WATER INTAKE CHARACTERISTICS OF SOILS IN SOME SELECTED MECHANIZED FARMS IN NIGER STATE

BY

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(88/1039)

SEPTEMBER 1995

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY
FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA
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DEPARTMENT OF AGRICULTURAL ENGINEERING

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A PROJECT REPORT

ON

WATER INTAKE CHARACTERISTICS OF SOILS IN SOME SELECTED MECHANIZED FARMS IN NIGER STATE, NIGERIA

BY

BAMBE CHARLES MOBOLAJI

Submitted in partial fulfilment of the requirements

for the Award of the degree of

Bachelor of Engineering (Agricultural Engineering)

C E R T I F I C A T I O N

This project on the "Water in take characteristics of soils in some selected mechanized farms in Niger State" has been read and approved as meeting the requirement of the Department of Agricultural Engineering in the School of Engineering and Engineering Technology, Federal University of Technology, Minna, Nigeria. For Bachelor of Engineering (B.ENG. HONS.) Degree in Agricultural Engineering.

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DEDICATION

To the Glory of God and to my parents Chief F. A. Bambe Mrs. T. E. Bambe for this Asset given to me.

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I would have loved to mention the names of everybody that has contributed to my academic success but time and space will not permit me.

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ABSTRACT

This project report presents the water intake characteristics of soils in some Selected Mechanized farms in Niger State.

The selected farms are the National Cereals Research (NCRI) Baddeggi, Guinness Farms Nigeria P.L.C., Kudu and N.Y.S.C. Farms Garatu. The Gravimetricand infiltration test was performed on three different condition of the soil. That is tilled, untilled and compacted Double ring infiltrometer was used to study the infiltration characteristics of the soil at the selected farms and Horton's equation was adopted for the data analysis.

From the analysis of data obtained, the soil characteristics constant K was obtained. Taking the tilled plot of N.C.R.I. farms Baddeggi, Guinness farms and N.Y.S.C. farms for instance, K is 3.50, K is 1.35 and K is 1.33 for N.C.R.I., Guinness and N.Y.S.C. farms respectively.

Also. the study indicated that the soil intake characteristic equation can be expressed for each of the selected farm taking the tilled conditions of soil as an example, f is $6.0 + 145.8e^{-1.3.5t}$, $f = 2.76 + 62.4e^{-1.35t}$ and f is $0.6 + 22e^{-1.33t}$.

These are the infiltration rate equations for N.C.R.I., Guinness and N.Y.S.C. farms. For the cummulative infiltration Depth Equation of the tilled soil of the farms, F is $6.0t + 41.6 [1 \quad e^{-3.50t}]$, F is $2.76 + 46.2 [1 - e^{-1.35t}]$ and F is $0.6t - 16.5 [1 - e^{-1.33t}]$ for N.C.R.I., Guinness and N.Y.S.C. farms respectively.

This study enables the comparison of the parameters obtained from the tilled conditions of three locations and the results will guide the company (farms) in designing a good and workable irrigation system in the future.

The equations derived for all conditions in these site is used [illegible] efficient irrigation design considering the tilled

CHAPTER 1

1.0 INTRODUCTION

1.1 Introductory Note

This study is aimed at evaluating the water intake characteristics of soils of the mechanized farm land of some selected farms in Niger State. The National Cereals Research Institute Baddeggi, Guinness Farms Nigeria P.L.C., Kudu and the National Youth Service Corp Farm, Garatu were selected for this study.

The study involve the performance of tests and analysis of results of three selected plots of the major project area in the farm. For a better insight into this study the following essential parameters are briefly described using the following terminologies.

Infiltration rate - It is the flux of water passing into the soil profile

Infiltration capacity -This is the maximum flux that can pass into the soil profile at a given time.

If the water supply rate (rainfall or irrigation) is less or equal to infiltration capacity, the infiltration rate is equal supply rate.

The following parameters were determined to evaluate the intake characteristics of soil:

i) Infiltration rate of the soil.

ii) Infiltration capacity of the soil

iii) Accummulated infiltration accummulative infiltration depth)

The infiltration characteristic curves such as Intake rate versus time relationship, accummulated infiltration depth versus time relationship were plotted to see the graphical relationship of the parameters required in evaluating intake characteristic of soils.

The intake or infiltration characteristics of the soil, is one of the dominant variables influencing irrigation and its knowledge is necessary for overall soil and water management. It is also useful to estimate catchment run-off models.

From the above parameters, accummulated infiltration or infiltration depth means the total quantity of water

1.2 OBJECTIVES OF THE STUDY

i) To study the intake characteristics of the soil at selected farm viz Plot of the experimental site at Baddeggi, Guinness farms, Kudu and N.Y.S.C. farms Garatu.

ii) To develop intake characteristic equations for the soils under conditions of ploughed, soil, uncultivated soils and compacted soils using the Horton's equation.

iii) To develop intake characteristic equation for the design of a workable irrigation system.

1.3 JUSTIFICATION OF THE PROJECT

The reasons for conducting this study are as follows:

i) Infiltration rate is usually been intensively studied for its undoubted importance in irrigation layout and design. Also, it is an important parameter to be given the best possible estimate in catchment run-off models.

ii) Infiltration is important for water to be conserved in the soil and for water to be made available to the plants.

If the infiltration rate is high, less water will run over the soil surface and erosion will be less in such a situation.

iii) Infiltration is the main source of soil moisture which sustains the growth of vegetation and the ground water supply of wells, springs and streams.

iv) The infiltration characteristic is necessary for soiland water conservation.

With specific regards to my project work, this study enables the comparison of the parameters obtained from the three locations and the results will guide the Company/Farms in designing a good and workable irrigation system in the future.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introductory Note

Infiltration datas are commonly expressed graphically with the rate as the ordinate and time as the abscissa Figure (2.1) represents a typical infiltration curve. Here, as usual, the potential infiltration capacity initially exceeds the rate of water application.

However, as the soil pores are filled with water and surface seal takes place, the rate of water intake gradually decreases. It then normally approaches a constant value which may be taken as the infiltration rate of soil.

2.1.1 THE HORTON'S EQUATION (1940)

Horton proposed an entirely empirical infiltration equation to represent the generally observed decrease of infiltration rate with time, tending to a steady - state value of water supply rate in excess of infiltration capacity.

Infiltration rate $f = fc + (fo - fc)e^{-kt}$ - 2.1 where fo is the initial infiltration rate.

fc is the steady state infiltration rate

k is a soil characteristic

t is time

fc is generally identified with constant of saturation (k sat) This method has been widely used by hydrologists but in practice the equation tends to under estimate the usually very rapid initial decrease of infiltration rate with time.

Although, generally accepted as an empirical equation. Eagleson (1970) shows that the equations are equivalent to the theoretical solution to horizontal infiltration. Equation (2.1) has three parameters fc, fo and k. While k is proposed as a soil characteristic and fc is equivalent to the saturated hydraulic conductivity while fo depends on the initial soil

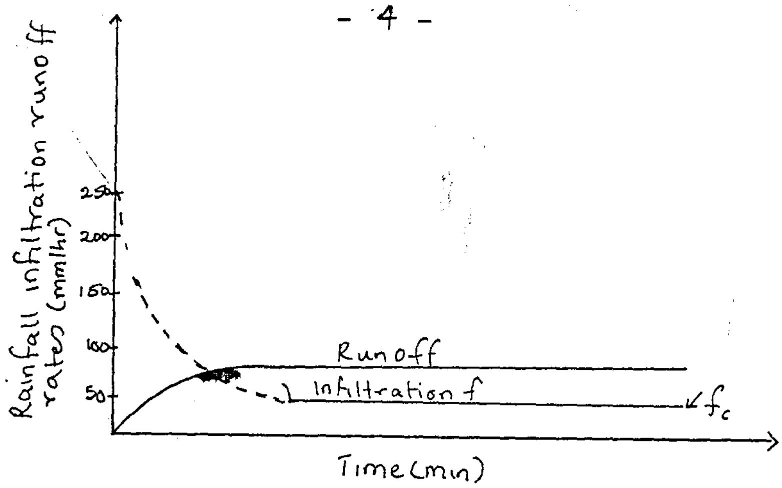

Fig 2.1 Typical Infiltration and runoff curves developed from Infiltrometer data.

In fig 2.1 the infiltration capacity did not drop to equal the ponding rate until several minutes after the take off of the infiltration. During this initial time period the infiltration rate was equal to ponding rate and less than the infiltration capacity.

Infiltration rate in the field usually shows a steep decline with time from the start of the application of water, particularly if water is ponded on the soil surface.

Horton (1940) suggested that the equation 2.1 represents the infiltration rate reasonably well, where fc, the final infiltration rate as t $\rightarrow \infty$ can usually be identified with Ko, the saturated hydraulic conductivity. The initial infiltration rate fo can be very large at the moment of first application of water in the infiltration test. The actual value used in equation (2.1) depends on the time interval that is used to get measurement of fo and rarely can it be less than one minute.

The actual rate of fall of infiltration is usually faster than exponential (Horton's 1940).

Difficulties may arise in giving a suitable value to the constant K, which has no physical meaning.

An example of an infiltration curve is shown in Fig.2.2 together with a sketch of a Horton type curve. In this example the observed infiltration rate declines faster than exponential

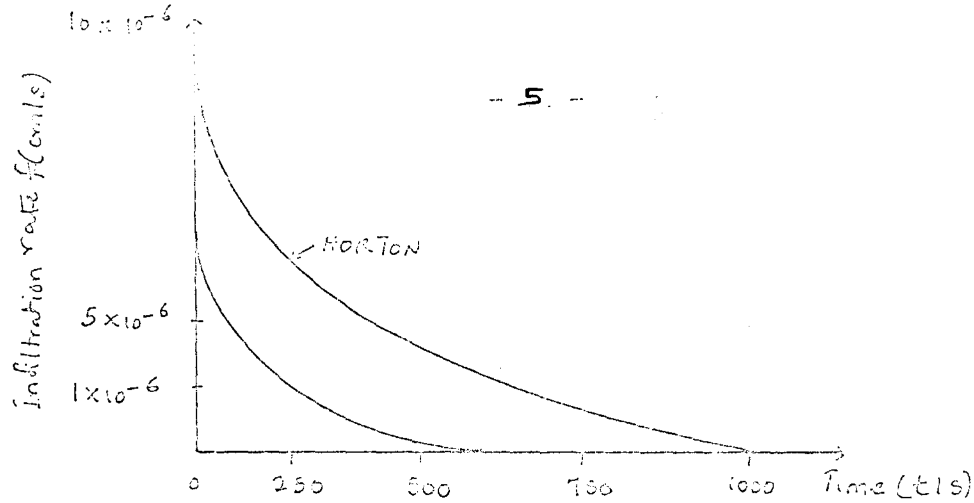

Fig 2.2a Infiltration rate as a function of time

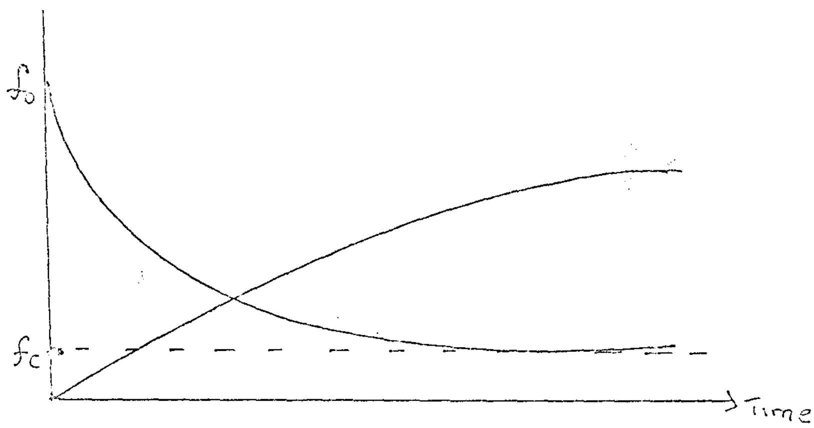

Fig 2.2b Infiltration rate and cummulative depth as a function of time

2.1.2 GREEN AND AMPTS (1911)

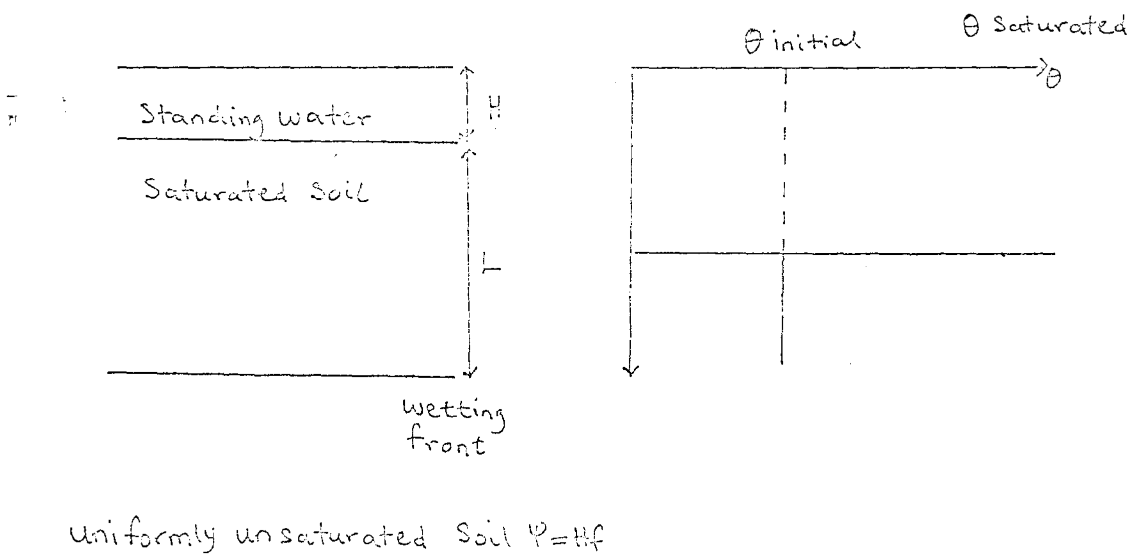

Fig 2.3 The downward movement of, water into the soil according to the concept of a capillary 'pull' at wetting front (After Green and Ampt 1911)

/. ......

From Darcy

Volume flow rate $Q = Ksat \frac{(Ho + L) - Hf}{L}$ (Unit Area) - 2.2

from continuity principle, as no storage is available in the saturated column the transmission rate through out the profile is Q

Q = rate of surface infiltration (i)

i.e. $Q = A + \frac{B}{L} = i$

Where A = Ksat B = Ksat (Ho - Hf)

If f is the difference in porosity across the front

(θ sat - θ initial)

$Q = \Delta f \cdot \frac{\partial L}{\partial t} = + \frac{B}{L}$

Integrating $\frac{t}{\Delta f} = \left(L - \frac{B}{A} \ln \frac{(LA + B)}{\frac{B}{A}} \right)$ - - - - 2.3

But Q = L   r = total volume of infiltrated water

.. $t = EQ - c \ln \left(1 + \frac{Q}{\frac{c}{A}}\right)$

Where $c = \frac{B \Delta f}{A}$

A = Ksat B = Ksat (Ho - Hf)

The method assumes a simplified wetting profile with a sharp division between uniformly saturated soil. This is not the case in practice but there are some experimental work to indicate that the equation performs well for coarse - grained soil.

2.1.3 KOSTIAKOV AND LEWIS:

Kostiakov and Lewis (1937) independently suggested the equation

$I = Kt^n$

for estimating infiltration rate .... (2.4)

where I is the infiltration rate (mm/hr)

t is the infiltration time (hr)

k and n are constants for a particular soil and condition, n has negative sign by integrating (2.2) with respect to time, the depth (F) of water that would have infiltrated into the soil up to that time is obtained

$$F = I \,\&\, T$$

$$= Kt^{n} \,\&\, T$$

$$= \frac{K}{n+1}\, t^{n+1} \quad \ldots \quad \ldots. \quad \ldots.. \quad (2.5)$$

That is, the cummulative infiltration F is the accummulated depth of water infiltrated during a given time period and is equal to the integral of the infiltration rate over the period

$$F(t) = \int_0^t f(t)\,dt \quad \ldots. \quad \ldots \quad \ldots. \quad (2.6)$$

and conversely, the infiltration rate is the time derivative of the cummulative infiltration

$$f(t) = \frac{dF(t)}{dt}$$

Infiltration [illegible] by the differential equation ([illegible] 1952)

From Darcy $$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left(K \frac{\partial \phi}{\partial z}\right) + \frac{\partial}{\partial z}(Kg) \quad \ldots. \quad (2.7)$$

Volume flow r the moisture content in volume of water per unit volume of soil

k = the unsaturated hydraulic conductivity (LT^{-1})

Ø = the capillary potential (L)

g = gravitational constant (LT^{-2})

Z = the co-ordinate in the vertical direction (L)

A general analytical solution to equation above cannot be obtained because both K and Ø are functions of θ. Graphical solutions have been made and numerical solutions are practical with computer.

Where S is the sorptivity of the soil

K is a constant

Then the instantaneous infiltration rate is

$$f = {}^{dF}/dt = \tfrac{1}{2}\, St^{-\frac{1}{2}} + K \ldots\ldots \quad \ldots \quad (2.8)$$

From which it can be seen that f becomes steady and equal to K [illegible] long enough for the first term to become negligible.

sorptivity is an important parameter in the description of both cummulative infiltration and the instantaneous infiltration rate. It is not a constant but becomes smaller as the initial water content (pressumed uniform) increases. Talsma (1969) worked out the optimum conditions for deriving s from data gained in the field from the standard ring - Infiltrometer. As equation (2,4) shows, I should plot on a straight line against $\sqrt{t}$, soon after the start of the experiment and before the processes represented by the second term contribute significantly for many soils the straight line plot of I vs t ½ is limited to three minutes and up to 10 minutes. Sometimes, after the first application of the water clothier and white (1986) applied the water to the surface through a porous plate, with hydrostatic pressure regulation, so that the matric potential at the soil surface is about -0,04m .

Slight suction is sufficient to drain gross fissures and holes and markedly improves the estimate of s, particularly when it is to be used in calculations involving rain-fed infiltration. They isolate a short soil column by sculpturing it and enclosed it with a sorptivity tube, mode of clear perspex so that the wetting front could be seen.

In sprinkler infiltrometers, excess water is sprayed or dripped onto the soilat a measured rate and the runoff from a central test plot within the sprayed area is collected and measured. The surrounding guard area is effective in preventing error from lateral movement.

Natural rainfall can be used as the source of supply when surface runoff and precipitation data are available for rain storms of sufficient intensity and duration. Zegelin and White (1982) described the design of a field sprinkler.

Infiltrometer, intended for use in constant flux experiments for a range of values of fo both smaller and larger than ko. They were able to verify that the expression for the time of incipient ponding, if fo>Ko; was calculated acceptably by the relation

$$tp = S^2/2\ fo\ (fo - ko)\ \ldots\ \ldots\ \ldots\ (2.9)$$

Where t_p = time of incipient ponding (sec)

S = sorptivity

f_o = Infiltration capacity at the onset of infiltration

k_o = Initial constant at f_o.

2.1.4 THE PHILIPS EQUATION

Philip (1954) developed a theoretical solution for one dimensional vertical infiltration into a soil profile surface moisture content of θ_o

$$Q = At^{\frac{1}{2}} + Bt + Ct^{\frac{3}{2}} + Dt^{2} \; .... \qquad (2.10)$$

Where the constants A,B,C etc. are functions of the soil properties D(θ), K(θ) and the initial and boundary conditions θ, θo.

The first term ($At^{\frac{1}{2}}$) represents the effect of suction (i.e. horizontal infiltration) and the remaining terms are effectively correction term to account for gravity (for small t, the first term will predominate.

Philip suggested that if t were not too large the series could be truncated i.e. $Q(t) = At^{\frac{1}{2}} + Bt$. as the constants decrease for the terms with higher powers of t. Then the infiltration rate

$$f = \frac{dQ}{dt} \text{ is given by } f(t) = \tfrac{1}{2} At^{-\frac{1}{2}} + B \quad ....(2.11)$$

Note that as t ---> infinity ( ) f ---> Ksat, which implies that B is equivalent to Ksat. However the approximate form of equation holds for t "not too large" hence the theoretical value of B is different to Ksat.

In practice, the truncated equation is widely used in an empirical manner with A and B empirically determined and B corresponding to Ksat. The equation has 2 parameters compared with the 3 requred by Horton's equation but has a slight problem of an indeterminate f(o). The equations were compared when used on the same run-off model by Dandy and Lichty.

Philip equation was easier to fit but the accuracy and sensitivity of the model were similar for both methods.

/ ....

2.1.5 THE HOLTAN'S EQUATION

The method discussed above have all been derived for continous rainfall input. In practice rainfall is intermittent so that it could be more convienient to consider infiltration as a function of stored soil moisture (This particularly applies to conceptual rainfall - run-off models incorporating a soil moisture storage component)

$$\text{Infiltration } f = A\,(Sa - F)^{1.4} + fc \quad \ldots\ldots\quad (2.12)$$

Where A, fc are constants for a given soil, Sa represents the total available water storage in the soil (saturation ---> permenent wilting point) and F in the accummulated soil moisture.

As infiltration proceeds, F increase and f decreases until F = Sa, when the soil profile is saturated f = fc.

i.e. $Ft = Ft - 1 + (ft - 1\ fc) \quad t$

$$ft = A\,(Sa - Ft)^{1.4} + fc \quad \ldots\ldots\quad \ldots\ldots\ \ldots\quad (2.13)$$

The Holtan's, Philip's and Horton's equations have been widely used in conceptual modelling of the rainfall - runoff process.

However the methods should be recognised as applying to idealised conditions (when theoretically-based) of uniform profile properties uniform initial moisture distributions and one-dimensional flow, or as being empirical simplifications.

2.2 MEASUREMENT OF INFILTRATION

The rate at which water can enter soil when not limited by the rate of supply is measured in the field with water either ponded on the surface or falling on it as artificial or natural rain at a rate sufficient to cause runoff. It is expressed in m/s or some convienient multiple of these units and is called infiltration capacity (Horton, 1940) or infiltrability (Hillel, 1971). It is a potential rate that is characteristic of the soil under specified conditions. In partcular, it varies with time during a test and with initial water content fig. (2.2)

Three methods of estimating infiltration characteristic of soil include:

a) the use of cylinder infiltrometers

b) measurement of subsidence of free water in a large basin and

c) estimating of accummulated infiltration from the water front advance data.

Among these methods the use of cylinder unfiltrometer is most popular and adapted in this study.

The method is described as follows. Infiltration characteristic of soils might be determined by pouring water in a metal cylinder installed on the field surface and observing the rate at which water level is lowered in the cylinder. In the earlier studies only a single cylinder was used and many of the data indicated a high degree of variability.

The variability was mainly due to the uncontroled lateral movement of water from the cylinder after the welting front reached the bottom of the cylinder. After the initiation of infiltration, while the wetting front is in the cylinder, the water subsidence rate corresponds to the infiltration rate. When the wetting front passes below the cylinder, a more or less divergence of flow will occur. The lateral movement of water from cylinder is minimized by ponding water in a guard cylinder of buffer area around which is constructed and used for the study.

Infiltration rate observed by cylinder infiltrometers are influenced by the cylinder diameter, thickness of cylinder, bevelling of the cylinder, bottom the method of driving the cylinder into the soil and the installation depth. The variability of data caused by ring placement could be overcome greatly by leaving the cylinders in place over a long period during a series of measurement.

The cylinder are usually about 25cm - 30cm deep and are formed of 2mm rolled steel. The inner cylinder, from which the infiltration measurement is taken is usually 30cm in diameter.

The outer cylinder, which is used to form a buffer pond is about 60cm in diameter. The cylinders are installed about 10cm deep in the soil. Care is taken to keep the installation depth of the cylinders the same in all experiments.

This can be accomplished by marking the outside and inside of the cylinders at the 10cm level and driving the cylinder into the ground by a falling weight type hammer striking on a wooden plant placed on top of the cylinder or by light blows with an ordinary hammer and using a short wooden plank to prevent damage to the edges of the metal cylinder.

The water level in the inner cylinder is read with the field type point guage or hook guage (sometimes an ordinary plastic scale placed in the inner cylinder or a manometer fixed to the outside of the cylinder are also used, but for accurate work a point guage or hook guage should be used). The point rod is set at the desired level to which water is to be added. Water is added to the inner cylinder from a container of known volume and a graduated jar.

It is added by pouring water on a piece of folded jute malting. The matting is used to preventing puddling and seal of the surface soil. After filling the cylinder to about three-fourth of the desired level the matting is removed.

A stop watch or the second's hand of a wrist watch is used to note the instant the addition of water begin and the time the water reaches the desired level. The total quantity of water added to the inner cylinder is determined by counting the number of full containers.

2.3 FACTORS AFFECTING INFILTRATION RATE

The movement of water into the soil by infiltration may be ...ation to the flow of water through the soil profile. Although such restriction often occurs at the soil surface, it may occur at some point in the lower ranges of the profile. The most important items influencing the rate of infiltration has to do with physical characteristic of the soil line texture and soil particle size.

Thus, the major factors affecting the infiltration of water into the soil are the initial moisture content, condition of the soil surface, hydraulic conductivity of the soil profile, texture, porosity degree of swelling of soil colloids and organic matter, vegetative cover, duration of ponding water, irrigation or rainfall and viscousity of water.

The antecedent soil moisture content had considerable influence on the initial rate and total amount of infiltration, both decreasing as the soil moisture content rises. The infiltration of any soil is limited by any restraint to the flow of water into and through the soil profile. The soil layer with the lowest permeability either at the surface or below it, usually determines the infiltration rate. Infiltration rates are also affected by the porosity of the soil which is changed by cultivation or compaction.

Cultivation influences the infiltation rate by increasing the porosity of the surface soil and breaking up the surface seals. The effects of tillage on infiltration usually lasts only until the soil settles back to its former condition of bulk density because of subsequent irrigation or ponding of water.

Infiltration rates are generally lower in soils of heavy texture than on soils of light texture. The influence of water depth over soil on infiltration rate was investigated by many workers. It has been established by Green and Ampt. Horton's (1940) and Green and Ampt (1911) that in surface irrigation increased depth increases initial infiltration slightly but [illegible] has negligible effect after prolonged irrigation.

Infiltration rates are also influenced by the vegetal cover. Infiltration rates on grass land is substantially higher than bare uncultivated land.

Additions of organic matter increase infiltration rate substantially. The hydraulic conductivity of the soil profile often change during infiltration not only because of the puddling of the surface caused by reorientation of surface particles and washing of finer materials into the soil viscosity of water influences infiltration. The high rate of infiltration in the tropics under otherwise comperable soil conditions is due to the low viscousity of warm water.

2.4 GRAVIMETRIC METHOD OF OBTAINING MOISTURE CONTENT, BULK DENSITY AND POROSITY MOISTURE CONTENT

2.4.1 MOISTURE CONTENT

Soil moisture content shall be determined gravimetrically as described in the method of soil analysis by BLACK (1965) by driving a cylindrical sample core into the soil to entrap soil at different depths of 0 - 15cm, 15 - 30cm and 30 - 45cm for each plot.

The samples are weighed each in the sample can and they are placed in the oven at 105°C for 24 hours. The cans with soils are weighed and the difference in the wet weight to the dry weight of soil is the moisture content of the soil.

The moisture content can be calculated by expressing it as percentage of dry weight is given below (Black 1965).

$$\theta g = \frac{Mw}{ms} \times 100 \qquad \ldots\ldots \quad \ldots\ldots \quad (2.17)$$

Where

θg = gravimetric water content percentage

Mw = Weight of water

Ms = Weight of soil after oven drying.

2.4.2 BULK DENSITY

The soil bulk density was determined from the undistured

... obtained by the Black's method (Black 1965)

The bulk density can be calculated using the expression below:

$$(D.b) = \frac{Ms}{V} \quad \ldots\ldots \quad \ldots \quad \ldots \quad (2.18)$$

$$(B.D) = \frac{M}{V} \quad \ldots \quad \ldots \quad \ldots \quad (2.19)$$

Where

D.b = Dry bulk density in (g/cm^3)

Ms = Weight of oven dried soil (g)

V = Volume of core sampler (cm^3)

B.D = Wet bulk density

M = Total weight of the soil (g)

V = Volume = TIr^2h ... . (2.20)

Where

r = Radius of sample core

h = height of sample core

2.4.3 POROSITY (n)

Porosity is the ratio of the volume of the void to the total volume of the soil. Void comprises of water and air and the total volume of the soil comprise of the volume of Void and that of the soil gram

$$V = Vv + Vs \quad \ldots \quad \ldots \quad \ldots \quad \ldots (2.21)$$

$$n = \frac{Vv}{V} \quad \ldots\ldots \quad \ldots \quad \ldots \quad .. \quad (2.22)$$

But according to (Black 1965), the result obtain from the gravimetric experiment can be adopted as follows:

$$n = (1 - \frac{Db}{B.D.}) \times 100 \quad \ldots\ldots \quad \ldots\ldots \quad \ldots (2.23)$$

Where

n = Total porosity percentage

Db = Dry bulk density ($glcm^3$)

B.D = Wet bulk density (g/cm^3)

2.5 CAUSES AND DETERMINATION OF SOIL COMPACTION

Constant action or movement of agricultural machines and equipments on soil cause a gradual compaction (elastic plastic and yield point). Compaction affects the soil surface and structure. Compaction causes a hard flat layer which has a negative effect on soil.

On compacted soils, it is difficult for water to permeate below the layer there by causing soil erosion or water logging.

Determination of soil compaction

The normal parameters to estimate the degree of soil compaction are maximum pressure of mechanical devices on soil Pk and normal stress Oo.5(--> a depth of 0.5m). To determine the maximum pressure of wheel tractor on the soil the following expression can be used

$$Pw = \frac{K_2}{K_1} \cdot Pw\ Aw \quad \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots\ (2.24)$$

Where PWAV Average pressure of wheel tractor on hard surface, which is determined experimentally:

Pw = Soil compaction

K_2 = Coefficient of longitudunal unequal distribution of pressure on contact surface K_1 = coefficient which depends on external diameter of tires K_1 = D.

$$Pw\ Aw = \frac{Gk}{Ak}$$

Gk = Vertical load on tractor in (KN)

Ak = Area of contact surface of tire with soil in meter square.

Horton's Equation:

In this study Horton's equation (2.1) shall be adopted to evaluate the intake characteristic of soil at the selected mechanised farms in Niger State.

The equation (2.1) is integrated as follows to evaluate the accummulated depth of water infiltrated during a given time period.

$$F = \int_0^t f dt$$

$$= \int_0^t fc + (fo - fc)e^{-kt}\, dt$$

$$= \int_o^t fcdt + \int_o^t (fo - fc)e^{-kt}\, dt$$

$$F = fct + (fo - fc)\left[-\frac{1}{k}e^{-kt}\right]_o^t$$

$$F = fct + \frac{fo - fc}{k}\left[-e^{-kt} + e^{o}\right] \quad \ldots\ldots \ldots \quad (2.25)$$

If $fo - fc = a$

$$F = fct + \frac{a}{k}\left[1 - e^{-kt} + e^{o}\right]$$

$$F = fct + \frac{a}{k}\left[1 - e^{-kt}\right]$$

where

F = Accummulated infiltration

fc = The constant infiltration capacity as t approaches infinity.

fo = Infiltration capacity at the on set of infiltration

k = a positive constant for a given soil and initial condition.

t = time.

In this study to determine the soil characteristic constant k, the Horton's equation (2.1) was transformed to equation of a straight line by taking the logarithum as follows

Horton's equation (2.1)

$$f = fct\ (fo - fc)e^{-kt}$$

to find the log on both sides

$$f = fc + (fo - fc)e^{-kt}$$

$$\text{Log } f = \text{log}fc + \log(fo - fc) + \log e^{-kt}$$

$$\text{Log } f = \log + \log e^{-kt}$$

$$\text{Log } f = \log fo + \log e^{-kt}$$

$$= \log fo - k.t \log e$$

$$\text{Logf} = \log fo - K \log e.t \quad \ldots\ldots\ldots\ldots \ldots \quad (2.26)$$

$$y = C + mx$$

which is a straight line graph with the intercept

c = log fo and gradient

m = gradient

CHAPTER 3

3.0 MATERIALS AND METHOD

3.1 Introductory Note

In this Chapter the procedure to determine the soil moisture content and infiltration rate are discussed below.

The infiltration rate experiment is to determine the rate at which water goes or penetrates into the soil at a known moisture, by obtaining the drop in height of water in the double ring infiltration at a fixed period of time.

3.1.2 GRAVIMETRIC TEST APPARATUS/MATERIALS

Moisture can and lids

Sample core

Cutlass

Plank

Oven

Weighing Machine.

3.1.3 SITE DESCRIPTION

The sites have a geographical coordinates of latitudes 9°45N longitude 6°07E for N.C.R.I. located at altitudes 70.5 metres above sea level and Guinness farm is located on latitude 9°N and longitude 5°30'E in Kudu, Mokwa Local Government.

The N.Y.S.C. farm is on latitude 9°41'N and longitude 6°20'E in Garatu.

Vegetationally, the three sites are located in the sudan guinea savannah region and has basically the rainy, harmattan and dry season weather.

3.1.4 EXPERIMENTAL LAYOUT

The design of experiments was a randomised complete block (R.C.B.) with three treatments. The tilled (T), Non-Tilled (NT) and Tractor tracks (Tt); and with three replicates. The experimental layout is illustrated in Fig. 3.1.

Plot sizes were 5m x 5m and seperated by 2 meter alley between each other. Plots were marked out in 3 sites to correspond to the Tilled (T), Non-Tilled (NT) and Tractor tracks (Tt). Other features of the sites are shown in Table 3.1.

The sample core is made of wrought iron and it is bevelled at an end.

The size of the sample core is 7cm diameter by 7.3cm in height.

3.1.5 PROCEDURE

The sample cores are placed on the soil (0 - 15cm) and driven in by applying force from weight. When the core is filled with soil, it is gently removed by placing a cutlass under the sample core; so as to prevent the soil in the core from falling off.

After removing the sample core from the soil, the soil is transfered into the moisture can and covered immediately to avoid moisture loss or gain by evaporation or condensation.

The cans are placed in a cool place after been filled with soil.

The same procedure is repeated for 15 - 30cm, and 30 - 45cm soil depth.

The cans are all covered with their lids after filling it with soil.

All the samples are taken gently in a container into the laboratory, where an electronic weighing machine is used to measure the weight of the cans and the soil.

The cans are all labelled and weighed before being taken to the field.

The cans are labelled in this way: For the tilled soil cans, we have: T1, 0 - 15, T1, 15 - 30, T1, 30 - 45 cm

T2, 0 - 15, T2, 15 - 30, T2, 30 - 45 cm

T3, 0 - 15, T3, 15 - 30, T3, 30 - 45 cm

This shows that for plot one of the tilled soil, T1 is used

The cans containing soil after being weighed are placed in the oven for 24 hours at a temperature of 105°C. AFter 24 hours, the oven is switched off and opened for the cans to cool a little before it is being weighed again and recorded. Empty can from the oven are re-weighed to make sure that the cans were properly weighed.

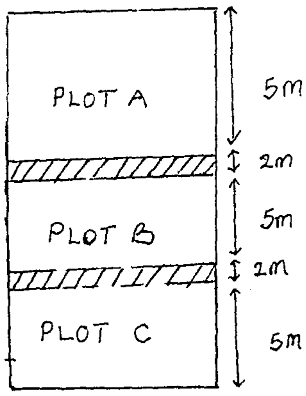

Fig 3.1 Layout of the experiment Showing treatments and Plots.

3.1.6 PLOT DESCRIPTION

3.1.6.1 The tilled Plot

It is an area that has always been cultivated for the past years and crops are planted on it.

It is to show the effect of infiltration on this soil. The soil had been tilled before this experiment was carried out. The tillage operation done on the plot is ploughing. This makes the soil loose and allows for easy percolation of water during the experiment.

3.1.6.2 The Non-tilled Plot

Due to the effect of continuous farming operation on the soil, by machine(s), is selected where the soil is almost its natural state for a long time without any machine relationship. Border between fields are normall used for this experiment. This will give room for comparison of the effect of machine operation on the soil and non machine operation on the soil.

3.1.6.3 The tractor trac ks plot.

This is an area where there has always been a constant machine traffic travel which the area experienced soil compaction.

The essense of this is to know the effect of soil compaction on the soil as regards its rate of infiltration

3.1.6.4 Crop Residue on Surface

This is the amount of plant that remains on the soil from the last season up to the present time before the experiment.

The table below shows the features of the plots.

Table 3.1 Features of the Tilled, Non-Tilledand Tractor Tracks Plots N.C.R.I.

Features	Tilled	Non-Tilled	Tractor Tracks
Types of farming operation done	Plowing	No farm operation	Tractor movement
Period operation last perform	3 days	5 years	3 days
Surface Configuration	Rough	Smooth	Compacted

This informations are gotten from the farm agronomy department of the farm.

Table 3.2 Features of the Tilled, Non-Tilled anand Tractor track plot of Guinness farm

Features	Tilled	Non-Tilled	Tractor Track
Type of farming operation done	Plowing and Fertilizer application	Non-farming operation	Tractor tracks
Period operation was last performed	2 Weeks	8 years	1 Week
Surface Configuration	Rough	Smooth	Compacted

Informations are gotten from the farm agronomy department of the farm.

Table 3.3 Features of the Tilled, Non-Tilled and Tractor plot of N.Y.S.C. Farm

Features	Tilled	Non-Tilled	Tractor track
Type of farming operation done	Plowing	No farming operation	Tractor tracks
Period operation was last performed	3 days	10 Years	3 days

In this study, Horton's equation was adopted to develop the intake characteristic equation for the soils encountered. The infiltration rate and accummulated infiltration depth equation shall represent the observed decrease of infiltration rate with time.

The choice of the Horton's equation for this study is due to the fact that the Horton's equation has the consideration for the accummulated depth equation and it has the easiest formular for calculating the infiltration depth.

3.2 NATIONAL CEREAL RESEARCH INSTITUTE, BADDEGGI

3.2.1 Introductory Note

In the 18th Century, awareness had already been created by researchers, to improve plant quality; in yield and resistance to diseases. This is gesture was also extended to some African countries by the developed country and in 1898 a research institute on cereals like rice, millet etc. was developed at Ibadan called Moore Plantation in Oyo - State of Nigeria.

Moore Plantation as at that time was the headquarters of cereals research institute in Nigeria. In 1984, the research institute felt there was need to centralize the programme, so that all states may benefit and the National Cereals Research Institute which was formally a branch was made the headquarters.

3.2.2 LOCATION

The National Cereals Research Institute (NCRI) Farm is located at latitude 9° 45N and longitude 6° 07E in Baddeggi, Bida Local Government of Niger State. It is about 90km away from Minna the Niger State Capital. N.C.R.I., is in the Sudan guinea Savannah region of Nigeria.

3.2.3 RAIN FALL

Rainfall normally occurs from March to October in Baddeggi, with its peak rainfall around July/August.

3.2.4. CROP GROWN

From informations collected at the N.C.R.I. library, the Baddaggi farm was proposed to grow different cereal crops but rice is the mandate crop of the farm. However, crop like cowpea, soya beans and pigeon pea are planted to replenish the soil.

Rice Plantation is done on the lowland and upland and this gives rise to the name; upland rice or lowland rice. Due to the high water level of the lowland area, the upland area was only choosen for the experiment.

Rice grown in the upland always requires water depth of between 900mm - 1500mm to thrive well.

3.2.5 TOPOGRAPHY

It is an area with gentle slope, this helps in the good drainage of the rice field.

3.2.6 CULTURAL PRACTICE

The N.C.R.I. farm has about 85 hecters of cultivable land for experimental research out of the 100 hecteres land mass.

There are different farm operation done in the N.C.R.I. farm like ploughing, harrowing planting, spraying of herbicides and harvesting. The tractor used in N.C.R.I. is the universal tractor. Steyr is the common model of tractor being used. The model used in the 8075 model with about 45 horse power. The various implements used for the farming operation are tractor drawn implements.

3.2.7 TYPE OF SOIL

The type of soil found in this area is a sandy loam soil, classified as the oxic paleustalf type of soil.

It is friable with low water retaining capacity. It is slightly acidic in nature with a P H of about 4.9 - 5.6.

It has a high organic matter level. This datas are gotten from the soil science department of the Federal University of Technology, Minna.

3.3 GUINNESS FARM NIGERIA P.L.C. KUDU

3.3.1 Introduction Note

In 1983, the Federal Government of Nigeria banned import of malt and barley for the production of beer. This was in line with the government policy to introduce self reliance and the use of local material in the production of goods and materials, beer inclusive.

Guinness Nigeria P.L.C. brewery was also affected with this policy. This led to the birth of Guinness farms a division of Guinness Nigeria P.L.C. brewery in 1986. The farm was intended to be an experimental farm to study and develop the various grain that are available in the country and to know the best type of grain that can be used for beer production. After the trial, the farm was developed into a full mechanzed farm to plant maize as its mandate crop.

Presently, Guinness farms can successfully produce one third of the maize used for beer production by the brewery. This maize is used in the production of Guinness extra stout, Harp lager beer and malta Guinness.

3.3.2 LOCATION

Guinness farms is located at latitude 9°N and longitude 5° 30'E in Kudu, Mokwa Local Government of Niger State. It is about 38km from Mokwa along the Bida - Mokwa way. The farm site is located in the Sudan Guinea Savannah region of Nigeria.

3.3.3 RAINFALL

Rainfall normally occurs from March to October with is peak around July/August. Table 1.2 gives the monthly rainfall value of Kudu from 1990 - 1994 (See Appendix D3).

3.3.4 CROP GROWN

Guinness farm being the major producer of the mother company's material, grows maize as its mandate crop.

/ ...

Crops like soya beans and cow pea are also grown to replenish the soil nutrients. The rain fall pattern has favoured the growth of maize in the area. Crops are grown once a year because they engage in rainfed farming.

3.3.5 3.3.5 TOPOGRAPHY

The area is generally flat with some rocky areas and this has rendered some areas uncultivable.

Generally, there are trees in the area which acts as wind breakers.

3.3.6 3.3.6 CULTURAL PRACTICE

The cultivable land of Guinness farms is about 3,800 hectares out of the 4000 hectares land mass. The land under cultivation is about 2,500 hectares.

There are various farming operations that are undergone on the farm. They include ploughing, which is done before the rain fully starts usually it is done after the first rain. Harrowing is done by a two row disc harrow. Some of the disc are the double gang harrow. The mechanical planter is used for planting. The fertilizer spreader is used for the application of fertilizer. The boom sprayer is used for the application of fertilizer. Fertilizer is applied twice, one after ploughing and the other one after planting. Harvesting is done with a combine harvester.

Various machines are employed for all this operations. In Guinness Farms, Massey Ferguson machines are used. Tractors of model 275, 290 of 45 horse power, the universal tractors used for fertilizer application and herbicides application. Farm operation like ploughing and harrowing is done with heavy duty tractors of model 3650, 3655. The harrow, ploughs attached to the tractor are trailed.

/ ....

3.3.7 SOIL TYPE

Kudu is in the sudan guinea savannah in Nigeria. Ferrasols is the common type of soil found in this area. They are reddish yellow in colour with a deep triable and porous nature.

It is a deep porous sandy or sandy loam soil with increasing clayey content.

3.4 THE NATIONAL YOUTH SERVICE CORP FARM

3.4.1 Introduction Note

The National Youth Service Corp Farm is purely operated by corpers of Niger State with the aim to improve and increase food for corper and the populace.

The farm was established in 1984. It is sited at Kilometer 32 along Minna - Bida Road.

The farm grows Rice as its mandate crop. Due to lack of labour, finance and machinery farm the has not being able to engage in extensive farming operation.

The farm is divided into three parts. A total of 10 hectares out of 100 hectares is under cultivation. Plot A of 3 hectares is used for seed raising and has been in use for about 10 years now. Plot B of 7 hectares is the new plot that has just been developed this year.

3.4.2 LOCATION

The National Youth Service Corp Farm is located at latitude 9° 41'N and longitude 6° 10'E in Garatu, Minna Local Government of Niger State. It is in the sudan guinea savannah.

3.4.3 RAIN FALL

Due to the problems mentioned in 1.41, there is no rainfall data for the area. Instead rainfall data for Minna is provided to give an idea of the rainfall pattern of the area. Rainfall is normally from March to October with its peak around July/August. Table 1.3 is provided in Appendix D5. /6....

/ ....

3.4.4 CROP GROWN

Rice is the major crop grown in the N.Y.S.C. Farm. The seed development farm is used in developing seeds that are used for planting of rice in the next season.

Due to the high percentage of clay and water retention ability of the soil, lowland rice is planted. Rice could have been grown all the year round but for lack of irrigation facility, rainfed farming is the regular practice each year.

3.4.5 TOPOGRAPHY

The area of the land is not regular. The area used for growing crops is flat but some areas are slopy. Drains are provided at the edges of the farm for conveyance of excess water.

3.4.6 CULTURAL PRACTICE

The N.Y.S.C. Farm has a land mass of 100 hectares but about 10 hectares is under cultivation.

The farming operations in area are ploughing, done with a disc harrow. Planting is done by a mechanicalplanter while fertiliser application is done manually. Herbicides are applied with a hand sprayer. The harvesting of the rice after its maturity is done manually.

The tractor used for the farming operation is asteyr 785 model which drew all the implements used behind it. The plough is a single row plough and the harrow is a double row type.

3.4.7 SOIL TYPE

Geretu being in the Sudan Guinea Savannah region has a loamy clay soil. It is blackish grey in colour with a sticky nature and it has boulders and cracks after high moisture loss.

It has a high percentage of clay and it is a water retaining type of soil. Informations are gotten from F.U.T., Minna, Soil Science department.

3.5 DETERMINATION OF SOIL BULK DENSITY (B.D)

The soil in the sample core are poured into cans with lids, weighed and placed in the oven to dry for 24 hours at a temperature od 105°C. The reading are recorded for all plots and treatments.

The samples are weighed again after 24 hours and the readings were also recorded. The data obtained were recorded in table 3.7 to 3.9 and equation (2.18) is used for the calculations.

The sample core has a diameter of 7.0cm. The radius of the core 3.5cm, the height of the core is 7.3cm. This core is used for all the experiment. This gives the same volume of samples for all the experiments.

3.6 DETERMINATION OF POROSITY

The porosity is determined by using the field data. Table reading (Tables 3.7 - 3.9).

Equation (2.23) was used for the calculation to obtain the ratio of the volume of pores (voids) to the total soil volume of all soils encountered. Tables (3.4 - 3.9) shows all gravimetric data and results.

3.7 INFILTRATION RATE APPARATUS/MATERIALS

Stop watch or wrist watch
Measuring Jug
2 Cylinders,
Ruler
Plank
Weight
Drum and Buckets.

In performing this experiment a double ring infiltrometer was constructed. The two cylindcical rings have a height of 250mm and the outer diameter is 600mm. The diameter of the inner cylinder is 300mm. The cylinders were constructed using galvanised flat sheet of 1.5mm thickness.

Plate 3.1.

Table 3.4: GRAVIMETRIC TEST FIELD DATA OF THE NATIONAL CEREAL RESEARCH INSTITUTE BADDEGI

	DEPTH( )	FRESH WEIGHT IN GRAMS - WEIGHT OF CAN 0.45(g)			DRY WEIGHT IN GRAMS - WEIGHT OF CAN 0.45(g)			DIFFERENCE WEIGHT IN (GRAMS)			MOISTURE CONTENT IN PERCENTAGE %		
		A	B	C	A	B	C	A	B	C	A	B	C
PLOT A(TILLED)	0 - 15	480.32	485.16	488.70	440.90	449.21	448.32	39.42	35.95	40.38	8.94	8.00	9
	15.- 30	490.79	500.63	508.16	450.16	463.36	463.50	40.63	37.27	40.66	9.05	8.04	9
	30 - 45	506.32	495.65	504.32	470.03	462.29	459.01	36.29	33.36	45.31	7.72	7.21	9
	Average	492.47	493.81	500.39	453.69	458.28	456.94	38.78	35.52	43.45	8.57	7.75	9
PLOT B(NON-TILLED)	0 - 15	410.31	503.75	512.39	469.[illegible]	462.78	470.74	40.63	40.97	41.65	8.65	8.85	8
	15 - 30	502.16	500.56	506.71	459.98	437.27	467.32	42.18	43.29	39.39	9.16	9.[illegible]	[illegible]
	30 - 45	496.78	508.13	508.91	452.66	462.00	464.75	44.12	46.13	44.16	9.74	9.98	9
	Average	503.08	504.14	509.33	460.77	460.68	467.60	42.31	43.46	41.73	9.18	9.43	8
PLOT C(TRACK)	0 - 15	496.80	497.19	407.78	460.69	466.72	464.11	36.11	30.47	33.67	7.83	6.52	7
	15 - 30	503.67	499.32	502.69	470.50	463.76	466.01	33.17	35.56	36.68	7.04	7.66	[illegible]
	30 - 45	500.39	502.36	505.12	461.49	463.17	455.63	38.90	39.19	49.49	8.43	8.46	1[illegible]
	Average	500.28	499.62	501.86	464.22	464.55	461.91	36.06	35.07	39.94	7.76	7.54	

Table 3.5: GRAVIMETRIC EEST FIELD ANALYSIS OF THE GUINESS FARM PLC KUDU

		FRESH WEIGHT IN (G) WEIGHT OF CAN 0.45(g)			DRY WEIGHT IN (GRAM) WEIGHT OF CAN 0.45(g)			DIFFERENCE IN WEIGHT IN (GRAM)			MOISTURE CONTENT IN PERCENT %	
	DEPTH	A	B	C	A	B	C	A	B	C	A	B
PLOT A(TILLED)	0-15	547.90	560.62	533.64	511.98	521.70	502.35	36.32	38.92	31.29	7.09	7.46
	15-30	548.00	568.26	574.28	517.64	534.86	540.08	30.36	33.40	34.20	5.86	6.24
	30-45	554.65	573.20	581.30	515.34	532.84	541.40	39.31	40.36	39.90	7.62	7.57
	Average	550.18	567.36	563.07	514.98	529.80	527.94	35.33	37.56	35.13	6.85	7.09
PLOT B(NON-TILLED)	0-15	598.60	574.48	588.60	562.31	539.16	551.88	36.29	35662	36.72	6.45	6.60
	15-30	560.00	575.42	586.29	522.81	535.44	547.29	38.29	39.29	39.00	7.32	7.46
	30-45	562.38	588.90	582.78	526.85	552.48	539.54	35.53	36.42	43.24	6.74	6.59
	Average	573.86	579.60	575.89	537.32	542.36	546.23	36.709	37.11	39.65	6.83	6.88
PLOT C(TRACK)	0-15	582.60	593.30	598.80	541.98	548.91	548.72	40.62	44.39	49.78	7.49	8.08
	15-30	590.63	599.30	609.35	547.34	552.52	561.05	43.29	46.78	48.30	7.91	8.46
	30-45	593.24	602.35	605.67	546.94	553.56	555.42	46.30	48.79	50.25	8.46	8.81
	Average	588.82	598.31	603.60	545.42	551.66	555.06	43.40	46.65	49.45	7.95	8.45

Table 3.6: GRAVIMETRIC TEST FIELD ANALYSIS OF THE NATIONAL YOUTH SERVICE CORP FARM GARATU

		FRESH WEIGHT IN GRAM WEIGHT OF CAN 0.45(g)			DRY WEIGHT IN (GRAM) WEIGHT OF CAN 0.45(g)			DIFFERENCE IN WEIGHT IN (GRAM)			MOISTURE CONTENT IN PERCENT %		
	DEPTH	A	B	C	A	B	C	A	B	C	A	B	C
PLOT A(TILLED)	0 - 15	498.60	443.83	426.78	460.27	409.63	410.58	38.33	34.20	16.20	8.32	8.34	3.
	15 - 30	452.77	462.38	431.51	426.78	415.80	406.25	25.09	46.58	25.26	6.08	11.20	6.
	30 - 45	387.84	384.62	498.29	358.76	348.38	345.65	29.08	36.24	52.64	8.10	10.40	15.
	Average	446.40	430.28	452.93	415.27	391.27	387.49	30.83	39.01	31.37	7.50	9.98	8.
PLOT B(NON-TILLED)	0 - 15	455.35	468.38	462.92	429.42	444.90	434.43	225.93	23.48	28.49	6.03	5.27	6.
	15 - 30	457.09	463.94	473.64	431.18	429.35	433.34	25.91	34.59	40.60	6.00	8.05	9.
	30 - 45	478.00	468.46	484.28	445.84	430.07	448.04	32.16	30.39	36.24	7.21	7.66	8
	Average	463.48	466.93	473.61	435.48	434.77	438.60	28.00	29.49	35.11	6.41	6.79	8
PLOT C(TRACK)	0 - 15	470.71	484.0	434.22	448.00	456.84	409.42	22.71	27.16	24.80	5.06	5.94	6
	15 - 30	454.26	509.10	451.50	434.98	486.79	423.79	19.18	22.31	4.40	4.58	4.58	6
	30 - 45	444.65	467.72	457.00	414.98	438.84	436.90	29.67	28.88	20.10	7.14	6.58	4
	Average	456.51	486.94	449.57	432.65	460.82	423.37	23.85	26.12	24.20	5.53	5.70	[illegible]

Table 3.7: NATIONAL CEREALS RESEARCH INSTITUTE BADDEGGI

		BULK DENSITY			POROSITY		
PLOT A (TILLED)	DEPTH (cm)	A	B	C	A	B	C
1	00-15	1.56	1.60	1.59	41.13	39.62	40.00
2	15-30	1.60	1.64	1.64	39.62	38.11	38.11
3	30-45	1.67	1.64	1.63	36.98	38.11	38.49
Average		1.61	1.63	1.62	39.24	38.61	38.87
PLOT B (NON-TILLED)							
1	0-15	1.67	1.65	1.67	36.98	37.73	36.98
2	15-30	1.63	1.62	1.66	38.49	38.86	37.35
3	30-45	1.61	1.64	1.65	39.24	38.11	37.73
Average		1.63	1.64	1.66	38.24	38.23	37.35
PLOT C (TRACK)							
1	0-15	1.63	1.66	1.65	38.49	37.35	37.73
2	15-30	1.67	1.65	1.66	36.98	37.73	37.35
3	30-45	1.64	1.64	1.62	38.11	38.11	38.86
Average		1.65	1.65	1.64	37.86	37.73	37.98

Table 3.8

GUINNESS FARM KUDU FIELD ANALYSIS

PLOT A (TILLED)	DEPTH cm	BULK DENSITY A	B	C	POROSITY A	B	C
1	0-15	1.82	1.86	1.78	31.32	29.81	32.83
2	15-30	1.84	1.90	1.92	30.06	28.30	27.54
3	30-45	1.89	1.89	1.92	28.67	28.67	27.54
	Average	1.85	1.88	1.87	30.02	28.93	29.30
PLOT B (NON-TILLED)							
1	0-15	2.00	1.911	1.96	26.52	27.92	26.03
2	15-30	1.86	1.89	1.94	29.81	28.07	26.79
3	30-45	1.87	1.96	1.92	29.43	26.03	27.54
	Average	1.91	1.92	1.94	27.92	27.34	26.79
PLOT C (TRACK)							
1	0-15	1.92	1.95	1.95	27.54	26.41	26.41
2	15-30	1.94	1.96	1.99	26.79	26.03	24.90
3	30-45	1.94	1.97	1.97	26.79	25.66	25.66
	Average	1.93	1.96	1.97	27.04	26.03	25.66

TABLE 3.9

NATIONAL YOUTH SERVICE CORP FARM GARATU

PLOT A (TILLED)	DEPTH cm	BULK DENSITY A	B	C	POROSITY A	B	C
1	0-15	1.63	1.45	1.46	38.49	45.28	44.90
2	15-30	1.51	1.47	1.44	43.01	44.53	45.66
3	30-45	1.27	1.23	1.23	52.07	53.58	53.58
	Average	1.47	1.38	1.38	44.52	47.80	48.05
PLOT B (NON-TILLED)							
1	0-15	1.52	1.58	1.54	42.64	40.37	41.88
2	15-30	1.53	1.52	1.54	42.26	46.64	41.88
3	30-45	1.58	1.53	1.59	40.37	42.26	40.00
	Average	1.54	1.54	1.55	41.76	43.09	41.25
PLOT C (TRACK)							
1	0-15	1.59	1.62	1.45	40.00	38.86	45.28
2	15-30	1.54	1.73	1.50	41.88	34.71	43.39
3	30-45	1.57	1.56	1.55	44.53	41.11	41.50
	Average	1.53	1.64	1.50	42.14	38.23	43.39

3.3 INFILTRATION RATE METHODOLOGY

Plots for the experiments were levelled by removing grasses and debris just at the surface. Care was taken so that the surface structure of the plot is not destroyed.

The double ring infiltrometer was placed on the selected plot.

First, the inner ring is placed on the soil. The ring is then inserted into the soil by placing a plank across the ring and tapped gently until the ring has gone into the soil within a depth of 100 - 150mm.

The inner ring has a ruler attached to the inner side. This allows for the reading of the water level as infiltration progresses.

For the tilled soil the inner ring is installed at a depth 130mm due to the loose nature of the soil to avoid water seepage. For the Non-tilled and compacted plots has their rings inserted to a depth of 130mm as well.

After the installation of the inner ring, the outer ring was also installed in the same manner to a depth of 150mm. During the installation of the outer ring, care was taken to centralize the distance between the two rings.

The depth is re-checked with a ruler to ensure a perfect level before commencing the experiment fully.

The distance between the two rings is also measured with a ruler as well.

A drum of water was placed close to the experimental site for constant water use.

A small quantity of grass is placed in the inner and outer ring of the infiltrometer to avoid puddling when pouring water in the rings. Water was measured with a four litre capacity can and the watch was set at zero reading. After the infiltrometer was put in place, water was powered into the inner ring and simultaneously the watch was started.

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The inner ring was filled up to a level of 22cm reading on the ruler in the inner cylinder. This implies that 22cm on the ruler is used as the reference point. When the inner ring has been filled up to the reference point, the outer ring was also filled up to the reference point. The water level in the inner ring was maintained in the outer ring.

On the tilled plot, the reading were taken every 2 minutes because of the high infiltration rate of the loose soil. Water percolation was very high at the initial point of the experiment.

For the non-tilled and compacted soil the reading were taken every 5 minutes or 10 minutes depending on the nature of the soil.

The readings vary depending on the type of soils and moisture content of the soil.

The time reference point also varies depending on the location.

After every reference time expires, a reading is taken and the rings are filled back to the reference water level taking cognisance of the inner ring.

The experiment continues for some time until when a constant reading value is obtained for about 3 to 5 times.

For every experiment, infiltration rate reading was not less than an hour but not more than 2 hours 30 minutes.

After every experiment, the rings were removed and taken to another plot.

The data obtained are shown in tables 3.10 to 3.12.

Three replicates were taken on each site.

Table 3.10: THE NATIONAL YOUTH SERVICE CORP FARM GARATU FIELD DATAS

PLOT A (TILLED)

Time	Water Level Reading	Difference	Water Level Reading	Difference	Water Level Reading	Difference	Time	Water Level Reading	Difference
0	22.00	0	22.00	0	22.00	0	0	22.00	0
10	18.00	4.0	18.50	3.5	16.20	310	10	20.00	200
20	20.00	2.0	20.00	2.0	19.50	2.5	20	20.50	1.5
30	20.50	1.5	20.40	1.6	20.50	1.5	30	21.00	1.0
40	21.00	1.0	20.80	1.2	21.00	1.0	40	21.10	0.9
50	21.20	0.8	21.10	0.9	21.20	0.8	50	21.70	0.7
60	21.20	0.8	21.10	0.9	21.20	0.8	60	21.70	0.7
70	21.50	0.5	21.30	0.7	21.40	0.6	70	21.50	0.5
80	21.50	0.5	21.50	0.5	21.40	0.6	80	21.50	0.5
90	21.70	0.3	21.70	0.3	21.70	0.3	90	21.70	0.3
100	21.70	0.3	21.70	0.3	21.70	0.3	100	21.70	0.3
110	21.70	0.3	21.70	0.1	21.90	0.1	110	21.90	0.1
120	21.70	0.3	21.90	0.1	21.90	0.1	120	21.90	0.1
130	21.90	0.1	21.90	0.1	21.90	0.1	130	21.90	0.1
140	21.90	0.1	21.90	0.1	21.90	0.1	140	21.90	0.1
150	21.90	0.1	21.90	0.1	21.90	0.1	150	21.90	0.1

Water Level Reading	Difference	Water Level Reading	Difference	Time	Water Level Reading	Difference	Water Level Reading	Difference	Water Level Reading	Difference
PLOT B (NON-TILLED)					PLOT C (TRACK)					
22.00	0	22.00	0	0	22.00	0	22.00	0	22.00	0
19.80	2.2	20.00	2.0	10	20.20	1.8	20.00	2.0	20.00	2.0
20.50	1.5	20.40	1.6	20	20.50	1.5	20.50	1.5	20.20	1.8
21.00	1.0	21.00	1.0	30	20.80	1.2	20.70	1.3	20.40	1.6
21.20	0.8	21.10	0.9	40	21.00	1.0	20.90	1.1	20.60	1.4
21.20	0.8	21.20	0.8	50	21.20	0.8	21.10	0.9	20.80	1.2
21.40	0.6	21.40	0.6	60	21.40	0.6	21.30	0.7	21.00	1.0
21.40	0.6	21.40	0.6	70	21.40	0.6	21.30	0.7	21.20	0.8
21.60	0.4	21.40	0.4	80	21.40	0.6	21.80	0.5	21.40	0.6
21.70	0.3	21.60	0.4	90	21.60	0.4	21.60	0.4	21.60	0.4
21.70	0.3	21.70	0.3	100	21.60	0.4	21.60	0.4	21.60	0.4
21.90	0.1	21.90	0.1	110	21.70	0.3	21.70	0.3	21.70	0.3
21.90	0.1	21.90	0.1	120	21.70	0.3	21.70	0.3	21.70	0.3
21.90	0.1	21.90	0.1	130	21.80	0.2	21.80	0.2	21.80	0.2
21.90	0.1	21.90	0.1	140	21.80	0.2	21.80	0.2	21.80	0.2
21.90	0.1	21.90	0.1	150	21.90	0.1	21.90	0.1	21.90	0.1

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Table 3.11: GUINESS FARM PLC KUDU FIELD DATA

PLOT A (TILLED)

Time	Water Level Reading	Difference	Water Level Reading	Difference	Water Level Reading	Difference	Time	Water Level Reading	Difference
0	22.0	0	22.00	0	22.00	0	0	22.00	0
5	16.5	5.5	16.70	5.3	16.50	5.5	5	18.50	3.5
10	17.7	4.3	17.50	4.5	17.50	4.5	10	18.80	3.2
15	18.2	3.8	18.00	4.0	18.20	3.8	15	19.00	3.0
20	18.6	3.4	18.50	3.5	18.60	3.4	20	19.20	2.8
25	19.00	3.0	18.90	3.1	19.00	3.0	25	19.40	2.6
30	19.30	2.7	19.30	2.7	19.20	2.8	30	19.60	2.4
35	19.50	2.5	19.70	2.3	19.25	2.5	35	19.70	2.3
40	19.90	2.1	20.00	2.0	19.80	2.2	40	19.90	2.1
45	20.00	2.0	20.00	2.0	19.90	2.1	45	20.00	2.0
50	20.20	1.8	20.30	1.7	20.10	1.9	50	20.10	1.9
55	20.20	1.8	20.50	1.5	20.20	1.8	55	20.30	1.7
60	20.60	1.4	20.70	1.3	20.50	1.5	60	20.50	1.5
65	20.60	1.4	20.80	1.2	20.70	1.3	65	20.70	1.3
70	20.80	1.2	21.00	1.0	20.90	1.1	70	20.80	1.2

PLOT B (NON-TILLED)					PLOT C (TRACK)					
Water Level Reading	Difference	Water Level Reading	Difference	Time	Water Level Reading	Difference	Water Level Reading	Difference	Water Level Reading	Difference
22.00	0	22.00	0	0	22.00	0.00	22.00	0.00	22.00	0.00
18.50	3.5	18.30	3.7	5	19.50	2.5	19.70	2.3	19.40	2.6
18.80	3.2	18.60	3.4	10	20.30	1.7	19.50	1.5	20.20	1.8
19.10	2.9	19.00	3.0	15	20.50	1.5	20.70	1.3	20.50	1.5
19.30	2.7	19.30	2.7	20	20.50	1.5	20.80	1.2	20.60	1.4
19.50	2.5	19.50	2.5	25	20.70	1.3	20.90	1.1	20.70	1.3
19.70	2.3	19.70	2.3	30	20.70	1.3	20.90	1.1	20.80	1.2
19.80	2.2	20.00	2.0	35	20.80	1.2	21.00	1.0	20.80	1.2
20.00	2.0	20.10	1.9	40	20.80	1.2	21.00	1.0	20.90	1.1
20.20	1.8	20.30	1.7	45	21.00	1.0	21.10	0.9	21.00	1.0
20.60	1.6	20.50	1.5	50	21.10	0.9	21.20	0.8	21.10	0.9
20.50	1.5	20.60	1.4	55	21.10	0.9	21.20	0.8	21.10	0.9
20.70	1.3	20.70	1.3	60	21.10	0.9	21.20	0.8	21.10	0.9
20.80	1.2	20.80	1.2	65	21.20	0.8	21.30	0.7	21.20	0.8
20.90	1.1	20.80	1.2	70	21.20	0.8	21.30	0.7	21.20	0.8

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75	20.80	1.2	21.00	1.0	21.10	0.9	75	20.80	1.2
80	21.00	1.0	21.10	0.[illegible]	21.10	0.7	85	21.00	1.0
85	21.00	1.0	21.30	0.7	21.30	0.7	85	21.00	1.0
90	21.00	1.0	21.30	0.7	21.30	0.7	90	21.20	0.8
95	21.20	0.8	21.30	0.7	21.40	0.6	95	21.20	0.8
100	21.20	0.8	21.50	0.5	21.50	0.5	100	21.20	0.8
105	21.30	0.7	21.50	0.5	21.50	0.5	105	21.30	0.7
110	21.50	0.5	21.50	0.5	21.60	0.4	110	21.30	0.7
115	21.50	0.5	21.60	0.4	21.60	0.4	115	21.40	0.6
120	21.50	0.5	21.60	0.4	21.60	0.4	120	21.40	0.6
125	21.70	0.3	21.60	0.4	21.60	0.4	125	21.40	0.6
130	21.70	0.3	21.70	0.3	21.60	0.4	130	21.50	0.5
135	21.70	0.3	21.70	0.3	2170	0.3	135	21.50	0.5
140	21.70	0.3	21.80	0.2	21.70	0.3	140	21.80	0.5
145	21.80	0.2	21.80	0.2	21.70	0.3	145	21.50	0.5
150	21.80	0.2	21.80	0.2	21.70	0.3	150	21.50	0.5

21.10	0.9	20.90	1.1	75	21.30	0.7	21.30	0.7	21.30	0.7
21.10	0.9	21.00	1.0	80	21.30	0.7	21.40	0.6	21.30	0.7
21.20	0.8	21.10	0.9	85	21.30	0.7	21.40	0.6	21.40	0.6
21.20	0.8	21.10	0.9	90	21.40	0.6	21.40	0.6	21.40	0.6
21.20	0.8	21.20	0.8	95	21.40	0.6	21.40	0.6	21.40	0.6
21.30	0.7	21.30	0.7	100	21.40	0.6	21.50	0.5	21.50	0.5
21.30	0.7	21.30	0.7	105	21.50	0.5	21.50	0.5	21.50	0.5
21.40	0.6	21.40	0.6	110	21.50	0.5	21.50	0.5	21.50	0.5
21.40	0.6	21.40	0.6	115	21.80	0.5	21.50	0.5	21.50	0.5
21.40	0.6	21.50	0.5	120	21.50	0.5	21.60	0.4	21.60	0.4
21.50	0.5	21.50	0.5	125	21.60	0.4	21.60	0.4	21.60	0.4
21.50	0.5	21.50	0.5	130	21.60	0.4	21.60	0.4	21.60	0.4
21.50	0.5	21.50	0.5	135	21.60	0.4	21.60	0.4	21.60	0.4
21.50	0.5	21.50	0.5	140	21.60	0.4	21.60	0.4	21.60	0.4
21.60	0.4	21.60	0.4	145	21.60	0.4	21.60	0.4	21.60	0.4
21.60	0.4	21.60	0.4	150	21.60	0.4	21.60	0.4	21.60	0.4

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Table 3.12: THE NATIONAL CEREALS RESEARCH INSTITUTE FARM FIELD DATA

	PLOT A (TILLED)						PLOT B (NON-TILLED)		
Time	Water Level Reading	Difference	Water Level Reading	Difference	Water Level Reading	Difference	Time	Water Level Reading	Difference
0	22.00	0	22.00	0	22.00	0	0	22.00	0
2	16.80	5.2	16.80	5.2	17.00	5.0	5	14.00	8.0
4	17.50	4.5	17.50	4.5	17.50	4.5	10	15.00	7.0
6	18.00	4.0	17.80	4.2	17.80	4.2	15	15.60	6.4
8	18.00	4.0	18.00	4.0	18.00	4.0	20	16.20	5.8
10	18.00	4.0	19.50	2.5	18.00	4.0	25	16.50	5.5
12	20.70	1.3	20.00	2.0	20.00	2.0	30	17.00	5.0
14	21.00	1.0	20.80	1.2	21.00	1.0	35	17.30	4.7
16	21.00	1.0	21.00	1.0	21.00	1.0	40	17.60	4.4
18	21.10	0.9	21.10	0.9	21.00	1.0	45	18.50	3.5
20	21.20	0.8	21.10	0.9	21.20	0.8	50	19.00	3.0
22	21.20	0.8	21.30	0.7	21.20	0.8	55	19.50	2.5
24	21.20	0.8	21.30	0.7	21.20	0.8	60	19.50	2.5
26	21.30	0.7	21.30	0.7	21.20	0.8	65	19.80	2.2
28	21.30	0.7	21.30	0.7	21.40	0.6	70	19.80	2.2
[illegible]	21.30	0.7	21.40	0.6	21.40	0.6	75	19.80	2.2

PLOT B(NON-TILLED)					PLOT C (TRACK)					
Water Level Reading	Difference	Water Level Reading	Difference	Time	Water Level Reading	Difference	Water Level Reading	Difference	Water Level Reading	Difference
22.00	0	22.00	0	0	22.00	0	22.00	0	22.00	0
13.00	9.0	14.00	8.0	5	19.50	2.5	19.20	2.8	19.50	2.5
15.00	7.0	15.00	7.0	10	20.00	2.0	20.00	2.0	20.00	2.0
16.00	6.0	15.50	6.5	15						
16.00	6.0	16.50	5.5	20	20.50	1.5	20.40	1.6	20.80	1.5
16.50	5.5	16.50	5.5	25						
17.00	5.0	17.00	5.0	30	20.70	1.3	20.70	1.3	20.50	1.5
17.30	4.7	17.40	4.6	35						
17.60	4.4	17.60	4.4	40	20.70	1.3	20.70	1.3	20.70	1.3
17.60	4.4	17.80	4.2	45						
18.50	3.5	18.80	3.2	50	20.90	1.1	20.80	1.2	20.90	1.1
19.00	3.0	19.00	3.0	55						
19.20	2.8	19.20	2.8	60	20.90	1.1	2[illegible].00	1.0	20.90	1.1
19.50	2.5	19.40	2.6	65						
19.90	2.1	19.40	2.6	70	21.00	1.0	21.00	1.0	21.10	0.9
20.20	1.8	19.90	2.1	75						
20.60	1.4	19.90	2.1	80	21.10	0.9	21.10	0.9	21.10	0.9

32	21.30	0.7	21.40	0.6	21.40	0.6	80	20.00	2.0
34	21.30	0.7	21.40	0.6	21.40	0.6	85	20.40	1.6
36	21.40	0.6	21.40	0.6	21.40	0.6	90	20.40	1.6
38	21.40	0.6	21.50	0.5	21.50	0.5	95	21.00	1.0
40	21.50	0.5	21.50	0.5	21±50	0.5	100	21.20	0.8
42	21.50	0.5	21.60	0.4	21.50	0.5	105	21.20	0.8
44	21.50	0.5	21.60	0.4	21.60	0.4	110	21.50	0.5
46	21.50	0.5	21.60	0.4	21.70	0.3	115	21.50	0.5
48	21.60	0.4	21.60	0.4	21.70	0.3	120	21.50	0.5
50	221.60	0.4	21.70	0.3	21.70	0.3	125	21.70	0.3
52	21.60	0.4	21.80	0.2	21.70	0.3	130	21.70	0.3
54	21.70	0.3	21.80	0.2	21.70	0.3	135	21.70	0.3
56	21.70	0.3	21.80	0.2	21.70	0.3	140	21.90	0.1
58	21.70	0.3	21.80	0.2	21.80	0.2	145	21.90	0.1
60	21.70	0.3	21.90	0.1	21.80	0.2	150	21.90	0.1
62	21.70	0.3	21.90	0.1	21.80	0.2			
64	21.70	0.3	21.90	0.1	21.80	0.2			
66	21.70	0.3	21.90	0.1	21.80	0.2			
68	21.70	0.3	21.90	0.1	21.80	0.2			
70	21.70	0.3	21.90	0.1	21.80	0.2			

20.80	1.2	20.20	1.8	85						
20.80	1.2	20.60	1.4	90	21.10	0.9	21.20	0.8	21.30	0.7
21.00	1.0	21.00	1.0	95						
21.00	1.0	21.10	0.9	100	21.20	0.8	21.20	0.8	21.30	0.7
21.00	1.0	21.30	0.7	105						
21.30	0.7	21.30	0.7	110	21.20	0.8	21.20	0.8	21.40	0.6
21.30	0.7	21.40	0.6	115						
21.50	0.5	21.40	0.6	120	21.30	0.5	21.40	0.6	21.60	0.4
21.50	0.5	21.60	0.4	125						
21.50	0.5	21.60	0.4	130	21.50	0.5	21.40	0.6	21.60	0.4
21.50	0.5	21.70	0.3	135						
21.80	0.2	21.70	0.3	140	21.70	0.3	21.60	0.4	21.60	0.4
21.80	0.2	21.80	0.2	145						
21.80	0.2	21.80	0.2	150	21.70	0.3	21.60	0.4	21.60	0.4

FIG. 2

2.1 . THE OVEN DRYING OF THE SOIL SAMPLES

2.2 THE WEIGHING OF THE OVEN DRIED SOILS

2.3 THE INSTALLATION OF THE INFILTROMETER

2.4 THE PONDING OF WATER IN THE INFILTROMETER

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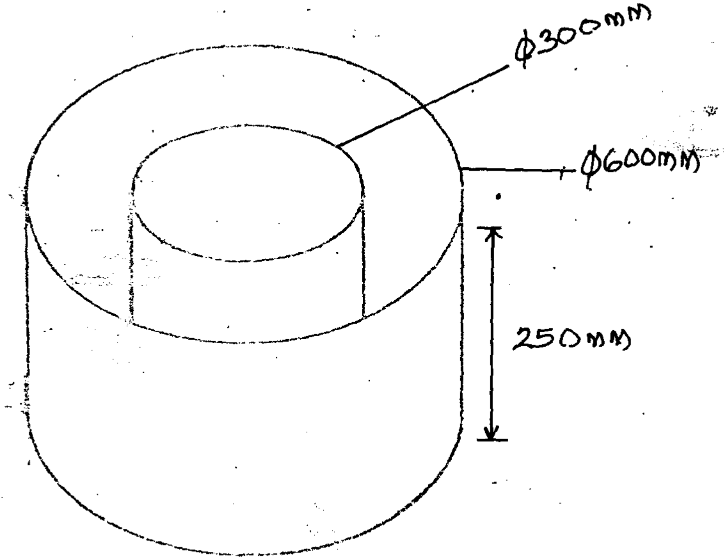
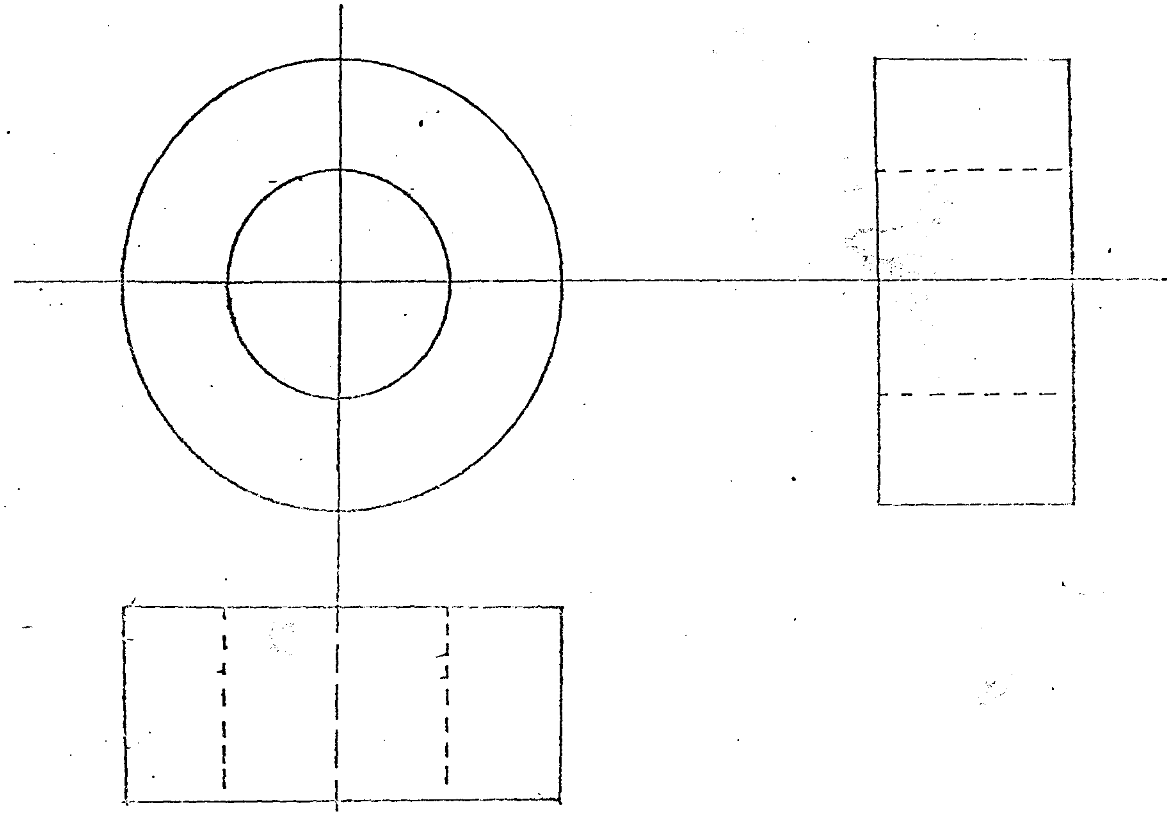


ISOMETRIC PROJECTION



ORTHOGRAPHIC PROJECTION.

TITLE	ISOMETRIC AND ORTHOGRAPIC	
	PROJECTION OF AN INFILTROMETER	
NAME	SAMBE C.M	REGN NO 38/1030
APPROVED	DR D ADRIDZI	SCALE 1:10

CHAPTER 4

4.0 ANALYSIS OF RESULTS

4.1 Introductory Note

In this Chapter all the values obtained from the infiltration test was computed and analised.

Result and tables are presented in tables 4.1 - 4.3. The following parameters were determined viz:

- The average infiltration depth in cm
- The average infiltration rate in cm/hr and
- The accummulated infiltration depth in cm/hr.

All the values presented in these tables 4.1 to 4.3 were computed using experimental data given in tables 3.10 - 3.12.

The graphs for all sites are also given using the normal graphs and the semi log graphs - See figures 4.1 - 4.9.

RESULTS AND DISCUSSIONS

4.2 The analysis of the field datas of various experiments from selected farm sites are presented below.

4.2.1 Analysis of Results

Soil moisture determination and measurement. The following parameters were obtained from the soil analysis carried out on the field and in the laboratory.

The result of the soil moisture content of the National Cereals Research Institute farm, Guinness Farms Nigeria P.L.C. and National Youth Service Corp farm are presented in Table 3.4 - 3.6.

From the average soil moisture content percentage given in tables 3.4 - 3.6, it can be observed that soil moisture percentage varies from different forms due to the soil moisture difference at various depth, the evaporation of water due to different weather condition.

The soil moisture increases with an increase in the difference in weight obtained from the fresh and dry weight of soil samples an average is obtained for every plot at different depths.

Table 4.1: DATA ANALYSIS OF THE INFILTRATION TEST TAKEN AT THE NATIONAL CEREALS RESEARCH INSTITUTE FARM BADDEGGI

	PLOT A (TILLED)				PLOT B (NON-TILLED)				PLOT C (TRACKS		
Time	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accumulated Depth cm/hr	Time	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accumulated Depth cm/hr	Time	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accu Dept
00	0.00	0.00		0	0.00	0.00		0	0.00	0.00	
2	5.06	151.8	0.06	5	8.33	99.96	8.33	10	4.6	27.6	
4	4.5	135.0	9.56	10	7.00	84.0	15.33	20	1.53	9.18	
6	4.13	123.9	13.69	15	6.16	73.92	21.49	30	1.36	8.16	
8	4.0	120.0	17.69	20	5.76	69.12	27.25	40	1.30	7.80	
10	3.5	105.0	21.19	25	5.50	66.00	32.15	50	1.13	6.78	
12	1.76	52.8	22.95	30	5.00	60.00	37.75	60	1.06	6.36	
14	1.06	31.8	24.01	35	4.66	55.92	42.41	70	0.96	5.76	
16	1.0	30.0	25.01	40	6.4	52.80	46.81	80	0.90	5.40	
18	0.93	27.9	25.94	45	4.03	48.36	50.84	90	0.80	4.80	
20	0.83	24.9	26.77	50	3.23	38.76	54.07	100	0.76	4.56	
22	0.76	22.8	27.53	55	2.83	33.96	56.90	110	0.73	4.38	
24	0.76	22.8	28.29	60	2.70	32.40	59.60	120	0.50	3.00	
26	0.73	21.9	29.02	65	2.43	29.16	62.03	130	0.60	3.00	
28	0.66	19.8	29.68	70	2.3	27.60	64.33	140	0.36	2.16	
30	0.63	18.9	30.31	75	2.03	24.36	66.36	150	0.36	2.16	

32	0.63	18.9	30.94	80	1.8	21.60	68.16
34	0.63	18.9	31.57	85	1.53	18.36	69.16
36	0.60	18.0	32.17	90	1.4	16.80	71.09
38	0.53	15.9	32.70	95	1.0	12.00	72.09
40	0.5	15.0	33.20	100	0.9	10.80	72.99
42	0.46	13.8	33.66	105	0.83	9.96	73.82
44	0.43	12.9	34.09	110	0.63	7.56	74.45
46	0.4	12.0	34.49	115	0.60	7.20	75.05
48	0.36	10.8	34.85	120	0.53	6.36	75.58
50	0.33	9.9	35.18	125	0.40	4.80	75.98
52	0.30	9.0	35.48	130	0.40	4.80	76.38
54	0.26	7.8	35.74	135	0.36	4.32	76.74
56	0.26	7.8	36.00	140	0.2	2.40	76.94
58	0.23	6.9	36.23	145	0.16	1.92	77.10
60	0.20	6.0	36.43	150	0.16	1.92	77.26
62	0.20	6.0	36.63				
64	0.20	6.0	36.83				
66	0.20	6.0	37.03				
68	0.20	6.0	37.23				
70	0.20	6.0	37.43				

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Table 4.1.1: ITERATED VALUES OF INFILTRATION FOR N.C.R.I.

PLOT A(TILLED)

TIME	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accumulated Infiltyation Depth cm/hr
0	0	0	0
5	11.41	136.92	11.42
10	9.78	117.36	21.19
15	3.32	39.84	24.51
20	2.26	27.12	26.77
25	1.13	13.56	27.90
30	1.65	19.80	29.55
35	0.30	3.60	29.85
40	1.33	15.96	31.18
45	1.09	13.[illegible]8	32.27
50	0.89	10.68	33.16
55	0.56	6.72	3[illegible].72
60	0.43	5.16	34.15
65	0.10	1.20	34.25
70	0.00	0.00	34.25

PLOT C (TRACKS)

TIME	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accumulated Infiltration Depth cm/hr
0	0	0	0
5	2.30	27.6	2.3
10	2.30	27.6	4.6
15	0.77	9.24	5.37
20	0.76	9.12	6.13
25	0.68	8.16	6.81
30	0.68	8.16	7.49
35	0.65	7.80	8.14
40	0.65	7.80	8.79
45	0.57	6.84	9.36
50	0.56	6.72	9.92
55	0.53	6.36	10.45
60	0.53	6.36	10.98
65	0.48	5.76	11.46
70	0.48	5.76	11.94
75	0.45	5.40	12.39
80	0.45	5.40	12.84
85	0.40	4.80	13.24
90	0.40	4.80	13.64
95	0.38	4.56	14.02
100	0.38	4.56	14.40

105	0.38	4.56	14.78
110	0.38	4.56	15.16
115	0.25	3.00	15.41
120	0.25	3.00	15.66
125	0.00	0.00	15.66
130	0.00	0.00	15.66
135	0.18	2.16	15.84
140	0.18	2.16	16.02
145	0.00	0.00	16.02
150	0.00	0.00	16.02

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Table 4.2a DATA ANALYSIS OF THE INFILTRATION TEST TAKEN AT THE NATIONAL YOUTH SERVICE CORP FARM GARATU

TIME	PLOT A (TILLED) Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accumulated Depth cm/hr	Time	PLOT B (NONTILLED) Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accumulated Depth cm/hr	Time	PLOT C (TRACK) Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Acc Dep
0	0	0	0	0	0	0	0	0	0	0	
10	3.76	22.56	3.76	10.	2.06	12.36	2.06	10	1.93	11.58	
20	2.16	12.96	5.72	20	1.53	9.18	3.59	20	1.6	9.6	
30	1.53	9.18	7.45	30	1.0	6.0	4.59	30	1.36	8.16	
40	1.06	6.36	8.51	40	0.86	5.16	5.45	40	1.16	6.96	
50	0.83	4.98	9.34	50	0.76	4.56	6.21	50	0.96	5.76	
60	0.83	4.98	10.17	60	0.6	3.6	6.81	60	0.76	4.56	
70	0.6	3.6	10.77	70	0.6	3.6	7.41	70	0.7	4.20	
80	0.53	3.18	11.30	80	0.46	2.76	7.87	80	0.56	3.36	
90	0.3	1.8	11.60	90	0.36	2.16	8.23	90	0.4	2.4	
100	0.3	1.8	11.90	100	0.3	1.8	8.53	100	0.4	2.4	
110	0.1	0.6	12.00	110	0.1	0.6	8.63	110	0.3	1.8	
120	0.1	0.6	12.10	120	0.1	0.6	8.13	120	0.3	1.8	
130	0.1	0.6	12.70	130	0.1	0.6	8.83	130	0.2	1.2	
140	0.1	0.6	13.903	140	0.1	0.6	8.93	140	0.2	1.2	
150	0.1	0.6	13.90	150	0.1	0.6	9.03	150	0.1	1.0	

Table 4.3: GUINNESS FARM NIGERIA PLC KUDU FIELD ANALYSIS

	PLOT A (TILLED)				PLOT B (UNTILLED)				PLOT C (TRACKS)		
TIME	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accomulated Depth(cm/hr)	Time	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accumulated Depth cm/hr	Time	Average Infiltration Depth cm/hr	Average Infiltration Rate cm/hr	Accu Dept
0	0.00	0.00	0.00	0	0.00	0.00	0.00	0	0.00	0.00	[illegible]
5	5.43	65.16	5.43	5	3.56	42.72	3.56	5	2.46	29.52	[illegible]
10	4.43	53.16	9.86	10	3.26	39.16	6.82	10	1.66	19.92	[illegible]
15	3.86	46.32	13.72	15	2.96	35.52	9.78	15	1.43	17.16	[illegible]
20	3.43	41.16	17.75	20	2.73	32.76	12.51	20	1.36	16.63	[illegible]
25	3.03	36.36	20.18	25	2.53	30.36	15.04	25	1.23	14.76	[illegible]
30	2.73	32.76	22.91	30	2.33	27.96	17.37	30	1.20	14.40	[illegible]
35	2.43	29.16	25.34	35	2.16	25.92	19.33	35	1.13	13.56	1
40	2.10	25.20	27.44	40	2.00	24.00	21.53	40	1.10	13.20	1
45	2.03	24.36	29.47	45	1.83	21.96	23.36	45	0.96	11.52	1
50	1.80	21.60	31.27	50	1.66	19.92	25.02	50	0.96	11.52	[illegible]
55	1.70	20.40	32.97	55	1.53	18.36	26.55	55	0.86	10.32	[illegible]
60	1.40	16.80	34.37	60	1.36	16.32	27.91	60	0.86	10.32	[illegible]
65	1.30	15.60	35.67	65	1.23	14.76	29.14	65	0.76	9.12	[illegible]
70	1.10	13.20	36.77	70	1.16	13.92	30.30	70	0.76	9.12	[illegible]
75	1.03	12.36	37.80	75	1.06	12.72	31.36	75	0.70	8.40	[illegible]
80	0.93	11.16	38.73	80	0.96	11.52	32.32	80	0.66	7.92	[illegible]
85	0.80	9.60	39.53	85	0.90	10.80	33.38	85	0.63	7.56	[illegible]
90	0.80	9.60	40.33	90	0.83	9.96	34.11	90	0.60	7.20	[illegible]
95	0.70	8.40	41.03	95	0.80	9.60	34.91	95	0.60	7.20	[illegible]
100	0.60	7.20	41.03	100	0.73	8.76	35.64	100	0.53	6.89	[illegible]

105	0.56	6.72	42.19	105	0.70	8.40	36.34	105	0.50	6.00
110	0.46	5.52	42.65	110	0.63	7.56	36.97	110	0.50	6.00
115	0.43	5.16	43.08	115	0.60	7.20	37.57	115	0.50	6.00
120	0.43	5.16	43.51	120	0.56	6.72	38.13	120	0.43	5.20
125	0.36	4.32	43.87	125	0.53	6.36	38.66	125	0.40	4.80
130	0.33	3.96	44.20	130	0.50	6.00	39.16	130	0.40	4.80
135	0.30	3.60	44.50	135	0.50	6.00	39.69	135	0.40	4.80
140	0.26	3.12	44.76	140	0.50	6.00	40.19	140	0.40	4.80
145	0.23	2.76	44.99	145	0.43	5.16	40.62	145	0.40	4.80
150	0.23	2.76	45.22	150	0.43	5.16	41.05	150	0.40	4.80

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The average Bulk density obtained increases with decrease in the average moisture percentage. The average porosity is observed to increase as the bulk density decreases.

The porosity of N.Y.S.C. farm is greater than that of N.C.R.I and Guinness this is because of the high percentage of clay present in the N.Y.S.C. farm soil but it was also observed that the bulk density of the N.Y.S.C. farms is the lowest.

4.2.2 Soil Characteristic constant K

The soil characteristic constant (K) of the three farms of study are determined as follows - See Table 4.1.

TABLE 4.1 The values of K for the tilled, untilled and compacted fields

Plot	N.C.R.I.	Guinness	N. Y. S. C.
TILLED	3.50	1.35	1.33
UNTILLED	1.32	0.93	1.21
COMPACTED	0.73	0.68	1.13

The samples of the calculations of this results above is given in Appendix C.

4.2.3 Infiltration depth rate equation (f)

The infiltration rate equation for each soil at the stated conditions are given as follows. From the Horton's equation $F = fc + (fo - fc)e^{-kt}$.

TABLE (4.2) INFILTRATION RATE EQUATIONS

PLOT	C.C.R.I	GUINNESS	N.Y.S.C.
TILLED	$F=6.0+145.8\ e^{-3.5t}$	$f=2.76+62.4\ e^{-1.35t}$	$f=0.6+22\ e^{-1.33t}$
UNTILLED	$f=1.92+98.0\ e^{-1.32t}$	$f=5.16+37.6e^{-0.93t}$	$f=0.6+11.8e^{-1.13t}$
COMPACTED	$f=2.16+25.4e^{-0.73t}$	$f=4.80+24.7e^{-0.65t}$	$f=1.0+10.58e^{-1.13t}$

4.2.4 CUMMULATIVE INFILTRATION DEPTH RATE EQUATION

The equation for the cummulative infiltration depth of each ... and soil conditions are given as follows:

TABLE (4.3) CUMMULATIVE INFILTRATION DEPTH EQUATIONS

Soil Condition	N.C.R.I.	GUINNESS	N.Y.S.C.
TILLED	$F=6.0t+41.6[1-e^{-3.50t}]$	$F=2.76t+46.2[1-e^{-1.35t}]$	$F=0.6t+16.5[1-e^{-.33t}]$
UNTILLED	$F=1.92t+74.2[1-e^{-1.32t}]$	$F=5.16+40.4[1-e^{-0.93t}]$	$F=0.6+9.8[1-e^{-1.21t}]$
COMPACTED	$F=2.16+34.8[1-e^{-0.73t}]$	$F=4.80t+36.4[1-e^{-0.68t}]$	$F=1.0t+9.4[1-e^{-1.13t}]$

4.2.5 OTHER PARAMITERS

4.2.6 Other parameters obtained from the analysis

The table below shows the values of some parameters used in deriving the f and F equation - See table 4.2 and 4.3.

PLOT	N.C.R.I.			GUINNESS			N.Y.S.C.		
	Time (Min)	fo	fc	time	fo	fc	Time	fo	fc
TILLED	70	151.8	6.0	150	65.16	2.76	150	22.56	0.6
UNTILLED	150	99.96	1.92	150	42.72	5.16	150	12.36	0.6
COMPACTED	150	27.60	2.16	150	29.52	4.80	150	11.58	1.0

4.3 DISCUSSIONS OF RESULTS

In the discussions of the results, the following limitations must be observed:

1. The moisture test was carried out at a depth of 0 - 15cm, 15 - 30cm and 30 - 45cm.
2. The volume of the sample cup used is 280.97cm^3.
3. A double ring infiltrometer of 30cm inner diameter and 60cm outer diameter was locally constructed and used with a thickness of 0.15cm.
4. The time of refilling the inner and outer cylinder after every reading varies with about 2 seconds.
5. Depth of installation of the cylinders at different sites varies but it is assumed that the experiments are subjected to the same conditions for all plots.
6. The soil moisture, texture and other properties varies at different plots under different conditions.

7. The condition of the soil vary due to the history and cultural practices on the soil.
8. The calibration could not be done due to the fact that a standard infiltrometer could not be secured for the experiment.

The limitations mentioned above will no doubt affect the results of the experiments obtained.

The results showed that the infiltration rate is higher in tilled soil than the non-tilled soil or compacted tractor tracks soils. This is attributed to the loss nature of the tilled soil and void spaces been created, the undisturbed nature of soil in the untilled soil and the increased soil strength in compacted soil.

This will affect the water that will infiltrate into the soil at a given time. The rate of runoff will be high in soil of low infiltration and hence proper drainage is needed to curtail water logging problem.

The graphs of average infiltration rate versus ponding time for the three sites at different conditions have their points scattered. A curved slope is obtained in this graph. From this graph it is observed that the scattered point is due to the difference in the soil Bulk density porosity and moisture. The graph representing Guinness has the highest infiltration rate. The graph of N.Y.S.C. has the lowest infiltration rate - See Fig (4.1 - 4.3)

The values of the graphs for the tilled soil is higher than that of non-tilled and compacted soil.

The graphs of the infiltration rate versus accurmulated depth for the sites have the same pattern but different values. This is due to the difference in moisture percentage bulk density and the different texture of soil. The physical properties and chemical properties of the soil also varies.

The points of the graph are scattered but the points falling on the best straight line is plotted.

The infiltration rate and accummulated depth of Guinness is the highest with that of N.Y.S.C. being the lowest.

The high clay percentage of N.Y.S.C. farm makes the infiltration rate low in this farm. The infiltration rate is higher on tilled soil than non-tilled and compacted.

The semi log graph of log f versus ponding time has scattered points too. The points along the best straight line is plotted for this graphs.

The ponding time for the tilled plot is not the same due to the different moisture of the soil bulk,density and porosity. Log f is higher in Baddeggi than tilled plots but the time is low this is due to the initial high rate of infiltration compared to the other farm plots.

The non-tilled plot graph has the highest log f in Guinness this is due to the sandy nature of Guinness soil.

For the compacted soil for all plots, the values of the logf and time is closely related. This is due to the effect of compaction on all the plots. Although there is higher initial value of log f in the N.Y.S.C. farm this is due to the low infiltration nature of the clayey soil and less effect of machine compaction in th[illegible] rm.

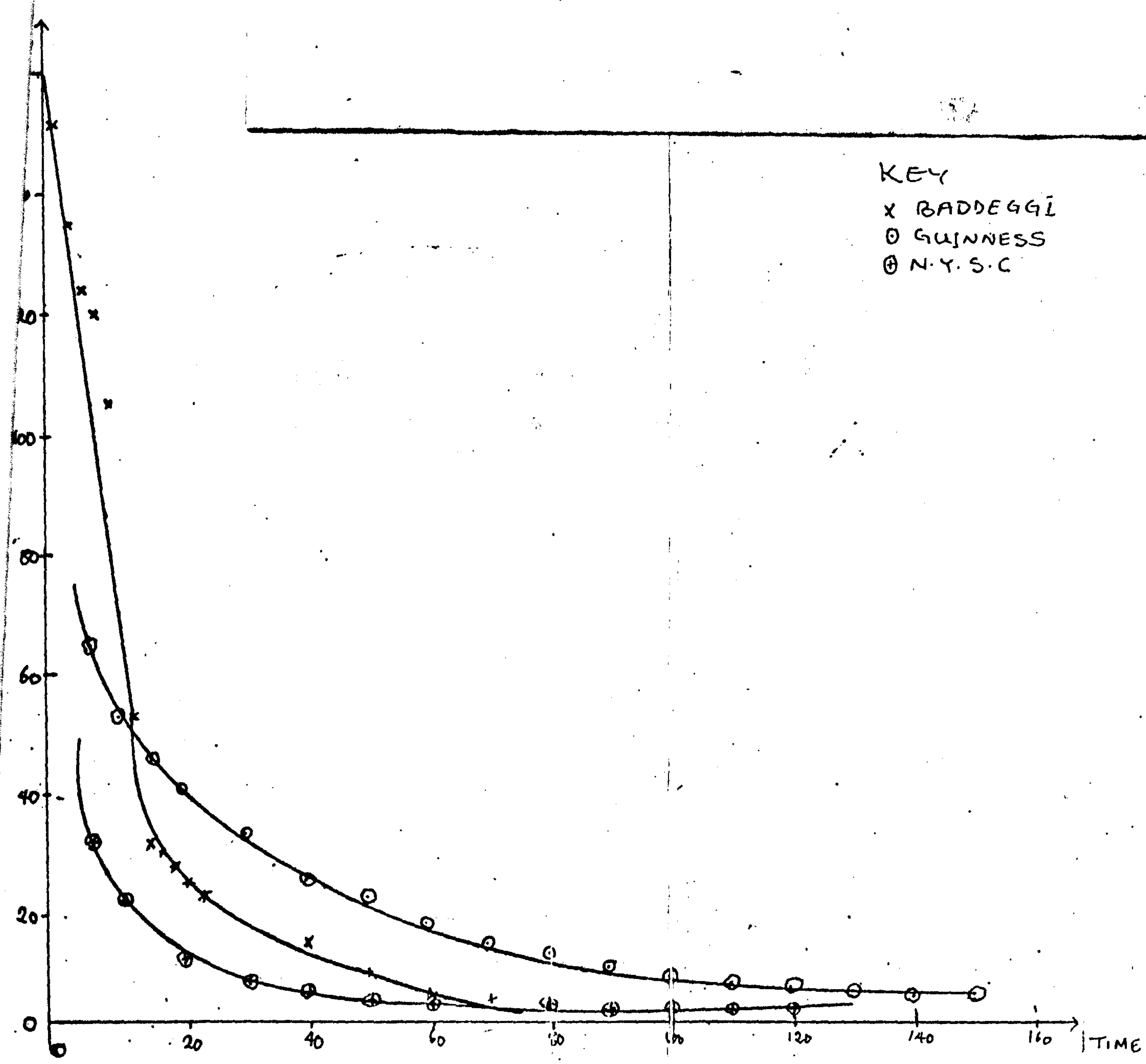
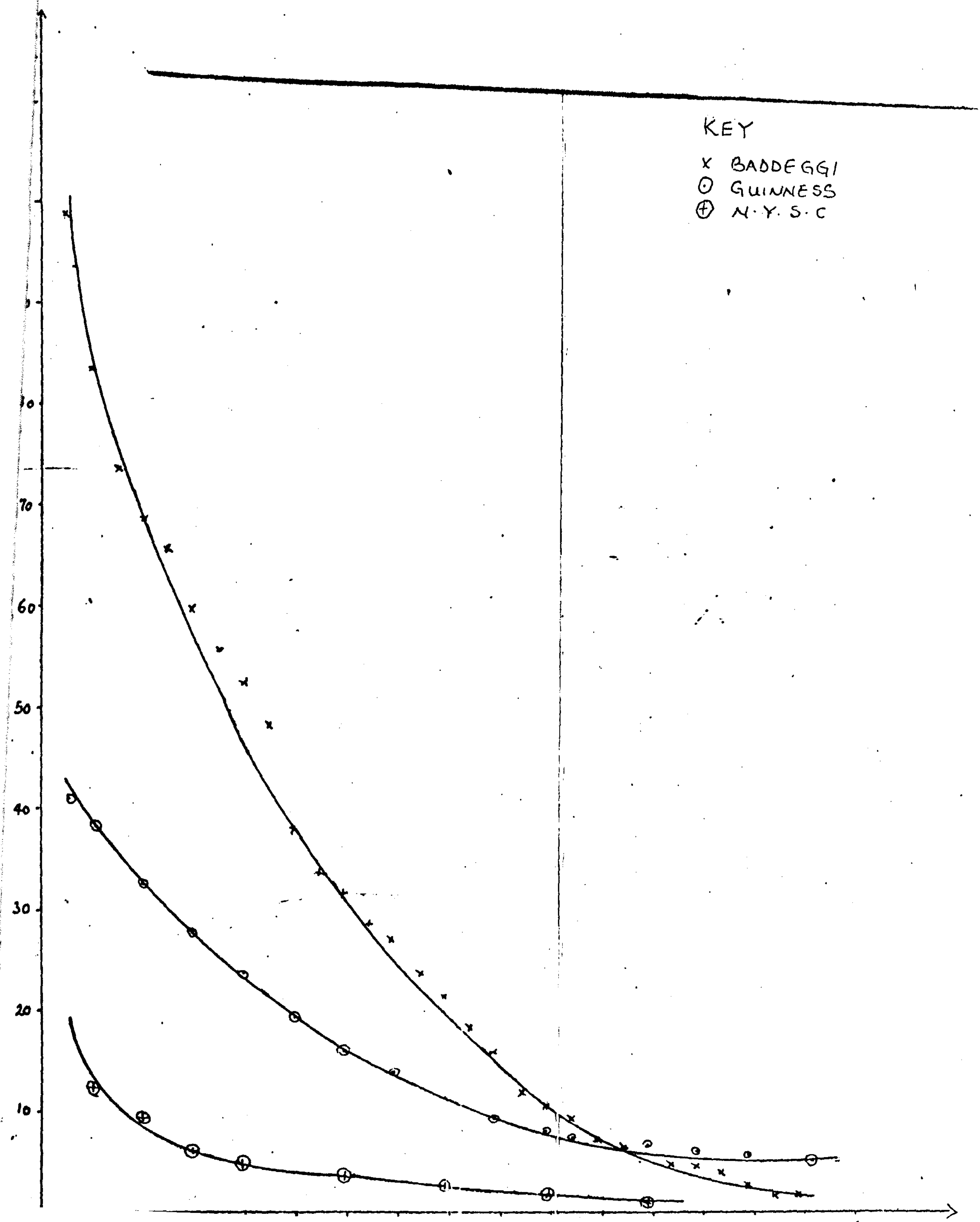


FIG. 4.1 AVERAGE INFILTRATION RATE VERSUS PONDING TIME FOR BADDEGGI, GUINNESS AND N.Y.S.C FARM


KEY
x BADDEGGI
⊙ GUINNESS
⊕ N·Y·S·C
10
20
30
40
50
60
70

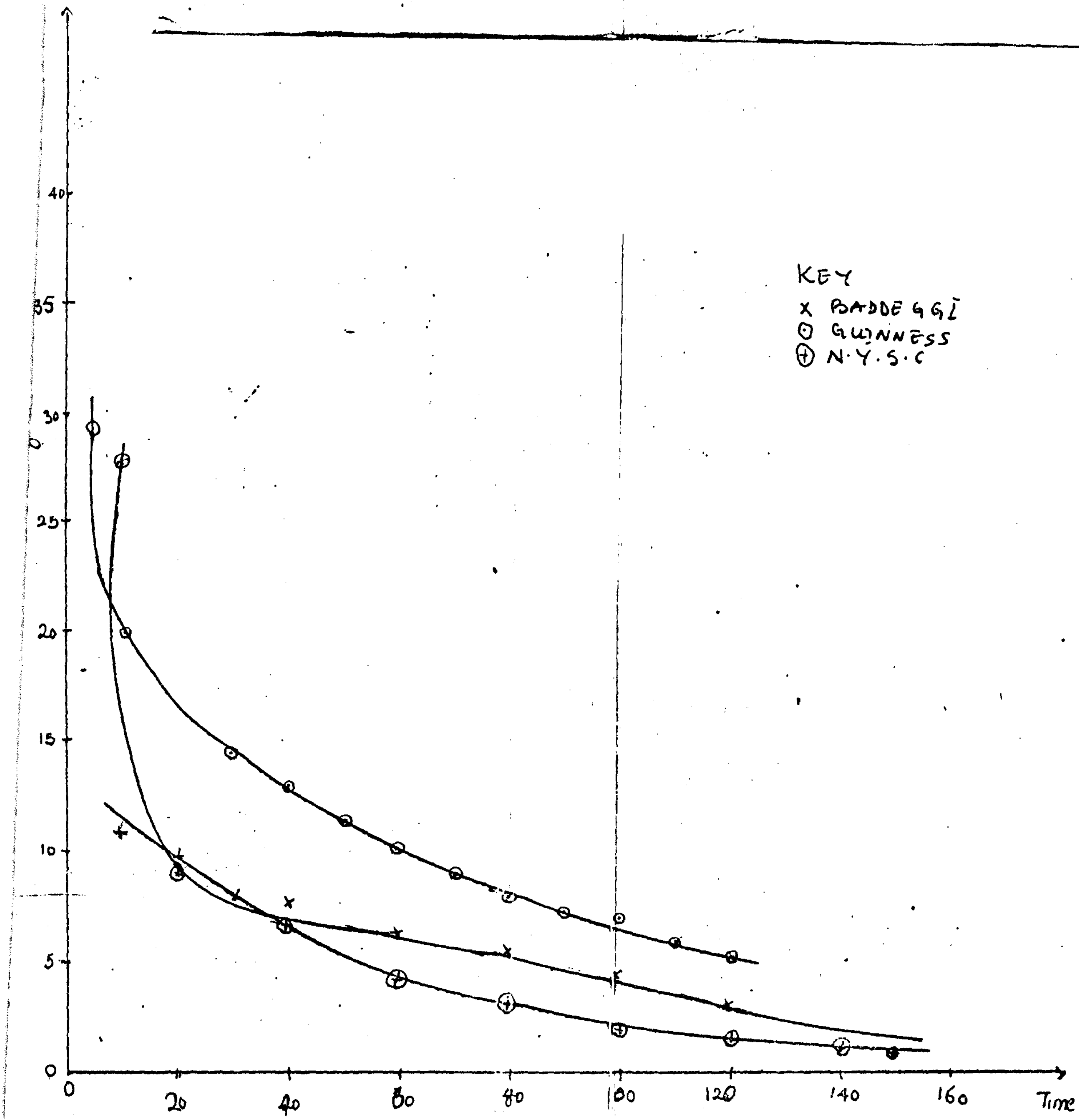


Fig. 4.3 AVERAGE INFILTRATION RATE VERSUS PONDING TIME FOR BADDEGGI, GUINNESS AND N.Y.S.C FARM FOR

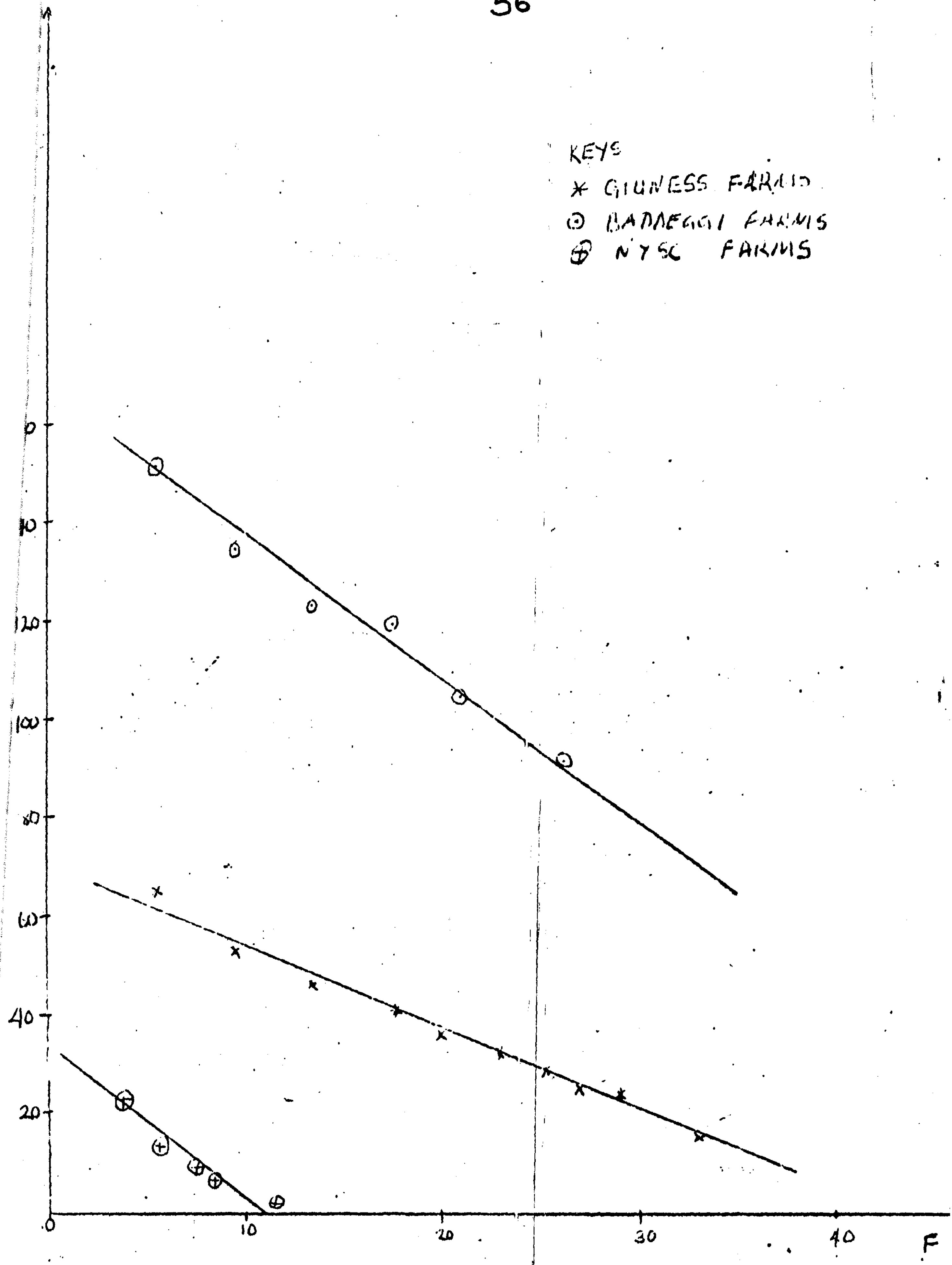
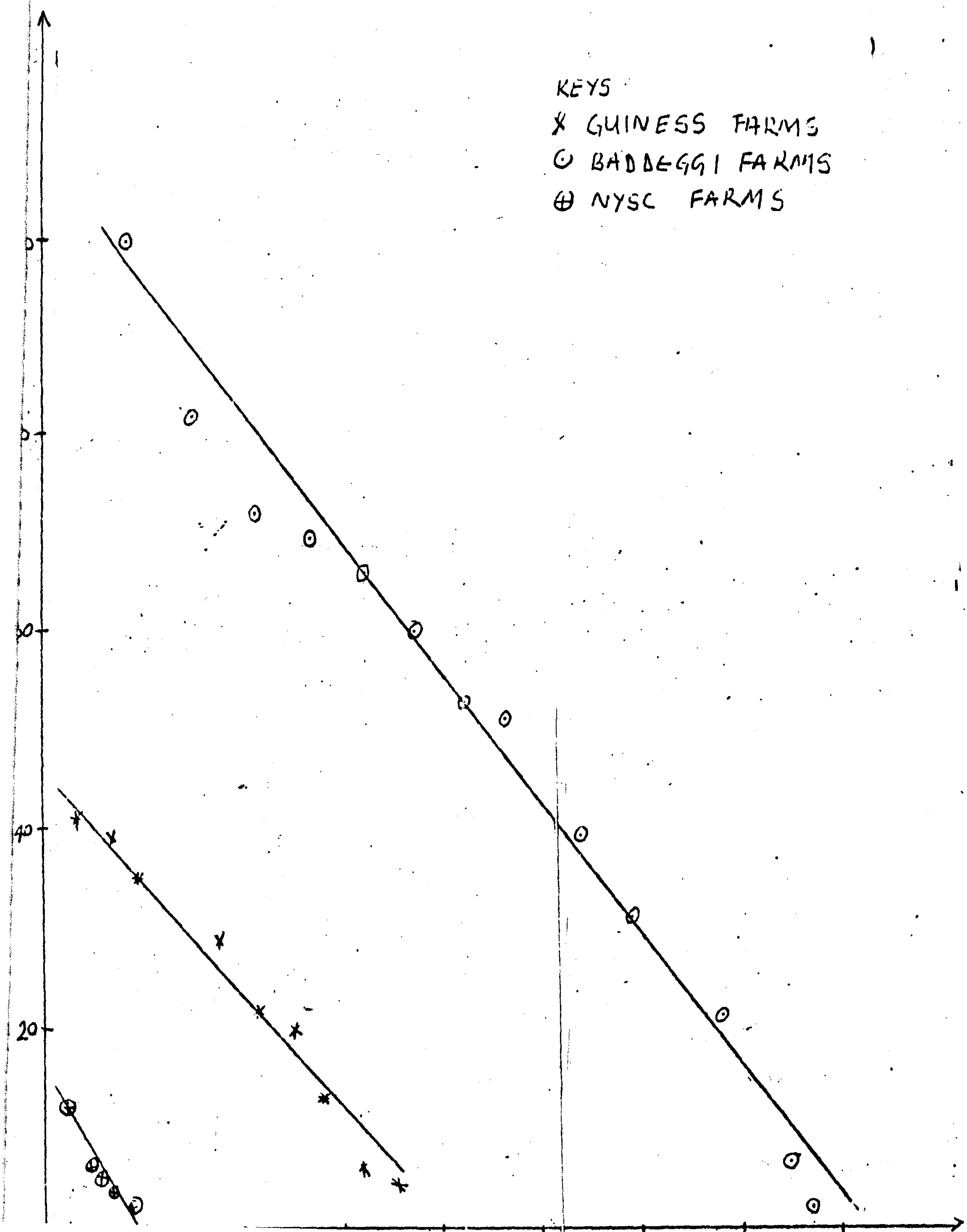


Fig 4.4 INFILTRATION RATE VERSUS ACCUMULATED DEPTH FOR TILLED PLOTS


KEYS
GUINESS FARMS
BADDEGGI FARMS
NYSC FARMS
40
20

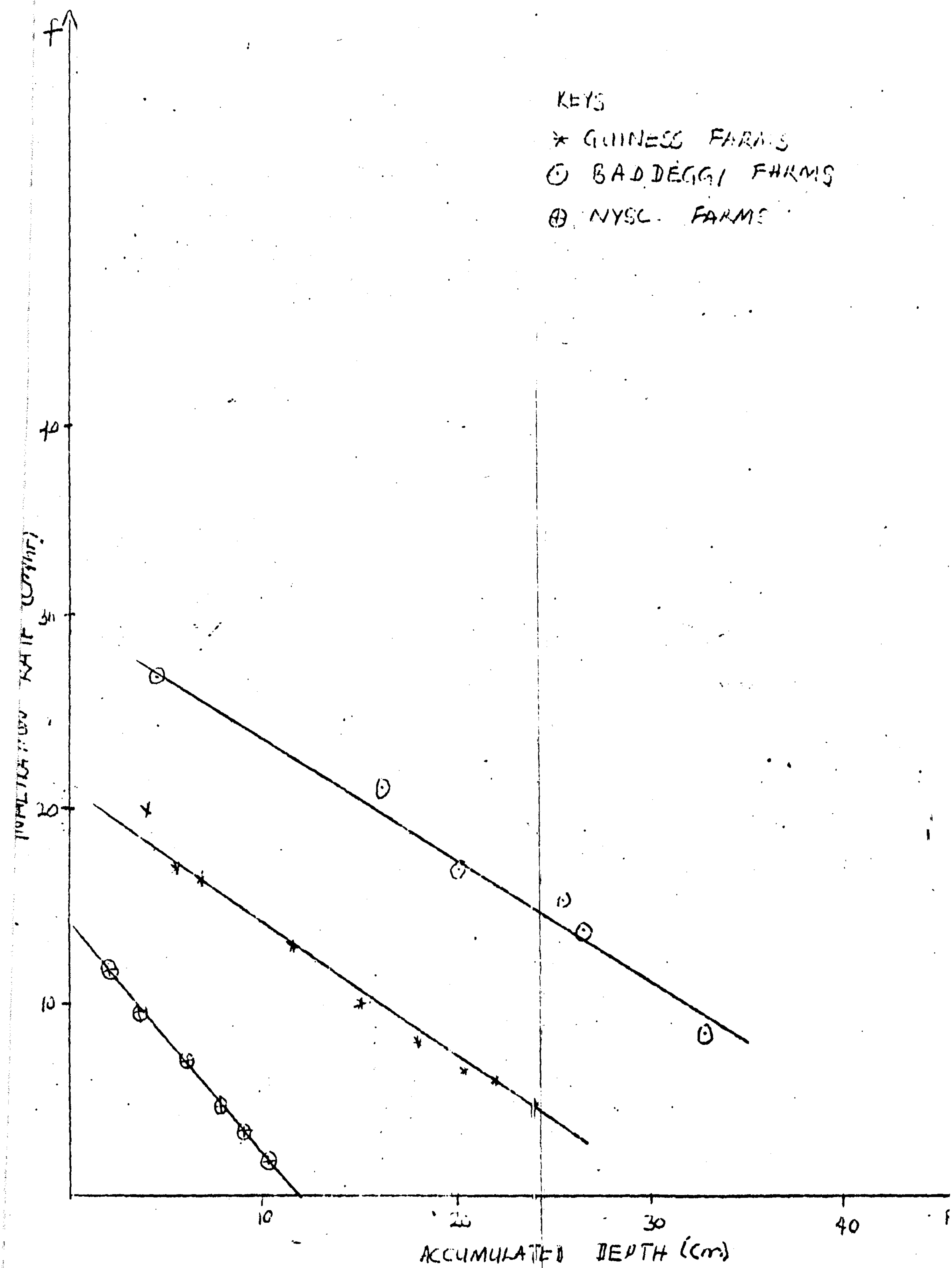


FIG. 4·6 INFILTRATION RATE VERSUS ACCUMULATED DEPT

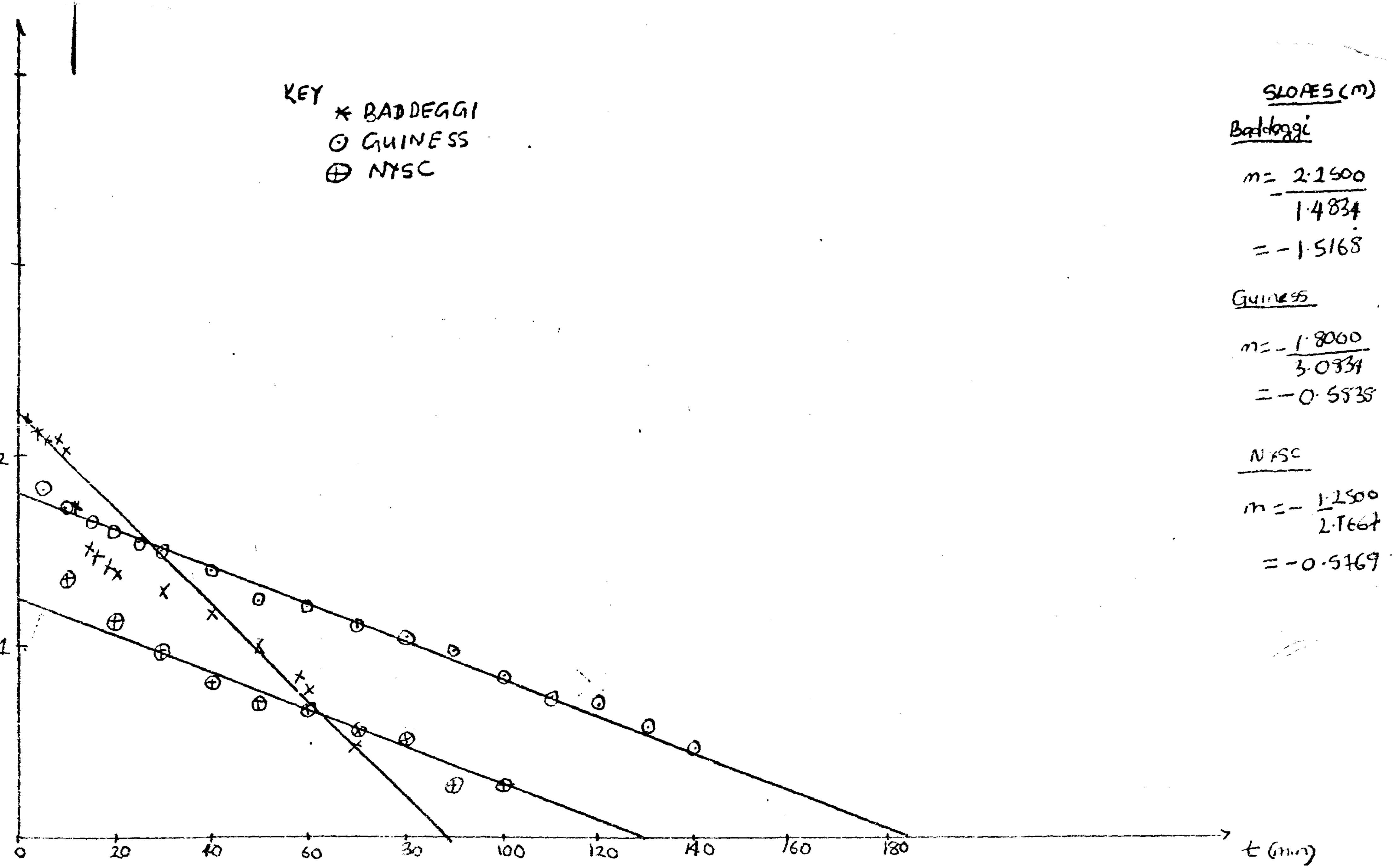
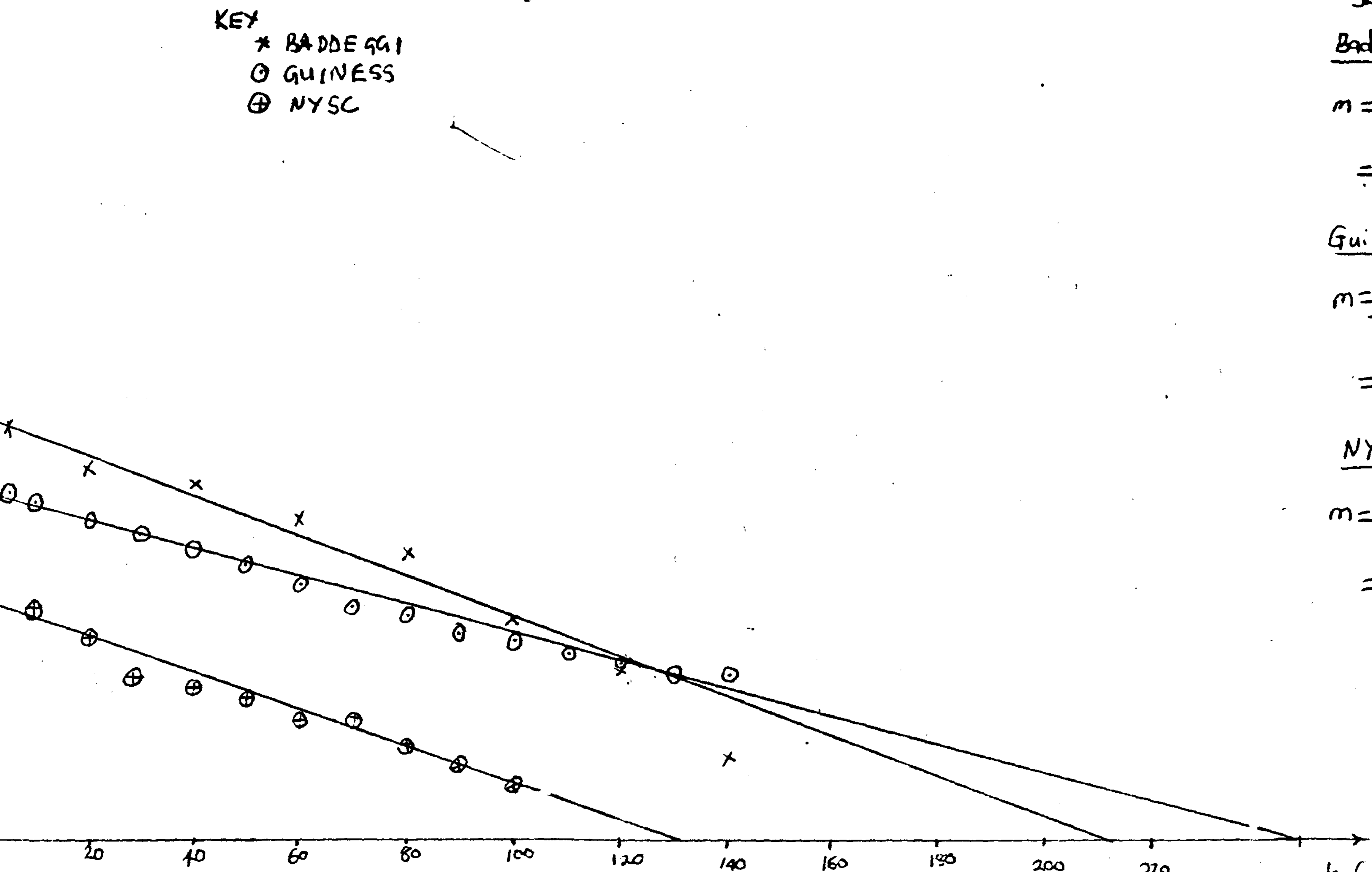


FIG 4.7 PLOT OF Log f VERSUS PONDING TIME t FOR BADDEGGI, GUINNESS AND N.Y.S.C TILLED PLOTS



SLOPES (m)

Baddeggi

$m = -\frac{2.025}{3.550}$

$= -0.5704$

Guiness

$m = -\frac{1.6625}{4.1333}$

$= -0.4022$

NYSC

$m = -\frac{1.150}{2.200}$

$= -0.5227$

Fig 4-8. PLOT OF Log f VERSUS PONDING TIME t FOR BADDEGGI, GUINNESS AND N.Y.S.C NON-TILLED PLOTS

SLOPES (m)

Baddeggi

$m = -\frac{1.1750}{3.7334}$

$= -0.3147$

Guiness

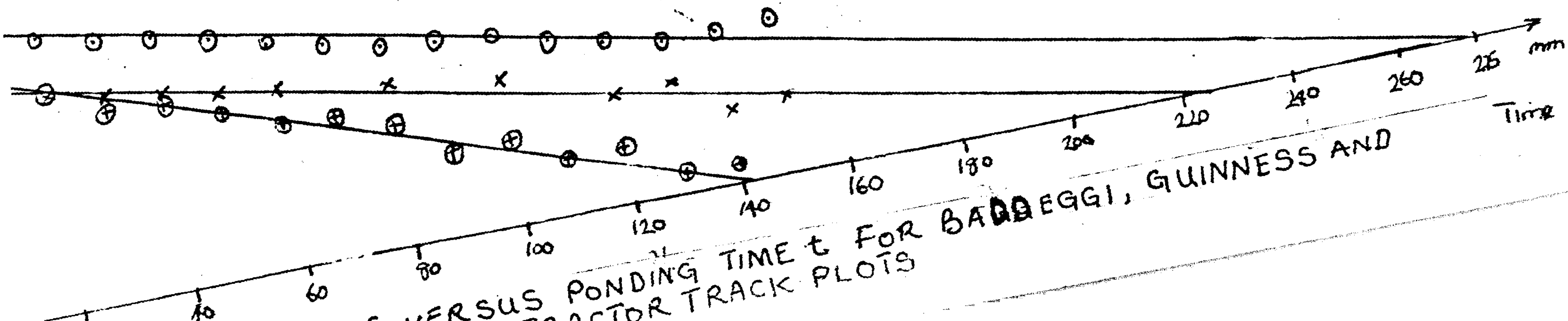
$m = -\frac{1.3500}{4.5667}$

$= -0.2956$

NYSC

$m = -\frac{1.1625}{2.3667}$

$= -0.4912$



... VERSUS PONDING TIME t FOR BADDEGGI, GUINNESS AND ... TRACTOR TRACK PLOTS

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

From the result obtained so far, the following conclusions were drawn:

i) The infiltration charateristic equations were obtained for each site at different conditions of tilled, non-tilled and compacted area - (Seee Table 4.2 - 4.3)

ii) From the characteristic equations derived the design of any irrigation system should consider these equations, before implementing the design. Soil characteristic equations should equally be derived for other soils to be considered for any irrigation system.

iii) An intake characteristic equation was developed for the use of the design of a workable and efficient irrigation system for the Farm of study.

From the experiments carried out so far and the results obtained the different characters of soils under differe conditions has given an idea of what one will expect if an irrigation system is introduced on these sites.

From the N.C.R.I. farm, it can be observed that under any condition, a minimum infiltration depth of about 5cm will be achieved every 30 minutes. Therefore in the design of any irrigation system, these results must be strictly adhered to so as to effect a proper water management. A depth of 8cm is attained after 30 minutes of infiltration in Guinness farms.

For the N.Y.S.C. farm, a depth of about 4cm will be attained after 30 minutes of water infiltration under the given soil condition.

This will mean that in the design of an irrigation system for this sites therate of water discharge/percolation on these sites must not exceed the limits given above at the stipulated time to

... irrigation water management and to prevent runoff

5.2 RECOMMENDATION

The compacted areas in the field should be reduced to the minimum area due to its negative effect infiltration rate. Although this cannot be completely eradicated but measures can be taken to reduce and guide against compaction .

These are:

- Implements with wide width of coverage should be used to reduce the number of machine travel on a field.
- There should be paths for machine movement to guide against random movement of machine on thefield.
- The use of very heavy machines should be reduced and appropriate machine should be used for the best suited operation.

- Since the effect of compaction is adverse the use of manure and deep tillage should be encouraged in mechanized fields.

It will be of advantage to always till the soil before any planting season so that the soil will accummulate enough moisture to meet the management allowable deficiency for different crops to be grown. This is due to the fact that infiltration rate is higher in tilled soil.

For the N.Y.S.C. farm, deep tillage is required because of the nature of the soil and the low infiltration rate.

A system like the border system of irrigation is good for this soil with low intake rate.

A good drainage system is also essential for all the types of soil encountered to prevent erosion.

/64....

APPENDIX A

Formulae used in the computation of parameters

(a) Horton's equation (1940)

$$f = fc\ t\ (fo - fc)e^{-kt} \quad \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots(1)$$

Where

f = Infiltration capacity or the maximum rate at which soil under a given condition can take water through its surface (LT^{-1})

fc = The constant infiltration capacity as t approaches infinity.

fo = Infiltration capacity at the onset of infiltration

k = A positive constant for a given soil and initial condition.

t = Time

(b) Infiltration rate equation from $f = fc + (fo - fc)e^{-kt}$ ....(1)

Finding log on both sides

$$f = fc + (fo - fc)e^{-kt}$$

$$\text{Log } f = \text{Log}fc + \text{Log }(fo - fc) + \text{Log } e^{-kt}$$

$$\text{Log } f = \text{Log }[fc\ \frac{(fo)}{fc}] + \text{Log } e^{-kt}$$

$$\text{Log } f = \text{Log } fo + \text{Log } e^{-kt}$$

$$= \text{Log } fo - K.t \log e$$

$$\text{Log } f = \text{Log } fo - K \text{ Log } e.t \quad \ldots\ldots\ldots\ldots \quad (2)$$

$$y = c + mx$$

$$\text{Slope} = m = -k \log e \quad \ldots\ldots \quad \ldots\ldots \quad ..(3)$$

$$\text{Intercept} = c = \log fo$$

$$y \text{ axis} = t$$

$$\text{Slope } m = \frac{y2 - y1 \text{ (Difference along y axis)}}{x2 - x1 \text{ (Difference along x axis)}}$$

(c) Accummulated infiltration Equation

$$F = \int_o^t f\,dt$$

$$= \int_o^t fc + (fo - fc)e^{-kt}\,dt$$

$$= \int_o^t Fc\,dt + \int_o^t (fo - fc)e^{-kt}\,dt$$

$$F = fct + (fo - fc)\left[-\frac{1}{k}e^{-kt}\right]_o^t$$

$$F = fct + \frac{fo - fc}{k}\left[-e^{-kt} + e^{\circ}\right] \quad \ldots\ldots\ldots \quad (5a)$$

If fo - fc = a

$$F = fct + \frac{a}{k}\left[-e^{-kt} + e^{\circ}\right]$$

$$F = fct + \frac{a}{k}\left[1 - e^{-kt} + e^{\circ}\right]$$

$$F = fct + \frac{a}{k}\left[1 - e^{-kt}\right] \quad \ldots\ldots\ldots \quad (5b)$$

(d) Gravimetric water content percentage equation

$$Qg = \frac{Mw}{Ms} \times 100 \quad (\%) \quad \ldots\ldots\ldots \quad (6)$$

Qg = Gravimetric water content percentage

Mw = Weight of water minus weight of can

Ms = Weight of soil after oven drying minus weight of can

(e) Bulk density equation

$$B.d\ (Db)\ \frac{Ms}{v} \quad (g/cm^3) \quad \ldots\ldots\ldots \quad (7)$$

Ms = Weight of soil after oven drying

v = volume of sample core = IIr^2h

B.d (Db) = Bulk density dry base

(f) Total porosity equation

$$Tp = 1 - \frac{B.d}{D.p}\ (Db) \times 100 \quad (g/cm^3) \quad \ldots\ldots\ldots \quad (8)$$

Tp = Total porosity %

B.d (Db) Bulk Density dry base (g/cm^3)

Particle density is 2.65 $(g.cm^3)$

Other formula

for the gravimetric test

(i) Moisture difference

Moisture difference = (Wet base weight of Soil sample - weight of can) - (Weight of dry soil - weight of can.)

(ii) Average Depth cm = $\frac{\text{Sum of all the depth replications}}{\text{Number of replications}}$

(iii) Average Rate (cm/hr) = $\frac{\text{Average depth x 60}}{\text{Time difference /interval}}$

(iv) Accummulated infiltration depth cm = Addition of initial depth and the present reading

APPENDIX B

Samples of calculations of parameters

Appendix B 1

(i) Gravimetric water content percentage

For the one replicates of 0 - 15cm depth of the National Cereals Research Institute Plot A

$$Qg = \frac{Mw}{Ms} \times 100$$

Parameter are as fined in Appendix A

$$\frac{499.05 - 0.45}{460.72 - 0.45} \times 100$$

$$= \frac{498.60}{460.27} - 460.27 \times 100$$

$$= \frac{38.33}{460.67} \times 100$$

$$= 8.32 \%$$

(ii) Bulk Density

$$Bd\ (Db) = \frac{Ms}{v}$$

This calculation shows the bulk density for the 0 - 15cm depth of Plot A, first sample at N.C.R.I.

$$B.d\ (Db) = \frac{460.27}{280.97}$$

$$= 1.63 \quad g/cm^3$$

Where Volume $= v = II \times r^2 \times h$

$$= II \times 3.5^2 \times 7.3$$

$$= 280.97 \ cm^2$$

Total Porosity

(iii) Total porosity for the first sample of Plot A experiment at N.C.R.I. 0 - 15 depth

$$1 - \frac{1.63}{2.65} \times 100$$

$$= \quad 38.49 \qquad (g/cm^3)$$

APPENDIX B 2

Calculation pertaining to other equations

All calculations in this section will be with respect to the experiment of the first experiment on Plot A of the Guinness Farm

i) Moisture difference $= \frac{548.35 - 0.45}{512.43 - 0.45}$ wet soil - can / dry soil - can

$= 547.90 - 511.98 = 36.32$ gram

ii) Moisture content percentage

$= \frac{\text{Moisture Difference}}{\text{Dry Weight}} \times 100$

$\frac{36.32}{511.98} \times 100$

$= 7.09\%$

iii) Average Depth $= \frac{5.5 + 5.3 + 5.5}{3}$

$= 5.43$ Gm

iv) Average depth $= \frac{5.43 \times 60}{5}$

$= 65.16$ cm/hr

v) Accummulated infiltration $= 0.00 + 5.43$

$= 5.43 + 4.43$

$= 9.86$ .... t

Slope

The slope of plot A of N.Y.S.C. is calculated

$M = - \frac{1.2500}{2.1667}$

$= - 0.5769$

Infiltration rate for the 10 minutes of infiltration on Plot A of N.Y.S.C. farm

$f = fc + (fo - fc)e^{-kt}$

from equation

$f = 0.6 + (22.56 - 0.6)e^{-1.33t}$

at 10 minutes

$= 0.6 + 21.96\ e^{-1.33 \times 10}$

$= 0.6 + 21.96\ .\ 2.72^{-13.3}$

$f = 0.60$cm for 10 minutes . of . infiltration (

Accummulated infiltration . for . Plot A at 10 minutes

$$F = fct + \frac{fo - fc}{k}[1 - e^{-kt}]$$

from the equation

$$F = 0.6\ t + \frac{22.56 - 0.6}{1.33}[1 - e^{-1.33t}]$$

At 10 minutes of infiltration

$$0.6 \ .\ 10 + \frac{22.56 - 0.6}{1.33}[1 - 2.72^{-1.33\ .\ 10}]$$

$$6.0 + \frac{21.96}{}[1 - 0.00000166]$$

$$= 6.0 + 16.51 \quad [0.99999834]$$

$$F = 22.51$$

Interpolation

YD = C x D - X2) ÷ (X1 - X2) x (Y1 - Y2) + Y2

X1 = ne increment of the table above the desired value

X2 = The reading in table for X1

X2 = the increment of the table below the desired value.

Y2 = the reading in the table for X2

Xb = the number at which the desired reading is found.

Example of the Baddeggi Plot A Iteration

X1 = 2 Y1 = 5.06 XD = 5

X2 = 8 Y2 = 17.69

YD = (XD - X2) ÷ (X1 - X2) x (Y1 - Y2) + Y2

YD = (5 - 8) ÷ (2 - 8) x (5.06 - 17.69) + 17.69

APPENDIX C

Determination of the value of k for Plot A

From the graph slope m = - k log e m = - 0.4330 k

For N.C.R.I.

M = - 0.4330 k

- 1.5163 = - 0.4330 k

$k = \frac{1.5163}{0.4330} = 3.5030 \simeq 1.35$

For Guinness

M θ - 0.4330 k

- 0.5838 = - 0.4330

$K = \frac{0.5838}{0.4330}$ 0 1.3483 $\simeq$ 1.35

For N.Y.S.C.

M = θ.4330 k

- 0.5769 = - 0.4330 k

$K = \frac{0.5769}{0.4330}$ 0 1.3323 $\simeq$ 1.33

Determination of the value of k for Plot B

For N.C.R.I.

M = - 0.4330 k

- 0.5704 = - 0.4330 k

$K = \frac{0.5704}{0.4330}$ 0 1.3173 $\simeq$ 1.32

For Guinness

M = - 0.4330 k

- 0.4022 = - 0.4330 k

$k = \frac{0.4022}{0.4330} = 0.9289 \simeq 0.93$

For N.S.Y.C.

M = - 0.4330 k

- 0.5227 = - 0.4330 k

$K = \frac{0.5227}{0.4330} = 1.2072 \simeq 1.21$

Determination of the value of k for Plot C

For N.C.R.I.

$M = - 0.4330\ k$

$- 0.3147 = - 0.4330\ k$

$K = \frac{0.3147}{0.4330} = 0.7268 \simeq 0.73$

For Guinness

$M = - 0.4330\ k$

$- 0.2956 = - 0.4330\ k$

$K = \frac{0.2956}{0.4330} = 0.6827 \simeq 0.68$

For N.Y.S.C.

$M = - 0.4330\ k$

$- 0.4912 = - 0.4330\ k$

$K = \frac{0.4912}{0.4330} = 1.1344 \simeq 1.13$

APPENDIX D 3

GUINNESS FARMS KUDU

RAINFALL MEASUREMENT RECORD FROM THE METROLOGY OFFICE

RAIN FALL DATA FOR GUINNESS FARM FROM 1990 - 1994

MONTH	1990	1991	1992	1993	1994
January	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	0.00
March	0.00	30.20	0.00	36.30	0.00
April	19.00	45.00	36.30	28.00	63.00
May	201.00	286.00	29.10	166.20	116.00
June	113.00	191.00	99,80	123.10	193.00
July	281.00	123.4	134.00	299.00	315.00
August	161.00	169.00	115.30	121,40	184.40
September	160.00	56.00	227.00	382.00	158.00
October	60.00	40.00	17.00	51.00	219.00
November	0.00	0.00	0.00	0.00	0.00
Dcember	0.00	0.00	0.00	0.00	0.00

FROM GUINNESS AGRONOMY DEPARTMENT

NATIONAL CEREALS RESEARCH INSTITUTE BADDEGGI

RAINFALL MEASUREMENT (mm) RECORD FROM THE METROLOGY OFFICE

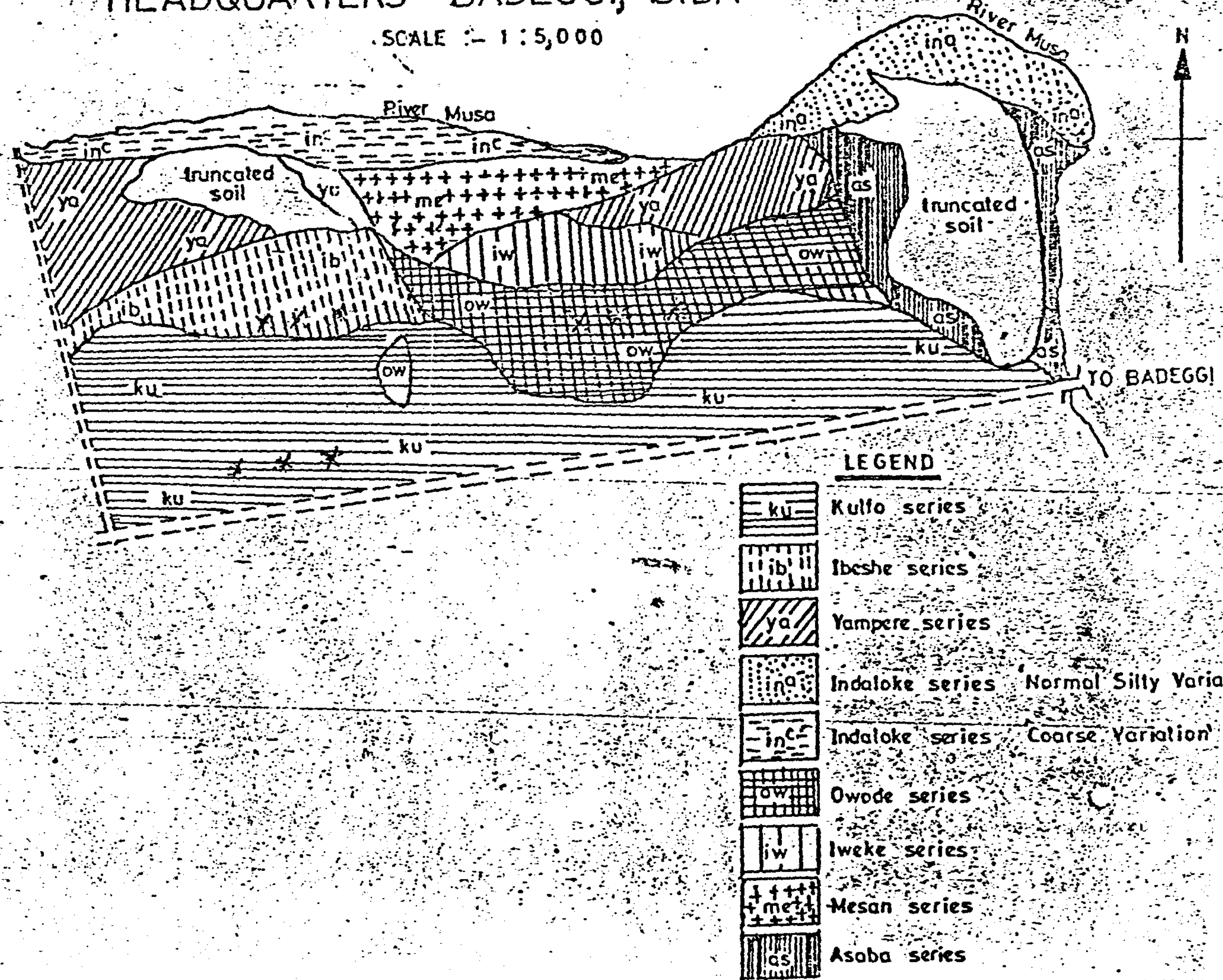
RAINFALL DATA FOR N.C.R.I. FARM FROM 1990 - 1994

MONTH	1990	1991	1992	1993	1994
January	0.00	0.00	0.00	0.00	0.00
February	0.00	0.00	0.00	0.00	0.00
March	0.00	0.00	0.00	61.60	0.00
April	127.30	98.30	141.70	8.90	38.90
May	101.90	109.70	136.60	154.70	171.90
June	145.60	113.40	133.90	241.80	151.40
July	165.50	155.20	128.60	206.90	75.80
August	140.70	268,90	148.40	308.40	425.70
September	105.60	187.80	216.00	240.40	194.00
October	41.40	107.30	31.50	152.80	102.10
November	0.00	0.00	0.00	0.00	0.00
December	0.00	0.00	0.00	0.00	0.00

FROM N.C.R.I AGRONOMY DEPARTMENT.

NATIONAL CEREALS RESEARCH INSTITUTE BADEGGI, P.M.B 8 BIDA
SOIL MAP OF THE FARMLAND OPPOSITE THE INSTITUTE'S HEADQUARTERS BADEGGI, BIDA

SCALE :- 1:5,000



FROM N.C.R.I AGRONOMY DEPARTMENT