

MODELLING OF INFILTRATION RATE OF RED SOIL UNDER DIFFERENT LAND USE PATTERNS

A Project Report

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CERTIFICATE

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".....the beauty of the designation is half veiled and the fragrance of the success half dull until the traces of all those enlightening the path are left to fly with the wind spreading word of thankfulness..." So, keeping this in view;

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CONTENTS

Chapter	Title	Page No.
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-8
III	MATERIALS AND METHODS	9-17
IV	RESULTS AND DISCUSSION	18-36
V	SUMMARY AND CONCLUSIONS	37-38
VI	SUGGESTIONS FOR FUTURE WORK	39
	REFERENCES	40-43
	APPENDICES	44-48

LIST OF FIGURES

Figure No.	Title	Page No.
3.1	Double Ring Infiltrometer	10
4.1	Comparison of infiltration capacity under different soil conditions	20
4.2	Comparison of cumulative infiltration capacity of ploughed, unploughed, compact and continuous fallow land	22
4.3	Observed and predicted infiltration rates of ploughed soil for Modified Kostiakov model	28
4.4	Observed and predicted infiltration rates of unploughed soil for Modified Kostiakov model	28
4.5	Observed and predicted infiltration rates of compact soil for Modified Kostiakov model	29
4.6	Observed and predicted infiltration rates of continuous fallow land for Modified Kostiakov model	29
4.7	Observed and predicted infiltration rates of ploughed soil for Horton's model	31
4.8	Observed and predicted infiltration rates of unploughed soil for Horton's model	31

4.9	Observed and predicted infiltration rates of compact soil for Horton's model	32
4.10	Observed and predicted infiltration rates of continuous fallow land for Horton's model	32
4.11	Observed and predicted infiltration rates of ploughed soil for Kostiakov model	34
4.12	Observed and predicted infiltration rates of unploughed soil for Kostiakov model	34
4.13	Observed and predicted infiltration rates of compact soil for Kostiakov model	35
4.14	Observed and predicted infiltration rates of continuous fallow land for Kostiakov model	35

LIST OF TABLES

Table No.	Title	Page No.
4.1	The observed infiltration rates (cm/h) under different soil conditions	19
4.2	The cumulative infiltration rates in cm under different soil conditions	21
4.3	Comparison between observed and simulated infiltration rates by different infiltration models for ploughed soil	23
4.4	Comparison between observed and simulated infiltration rates by different infiltration models for unploughed soil	24
4.5	Comparison between observed and simulated infiltration rates by different infiltration models for compact soil	25
4.6	Comparison between observed and simulated infiltration rates by different infiltration models for continuous fallow land	26
4.7	The constants and coefficients of Modified Kostiakov Model under different soil conditions for estimating infiltration rate	27
4.8	The coefficients of Horton's model under different soil conditions for estimating infiltration rate	30
4.9	The constants and coefficients of Kostiakov model under different soil conditions for estimating infiltration rate	33

LIST OF PLATES

Plate No.	Title	Page No.
3.1	Point gauge	11
3.2	Marking of water level in the outer and inner ring	12
3.3	Installation of inner ring	12
3.4	Installation of outer ring	13
3.5	Adjustment of vernier scale	13
3.6	Filling the water in the outer ring	14

LIST OF APPENDICES

Table No.	Title	Page No.
1	Experimental Data of Infiltration Capacity in Ploughed Land in Trail- I	42
2	Experimental Data of Infiltration Capacity in Ploughed Land in Trail- II	42
3	Average infiltration rate in ploughed land	43
4	Experimental Data of Infiltration Capacity in Unploughed Land in Trail-I	43
5	Experimental Data of Infiltration Capacity in Unploughed Land in Trail-II	44
6	Average infiltration rate in unploughed land	44
7	Experimental Data of Infiltration Capacity in Continuous fallow Land in Trail- I	45
8	Experimental Data of Infiltration Capacity in Continuous fallow Land in Trail- II	45
9	Average infiltration rate in continuous fallow land	45
10	Experimental Data of Infiltration Capacity in Compact Land in Trail-I	46

ABSTRACT

Modelling of infiltration rate of Red soil under different land use patterns was carried at “FRUIT RESEARCH STATION” Sangareddy, Medak district of a latitude of 17.6294° N and longitude of 78.0917° E. Infiltration is a dynamic process, variable in time and space and plays a vital role in the replenishment of soil water which is responsible for the growth and development of crops. Infiltration rates are influenced by the vegetal cover and cultivation practices. It plays an important role in design of farm irrigation, scheduling of irrigation etc.

Infiltration rate was estimated in red soil with Double ring infiltrometer for the four soil conditions namely 1) Ploughed condition 2) Unploughed condition 3) Compacted soil and 4) Continuous fallow land. Three empirical models namely 1) Kostiakov model 2) Modified Kostiakov model and 3) Horton's model were selected to develop constants and coefficients in order to predict the infiltration rate. Using the estimated coefficients and constants, the three infiltration equations for different soil conditions were formulated.

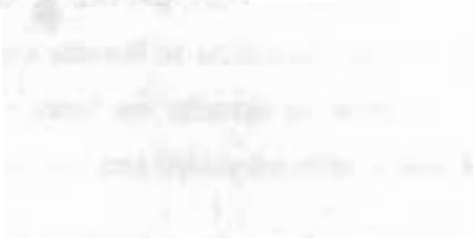
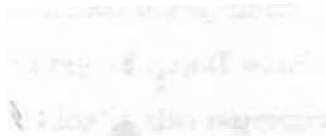
For the ploughed land, it was found that, the Horton's model with correlation coefficient as 0.99 fitted well followed by Modified Kostiakov and Kostiakov. In unploughed land, the both Modified Kostiakov and Horton's models gives the best fit with correlation coefficient of 0.99 followed by Kostiakov model. In Compact land, it was found that, the Horton's model gives the best fit with correlation coefficient as 0.99 followed by Modified Kostiakov and Kostiakov model. In Continuous fallow land, it was found that, the Horton's model gives the best fit with correlation coefficient as 0.99 followed by Modified Kostiakov and Kostiakov model

Hence it can be concluded that Horton's model can be effectively used for the soils of this region for different land use patterns.

Key words: Infiltration, Infiltration rate, Double ring infiltrometer,



INTRODUCTION



CHAPTER I

INTRODUCTION

Water is essential constituent of all life on earth. In spite of the fact that water is a vital source of life, it is simultaneously considered as a source of destruction, induced mainly by river floods related to heavy precipitation. These floods are real threat to humankind since old ages and are still so at the present time. Substantially, flooding involves many risks and causes significant damage to the area in which it takes place. Infrastructure close to rivers can be destroyed. In addition, floods induce great soil erosion resulting significant losses in soil as well as the deterioration in soil quality. This adversely affects agricultural production. Moreover, floods generated by heavy rainfall water can produce surface runoff which causes pollution of surface water with conveyed chemicals, fertilizers and pesticides.

Infiltration is one of the major components of the hydrology cycle. Water that falls as precipitation may run over land eventually reaching streams, lakes, rivers and oceans or infiltrate through the soil surface into the soil profile. Water that runs off over land causes erosion, flooding and degradation of water quality. Infiltration, on the other hand, constitutes the sole source of water to sustain the growth of vegetation, is filtered by the soil which removes many contaminants through physical, chemical and biological processes, and replenishes the ground water supply to wells, springs and streams (Rawls *et al.*, 1993; Oram 2005). The ability to quantify infiltration is of great importance in watershed management. Prediction of flooding, erosion and pollutant transport depends on the rate of runoff which is directly affected by the rate of infiltration. Quantification of infiltration is also necessary to determine the availability of water for crop growth and to estimate the amount of additional water needed for irrigation. Also, by understanding how infiltration rates are affected by surface conditions, measures can be taken to increase infiltration rates and reduce the erosion and flooding caused by overland flow.

The infiltration rate is of prime importance to irrigation engineers as it influences the application rate of infiltration. It is difficult to design an irrigation system without proper knowledge of infiltration characteristics of soil. In dry land agriculture, infiltration characteristics will also be required for proper water management. It is useful for

determination of availability of water for plants, runoff rate and percolation. Accurate determination of infiltration rate is useful for mitigation of hydrological risk. The occurrence of overland flow and an evaluation of the risk of overland flow are needed in order of transferring pollutants from soil to rivers and lakes. Further the prediction of runoff has a crucial role in designing hydraulic structures as well as water resources planning and management.

Infiltration is the downward entry of water into the soil. The velocity with which water enters the soil is infiltration rate. Infiltration rate is expressed in centimeter per hour. This rate depends on soil texture (amount of sand, silt and clay) and on soil structure. Water from rainfall or irrigation must first enter the soil.

When water is supplied at a rate that exceeds the soil infiltration capacity, it moves down slope as runoff on sloping land or ponds on the surface of level land. When runoff occurs on bare or poorly vegetated soil, erosion takes place. Runoff carries nutrients, chemicals, and soil with it, resulting in decreased soil productivity, off-site sedimentation of water bodies and diminished water quality. Sedimentation decreases storage capacity of reservoirs and streams and can lead to flooding.

Restricted infiltration and ponding of water on the soil surface results in poor soil aeration, which leads to poor root function and plant growth, as well as reduced nutrient availability and cycling by soil organisms. Ponding and soil saturation decreases soil strength, destroys soil structure, increases detachment of soil particles, and makes soil more erodible. Pondered water is subject to increased evaporation, which leads to decreased water available for plant growth.

Infiltration modeling approaches are often separated into three categories: physically based, approximate, and empirical models. The physically based approaches require solution of the Richards' equation (Richards, 1931), which describes water flow in soils in term of the hydraulic conductivity and the soil water pressure as function of soil water content, for specified boundary conditions. Solving this equation is extremely difficult for many flow problems requiring detailed data input and use of numerical methods (Rawls *et al.*, 1993).

Skaggs and Khaleel (1982) stated that although numerical methods that allow the hydrologist to quantify the vertical percolation of water are critical for assessment of ground water recharge and in the analysis of contaminant movement through soil, numerical solutions are costly, data intensive and time intensive computational procedures requiring numerous field measurements to be made and therefore rarely used in practice. A simplified approach includes empirical models such as Kostiakov, Horton's and Modified Kostiakov require minimum amount of data. Empirical models tend to be less restricted by assumptions of soil surface and soil profile conditions, but more restricted by the conditions for which they were calibrated, since their parameters are determined based on actual field measured infiltration data (Hillel, 1998; Skaggs and Khaleel, 1982).

Hence, there is a need to determine such an important characteristic, i.e. constant infiltration rates for different soils, effect of cultivation on infiltration, and assessment of the suitability of different models for estimation of infiltration rate of particular soil under particular soil condition. Thus, the present study aims at achieving the following objectives.

1. To determine and compare the infiltration rate of red soil under different land use patterns by using double ring infiltrometer.
2. Modelling the empirical infiltration equation with the observed field data.
3. To find the best empirical infiltration model for the red soil under different land use patterns.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The literature available on infiltration rate is reviewed extensively and presented briefly.

Amit *et al.* (2014) conducted experiment on estimation of infiltration rate using single and double ring infiltrometer and compared these results with Horton's equation. The results indicate that double ring infiltrometer is more accurate than single ring infiltrometer.

Amreeta Champatiray *et al.* (2014) revealed that the rate of infiltration is equal in both of the methods applied. Finally it can be concluded that the 30-60 double ring infiltrometer can give better performance than double ring infiltrometer of 15 cm-30 cm. The garden soil infiltrated more rapidly than the forest soil due to having more hydraulic conductivity values as calculated by Hortons equation. The soil has more conductivity values in the months of September and October than that of other months. The natural soil had a high infiltration rate compared to the other fields due to the deep cracks in the soil and the low initial water content.

Ieke Wulan Ayu *et al.* (2013) were noticed that estimated value of soil infiltrability using Horton Model is similar with the value of infiltration measurement in the field. The highest infiltration rate occurs in lowland rainfed (rainfed sawahlanduse) and lowest rate of infiltration on the dryland (Tegalan landuse). Soil infiltrability was influenced by the rainfall, vegetation type, soil water content and soil characteristics. Soil properties that affect the process of infiltration are soil structure, texture, soil organic matter content, bulk density, particle density, and initial soil moisture content.

Adeniji *et al.* (2013) concluded that high level of dependence of infiltration rate on the soil fine fraction. The infiltration equation as obtained using the regression analysis is of a polynomial function with three coefficients believed to be functions of soil fine fraction also in polynomial best fits. A model was generated that could be used to estimate the infiltration rate of any soil at a time t , if the fine fraction of the soil is known, all other factors remaining constant. Hence better result can obtained if attempts are made to eliminate all the other soil factors such as soil texture and moisture content.

Nimblakar *et al.* (2012) revealed that constant infiltration rate of clay unploughed and clay ploughed soil was 1.2 cm/hr and 1.6 cm/hr. respectively. For black cotton compact soil 1.2 cm/hr, black cotton ploughed soil 1.6 cm/hr, black cotton harrowed soil 1.46 cm/hr, and for sandy soil 8.53 cm/hr in the selected region. The infiltration model varies from soil to soil and soil type. From the correlation coefficient and standard error calculations it was found that for all type of soils and their conditions Horton's model is best fitting with high degree of correlation coefficient and minimum standard error except for ploughed clay soil to which Green – Ampt model is best fitting. The Horton's model is best fitting with measured values of infiltration rates for all types of soils and soil conditions except for ploughed clay soil in the region. The soil condition affects the infiltration rate. From the graphs of infiltration rates against time it is found that initially infiltration rates were high and decreased with time up to constant infiltration rate

Tarek Selim *et al.* (2011) were showed that the initial infiltration rate depends mainly on the initial water content in heavy clay soil. The infiltration rate was affected by the amount of cracks caused by plant roots, earth movement and desiccation of clay. The fish farm in heavy clay soil did not increase the soil permeability except the top layer (mud layer) due to the presence of large number of wide and deep cracks resulting from desiccation. The natural soil had a high infiltration rate compared to the other fields due to the deep cracks in the soil and the low initial water content.

Osuji *et al.* (2010) conducted experiment on infiltration characteristics of soils under selected land use practices. The results indicate that high average infiltrations were observed under bush fallow and also under continuously fallow cultivated land.

Eze Bassey Eze *et al.* (2010) concluded that studies on infiltration rates of soils are required in solving many hydrological problems such as runoff estimation, soil moisture budgeting irrigation planning, land use planning and management. This research shows that vegetation cover is one of the most important factors that accelerates infiltration rate and thus reduces overland flow which and ultimately in turns conserves the soil. The mean for vegetal cover was as high as 158.8 mm/hr. The sand, silt and clay contents of the soils had mean values of 70.3, 15.4 and 14.3 per cent which shows that the area is dominated by sandy soil. The area is unsuitable for surface irrigation due to its high infiltration capacity. It is recommended that human activities in the form of deforestation, bush burning and

grazing by livestock should be discouraged, while in this area; planting of trees on bare lands should be encouraged to reduce erosion.

Doktors Der Naturwissenschaften *et al.* (2009) the experiment was conducted to identify the most important factors affecting the infiltration capacity of agricultural soils as a conservation method of soils against the flooding produced by either rivers or heavy precipitation revealed that water flooding induced by heavy rainfalls or river floods is still considered a serious problem at the present time. Frequent floods can lead to soil erosion induced by the high surface runoff. In addition, floods may result in loss of homes and a lot other damages.

The discussion of work results focused on the evaluation of the main factors like land use, farming system, soil tillage and fertilization treatments, which strongly influence soil properties leading to change in the infiltration capacity of agricultural soils.

Igbadun and Idris (2007) studied on four models for the hydromorphic soil of Zango Plain, concluded that Zaria provided good overall agreement with field-measured cumulative infiltration depths, and are therefore capable of simulating infiltration for the soil studied. The Kostiakov's model and Modified Kostiakov (A) were found to provide the best fit for all part of the field whether close to the stream where the hydraulic conductivity was low or farther upland.

Gregory *et al.* (2006) conducted experiment on the effect of compaction caused by relatively light construction equipment and very heavy equipment for the purposes of determining potential infiltration rates. The results indicate that soil compaction was shown to have a negative effect on infiltration rates of soils in north central Florida. The lowest level of compaction resulted in significantly lower infiltration rates therefore any amount of compaction must be avoided on these soils if runoff from development sites is to be minimized.

Mohd Fazly Yousof *et al.* (2005) conducted experiment conducted on infiltration study in urban soils. The results indicate that the soil infiltration and permeability capacity must be well known to engineers specially. By developing the infiltration map designer could make a proper decision in applying control at source approach. The better area have high permeability soil type especially for the undeveloped area with this infiltration

designer could make a right choice in designing urban storm water drainage for future for those undeveloped area.

Mohan and Kumari (2005) studied on recharge estimation using infiltration Models. Different infiltration models were tested at 50 locations in a basin based on the soil type and land use variations at Neyveli. The results indicate that the concluded that the Infiltration models namely Green Ampt Model, Modified Kostiakov model and Horton model were found to be statistically fit to the observed field data. The results were compared with that of the standard SWAT (Soil and Water Assessment Tool) Model developed by the USDA, agricultural research service (ARS). The study concluded that Horton Model is the most appropriate infiltration model for estimating recharge in Neyveli region.

Bean *et al.* (2004) studied on the infiltration rates of PICP near fines and free of fines. The results indicate that infiltration rates of PICP filled with gravel are not limited by their surface infiltration capacity provided they are sited in areas free of soil disturbances. The average PICP infiltration rate was 2000 cm/hr, while the PICP sites near disturbed soils with fines was 61 cm/hr, a decrease of almost 97%. The analysis showed a significant difference in surface infiltration rates at a confidence level of 99.5%. PICP sites free of fines have significantly higher infiltration rates than PICP sites with sandy fines in present.

Jimenez *et al.* (2004) conducted experiment on influence of pumice mulch on soil infiltration rate. The results indicate that the basic infiltration rate was high for mulched soil than the uncovered soil and also the mulched soil take longer time to research steady infiltration rate.

Singh and Bhakar (2004) concluded that a study on comparison of infiltration equations for different land covers. A comparison of various infiltration equations e.g. Kostiakov equation, modified Kostiakov equation, Green Ampt and Horton equation were made. The various land covers in a sandy loam, soils e.g. cultivated land, fallow land, Pasture land and farm pond bed were considered.

Robert Pitt *et al.* (2002) conducted experiment on compacted urban soils effects on infiltration rate. The results indicate that infiltration rates can easily be made if published soil maps are used in conjunction with most available models for typically disturbed urban

soils, as these tools ignore compaction. Knowledge of compaction (which can be measured using a cone penetrometer, or estimated based on expected activity on grassed areas, or directly measured) can be used to more accurately predict storm water runoff quantity. Important differences were found during many tests. The 2-hour averaged infiltration rates and their COVs in each of the four major groupings. The data can be fitted to conventional infiltration models, but the high variations within each of these categories makes it difficult to identify legitimate patterns, implying that average infiltration rates within each event may be most suitable for predictive purposes. The remaining uncertainty can probably best be described using Monte Carlo components in runoff models.

CHAPTER III
MATERIALS AND METHODS

MATERIAL & METHODOLOGY

CHAPTER III

MATERIALS AND METHODS

Study Area

The experiment entitled “Modelling of infiltration rate of Red soil under different land use patterns” was conducted at “FRUIT RESEARCH STATION” Sangareddy. Sangareddy is located in Medak District of Telangana. It is located in Central Telangana zone with Latitude of 17.6294° N and longitude of 78.0917° E. The annual rainfall of Sangareddy is 910 mm. The predominant soils of Sangareddy are red and black soils. The major crop grown is Sugarcane. Materials used and methodology followed during the experimentation is presented in this chapter.

3.1 Experimental Setup

The infiltration rate was estimated in red soils for different land use patterns. Type of soil, crop and management practices affects the infiltration rate. Hence, to study the impact of above parameters the infiltration rate was studied under ploughed, unploughed, compact and continuous fallow land.

The experimental set up used in the present study comprises double ring infiltrometer and point gauge for accurate measurement of infiltration. The description of the equipment used is as follows

3.1.1 Double ring infiltrometer

The standard double ring infiltrometer set consists of a pair of concentric rings (Fig 3.1). The diameter of inner ring is 30 cm and outer ring is 60 cm and both rings have depth of 30 cm. The double ring infiltrometer made of 14 gauge rust resistant galvanized steel sheet. The purpose of outer ring is to create a one dimensional flow of water from the inner ring as the analysis of data is simplified. The inner ring is used for measuring infiltration rate of water. One side (Bottom side) of two rings is sharpened for easy insertion of rings into soil. The other side is made hard. Inner and outer rings consist of projections. These projections are useful for easy carrying of rings and also used as guides while inserting infiltrometer into the ground. The rings were driven 10 cm deep into soil by

using falling weight type hammer striking on a wooden plank placed on top of ring uniformly without or undue disturbance to soil surface.

Top View

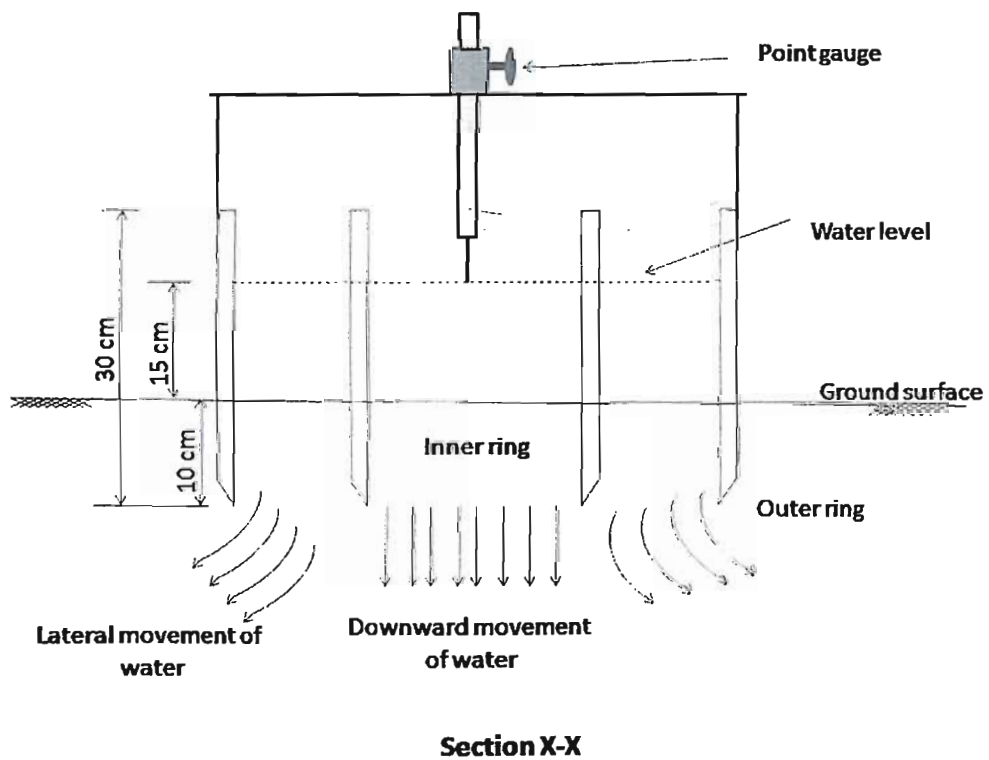
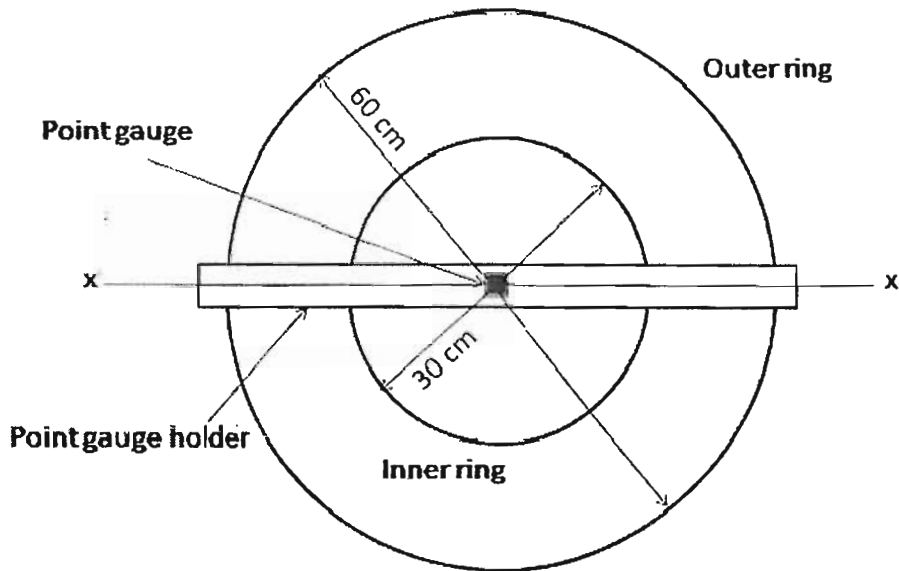


Fig. 3.1. Double Ring Infiltrometer

3.1.2 Point gauge

The point gauge is made of invar steel graduated in metric units on main scale and vernier scale. The main scale is attached to a square MS steel rod having a length of 40 cm on one side and carries threads. The main scale consists of graduations up to 30 cm. At the bottom of this square rod, a small needle extension of 10 cm in length is provided. The needle has a sharp tip at the bottom. Over this main scale, vernier scale is attached with a rack and pinion mechanism. The vernier scale is graduated to a length of 10 cm with the marked lines from 0 to 10. The vernier scale is stationary and main scale moves vertically up and down helps in touching the water surface and to read measurements on main and vernier scale. The point gauge is fitted on a holder.



Plate 3.1. Point gauge

3.2 Installation of Infiltrometer

For accurate installation of infiltrometer, the land was neatly cleaned by removing small obstacles such as stones or twigs, etc. By putting the inner ring with the cutting edge facing with the help of impact absorbing hammer slowly inserted ring about 10 cm vertically into the soil by hitting on the driving plate. The ring is driven into the ground by falling weight type hammer striking on top of the rings or by light blows with an ordinary hammer and using a short wooden plank to prevent damage to the edges of the metal rings. To avoid the disturbance of the soil, the vibrations are avoided by standing one or two persons on the ring. After installing inner ring, placed the outer ring with the cutting edge facing down and exact concentric with inner cylinder. With the help of driving plate and impact absorbing hammer slowly inserted the outer ring. The both cylinders are installed about 5 cm deep in the soil. Care is taken to keep the installation depth of the rings same in all experiments. This is accomplished by marking the outside of the rings at the 5 cm level and driving the rings up to the mark.



Plate 3.2. Marking of water level in the outer and inner ring



Plate 3.3. Installation of inner ring



Plate 3.4. Installation of outer ring

3.3 Measurement of Infiltration Rate using Double Ring Infiltrometer

For measuring the infiltration rate of the soil, the outer ring is filled with water, then immediately in the inner ring to approximately 15 cm depth. To avoid the seepage of water from inner ring to outer and vice-versa, the water levels in both the cylinders are kept approximately same. After filling water, the infiltration depth in inner ring is determined with the help of point gauge after five minutes.

Water level in the inner ring as indicated on the point gauge is measured starting with small time intervals.



Plate 3.5. Adjustment of vernier scale



Plate 3.6. Filling the water in the outer ring

The water is refilled into both rings when the water level has reached near to 5 cm mark. Care is taken to fill the container completely each time before adding water to the rings. This process is continued till constant infiltration rate is attained. The readings have been taken in three trails at each experimental setup. The infiltration rate is calculated by the following formula

$$\text{Infiltration rate (cm/h)} = \frac{\text{Initial water depth (cm)} - \text{Final water depth (cm)}}{\text{Time required, h}}$$

3.4 Un-installation of Double Ring Infiltrometer

After completion of the infiltration test, the infiltrometer rings are removed from the soil by light hammering on the sides, (the rings should be hammered only with a rubber hammer to prevent denting) and by moving the ring back and forth, and by lifting up by holding projections at the top of the rings.

3.5. Modeling of Infiltration Equations

Different types of infiltration models are available in literature to estimate infiltration rate which have been listed below.

1. Kostiakov model
2. Modified Kostiakov model
3. Hortons model
4. Green-ampt model
5. Holton's model
6. Philips model
7. Modified Lewis model

However, three empirical models are selected to simulate infiltration rate in view of availability of data. They are Kostiakov, Modified Kostiakov and Horton's model.

3.5.1 Kostiakov equation

Kostiakov (1932) and independently Lewis (1938) proposed a simple empirical infiltration equation based on curve fitting from field data. It relates infiltration to time as a power function:

$$F_p = a t^b$$

Where

F_p = Cumulative infiltration capacity [cm/h],

t = Time after infiltration starts [h], and

a and b are constants that depend on the soil and initial conditions.

The parameters, a and b must be evaluated from measured infiltration data. The equation describes the measured infiltration curve for the same soil and initial water condition, allows prediction of an infiltration curve using the same constants developed for those conditions.

Criddle *et al.* (1956) used the logarithmic form of the equation with same parameters

$$\text{Log } F_p = \log a + b \log t$$

The parameter values for a and b are determined by plotting log F_p against log t . This results in a straight line if the Kostiakov equation is applicable to the data. The intercept of the equation (infiltration rate at time $t = 1$) is log a and the slope is b. The a and b values ranges between 0 to 1.

The higher the value of b, the steeper the slope and the greater the rate of decline of infiltration. The greater the value of b, the greater the initial infiltration value. The Kostiakov equation is widely used because of its simplicity, ease of determining the two constants from measured infiltration data and reasonable fit to infiltration data for many soils over short time periods.

3.5.2 Modified Kostiakov equation

$$f = at^b + c$$

Where

f is cumulative infiltration at any time t [cm/hr].

t is time in min.

a , b and c are constants whose values depend on soil type (0 to 1)

3.5.3 Horton's equation

The Horton model of infiltration (Horton, 1939, 1940) is one of the best-known models in hydrology. Horton recognized that infiltration capacity (I) decreased with time until it approached a minimum constant rate (f_c). He attributed this decrease in infiltration primarily to factors operating at the soil surface rather than to flow processes within the soil discovered. Horton's perceptual model of infiltration processes was far more sophisticated and complete than normally presented in hydrological texts.

$$I = f_c + (f_o - f_c) e^{-k t}$$

Where

I = Infiltration capacity or potential infiltration rate [cm/h],

f_c = Final constant infiltration rate [cm/h],

f_o = Initial infiltration capacity [cm/h],

k = Horton's decay coefficient which depends upon soil characteristics and vegetation cover

t = Time after start of infiltration (h).

The parameters, f_o , k , and f_c can be evaluated from measured infiltration data. Subtracting f_c from both sides of equation and then taking the natural log of each side gives the following equation for a straight line.

$$\ln (I-f_c) = \ln (f_o-f_c) - kt$$

3.6 Correlation coefficient

The validity of empirical models can be verified by determining correlation coefficient. It explains the relationship between observed data and calculated data of infiltration rate.

Correlation coefficient is "A measure of the strength of linear association between two variables", Correlation coefficient is always between -1.0 and +1.0. If the correlation is positive, a positive relationship exists. If it is negative, the relationship is negative.

The mathematical formula for computing r is

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2} \sqrt{n(\sum y^2) - (\sum y)^2}}$$

Where n is the number of pairs of data



RESULTS & DISCUSSIONS



CHAPTER IV

RESULTS AND DISCUSSIONS

A series of experiments leading to determination of “Modelling of infiltration rate of red soil under different land use patterns” have been conducted at Fruit Research Station, Sangareddy. The data collected on depletion of water in inner ring of double ring infiltrometer under different soil conditions were determined. Different model equations for the soils have been developed and the results pertaining to the experiment were presented in this chapter.

4.1 General observations

In all the experiments, initially infiltration rates are high. Infiltration rates gradually decreased and reached a constant value after few hours. The infiltration rates are not same for all land use conditions. The infiltration rates are high for unploughed condition of soils than the ploughed soils. In continuous fallow, because of low moisture content and uncultivated land since 3 years, infiltration rate are almost 35 times greater than compact soil and 9 to 10 times greater than the ploughed and unploughed soil. It has also taken much more time to attain constant infiltration rates. Ploughed and unploughed land has almost same infiltration rates.

4.2. Comparison of infiltration rates under different soil conditions

Observed infiltration rates of four treatments were presented in table 4.1. From the table it was clear that initially infiltration rates were very high. For the ploughed land, initially infiltration rate was 8.4 cm/h and later on infiltration rates gradually decreased and attained a value of 2.4 cm/h after 20 min. For the unploughed land initially infiltration rate was 9.6 cm/h later it gradually decreased and attained a value of 2.4 cm/h after 25 min. The basic infiltration rates of ploughed and unploughed soils were coincided with each other.

Table 4.1. The observed infiltration rates (cm/h) under different soil conditions

Time, min	Time, h	Infiltration rate (cm/h)			
		Ploughed land (T ₁)	Unploughed land (T ₂)	Compact soil (T ₃)	Continuous fallow land (T ₄)
5	0.08	24	9.6	2.4	84.0
10	0.16	10.8	4.8	1.8	36.0
15	0.25	10.8	3.6	1.8	18.0
20	0.33	7.2	2.4	1.2	13.2
25	0.41	7.2	2.4	1.2	9.6
30	0.50	6.0	2.4	1.2	7.2
35	0.58	4.8	2.4	1.2	4.8
40	0.66	4.8	2.4	1.2	4.8
45	0.75	4.8	2.4	1.2	4.8
50	0.83	3.6	2.4	1.2	-
55	0.91	3.6	2.4	1.2	-
60	1.00	3.6	2.4	1.2	-
65	1.08	-	2.4	1.2	-
70	1.16	-	2.4	1.2	-
75	1.25	-	2.4	1.2	-
80	1.33	-	-	1.2	-
85	1.44	-	-	1.2	-
90	1.50	-	-	1.2	-
95	1.58	-	-	1.2	-
100	1.66	-	-	1.2	-
105	1.75	-	-	1.2	-
110	1.83	-	-	1.2	-
115	1.99	-	-	1.2	-

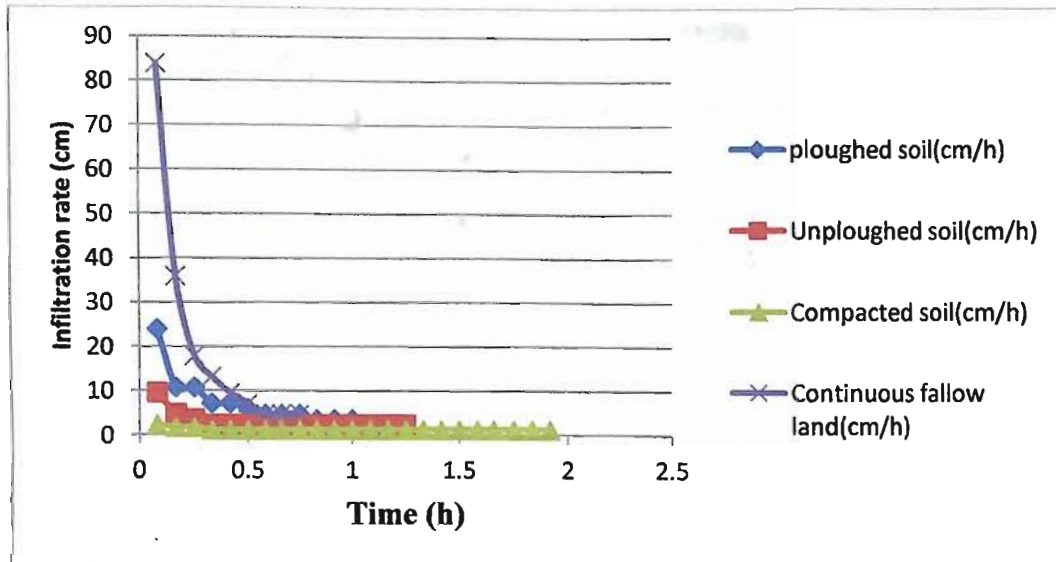


Fig. 4.1. Comparison of infiltration capacity under different soil conditions

For the compact land, the initially infiltration rate was 2.4 cm/h and later it attained a value of 1.2 cm/h after 110 min. For the continuous fallow land, initially infiltration rate was 84 cm/h and later it attained a value of 4.8 cm/h after 45 min. The trend of infiltration rate under different soil conditions were clearly shown in Fig. 4.1.

As discussed in above four conditions, the infiltration rate of continuous fallow land was different as compared to other three conditions. It was also found that the infiltration rate was high in continuous fallow land i.e., 4.8 cm/h and low in compact land i.e., 1.2 cm/h.

Table 4.2. The cumulative infiltration rates in cm under different soil conditions

Time , min	Time, h	Cumulative Infiltration rate cm			
		Ploughed land (T ₁)	Unploughed land (T ₂)	Compact soil (T ₃)	Continuous fallow land (T ₄)
5	0.08	2.0	0.8	0.20	7.0
10	0.16	2.9	1.2	0.35	10.0
15	0.25	3.8	1.5	0.50	11.5
20	0.33	4.4	1.7	0.60	12.6
25	0.41	5.0	1.9	0.70	13.4
30	0.50	5.5	2.1	0.80	14.0
35	0.58	5.9	2.3	0.90	14.4
40	0.66	6.3	2.5	1.00	14.8
45	0.75	6.7	2.7	1.10	15.2
50	0.83	7.0	2.9	1.20	-
55	0.91	7.3	3.1	1.30	-
60	1.00	7.6	3.3	1.40	-
65	1.08	-	3.5	1.50	-
70	1.16	-	3.7	1.60	-
75	1.25	-	3.9	1.70	-
80	1.33	-	-	1.80	-
85	1.44	-	-	1.90	-
90	1.50	-	-	2.00	-
95	1.58	-	-	2.10	-
100	1.66	-	-	2.20	-
105	1.75	-	-	2.30	-
110	1.83	-	-	2.40	-
115	1.99	-	-	2.50	-

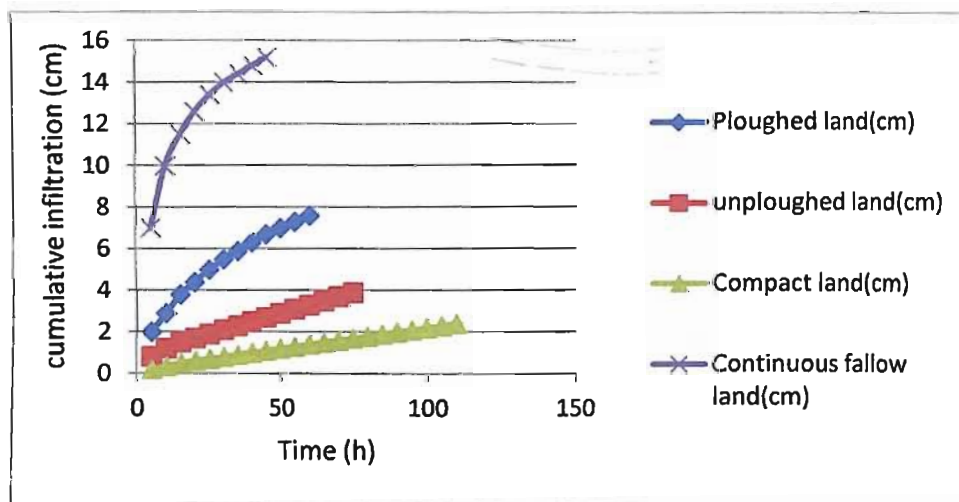


Fig. 4.2. Comparison of cumulative infiltration capacity under different soil conditions.

For the compact land, the initially cumulative infiltration depth was 0.2 cm, later it attained a value of 2.5 cm after 115 min. For the continuous fallow land, the initially cumulative infiltration depth was 7 cm, later it attained a value of 15.2 cm after 45 min.

As discussed in above four conditions, the cumulative infiltration depth of continuous fallow land was differing as compared to other three conditions. It also found that the cumulative infiltration depth is high in continuous fallow land i.e., 15.2 cm and low in compact land i.e., 0.2 cm.

Table 4.3. Comparison between observed and simulated infiltration rates by different Infiltration models for ploughed soil

Time, min	Time, h	Observed infiltration rate, cm/h	Infiltration rate Modified Kostiakov model, cm/h	Infiltration rate Horton's model, cm/h	Infiltration rate Kostiakov, cm/h
5	0.080	24.0	25.2	23.68	24.48
10	0.167	10.8	9.60	10.56	11.16
15	0.250	10.8	8.40	10.45	8.76
20	0.330	7.20	6.00	6.97	7.44
25	0.416	7.20	7.20	6.92	6.66
30	0.500	6.00	4.80	5.77	6.00
35	0.580	4.80	6.00	4.67	5.64
40	0.670	4.80	4.80	4.65	5.28
45	0.750	4.80	4.80	4.63	4.92
50	0.833	3.60	4.68	3.60	4.68
55	0.916	3.60	3.72	3.60	4.56
60	1.000	3.60	4.68	3.60	4.20

Comparison of observed and predicted infiltrations for ploughed soil by different models

The computed values of infiltration rates by different models for ploughed soil were presented in Table 4.3. Initial infiltration rate predicted by Horton's equation is 23.68 cm/h, which is near to observed infiltration rate 24 cm/h. Similarly, it was predicted by Kostiakov equation as 25.2 cm/h differentiating highly from observed value. The infiltration rates were decreased from 25.2 to 4.68 cm/h in case of Modified Kostiakov, 24.28 to 4.2 cm/h for Kostiakov and 23.68 to 3.6 cm/h for Horton's model respectively. From the results, it was clear that the infiltration values obtained by Horton's model are nearer to observed values. Hence, Horton's model with the estimated coefficients can be used effectively to calculate infiltration rate in the absence of field data.

Table 4.4. Comparison between observed and simulated infiltration rates by different infiltration models for unploughed soil

Time, min	Time, h	Observed Infiltration rate, cm/h	Infiltration rate Modified Kostiakov model, cm/h	Infiltration rate Horton's model, cm/h	Infiltration rate Kostiakov, cm/h
5	0.08	9.6	9.6	9.54	9.36
10	0.167	4.8	4.8	4.76	4.56
15	0.25	3.6	3.6	3.57	3.6
20	0.33	2.4	2.4	2.4	3.24
25	0.416	2.4	2.4	2.4	2.76
30	0.5	2.4	2.4	2.4	2.64
35	0.58	2.4	2.4	2.4	2.4
40	0.67	2.4	2.4	2.4	2.4
45	0.75	2.4	2.4	2.4	2.16
50	0.83	2.4	2.4	2.4	2.04
55	0.916	2.4	2.4	2.4	1.92
60	1	2.4	2.4	2.4	1.92
65	1.08	2.4	2.4	2.4	1.92
70	1.16	2.4	2.4	2.4	1.68
75	1.25	2.4	2.4	2.4	1.8

Comparison of observed and predicted infiltrations for unploughed soil by different models

The computed values of infiltration rates by different models for Continuous fallow land were presented in Table 4.4. Initial infiltration rate predicted by Modified Kostiakov equation was 9.6 cm/h, which is neared to observed infiltration rate 9.6 cm/h. The same value predicted by Modified Kostiakov equation is 9.36 cm/h differing highly from observed value. The infiltration rates were decreased from 9.6 to 2.4 cm/h for Modified Kostiakov, 9.36 to 1.8 cm/h for Kostiakov and 9.54 to 2.4 cm/h for Horton's model respectively. From the results, it was clear that the infiltration values obtained by Modified Kostiakov model are nearer to observed values. Hence, Modified Kostiakov model with the estimated coefficients can be used effectively to calculate infiltration rate in the absence of field data.

Table 4.5 Comparison between observed and simulated infiltration rates by different infiltration models for compact soil

Time, Min	Time, h	Observed Infiltration rate, cm/h	Infiltration rate Modified Kostiakov model, cm/h	Infiltration rate Horton's model, cm/h	Infiltration rate Kostiakov model, cm/h
5	0.080	2.4	2.64	2.38	1.68
10	0.16	1.8	1.92	1.78	1.56
15	0.250	1.8	1.56	1.76	1.44
20	0.330	1.2	1.56	1.20	1.32
25	0.410	1.2	1.56	1.20	1.32
30	0.500	1.2	1.32	1.20	1.20
35	0.580	1.2	1.32	1.20	1.20
40	0.660	1.2	1.44	1.20	1.20
45	0.750	1.2	1.32	1.20	1.20
50	0.833	1.2	1.20	1.20	1.08
55	0.916	1.2	1.20	1.20	1.08
60	1.000	1.2	1.32	1.20	1.08
65	1.083	1.2	1.08	1.20	1.08
70	1.160	1.2	1.20	1.20	1.08
75	1.250	1.2	1.20	1.20	1.08
80	1.330	1.2	1.20	1.20	0.96
85	1.416	1.2	1.08	1.20	0.96
90	1.500	1.2	1.08	1.20	0.96
95	1.583	1.2	1.08	1.20	0.96
100	1.667	1.2	1.20	1.20	0.96
105	1.750	1.2	1.08	1.20	0.96
110	1.830	1.2	1.08	1.20	0.96
115	1.916	1.2	0.96	1.20	0.96

Comparison of observed and predicted infiltrations for compact soil by different models

The computed values of infiltration rates by different models for compacted soil were presented in Table 4.5. Initial infiltration rate predicted by Horton's equation was 2.38 cm/h, which was nearer to observed infiltration rate 2.4 cm/h. The same value predicted by Kostiakov equation was 1.68 cm/h differing highly from observed value. The infiltration rates decreased from 2.64 to 0.96 cm/h for Modified Kostiakov, 1.68 to 0.96 cm/h for Kostiakov and 2.38 to 1.2 cm/h for Horton's model respectively. From the results, it was clear that the infiltration values obtained by Horton's model were

nearer to observed values. Hence, Horton's model with the estimated coefficients can be used effectively to calculate infiltration rate in the absence of field data.

Table 4.6. Comparison between observed and simulated infiltration rates by different infiltration models for continuous fallow land

Time, min	Time, h	Observed Infiltration rate, cm/h	Infiltration rate Modified Kostiakov model, cm/h	Infiltration rate Horton's model, cm/h	Infiltration rate Kostiakov, cm/h
5	0.080	84.0	4.351	83.30	90.48
10	0.167	36.0	8.177	35.73	24.12
15	0.250	18.0	11.87	17.64	16.92
20	0.330	13.2	15.51	12.89	13.44
25	0.416	9.6	19.08	9.38	11.40
30	0.500	7.2	22.61	7.07	10.08
35	0.580	4.8	26.11	4.80	8.88
40	0.670	4.8	29.58	4.80	8.16
45	0.750	4.8	33.03	4.80	7.32

Comparison of observed and predicted infiltrations for continuous fallow land by different models

The computed values of infiltration rates by different models for Continuous fallow land was presented in Table 4.6. Initial infiltration rate predicted by Horton's equation was 83.3 cm/h, which was nearer to observed infiltration rate 84 cm/h. It was predicted by Modified Kostiakov equation as 4.35 cm/h differing highly from observed value. The infiltration rates decreased from 4.35 to 33.03 cm/h for Modified Kostiakov, 90.48 to 7.32 cm/h for Kostiakov and 83.3 to 4.8 cm/h for Horton's model respectively. From the results, it was clear that the infiltration values obtained by Horton's model were nearer to observed values. Hence, Horton's model with the estimated coefficients can be used effectively to calculate infiltration rate in the absence of field data.

Comparison of Modified Kostiakov model under different soil conditions

Mathematical analysis was carried out to develop a mathematical relationship between infiltration rate and time for different soil conditions. The constant b values were obtained from the graph between infiltration rate and time. Then algebraic equations with two variables a and α . Then taking the value of a, b and α , the equation has been formulated. The equations that are developed for different soil conditions are given below

(i) In ploughed condition $y = 0.69 t^{0.57} + 0.38$

(ii) In unploughed condition $y = 0.23 t^{0.64} + 0.23$

(iii) In compact land $y = 0.0567 t^{0.801} + 0.0181$

(iv) In continuous fallow land $y = 0.91 t^{0.94} + 0.19$

The computed constants and coefficients of Modified Kostiakov model under different soil conditions were presented in Table 4.7 and depicted in Fig. 4.3 to 4.6.

Table 4.7. The constants and coefficients of Modified Kostiakov Model under different soil conditions for estimating infiltration rate

S. No	Condition	a	b	α	R ²
1	Ploughed land	0.690	0.380	0.570	0.9596
2	Unploughed land	0.230	0.220	0.640	0.9999
3	Compact land	0.056	0.018	0.801	0.7823
4	Continuous fallow land	0.910	0.190	0.940	0.7823

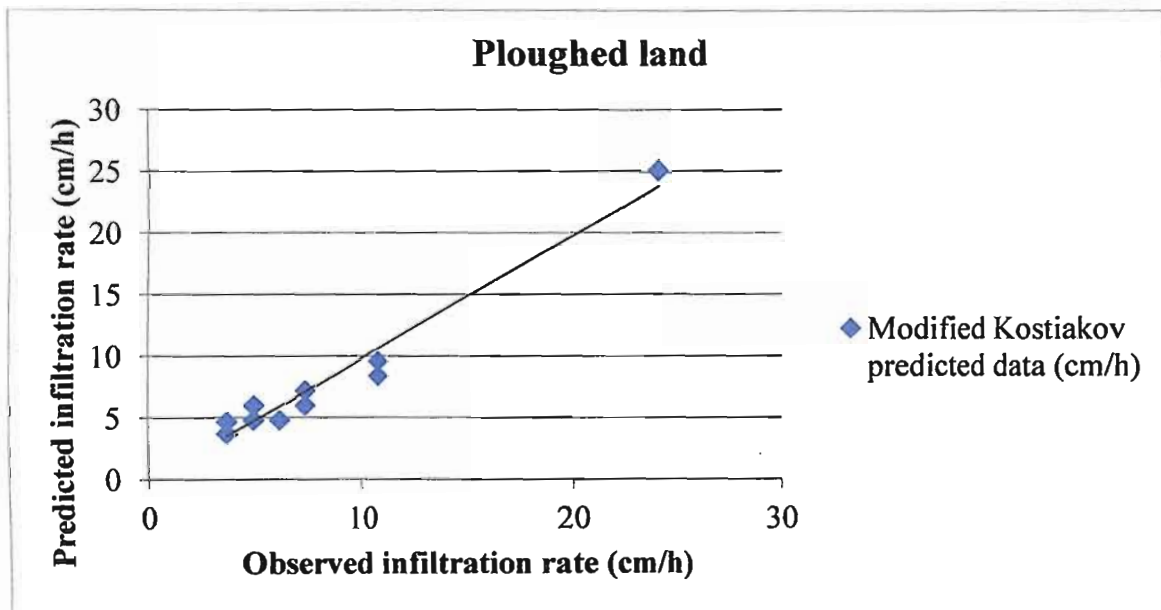


Fig. 4.3. Observed and predicted infiltration rates of ploughed soil for Modified Kostiakov model

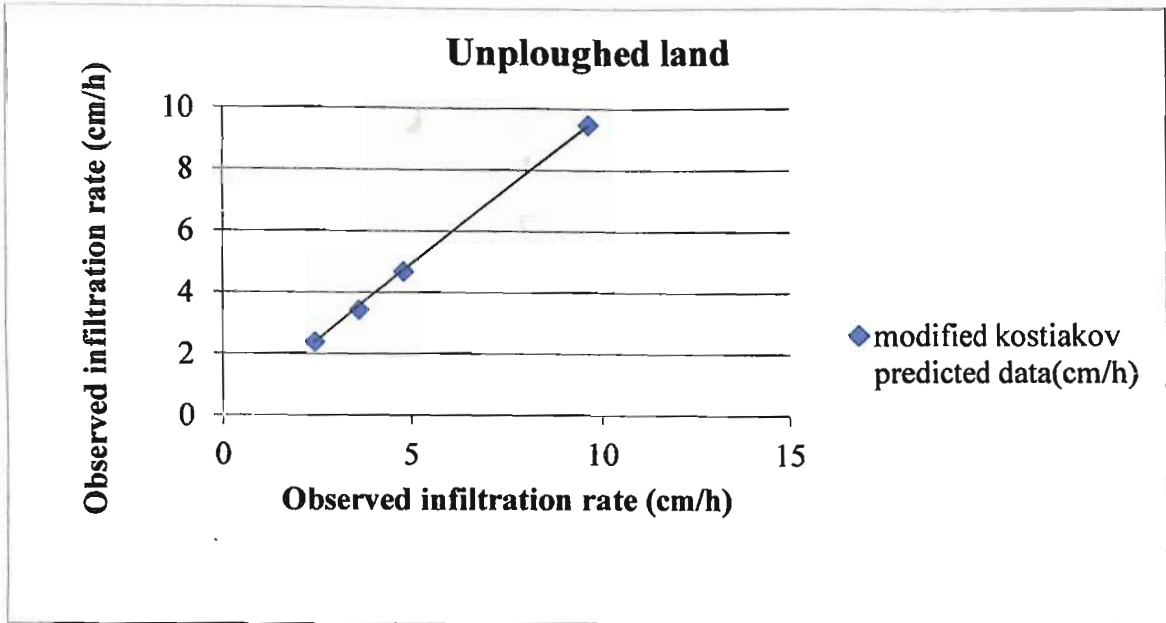


Fig. 4.4. Observed and predicted infiltration rates of unploughed soil for Modified Kostiakov model

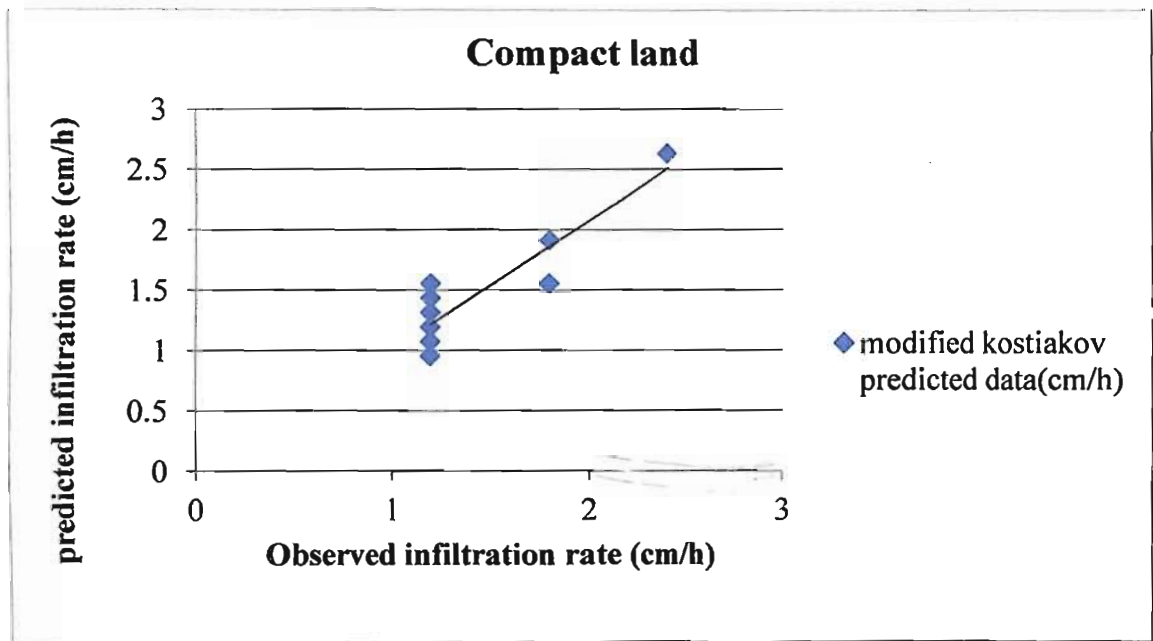


Fig. 4.5. Observed and predicted infiltration rates of compact soil for Modified Kostiakov model

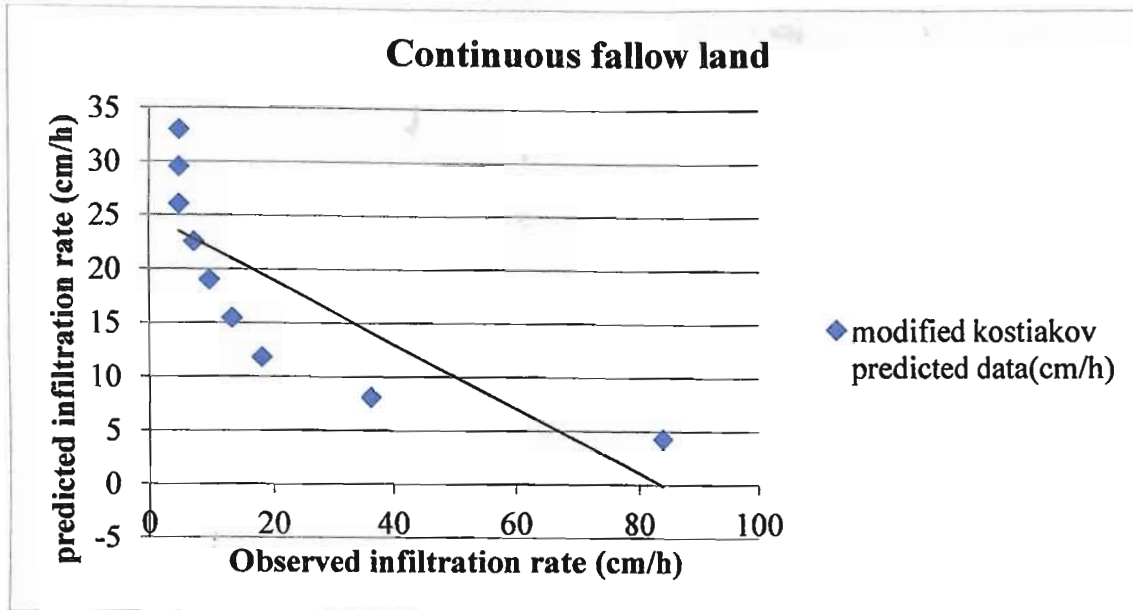


Fig. 4.6. Observed and predicted infiltration rates of continuous fallow land for Modified Kostiakov model

The scattered diagrams (Fig. 4.3 to 4.6) have clearly indicated that there was good agreement between observed and predicted infiltration rate. Determination coefficient (R^2) value explains that about 78 % to 99 % variation was noticed in infiltration rate due to variation in soil condition. The Correlation coefficients were 0.95, 0.99, 0.78 and 0.78 for ploughed, unploughed, compact and continuous fallow lands respectively. From the results it was finally concluded that the unploughed land with correlation coefficient 0.99 fits best to the observed values followed by ploughed, compact and continuous fallow land.

Comparison of Horton’s model under different soil conditions

Mathematical analysis was carried out to find out the coefficient k value and the Horton’s equation has been formulated for different soil conditions which were given below

- (i) In ploughed condition $I = 3.6 + 20.4 \times e^{-0.196 t}$
- (ii) In unploughed condition $I = 2.4 + 7.2 \times e^{-0.094t}$
- (iii) In compact land $I = 1.2 + 1.2 \times e^{-0.245 t}$
- (iv) In continuous fallow land $I = 4.8 + 3.6 \times e^{-0.1103 t}$

The coefficient of Horton's model under different soil conditions were presented in Table 4.8. It indicates that smaller value of k leads to accurate prediction of infiltration rate. This was clearly seen in case of unploughed soil.

Table 4.8. The coefficients of Horton's model under different soil conditions for estimating infiltration rate

S. No	Condition	k	R ²
1	Ploughed land	0.196	0.999
2	Unploughed land	0.094	0.999
3	compact land	0.245	0.998
4	Continuous fallow land	0.1103	0.990

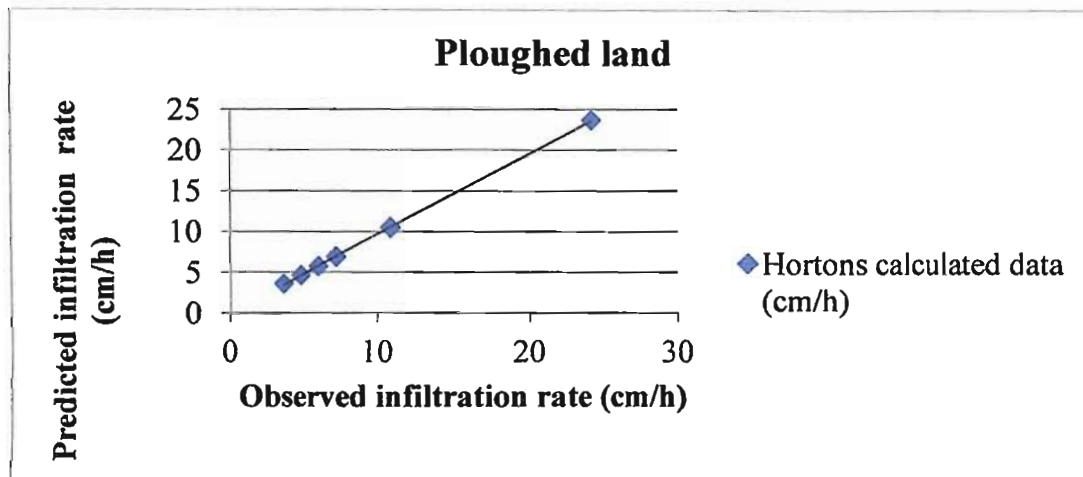


Fig. 4.7. Observed and predicted infiltration rates of ploughed soil for Horton's model

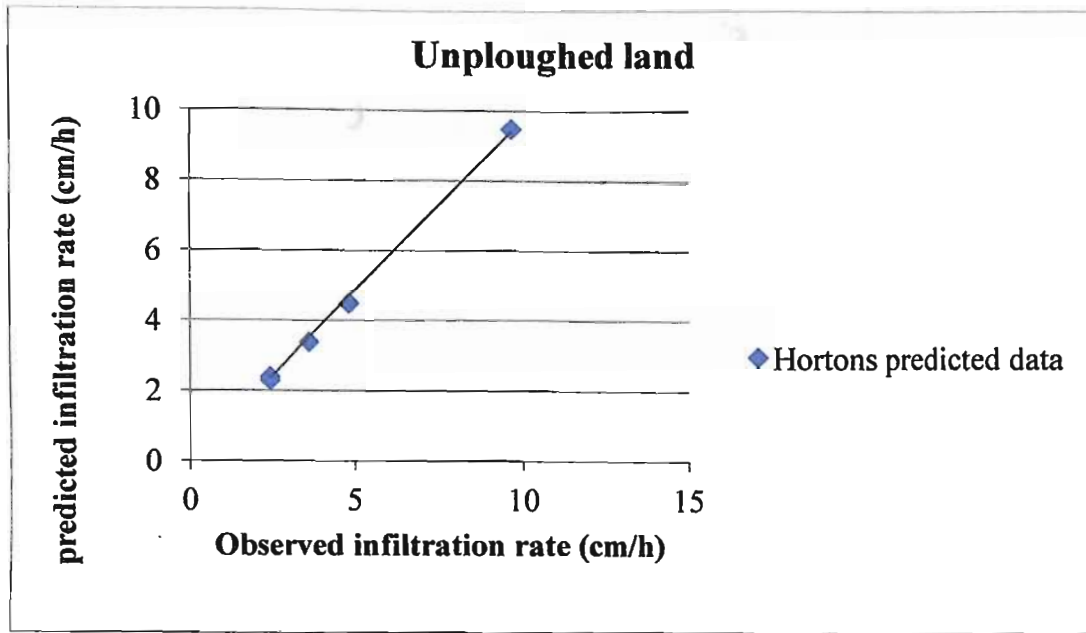


Fig. 4.8. Observed and predicted infiltration rates of unploughed soil for Horton's model

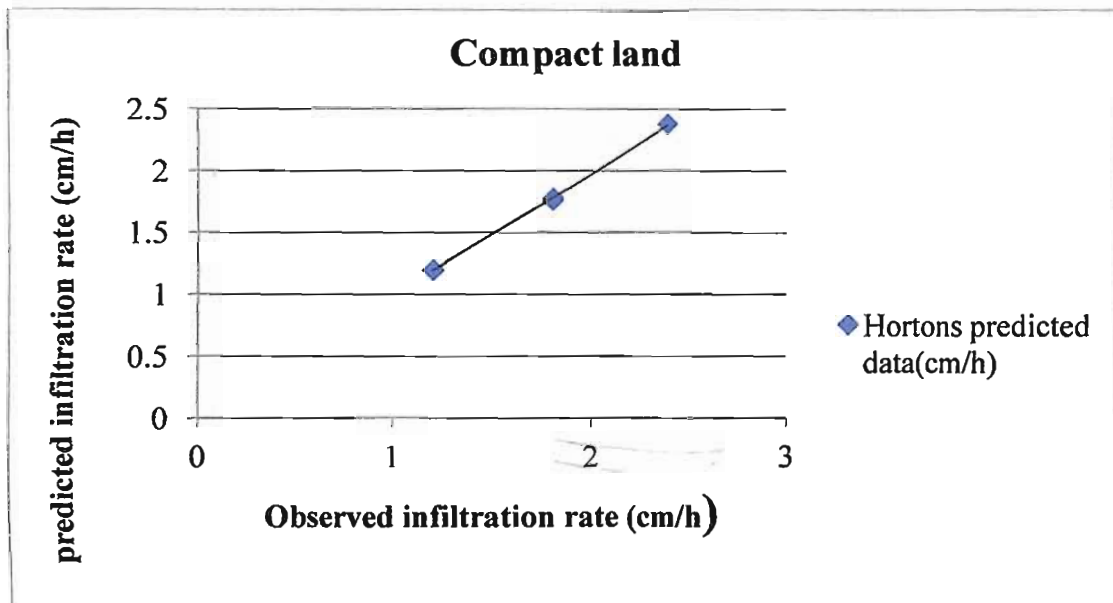


Fig. 4.9. Observed and predicted infiltration rates of compact soil for Horton's model

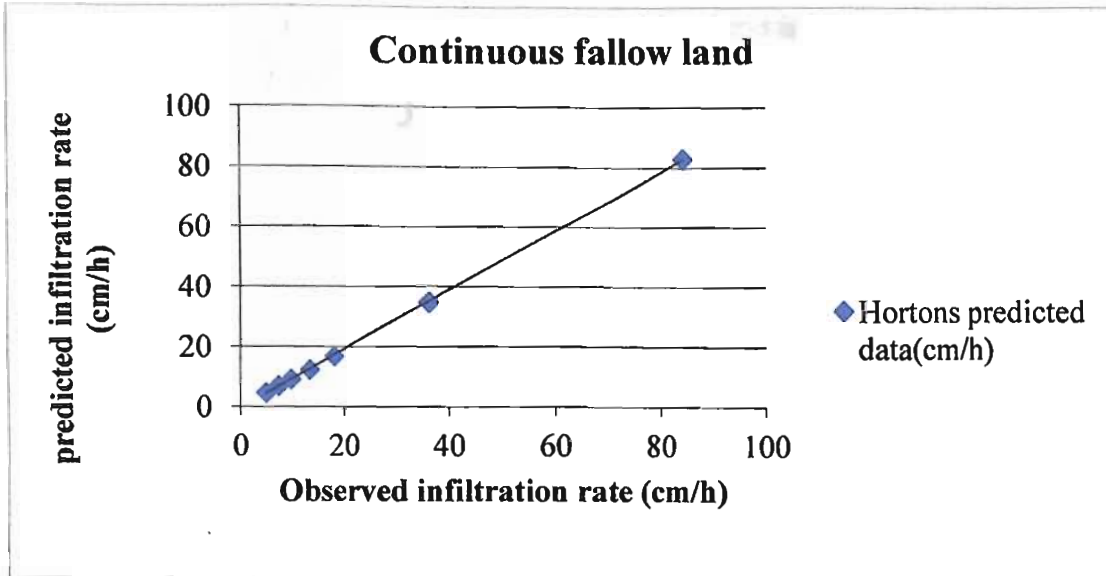


Fig. 4.10. Observed and predicted infiltration rates of continuous fallow land for Horton's model

The scattered diagrams (Fig. 4.7 to 4.10) have clearly shows that observed versus predicted values cluster give closely to the 1:1 line, indicating a good fit of the model. The Correlation coefficients were 0.99, 0.99, 0.99 and 0.99 for ploughed, unploughed, compact and continuous fallow lands respectively. From the results it was finally concluded that the unploughed land with correlation coefficient 0.99 fits best to the observed values followed by ploughed, compact and continuous fallow land.

Comparison of Kostiakov model under different soil conditions

Regression analysis was carried out to estimate the constant a and power coefficient α and different equations were formulated for different soil conditions which were presented below

(i) In ploughed condition $F_p = 0.0544 \times t^{0.7983}$

(ii) In unploughed condition $F_p = 0.3096 \times t^{0.5748}$

(iii) In compact land $F_p = 0.0548 \times t^{0.7957}$

(iv) In continuous fallow land $F_p = 0.228 \times t^{0.3396}$

The empirical constant and coefficient developed for the estimation of infiltration rate using Kostiakov model for different soil conditions were presented in Table. 4.9. The coefficient

a and power coefficient α values have not shown any trend in estimation of infiltration rate. It indicates that infiltration rate varies in different soil conditions. The explained total variation in infiltration rate indicated by coefficient of determination for different soil conditions varied between 81 % to 98 %. It indicates the predictive capability of the Kostiakov model was very high.

Table 4.9. The constants and coefficients of Kostiakov model under different soil conditions for estimating infiltration rate

S.No	Condition	A	α	R ²
1	Ploughed land	0.0544	0.7983	0.9787
2	Unploughed land	0.3096	0.5748	0.9548
3	Compact land	0.0548	0.7957	0.8117
4	Continuous fallow land	0.228	0.3396	0.9605

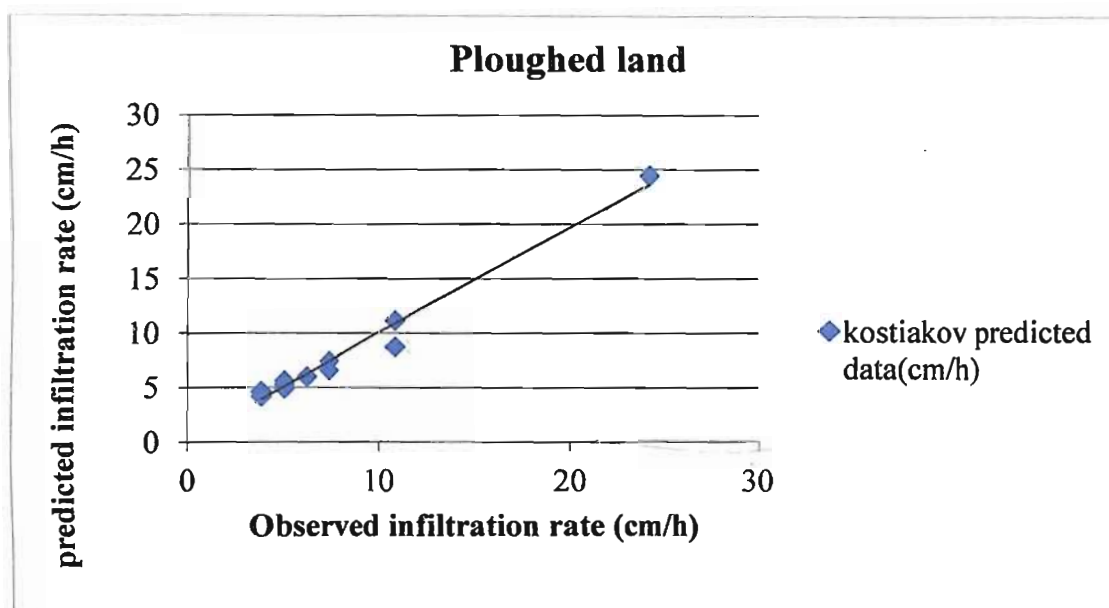


Fig. 4.11. Observed and predicted infiltration rates of ploughed soil for Kostiakov model

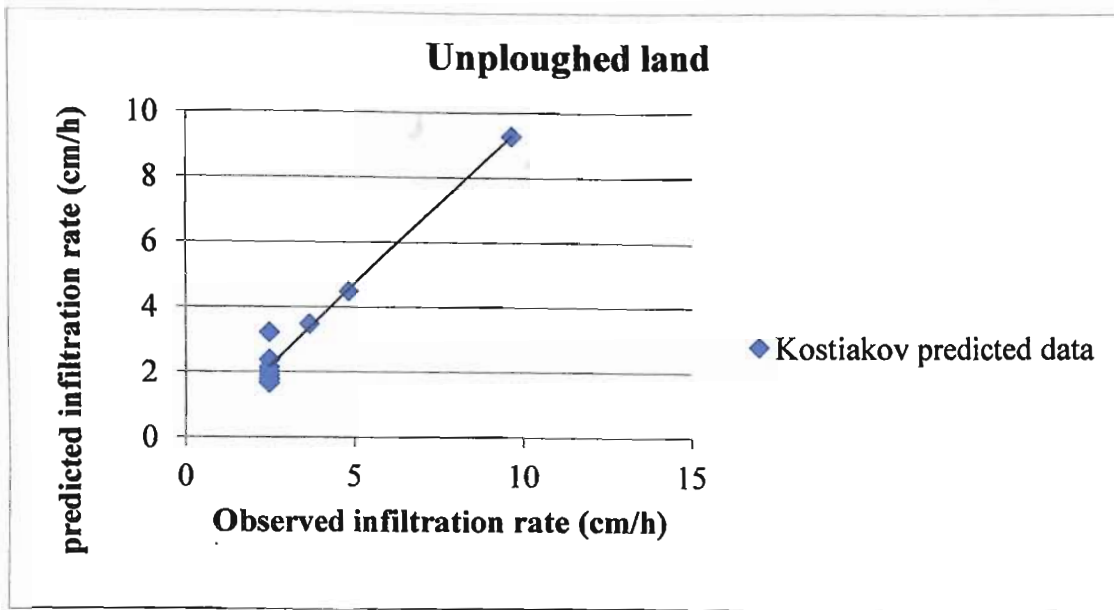


Fig. 4.12. Observed and predicted infiltration rates of unploughed soil for Kostiakov model

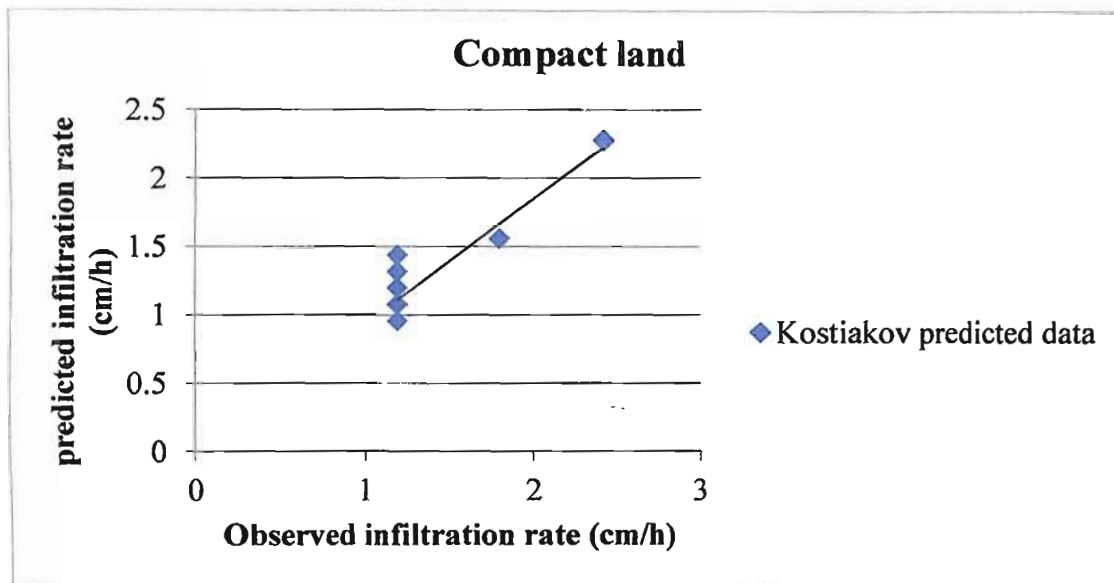


Fig. 4.13. Observed and predicted infiltration rates of compact soil for Kostiakov model

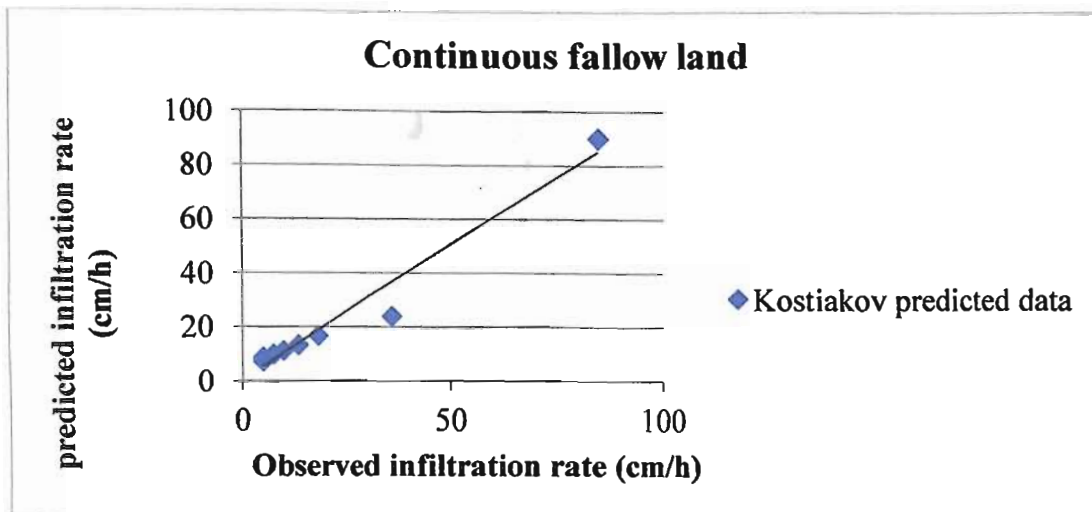


Fig. 4.14. Observed and predicted infiltration rates of continuous fallow land for Kostiakov model

The scatter diagrams (Fig. 4.11 to 4.14) representing observed and predicted infiltration rates for different soil conditions were presented. The correlation coefficients were 0.97, 0.95, 0.81 and 0.96 for ploughed, unploughed, compact and continuous fallow lands respectively. From the results it was finally concluded that the ploughed land with correlation coefficient 0.97 fits best to the observed values followed by continuous fallow land, unploughed land and compact land.

Hence, the above developed models can be very useful for estimation of infiltration rate of red soil under different soil conditions there by runoff from the field can be assessed.

SUMMARY AND CONCLUSION

SUMMARY & CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

Infiltration is an important soil parameter that determines the maximum rate at which water can enter the soil under specific conditions. It plays an important role in design of farm irrigation, scheduling of irrigation, application rate of irrigation water, for calculation of conveyance losses, irrigation efficiency, field capacity, wilting point and field drainage, availability of nutrients, accumulation of salts, watershed modeling and prediction of surface runoff. Keeping in view of importance of infiltration the study was conducted to observe the infiltration rate under different soil conditions namely, ploughed, unploughed compact and continuous fallow land in FRS, Sangareddy.

Double ring infiltrometer was used to obtain infiltration rate values for different soil conditions. Using the field data constants and coefficients were found out in order to develop mathematical equations for infiltration rate.

The following conclusions are drawn from the experiment:

1. Constant infiltration rate of ploughed, unploughed compact and continuous fallow land use pattern of red soil was 3.6 cm/h, 2.4 cm/h, 1.2 cm/h and 4.8 cm/h respectively.
2. Infiltration rate gets affected by soil condition
3. The cultivated land has shown considerable impact on higher infiltration rate was noticed due to increase in porosity.
4. Average infiltration rate decreases as time increases which is an indication of higher degree of saturation of soil as time progresses.
5. For ploughed land, the empirical infiltration equations developed are

i) Kostiakov equation is $F_p = 0.0544 \times t^{0.7983}$

ii) Modified Kostiakov equation is $y = 0.69 t^{0.57} + 0.38$

iii) Horton's equation is $I = 3.6 + 20.4 \times e^{-0.196 t}$

6. For unploughed land the empirical infiltration equations developed are

i) Kostiakov equation is $F_p = 0.3096 \times t^{0.5748}$

ii) Modified Kostiakov equation is $y = 0.23 t^{0.64} + 0.23$

iii) Horton's equation $I = 2.4 + 7.2 \times e^{-0.094t}$

7. For compact land the empirical infiltration equations developed are

i) Kostiakov equation is $F_p = 0.0548 \times t^{0.7957}$

ii) Modified Kostiakov equation is $y = 0.0567 t^{0.801} + 0.0181$

iii) Horton's equation $I = 1.2 + 1.2 \times e^{-0.245 t}$

8. For continuous fallow land the empirical infiltration equations developed are

i) Kostiakov equation is $F_p = 0.228 \times t^{0.3396}$

ii) Modified Kostiakov equation is $y = 0.91 t^{0.94} + 0.19$

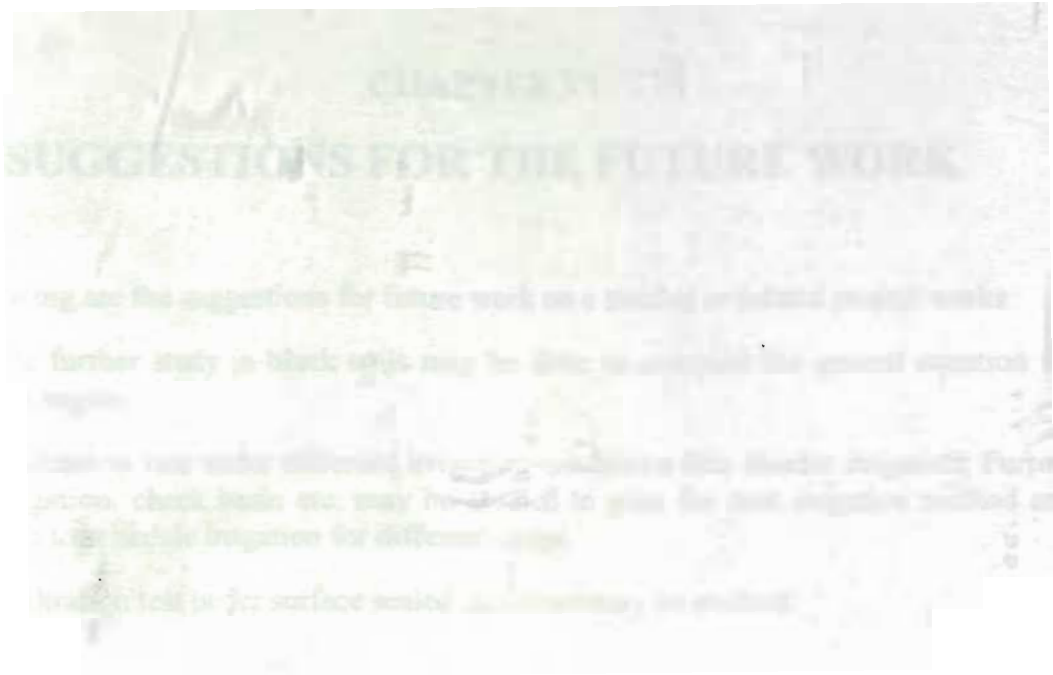
iii) Horton's equation $I = 4.8 + 3.6 \times e^{-0.1103 t}$

9. The coefficients and constants of infiltration models vary for different soil conditions. Which clearly shows that infiltration rate is different in different soil conditions.

10. Horton's model can be effectively used for predicting infiltration rate in ploughed, compact and continuous fallow land in red soils.

11. Modified Kostiakov model can be used to predict infiltration rate accurately in unploughed soil.

12. Based on the predicted infiltration rate runoff can be assessed which in turn help in finalising the irrigation scheduling for the crops grown. The best method of irrigation and frequency of machine operations during the cropping season can also be worked out.



SUGGESTIONS FOR FUTURE WORK



CHAPTER VI

SUGGESTIONS FOR THE FUTURE WORK

The following are the suggestions for future work on a similar or related project works

1. The further study in black soils may be done to compute the general equation for this region.
2. Infiltration rate under different irrigation conditions like Border irrigation, Furrow irrigation, check basin etc. may be studied to plan for best irrigation method and also to schedule irrigation for different crops.
3. Infiltration test under surface sealed condition may be studied.

REFERENCES

Salim and Nashed/Hydril. 2012. The Evaluation and Determining of soil water content. *Chemical Journal of Islamic and Applied Sciences* 04-95, 2012.

R. G. Ussiri, J. M. S. and A. A. 2011. Variation of infiltration characteristics in a laboratory study. *International Journal of Engineering and Technology (IJET)*, Volume 3, Issue 2, August 2011, ISSN: 2277-3754, pp.454-459.

and T. G. 1985. Effects of different land uses on infiltration in soil. *Hydrological Science Journal*, 30(1), 1985, pp.371-401.

J. J. Infiltration Characteristics of Two Major Agricultural Soils in North Carolina. *Journal of Soil and Water Conservation*, 1978, pp.170-171.

REFERENCES

W. J. and D. A. 2004. Study on the infiltration characteristics of soil. *Water and Environment Science and Technology*, 4(1), 2004, pp.1-10.

and C. 2004. Modeling water infiltration into soil. *Hydrological Processes*, 18(1), 2004, Copyright© 2004.

and H. 1978. A field method for the measurement of soil water content. *Water Resources Research*, 14(1), 1978, pp.1-10.

T. 2004. The infiltration characteristics of soil. *Journal of Soil and Water Conservation*, 18(1), 2004, pp.1-10.

and S. 2004. The infiltration characteristics of soil. *Journal of Soil and Water Conservation*, 18(1), 2004, pp.1-10.

REFERENCES

- Abu-Bakr Rahimi and Motalleb Byzedi. 2012. The Evaluation and Determining of soil infiltration Models Coefficients. Australian Journal of Basic and Applied Sciences, 6(6): 94-98, 2012.
- Adeniji, F. A., B. G. Umara, J. M. Dibal and Amali A. 2013. Variation of infiltration rates with soil texture. A laboratory study. International Journal of Engineering and Innovative Technology (IJEIT). Volume 3, Issue 2, August 2013. ISSN: 2277-3754, ISO 9001:2008, pp-454-459.
- Agnihotri R. C. and R. C. Yadav.1995. Effects of different land uses on infiltration in soil susceptible to gully erosion. Hydrological sciences -journal- des sciences hydrologiques, 40, 3, June.1995, pp 395-401.
- Ahaneku, I.E. 2011. Infiltration Characteristics of Two Major Agricultural Soils in North central Nigeria. Agricultural Science Research Journal vol. 1(7); pp.166-171, September 2011, ISSN: L-2026-6073 ©2011 International Research Journals.
- Bean. E.Z., Hunt W.F. and Bidelspanch D.A. 2004. Study on the surface infiltration rate of permeable pavements. Water and Environment Specialty Conference of the Canadian Society for Civil Engineering. June 2-5, 2004, pp 1-10.
- Chen-Wuing Liu, Shih-Kai Chen and Cheng-Shin Jang .2004. Modelling water infiltration in cracked paddy field soil. Hydrol. Process 1 September 2003. Copyright© 2004 John Wiley & Sons, Ltd.
- Cressie, N.A. and Horton. R. 1987. A robust-resistant spatial analysis of soil water infiltration. Water Resources Research, 23 (5), 911-917.
- Diamond J. and T. Shanley.1998. Infiltration rate assessment of some major soils. The Science of Farming and Food. ISBN 1901138 95 4. September 1998, pp 1-16.
- Doktors Der Naturwissenschaften 2009. Studies on factors affecting the infiltration capacity of agricultural soils. ISBN 978-3-930037-54-4. pp 1-173

- Duiker, S. W, Flanagan D. C. and R. Lal. 2001. Erodability and infiltration characteristics of five Major soils of southwest Spain S. W. Duiker *et al.* *Catena* 45 (2001) 103–121.
- Eduardo. 1988. Comparison of infiltration measuring methods for surface irrigation in volcanic ash soil. *Journal of irrigation and drainage engineering*, Vol.114, No.1, February, 1988.
- Eze Bassey Eze, Devalsam Imoke Eni and Oko Comfort. 2011. Evaluation of the infiltration capacity of soil in Akpabuyo local government area of cross river, Nigeria. *Journal of geography and geology*. Vol. 3, No. 1;September 2011. pp 189-199.
- Fok. 1986. Derivation of Lewis-Kostiakov Intake Equation. *Journal of Irrigation and Drainage Engineering*, 1986, Vol. 112.
- Franzluebbers, A.J. 2001. Water infiltration and soil structure related to organic matter and its stratification with depth. *Soil & Tillage Research*. 66 (2002) 197–205.
- Gregory, J. H, Dukes M. D., Jones P.H. and Miller G. L. 2006. Effect of urban soil compaction on infiltration rate. *Journal of Soil and Water Conservation*, Volume 61, Number 3.
- Gregory, J.H., M.D. Dukes, P.H. Jones, and G.L. Miller.2006. Effect of urban soil compaction on infiltration rate. Reprinted from the *Journal of Soil and Water Conservation* Volume 61, Number 3 Copyright © 2006 Soil and Water Conservation Society, pp 117-124.
- Indrawan, G. B, Rahardjo, H. and Leong E. C. 2006. Study of Infiltration Characteristics in the Field. *Unsaturated Soils 2006*: 179-190. American Society of civil engineers library.
- Jagdale Satyawalan Dagadu and Nimbalkar, P. T.2012. Infiltration studies of different soils under different soil conditions and comparison of infiltration models with field data. *International Journal of Advanced Engineering Technology* E-ISSN 0976-3945.

- Jejurkar C.L. and M.P. Rajurkar 2012. Infiltration studies for varying land cover conditions. International Journal of computational engineering research. ISSN: 2250-3005.
- Jin He , Qingjie Wang , Hongwen Li, J. N. Tullberg , A. D. McHugh Yuhua Bai, Xuemin Zhang, Neil McLaughlin and Huanwen Gao .2009. Soil physical properties and infiltration after long-term no-tillage and ploughing on the Chinese Loess Plateau. New Zealand journal of crop and horticultural science, 2009, Vol. 37: 157–166.
- Keith Beven. (2004). Robert E. Horton’s perceptual model of infiltration processes. Hydrol. Process. 18, 3447–3460 (2004).
- Lentz, R.D and Bjorneberg, D.L. 2011. Influence of irrigation water properties on Furrow infiltration. R.D Lentz and D.L. Bjorneberg, USDA-ARS, Northwest irrigation and soil research lab, 3793 N. 3600E. Kimberly, ID 83341 USA.
- Makungo R. and J.O. Odiyo.2003. Determination of Steady State Infiltration Rates for Different Soil types in Selected Areas of Thulamela Municipality, South Africa, pp 1-8.
- Mbagwu JSC. 1993. Analysis of physical properties controlling steady-state Infiltration rates on tropical savannah soils. International Report No. IC/93/289, International Centre for Theoretical Physics, Italy.
- Mohan, S., Kumari, S., —Recharge estimation using Infiltration models, Journal of Hydraulic Engg., Vol. 11, pp 1- 10. 2005
- Novak, Simunek , V. J, and M. Th. Van Genuchten. 2000. Infiltration of Water into Soil with Cracks. Journal of Irrigation and Drainage Engineering, January, February 2000 / 41-47.
- Osuji, G. E, Okon M. A., Chukwuma M. C. and Nwarie I. I. 2010. Infiltration characteristics of Soils under Selected Land Use Practices in Owerri, Southeastern Nigeria. World Journal of Agricultural Sciences 6 (3): 322-326, 2010.

- Oyenarte, N.A, Mateos L, Palomo, M.J .2002. Infiltration variability in furrow irrigation. *Journal of Irrigation Drainage Engineering*. ASCE128: 26-33.
- Singh, R. V., Bhakar, S. R., Comparison of different infiltration equations on different land covers, *Journal of IWRS*, Vol. 24, pp19 – 26, 2004.
- Sorman ALI, U., Mohammad J, Abdulrazzak, Mohammed A, and SH. Ugas.1995. Application of infiltration models to field data from Wadi Tabalah. *IAHS Publ. no. 232*, 1995.
- Srinivasan, K and poongothai. S. 2013. Assessment of infiltration rate of a tank irrigation watershed of wellington reservoir, Tamilnadu, India. *American Journal of Engineering Research*. Volume -02 ISSN: 2320-0847 p-ISSN: 2320-0936, pp-41-48.
- Tarek selim. 2011. The effect of land use on soil infiltration rate in a heavy clay soil in Egypt . *VATTEN 67*:161–166. Lund 2011.
- Teagasc. 2003. Infiltration rate assessment of some major soils. *Irish Geography*, Volume 36(1), 2003, 32-46.
- Tony L. T. Zhanl and Charles W. W. Ng, M.ASCE.2004. Analytical Analysis of Rainfall Infiltration Mechanism in Unsaturated Soils. *International journal of geomechanics* © asce/december 2004, pp 273-284.
- Walsh E. and K.P. McDonnell. 2012. The influence of measurement methodology on Soil infiltration rate. *International journal of soil science*, October 2012, pp-168-176.
- Yang, H., H. Rahardjo and E.C. Leong. 2006. Behavior of Unsaturated Layered Soil Columns during Infiltration. *Journal of hydrologic engineering* © asce July/August 2006.

APPENDICES

APPENDICES

Table 1. Experimental Data of Infiltration Capacity in Ploughed Land in Trail- I

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	2	2	2	24
2	10	0.08	5	2	2.9	0.9	2.9	10.8
3	15	0.08	5	2.9	3.8	0.9	3.8	10.8
4	20	0.08	5	2.8	4.4	0.6	4.4	7.2
5	25	0.08	5	4.4	5	0.6	5	7.2
6	30	0.08	5	5	5.5	0.5	5.4	6
7	35	0.08	5	5.5	5.9	0.4	5.9	4.8
8	40	0.08	5	5.9	6.3	0.4	6.3	4.8
9	45	0.08	5	6.3	6.7	0.4	6.7	4.8
10	50	0.08	5	6.7	7	0.3	7	3.6
11	55	0.08	5	7	7.3	0.3	7.3	3.6
12	60	0.08	5	7.3	7.6	0.3	7.6	3.6

Table 2. Experimental Data of Infiltration Capacity in Ploughed Land in Trail- II

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	2	2	2	24
2	10	0.08	5	2	2.9	0.9	2.9	10.8
3	15	0.08	5	2.9	3.8	0.9	3.8	10.8
4	20	0.08	5	2.8	4.4	0.6	4.4	7.2
5	25	0.08	5	4.4	5	0.6	5	7.2
6	30	0.08	5	5	5.5	0.5	5.4	6
7	35	0.08	5	5.5	5.9	0.4	5.9	4.8
8	40	0.08	5	5.9	6.3	0.4	6.3	4.8
9	45	0.08	5	6.3	6.7	0.4	6.7	4.8
10	50	0.08	5	6.7	7	0.3	7	3.6
11	55	0.08	5	7	7.3	0.3	7.3	3.6
12	60	0.08	5	7.3	7.6	0.3	7.6	3.6

Table 3. Average infiltration rate in ploughed land

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	2	2	2	24
2	10	0.08	5	2	2.9	0.9	2.9	10.8
3	15	0.08	5	2.9	3.8	0.9	3.8	10.8
4	20	0.08	5	2.8	4.4	0.6	4.4	7.2
5	25	0.08	5	4.4	5	0.6	5	7.2
6	30	0.08	5	5	5.5	0.5	5.4	6
7	35	0.08	5	5.5	5.9	0.4	5.9	4.8
8	40	0.08	5	5.9	6.3	0.4	6.3	4.8
9	45	0.08	5	6.3	6.7	0.4	6.7	4.8
10	50	0.08	5	6.7	7	0.3	7	3.6
11	55	0.08	5	7	7.3	0.3	7.3	3.6
12	60	0.08	5	7.3	7.6	0.3	7.6	3.6

Table 4. Experimental Data of Infiltration Capacity in Unploughed Land in Trail-I

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	0.8	0.8	0.8	9.6
2	10	0.08	5	0.8	1.2	0.4	1.2	4.8
3	15	0.08	5	1.2	1.5	0.3	1.5	3.6
4	20	0.08	5	1.5	1.7	0.2	1.7	2.4
5	25	0.08	5	1.7	1.9	0.2	1.9	2.4
6	30	0.08	5	1.9	2.1	0.2	2.1	2.4
7	35	0.08	5	2.1	2.3	0.2	2.3	2.4
8	40	0.08	5	2.3	2.5	0.2	2.5	2.4
9	45	0.08	5	2.5	2.7	0.2	2.7	2.4
10	50	0.08	5	2.7	2.9	0.2	2.9	2.4
11	55	0.08	5	2.9	3.1	0.2	3.1	2.4
12	60	0.08	5	3.1	3.3	0.2	3.3	2.4
13	65	0.08	5	3.3	3.5	0.2	3.5	2.4
14	70	0.08	5	3.5	3.7	0.2	3.7	2.4
15	75	0.08	5	3.7	3.9	0.2	3.9	2.4

Table 5. Experimental Data of Infiltration Capacity in Unploughed Land in Trail-II

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	0.8	0.8	0.8	9.6
2	10	0.08	5	0.8	1.2	0.4	1.2	4.8
3	15	0.08	5	1.2	1.5	0.3	1.5	3.6
4	20	0.08	5	1.5	1.7	0.2	1.7	2.4
5	25	0.08	5	1.7	1.9	0.2	1.9	2.4
6	30	0.08	5	1.9	2.1	0.2	2.1	2.4
7	35	0.08	5	2.1	2.3	0.2	2.3	2.4
8	40	0.08	5	2.3	2.5	0.2	2.5	2.4
9	45	0.08	5	2.5	2.7	0.2	2.7	2.4
10	50	0.08	5	2.7	2.9	0.2	2.9	2.4
11	55	0.08	5	2.9	3.1	0.2	3.1	2.4
12	60	0.08	5	3.1	3.3	0.2	3.3	2.4
13	65	0.08	5	3.3	3.5	0.2	3.5	2.4
14	70	0.08	5	3.5	3.7	0.2	3.7	2.4
15	75	0.08	5	3.7	3.9	0.2	3.9	2.4

Table 6. Average infiltration rate in unploughed land

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	0.8	0.8	0.8	9.6
2	10	0.08	5	0.8	1.2	0.4	1.2	4.8
3	15	0.08	5	1.2	1.5	0.3	1.5	3.6
4	20	0.08	5	1.5	1.7	0.2	1.7	2.4
5	25	0.08	5	1.7	1.9	0.2	1.9	2.4
6	30	0.08	5	1.9	2.1	0.2	2.1	2.4
7	35	0.08	5	2.1	2.3	0.2	2.3	2.4
8	40	0.08	5	2.3	2.5	0.2	2.5	2.4
9	45	0.08	5	2.5	2.7	0.2	2.7	2.4
10	50	0.08	5	2.7	2.9	0.2	2.9	2.4
11	55	0.08	5	2.9	3.1	0.2	3.1	2.4
12	60	0.08	5	3.1	3.3	0.2	3.3	2.4
13	65	0.08	5	3.3	3.5	0.2	3.5	2.4
14	70	0.08	5	3.5	3.7	0.2	3.7	2.4
15	75	0.08	5	3.7	3.9	0.2	3.9	2.4

Table 7. Experimental Data of Infiltration Capacity in Continuous fallow Land in Trail- I

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	5.8	5.8	5.8	69.6
2	10	0.08	5	5.8	7.1	1.3	7.1	15.6
3	15	0.08	5	7.1	8.1	1.0	8.1	12
4	20	0.08	5	8.1	8.8	0.7	8.8	8.4
5	25	0.08	5	8.8	9.4	0.6	9.4	7.2
6	30	0.08	5	9.4	9.9	0.5	9.9	6
7	35	0.08	5	9.9	10.3	0.4	10.3	4.8

Table 8. Experimental Data of Infiltration Capacity in Continuous fallow Land in Trail- II

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	5.8	5.8	5.8	69.6
2	10	0.08	5	5.8	7.1	1.3	7.1	15.6
3	15	0.08	5	7.1	8.1	1.0	8.1	12
4	20	0.08	5	8.1	8.8	0.7	8.8	8.4
5	25	0.08	5	8.8	9.4	0.6	9.4	7.2
6	30	0.08	5	9.4	9.9	0.5	9.9	6
7	35	0.08	5	9.9	10.3	0.4	10.3	4.8

Table 9. Average infiltration rate in continuous fallow land

S No	Time, min	Time, h	Time interval, min	Water levels, cm		Infiltration, cm	Cumulative infiltration, cm, Fp	Infiltration Capacity, cm/h, I
				Initial	Final			
1	5	0.08	5	0	5.8	5.8	5.8	69.6
2	10	0.08	5	5.8	7.1	1.3	7.1	15.6
3	15	0.08	5	7.1	8.1	1.0	8.1	12
4	20	0.08	5	8.1	8.8	0.7	8.8	8.4
5	25	0.08	5	8.8	9.4	0.6	9.4	7.2
6	30	0.08	5	9.4	9.9	0.5	9.9	6
7	35	0.08	5	9.9	10.3	0.4	10.3	4.8

Table 10. Experimental Data of Infiltration Capacity in Compact Land in Trail-I

S.N O	Time (min)	Time (h)	Time interval	Water levels		Infiltration cm	Cumulative Infiltration Cm	Infiltration Capacity, cm/h,I
				Initial	Final			
1	5	0.08	5	0	0.2	0.2	0.2	2.4
2	10	0.08	5	0.2	0.35	0.15	0.35	1.8
3	15	0.08	5	0.35	0.5	0.15	0.5	1.8
4	20	0.08	5	0.5	0.6	0.1	0.6	1.2
5	25	0.08	5	0.6	0.7	0.1	0.7	1.2
6	30	0.08	5	0.7	0.8	0.1	0.8	1.2
7	35	0.08	5	0.8	0.9	0.1	0.9	1.2
8	40	0.08	5	0.9	1.0	0.1	1.0	1.2
9	45	0.08	5	1.0	1.1	0.1	1.1	1.2
10	50	0.08	5	1.1	1.2	0.1	1.2	1.2
11	55	0.08	5	1.2	1.3	0.1	1.3	1.2
12	60	0.08	5	1.3	1.4	0.1	1.4	1.2
13	65	0.08	5	1.4	1.5	0.1	1.5	1.2
14	70	0.08	5	1.5	1.6	0.1	1.6	1.2
15	75	0.08	5	1.6	1.7	0.1	1.7	1.2
16	80	0.08	5	1.7	1.8	0.1	1.8	1.2
17	85	0.08	5	1.8	1.9	0.1	1.9	1.2
18	90	0.08	5	1.9	2.0	0.1	2.0	1.2
19	95	0.08	5	2.0	2.1	0.1	2.1	1.2
20	100	0.08	5	2.1	2.2	0.1	2.2	1.2
21	105	0.08	5	2.2	2.3	0.1	2.3	1.2
22	110	0.08	5	2.3	2.4	0.1	2.4	1.2
23	115	0.08	5	2.4	2.5	0.1	2.5	1.2