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# INFILTRATION STUDIES IN JAMMU REGION

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# PREFACE

Infiltration characteristics of a soil is an important parameter required for many hydrological studies and simulation of flow process. It is a basic parameter for developing an integrated crop , soil & water management plan . The knowledge of infiltration is of great importance to hydrologists/ irrigation Engineers, agronomists, soil conservationists, ecologists, geomorphologists and geohydrologists in their respective areas of studies.

National Institute of Hydrology proposed to carryout infiltration studies and to prepare thematic map of infiltration characteristics for the country. With this national objective the present study was conducted by NIH Regional Centre, Jammu for Jammu region. It is expected that the results of this study will be useful to scientists, planners and local water use organizations in their watershed development programme.

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( SATISH CHANDRA )

DIRECTOR

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## ABSTRACT

The phenomenon of infiltration, that is the process of water entry into the soil deserves a special place in hydrologic studies. In the present study an attempt has been made to develop infiltration curves for Jammu region in the state of J & K . Double ring cylinder infiltrometer tests were conducted at 19 places within region under different landuses and soils on different dates . The soil informations were obtained from Directorate of Agriculture , Jammu . Moreover, the soil textures were also determined in the field using wet method or method of rolling as an ancillary informations .

The regression analysis was performed between field observations for Kostiakov (1932) type infiltration function ($Y = a\ t^b$) using multiple linear regression programme MULTI . FOR after transforming the function into the linear form through logarithmic transformation. The results showed that the infiltration rates were higher for forest lands than grass, agriculture and bare lands. The correlation coefficients for the regression equation varied from 0.98 to 0.99 , 0.97 to 0.99, 0.95 to 0.99 and 0.96 to 0.99 for soils under bare, agriculture, grass and forest lands respectively.

## 1.0 INTRODUCTION

Infiltration is the downward movement of water through soil surface due to the combined forces of the capillarity and gravity contributing to replenishment of soil moisture, recharge of aquifers and ultimately augmenting the stream flows during dry periods. This is an important parameter for hydrologists and watershed managers. Knowledge of infiltration characteristics of the basin helps in estimating the quantity of rainfall excess resulting from a stream. Infiltration is one of the basic parameters for developing an integrated crop , soil and water management plan and often used in on farm irrigation water management practices. Hydrologic importance of the process is to be seen from the fact that it marks the transition from fast moving surface water to slow moving soil and ground water.

Infiltration characteristics are very useful to the agronomists and ecologists who are concerned with the availability of soil moisture in the root zone of crops and plants. The plant growth may be affected in the conditions of water logging or moisture stress. Therefore, the infiltration is very important for assessing the soil moisture deficits and accordingly planning irrigation and drainage systems.The knowledge of infiltration is also useful to soil conservationist for planning devices to dissipate the energy of flowing water to minimise soil erosion. He may suitably plan engineering and forestry measures to induce infiltration through the land surface depending upon the soil infiltration characteristics. A geomorphologist may be interested in the magnitude, frequency and and spatial characteristics of infiltration related to rainfall intensity for preventing land slips due to overland flow.

Computer models of runoff process of a hydrologic system have been devised to simulate annual hydrograph and to estimate the frequency and magnitude of high and low flows in rivers with little or no hydrologic records. Such models reflect varying views of how the source areas generate stream flow. Traditional engineering models are mostly infiltration based.

Keeping in view the importance of infiltration characteristics in hydrology or watershed management practices the report attempts to determine infiltration characteristics of Jammu region with the help of field experiments since existing data are not available in the area .

## 2.0 REVIEW

### 2.1 General :

The term infiltration was used in the United States by Goerge P.Marsh, a careful observer of natural phenomena, and he published the edition" Man and Nature " in 1861. Ivan Houk (1921), in connection with the studies leading to the development of the Miami conservancy District in Ohio, under Arthur E. Morgan, reported the results of measurements of " soil absorption" for several conditions in the vicinity of the Miami River. This term was used in reference to the difference between rainfall and runoff of small areas while formulating the plans for the Miami flood control Project. In the mid of 1930, the American Geophysical union established a research committee on infiltration, a process which was regarded as of having significant role on water resources planning.

Infiltration may be defined as the process of water entry into the soil, generally by downward flow through all or part of the soil surface. Water may enter the soil through the entire surface uniformly as under ponding or rain, or it may enter the soil through furrows. Infiltration rate is the volume of water entering the soil profile per Unit of Soil surface area and time. The maximum rate at which a given soil in a given condition can absorb water is known as infiltration capacity or infiltrability of the soil.

## 2.2 Factors Affecting Infiltration :

The factors which mostly affect the infiltration capacity are intensity and duration of rainfall, soil characteristics, condition of soil (Soil moisture content), vegetal cover, land use, entrapped air, depth of the ground water and weather (temperature) etc.

Infiltration rate is a function of both rainfall rate and soil conditions. If the rainfall rate is less than infiltration capacity rate, infiltration may continue indefinitely at a rate equal to the rainfall rate without ponding at the surface. When rainfall rate is more than the infiltration capacity, the infiltration rate is limited by the capacity of the soil to absorb water. This results in surface ponding and water becomes available for runoff.

The soil texture controls the infiltration rate until the soil behind the wetting front reaches saturation. As soon as the water content of the soil reaches saturation, the hydraulic conductivity begins to control the infiltration rate. The depth of the soil profile and its initial moisture content determines the amount of infiltrated water which can be stored in the soil before saturation is reached. Higher the initial moisture content, lower will be the infiltration capacity. Organic matter content promotes soil aggregation and ultimately that will cause rapid infiltration and drainage.

Vegetal cover and land use are very important factors for affecting the infiltration rates. The vegetal cover provides protection against rain drop impact which reduces the soil erosion. Vegetal cover facilitates high rate of infiltration which in turn reduces the surface runoff. Mulching greatly improves the infiltration rates by absorbing the raindrop impact and prevents the formation of impervious surface layer.

The entrapment of soil air builds up air pressure, which reduces the infiltration rate. Besides these factors, the depth of ground water table, weather (temperature) and man's activities also affect the process of infiltration.

## 2.3 Theory of Infiltration :

Green and Ampt (1911) developed infiltration equation from a ponded surface in deep homogeneous soil with uniform initial water content based on Darcy type water flux. Infiltration has to be proportional to the total gradient, including suction effect. Therefore,

$$f = \frac{Ks(H + \psi + Lf)}{Lf} \quad (1)$$

Where, f is infiltration rate or capacity (units of velocity ), H is a some level of ponding on the surface, $\psi$ is a suction effect due to dryness at lower levels, Lf is the increasing depth of the water front and Ks is saturated hydraulic conductivity. It is assumed that the wet front moves as piston. If H is assumed small , eqn. 1 can be expressed as

$$f = Ks + \frac{Ks\ S\ \psi}{y} \quad (2)$$

Where y is the total infiltrated water given by $(\theta_s - \theta_i)$ Lf = SLf, and S is the initial moisture (as a fraction volume) deficit of the soil column. Haan et al. (1982) have also provided a good summary of results to the Green and Ampt model.

Kostiakov (1932) proposed an empirical equation and generally known as Kostiakov equation (Lewis, 1937, Criddle et al., 1956, Haise et al., 1956). The equation is given as :

$$y = a\,t^{b} \qquad (t \neq 0) \qquad (3)$$

Where y is cumulative depth of water infiltered (cm); t is time elapsed from start of the ponding of the water (hr), a and b are empirical constants.

Horton (1933) defined infiltration as the process involved when water soaks into the ground. The rate at which water can enter the soil is called the infiltration capacity, (Horton, 1940, Fleming et al. 1975). After a period of 1-2 hours water infiltrates at a slow steady rate. This is called the basic infiltration rate . The proposed Horton's equation for infiltration capacity (cm/hr) at time t is :

$$f = fe + (fo - fe)\,e^{-kt} \qquad (4)$$

Where k is a constant representing the rate of decrease in infiltration f; fe is final or equilibrium capacity ( cm/hr) ; and fo is initial infiltration.

Klute (1952) defined infiltration into unsaturated soil by differential equation as **given under**

$$\frac{\delta \theta}{\delta t} = \frac{\delta}{\delta z}\left(K \frac{\delta \phi}{\delta z}\right) + \frac{\delta}{\delta z}(K.g) \qquad (5)$$

Where, $\theta$ is the moisture content in volume of water per unit volume of soil, K is the unsaturated hydraulic conductivity (L/T), $\phi$ is the capillary potential (L) , g is gravitational constant ( $L/T^2$ ) and Z is the Co-ordinate in the vertical direction (L).

Philip (1957) suggested the following theoretical infiltration equation based on physical properties of soil and analysis of penetration into a uniform soil.

$$y = Sp\ t^{0.5} + a\ t \qquad (6)$$

Where , y is cumulative infiltration (cm) at time t , Sp is 'sorptivity' parameter that relates to capillarity or soil matrix forces, and a is soil parameter relating to transmission of water through the soil or gravity force.

Soil Conservation Service (1968) empirically obtained runoff over finite areas for various regions in the United States. The equation is

$$P - y - Ia = Rs = \frac{(P-Ia)^2}{(P - Ia + S)} \qquad (7)$$

$$P \geq Ia$$

$$S \geq Ia + y$$

Where, P is volume of total precipitation, y is volume total infiltration, Ia is an initial retention volume and S is the potential maximum surface retention. The initial abstraction Ia is commonly taken as Ia = 0.2 S . The retention volume is given by

$$S \text{ (inches)} = \frac{1000}{CN} - 10 \qquad (8)$$

Where CN is called curve number , a parameter dependent on soil type , use , and antecedent moisture conditions.

Holton (1971) proposed the following equation for infiltration capacity (cm/hr) at time t,

$$f = ci\ Sa^{n} + t\ fe \qquad (9)$$

Where, i is infiltration capacity per unit of available storage ; Sa is available storage which is the difference between the potential soil moisture storage and the cumulative (cm), n is a coefficient that relates to soil texture ; fe is constant rate of infiltration after prolonged wetting of soil (cm/hr) and the value of C is given as 0.69 for cm (1.0 for inches).

**2.4 Infiltration Studies in Abroad :**

Duley (1939) showed in his experiments on infiltration that infiltration decreases rapidly during rainfall because of formation of thin compact layer on soil surface. Browning (1939) observed that soil swells at the expense of soil pores. He generalized that factors responsible for pore size distribution in soil shall influence the rate of infiltration.Christiansen (1944) showed that entrapped air in the soil decreases infiltration considerably.

Kittredge (1948) concluded that the difference in infiltration between forested and cropped soils may be in the ratio of 100 to 2. Annon (1962) also reported that the infiltration rate was highest in the forest land in comparison to grass or bare and agricultural soils.

Musgrave (1955) concluded from his study on infiltration that the various factors such as surface condition and cover , internal soil characters and profile, soil moisture status, duration of rainfall and application of water , season of the year, temperature of soil water etc. affect intake of water by soils.

Hay and Subramanyam (1955) found that generally field infiltration rates become constant after three hours. Infiltration rates were increasing in the order of bare land, scrub forest and ploughed land respectively.

Wood (1977) conducted infiltration studies on various vegetal covers adjacent to agricultural areas. He observed that the water infiltration rates were higher on 14 out of 15 forest sites than in the adjacent sites used for agriculture. Lee (1980) concluded in his study that forest fires may decrease infiltration rates significantly.

Walfe et al. (1988) have formulated three layer infiltration model using the Green and Ampt approach (1911) The characteristics of the surface and tilled are transient being subject to surface sealing and consolidation respectively.

**2.5 Infiltration Studies in India :**

Mistry and Chatterjee (1965) conducted infiltration studies in Bihar and recorded average infiltration rates as 26,12 and 9 cm/hr under forests , grasslands and croplands respectively.

Tejwani et al. (1975) reported average infiltration rates under different types of site conditions. They found infiltration rates 1.0,2.60 and 17.0 cm/hr for agricultural land, grass land and woodland respectively in Bellary. The infiltration rates in Ootacamund under Shola forest , Broom and Grazed grass land were recorded 12.50, 11.25 and 6.25 cm/hr respectively.

Mathur et al. (1982) found higher infiltration rate in the forest soils than in adjacent agricultural soil subject to continued cultivation. He also showed that infiltration capacity of forest land may decrease abruptly as a result of forest fires that destroy organic layer (litter and humus) as well as vegetation at the forest floor and compact the soil.

Dhruvanarayana and Shastri (1983) conducted a comparative study on different forest covers in Dehradun (North Western Himalayan Region) and recorded initial infiltration rates as 54.0, 21.4, 12.0,9.6 , 9.6 and 7.6 cm/hr under Eucalyptus, sal , chir,teak, Bamboo and grass land respectively . In the same study effects of the fire on infiltration in chir plantation was studied and infiltration was reduced by value of 3.6 cm/hr. The analysis of infiltration data from small forests and agriculture watershed in Doon Valley indicated that the rate of infiltration was twice in forest watershed (shorea Robusta) as compared to agriculture watershed.

Soni et al. (1985) have conducted infiltration studies in the experimental plantations of Forest Research Institute & College, Dehradun under Pinus Roxburghii plantation, Sal plantation, Teak plantation, Bamboo plantation, Eucalyptus plantation and ungrazed grassland . The infiltration rates were found to be highest in Eucalyptus and lowest in Pinus (after burning) . Infiltration capacities under different vegetation covers were found positively correlated with soil porosity and negatively with bulk density.

Soni and Singh (1988) developed a methodology for an average infiltration function from point infiltration measurements using cylinder infiltrometers. The natural logarithm of cumulative infiltration at 15,30,45,60,75,90,105,120,135,150,165,180,and 195 minutes elapsed time were found to be normally distributed. It is, therefore, concluded that geometric mean of cumulative infiltration observed at different locations should be taken to arrive at the average cumulative infiltration values for the entire field.

Om Kar and Pal (1990) conducted infiltration tests prior to irrigating wheat crop for evaluating performance of border irrigation system. Regression analysis was performed for Kostiakov (1932) infiltration function ( $y = a t^b$ ) between cumulative depth of water infiltered, y (dependent variable) and elapsed time, t (independent variable). The constants a and b in Kostiakov (1932) infiltration function were found to be higher prior to first irrigation than second one. It may be concluded that infiltration rates decreased prior to second irrigation mainly due to surface sealing by smaller soil particles and rising of moisture level during first irrigation. The correlation coefficients for the function were ranged from 0.94 to 0.99 in all experiments.

Ranganna et al. (1991) carried out infiltration tests on different soils in Pavanje river basin in Dakshina Kannada district of Karnataka State. They observed that constant infiltration rates were highest in sandy soils . However, there were a few cases of constant infiltration rates quite high in lateritic soils . This may be due to other factors which affect infiltration viz., soil surface conditions, depth of surface detention, compaction , soil moisture content, macrostructures of soils etc.

## 3.0 STATEMENT OF THE PROBLEM

Infiltration characteristics of a soil is an important parameter for hydrological modeling . It is essential to know the rates at which different soils will take in water under different conditions. Infiltration rates are affected by a number of factors of which soil moisture, soil texture and vegetal cover are most important. It is a basic parameter for developing an integrated crop, soil and water management plan. The knowledge of infiltration is of great importance to a hydrologist in estimating rate of runoff and peak flow with time, to a soil scientist / agronomist in estimating the availability of soil moisture, to irrigation and drainage engineers in planning and designing various water resources development projects.

Infiltration measurements in India have been made in a large number using different methods ranging from simple infiltrometer to rainfall simulator .Many agencies like AIS & LUS, CWSCTRI Dehradun and various academic organizations have conducted studies to ascertain the infiltration characteristics of various river basins . However, there are following reasonable gaps regarding infiltration studies conducted so far:

1. Infiltration data for many basins are not available.
2. Preparation of thematic maps for different basins have not been done.

3. Data availability and studies on infiltration at vegetated and snow covered soil surfaces are very limited.

4. The hydrological parameterizations of surface runoff and ground water have been well achieved , however, studies concerning with infiltration process still lag behind.

Keeping in view the various existing gaps, National Institute of Hydrology proposed to conduct field infiltration tests on National level. The study aims to prepare an all India infiltration map and to determine average cumulative infiltration function from point infiltration measurements. In pursuit of these objectives the NIH Regional Centre, Jammu has carried out field tests in several places within Jammu Region.

## 4.0 STUDY AREA

### 4.1 Location:

The present study was conducted for Jammu region consisting the districts of Jammu, Kathua and Udhampur in J & K, India . The Jammu region is bounded between latitude 32° 17' to 34° 08' and longitude 74° to 76° 30'. Field infiltration tests were carried out at 19 places within the region (Fig. 1). The total geographical area comprising all the districts of Jammu region is 27, 371 Sq. km. The region being within sub Himalayas the topographical features and elevations vary abruptly from one location to another

### 4.2 Geology

Jammu region is mainly dominated by tertiary group. It consists of mostly lime stone, compact quartzite, calcareous slate or shale. These are believed to be of carboniferous age.However, karewa group is present all along the foot of the mountains. This is chiefly formed of alluvial or lacustrine materials. They belong to pre- historic and pleistocene age. The geological map of Jammu region is given in Fig.2.

### 4.3 Soils

The soils of Jammu region shows a great heterogeneity. The soils of the foot hills and areas adjacent to them comprises of loose boulders and gravel with ferruginous clay.These types of

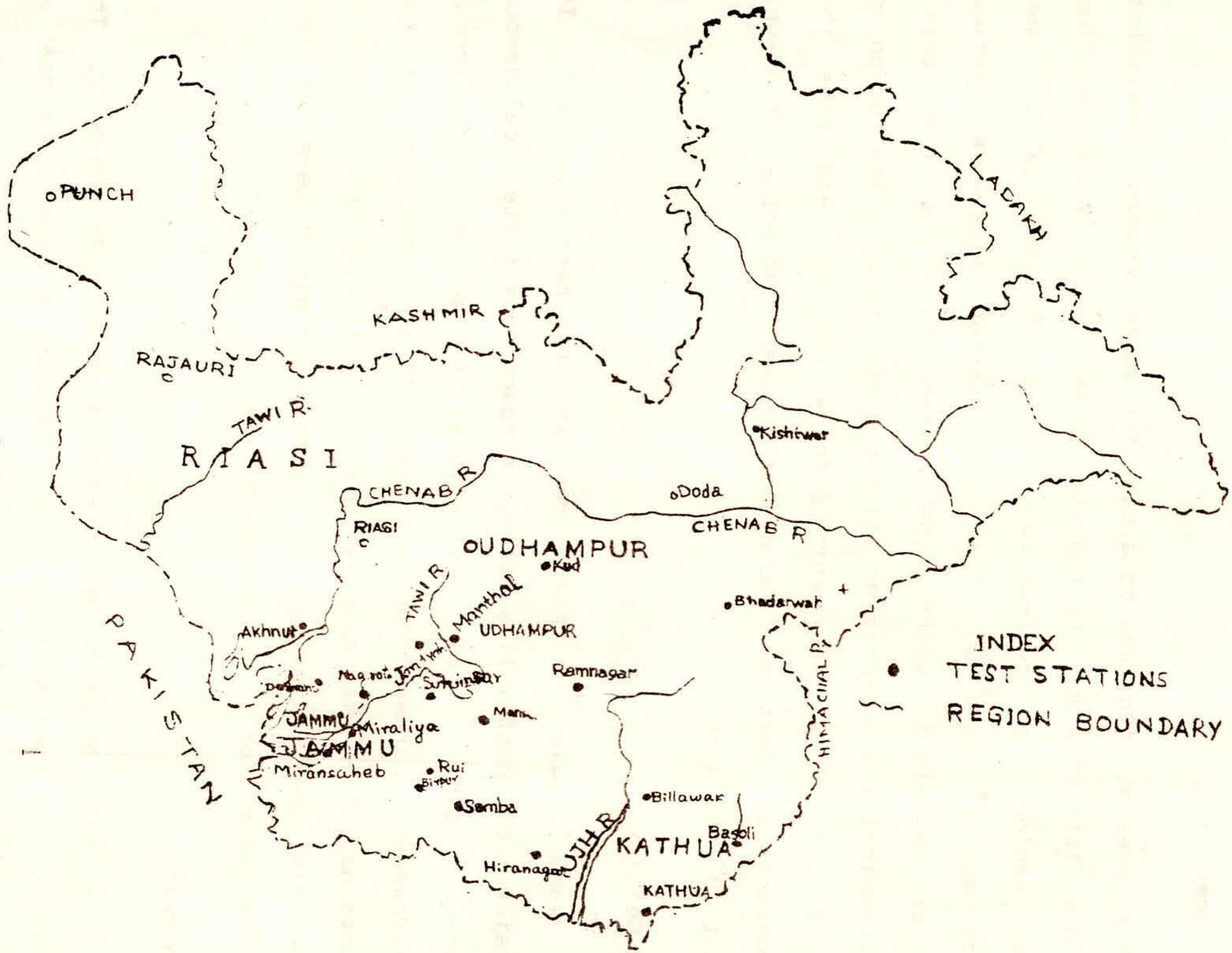
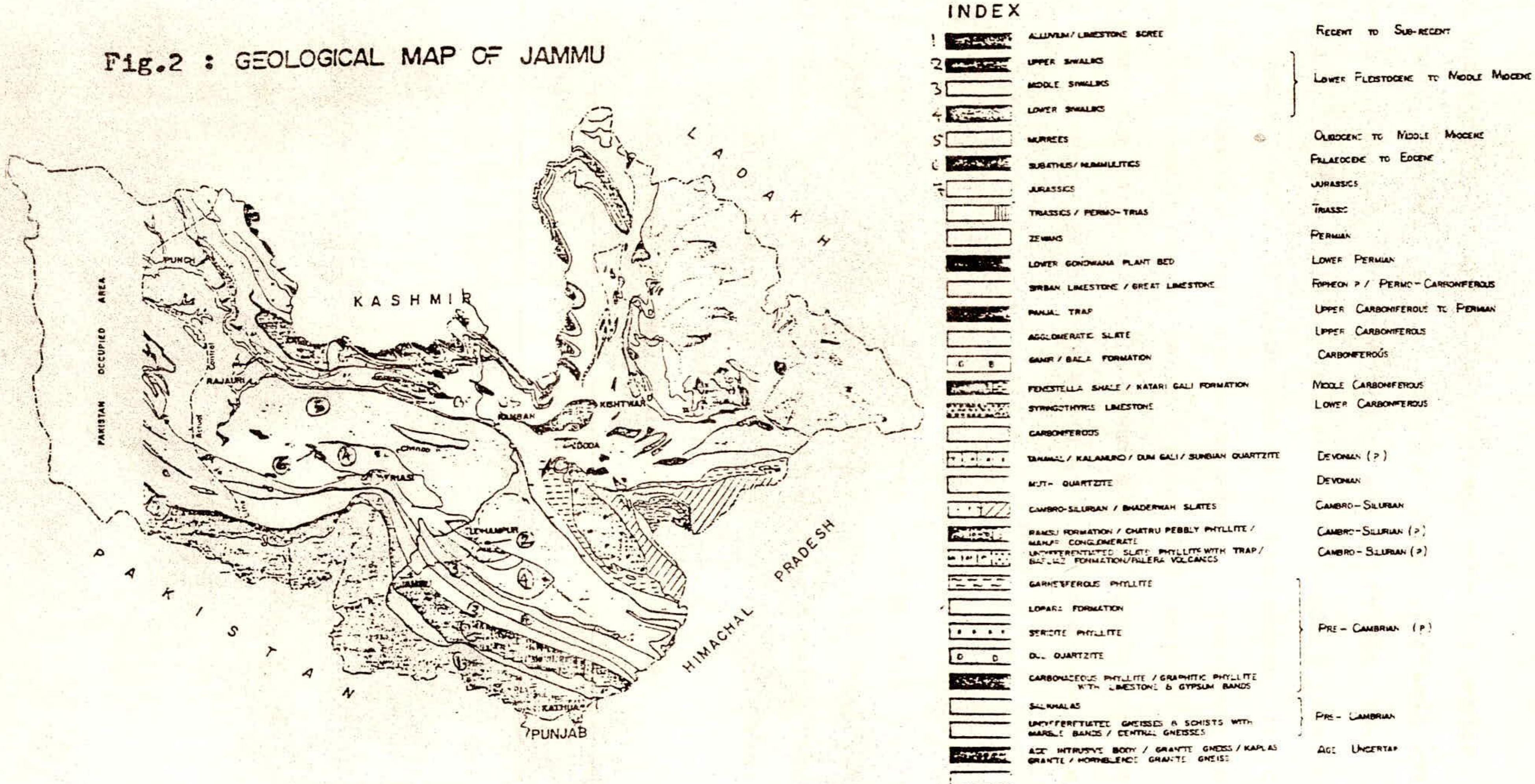



Fig. 1: Index Map Showing Test Sites of Jammu Region.

Fig.2 : GEOLOGICAL MAP OF JAMMU



soils spread all over the District of Kathua, Jammu and Rajauri and are generally loamy but poor in clay content . The alluvium plains are generally low in nitrogen and medium in phosphorous and potash. In the middle mountain region, the soils are mainly formed of decomposed rocks and peat. Due to decomposition of natural vegetation these soils are rich in organic matter and heavy in texture. The valley basins in Kishtwar and Bhadarwah and on the slopes of the lower hills contain sub montane and mountain meadow soils. The whole region is susceptible to soil erosion in large extent.

Textural analysis of soils was carried out in the field based on wet method (method of rolling) as an ancillary informations( Fig. 3). However, the major soil informations were collected from Directorate of Agriculture, Jammu. The soil type reference of different sites are given in Table-1.

Table-1

Soils of Different Places in Jammu Region

| S.No. | Site | District | Soil Type Reference |
|---|---|---|---|
| 1 | Mansar | Jammu | A |
| 2 | Nagrota | -do- | B |
| 3 | Rui | -do- | A |
| 4 | Akhnoor | -do- | C |
| 5 | Domana | -do- | C |
| 6 | Pounichak | -do- | A |
| 7 | Birpur | -do- | A |
| 8 | Jandrah | -do- | B |
| 9 | Miraliya | -do- | A |
| 10 | Miransaheb | -do- | A |

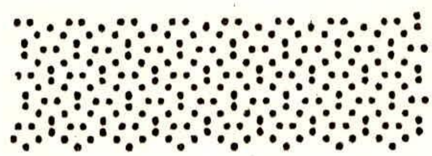
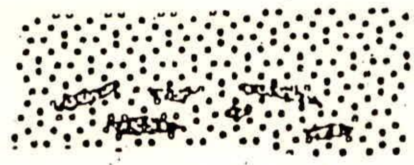
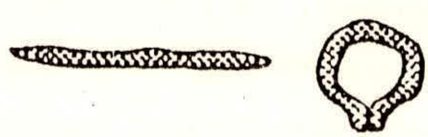
| Texture | View of sample in plane projection after rolling |
|---|---|
| No roll forms - sand |  |
| Beginnings of a roll - sandy loam |  |
| The roll breaks during rolling - light loam |  |
| The roll is continuous, but breaks when a ring is formed - medium loam |  |
| The roll is continuous, but the ring cracks - heavy loam |  |
| The roll is continuous, the ring is whole - clay |  |

Fig.3 Criteria for Determining Soil Texture in the Field

| | | | |
|---|---|---|---|
| 11 | Surinsar | -do- | D |
| 12 | Hiranagar | kathua | E |
| 13 | Palas | -do- | A |
| 14 | kathua | -do- | F |
| 15 | Billawar | -do- | A |
| 16 | Ramnagar | Udhampur | G |
| 17 | Manthal | -do- | H |
| 18 | Kud | -do- | G |

The soil type reference given in Table-1 are being discussed as under:

A : Moderately deep to deep sandy loam to silt clay loam.

B : Upper pediment plain cultivated and sandy loam to silt clay loam.

C : Texture varies between sandy loam / silt loam to silt clay with an increase in the clay contents in the lower horizons.

D : Moderately shallow with sandy loam to loamy sand.

E : Fallow and waste land area , moderately shallow, deep to very deep, sandy loam/ silt loam to silt clayloam.

F : Moderately deep to deep and moderately shallow near the river bed having sandy loam to loamy sand texture with a very little variation in soil profiles below.

G : Shallow to medium in upper parts and medium to deep in lower parts, moderately well drained to excessively drained, fine calcareous / non calcareous , fine silt to sandy loam on surface.

H : Ustochrepts, fine, loamy calcareous, excessively drained, shallow to medium deep, 33 to 50% slopes and moderately dissected.

### 4.4 Climate:

The most of Jammu region experiences tropical heat . The total annual rainfall is about 1052 mm which gradually increases towards the north. The hot season, as in the Punjab, begins in the middle of March and lasts till the end of June when the summer rains begin . These last till the end of September . In the middle mountainous part of the region the climatic conditions vary from place to place in accordance with their elevations . This part of the region experiences extremely rigorous and long winter with a short rise in temperature in summer.

### 4.5 Landuse / Land cover:

The region has about 30% forest , 40% agriculture , 20% barren land and 10% built-up land. The main crops grown are paddy, wheat, maize , barley, oil seeds, pulses and fruits. However , lowlands are mainly dominated by paddy and in hilly tracts maize is grown on terraces.

## 5.0 METHODOLOGY

Commonly used methods for determining infiltration capacity are hydrograph analysis and infiltrometer studies. Infiltrometers are usually classified as rainfall simulators or flooding devices. Flooding infiltrometers are usually rings or tubes inserted in the ground. Water is applied and maintained at a constant level and observations made of the rate of the replenishment required. The present study has been conducted for bare, agriculture, grass and forest lands using double ring cylinder infiltrometer ( Plate 1 to 4 ).

### 5.1 Construction of Infiltrometers :

With double cylinder infiltrometer, a small cylinder is placed concentrically inside another cylinder. Diameters were 30 cm for inner cylinder and 45 cm for outer cylinder. The height was 45 cm for both cylinders. The edge of cylinder should be beveled to reduce soil disturbance when the cylinder is pushed or driven into the soil. The diameter should be as large as practicable to get a true measure of the vertical infiltration.

### 5.2 Installation of Infiltrometers:

Cylinder infiltrometers should be installed with as little disturbance of the soil as possible. The soil surface should leave in its natural condition and remove only woody stems, rocks, or other items that may get caught under the cylinder edge on inserting the device. The depth of penetration of the cylinder

Plate-1 Infiltration Test at Pounichak in Bareland

Plate-2 Infiltration Test at Pales in Agriculture field

Plate-3 Infiltration Test at Nagrota in Grassland

Plate-4 Infiltration.Test at Manthal in Forestland should be as small as possible to minimize soil disturbance, but large enough to prevent water from blowing out a hole under the cylinder wall. Penetration of about 5 - 10 cm is sufficient. If the soil surface is cracked, the cylinder should penetrate the soil at least as deep as the cracks, to prevent water from escaping laterally through cracks below the cylinder. If after installing the cylinder there is some separation between the soil inside the cylinder and the cylinder wall, the soil should be pushed or packed back against the cylinder.

### 5.3 Measurement of Infiltration:

The water used in infiltrometer tests must be of the same quality and composition as the water in the real systems for which the infiltration rate is to be predicted. Also, the water must be at about the same temperature as the soil. Equal water levels must be maintained in both cylinders (Bouwer, 1963) and the infiltration rate is measured on the inner cylinder only. The thought behind the double cylinder system was to let the outer annular space between the two rings to absorb all the edge and divergence effects, so that the infiltration from the inner ring would be a true measure of the vertical infiltration rate of the soil.

Double ring cylinder infiltrometers could be effective only where there is a surface crust, an impeding layer on the surface, or other soil condition that makes it different to get a good bound between the undisturbed soil and the cylinder wall. Leakage along the cylinder wall can be minimized by placing another cylinder around the infiltrometer and maintaining the water level in there at exactly same height as in the inner cylinder.

## 6.0 RESULTS

The data obtained during field experiments were analysed using multiple linear regression program MULTI.FOR to compute the coefficients of Kostiakov (1932) type infiltration function. The infiltration curves for different landuses and soils were developed. The results obtained are discussed as under:

### 6.1 Infiltration Rates Under Different Landuses:

The field tests were conducted for bare, agriculture, grass and forest lands. Table-2 gives the initial and final infiltration capacities for different land uses and results are described through corresponding infiltration curves (fig. 4 to 7). It was found that the initial infiltration capacities for bare, agriculture, grass and forest lands were varied from 12.0 to 18.0, 17.0 to 24.0, 12.0 to 36.0 and 18.0 to 72.0 cm/hr respectively.Whereas, the final infiltration capacities for same landuses were found 0.3 to 2.4, 1.2 to 3.0, 0.3 to 6.3 and 0.6 to 1.2 cm/hr respectively.

Table - 2

Infiltration Rates Under Different Landuses

| Landuse | Site | Infiltration rate (cm/hr) | | | Date |
|---|---|---|---|---|---|
| | | Initial | Average | Final | |
| Bare Land | Hiranagar | 12.0 | | 0.6 | 27.3.93 |
| | Mansar | 12.0 | 14.75 | 2.4 | 28.9.92 |
| | Pounichak | 17.0 | | 0.7 | 13.05.92 |

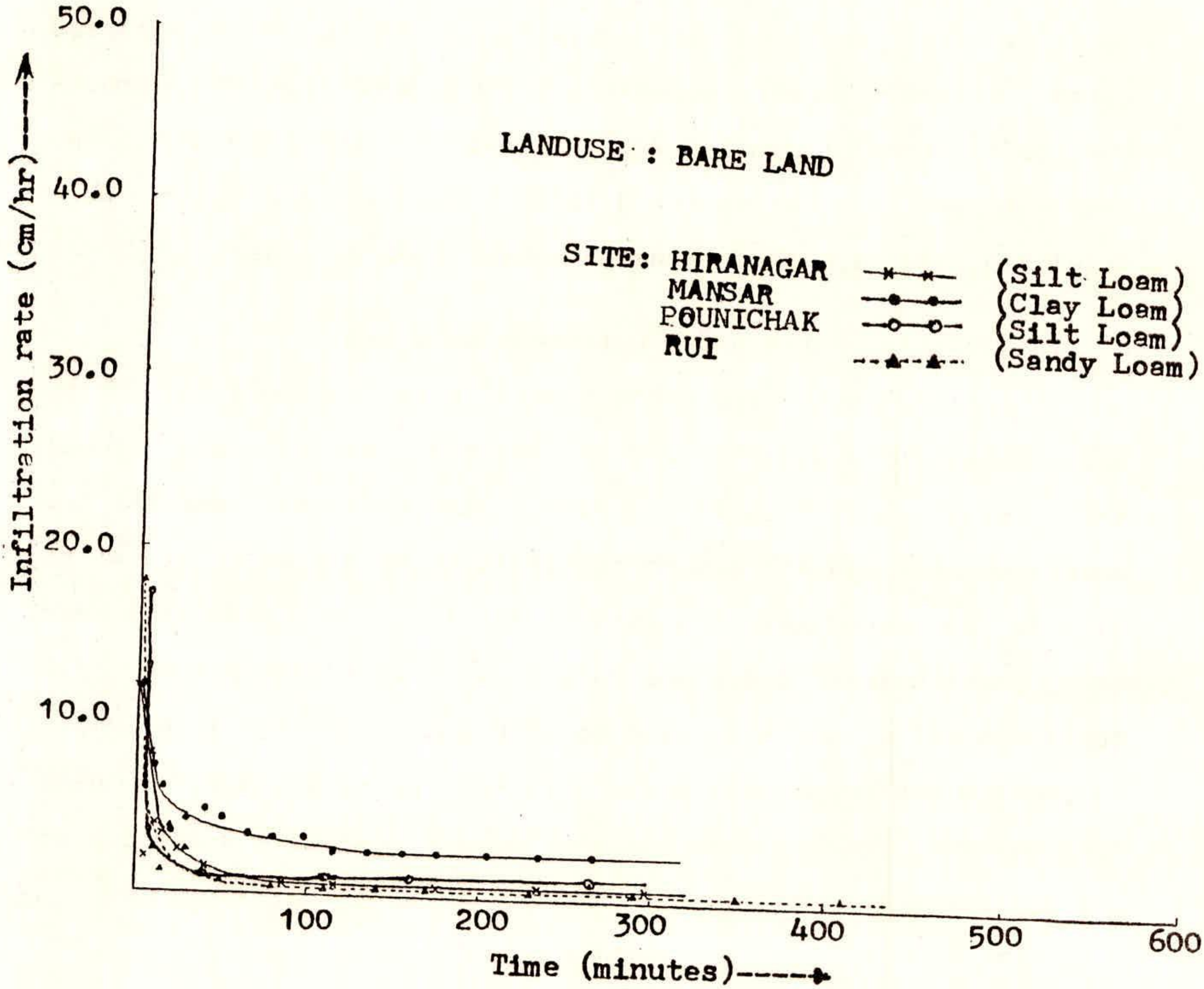



Fig. 4: Infiltration Curves for Bare Lands

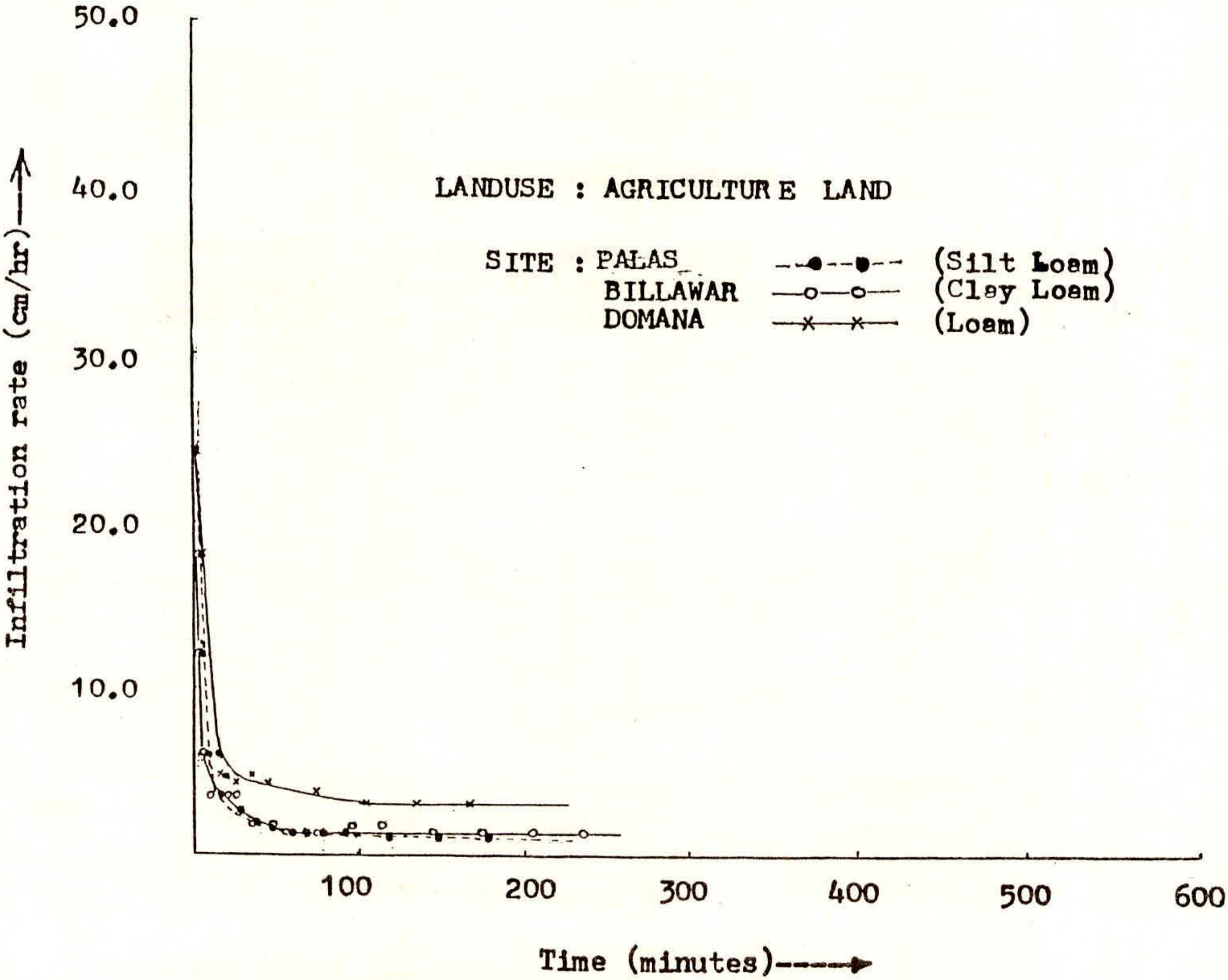



Fig. 5 : Infiltration curves for Agricultural lands

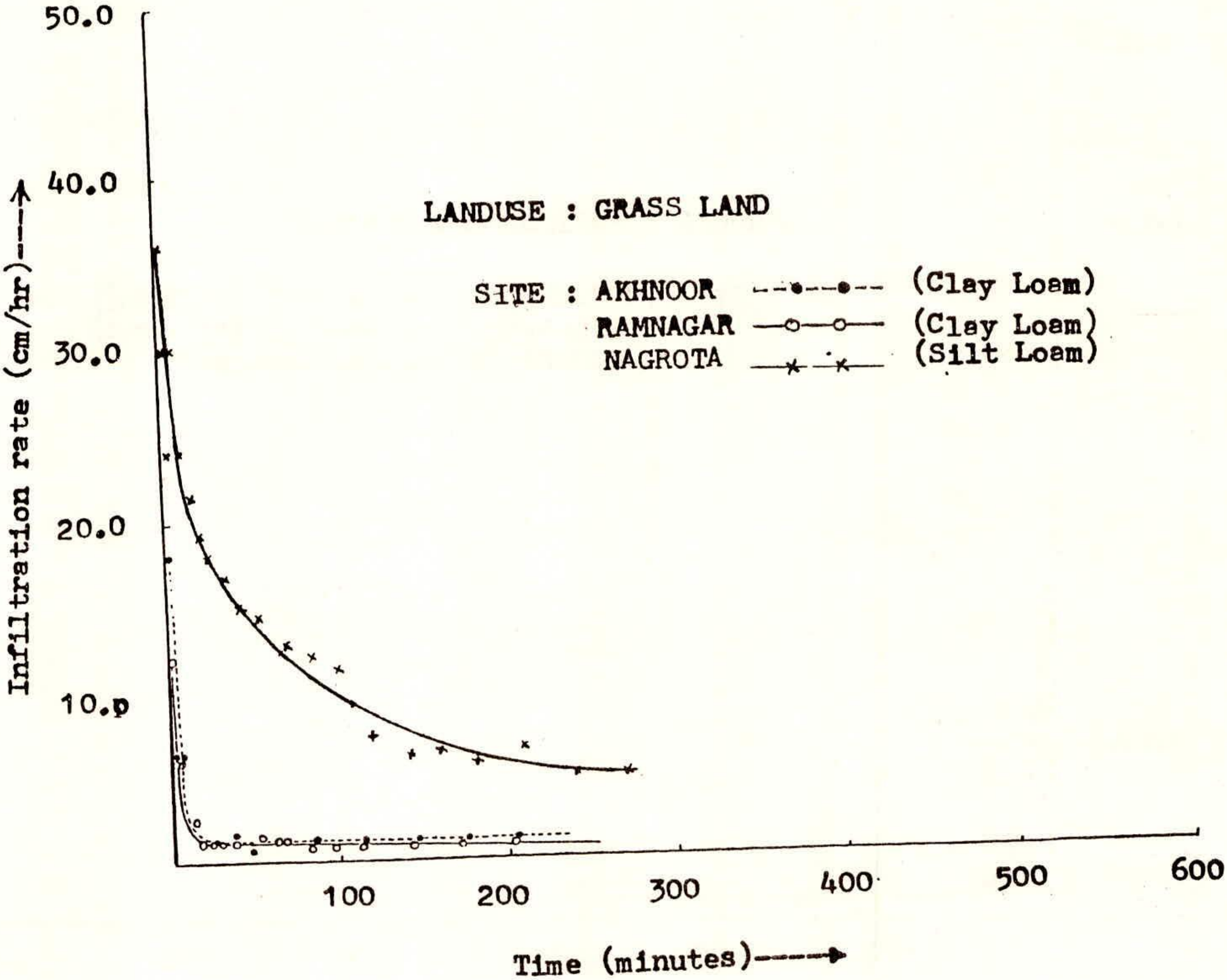



Fig. 6 (a) : Infiltration Curves for Grass lands

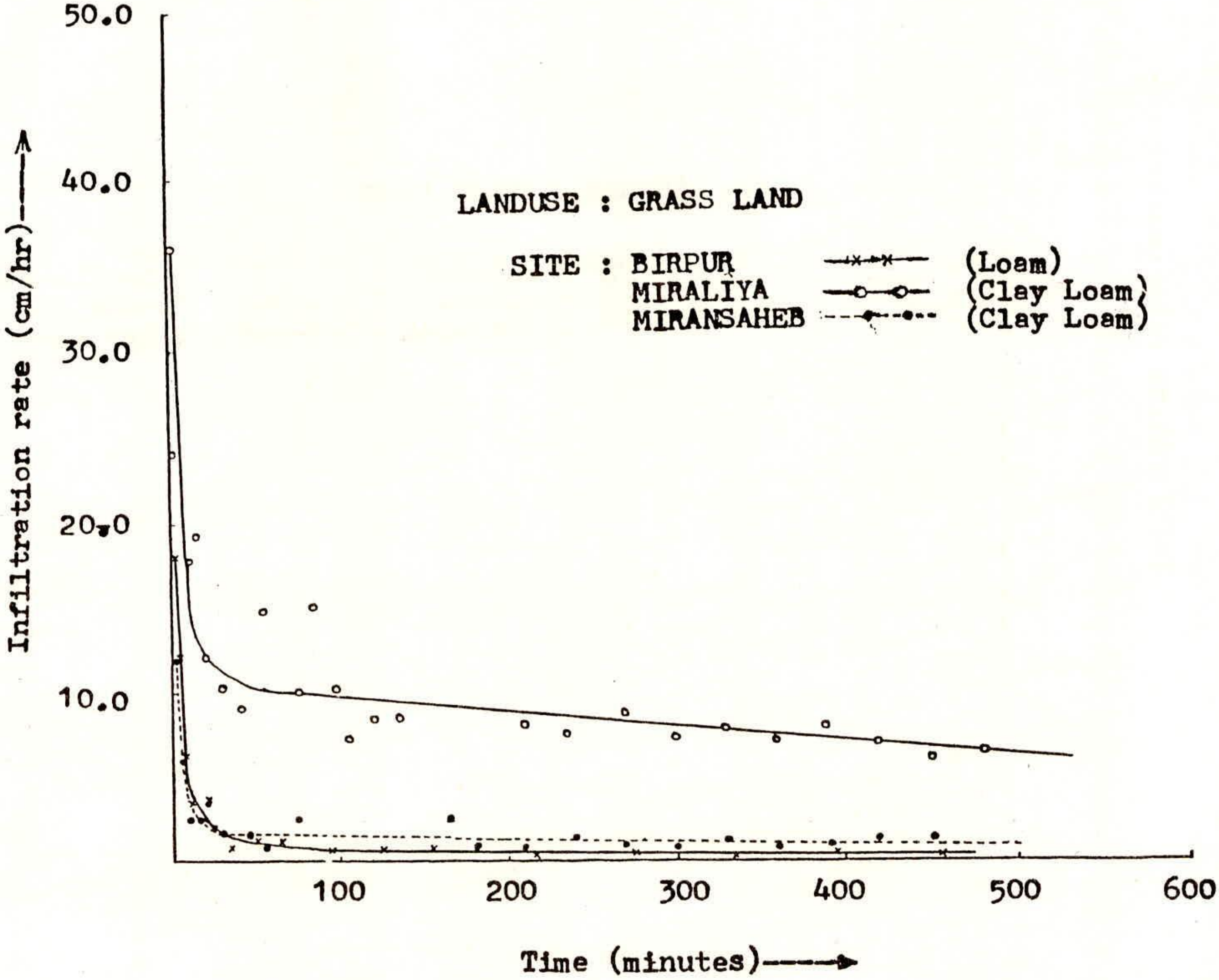



Fig. 6(b) : Infiltration Curves for Grass lands

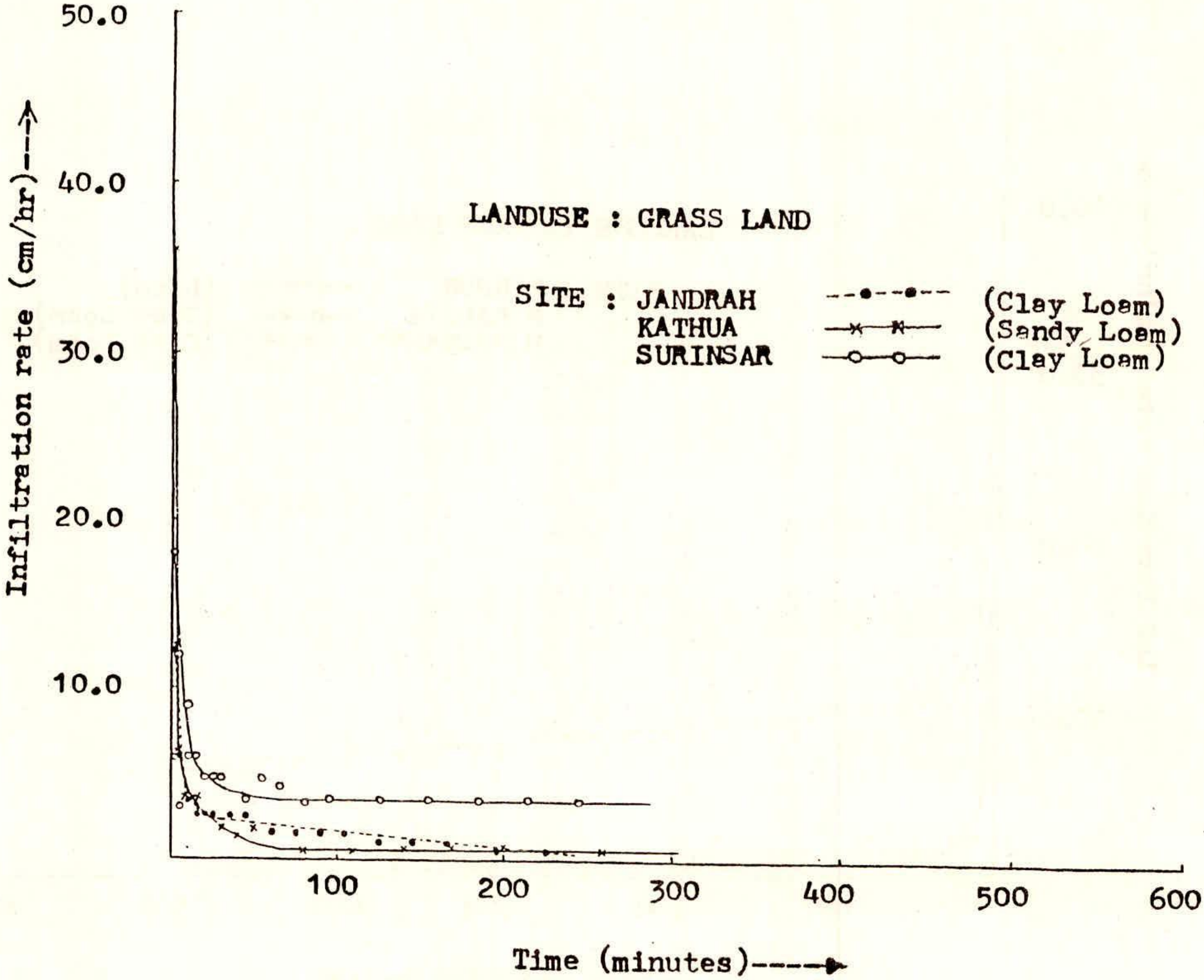



Fig. 6(c) : Infiltration Curves for Grass lands

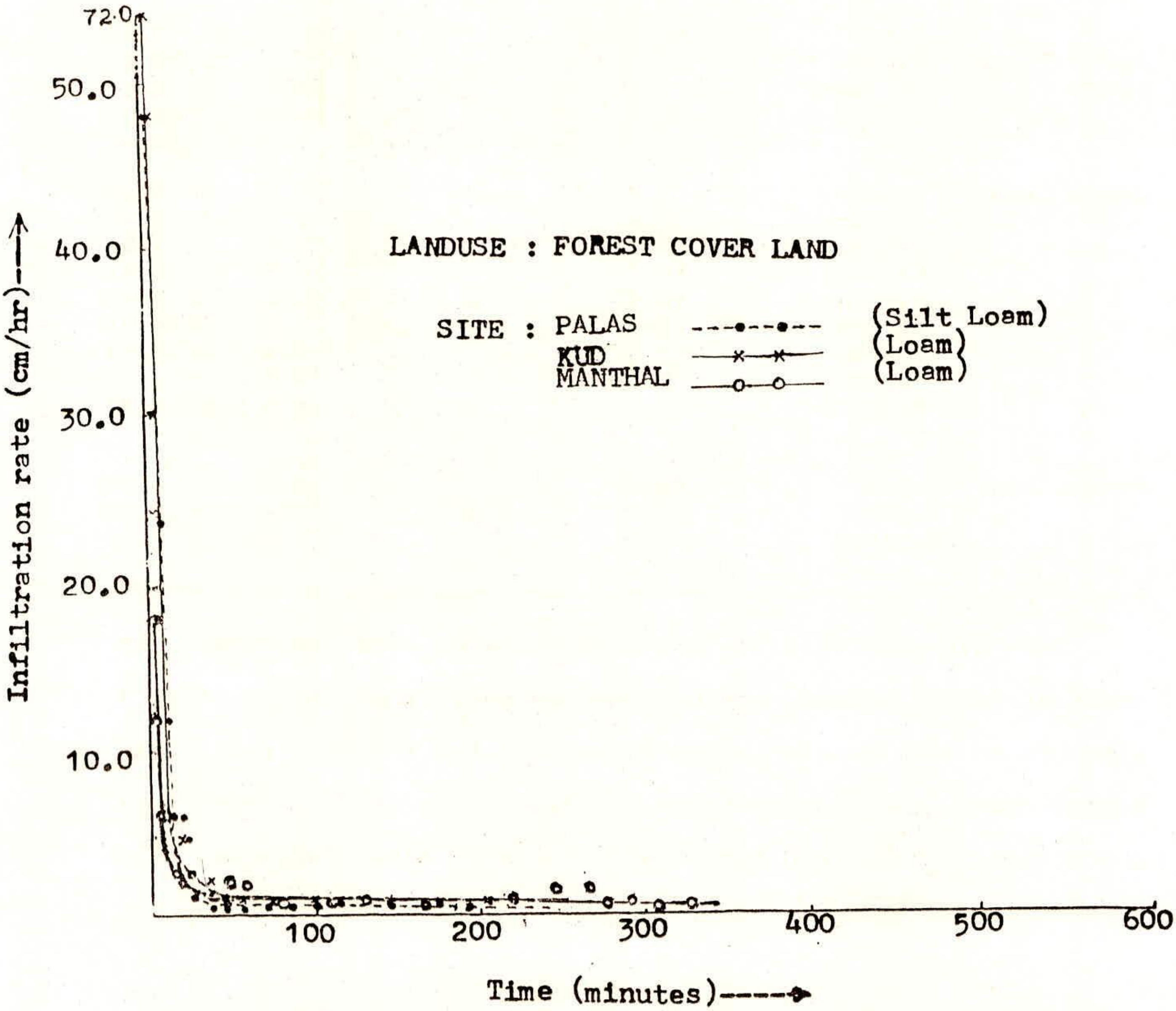



Fig. 7 : Infiltration Curves for Forest Covers

| | | | | | |
|---|---|---|---|---|---|
| Agriculture Land | Rui | 18.0 | | 0.3 | 31.10.92 |
| | Palas | 24.0 | | 1.2 | 10.04.93 |
| | Billawar | 17.0 | 21.0 | 1.2 | 10.04.93 |
| | Domana | 22.0 | | 3.0 | 07.04.93 |
| Grass Land | Akhnoor | 18.0 | | 1.2 | 07.4.93 |
| | Birpur | 18.0 | | 0.3 | 23.9.92 |
| | Jandrah | 12.0 | | 0.9 | 03.3.93 |
| | Kathua | 36.0 | | 0.6 | 31.10.92 |
| | Miraliya | 36.0 | 22.0 | 6.3 | 20.9.92 |
| | Miransaheb | 12.0 | | 0.7 | 20.9.92 |
| | Ramnagar | 12.0 | | 0.8 | 02.4.93 |
| | Surinsar | 18.0 | | 3.6 | 28.9.92 |
| | Nagrota | 36.0 | | 5.0 | 02.4.93 |
| Forest Land | Palas | 48.0 | | 0.7 | 10.4.93 |
| | Kud | 72.0 | 46.0 | 1.2 | 04.5.93 |
| | Manthal | 18.0 | | 0.6 | 30.9.92 |

The average initial infiltration rates were decreased in order of forest, grass, agriculture and bare lands .Annon (1962) also found infiltration rates highest in the forest lands than grass, bare and agricultural soils. Wood (1977), Mistry & chatterjee (1965) and Mathur et al. (1982) also supported the present study.

## 6.2 Infiltration Rates in Different Soils:

The infiltration curves of different soils for Jammu region were also developed (Fig.8a to 11). The initial and final infiltration capacities for clay loam, sandy loam, silt loam and loam soils are given in Table 3. The initial infiltration capacities varied from 12.0 to 42.0, 18.0 to 36.0 ,12.0 to 36.0 and 18.0 to 72.0 cm/hr for clay loam, sandy loam , silt loam and

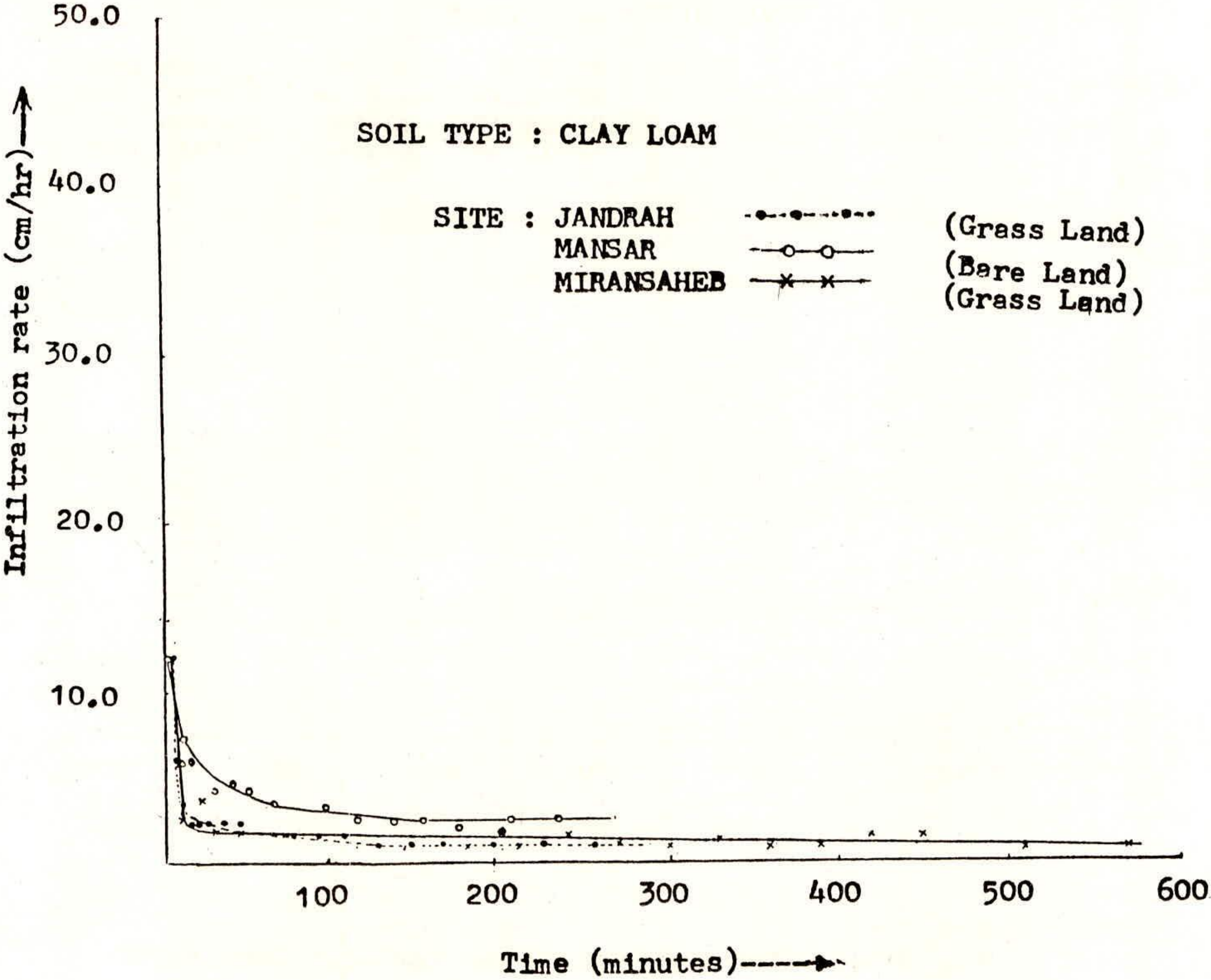



Fig. 8(a) : Infiltration Curves for Clay Loam Soils

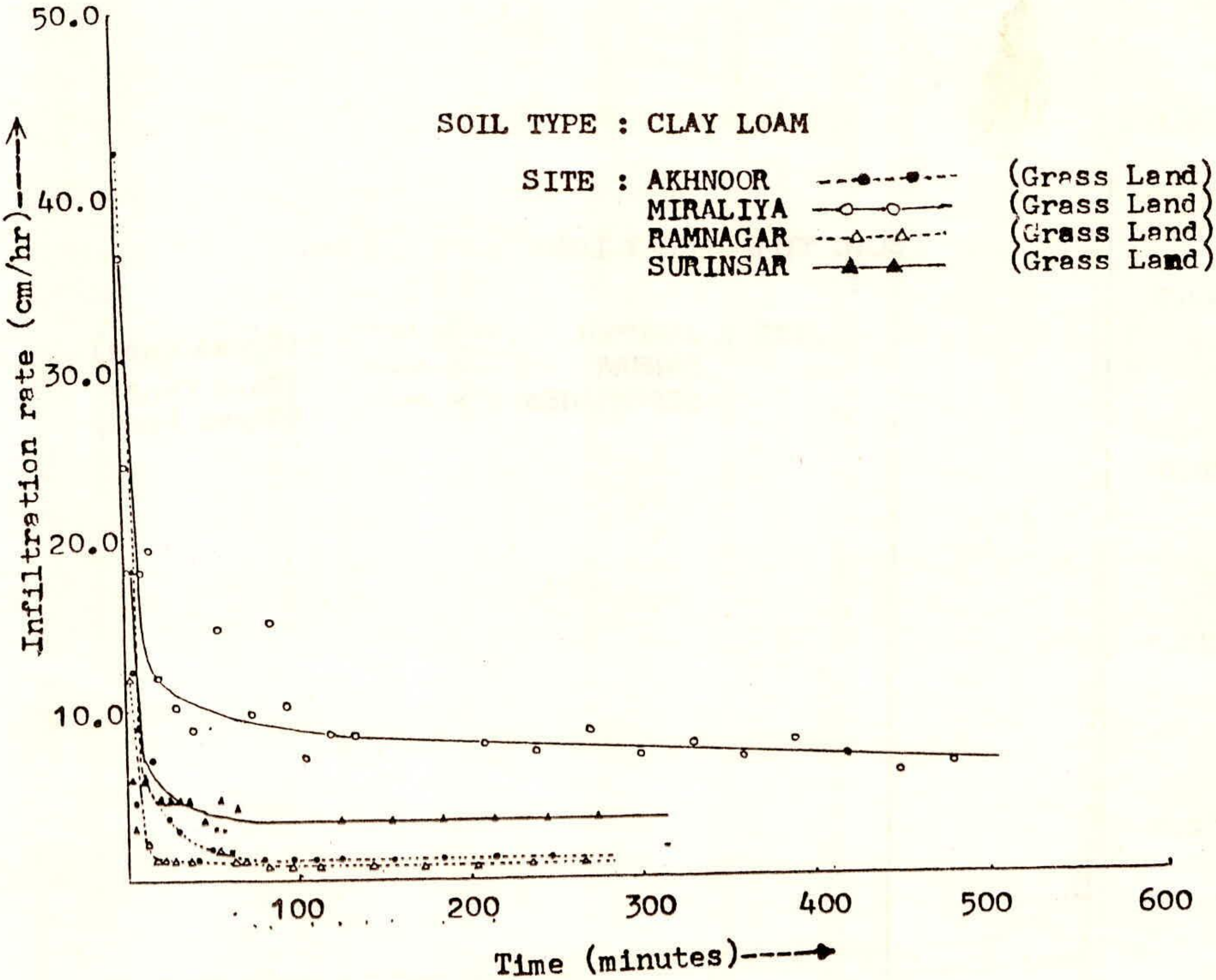



Fig. 8(b) : Infiltration Curves for Clay Loam Soils.

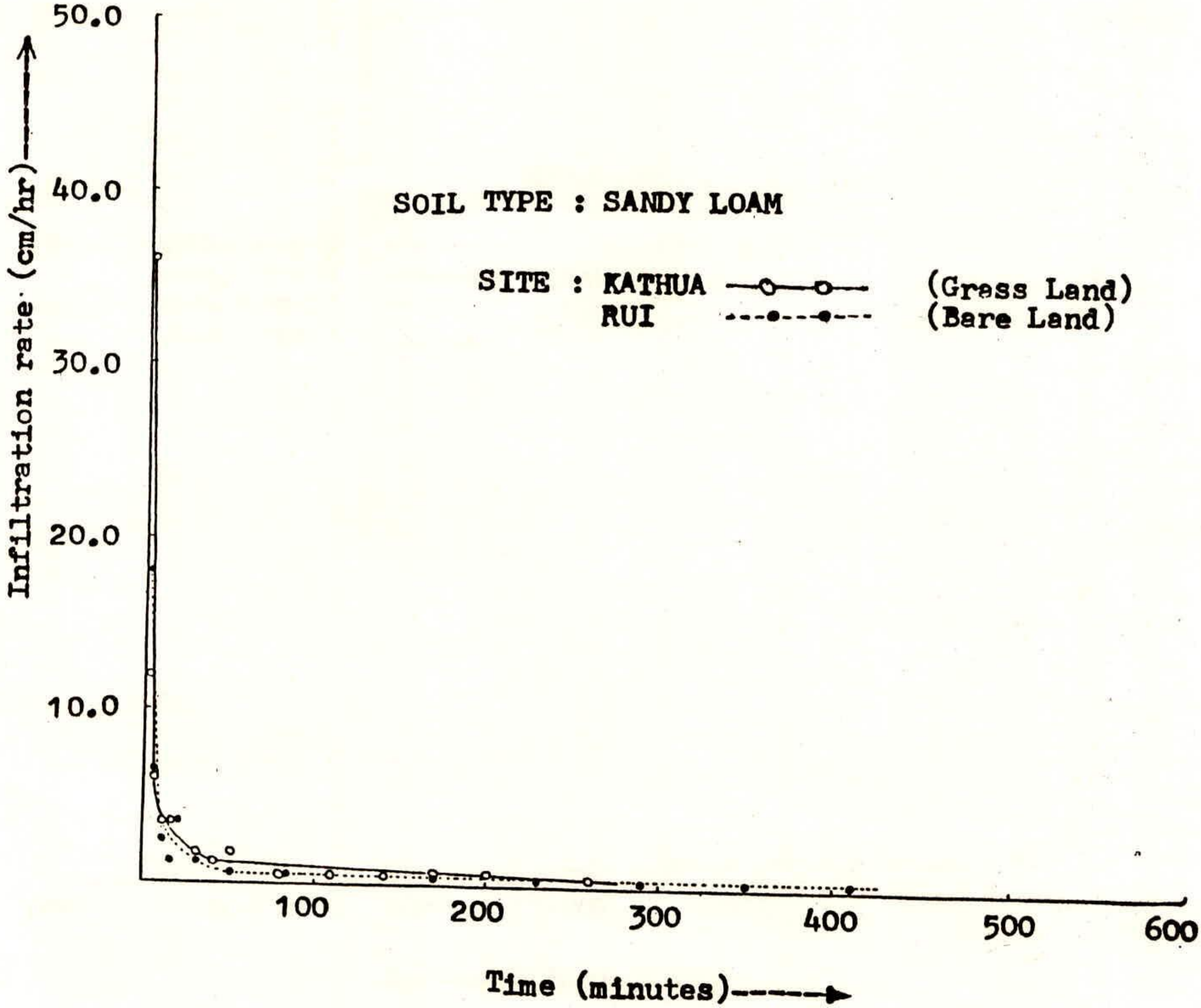



Fig. 9 : Infiltration Curves for Sandy Loam Soils.

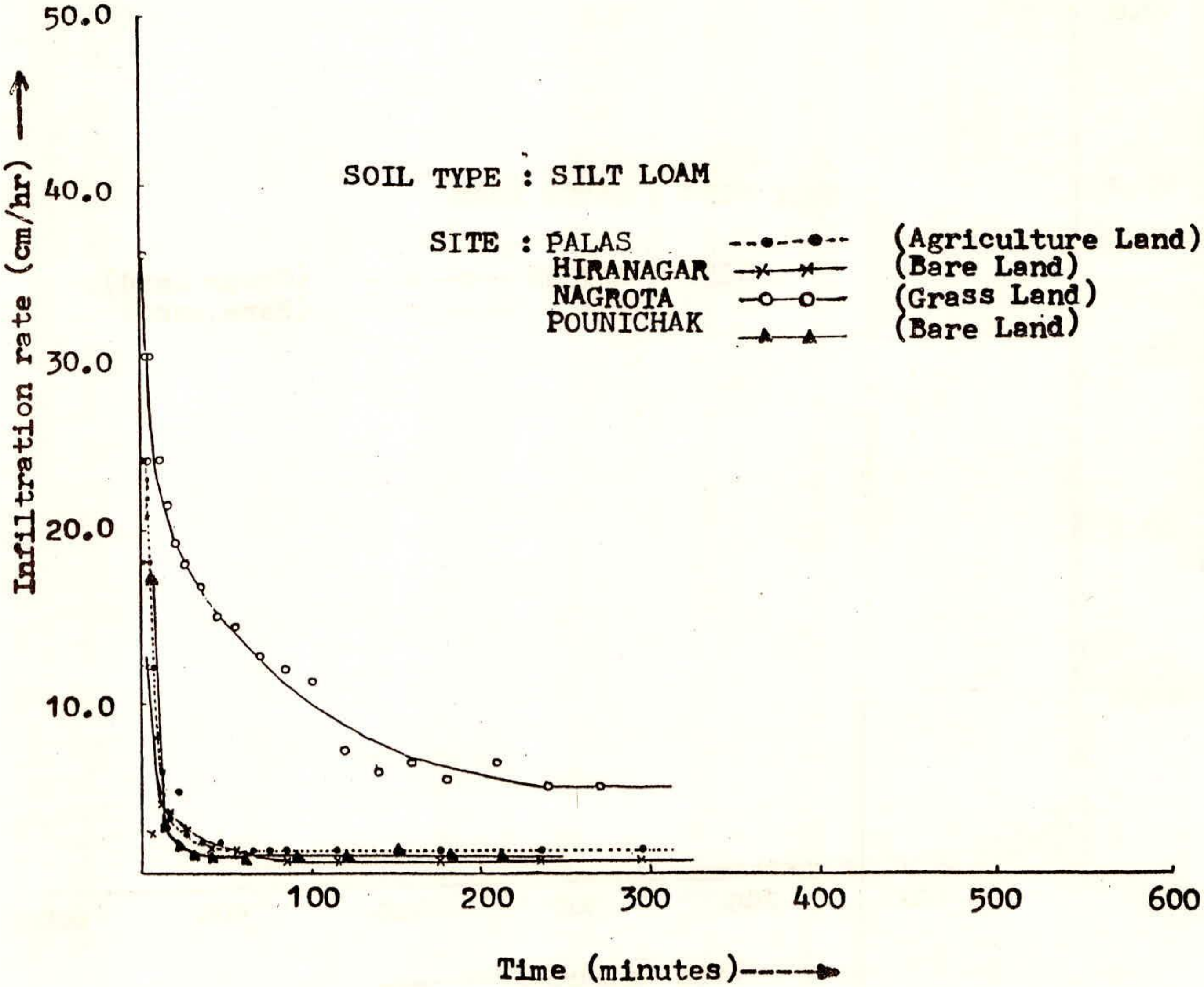



**Fig. 10 : Infiltration Curves for Silt Loam Soils.**

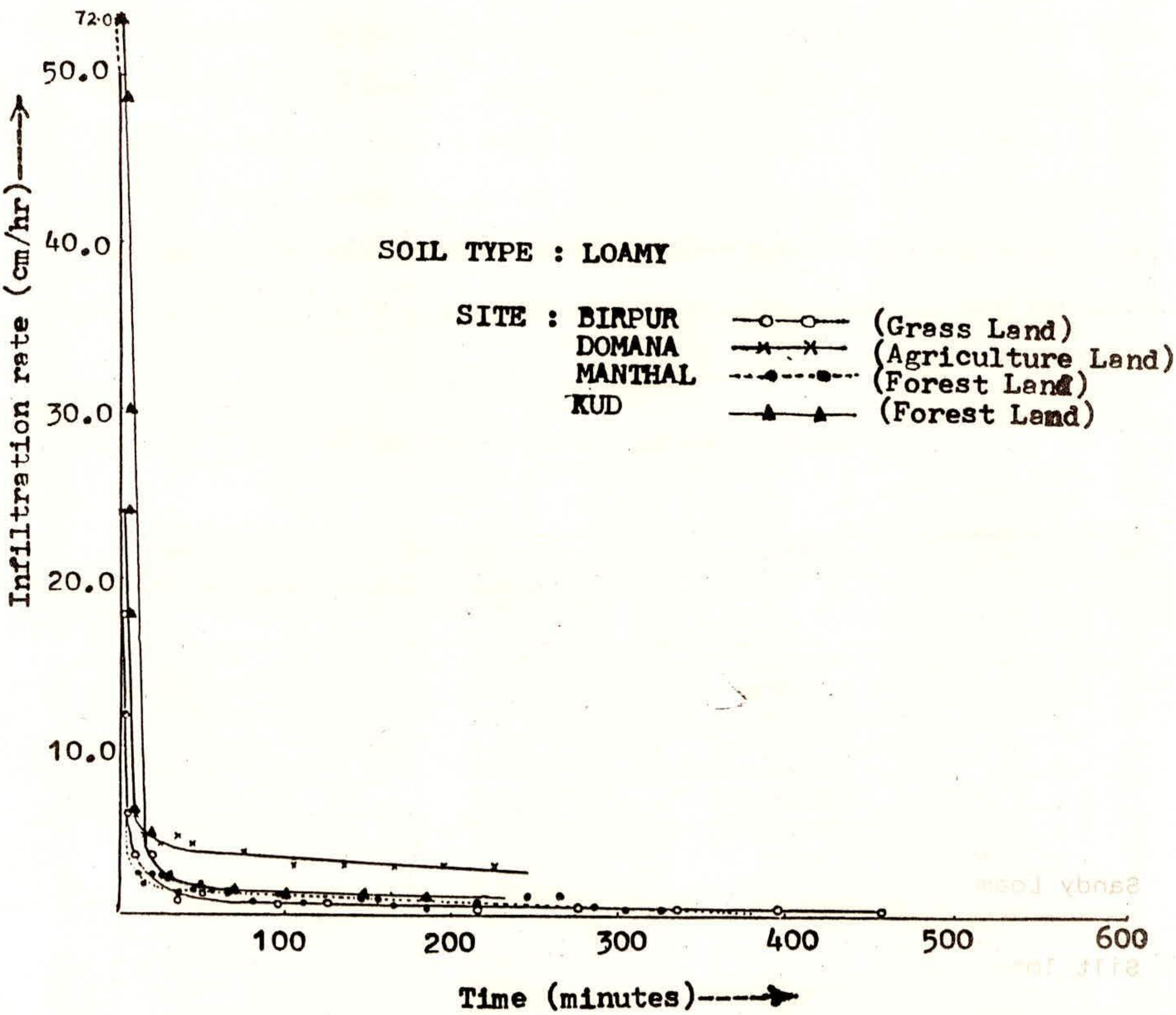



**Fig. 11 : Infiltration Curves for Loamy Soils.**

loam soils respectively. It may also be inferenced that the average initial infiltration capacity was highest for sandy loam soils under study. Raganna et al. (1991) also found highest constant infiltration rates in sandy soils. However, loam soil at Kud has resulted highest initial infiltration rate which may be obtained due to impact of forest on soils.

Table-3

Infiltration Rates in Different Soils

| Soils | Site | Infiltration Rates ( cm/hr) | |
|---|---|---|---|
| | | Initial | Final |
| Clay Loam | Akhnoor | 42.0 | 1.20 |
| | Jandrah | 12.0 | 0.90 |
| | Mansar | 12.0 | 2.40 |
| | Miraliya | 36.0 | 6.25 |
| | Miransaheb | 12.0 | 0.70 |
| | Ramnagar | 12.0 | 0.70 |
| | Surinsar | 18.0 | 0.30 |
| Sandy Loam | Kathua | 36.0 | 0.60 |
| | Rui | 18.0 | 0.30 |
| Silt loam | Palas | 24.0 | 1.20 |
| | Hiranagar | 12.0 | 0.60 |
| | Nagrota | 36.0 | 5.00 |
| | Pounichak | 17.0 | 0.70 |
| Loam | Birpur | 18.0 | 0.30 |
| | Domana | 22.0 | 3.00 |
| | Manthal | 18.0 | 0.60 |
| | Kud | 72.0 | 1.20 |

## 6.3 Relationships between Cumulative Infiltration(cm) and Elapsed Time(min) :

The relationships between cumulative depth of infiltered water (dependent variable) and elapsed time (independent variable) were developed for Kostiakov (1932) type infiltration function( $Y = a t^b$ ).The unknown coefficients a and b were obtained using multiple linear regression program MULTI.FOR after transforming the function into the linear form through logarithmic transformation. The results were presented in the form of linear equation log Y = b logt + log a (Table-4). It is evident from the table that the correlation coefficients were varied from 0.98 to 0.99, 0.97 to 0.99, 0.95 to 0.99 and 0.96 to 0.99 for bare, agriculture, grass and forest lands respectively.

Table-4

Regression Equations with Correlation coefficients for Different Sites

Regression Equation, $y = a t^b$, or
$\log y = b \log t + \log a$

| S.No. | Site | Landuse | Equations | Correlation Coefficients |
|---|---|---|---|---|
| 1 | Hiranagar | Bare | logy=0.60logt-1.61 | 0.98 |
| 2 | Mansar | -do- | logy=0.75logt-1.52 | 0.99 |
| 3 | Pounichak | -do- | logy=0.43logt-0.39 | 0.99 |
| 4 | Rui | -do- | logy=0.37logt-0.92 | 0.99 |
| 5 | Palas | Agriculture | logy=0.52logt-0.68 | 0.97 |
| 6 | Billawar | -do- | logy=0.54logt-1.12 | 0.99 |
| 7 | Domana | -do- | logy=0.63logt-0.82 | 0.99 |
| 8 | Akhnoor | Grassland | logy=0.33logt-0.86 | 0.95 |

| | | | | |
|---|---|---|---|---|
| 9 | Birpur | -do- | logy=0.44logt-0.79 | 0.99 |
| 10 | Jandrah | -do- | logy=0.63logt-1.59 | 0.99 |
| 11 | Kathua | -do- | logy=0.35logt-0.42 | 0.99 |
| 12 | Miraliya | -do- | logy=0.76logt-0.46 | 0.99 |
| 13 | Miransaheb | -do- | logy=0.61logt-1.58 | 0.99 |
| 14 | Ramnagar | -do- | logy=0.50logt-1.28 | 0.99 |
| 15 | Surinsar | -do- | logy=0.76logt-1.48 | 0.99 |
| 16 | Nagrota | -do- | logy=0.76logt-0.33 | 0.99 |
| 17 | Palas | Forest | logy=0.31logt-0.04 | 0.99 |
| 18 | Kud | -do- | logy=0.33logt+0.56 | 0.96 |
| 19 | Manthal | -do- | logy=0.46logt-0.88 | 0.99 |

## 7.0 CONCLUDING REMARKS

The field tests were carried out for Jammu region in the state of Jammu and Kashmir using double ring cylinder infiltrometer . It is a part of infiltration study being undertaken by the National Institute of Hydrology on national level. The study was conducted for bare,agriculture, grass and forest lands with different soils.

The forest lands have resulted highest infiltration rates than grass, agriculture,and bare lands. The correlation coefficients of linear equation (log y = b log t + log a) were ranged from 0.98 to 0.99, 0.97 to 0.99, 0.95 to 0.99 and 0.96 to 0.99 for bare, agriculture, grass and forest lands respectively. It may also be concluded that the initial average infiltration rates for forest lands were about two and three times more than grass/agriculture and bare lands respectively. moreover, the impact of forest on infiltration characteristics may also be well recognised from field experiments conducted at Palas in forest and agriculture lands. The initial infiltration rates were recorded 24.0 and 48.0 cm/hr for agriculture and forest lands at Palas respectively.

The initial infiltration rates for clay loam, sandy loam, silt loam and loam soils under study were recorded 12.0 to 42.0, 18.0 to 36.0 , 12.0 to 36.0 and 18.0 to 72.0 cm/hr respectively. The average initial infiltration capacity was highest for sandy loam soils under study. However, the impact of forest cover on infiltration characteristics of soils can also be seen from field experiments conducted at Kud where loam soil resulted highest initial infiltration rate. Therefore, it may be concluded that the landuse is a major factor which affects infiltration rates extensively.

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