EFFECTS OF TILLAGE ON SOIL PHYSICAL PROPERTIES IN LATERITE SOIL

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DECLARATION

We here by declare that this project entitled **"EFFECTS OF TILLAGE ON SOIL PHYSICAL PROPERTIES IN LATERITE SOIL"** is a bonafide record of project work done by us during the course of project and the report has not previously formed the basis for the award to us for any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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Dedicated to all

Agricultural Engineers

CONTENTS

Chapter No	Title	Page No
i	List of tables	
ii	List of figures	
iii	List of plates	
iv	Abbreviations	
I	Introduction	
II	Review of literature	
III	Materials and methods	
IV	Results and discussion	
V	Summary and conclusion	
v	References	
vi	Appendix	
vii	Abstract	

LIST OF TABLES

LIST OF FIGURES

Fig No	Title	Page No
1	Layout of plot under primary, secondary, primary and secondary together an no tillage	
2	Particle size distribution curve	
3	Variation of moisture content with treatment	
4	Variation of bulk density with treatments	
5	Variation of particle density with treatments	
6	Variation of porosity with treatments	
7	Variation of hydraulic conductivity with treatments	
8	Infiltration curve showing accumulated infiltration and infiltration rate of primary tilled soil	
9	Infiltration curve showing accumulated infiltration and infiltration rate of secondary tilled soil	
10	Infiltration curve showing accumulated infiltration and infiltration rate of primary and secondary tilled soil	
11	Infiltration curve showing accumulated infiltration and infiltration rate of no tilled soil	
12	Comparison of accumulated infiltration, depth of treatments	

LIST OF PLATES

Plate No	Title	Page No
1	Location of plot	
2	Plot undergone primary tillage	
3	Plot undergone secondary tillage	
4	Plot under primary and secondary tillage together	
5	Plot under no tillage	
6	Sieve analysis	
7	Soil sample kept for drying	
8	Core cutter method	
9	Constant head permeameter test	
10	Determining infiltration rate by double ring infiltrometer	
11	Soil pH determination	

Symbols and Abbreviations

°C	Degree Celsius
'	Minute
"	Second
/	Per
%	Percentage
Φ	porosity
µm	micrometre
Acc.I	accumulated infiltration
BD	bulk density
cm	centimetre
D	particle size
Dept.	department
df	degree of freedom
et al.	and other people
etc	etcetera
F-cal	F-value calculated
F-tab	F-value from ANOVA table
h	hour
I_{avg}	average infiltration
J.	journal
K	hydraulic conductivity
k	intrinsic permeability
KCAET	Kelappaji College of Agricultural Engineering and Technology
kg	kilogram
Km	kilometre
ln	natural logarithm

log	logarithm
SWCE	Soil and Water and Conservation Engineering
MB	mouldboard
mg	milligram
min	minutes
mm	millimetre
N	cumulative percentage finer
No.	number
s	second
V	volume
W	water content
T	treatment
R	Replica
NT	No tillage
PT	Primary tillage
ST	Secondary tillage
PST	Primary and secondary tillage together
IR	Infiltration rate

INTRODUCTION

CHAPTER I

INTRODUCTION

In the process of growing crops on farms, we use a number of farming practices to manage soil in the field. These include tilling, cultivating, adding fertilizers and lime, growing cover crops, applying compost or manure, rotating crops, and other practices. Many years of agricultural research have shown us that how and when we use these practices makes a big difference to the quality of our soils. When we use these practices correctly, we can improve soil fertility, soil physical structure, and biological activity, and also protect soils from erosion. Soils that are properly managed for soil quality produce healthier, higher-yielding crops.

Tillage is a technique of manipulating the soil in preparation for crop production. The aim is to manage various characteristics of the soil, such as water retention, temperature, infiltration, and evapotranspiration. The method of tillage has been employed by farmers for hundreds of years. First performed manually, by human workers, tillage was achieved by pulling ploughs through the field, or by using hoofed animals to trample the soil. Now, machinery is used to have the same effect of churning up the soil.

There are several reasons for using tillage in agriculture. The main objective is to create grooves in the soil that are deep enough to successfully plant and grow crops. Other major objectives of tillage include aerating the soil, incorporating crop residues, and killing weeds. Farmers use tillage to ensure the success of their crop yields and by not only promoting a preferable environment for seedling establishment but also by thoroughly incorporating fertilizers and herbicides into the land while controlling for weeds.

The act of tilling soil is an ancient technique, despite the plough machines we are used to in modern times. Using hand held tools like the hoe, or using animals and slaves to turn and trample soil is a many centuries old idea. The human tilling methods include the usage of shovelling, picking, hoeing, raking etc. Later, people began to integrate horse- and oxen-drawn implements initially made from wood and then from iron and steel in following decades. Mechanization replaced draft animals and paralleled the development of the oil and gas industry. Mechanization not only reduces labour requirement but also the time consumed by different farm operations. The applications of machines for agricultural production not only reduce burden and drudgery of farm work, but also increase the efficiency of work. Today, mechanized implements are becoming wired up with sensors, circuits and screens coupled with hydraulics. This allows producers to monitor progress in real time without leaving the tractor's cab, except for the initial adjustments to the field's current soil moisture conditions.

Many tillage operations are designed to loosen and homogenize soil within the zone of tillage, but some tillage operations are intended to shape or firm soil. The practices developed, with whatever equipment used, can be broadly classified into no tillage, primary tillage, secondary tillage, minimum tillage, conservation tillage, conventional tillage and mulch tillage.

Primary tillage is the first soil tillage after the last harvest. It is normally conducted when the soil is wet enough to allow ploughing and strong enough to give reasonable levels of traction. This can be immediately after the crop harvest or at the beginning of the next wet season. When there is sufficient power available some soil types are ploughed dry. crops. Mouldboard plough, disc plough are examples of primary tillage implement. disc harrow, cultivator, rotovator etc are examples for secondary tillage implement.

The objectives of primary tillage are:

- to attain a reasonable depth (10-15 cm) of soft soil with varying clod sizes;
- kill weeds by burying or cutting and exposing the roots
- soil aeration and water accumulation; depending on the soil type and the plough the soil will normally be inverted aerating the deep layers and trapping water during a rainfall event
- chop and incorporate crop residues.

Secondary tillage is any working completed after primary tillage and is undertaken for reducing clod size, weed control, incorporation of fertilizers, puddling and levelling soil surface. Secondary workings are usually shallower and less aggressive than primary tillage.

Fundamental objectives of tillage:

- To prepare a suitable seedbed
- To remove or destroy weeds
- To eliminate competition from weed growth
- To improve the physical condition of the soil
- To control insects, other pests, and disease organisms

Tillage Effects on Soil and Crop Production:

- The soil environment greatly influences crop response and can be altered by crop rotation, tillage and other crop soil management practices.
- The two practices with major impact on soil conservation are crop residue management and tillage. The traditional ploughing-in of crop residues is now giving way to surface soil residue management, which is more related to soil and water conservation, particularly in the semi-arid tropics.
- Tillage effects on soils are closely related to the management of crop residues in and on the surface of the soil.

Tillage Effect on Crop Yield:

A large volume of experimental data has been published on tillage effects on crop yields under various climates, agro-ecological conditions, soils, crops and residue management systems. Under some of these conditions, the tillage effect is either closely linked to soil aggregation, hence water infiltration rate and water storage capacity, or indirectly related to soil and water conservation. It is evident from the extensive published data on tillage that the effect of tillage on crop yield differs with different soil and its conditions. The choice of tillage methods depends on several factors but soil properties play an important role in determining intensity, frequency and type of tillage required. In addition to the soil factors, climatic factors such as soil temperature regimes, rainfall characteristics and length of growing season should be taken into account. The relationship between tillage and climate underscores the importance of soil and crop specificity in determining the exact nature of tillage operations. Tillage modifies the soil structure, decreases soil penetration resistance and soil bulk density. This also improves porosity and water holding capacity of the soil. Continuity of pore network is also interrupted by the tillage operation, which increases the tortuous of soil. This all leads to a favourable environment for crop growth and nutrient use.

The goals of tillage operations can be divided into three categories: physical, chemical, and biological benefits/improvements derived from the soil. These are the following:

Physical benefits/improvement of soil due to tillage:

- To cut loose, shelter the dense soil to the desired depth and break the clods and crust to a desirable extent for a suitable seedbed for planting.
- To cover and pack the seeds or planting propagates with soil.
- To improve the capacity of soil to receive rain or irrigation water, retain and release moisture for crop plants, or increase percolation or drying of excess soil water.
- To redistribute the soil constituents, particularly soil particles, organic matter, micro-organisms, moisture, and air.
- To maintain the proper structural condition of the soil.
- To incorporate crop residues, green manure, and other organic manure fertilizers.
- To prepare the land surface suitable for easy, early, and uniform irrigation and drainage water distribution.
- To increase soil aeration, particularly in non-capillary spaces.
- To reduce soil erosion, degradation, and depletion.
- To modify the thermal capacity of the soil.

Chemical benefits/improvements of soil due to tillage:

- To accelerate the weathering of soil
- To improve the availability of plant nutrients by enhancing the decomposition of organic matter, mineralization, etc.
- To remove toxic gases from the prolonged reduced soil conditions and detoxify soil from any harm of agrochemicals.
- To reclaim problem soils.

Biological benefits/improvements of soil due to tillage:

- To control soil-borne insect pests, pathogens, and larger soil animals, including rodents
- To improve the distribution of nutrients.
- To improve the growth of roots by reducing penetration resistance of the soil promoting roots respiration affects the moist zone of the soil.
- To provide an optimum habitat that encourages early and uniform growing and seedlings establishment.
- To provide better anchorage to crop plants and the underground development of storage roots and stems.
- To encourage soil-inhabiting growth and activity, beneficial flora and fauna, including symbiotic bacteria.
- To provide suitable conditions for necessary field operations, for instance, planting and harvesting quickly, smoothly, and uniformly.

Tillage effects on soils are closely related to the management of crop residues in and on the surface of the soil the crop and land management practices affect soil cover, organic matter, soil structure, and/or porosity. Placement of residues affects the soil surface temperature, rate of evaporation and water content, and nutrient loading and rate of decay. Plant and residue cover protects soil from the harmful effects of raindrops and soil erosion. When eroded soil particles fill pore space, porosity is reduced and bulk density increases.

Soil parameters that are adversely affected by compaction or loosening of soil particles are those which control the content and transmission of water, air and heat. An understanding of how different tillage methods affect these soil physical parameters will be of importance for their proper management. The objective of this study is:

- To evaluate the tillage effects on moisture content, bulk density, porosity, particle density, saturated hydraulic conductivity, infiltration and pH of laterite soil.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Tillage is the manipulation of the soil into a desired condition by mechanical means; tools are employed to achieve some desired effect (such as pulverization, cutting, or movement). Soil is tilled to change its structure, to kill weeds, and to manage crop residues. Tillage operations generally loosens the soil. Tillage effect the soil physical properties such as soil structure, soil porosity, soil bulk density, soil permeability and infiltration rate. Farmers must consider these properties when deciding when and how to till their fields for optimal results.

Burwell et al (1966) found that cumulative infiltration was greater for ploughed than unploughed soils. They compared two types of tillage Practices, namely tillage and clean tillage (mouldboard ploughing, disking and harrowing). The results showed that the cumulative infiltration was greater for minimum tillage due to the roughness of the surface.

A. Klute (1982) stated that the water retention, hydraulic conductivity, and diffusivity of soils as functions of water content and suction are the hydraulic properties of soils, and plays an important central role in determining the movement and storage of water in soil. The general purpose of tillage is to create a soil environment favourable to the desired plant growth. Soil water relations are an important aspect of the soil environment of the plant. The reported effects are somewhat scattered and often apparently contradictory. Tillage operations modify the bulk density (i.e., porosity) and pore size distribution of the soil. These properties are highly determining factors for the hydraulic properties.

Blevins et al. (1983) reported that tillage had no effect on bulk density after a 10-year period of tillage treatments on a medium textured soil. However, other studies have reported a drastic increase in bulk density with no-till compared to mouldboard ploughing of a clay loam soil. He also found similar bulk density values with conventional and no-till systems and smaller bulk density with chisel tillage on a poorly drained soil.

Johnson et al. (1984) compared three conservation tillage systems, chisel ploughing, till plant and no till, to conventional mouldboard ploughing. Soil moisture advantages with conservation tillage varied because of profile water content, delayed plant growth and soil characteristics.

Voorhees et al. (1984) found that the greater soil water stored is with the no tillage systems, compared to the conventional tillage system has generally has not resulted in proportional increase in crop yield. Apparently greater yield potential represented by additional water stored with no tillage is offset by other conditions in the soil environment that limit yield.

Kladivko et al. (1986) conducted a two-year field experiment to compare four different tillage systems: conventional tillage, chisel plough, no-till, and ridge-till. They monitored soil moisture, bulk density, soil organic matter, and nutrient availability, as well as crop yields. The results showed that no-till and ridge-till had higher soil moisture levels and lower bulk densities compared to conventional tillage and chisel plough. Additionally, no-till and ridge-till had higher soil organic matter levels and greater nutrient availability, resulting in higher crop yields.

D. K. Cassel (1990) evaluated the effects of tillage implement disturbance on the physical properties of soil have been widely studied. However, because soil properties resulting from the use of a given implement vary due to implement factors (depth and speed of tillage) and soil factors (water content, texture, residue cover, etc.), soil properties for a given operation are difficult to visualize, let alone predict. Considered are soil mechanical properties (surface micro-relief, aggregate size distribution and bulk density) and hydraulic properties and processes (water retention, saturated conductivity, infiltration and evaporation).

T.J. Logan, R. et al. (1991) indicates that tillage systems affect soil physical, chemical and biological properties. Among drastic tillage-induced changes in soil properties are bulk density, infiltration rate, aggregation and aggregate size distribution, soil organic carbon and nutrient profile, microbial activity and species diversity, and the population of earthworms. Macropores and bio channels are usually more prevalent in conservation tillage than conventional-tillage systems. Conservation tillage induces stratification of soil organic matter and related nutrients, enhances the activity of soil fauna and leads to acidification. The magnitude of these changes depends on the soil type, the cropping systems and the type of conservation tillage adopted.

O. Babalola et al. (1993) says that soil tillage involving deep plough-till and soil inversion has proven beneficial on compact soils of arid and semi-arid regions. Plough-based systems not only reduce soil bulk density and soil strength but also improve the efficiency of water and nutrient use. The Conservation tillage systems, particularly no-till and reduced tillage, offer promising solutions for improving soil physical, chemical, and biological properties in the region. Conservation tillage systems such as no-till and reduced tillage have been shown to improve soil physical properties, particularly soil structure and water-holding capacity.

A.R Dexter (1996) says that tillage is a common practice used in agriculture to prepare the soil for planting and to control weeds. However, it can also have a significant impact on the physical properties of the soil. It includes structure, water, aeration, and strength and stability. Tillage can also have an impact on soil compaction.

Logsdon et al. (1999) from studies on macro porosity and its relation to saturated hydraulic conductivity under different tillage practice have shown that the loosening of surface soil by tillage operations increases the total soil porosity.

Ferreras et al. (2000) revealed that no tillage and conventional tillage shows high bulk density and low aggregate stability, therefore, they are susceptible to increased structural damage in continuous cropping. The low soil porosity and greater percentage of small pores (<20 mm) in no tillage affected soil saturated hydraulic conductivity.

Jimmy et al. (2005) investigated the effects of different tillage operations on bulk density, and the hydraulic properties of a loamy sand soil. A replicated randomised complete block design with treatments consisting of (i) no-tillage (NT), (ii) manual tillage (MT), (iii) plough-plough tillage (PP) and (iv) plough-harrow (PH) operations established. bulk density, penetration resistance and saturated hydraulic conductivity were determined weekly over a period of 8 weeks after tillage operations. All the tillage operations were significantly different in their effects on soil density and was in the descending order of NT > MT > PP > PH. The soil bulk density decreased with the degree of soil manipulation during tillage practices, with NT having the highest (1.28 g cm^{-3}) and PH having the least (1.09 g cm^{-3}). The soil penetration resistance was consistent with bulk density data, with NT also having the highest resistance of 0.65 kg cm^{-2}. Soil saturated hydraulic conductivity at 8 weeks after tillage decreased with increased intensity of soil manipulation by tillage. The highest conductivity was recorded under NT and the least under PH.

J. Lipiec et al. (2005) concluded that soil porosity and water infiltration are crucial factors that affect soil productivity. Tillage methods, which involve mechanical manipulation of soil, can significantly impact soil porosity and water infiltration. It aims to explore the effects of different tillage methods on soil porosity and water infiltration. The studies shows that conventional tillage, which involves ploughing and cultivation, can lead to a decrease in soil porosity and water infiltration. This is because conventional tillage disrupts soil structure, breaks up soil aggregates, and compacts the soil. Soil pores are filled with soil particles, reducing the space available for water to infiltrate. In no-till or reduced tillage methods, which involve minimal disturbance of the soil, have been shown to improve soil porosity and water infiltration.

Lampurlane et al. (2006) on his study on Hydraulic conductivity, residue cover and soil surface roughness under different tillage systems in semiarid conditions, found that with the adoption of no tillage there can be a decrease in hydraulic conductivity due to reduction in soil porosity. This negative effect no tillage of on infiltration can be counteracted by the presence of residues on the soil surface, resulting in greater water storage. The amount of surface residues plays an important role in soil water conservation, especially in no tillage fallows.

Glab and Kulig (2008) showed that minimal and no tillage would decrease the soil porosity for aeration, but increase the capillary porosity; as a result, it enhances the water capacity of soil along with bad aeration of soil.

Martinez et al. (2008) has an opinion that no-tillage systems affect soil properties depending on the soil, climate, and the time since its implementation. In heavy no-tilled soils a surface compacted layer is commonly found. Such layer can affect root growth and soil water infiltration.

Pires et al. (2016) examines the impact of different tillage systems on soil structure, including conventional tillage, minimum tillage, and no-tillage. They investigate changes in soil porosity, aggregation, and bulk density, as well as soil organic matter and water content. It concludes that no-tillage systems preserve soil structure and reduce soil compaction, while conventional tillage can lead to negative changes in soil structure and a reduction in soil quality.

Maharjan et al. (2018) suggested that tillage is a primary field operation aiming to modify the soil structure to favour agronomic and soil related processes such as soil seed contact, root proliferation, water infiltration, incorporation of residues, breakdown of soil organic matter and land forming. The modification of the soil physical and chemical properties especially in the upper soil layers after a tillage operation can be huge.

A study by Adekiya et al. (2020) found that no-till increased hydraulic conductivity in laterite soil due to reduced soil disturbance and improved soil structure.

Amami et al. (2021) found that mouldboard ploughing enhanced soil infiltration capacity relative to the no-tillage treatment. The mean saturated hydraulic conductivity was highest under MP.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

A field study was conducted to study the effect of different tillage practices on soil physical properties. Various methods and techniques used in the data generation and validation are described in this chapter.

3.1 Description of study area

3.1.1 Location of the study

Field experiments were conducted in the farm of KCAET campus, Tavanur, at 10˚ 51' 8.226” North Latitude and 75˚59' 18.456" East Longitude. It comes under Malappuram District of Kerala State in India. The soil type of study area is laterite.

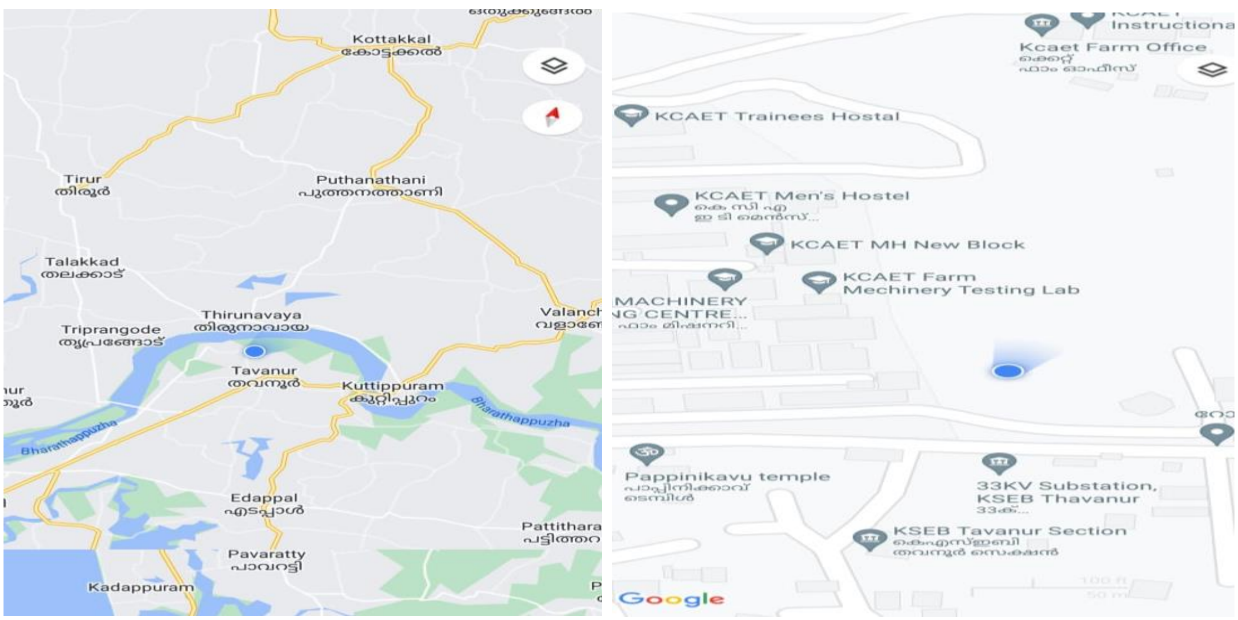

Plate 1 Location of the plot

3.1.2 Climate

Agro-climatically the area falls within the border line of northern zone, central zone and kole lands of Kerala. The average annual rainfall received in the area is about 2900 mm and has a humid climate. Medium to high rainfall zones are available within 10-15 km of the area. The area receives the rainfall mainly from south-west monsoon and north-east monsoon. The average maximum temperature of the study area was 34 °C and the average minimum temperature was 26°C.

3.2 Experimental details

3.2.1 Tillage treatments

The experiment was conducted during the month of March – May. Four plots on the backyard of indoor court were selected for the experiment. Each plot was treated with different tillage activities. The first plot was subjected to primary tillage alone and secondary tillage alone was done in second plot. Primary tillage and secondary tillage together were carried out in the third plot. The fourth plot was kept undisturbed considered as No-tillage. In each plot five replicates were made and each replicate is of 15 x 1.5 m.

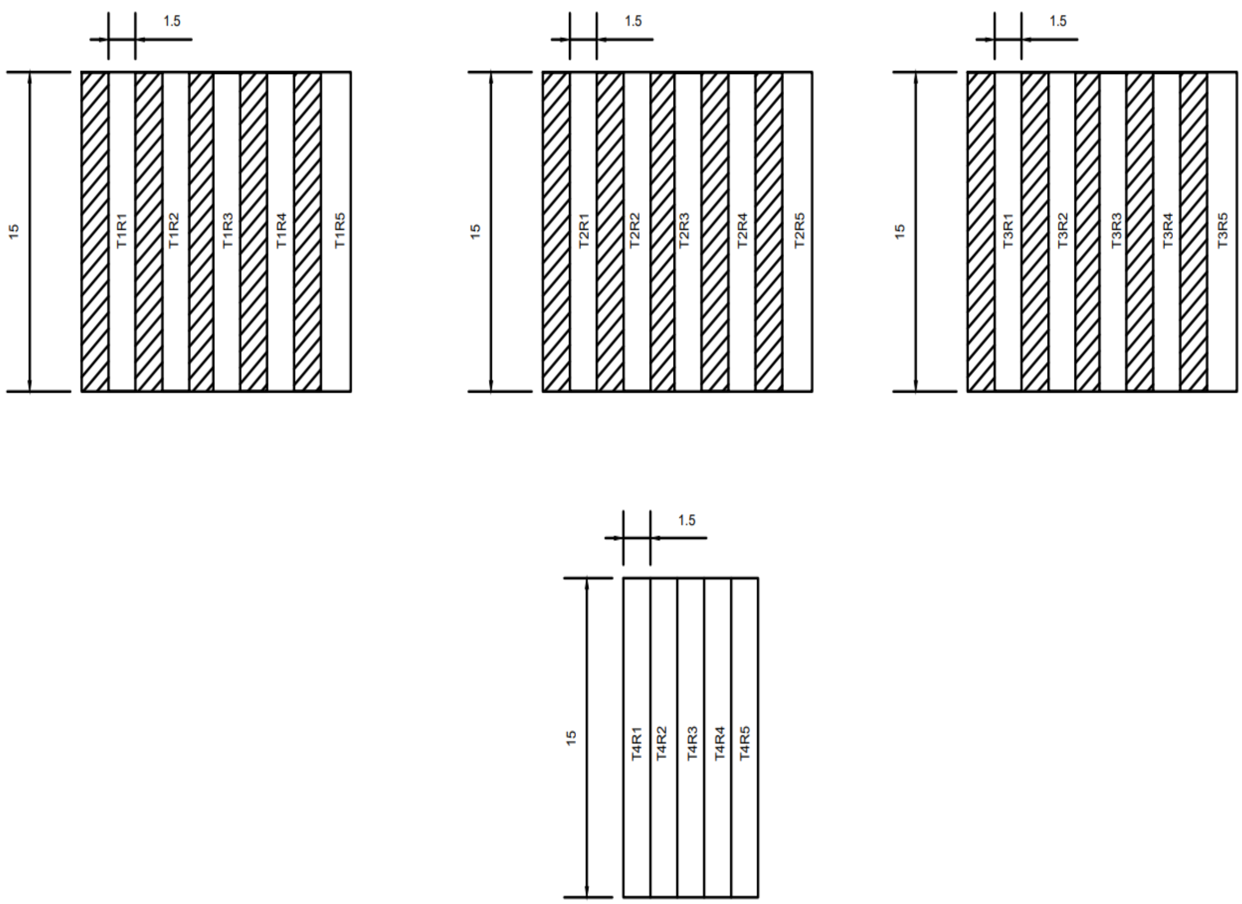

Fig 1. layout of plot under primary, secondary, primary and secondary together and no-tillage respectively

T1R1 - replica 1 of primary tillage

T1R2 - replica 2 of primary tillage

T1R3 - replica 3 of primary tillage

T1R4 - replica 4 of primary tillage

T1R5 - replica 5 of primary tillage

T2R1 - replica 1 of secondar tillage

T2R2 - replica 2 of secondary tillage

T2R3 - replica 3 of secondary tillage

T2R4 - replica 4 of secondary tillage

T2R5 - replica 5 of secondary tillage

T3R1 - replica 1 of primary and secondary tillage together

T3R2 - replica 2 of primary and secondary tillage together

T3R3 - replica 3 of primary and secondary tillage together

T3R4 - replica 4 of primary and secondary tillage together

T3R5 - replica 5 of primary and secondary tillage together

T4R1 - replica 1 of no tillage

T4R2 - replica 2 of no tillage

T4R3 - replica 3 of no tillage

T4R4 - replica 4 of no tillage

T4R5 - replica 5 of no tillage

3.2.1.1 Primary tillage (PT)

Primary tillage loosens the soil and mixes in fertilizer or plant material, resulting in soil with a rough texture. In primary tillage treatment, the mould board plough mounted on a tractor is used to plough the soil. Mouldboard ploughs are used where soil inversion is necessary. The maximum depth of tillage was maintained at 15cm. The parts of mouldboard plough are frog or body, mouldboard or wing, share, landside, connecting rod, bracket and handle. This type of plough leaves no unploughed land as the furrow slices are cut clean and inverted to one side resulting in better pulverization. The two bottom MB Plough is used for the primary tillage. We have made five replications of primary tillage in the same plot and various studies on the soil physical properties have been done.

Plate 2 Plot undergone primary tillage

3.2.1.2 Secondary tillage (ST)

Secondary tillage is a finer or lighter operation used to clean the soil, break up clods, and incorporate manure and fertilizers. Secondary tillage is often shallower and more gentle than primary tillage. Tractor mounted power harrow is used for secondary tillage. Power harrow is used here is of specifications

Plate 3 Plot undergone secondary tillage

3.2.1.3 Primary with secondary tillage (PST)

Secondary tillage involved in the use of power harrow mounted on a tractor to plough the soil. The first ploughing was done by MB plough followed one day after, by another round of ploughing using power harrow mounted on the tractor. For both ploughing operations the maximum depth of tillage was maintained at 15-20cm.

Plate 4 Plot undergone primary and secondary tillage together

3.2.1.4 No tillage (NT)

In NT, vegetation on the plots were manually cleared. The goal of no tillage is to minimize soil erosion, improve soil health.

Plate 5 Plot taken as No tillage

3.2.2 Data generation

3.2.2.1 Particle size distribution

Particle size distribution refers to the range of sizes of particles in a sample of material. This can include particles of various shapes and sizes, such as powders, granules, or fibers. The percentage of various sizes of particles in the dry soil sample was found by particle size analysis or mechanical analysis. Mechanical analysis was meant for the separation of soil into its different size fractions.

3.2.2.2 Sieve analysis

Sieve analysis is a method that is used to determine the grain size distribution of soils that are greater than 0.075 mm in diameter. It is usually performed for sand and gravel. In the BS and ASTM standards, the sieve sizes are given in terms of the number of openings per inch. The number of openings per square inch is equal to the square of the number of sieves. The sieves used for fine sieve analysis are: 2.0 mm, 1.0 mm, 600 µm, 425 µm, 300 µm, 150 µm, & 75 µm IS sieves.

For this purpose, about 1kg of soil was collected from each site after removing a top layer of 15cm depth. The oven dried soil of about 500 g soil was taken for analysis each time. Sieving was performed by arranging the various sieves one over the other in the order of their mesh openings- the largest aperture sieve being kept at the top and the smallest aperture sieve being kept at the bottom. A receiver was kept at the bottom and a cover was kept at the top of the whole assembly. The weighed oven dried soil sample was put on the top sieve, and whole assembly was fitted on a sieve shaking machine. The amount of shaking depends upon the shape and the number of particles. At least ten minutes of shaking was done for soils with small particles. The portion of the soil sample retained on each sieve was weighed. During our experiment we have shaken the assembly for about 15 minutes. Then we weighed soil retained on each sieve by taking its weight separately and calculated the percent retained, cumulative percent retained and cumulative percent finer.

Plate 6 Sieve Analysis

3.2.2.3 Particle size distribution curve

The results of the mechanical analysis are plotted to get a particle size distribution curve with the percentage finer (N) as the ordinate and the particle diameter as the abscissa, the diameter being plotted on a logarithmic scale.

3.2.2.4 Moisture content

The method is based on removing soil moisture by oven-drying a soil sample until the weight remains constant. The moisture content (%) is calculated from the sample weight before and after drying. The moist sample was kept in clean container. The mass of the soil and container with lid was determined. With the lid removed, the container was then placed in the oven and maintains the temperature of the oven between 105 ℃ -110 ℃ for about 16-24 hours. After drying the container was removed from the oven and allowed to cool. The lid was then replaced, and the mass of the container and the dry soil was found. The water content was calculated by the following equation:

$$W = \frac{M_2 - M_3}{M_3 - M_1}$$

Where,

M_1= mass of container with lid, g

M_2= mass of container with lid and wet soil, g

M_3= mass of container with lid and dry soil, g

Plate 7 Soil sample kept for drying

3.2.2.5 Soil Bulk Density

Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. The core cutter method is a commonly used field method for determining the bulk density of soil. Select a suitable location in the field where the soil bulk density needs to be determined. Choose a core cutter of known volume and weight. A core cutter consisting of a steel cutter, 10 cm in diameter and 12.5 cm high, and a 2.5 cm high dolly was driven in the cleaned surface with the help of a rammer, till about 1 cm of the dolly protruded above the surface. Dig out the container from the soil and trim off excess soil from the cutter. Soil bulk density was determined from these undisturbed cores as mass per volume of dried soil. The samples were collected a day after the treatments were applied. In this experiment we have collected samples from 20 plots and calculated the bulk density of each sample. For the calculation first determine the volume of the core cutter and then by dividing the weight of soil by the volume of core cutter gives the bulk density.

Plate 8 Core Cutter Method

3.2.2.6 Soil Particle Density

Particle density is defined as the mass of a unit volume of sediment solids. Particle density is the mass of soil divide with the volume of soil sample. An amount of soil was kept for oven drying and the oven dried sample was added to a known volume of water and the increase in elevation of water level was noted. This gives the volume of the soil solids.

$$\gamma_p = \frac{M}{V}$$

γ_p = particle density, g/cm^3

M = Mass of the soil, g

V = Volume of soil solid, cm^3

3.2.2.7 Porosity

Porosity is the percentage of void space in a rock. Porosity is the percentage of void space in a rock. It is defined as the ratio of the volume of the voids or pore space divided by the total volume. It is written as either a decimal fraction between 0 and 1 or as a percentage. The value for porosity was calculated from the bulk density and particle density as:

$$\Phi = 1 - \frac{\gamma_{\text{bulk}}}{\gamma_{\text{particle}}}$$

Where,

Φ = Porosity, %

γ_{bulk} = Bulk Density, g/cm^3

γ_{particle} = Partcle Density, g/cm^3

3.2.2.8 Saturated hydraulic conductivity

Prepare the soil specimen in the permeameter mould and saturate it. Permeameter is of size 12.5 cm in length and 10 cm in diameter. Constant head test is carried out to find out the permeability in this case.

Keep the permeameter mould assembly in the bottom tank with water level above the outlet of the mould. Connect the water inlet nozzle of the mould to the stand pipe filled with water. Permit water to flow for some time through the soil in the mould till steady state of flow is reached. The testing apparatus is equipped with a adjustable constant head reservoir and an outlet reservoir which allows maintaining a constant head during the test. During the test, the amount of water flowing through the soil column is measured for given time intervals. One can calculate the permeability of the sample as

$$\mathrm{K} = \frac{\mathrm{QL}}{\Delta \mathrm{h} \times \Delta \mathrm{t} \times \mathrm{A}}$$

Where,

Q = Volume of water passing, g/cm^3

L = Height of soil sample column, cm

Δh = Constant head, cm

Δt = Time interval, s

A = Area of cross section, m^2

Plate 8 Constant Head Permeameter Test

3.2.2.9 Infiltration Rate

Soil infiltration rate (IR) is defined as the volume flux of water flowing into the profile per unit of soil surface area under any set of circumstances. We calculate the infiltration rate by a device called infiltrometer. Commonly used infiltrometer are single ring or double ring infiltrometer, and also disc permeameter. Double ring infiltrometer of 15 and 30 cm of rings are used here. The device is installed into the field by driving it into depth of 10 cm with the help of a hammer. Then the two rings are filled with water at a level of 20 cm in both. A stopwatch is started at the very instant of water application. The difference between the quantity of water added and the volume of water in the cylinder at the instant it reaches the desired point was taken as the quantity of water that infiltrates during the time interval between the start of filling and the first measurement. After the initial reading the water level measurements are made at frequent intervals to determine the amount of water that has infiltrated during the time interval. Water was added quickly after each measurement so that a constant average infiltration head could be maintained. The buffer pond was filled with water immediately after filling the inner cylinder to have an equal water level. The experiment was followed till considerable readings are obtained. Then the readings (water level) at regular intervals are taken and are tabulated and infiltration rate is determined. Using this data an equation of following form was developed to find functional relationship

$$y = ae^{bt}$$

Where,

y = accumulated infiltration in cm

t = elapsed time, min

a, b = constant

Plate 9 Determining infiltration rate by double ring infiltrometer

3.2.210 Soil pH

Soil pH is a measure of the acidity or basicity of a soil. Soil pH is a key characteristic that can be used to make informative analysis both qualitative and quantitatively regarding soil characteristics. The soil pH was calculated using digital pH meter. 10 grams of sample were taken and 20 ml of distilled water was added to it and stirred for 5 minutes. Then it was kept undisturbed for 30 minutes and stirred and tested. The pH meter was calibrated using pH 4 and 9.

Plate 10 Soil pH determination

3.3 Analysis of the data observed

Using Data analysis in Microsoft Excel the statistical analysis of the data was obtained. To find the significant difference in the treatments variance analysis was done. 5% significance was used. Critical differences in treatments were also calculated the The results are represented in the next chapter.

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to determine the effects of different types of tillage on the soil physical properties in laterite soil. In this study soil properties such as moisture content, bulk density, particle density, porosity, infiltration rate, saturated hydraulic conductivity and pH was analysed. Tractor specification was used for tillage activity and the equipment's used was mouldboard plough for primary tillage and vertical disc power harrow for secondary tillage. The various results obtained after the analysis is depicted in this chapter

4.1 Evaluation of Soil Physical Properties

The results of soil textural analysis are mentioned in the APPENDIX I. A graph was plotted to find the texture of the soil by using sieve analysis method. The particle distribution curve is plotted where particle size (mm) on the abscissa in logarithmic scale and percentage finer (N) on the ordinate. Figure 2 represents the resulting particle distribution curve of for different treatments. from the graph it is clear that all the four treatments almost fall in same soil texture. The figure shows that the soil sample consists of sand, silt and of clay. As per USDA classification chart, the textural class of the soil was found to be sandy loam.

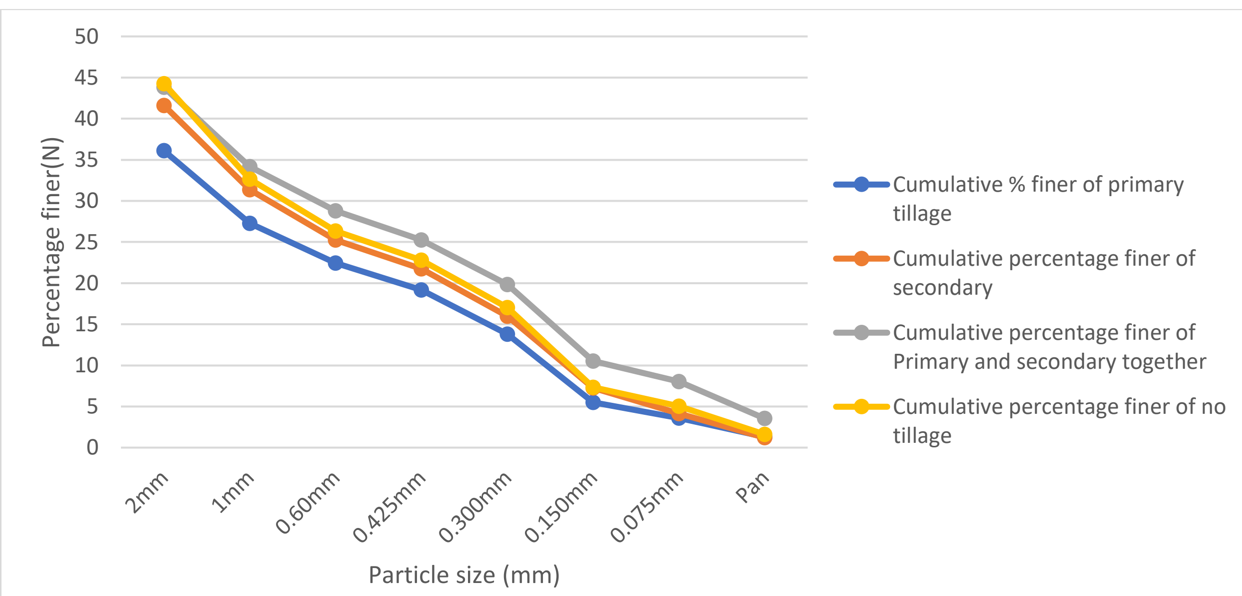

Fig 2. Particle Distribution Curve

4.2 Moisture Content

The moisture content of the soil sample was found by oven drying method. The moisture content obtained for different treatments are represented in the APPENDIX II. A graph was plotted to show the variation of moisture content with respect to the different treatments. Here the x axis shows the replication and moisture content in % is shown in the y axis. From the graph it is clear that the plot where primary and secondary together performed has higher moisture content and it is about an average of 23.027%.

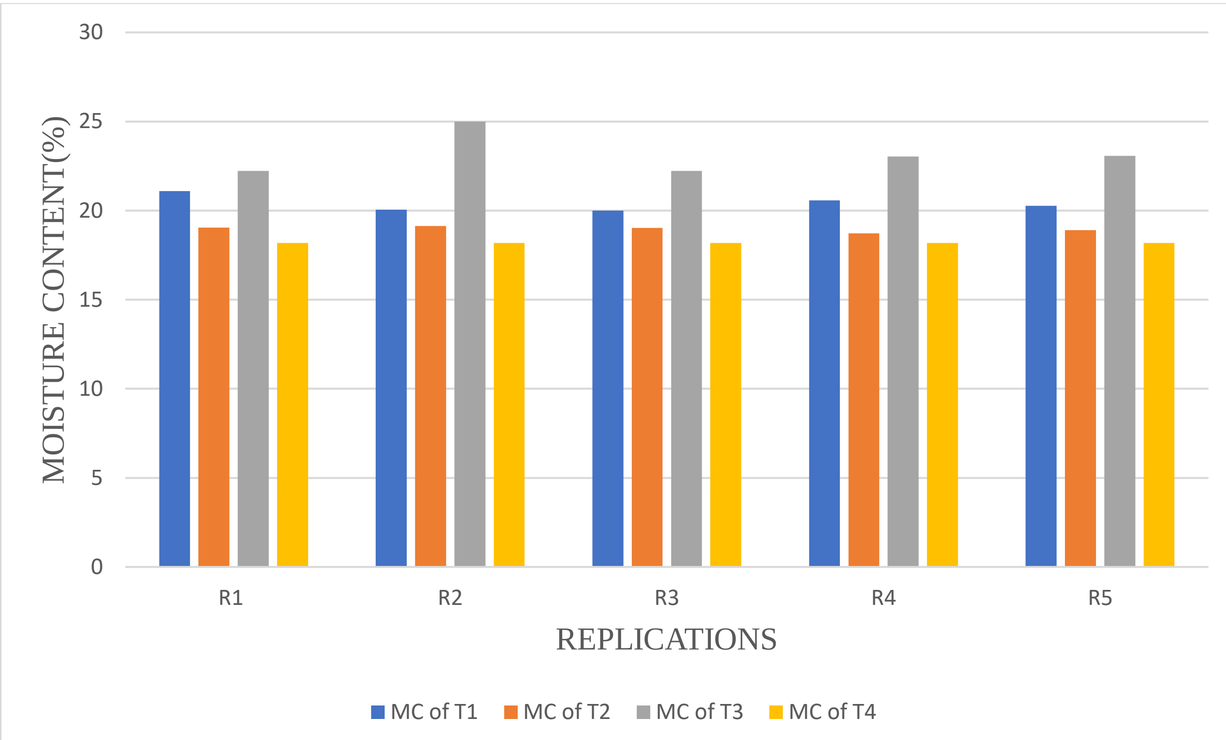

Fig 3. variation of moisture content with treatment

Table 1. Summary of moisture content

Groups	Count	Sum	Average	Variance
Column 1	5	101.98	20.396	0.20108
Column 2	5	94.83	18.966	0.02558
Column 3	5	115.54	23.108	1.29107
Column 4	5	90.9	18.18	0

Table 2. Anova of moisture content

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	70.46206	3	23.48735167	61.90126483	5.05E-09	3.238872
Within Groups	6.07092	16	0.3794325			
Total	76.53298	19				

4.3 Bulk Density

The bulk density of soil in the experiment was found by core cutter method. The weight of soil, volume and the bulk density are shown in the APPENDIX III. Here we prepare a graph showing bulk density on abscissa and treatments on the ordinate. The bulk density is more for no tilled soil and it is about 1.773 %. The bulk density of soil decreases with increase in porosity. The difference in bulk density of different tillage activity is shown in the figure below. It is clear here that bulk density decreases with tillage in the order T4> T1> T2> T3.

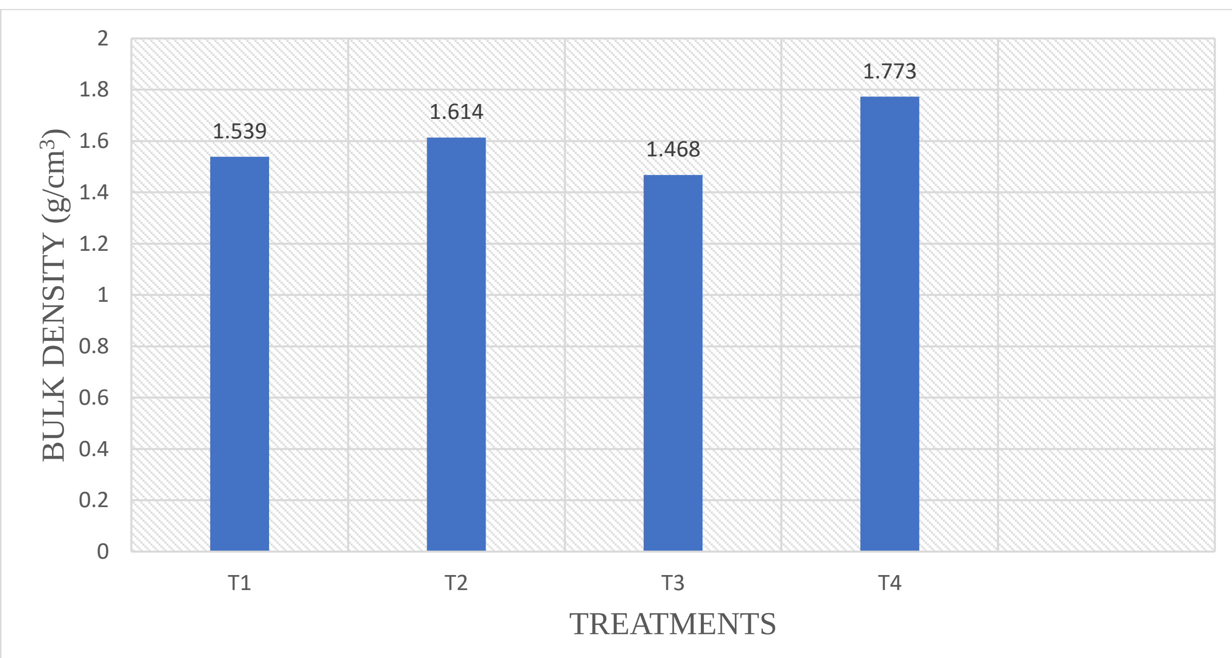

Fig 4. Variation of bulk density with treatment.

Table 5. Summary of bulk density

Groups	Count	Sum	Average	Variance
Column 1	5	7.71	1.542	0.00002
Column 2	5	8.25	1.65	0.0004
Column 3	5	7.31	1.462	0.00017
Column 4	5	8.82	1.764	0.00013

Table 6. Anova of bulk density

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.258615	3	0.086205	478.9167	7.19E-16	3.238872
Within Groups	0.00288	16	0.00018			

4.4 Particle Density

Particle density is calculated as mass of soil to the volume of soil solid for that an amount of soil is kept for oven drying and the oven dried sample is added to known volume of water and the increase in elevation of the water level is noted. This gives the volume of soil solids. The observations are shown in the APPENDIX IV.

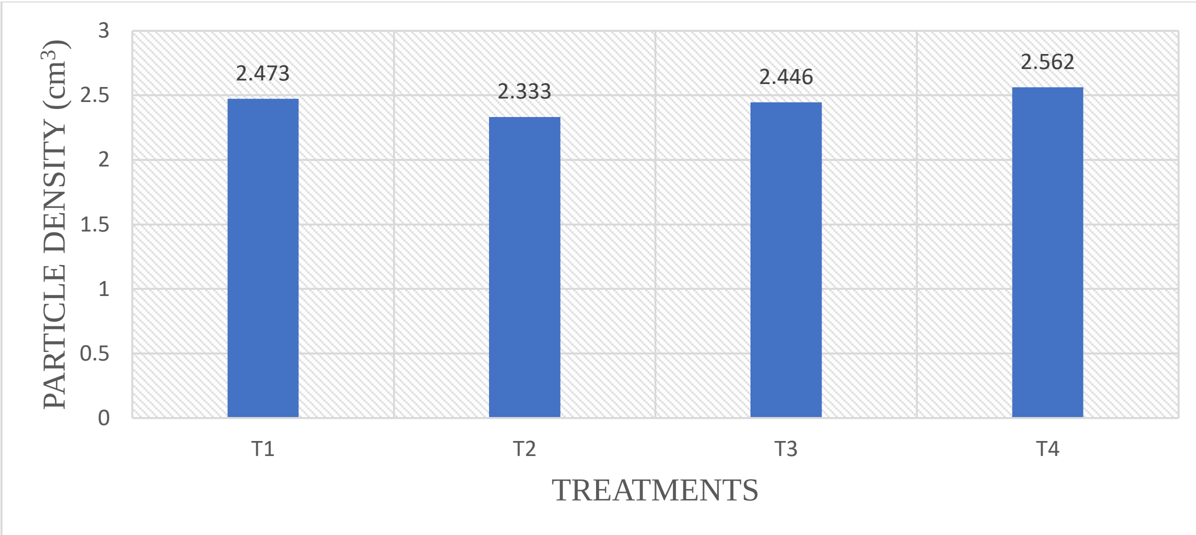

Fig 5. Variation of particle density with treatments.

From the above graph it is clear that the particle density is almost same for the four treatments. So, it is concluded that there is no much alteration for particle density due to tillage.

Table 3. Summary of particle density

Groups	Count	Sum	Average	Variance
Column 1	5	12.47	2.494	0.00068
Column 2	5	11.77	2.354	0.00298
Column 3	5	12.5	2.5	0.00095
Column 4	5	12.78	2.556	0.00083

Table 4. Anova of particle density

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.11092	3	0.036973	27.18627	1.61E-06	3.238872
Within Groups	0.02176	16	0.00136			
Total	0.13268	19				

4.5 Porosity

Porosity is measured from the particle density and bulk density explained above. The calculation carried out is shown in the APPENDIX V. A graph is drawn showing porosity on abscissa and treatments on the ordinate. It is clear from the graph that porosity increase with tillage. Porosity is more for treatment T3 while bulk density was very less for this treatment.

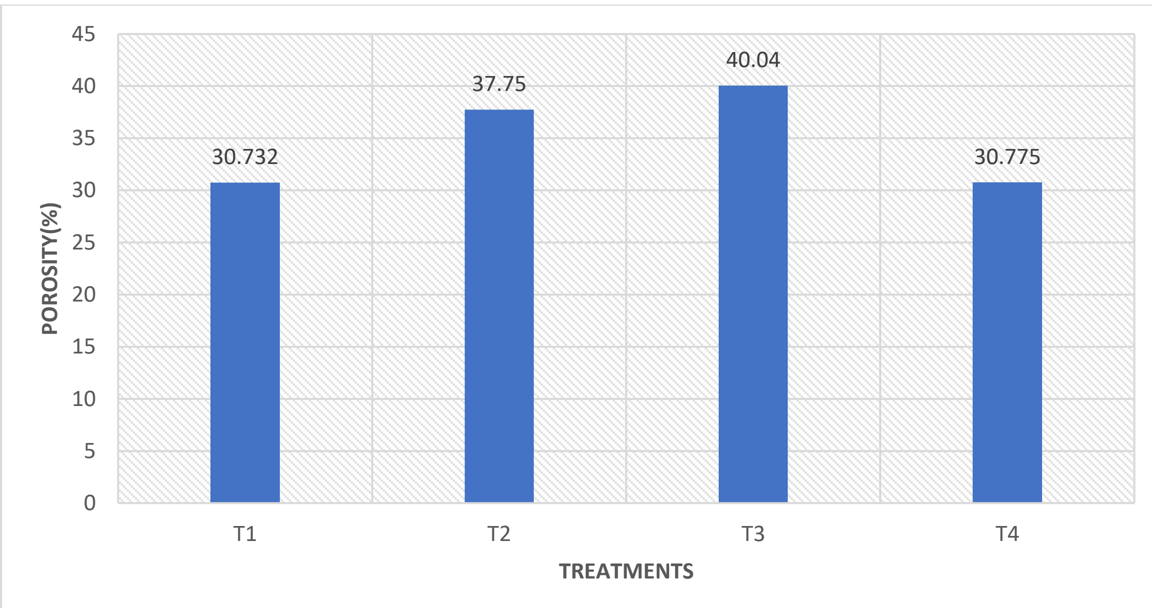

Fig 6. Variation of porosity with treatments.

4.6 Hydraulic Conductivity

Hydraulic conductivity was measured by constant head permeameter test. The saturated hydraulic conductivity or permeability was experimentally found out and data is given in APPENDIX VI. The mean permeabilities of the four treatments are given in APPENDIX VI. A graph has been plotted with hydraulic conductivity on the abscissa and treatments on the ordinate. Here it is clear that T3 shows more hydraulic conductivity of about 49.12%. the hydraulic conductivity order for different tillage will be T3> T1> T2> T4.

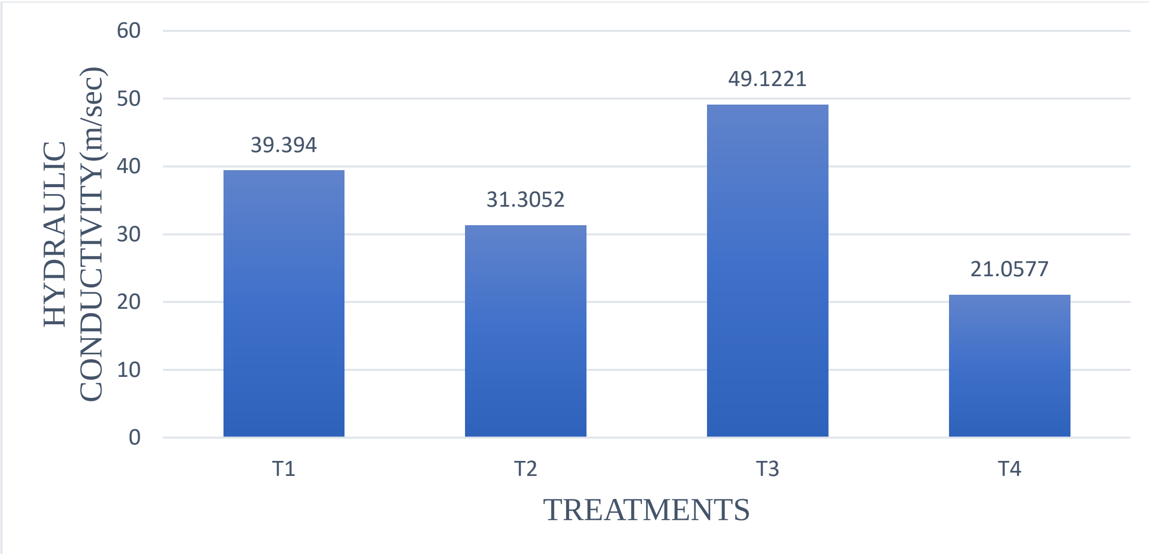

Fig 7. Variation of hydraulic conductivity with treatments

Table 7. Summary of hydraulic conductivity

Groups	Count	Sum	Average	Variance
Column 1	5	196.625	39.325	0.511825
Column 2	5	173.956	34.7912	5.244021
Column 3	5	249.329	49.8658	0.480311
Column 4	5	104.606	20.9212	0.011068

Table 8. Anova of hydraulic conductivity

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2159.717	3	719.9058	460.9444	9.73E-16	3.238872
Within Groups	24.9889	16	1.561806			
Total	2184.706	19				

4.7 Infiltration

A double ring infiltrometer test was conducted to determine the infiltration rate of the soil in each treatment plots. The field data on cylinder infiltrometer from each treatment is given in APPENDIX VII.

4.7.1 Primary Tillage

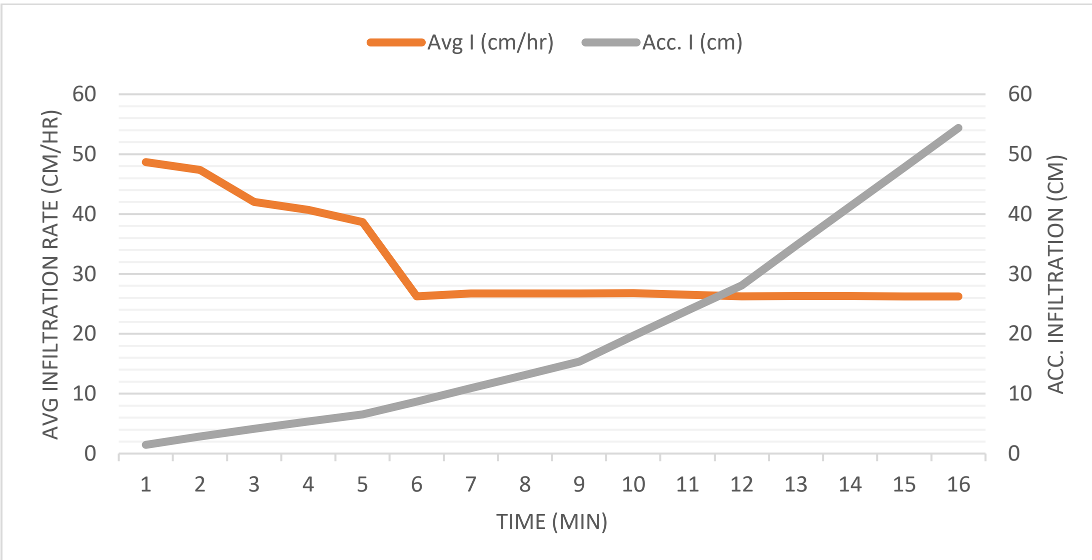

Fig. 8. Infiltration curves showing accumulated infiltration and infiltration rate of primary tilled soil

The APPENDIX VII shows the readings obtained in the double ring infiltrometer experiment from primary tilled land.

The functional relationship between accumulated infiltration and time is given as

$$Y = 1.973e^{0.2207t}$$

4.7.2 Secondary Tillage

The APPENDIX VII shows the readings obtained in the double ring infiltrometer experiment from secondary tilled land.

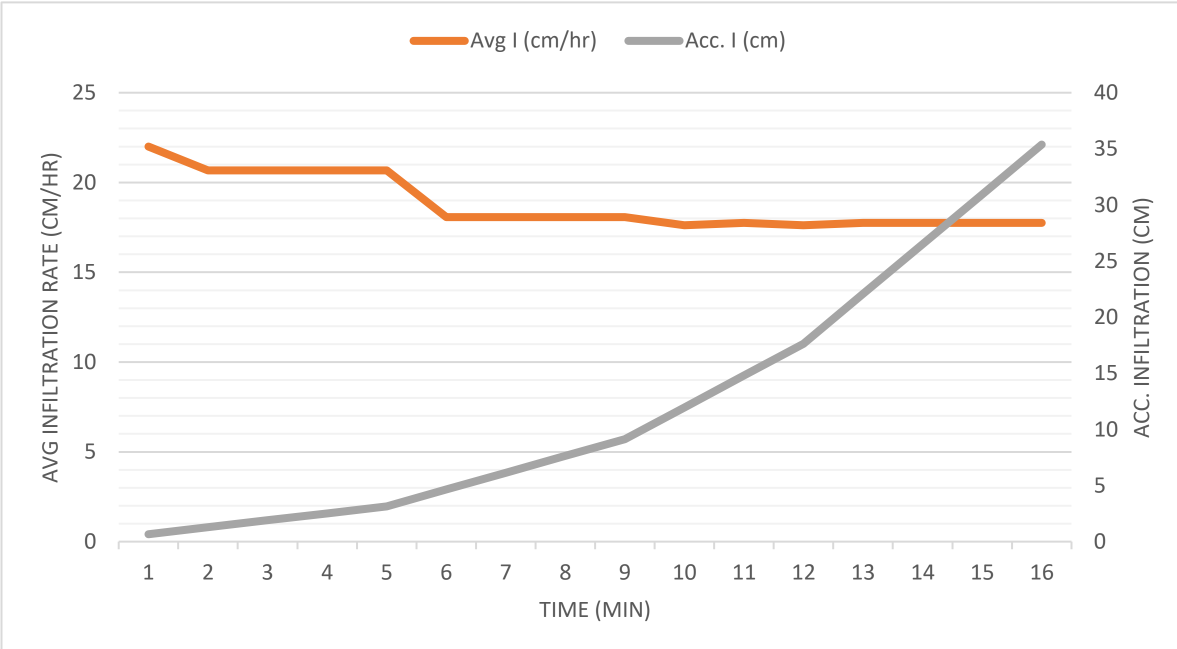

Fig. 9. Infiltration curves showing accumulated infiltration and infiltration rate of secondary tilled soil

The functional relationship between accumulated infiltration and time is given as

$$Y = 0.8613e^{0.2496t}$$

4.7.3. Primary and Secondary tillage together

The APPENDIX VII shows the readings obtained in the double ring infiltrometer experiment from secondary tilled land.

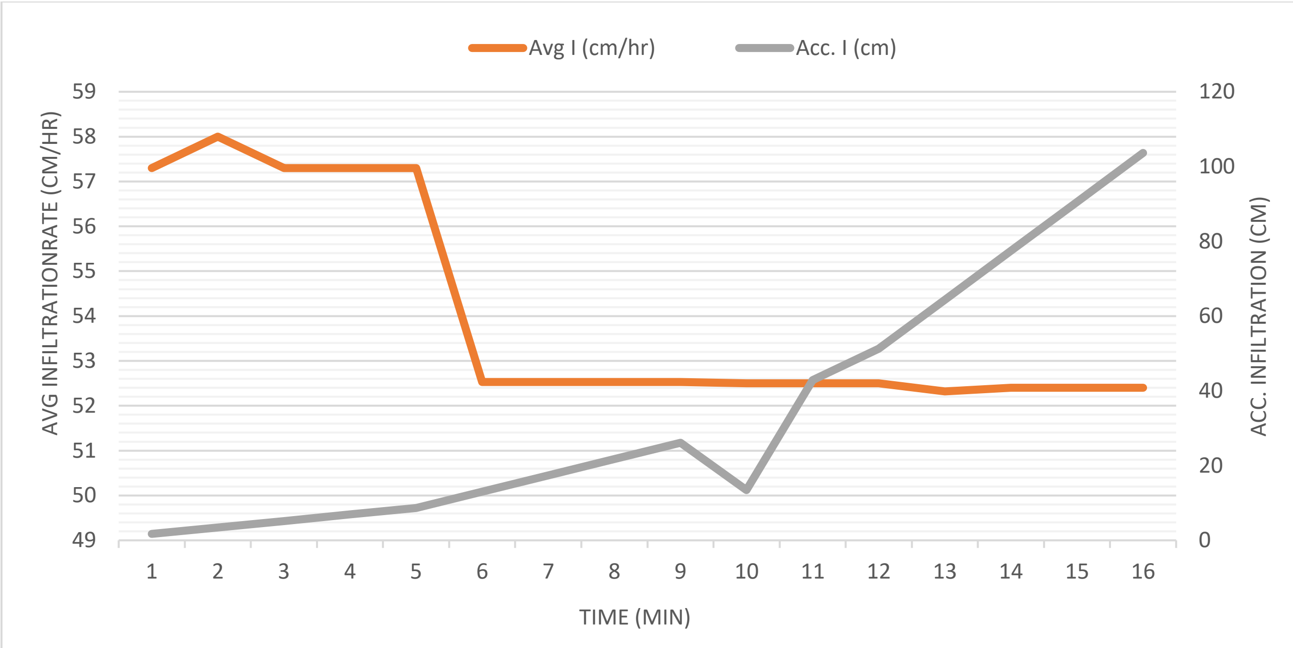

Fig. 10. Infiltration curves showing accumulated infiltration and infiltration rate of soil treated with primary secondary tillage together

The functional relationship between accumulated infiltration and time is given as

$$Y = 2.2388e^{0.2524t}$$

4.7.4 No tillage

The APPENDIX VII shows the readings obtained in the double ring infiltrometer experiment from no tilled land.

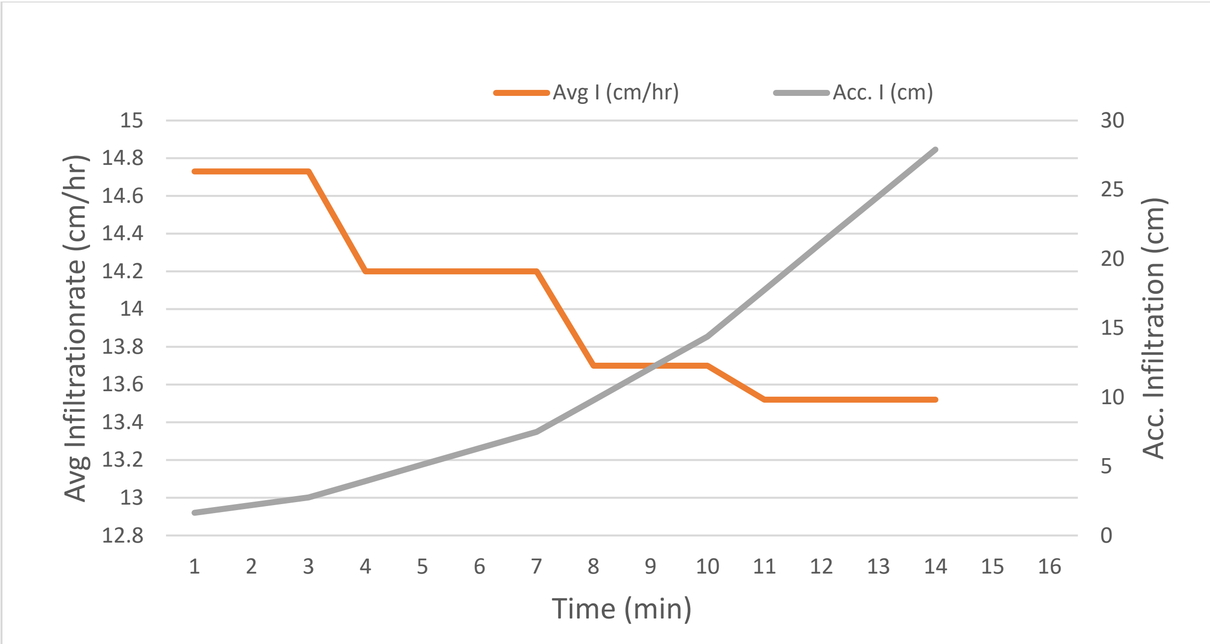

Fig. 11. Infiltration curves showing accumulated infiltration and infiltration rate of no tilled soil

The functional relationship between accumulated infiltration and time is given as

$$Y = 1.5419e^{0.2189t}$$

4.7.5 Log –Log graph

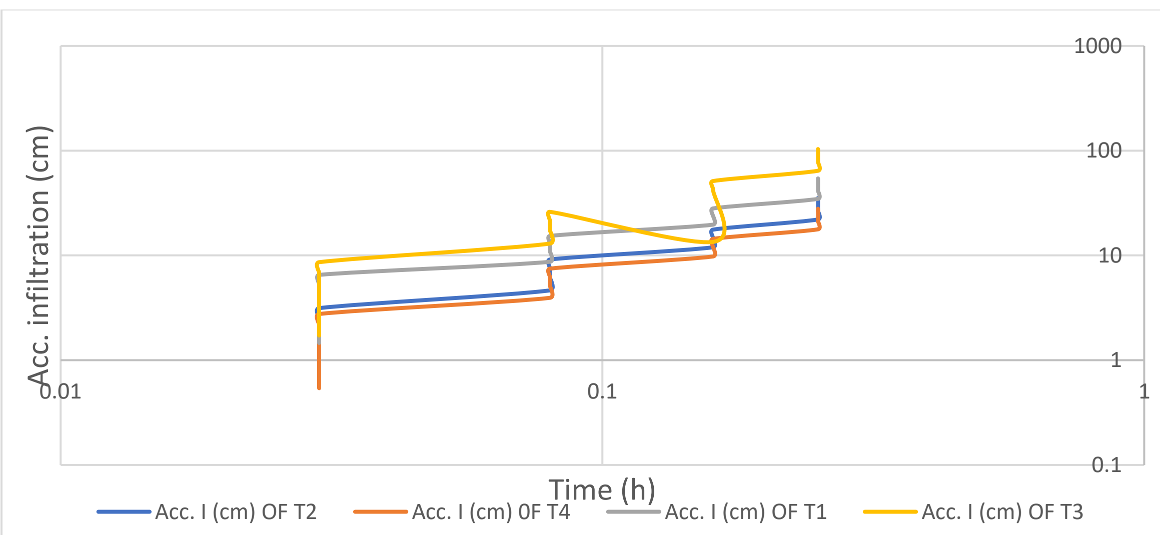

Fig. 12. Comparison of accumulated infiltration depths of treatments

4.8 Soil pH

Soil pH was measured using digital pH meter and it is observed that the pH of the soil is not affected by tillage since the process is only mechanical manipulation. pH was observed between 5.5 and 6.

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The study entitled “Effect of Tillage on Soil Physical Properties on laterite soil” was aimed to assess the properties such as moisture content, bulk density, particle density, porosity, saturated hydraulic conductivity, pH and infiltration of soil. Tillage treatments include primary tillage, secondary tillage, primary and secondary tillage together, and no tillage.

Tillage operation is the mechanical manipulation of soil to develop a desirable soil structure for a seed bed and to establish specific surface configuration for planting, irrigation, drainage, harvesting operations etc.

The average moisture content of soil increases in the order no tillage ≈ secondary tillage < primary tillage < primary and secondary tillage together. Moisture content increases with tillage because of increase in the void ratio.

The bulk density of the soil reduces with tillage because of its increase in its void ratio. The bulk density determines the looseness of the soil. No tilled soil has more bulk density compared to the other treatments. It is because of its compacted nature. Tillage increases the total volume of the soil. Thus reduces the bulk density.

The particle density was observed to be similar for all the treatments. Although tillage resulting a change in both bulk density and porosity, it does not affect particle density. It remains constant because tillage and other short-term changes do not alter the total amount or the chemical composition of the soil mineral particles.

The porosity of the soil increases with tillage. Porosity increases in the order no tillage < primary tillage < secondary tillage <Primary and secondary tillage together. Increase in porosity increase the water holding capacity of the soil.

The saturated hydraulic conductivity plays a crucial role in issues connected with the flow of ground water, migration of fertilizers, pollutants and stability analysis. Tillage practices highly influence the saturated hydraulic conductivity of the soil. Saturated hydraulic conductivity increases in the order no tillage < secondary tillage < primary tillage <primary and secondary

tillage together. The higher saturated hydraulic conductivity was apparently caused by greater macro porosity.

Infiltration rate of the soil determine the intake rate of water by the soil. Infiltration rate of the soil increases with tillage, because of increase in porosity. Increase in infiltration with tillage in the order no tillage < secondary tillage < primary tillage < primary and secondary tillage together.

pH is the measure of acidity or basicity of the soil which give both qualitative and quantitative characteristics of soil. pH was found to be unaltered for different tillage treatments.

Tillage makes the soil suitable for cropping by enhancing the moisture availability to the plants. Also, tillage enhances the ground water recharge by increasing the infiltration rate and saturated hydraulic conductivity of the soil. Thus, tillage practices improve the overall properties of soil.

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V

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APPENDIX

vi

APPENDIX I

Grain size distribution of Primary tillage soil

Mass of dry soil sample = 475g

Sl.No.	IS Sieve	Particle Size D (mm)	Mass retained (g)	% retained	Cumulative % retained	Cumulative % finer
1	2	2mm	303.5	63.89	63.89	36.11
2	1	1mm	42	8.84	72.73	27.27
3	0.60	0.60mm	23	4.84	77.57	22.43
4	0.425	0.425mm	15.5	3.26	80.83	19.17
5	0.3	0.300mm	25.5	5.36	86.19	13.81
6	0.15	0.150mm	39.5	8.31	94.5	5.5
7	0.075	0.075mm	9	1.89	96.39	3.61
8	Pan	Pan	11	2.31	98.7	1.3

Grain size distribution of the Secondary tillage soil

Mass of dry soil sample = 469.4g

Sl.No.	IS Sieve	Particle Size D (mm)	Mass retained (g)	% retained	Cumulative % retained	Cumulative % finer
1	2	2mm	274.1	58.39	58.39	41.61
2	1	1mm	48.1	10.24	68.63	31.37
3	0.60	0.60mm	28.8	6.13	74.76	25.24
4	0.425	0.425mm	16.5	3.51	78.27	21.73
5	0.3	0.300mm	27	5.75	84.02	15.98
6	0.15	0.150mm	40.9	8.71	92.73	7.27
7	0.075	0.075mm	14.7	3.13	95.86	4.14
8	Pan	Pan	13.8	2.93	98.79	1.21

Grain size distribution of Primary and Secondary tillage soil

Mass of dry soil sample = 478.3g

Sl.No.	IS Sieve	Particle Size D (mm)	Mass retained (g)	% retained	Cumulative % retained	Cumulative % finer
1	2	2mm	268.8	56.19	56.19	43.81
2	1	1mm	46.1	9.63	65.82	34.18
3	0.60	0.60mm	25.8	5.39	71.21	28.79
4	0.425	0.425mm	17	3.55	74.76	25.24
5	0.3	0.300mm	25.8	5.39	80.15	19.85
6	0.15	0.150mm	44.6	9.32	89.47	10.53
7	0.075	0.075mm	12	2.5	91.97	8.03
8	Pan	Pan	21.5	4.49	96.46	3.54

Grain size distribution of No tillage soil

Mass of dry soil sample = 472.8g

Sl.No.	IS Sieve	Particle Size D (mm)	Mass retained (g)	% retained	Cumulative % retained	Cumulative % finer
1	2	2mm	263.5	55.73	55.73	44.27
2	1	1mm	55	11.63	67.36	32.64
3	0.60	0.60mm	29.9	6.32	73.68	26.32
4	0.425	0.425mm	16.75	3.54	77.22	22.78
5	0.3	0.300mm	27.28	5.76	82.98	17.02
6	0.15	0.150mm	45.75	9.67	92.65	7.35
7	0.075	0.075mm	11	2.32	94.97	5.03
8	Pan	Pan	16.2	3.42	98.39	1.61

APPENDIX II

Determination of moisture content by oven drying method.

Sl. No	Description	Wt. Of Vessel(1)	Wt. of vessel + soil (W2)	Wt. of vessel + soil after drying (W3)	Moisture content
1	T1R1	13.5	17.3	16.64	21.09
2	T1R2	11	18.64	17.34	20.05
3	T1R3	12	17.04	16.2	20
4	T1R4	13	17.22	16.5	20.57
5	T1R5	12.5	16.95	16.2	20.27
6	T2R1	11	16	15.2	19.04
7	T2R2	16	21.6	20.7	19.14
8	T2R3	11.5	16.38	15.6	19.02
9	T2R4	13.5	19.08	18.2	18.72
10	T2R5	12.5	18.66	17.68	18.91
11	T3R1	11.5	17	16	22.22
12	T3R2	11.5	16.5	15.5	25
13	T3R3	11.5	17	16	22.22
14	T3R4	12	20	18.5	23.03
15	T3R5	11	19	17.5	23.07
16	T4R1	13.5	20	19	18.18
17	T4R2	12.5	19	18	18.18
18	T4R3	12.5	19	18	18.18
19	T4R4	13.5	20	19	18.18
20	T4R5	12.5	19	18	18.18

APPENDIX III

Determination of bulk density of primary tillage

Treatment	Mass of core cutter(g)	Mass of soil+ core cutter (g)	Mass of soil (g)	volume (cm^3)	Bulk Density (g/cm^3)
T1R1	928	2439.1	1511.1	981.25	1.54
T1R2	985	2505.9	1520.9	981.25	1.55
T1R3	928	2493.1	1511.1	981.25	1.54
T1R4	985	2496.1	1511.1	981.25	1.54
T1R5	928	2496.1	1511.1	981.25	1.54
					Avg BD=1.539

Determination of bulk density of secondary tillage

Treatments	Mass of core cutter(g)	Mass of soil+core cutter (g)	Mass of soil (g)	volume (cm^3)	Bulk Density (g/cm^3)
T2R1	928	2566.6	1638.6	981.25	1.67
T2R2	928	2566.6	1638.6	981.25	1.67
T2R3	985	25604	1619	981.25	1.65
T2R4	985	2584.4	1599.4	981.25	1.63
T2R5	928	2527.4	1599.4	981.25	1.63
					Avg BD=1.614

Determination of bulk density of primary and secondary tillage together

Treatments	Mass of core cutter(g)	Mass of soil+core cutter (g)	Mass of soil (g)	volume (cm^3)	Bulk Density (g/cm^3)
T3R1	928	2360.6	1432.6	981.25	1.46
T3R2	985	2427.4	1442.4	981.25	1.47
T3R3	928	2341	1413	981.25	1.44
T3R4	985	2427.4	1442.4	981.25	1.47
T3R5	928	2370.4	1442.4	981.25	1.47
					Avg BD=1.468

Determination of bulk density of no tillage

Treatments	Mass of core cutter(g)	Mass of soil+core cutter (g)	Mass of soil (g)	volume (cm^3)	Bulk Density (g/cm^3)
T4R1	928	2655	1727	981.25	1.76
T4R2	985	2721.8	1736.8	981.25	1.77

T4R3	928	2645.1	1717.1	981.25	1.75
T4R4	928	2655	1727	981.25	1.76
T4R5	985	2731.6	1746.6	981.25	1.78
					Avg BD=1.773

APPENDIX IV

Determination of particle density of primary tillage.

Treatments	Mass of soil (g)	Initial volume of water (ml)	Final volume of water (ml)	Change in volume (ml)	particle Density (g/cm^3)
T1R1	30	40	52	12	2.5
T1R2	30	40	51.9	11.9	2.52
T1R3	30	40	52	12	2.5
T1R4	30	40	52.2	12.2	2.45
T1R5	30	40	52	12	2.5
					Avg PD = 2.473

Determination of particle density of secondary tillage

Treatments	Mass of soil (g)	Initial volume of water (ml)	Final volume of water (ml)	Change in volume (ml)	particle Density (g/cm^3)
T2R1	30	40	52.6	12.6	2.38
T2R2	30	40	52.5	12.5	2.4
T2R3	30	40	53	13	2.3
T2R4	30	40	53.1	13.1	2.29
T2R5	30	40	52.5	12.1	2.4
					AvgPD = 2.333

Determination of particle density of primary and secondary tillage together

Treatments	Mass of soil (g)	Initial volume of water (ml)	Final volume of water (ml)	Change in volume (ml)	particle Density (g/cm^3)
T3R1	30	40	51.8	11.8	2.53
T3R2	30	40	51.9	11.9	2.52
T3R3	30	40	52	12	2.5
T3R4	30	40	52	12	2.5
T3R5	30	40	52.2	12.2	2.45
					Avg PD = 2.446

Determination of particle density of no tillage

Treatments	Mass of soil (g)	Initial volume of water (ml)	Final volume of water (ml)	Change in volume (ml)	particle Density (g/cm^3)
T4R1	30	40	51.8	11.8	2.53
T4R2	30	40	51.5	11.5	2.6
T4R3	30	40	51.8	11.8	2.53
T4R4	30	40	51.7	11.7	2.56
T4R5	30	40	51.7	11.7	2.56
					AvgPD = 2.562

APPENDIX V

Determination of porosity of primary tillage.

TREATMENTS	BULK DENSITY (g/cm^3)	PARTICLE DENSITY (g/cm^3)	POROSITY (%)
T1R1	1.54	2.5	29.83
T1R2	1.55	2.52	30.4
T1R3	1.54	2.5	28.2
T1R4	1.54	2.45	28.8
T1R5	1.54	2.5	32.08
			Avg n = 30.732

Determination of porosity of secondary tillage

TREATMENTS	BULK DENSITY (g/cm^3)	PARTICLE DENSITY (g/cm^3)	POROSITY (%)
T2R1	1.67	2.38	38.4
T2R2	1.67	2.4	38.4
T2R3	1.65	2.3	38.4
T2R4	1.63	2.29	37.1
T2R5	1.63	2.4	38.4
			Avg n = 37.75

Determination of porosity of primary and secondary tillage together

TREATMENTS	BULK DENSITY (g/cm^3)	PARTICLE DENSITY (g/cm^3)	POROSITY (%)
T3R1	1.46	2.53	42.2
T3R2	1.47	2.52	41.6
T3R3	1.44	2.5	42.4
T3R4	1.47	2.5	41.2
T3R5	1.47	2.45	40
			Avg n = 40.04

Determination of porosity of no tillage

TREATMENTS	BULK DENSITY (g/cm^3)	PARTICLE DENSITY (g/cm^3)	POROSITY (%)
T4R1	1.76	2.53	30.4
T4R2	1.77	2.6	31.9
T4R3	1.75	2.53	30.8
T4R4	1.76	2.56	31.25
T4R5	1.78	2.56	30.4
			Avg n = 30.755

APPENDIX VI

Determination of hydraulic conductivity of primary tillage.

Sl. No	Treatment	Volume, q	Length, l	Area, A	Height, h	Time, t	Hydraulic conductivity, K (cm/day)
		(m^3)	(m)	(m^2)	(m)	(s)	$K = \frac{ql}{Aht}$
1	T1R1	0.1×10^{-3}	0.125	0.00785	0.9	385	39.705
2	T1R2	0.1×10^{-3}	0.125	0.00785	0.9	387	39.5
3	T1R3	0.1×10^{-3}	0.125	0.00785	0.9	395	38.5
4	T1R4	0.1×10^{-3}	0.125	0.00785	0.9	395	38.7
5	T1R5	0.1×10^{-3}	0.125	0.00785	0.9	380	40.22

Determination of hydraulic conductivity of secondary tillage

Sl. No	Treatment	Volume, q	Length, l	Area, A	Height, h	Time, t	Hydraulic conductivity, K (cm/day)
		(m^3)	(m)	(m^2)	(m)	(s)	$K = \frac{ql}{Aht}$
1	T2R1	0.1×10^{-3}	0.125	0.00785	0.9	420	36.396
2	T2R2	0.1×10^{-3}	0.125	0.00785	0.9	428	35.71
3	T2R3	0.1×10^{-3}	0.125	0.00785	0.9	430	35.716
4	T2R4	0.1×10^{-3}	0.125	0.00785	0.9	432	35.386
5	T2R5	0.1×10^{-3}	0.125	0.00785	0.9	435	30.748

Determination of hydraulic conductivity of primary and secondary tillage together

Sl. No	Treatment	Volume, q	Length, l	Area, A	Height, h	Time, t	Hydraulic conductivity, K (cm/day)
		(m^3)	(m)	(m^2)	(m)	(s)	$K = \frac{ql}{Aht}$
1	T3R1	0.1×10^{-3}	0.125	0.00785	0.9	300	50.955
2	T3R2	0.1×10^{-3}	0.125	0.00785	0.9	310	49.311
3	T3R3	0.1×10^{-3}	0.125	0.00785	0.9	308	49.632
4	T3R4	0.1×10^{-3}	0.125	0.00785	0.9	305	50.12

5	T3R5	0.1×10^{-3}	0.125	0.00785	0.9	310	49.311

Determination of hydraulic conductivity of no tillage

Sl. No	Treatment	Volume, q	Length, l	Area, A	Height, h	Time, t	Hydraulic conductivity, K (cm/day)
		(m^3)	(m)	(m^2)	(m)	(s)	$K = \frac{ql}{Aht}$
1	T4R1	0.1×10^{-3}	0.125	0.00785	0.9	728.4	20.9
2	T4R2	0.1×10^{-3}	0.125	0.00785	0.9	735	20.798
3	T4R3	0.1×10^{-3}	0.125	0.00785	0.9	730	20.94
4	T4R4	0.1×10^{-3}	0.125	0.00785	0.9	732	20.883
5	T4R5	0.1×10^{-3}	0.125	0.00785	0.9	725	21.085

APPENDIX VII

Observations of double ring infiltrometer

Primary tillage

SI. NO.	Time	TIR1	T1R2	T1R3	T1R4	T1R5	Avg R (cm)	Avg I (cm/hr)	Acc. I (cm)
1	2	1.5	1.4	1.4	1.6	1.4	1.46	48.67	1.46
2	2	1.4	1.4	1.4	1.4	1.5	1.42	47.34	2.88
3	2	1.4	1.2	1.2	1.3	1.2	1.26	42	4.14
4	2	1.3	1.2	1.2	1.2	1.2	1.22	40.67	5.36
5	2	1.2	1.2	1.2	1	1.2	1.16	38.67	6.52
6	5	2.1	2.3	2.2	2.3	2	2.18	26.26	8.7
7	5	2.2	2.2	2.2	2.3	2.2	2.22	26.74	10.92
8	5	2.2	2.2	2.2	2.3	2.2	2.22	26.74	13.14
9	5	2.2	2.2	2.2	2.3	2.2	2.22	26.74	15.36
10	10	4.3	4.3	4.5	4.2	4.2	4.3	26.8	19.66
11	10	4.4	4.2	4.2	4.2	4.2	4.24	26.5	23.9
12	10	4.2	4.2	4.2	4.2	4.2	4.2	26.25	28.1
13	15	6.6	6.6	6.5	6.6	6.6	6.58	26.32	34.68
14	15	6.6	6.6	6.5	6.6	6.6	6.58	26.32	41.26
15	15	6.6	6.5	6.5	6.6	6.6	6.56	26.24	47.82
16	15	6.6	6.6	6.5	6.5	6.6	6.56	26.24	54.38
								19.307	

Secondary tillage

SI. NO.	Time(min)	T2R1	T2R2	T2R3	T2 R4	T2 R5	Avg R (cm)	Avg I (cm/hr)	Acc. I (cm)
1	2	0.7	0.7	0.6	0.7	0.6	0.66	22	0.66
2	2	0.6	0.6	0.6	0.7	0.6	0.62	20.67	1.28
3	2	0.6	0.6	0.6	0.7	0.6	0.62	20.67	1.9
4	2	0.6	0.6	0.6	0.7	0.6	0.62	20.67	2.52
5	2	0.6	0.6	0.6	0.7	0.6	0.62	20.67	3.14
6	5	1.5	1.5	1.5	1.5	1.5	1.5	18.07	4.64
7	5	1.5	1.5	1.5	1.5	1.5	1.5	18.07	6.14
8	5	1.5	1.5	1.5	1.5	1.5	1.5	18.07	7.64
9	5	1.5	1.5	1.5	1.5	1.5	1.5	18.07	9.14
10	10	2.9	2.9	2.8	2.8	2.8	2.82	17.62	11.96
11	10	2.8	2.8	2.8	2.8	2.9	2.84	17.75	14.8
12	10	2.8	2.8	2.8	2.9	2.8	2.82	17.62	17.62

13	15	4.5	4.5	4.4	4.5	4.4	4.44	17.76	22.06
14	15	4.5	4.5	4.4	4.5	4.4	4.44	17.76	26.5
15	15	4.5	4.5	4.4	4.5	4.4	4.44	17.76	30.94
16	15	4.5	4.5	4.4	4.5	4.4	4.44	17.76	35.38

Primary and secondary tillage together

SI. NO.	Time	T3R1	T3R2	T3R3	T3R4	T3R5	Avg R (cm)	Avg I (cm/hr)	Acc. I (cm)
1	2	1.8	1.7	1.7	1.7	1.7	1.72	57.3	1.72
2	2	1.8	1.8	1.7	1.7	1.7	1.74	58	3.46
3	2	1.8	1.7	1.7	1.7	1.7	1.72	57.3	5.18
4	2	1.8	1.7	1.7	1.7	1.7	1.72	57.3	6.9
5	2	1.8	1.7	1.7	1.7	1.7	1.72	57.3	8.62
6	5	4.4	4.4	4.3	4.4	4.3	4.36	52.53	12.98
7	5	4.4	4.4	4.3	4.4	4.3	4.36	52.53	17.34
8	5	4.4	4.4	4.3	4.4	4.3	4.36	52.53	21.7
9	5	4.4	4.4	4.3	4.4	4.3	4.36	52.53	26.06
10	10	8.4	8.4	8.4	8.4	8.4	8.4	52.5	13.46
11	10	8.4	8.4	8.4	8.4	8.4	8.4	52.5	42.86
12	10	8.4	8.4	8.4	8.4	8.4	8.4	52.5	51.26
13	15	13.1	13	13.1	13.1	13.1	13.08	52.32	64.34
14	15	13.1	13	13.2	13.1	13.1	13.1	52.4	77.44
15	15	13.1	13	13.2	13.1	13.1	13.1	52.4	90.54
16	15	13.1	13	13.2	13.1	13.1	13.1	52.4	103.64

No tillage

SI. NO.	Time(min)	T4R1	T4R2	T4R3	T4 R4	T4 R5	Avg R (cm)	Avg I (cm/hr)	Acc. I (cm)
1	2	0.6	0.6	0.5	0.4	0.4	0.54	14.21	0.54
2	2	0.6	0.6	0.5	0.4	0.4	0.54	14.21	1.08
3	2	0.6	0.6	0.6	0.4	0.4	0.56	14.73	1.64
4	2	0.6	0.6	0.6	0.4	0.4	0.56	14.73	2.2
5	2	0.6	0.6	0.6	0.4	0.4	0.56	14.73	2.76
6	5	1.2	1.2	1.2	1.1	1.1	1.18	14.2	3.94
7	5	1.2	1.2	1.2	1.1	1.1	1.18	14.2	5.12
8	5	1.2	1.2	1.2	1.1	1.1	1.18	14.2	6.3
9	5	1.2	1.2	1.2	1.1	1.1	1.18	14.2	7.48
10	10	2.3	2.3	2.4	2.2	2.2	2.3	13.7	9.78
11	10	2.3	2.3	2.4	2.2	2.2	2.3	13.7	12.08
12	10	2.3	2.3	2.4	2.2	2.2	2.3	13.7	14.38
13	15	3.4	3.4	3.4	3.3	3.3	3.38	13.52	17.76

14	15	3.4	3.4	3.4	3.3	3.3	3.38	13.52	21.14
15	15	3.4	3.4	3.4	3.3	3.3	3.38	13.52	24.52
16	15	3.4	3.4	3.4	3.3	3.3	3.38	13.52	27.9

APPENDIX VIII

Observations of pH meter

SI. No.	Treatments	pH
1	T1R1	5.5
2	T1R2	5.4
3	T1R3	5.5
4	T1R4	5.6
5	T1R5	5.5
6	T2R1	5.4
7	T2R2	5.4
8	T2R3	5.5
9	T2R4	5.5
10	T2R5	5.5
11	T3R1	5.6
12	T3R2	5.6
13	T3R3	5.5
14	T3R4	5.5
15	T3R5	5.6
16	T4R1	5.5
17	T4R2	5.6
18	T4R3	5.5
19	T4R4	5.5
20	T4R5	5.6

ABSTRACT

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Tillage is the mechanical manipulation of soil to provide favourable condition for crop production. It breaks the compact surface of earth to certain depth and loosens the soil mass so that roots of the crop penetrate and spread into the soil. These include ploughing, harrowing, mechanical destruction of weeds and breaking of soil crust.

The study was designed to evaluate the effects of tillage types primary tillage, secondary tillage, primary and secondary tillage together and no tillage on properties of agricultural soils. Particle size distribution, bulk density, particle density, porosity, hydraulic conductivity, infiltration rate, soil pH and soil moisture content were determined to investigate the impacts of tillage on soil properties. The study was carried out in 20 plots, each measuring 22.5 square meters.

The results showed that soil is of sandy loam texture, no tilled soil have higher bulk density, soil which is treated with primary and secondary tillage together have higher porosity, hydraulic conductivity and infiltration rate, tillage induce no effect on particle density. Generally, the results showed that tillage types have a significant impact on soil properties.