rich in moisture content , more specific gravity and other factor like void ratio , density , porosity not having enough difference when compare to the another field (B) where the passes of tractor is minimum is having all the readings medium likewise having medium compaction , low moisture content medium specific gravity but the third field (C) which is cultivated by tractor is possess very high compaction and very low infiltration rate , less specific gravity , no moisture content and all another factors or tests do not have very much different.

Many researchers inform that soil compaction is a form of physical degradation resulting in densification and distortion of the soil where biological activity, porosity and permeability are reduced, strength is increased and soil structure partly destroyed. Compaction can reduce water infiltration capacity and increase erosion risk by accelerating run-off. The compaction process can be initiated by wheels, tracks, rollers or by the passage of animals [7,8].

some soils are naturally compacted, strongly cemented or have a thin topsoil layer on rock subsoil. Soils can vary from being sufficiently strong to resist all likely applied loads to being so weak that they are compacted by even light loads.

In arable land with annual ploughing, both topsoil and subsoil compaction is possible. A feature of compacted soils is the formation of a pan-layer, caused by the tractor tires driving directly on the subsoil during ploughing. The pan-layer is less permeable for roots, water and oxygen than the soil below and is a bottleneck for the function of the subsoil. Unlike topsoil, the subsoil is not loosened annually, compaction becomes cumulative and over time, a homogeneous compacted layer is created. Evaluation of soil compaction due to its negative effect on the rate of agricultural production and plant growth is important because soil compaction can easily reduce yield up to 10% through destruction of soil structure and reduction of water flow into the soil, which can lead to soil degradation [8]. Though precision farming methods that restrict traffic can reduce soil compaction, modern tractors are heavier than in the past with higher capacity of traction and carting resulting in a greater potential for compaction [9,10].

4. CONCLUSION

The experimental study that was conducted in to find out the impact of farm machinery on the soil physical properties has been successfully completed. The conclusions can be made on the basis of the above study that the farm machinery has a great impact on the soil physical properties. Many of researchers have done research and concluded that farm machinery increase the compaction of soil.

Today the application on Engineering and technology agriculture is increasing. Farming by the animal is still very common and popular in rural areas. Farming by animal having advantages for soil structure and cropping yield, but the disadvantages by the animal farming is time taking operation, high labor cost and less production. Most of farmers uses tractor for agriculture and other purpose with the help of costume hiring services but the major disadvantage associated with the tractor is resulting major soil compaction.

An agriculture operation by the animals is natural, cheaper and eco-friendly way of agriculture and most of farmers still use it. But in future agriculture by animal having less scope, farm machinery will take the place of animal.

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