SOIL MOISTURE BALANCE: A CASE STUDY OF FEDERAL UNIVERSITY OF TECHNOLOGY BOSSO CAMPUS EXPERIMENTAL FARM LAND.

BY

HUSSAINI ANGULU GABI

PGD/AGRIC/SEET/98/99/55

A

THESIS

SUBMITTED TO THE POST GRADUATE SCHOOL OF
FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA, NIGER STATE.
FOR THE AWARD OF POST GRADUATE DIPLOMA, AGRIC
ENGINEERING (SOIL & WATER OPN)
SCHOOL OF ENGINEERING. FEDERAL UNIVERSIYT OF
TECHNOLOGY MINNA.

AUGUST; 2000.

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CERTIFICATION

I certify that this work was carried out by **GABI HUSSAINI ANGULU** in the Department of Agricultural Engineering, Federal University of Technology, Minna.

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Engr. N.A. Egharevba
(Project supervisor)

Date

………………………… ………………………

Engr. (Dr. M.G. Yisa
(Head of Department Agric Engineering)

Date

……………………… ………………………

Prof. J.O Adeniyi
(Dean Post Graduate School)

Date

DEDICATION.

This work is dedicated to my family.

ACKNOWLEDGEMENT

I sincerely acknowledge the contributions of Engr. N.A. Egharevba My project supervisor who through patience and brotherly advice made this work what it has turned out to be. I also thank him so much for relentlessly reading my manuscripts several times and offering useful pieces of advice. As a result of his guidance and objective criticisms and suggestions, I have been able to achieve more mature and scholarly perspectives. In the same vein, I will thank Engr. Musa who acted as my second supervisor for the useful materials he made available to me.

My thanks also go to all the lecturers in the Department who consciously or unconsciously contributed to the success of this work.

To the management, upper Niger River Basin Minna, especial the Authority's Engineers, officers and staff, I am grateful for their active cooperation.

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For capable and cheerful people of Gabi in Lapal Local Govt. Area.

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My thank goes most especially to our Almighty Allah for allowing me begin this ~~easy~~ course and for me to be able to finish it.

DECLARATION.

I hereby declare that the project work is an original concept wholly carried out by me, under the supervision of Engr. N.A Egharevba Agricultural Engineering, Federal University of Technology Minna.

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Hussaini Angulu

ABSTRACT

Investigation on soil moisture balance carried out at research farm of the federal university of Technology Bosso campus- Minna.

The field was arranged in form of a rectangular grid and them linear interpolation between pairs of points were calculated to locate the points out which the require contours cut the grid line.

Physical properties determined include, moisture content, sieve analysis and hydraulic conductivity. Climatologically data were also collected from Minna Airport and River Basin Authority Meteorological department to determine the rainfall amount, rainfall distribution and frequency.

From the data collected the total amount of rainfall during the time of study was 1224mm.

Average infiltration rate for plot, A,B,C and D are: 24.00cm/hr (Rapid) 8.255cm/hr (moderately Rapid), 9.666cm/hr (moderately Rapid) and 13.10cm/hr (Rapid) respectively.

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CHAPTER ONE

1.0 INTRODUCTION.

The soil moisture balance of an area depends on meteorological factors influencing precipitation and evaporative loss from plants and the soil as other factors influencing surface and subsurface water movement, soil infiltration, percolation, and water storage capacity characteristics, crop special and development stage and agricultural practices. These factors presents enormous problems and means that soil moisture balance studies are inevitable a simplification. The degree of simplification will be related to the purpose of the study. In practice, assumptions and simplifications are adopted. A common assumption is that all the precipitation infiltrates into the soil and therefore, strictly speaking, there is no "surface" runoff, a water surplus occurring only when the soil moisture storage capacity has been exceeded. A second frequent assumption is that the rate of evaporation (transpiration) does not change with change in the amount of available water (O.D. Aveke 1984). If the face that plants may experience difficulty in obtaining water once soil moisture falls below filed capacity, with a resultant fall in evaporate aspiration, is taken into account, then the calculation is sometimes termed a modulated soil moisture balance of a field is a statement of all gains, losses and changes of storage of moisture occurring in a given field within specified boundaries during a specified period of time. The task of monitoring and controlling the soil moisture balance is vital to the efficient management of water and soil. A knowledge of the soil moisture balance is necessary to evaluate the possible methods to minimize loss and to maximize gain and utilization of moisture which is so often the limiting factors in crop production.

Gains of moisture in the field are generally due to precipitation and irrigation. Occasionally, there may be gains due to accumulation of run off from higher. Tracts of land, or to capillary rise from below (especially, where a water table is present at a shallow depth). Losses of moisture include surface runoff from the field deep percolation, out of the root zone (drainage), evaporation. From the soil surface, and transpiration from the crop.

The change in storage of moisture in the field can occur in the soil as well in the plants. The total change in storage must equal the deliverances between the sum of all gains and the sum of all losses. Accordingly, the soil moisture balance equation may be stated as: Gains losses = change in storage $(P + I) - (R + D + E + T) = \Delta s + \Delta v$ (Aveke 1984)

In which, P, is precipitation, I, irrigation, R, runoff from the filed, D, downward drainage out of root zone, E, evaporation. From the soil T, transpiration by the crop, Δs, the change in soil moisture content of the root zone, and Δv. the change in plant content. All of these qualities are usually expressed in terms of groundwater depth per unit land area (ha/cm) or units of depth (cm).

An important consideration in soil moisture balance studies is the period, or time interval, for which the balance is made. Too short a period might be impractical, while too long a period might mask the occurrence of short term critical stages. At such critical stages as flowering and fruit set even temporary imbalance in crop-water statues can have a lasting effect. It is necessary to ensure that the soil moisture balance is maintained positive continuously during the growing season.

The most common cause of plant death is the lack of sufficient water to replace that lost by transpiration. Even a temporary water deficit can sometimes be fatal. Pants have a number of ways of avoiding the build-up of water deficits.

The may increase their efficiency of water intake, for example, by extending their root systems. In irrigation control, it is often considered advisable to allow the development of some deficit, at non-critical periods, to encourage plant to do this. Effective rooting depth tends to increase in decrease in soil moisture and roots are finer and have more and longer branches under moisture stress. Frequent irrigation leads to the development of shallow, horizontally spread root systems which cause problems during dry conditions. Examples of experiments investigating the effects of plant water stress on rooting systems, including implication for irrigation are presented by Meyer and Ritchie (1980)

1.1 OBJECTIVES OF THE STUDY.

The main objectives of this study include the following.

1. To provide a general overview of the water conditions in the study area. Here precipitation potential and actual evaporation, soil moisture are being considered
2. To assess the suitability of the area for a particular crop and vice versa.
3. To asses irrigation requirement both quantity and interval. Alternatively, in the case where there is a surplus, a soil moisture balance will indicate its magnitude and hence drainage requirements.

Or

To advice on irrigation period and frequency: from season flux of water table.

1.2 SCOPE AND LIMITATIONS.

The scope of this research covered only Federal University of Technology research farm, with the view of determining

- Topographic map of the study area.

- Infiltration rate of the study area
- Soil analysis of the study area
- Climatic condition of the area
- Ground water Table of the area
- Hydraulic conductivity of the area

One of the limitations of the study is the relatively short period of the data . Another limitation is the scope in terms of area coverage. The data were collected from a locations and may be if they were to be collected over a wider area, the study will provide insight for agricultural planning.

1.3 JUSTIFICATION

The study is important because it will enable one to assess the soil moisture, use by a tabular crop or vegetation and as well determine the soil moisture yield relationship.

This study is justified because it would form part of a model for investigations rainfall-runoff relationships and stream flow prediction from climatic data

The effect irrigation, changing land use and management practical can be analysed by experiments.

To advise farmer on the best possible irrigation system layout.

To investigate the availability and rate of contribution of ground water to wet water requirement of field crops during growth stage, maturity and pre-harvest.

A knowledge of the soil moisture balance is necessary to evaluate the possible methods to minimize and to maximize gain.

CHAPTER TWO

2.0 LITERATURE REVIEW.

Minna experiences two distinct seasons the dry and wet season, the wet season starts by March and ends in October an average of eight months and the remaining (A) months, November to February covers the dry season period.

Adefolalu (1986) in his contribution explained that during the wet season every where get wet, the rivers, streams filled up to their paves and in some cases over flowing their banks. This can lead to flood. Lack of good water drainage and water channels for easy water flow may lead to water flooding farms, houses and other places which will lead to lost of lives and properties. Ojo 1977 and Obasi el al (1987) show that variability in Nigeria reveal that apart from the rainfall amount other measure of precipitation effectiveness.

Similarly, Denmeed et al (1980) carried out an experiment to determine the effect of soil moisture stress at different stages of growth on the development and yield of corn. During the experiment, plants were subjected to successive drying cycles in which the soil moisture content was depleted to the wilting point at three stages of growth.

In the final analysis, they realized that stem elongation was reduced by stress in the vegetative stage of growth. The rate of stem elongation declined when the available soil moisture was depleted by about 75%. Regarding the leaf area of corn due to moisture stress.

The effect of soil moisture tensions on growth of wheat was examined by Lehane et al (1982). This involved a green house experiment in which wheat was grown on a limited amount of soil moisture

Soil moisture and hence the decision as to appropriate values of the former presents problems this aspect is discussed by change (1968) Baier (1981) and Giambelluca (1986), for example the time period considered for the calculation (i.e month weekly daily basis) is important, Doorenbous and Pruitt (1977) examine soil water balance applications in irrigation scheduling and Baier (1981) considers their use in crop yield models. Oldeman and Frere (1982) describe methods of calculating the soil water balance with particular reference to humid regions of south east Asia. The moisture balance for rice is considered by Robertson (1995) in this case water storage comprising both water in saturated soil and depth in the flooded paddy. Use of the water balance in assessing irrigation, need is considered. In using a water balance approach to estimate evaporation, McGowan and Williams (1989) refer to the problem of distinguishing the later from drainage. They describe, a simple graphical approach to overcome the problem. Problems of soil-moisture assessment, have implication for the use of water balance approaches to estimate water use by a crop, although McGowan and Williams (1980) suggest that neutron probe errors can be made small enough for such a purpose. However, it is because there are problems that a water balance approach to estimate soil moisture is important for various purpose such as those indicated above. To illustrate the application of the water balance method to agriculture, a number of case studies of different of different types will be used.

Dagg (1985) used a simple water balance approach to test the suitability of a marginal area in Kenya for growth of two varieties of maize. The calculations were carried out using monthly values. A reliable rainfall amount which could be expected of years out of 10 on average rather than mean monthly rainfall was used. use was made of E_t/E_o ratios for the two varieties at different states of their growth and an E_o estimate (using the pen an formula) in order to calculate E_t. It was assumed that all the rain infiltrated into the soil. The results of the calculations supported the observed facts of maize cultivation in the area. In particular, the imported variety of maize, which had a shorted growing season then the local variety, but higher water demand at certain stages of its growth, was found at certain stages of its growth, was found to be mare suited to the rainfall season. The local variety, with a longer season, was likely to be subjected to moisture stress towards the end.

Geambelluca (1986) used a modulated monthly water balance to examine hand use impacts on the hydrology of oahu, Hawaii plantation crops (sugar cane and pine apple) hand most impact on ground water recharge, urban influence varying with climate.

Since plant water relations over short period are important, a more detailed analysis than monthly conditions is offer necessary, particularly for irrigation. It was pointed out that some plants suffered a decline in photosynthetic rate. With even slight water stress and therefore, would require frequent irrigation. The complexities of water availability in relation to soil type, rooting habits and transpiration rate were discussed. This will influence the level of moisture which must be maintained in the soil and hence the frequency of irrigation. Therefore, irrigation practices will need water balance calculations over different time periods depending on crop type and environmental conditions. Crops reacting to a slight water stress may need daily or 5 days calculations on, say, a weekly on fortnightly basis.

A water balance approach was adopted by Munro and wood (1984) in analyzing water requirements and yield of Maize in Mahawi. The basis system of irrigation was used and irrigation treatments were based on reaching of an evaporation pan (122cm diameter, 42cm deep used in East and central Africa) multiplied by a series of irrigations factors" ranging from 0.6 to 2.4. A running water balance was kept for each treatment (irrigation factor) and 50mm of water were applied when the cumulated soil water deficit reached or exceeded this amount.

In Uganda, Rikks and Harrop (1989) used a water balance approach in an experiment concerning irrigation and fertilizer use on cotton. For irrigation control, the water balance, including rainfall, irrigation and crop water requirements was used to determine the occurrence of a moisture deficit. The crop water use was determined by applying a serious of crop factors of growth to a pen man open –water surface evaporation figure. An important conclusion was that the use of a water balance approach reduced water expenditure, toward labor cost and gave similar yields to a preset pattern of irrigation at regular intervals.

In Kenya, Lalallib (1983) examined the use of water deficit and crop water use. He assessed the impact of water deficits on yields and also related this to irrigation derived form this experiment were quoted: Hudson (1980) examined the water storage capacities of various soils in Barbados. He then set those in irrigation and cultivation decision making and as the basis for an ecological grouping of sugar estates according to their probable water balances.

A modulated water balance approach was used by smith (1986) fro coconut in Trinidad. He assumed that the ratio of the actual evaporation to the potential evaporation (water freely available) varied linearly with the soil moisture deficit. The water balance approach was used on a weekly basis to determine soil- moisture deficit which was then correlated against yield of dry copra. This relation was compared with the relation between rainfall and in almost every case the soil moisture deficit was more closely related to yield than was rainfall. A regression relation between yield of dry copra and an integrated soil moisture deficit over the 29 months before harvesting was derived. This is an example of a fairly advanced application of the water balance method.

In Colombia, Jones, Pena and Canabaly (1980) used a soil water balance to investigate water relations of several tropical grasses. In both wet and dry seasons dry matter production was closely related to transpiration as estimated by the water balance model. Reddy (1983) used a water balance to estimate soil moisture loss under cropped and fallow situations in India. Estimated evaporation and soil-moisture compared favorable with observed values. Hari Krishna (1982) discussed a water balance mode for small agricultural water sheds in India to evaluate hydrological response to traditional and improved land management techniques.

Stewart and Hash (1982) used a water balance approach for maize in Machakos District, Kenya they evaluated the suitability of a given crop for any location. Individual seasons were categories according to date of rain onset and adequacy of rainfall for maize. This allowed recommendations on seed and fertilizer rates and thinning out of plants to be made and prediction of yields for planning purposes. Porter (1984) used a daily balance with separate scheduling of soil evaporation and crop transpiration in Kenya. Runoff and drainage when soils reached field capacity was made soil specific and there was careful speciation of rooting depth, soil depth, moisture availability and crop transpiration coefficients. Effects on soil moisture of soils with farmyard manure were allowed for.

In southern Brazil, daily modulated soil moisture budgets for corn, soyabeen and upland rice were examined by Damota (1983) and Damota et al (1984). A daily water stress index was calculated, based on the assumption that yield reduction is proportional to reduction in evaporation below the maximum. Indixes were summed and models developed for yield prediction.

Field moisture capacity, the content after natural drainage, is determined not only by the water characteristics of the soil and the layers of the soil profile, but also by the water condition of the subsoil.

Tenasansa (1982) using soil columns of a volcanic ask soil, showed that a considerable amount of water was transferred from the subsoil to the surface soil during a dry season. Kira et al (1983) obtained the same result. They placed a sheet of from horizontally into a test plot at a depth of 45cm to disrupt water transferred from the sub-soil to the surface soil, and measured the changes of water suction is this plot (plot A) and in another test plot (plot B) without the out off. Both plots were protected from rainfall. Although the upland rice in plot A exhibited signs of wilting by mid September, plot B did not show signs of wilting until harvesting began at the end of October.

The suction at 60 and 90cm increased less rapidly in plot A then in plot B. water must have been transferred form the sub-soil to surface soil inconsiderable amounts.

Nakano (1980) found that the amount at of water moving upward form the subsoil to the surface larger was about one third of evaporation aspiration. Nakajimada (1986) observed that water suction at a depth of 45cm in a bare red-yellow soil did not exceed 100cm H_2O even with low rainfall. All these results indicate that a considerable quantity of water moves up from the subsoil.

Percolation of water through the subsoil in rice paddy field is an important management factor for rice culture in Japan. Excess percolation causes a large water requirement injury due to low water temperature, and fertilizer loss. But adequate percolation is said to have some to the soil and eliminating harmful materials (Ishihara 1986).

Isozaki (1987) has shown that maximum rice yields occur at percolation loss values in the range of 10 to 20mm/day.

Brandt et al (1981) studied infiltration from trickler source and concluded that the vertical component of the wetted.

Musa (1984) conducted an experiment in two dimensional water movement from conventional trickle irrigation line source on a sandy loam soil, with two different discharge rates. The result showed that the average vertical advance of wetting front measured at the symmetrical axis of the profile (H_2O) as a function of the volume of water applied indicated that an increase in the conductivity of soil increases the vertical advance but decrease the horizontal advance at both application rates tested.

2.1 GEOLOGICAL FORMATION

The geology of Bosso (Niger state) is divided into the distinct geological zones. The basement complex and the Nupe sand stone. Marklock Group Nigeria limited (1986) final on Niger state Regional planning. The dividing line runs in an approximately straight line N.W. S.E Orientation from just south of Kontagora to just North of Lapai. The other significant, but much smaller, zone is the area of River alluvium which is mainly found along the lower readers of the Kaduna and Gboko rivers as they flow over the Nupe sand stones zone along the river Niger as it runs alongside the states southern boundary. Each geological formation exhibits different topographical, hydrological and soil features which are highly influential in determining existing settlement distribution. (max lock Group Nig. Ltd. 1980).

2.1.0 DESRIPTION AND CLASSIFICATION OF SOIL

The soil as very complex, made up of a heterogeneous mixture of solid, liquid, and gaseous material. The solid phase is composed of a mineral portion, containing particles of varying seizers, shapes and chemical composition is very heterogeneous, containing a diverse population of life, active organism as well as plant and animal residue in different stages of decomposition. The liquid phase consists of soil water, which fills parts or all of the spaces between the solid particles. The water phase containing solute that may have been dissolved form the soil mineral or may have entered through the soil surface. The water phase is held by force in the soil matrix and varies significantly in mobility depending on its location. The gaseous or vapor phase occupied the part of the pore space between the soil particle that is not filled with water, its composition can differ considerable from that of the air above soil surface and may change dramatically in a short time period. The chemical and physical relationship among the constituent of the solid, liquid and gaseous phases are affected not only by the properties of each component but also by temperature, pressure and light.

The soil solid phase has a dominant influence on many water, heat, and solute transport and retention processes therefore, characterizing the physical and chemical properties of the soil, solid phase is essential to an understanding of many of the practical agricultural and environmental problems within the preview of modern soil physical research. The soil phase consists of particles of vastly different shapes and sizes, which range from the lower limit of colloidal state of the coarset fraction of sand and gravel. The different particles, especially those of colloidal dimension may be found in states ranging form almost complete dispersions nearly perfect aggregation. In most solids, however, there is only a partial aggregation of individual particles.

The completely dispense or primary particles are usually referred to as textural separates. The aggregate formed from a consolidation of individual particles are generally regarded as the structural unit. (chow, 1998)

2.2.1 PHYSICAL PROPERTIES OF SOILS

The soil is a complex mechanical system. For a soil to be in good physical condition for plant growth, the water and solid particles must be in the right proportional at all times. Every can of soil that is expected to support plant life must be.

1- Open enough to permit the right amount of rain water or irrigation water to enter the soil, but not so open as to allow excessive loss of water and plant nutrients by deep percolation.

2- Sufficient retention of moisture to supply roots with all needed water, but not so retentive as to create undesirable water tables.

3- Well enough a created to permit all plant root cells to obtain oxygen of all times, but not excessively a crated to the point of preventing a continuous of contact of roots with moist soil particles (Donahue, 1982).

2.2.2 SOIL MOISTURE.

The size of particles making up a soil determine its texture. The particles range than 1.00 millimeter no diameter are gravel, particles from 0.05 to 1.millmedre in diameter are sand, particles from 0.002 to 0.05 millimeter are clay. Most soils contain a mixture of sand, silt and day. If sand particles dominate, the soil is called sand. If clay particles dominate, it is called clay silt falls between clays and sands. Loam are medium textured soils having about equal amounts of clay, silt and sand particles. Sand grains feel grittily to the finger and can be distinguished without difficulty by the unaided eye. Silt barely visible to the flour. The individual particles of the clay fractions many of which are inorganic colloids, are not distinguished by the eye, and a large portion of them are too small to be seen under a microscope it is this fraction that makes soils swell and becomes sticky when wet and becomes brittle on drying (Donahue (1982).

2.2.3 MOISTURE CONTENT

Measurement of water stored in soils and capacity of soils to store water are very important. Some soils produce crops despite the lapse of many clays, and sometimes weeks, between periods of rainfall is evidence of their capacity to store available water, since all growing plants require water continuously.

In irrigated regions the capacity of soil to store available water for the use of growing crops is of special importance and interest because the depth of water to apply in each irrigation, and the interval between irrigation and both influenced by storage capacity of the soil.

Knowledge of the capacity of soils to retain available irrigation water is also essential for efficient irrigation. If the irrigation applies mare water than the root zone soil reservoir can retain at single irrigation, the excess is wasted. If it applies less then the solid will retain, the plant may wilt from lack of water before the next irrigation unless water is applied frequently than otherwise be necessary.

It is important to find the available water capacity for different soil i.e the field capacity less the moisture content at the permanent wilting point. (Vangum, Orson, and Glen (1980).

Method of measuring moisture content includes:

1. Appearance and feel of soil.
2. Gravimetric determination.
3. Using electrical properties of porous block.
4. Tensiometer.
5. Neutron method.

2.3.0 WATER HOLDING CAPACITY

The moisture content of a sample of soil is usually defined as the amount of water lost when dried at 105C, expressed either as the weight of water pr unit weight of dry soil or as the volume of water per unit volume of bulk soil. Although useful, such information is not a clear indication of the availability of water for plant growth the differences exist because the water retention characteristic may be different for different soil.

About half a soil's volume is pore space which is occupied by varying the amount of air and water, depending on how wet the soil is. Water is held in the pore spaces in the form of films adhering to the soil particles the smaller pores in the soil are called micro pores, the larger ones are macropores. Macrospores do not hold well because the water films become too think to adhere well to the surrounding soil particles it is not worthy that drainage takes place within macro-pores and water holding capacity within micropores. (Donahue (1982).

2.3.1 PERMEABILITY.

Permeability is defined as the readiness with which a soil transmit fluids. A high permeability is essential for teaching down the excessive soil or removal of sodium (Na) released by the application of gypsum in alkali soil. Again, the permeability decrease with the increase of dispensability and exchangeable sodium percentage of the soil. Generally water moves slowly downwards through a highly dispersed soil because the micropores are chocked by the swelling to dispersed clay. However, when the applied water contains sufficient divalent cation is suppresses diffused double lay of clay particles and increase soil permeability. Soil permeability also depends on soil texture, structure and depth of the water table. (David, Eagle and Finnery 1986).

2.3.2 SOIL PLANT WATER RELATIONSHIPS

Soil- plant water relationships relate to the property of soil and plant that affect the movement, retention and use of water. Soil provides the room no water to be used by plant through the roots present in the same medium. Water, as such and also as a carrier of large amount of nutrient is required in a large measure for the successful growth span of a crop, it becomes essential to apply additional water to the soil for plant use in the from of irrigation. The rate of entry of water into the and its retention, movement and availability to plant roots are physical properties of soil in relation to water from efficient management of irrigation agriculture (Michael 1985).

2.4.0 PHYSICAL HYDROLOGY AND WATER STORAGE

The infiltration capacity of a soil depends on the availability of water, porosity, the vegetative cover as well as on the intensity of rainfall. All loose, permeable soil has a higher in filtration capacity than a compacted clayed soil. A high intensity rainfall tends to clog the soil intensities with finer particles through impact action and therefore tends to reduce the rate of infiltration grass and other vegetation cover reduce the impart of rain drops on the soil and therefore, enhance its infiltration. Since the water content of a soil changes as it absorbs water, the infiltration capacity of the ground changes continuously during a rain storm until saturation is reached. Before saturation, the infiltration rate is normally equal to the intensity of rainfall equal to the intensity or rainfall both being less than the infiltration capacity. However as saturation is approached, infiltration rate approaches the reduced infiltration capacity. The excess of rainfall over the infiltration water accumulates and begins to flow as surface run off. (Michael (1985).

2.4.1 HYDROLOGICAL CYCLE.

All stream flow into the sea, yet the sea is not full though the streams the streams are still flowing (Ecclesiastics 1:7). The explanation of this enigma is so well known today even to the school child that we often forget that the role play by evaporation and perspiration is far from obvious and it was not fully understood until modern times. The origin and movement of ground water was less obvious to the ancients. Today we can visualize the ever changing migration of atmospheric, surface and ground water as a complex interdependent called collectively the hydrological cycle. figure 2:1:0 Although the hydrologist is concerned chiefly with ground water, all aspects of the hydrological cycle must be understood at least in genera way before an accurate picture of the subsurface portion of the cycle can be achieved.

The oceans are the immense reservoir from which all water originate and to which all water returns. This statement is somewhat simplistic because not all water particles are in the process of completing the hydrological cycle at all times. They are built in loops for example, when water evaporate from land and returns to land as precipitation only evaporate and so on. But in its most elaborate cycle, water evaporate from the ocean forms cloud. Which moves inland and condense to fall to the earth as precipitation. From the earth though river and under ground water runs off the magnetic metamorphic sources but there is also a constant subtraction of water that is incorporated in the structure of minerals within sedimentary deposits. Geologic evidence strongly suggests that the volume of water in the oceans has remained reasonably constant during the past 500,000,000 years, so the total amount within the hydrologic cycle must have also remained nearly constant (Stanley Davies and Roger (1966).

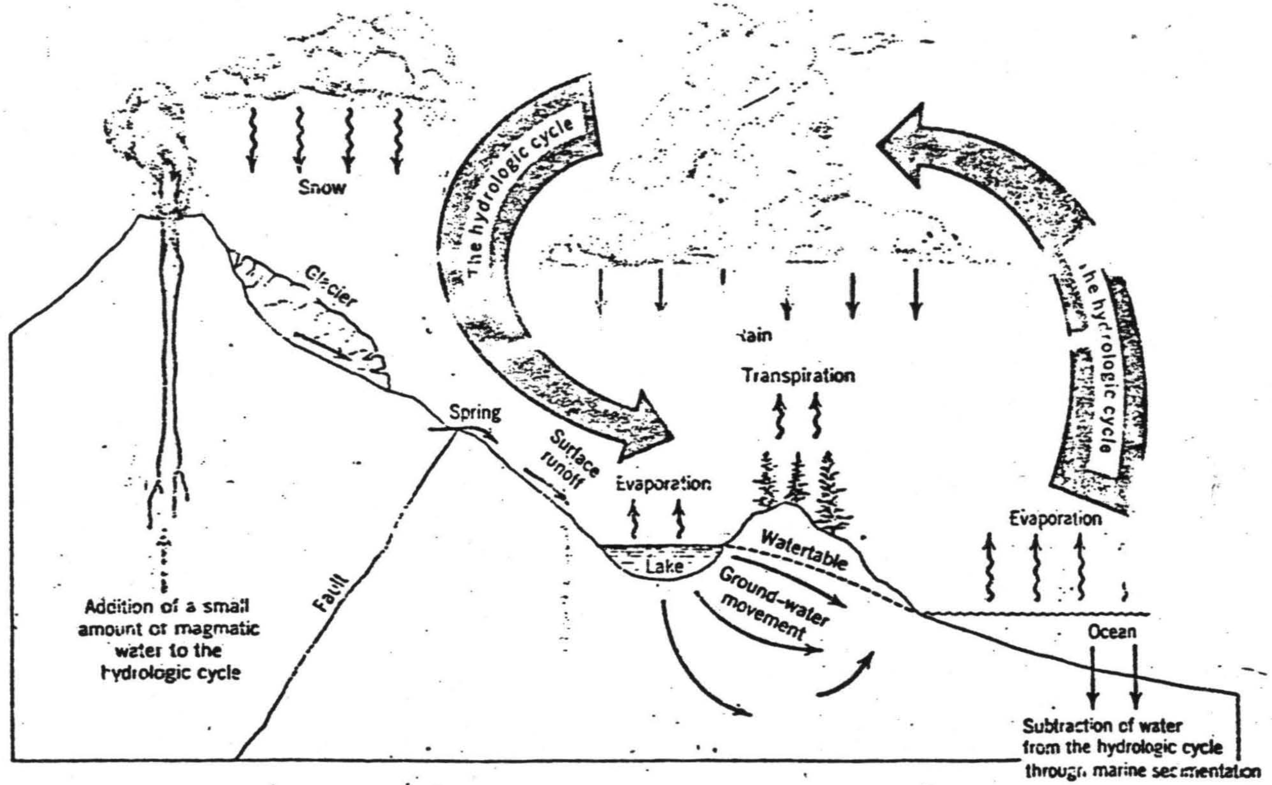


Figure 2.1 _ The hydrologic cycle.

Source hydrogeology by stanley , Davies and Roger 1966.

2.4.2 GROUND WATER.

Ground water is water beneath the soil surface where voids in the soil are substantially filled with water. Upward movement of ground water by capillary from the water table into the root zone can be a major source of water for plant growth. To be most effective without seriously restricting growth, ground water should be near but below the depth form which the major portion of the plants water needs are extracted.

If, growth is within the normal root zone, plant growth is suppressed. If ground water is too near the surface, the wind's ability to economically produce most crops become almost mil. However, a water table within the lower portion of the root zone may supply a considerable amount of water and thereby reduce the cost of irrigation more than it offsets the loss of production. The optimum depth of the water table is that depth which gives the maximum economic return. (Vaughn, Orsonn, Isrealse and stringm 1980).

2.4.3 SURFACE RUN-OFF

The run-off resulting from a given storm is obtained by subtracting the amount of infiltration and surface retention from the rainfall. Surface retention includes depression surface (Interception by vegetation, and water stored in puddles, ditches etc) and evaporation during rainfall. Thus mathematically surface run off in given by:

$$\mathbf{Q = R - 1 - S.}$$

Where: Q = surface run-off.

R = Rainfall.

I = Infiltration.

S = retention storage.

The evaporation component of retention storage is considered to be small.

2.4.4 INFILTRATION

This is the process by which part of precipitation (rain water) waters the subsurface. During a rainstorm, water particles enter voids in the soil and fill them to saturation under sufficient rainy condition and water particles move down freely to join the underground reservoir. The ground is known as the infiltration rate (chow 1988).

2.4.5 HYDRAULIC CNDUCTIVITY.

The rate of flow of ground water is response to a given hydraulic gradient is dependent upon the hydraulic conductivity of the aquifer. The hydraulic conductivity, as applied to an aquifer, is defined as the rate of flow of water in litres per day through a horizontal cross sectional area of one square metre of the aquifer under a hydraulic gradient of one metre at eh prevailing temperature of water. (Mazumder 1983).

2.4.6 IRRIGATION.

Irrigation generally is defined as the application of water to soil for the purpose of supplying the moisture essential for the plant growth. However, a broader and more inclusive definition is that irrigation is the application of water to the soil for a number of the following eight purposes.

1. To add water to soil to supply the moisture essential for plant growth.
2. To provided crop insurance against short duration droughts.
3. To cool the soil and atmosphere, thereby making more favorable environment for plant growth.
4. To reduce the hazard of frost.
5. To reduce the out or dilute salts in the soil
6. To reduce the hazard of soil piping.

7. To soften tillage pans and clogs
8. To delay bud formation by explorative cooling.

Irrigation may be accomplished in five different ways:

1. By flooding
2. By means of furrows large or small
3. By applying water underneath the land surface through sub-irrigation, thus causing the water table to rise.
4. By sprinkling
5. Or by trickle systems.

Water to supply moisture essential for pant growth may came for five source, none of which should be ignored when irrigation. Water requirements are estimated.

1. Precipitation.
2. Atmospheric water other the precipitation.
3. Flood water.
4. Ground water.
5. Irrigation water.

Failure to consider all five sources and the proportion of water that each supplies to total plant needs may result in faulty design of an irrigation system. in some are us one of the five sources may supply the major portion of plant needs; in other areas two or more will contribute appreciable amounts of water for plant growth. (Vaughn, Orson, and Glen (1980)

2.5.0 DRAINAGE.

Adequate drainage of crop-producing land requires a general lowering of shallow water table. Experience has demonstrated fully the need for drainage of irrigated land. In some valleys the higher lands never require drainage, but the need for drainage of the lower lands in frequently a result of the irrigation of the higher lands. From 20-30 percent of the irrigated lands in arid regious need drainage to perpetuate their productivity. The reclamation of saline and alkali soils has many important phases, but adequate lowering of the water table by drainage is a first and basic necessity.

Irrigation and drainage in aerial regions are complementary particles, the necessity for drainage being increased by low efficiencies in the conveyance and application of irrigation water.

2:5:1 BENEFITS OF DRAINAGE.

Adequate drainage improves soil structure and increases and perpetuates the productivity of soils. Drainage is the first essential in reclamation of water logged saline and alkali soils. Drainage benefits irrigation agriculture and the public in many ways example, adequate drainage:

1. Facilitates early ploughing and planting
2. Lengthens the crop growing season.
3. provides more available soil moisture and plant food by increasing the depth of root-zone soil.
4. Helps in soil ventilation.
5. Decreases the soil erosion and gulling by increasing water infiltrations into soils
6. favours the growth of soil bacterial.
7. leaches excess salts from soil, and
8. Assures higher soil temperature.

Drainage also improves sanitary and health conditions and makes rural life more attractive (Vaughn, Orson and Glen 1980)

2.5.0 WATER BALANCE.

Once the extent of an aquifer has been established and its abundances identified, it should be possible to quantify the volume of water that are passing through the ground water system. The amount of recharge can be assessed using information about rainfall and evaporation. Discharges form the aquifer can be estimated from spring flow measurement stream gauges and amount of water pumped from local wells. This stage of all previous work and is the point at which it be comes possible to start to answer those questions which caused you to initiate the investigation in the first place. This may include the availability of ground water resources and the suitability of the resources abstraction, or the treat of pollution from the proposed waste disposal operations.

Ground water recharge to an aquifer can not be measured, directly but only inferred from other measurements. As ground water is part of the hydrological cycle measurements of other components of the cycle can be used to estimate the value of the resources, using a technique called a water balance. In this type of calculation it is assumed that all the water leaving an area, plus or minus any change in storage. This can be written more fully as in the equation given below: (Barssington 1993).

INFLOWS:

(Rainfall + recharge from surface water + sea water intrusion + inflow from other aquifers to leakage + artificial recharge.) = (abstraction + spring flow + base flow in river + discharge to the sea + flows to other aquifer + evapotranspiration) + (change in aquifer storage).

CHAPTER THREE

3.0 MATERIALS AND METHODS.

3.1 LOCATION OF STUDY AREA.

This study was carried out for the month of 26th October 1999, at research farm of the Federal University of Technology, Minna (9°40' N, 6°30' E 30 elevation). Minna lies within the southern guinea savanna zone of Nigeria and has a humid semi arid tropical climate with a mean annual precipitation of 120mm (90% which falls between the month of June and August). Wet season temperature average about 20°C. The peaks are 40°C (February, March) and 36°C November – December).

Mean monthly rainfall during this study period was 208.5mm, relative humid 82. 4%, minimum temperature 21.6°C and maximum temperature 30.7°C (Nigeria Airport Authority Minna. Table 3:1)

TABLE 3.1

RAINFALL AT FUT MINNA (BOSSO MAIN CAMPUS)

Yr/moth	Jan	Feb.	Mar	April	May	June	July	Aug	Sept	Oct	Nov.	Dec.	Total
1980	0.0	0.0	0.0	4.7	22.6	138.5	282.4	390.3	323.2	94.7	0.0	0.0	1356.4
1981	0.0	0.0	17.4	204.8	262.33	131.7	377.2	242.9	121.9	121.9	4.6	0.0	1556.6
1982	0.0	0.0	15.4	16.2	130.3	196.1	262.7	422.3	135.5	148.7	7.6	0.0	1334.9
1983	0.0	0.0	61.2	17.3	141.7	250.6	214.8	185.6	148.1	93.3	0.0	0.0	891.9
1984	0.0	0.0	61.2	17.3	137.3	250.6	233.3	249.7	176.6	61.0	0.0	0.0	1191.4
1985	0.0	0.0	57.8	20.3	137.3	190.0	139.0	302.4	276.7	47.7	0.0	0.0	1171.2
1986	0.0	0.0	39.6	15.4	36.0	183.3	251.7	243.0	315.8	83.8	19.6	0.0	1243.8
1987	0.0	0.0	13.5	44.6	104.5	83.0	143.7	238.5	94.6	100.1	0.0	0.0	822.5
1988	0.0	0.0	0.0	0.0	81.5	132.0	218.3	350.1	403.6	33.1	0.0	0.0	1218.6
1989	0.0	0.0	5.0	49.5	765.0	193.7	193.7	248.7	202.0	79.0	0.0	0.0	1259.4
1990	0.0	0.0	0.0	177.2	225.2	80.5	256.3	185.8	145.6	110.5	0.0	0.0	1181.9
1991	0.0	0.0		114.5	335.0	180.1	192.9	268.5	190.8	33.9	0.0	0.0	1316.7
1992	0.0	0.0	1.3	158.2	176.8	162.9	196.4	231.5	230.3	46.6	32.9	0.0	1241.9
1993	0.0	0.0	0.0	0.0	174.4	170.5	189.7	271.1	178.3	63.3	0.0	0.0	1047.3
1994	0.0	0.0	7.3	72.5	144.4	239.0	142.5	367.2	261.3	208.1	0.0	0.0	1412.3
1995	0.0	0.0	0.0	100.5	123.3	144.5	153.2	409.0	185.7	135.5	23.6	0.0	1279.3
1996	0.0	0.0	0.0	48.6	164.7	225.0	259.7	257.0	191.1	127.9	0.0	0.0	1278.0
MEAN.			12.8	13.0	147.2	172.3	205.8	294.0	218.1	93.5	5.5	0.0	

SOURCE: MINNA AIRPORT METEOLOGICAL DEPT.

From table 3.1, rainfall at the site spread over a period of eight to nine months every year, with December, January and February not reading any measurable rainfall over the period of record. Rain becomes steady in the month of April and ends in October, with only sparse rains in March and November in some years (figures 3.1 and 3.3). The mean annual rainfall cover the period in 1224mm. From the same table August is the month of heaviest rainfall at the site. or study area.

TABLE 3:2 DATA ON RADIATION, RAINFALL, SUNSHINE, RELATIVE HUMIDITY AND TEMPERATURE AT MINNA AIRPORT

		GLOBAL SOLAR RADIATION	MEAN MONTHLY TEMP.	MEAN MONTHLY RAINFALL	RELATIVE HUMIDITY	EVAPORATION
DAY LENGTH	SUNSHINE (HRS)	Cal/cm²/day	(°C)	(mm)	(%)	(ML)
J. 11.6	6.5	143	35.5	0.0	25	13.5
F. 11.8	7.1	169	37.7	0.0	31	14.5
M. 12.0	6.8	172	37.1	13.5	43	12.1
A. 12.3	6.9	183	37.9	44.6	41	14.4
M. 12.5	9.0	175	36.9	104.5	61	9.6
J. 12.7	6.3	133	31.4	83.9	79	4.1
J. 12.6	5.8	128	30.5	143.7	83	2.9
A. 12.5	5.4	125	29.9	238.5	85	2.4
S. 12.2	6.3	145	30.5	94.6	81	2.7
O. 11.9	7.9	165	32.2	100.1	69	4.3
N. 11.7	8.3	171	35.2	0.0	39	9.6
D. 11.6	8.6	149	35.1	0.0	34	13.3
MEAN = 12.12						

SOURCE: MINNA AIRPORT, NIGER STATE.

CLIMATIC DATA
MINNA

T-3-2

1994

Month	Rain fall Total (mm)	Cumulative Total (mm)	Max ^{0}C Temp	Min ^{0}C Temp	R/H %	Sunshine hrs/Total
January	0.0	0.0	34	18	66	------
February	0.0	0.0	37	18	46	------
March	0.0	0.0	40	24	66	------
April	38.9	38.9	37	24	69	------
May	171.9	210.8	34	24	80	------
June	151.4	362.2	32	23	84	------
July	75.8	438.0	32	23	84	------
August	425.7	863.7	31	23	85	------
September	194.0	1057.7	31	23	85	------
October	102.1	1159.8	33	23	81	------
November	0.0	1159.8	34	19	69	------
December	0.0	1159.8	34	15	55	------

Sources:- Nigerian Meteorological Services: Lagos

CLIMATIC DATA
MINNA

T- 3.4

1995

Month	Rain fall Total (mm)	Cumulative Total (mm)	Max ^{0}C Temp	Min ^{0}C Temp	R/H %	Sunshin hrs/total
January	0.0	0.0	34	15	50	-----
February	0.0	0.0	36	17	40	-----
March	22.9	22.9	39	24	69	-----
April	43.8	66.7	38	26	69	-----
May	92.3	159.0	35	24	75	-----
June	128.7	287.7	33	24	81	-----
July	236.7	524.4	32	23	84	-----
August	307.5	831.9	31	23	85	-----
September	152.2	984.1	32	23	85	-----
October	105.6	1089.7	33	23	81	-----
November	12.3	1102.0	35	19	67	-----
December	0.0	1102.0	35	17	69	-----

Sources:- Nigerian Meteorological Services: Lagos

CLIMATIC DATA
MINNA

T - 3.5

1996

Month	Rain fall Total (mm)	Cumulative Total (mm)	Max ^{0}C Temp	Min ^{0}C Temp	R/H %	Sunshine hrs/total
January	0.0	0.0	35	15	50	-----
February	18.9	18.9	37	21	40	-----
March	0.0	18.9	38	24	69	-----
April	12.6	31.5	39	25	69	-----
May	2.0	33.5	33	24	75	-----
June	190.7	224.2	30	23	81	-----
July	201.8	426.0	29	23	84	-----
August	326.1	752.1	31	13	85	-----
September	170.5	922.6	31	22	85	-----
October	41.3	963.9	33	18	81	-----
November	0.0	963.9	36	19	67	-----
December	0.0	963.9	34	17	69	-----

Sources:- Nigerian Meteorological Services: Lagos

CLIMATIC DATA
MINNA

T-3.6

1997

Month	Rain fall Total (mm)	Cumulative Total (mm)	Max ^{0}C Temp	Min ^{0}C Temp	R/H %	Sunshine hrs/total
January	0.0	0.0	34	16	32	-----
February	0.0	0.0	38	19	69	-----
March	64.9	64.9	37	24	72	-----
April	53.9	118.8	33	23	84	-----
May	129.3	248.1	32	23	81	-----
June	279.2	527.3	31	21	97	-----
July	219.0	746.3	22	24	81	-----
August	227.2	973.5	32	23	77	-----
September	145.7	1119.2	29	22	86	-----
October	135.4	1254.6	35	23	81	-----
November	7.2	1261.8	36	20	66	-----
December	0.0	1261.8	35	17	54	-----

Sources:- Nigerian Meteorological Services: Lagos

CLIMATIC DATA
MINNA

1998

T-3.7

Month	Rain fall Total (mm)	Cumulative Total (mm)	Max ^{0}C Temp	Min ^{0}C Temp	R/H %	Sunshine hrs/total
January	0.0	0.0	40	24	65	-----
February	0.0	0.0	39	24	29	-----
March	0.0	0.0	41	27	58	-----
April	67.1	67.1	34	24	82	-----
May	213.2	270.3	34	27	85	-----
June	75.5	345.8	32	24	77	-----
July	239.7	585.5	27	24	88	-----
August	145.5	631.0	28	24	86	-----
September	153.7	784.7	31	23	84	-----
October	103.0	887.7	34	24	77	-----
November	0.0	887.7	36	17	73	-----
December	0.0	887.7	35	16	62	-----

Sources:- Nigerian Meteorological Services: Lagos

CLIMATIC DATA
MINNA.

1999

T- 3.8

Month	Rain fall Total (mm)	Cumulative Total (mm)	Max ^{0}C Temp	Min ^{0}C Temp	R/H %	Sunshin hrs/total
January	0.0	0.0	35	17	54	-----
February	2.8	2.80	37	20	57	-----
March	0.8	3.6	58	25	68	-----
April	112.1	115.7	37	24	70	-----
May	135.5	251.1	34	23	79	-----
June	196.8	447.9	32	23	85	-----
July	264.1	712.0	31	23	87	-----
August	194.5	906.5	30	23	86	-----
September	153.7	1060.2	31	23	86	-----
October	98.0	1158.2	33	23	85	-----
November	0.0	1158.2	35	21	72	-----
December						

Sources:- Nigerian Meteorological Services: Lagos

CLIMATIC DATA
MINNA

T-3.9

Daily Reading for Month of Sept. 1999 — **Daily readings for Month of Oct. 1999**

	Rain. Mm	Max. Temp ^0C	Min Temp. ^0C	R/H %			Rain. Mm	Max. Temp ^0C	Min Temp. ^0C	R/H %
1	5.3	30	23	83		1	0.0	31	22	89
2	9.2	30	23	91		2	0.0	33	24	82
3	0.0	32	22	90		3	0.0	32	24	84
4	0.0	31	24	82		4	17.1	33	33	77
5	31.4	31	24	80		5	0.0	31	22	92
6	18.8	29	21	86		6	0.0	32	23	83
7	0.0	28	21	88		7	11.2	32	24	77
8	0.0	31	23	89		8	0.0	27	21	95
9	1.5	30	25	84		9	23.5	32	22	90
10	2.5	32	24	74		10	0.7	32	22	90
11	0.0	30	24	82		11	0.0	32	23	89
12	10.6	32	24	88		12	8.8	33	23	81
13	16.0	31	22	91		13	21.9	32	23	86
14	0.0	32	23	88		14	0.7	30	23	95
15	0.0	32	23	82		15	2.5	30	23	93
16	17.1	26	24	85		16	0.4	31	23	92
17	1.1	31	21	96		17	3.8	33	22	81
18	0.0	33	21	90		18	2.4	33	22	84
19	5.2	30	24	85		19	6.0	32	23	81
20	0.0	31	23	82		20	0.0	34	23	81
21	0.1	32	23	90		21	0.0	35	23	85
22	0.0	31	24	80		22	5.0	35	25	92
23	0.0	32	24	81		23	0.0	32	24	86

24	5.3	31	22	84		24	0.0	32	23	84
25	0.0	31	21	89		25	0.0	34	24	85
26	0.0	31	24	84		26	0.0	34	24	82
27	8.0	31	24	86		27	27	34	24	80
28	3.8	26	22	97		28	0.0	34	24	79
29	4.7	31	21	86		29	0.0	33	25	78
30	6.1	32	23	86		30	0.0	34	24	78
						3.1	0.0	34	23	89

Sources: Nigerian Meteorological Services – Lagos

CLIMATIC DATA

T-3.10

MINNA.

Daily Reading for

Month of Nov. 1999

Daily readings for

Month of Dec. 1999

	Rain. Mm	Max. Temp °C	Min Temp. °C	R/H %			Rain. Mm	Max. Temp °C	Min Temp. °C	R/H %
1	0.0	33	24	82		1	0.0	35	22	
2	0.0	35	24	77		2	0.0	36	18	
3	0.0	36	25	82		3	0.0	36	14	
4	0.0	34	24	80		4	0.0	34	15	
5	0.0	33	20	88		5	0.0	36	15	
6	0.0	33	20	77		6	0.0	35	16	
7	0.0	34	19	64		7	0.0	36	15	
8	0.0	36	21	60		8	0.0			
9	0.0	36	22	65		9	0.0			
10	0.0	36	23	75		10	0.0			
11	0.0	36	22	78		11				
12	0.0	35	18	73		12				
13	0.0	36	17	61		13				
14	0.0	36	20	60		14				
15	0.0	36	20	67		15				
16	0.0	35	21	74		16				
17	0.0	36	22	76		17				
18	0.0	34	18	75		18				
19	0.0	35	19	63		19				
20	0.0	36	20	74		20				
21	0.0	36	19	69		21				
22	0.0	35	17	77		22				
23	0.0	37	19	74		23				

24	0.0	35	20	66		24				
25	0.0	36	22	71		25				
26	0.0	37	21	76		26				
27	0.0	34	22	64		27				
28	0.0	33	23	71		28				
29	0.0	34	22	64		29				
30	0.0	35	22	74		30				
						3.1				

Sources: Nigerian Meteorological Services – Lagos

3.2 SOIL INFILTRATION RATE

Plots for the experiments were leveled by removing grasses and debries 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 the gone into the soil within a depth of 100-150mm in-order to prevent seepage.

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 loose soil, the inner ring is installed at a depth 30mm to avoid water seepage.

After the installation of the inner ring, the out 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 inner and outer ring of the infittrometer to avoid pudding or splashing on soil when pouring water in the rings. Water was measured with a four titers capacity cane and the watch was set at zero reaching. After the infiltrometer was put in place, water was purored into the inner ring and simultaneously the watch was started.

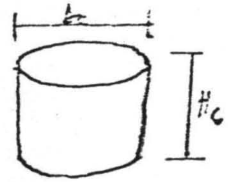
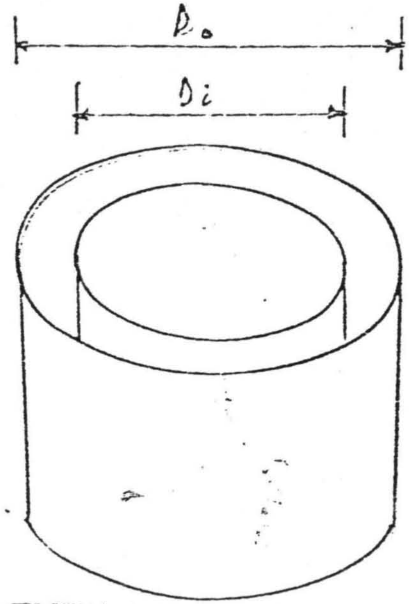


Fig 3.8: Cross section of installed core sampler
Hc = Height of core sampler = 7.5 cm
Dc = Diameter of core sampler. = 7.5 cm



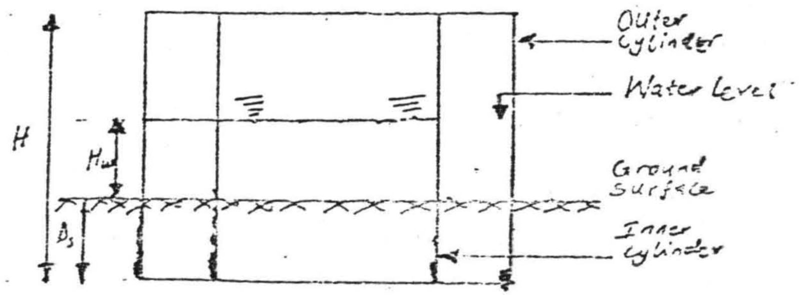


Fig 3.2: Isomatric view of infiltrometer
Di = Diameter of inner cylinder – (30 cm)
Do = Diameter of outer cylinder (60 cm)

Fig 3.2: Cross section of installed infitrometer.
H = Height of cylinder (25 cm)
H_W = Height of water (ponded) (11 cm)
D_S = Depth of cylinder in the soi[l] (4 cm)

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 in the inner ring was maintained in the outer ring.

In plot 1, the reading were taken every 1min, or 2mins because of the high infiltration rate of the loose soil. Water percolation was very high at the initial point of the experiment.

For other plots reaching were taken every 5minutes or 10mins depending on the nature of the soil.

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

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

The experiment continues for sometimes 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 30mins

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

The data obtained are shown in table (3:2;1)

3.3 HYDRAULIC CONDUCTIVITY

Core samples were used to excavate soil sample in an air distributed form from the field to the laboratory once moisture cans were used to collect sample for moisture content determination at different depths. Retort stands and measuring beakers were also used for the hydraulic conductivity experiment set up. Core sample are column pipes open at both ends of diameter 7.0m and

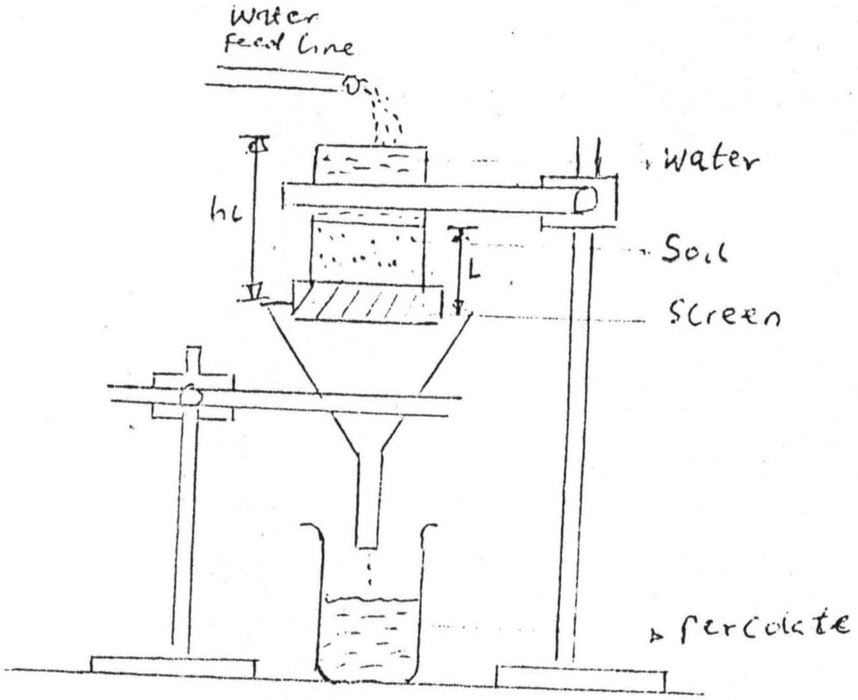


FIG 3.3: SET UP CONSTANT HEAD PERMEABLE
FOR HYDRAULIC CONDUCTIVITY DETERMINATION

height 7.5cm, they are used because they allow on dimensional flow according to Darcy's experiments.

3.4 . TOPOGRAPHY

The study area covered area of 24.77.85sq m with contour interval of 1.0m The contours from the Topographic mapping are scattered that shows that the area is level, but if the conform are closed, this shows that there is need for leveling exercise.

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

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

Fig 3:5: 1 shows the Topographic mapping of the study area.

3.5.0 SOIL DESCRIPTION AND SOIL SAMPLING.

Soil of Minna association has been described as Alfisols derived from basement complex rocks (Anon, 1990). They range from shallow to very deep soils overlying deeply weathered gneisses and migmatites. Some are under lain by iron pan at varying depth. They are strong brown to red sandy clay or clay with often gravely loamy sand or sand surface layer.

Surface (0-20cm) soil sample was collected form the farm and was air dried and passed through a 2mm sieve. A sub sample of the soil was subjected to routine soil analysis using the procedure by Juo (1979). Soil particle size was determining by the hydrometer method, while PH was determined in 1:2 soil water suspension and in 0.01m cac12 organic carbon content by walk leg Black method and the exchangeable acidity (H^+ and Al^{3+}) was determiner by the

titration method, the exchangeable cautions was estimated by the Ammmoium Acetate (NH_4OA_c) digestion method, while the total nitrogen was estimated using the micro jeldahl procedure and the available phosphorus by Bray 1 method. Results of the soil analysis are shown in Table 1.

TABLE 1: Some physical and chemical characteristics of the soil of the experimental site:

Parameters	Values.
Sand (%)	80.08%
Silt (%)	17.28%
Clay (%)	2.64(%)
Textural class	Loamy sand
Soil P^H (H_2O) 1:2	6.44
P^H (0.01m Ca CL_2) 1.2	5.90
Organic Carbon (%)	0.027
Organic matter (%)	0.046
Available P (ppm) Bray 1	30.96
Total N (%)	0.08
Exchangeable cations	(Meq/100g soil)
Ca^{2+}	5.25MeqC_a $^{2+}$/100g soil.
Mg^{2+}	9.28Meq/Mg^{2+}/100g soil.
K^{2+}	0.23Meqk $^{+}$/100g soil.
Na^{+}	0.30. MeqNa^{+}/100g soil
Exchange acidity	
Al 3+ H+	6.53 Meq/100g soil.
CEC	15.09Meq/100g soil.

Those containers were clearly labeled to distinguish the sample depth and location. The container containing the soil after weighing them were placed in the over for 24hours at the temperature of 105oC, After 24hrs, the oven is switched off and opened for the cans to cool a little before it is being reweighed at room temperature and recorded. The bulk density and porosity are then calculated. (Table 4:1)

3.5.1 SOIL TEXTURE

This test is designed to separate soil into its three basic mineral fractions: sand, silt clay particles the amount of time required for the soil particles of various sizes to settle in the soil separation tube form the basis for this test. It is them possible from the amount material collected in each tube to determine the approximate percentage of each. Fraction as represented in the original soil sample.

The procedure for preparation of the soil sample for testing or analysis is described below:

The separation tubes should be marked for identification is the following manner: mark the first sedimentation tube "A" the second 'B' and the third "C"

PROCEDURE

1. Place the three soil separation tubes in the rack provided for this purpose.
2. Add the soil sample to separate tube "A" until it is even with line 15.
   Note: Gently tap the bottom of the tube on a firm surface to pack the soil and eliminate air spaces.
3. Using the pipe provided add IML of "Texture Dispersing Read end (5044) to the sample in soil separation tube A

4. Then add tap water to line 45.
5. Cap soil separation tube "A and gently shake for two minutes, making sure all the soil sample is thoroughly mixed with water.
6. Remove the cap and place soil separation tube "A" in the rack and allow to stand undisturbed for 30 seconds.

The sample is now ready for separation. The separation is accomplished by allowing a predetermined time for each fraction to settle out of the solution be sure that you continue to gently shake the separation tube up to the time of the first separation.

7. After 30 seconds has elapsed, carefully pour off all the solution into soil separation tube "B" to stand undisturbed for 30minutes. Return tube "A" to the rack.
8. Upon standing 30 minutes the remaining solution in soil separation tube "B" is carefully poured into soil separation tube "C" . Return Tube "B" to the rack.
9. Add 1ml of soil Flocculation Reagent (5643) to soil separation Tube "C" cap and gently shake for owe minute.
10. Place the soil separation Tube "C" in the rack and allow to stand until all the clay in suspension settles. This may require up to 24hours.

Note: Unless there is further use of the clay sample for air drying and study as described later, it is not necessary to wait for the suspension to settle.

Due to the colloidal nature of clay in solution and there is tendency to swell and form a gel, the portion of clay remaining in tube "C" is not used to determine the clay fraction present in the soil. The clay fraction is calculated by adding the sand and silt fraction and subtracting the total from the initial and subtracting this total from the initial volume of soil used for the separation.

3.6.0 INSTALLATION OF PIPES: -

Materials used are pegs, cutlass, dumpy level, ranging pole and a staff. A cutlass was used to clear the points of pipe installation, a head driven anger of length 1.5m and shovel diameter of 5cm was used to drill the holes or to 1m depth. 150cm, since 100cm below ground surface is the depth of interest. They are radically perforated at 2cm apart across the depth of the pipe to allow sufficient and effective in flow of ground water into the pipe to assume its original form and level (fig. 3.3)

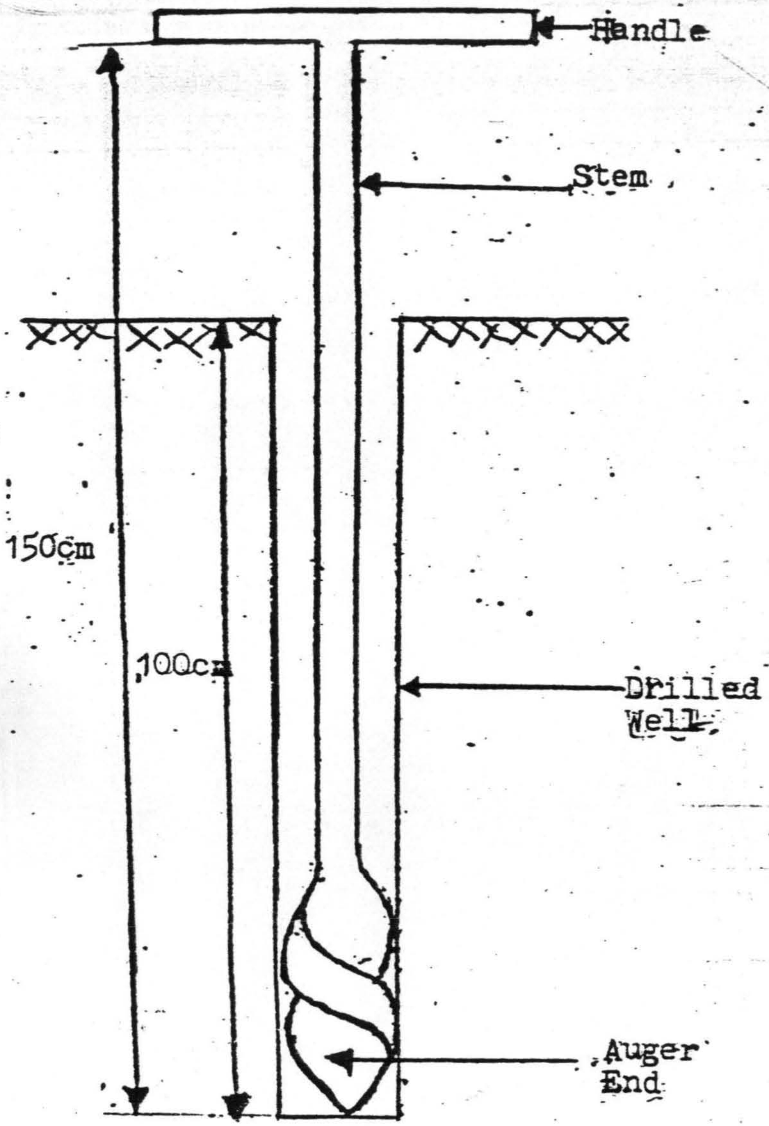
3.6.1 EXPERIMENTAL LAYOUT.

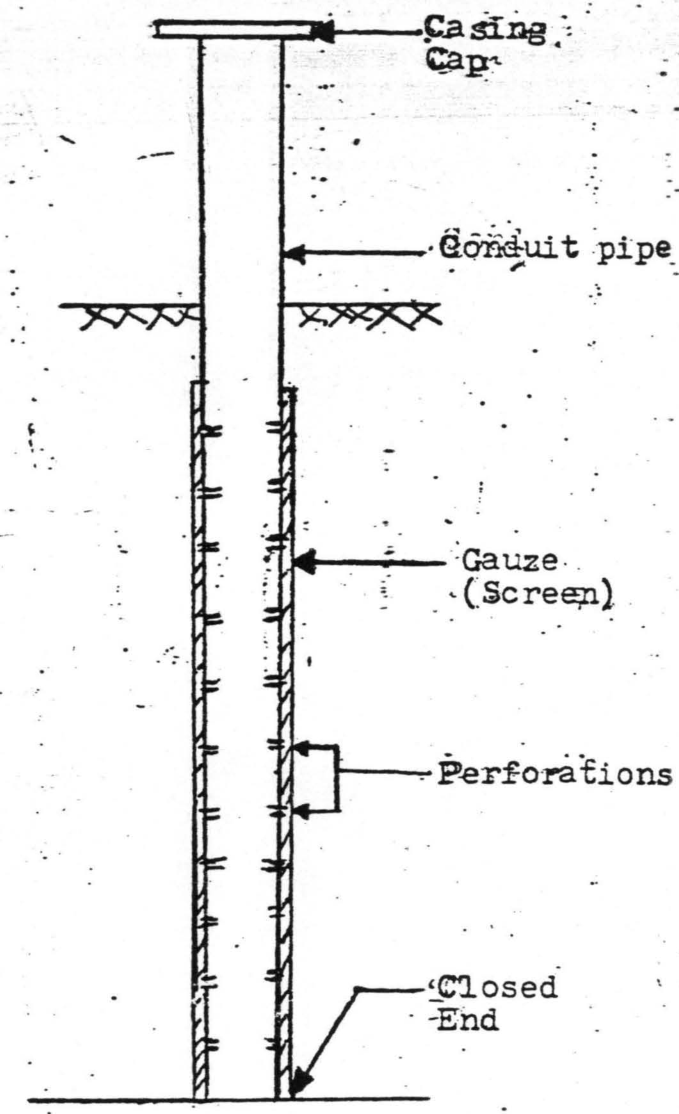
The grid system in survey method squares was used, established points were marked out along he experiment area in order to centralize the positioning of the piezometer pipe along the edges if the area.

The first three pipes were installed at distant of 20metres apart. The second three were also installed at 20metres apart, while the last set were installed at 20metres along the edges of the area.

3.6.2 PIEZOMETER INSTALLATION

Hand driven anger of length 1.5m and screw diaineter of 5.cm was to drill out holes or wells at the specified location. The pipe were buried with their perforated end below the ground surface. At the neck of the pipe on the ground surface the clearance between the hole or well and the pipe was sealed up using concrete mix to disallow the vertical flow of water into the well, by run off or precipitation (fig. 3.6)





(SOURCE IDRIS 1997)

Fig 3.3: HAND DRIVEN AUGER USED TO DRILL OUT WELL

Fig 3.5: CROSS SECTION OF CONSTRUCTED PIEZOM[illegible]TRIC PIPE

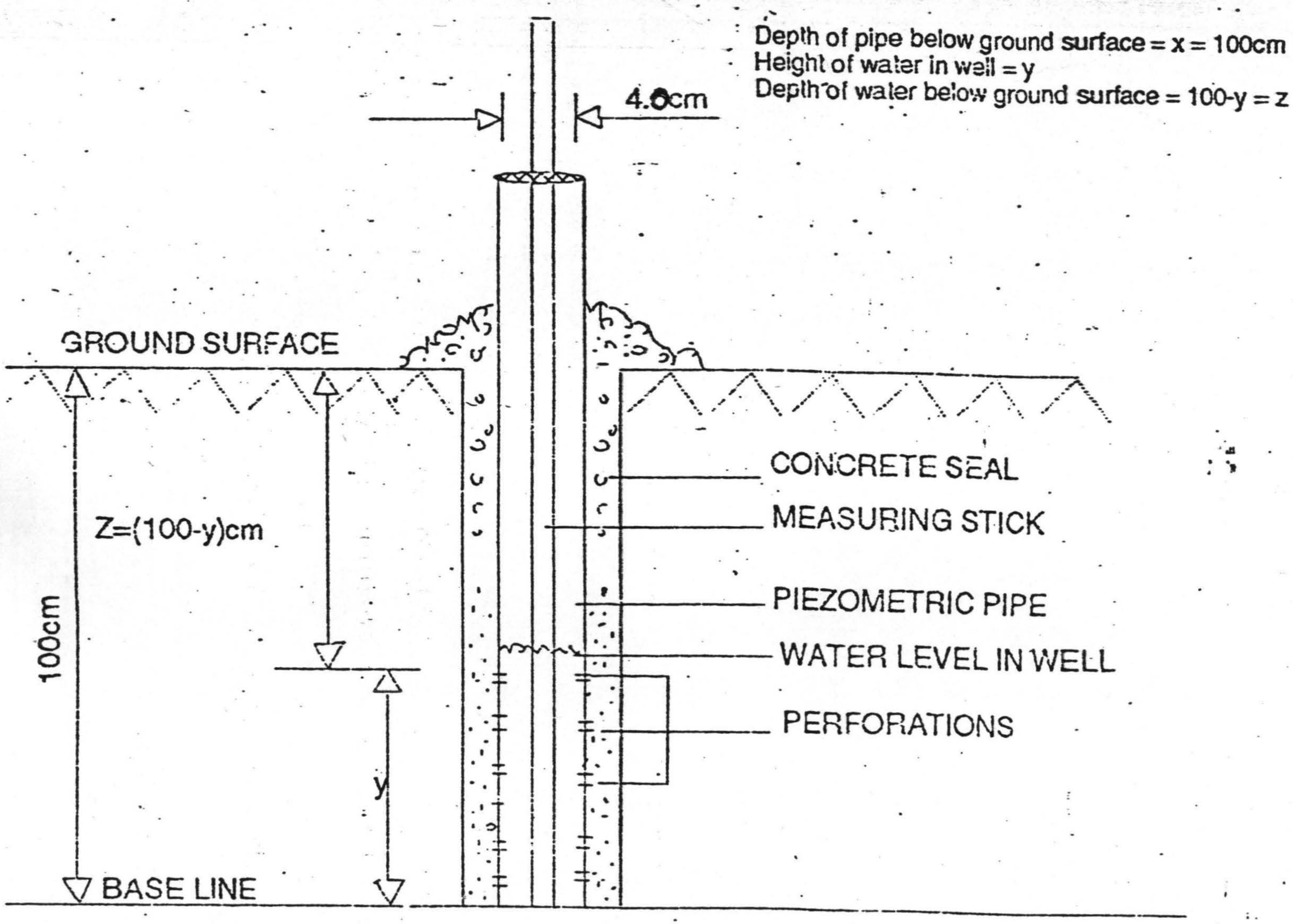


Fig 3.4 CROSS-SECTION PIEOMETER INSTALLATION (~~Source, Idris 19—~~)
[SOURCE, IDRIS (1997)]

3.6.3 INVESTIGAION METHODS

This pipe was installed on the 3rd August 2000. and the readings were taken subsequently at interval of 2days. A straight long wooden plank ruled on the edge along the length with chalk was inserted in the installed pipe and allowed to slay for some time so that the water in the pipe dissolve the chalk rulings to its standard met rule and read as height of water in the hole or well. This is subtracted from 100cm to the actual reaching that is level of water beneath ground surface (Fig: 3.6.3).

3.7.0 DETERMINATION OF SOIL PROPERTIES.

3.7.1 MOISTURE CONTENT

Soil sample were collected with a soil anger. The sample were taken from the soil desired depth of (0-20)cm, (20-40)cm and (60-80) cm for each soil type. They were collected in air tight aluminum container and pre-treatment. The laboratory or office for pres treatment. The pretreatment involved air-drying for 2-3 days after which they were grinded with a porcelain mortar and pestle and sieved using a 2mm- mesh soil sieve.

These containers were Cleary labeled to distinguish the sample depth and location. The container containing the soil after weighing them were placed in the over for 24hours at the temper nature of 105°C After 24hr, the oven is switched off and opened for the cans to cool a little before it is Bering reweighed at room temperature and recorded. The bulk density and porosity are then calculated. (Table 4:12)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 DISCUSSIONS OF RESULTS.

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

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

The graphs of accumulated water intake and water intake for the four plots are shows is (figure 4.1 – 4.4). From this graph it is observed that the scattered point is due to the difference is bulk density, porosity and moisture.

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

The results obtained for the soil moisture content analysis was presented in table 4:1

The result obtained form sieve analysis was presented in table 4.1.1

4.2.1 PHYSICAL PROPERTIES

From the results obtained as in Table 4.2 the first plot contains clay (26.7%) silt (23.3%), sand (50%) when measured on the textural triangle it was discovered that the sample fits into: - sandy clay loam (SCL), sandy loam, SL, sandy loam (SL), and sandy clay loam (SCL). For (Plot 2 and 3) (See table 4.2)

The fourth plot also contains: - clay (11.8%), silt (8.7%) and sand (78.5%). Also contains loam sandy (LS), sandy loam (SL) and sandy loam (SL).

TABLE 4.2: RESULT OF PARTICLE SIZE ANALYSIS AT FEDERAL UNIVERSITY EXPERINMENT FARMLAND, MINNA.

Plot Sample	Soil Depth (cm)	% Clay	% Silt	% Sand	Textural Class
Plot 1	0 - 20	26.7	23.3	50.0	SCL
	20 - 40	12.0	14.7	73.3	SL
	40 - 60	18.0	10.0	72.0	SL
	60 - 80	26.0	17.3	56.7	SCL
Plot 2	0 - 20	15.4	21.3	6.33	SL
	20 - 40	14.7	20.0	65.3	SL
	40 - 60	12.0	12.7	75.3	SL
	60 - 80	12.7	17.3	70.0	SL
Plot 3	0 - 20	18.7	28.0	53.3	SL
	20 - 40	24.0	4.7	71.3	SL
	40 - 60	10.6	2.7	86.7	LS
	60 - 80	10.7	6.0	83.3	LS
Plot 4	0 - 20	11.8	9.7	78.5	LS
	20 - 40	17.2	15.9	66.9	SL
	40 - 60	10.4	21.3	68.3	SL
	60 - 80	14.8	12.9	72.3	SL

SL = sandy Loam, LS = Loamy Sand, SCL = Sandy clay Loam

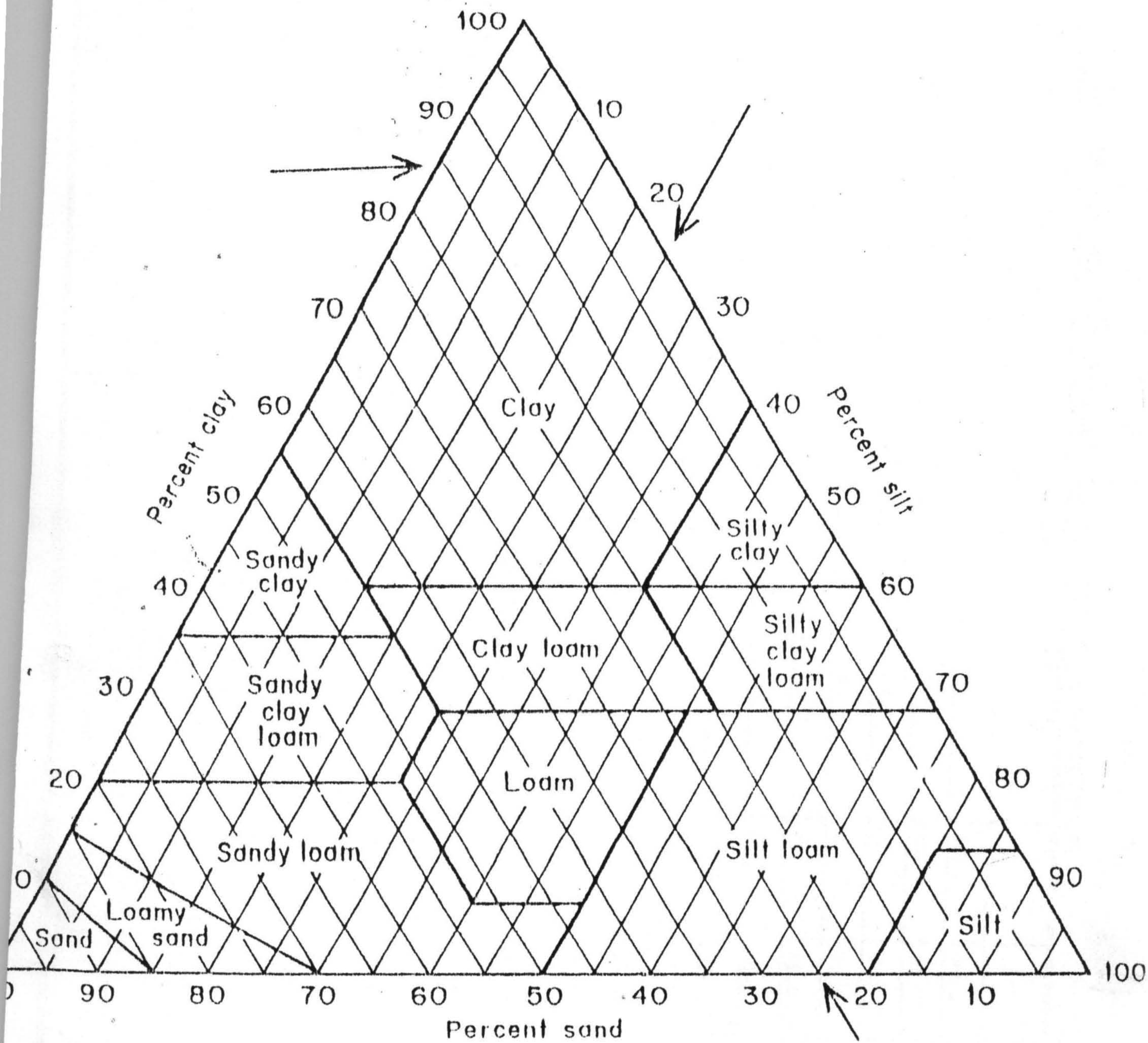


FIGURE 4·2 The USDA soil triangle

TABLE (2)

MONTH	RAINFALL	ET.	SURPLUS	DEFICIT.
JAN: 99	0.0	201.5	-	201.5
FEB: 99	2.8	182.7	-	179.9
MAR: 99	0.8	195.3	-	194.5
APR: 99	112.1	179.8	-	67.7
MAY: 99	135.5	136.4	-	0.9
JUNE: 99	196.8	108.5	88.3	-
JULY: 99	264.1	105.4	158.7	
AUG: 99	194.5	86.8	107.7	-
SEPT: 99	153.7	89.9	63.8	-
OCT: 99	98.0	117.8	-	-
NOV: 99	0.0	189.1	-	19.8
DEC: 99	0.0	192.2	-	189.1
				192.2
	1158.3	**1785.4**	**418.6**	**1045.6**

To compute the soil moisture balance of the study area, we use Table 1 & 2 for the equation below: -
Inflow: outflow:
Rain + Irr + Gw = Runoff + Drainage + E_T + soil moisture
= R + Irr + Gw = Runoff + Drainage + E_T + soil moisture content
Where:

R= 1158.3
Irr = 1045.6
Gw = 0
R-off = 0
E_T = 1,785.4
Drainage = 4128.6

: - R + irr = Drainage + E_T + soil moisture content (less Gw & Runoff)
= 1158.3 + 1045.6 = 4186 + 1,785.4 + soil moisture content
: - 2203.9 = 2204 + soil moisture content.
: - Soil moisture = 2204 – 2203.9 =0
Soil moisture content = 0
This means, the soil moisture content of the study area is balanced.

TENSIOMETER READINGS OF THE STUDY AREA FOR THE THREE MONTHS (JUNE-AUG: 2000).

DATE	DEPTH (CM)	PLOT (A)	PLOT (B)	PLOT (C)
9/6/2000	15	13	9	9 = 30 MINS 10 = 45 MINS
12/6/2000	"	14	[illegible]	9
16/6/2000	"	7	6	1
19/6/2000	"	11	8	7
	"	12		
23/6/2000	"	8	9	3
26/6/2000	"	11	11	7
30/6/2000	"	14	15	10
3/7/2000	"	11	18	8
7/7/2000	"	8	11	5
10/7/2000	"	11	12	7
14/7/2000	30	9	10	8
	60	7	8	6
17/7/2000	70	7	10	8
	6	7	7	8
21/7/2000		6	9	4
		4	6	3
24/7/2000		8	7	7
		6	6	6
28/7/2000		8	11	8
		7	9	6
31/7/2000		8	10	7
		7	8	5
4/8/2000		7	4	4
		4	4	2
7/8/2000		8	7	6
		6	6	5
11/8/2000		7	5	5
		6	5	4
14/8/2000		4	4	3
		2	3	3
18/8/2000		4	4	3
		3	4	3
21/8/2000		4	4	3
		3	3	3

APPENDIX (F)

'OTENTIAL EVAPORATION DETERMINATION BLANY MORIN NIGERIA (1984) METHOD:

$$Etp = \frac{r_f(0.45T + 8)(520 - R^{1.31})}{100}$$

:re E_{tp} = Potential evapotranspiration mm/day

R_f = Ratio of maximum possible radiation to the annual maximum.

Γ = Summation of the daily mean of relative humidity over a month and divided by the number of day in that month.

Inflow = Outflow

ıation: Rain + Irr + Gw = R off + Draining + E_t + Soil moisture

study area Data collected:

$$R_f = \frac{143}{1858}$$

T = 35.5

R = 25

ıerefore, $E_{tp} = \frac{0.0769\ (23.975)\ 452.2}{100}$

E_{tp} = 8.34mm/day

APPENDIX ( )

LD WATER BALANCE ? Hismishra, T.R. Rathore (1990)

$(P-Ro)+I_R+DS = E_T + P_C$ 2.1.61

= PRECIPITATION; I_R = IRRIGATION, Ro=RUN OFF,

ANGE IN STORAGE, ET= EVAPOTRANSPIRATION PC = PERCOLATION:

NET WATER REQUIREMENT G.W.C = GROUND WATER CONTRIBUTION.

12.

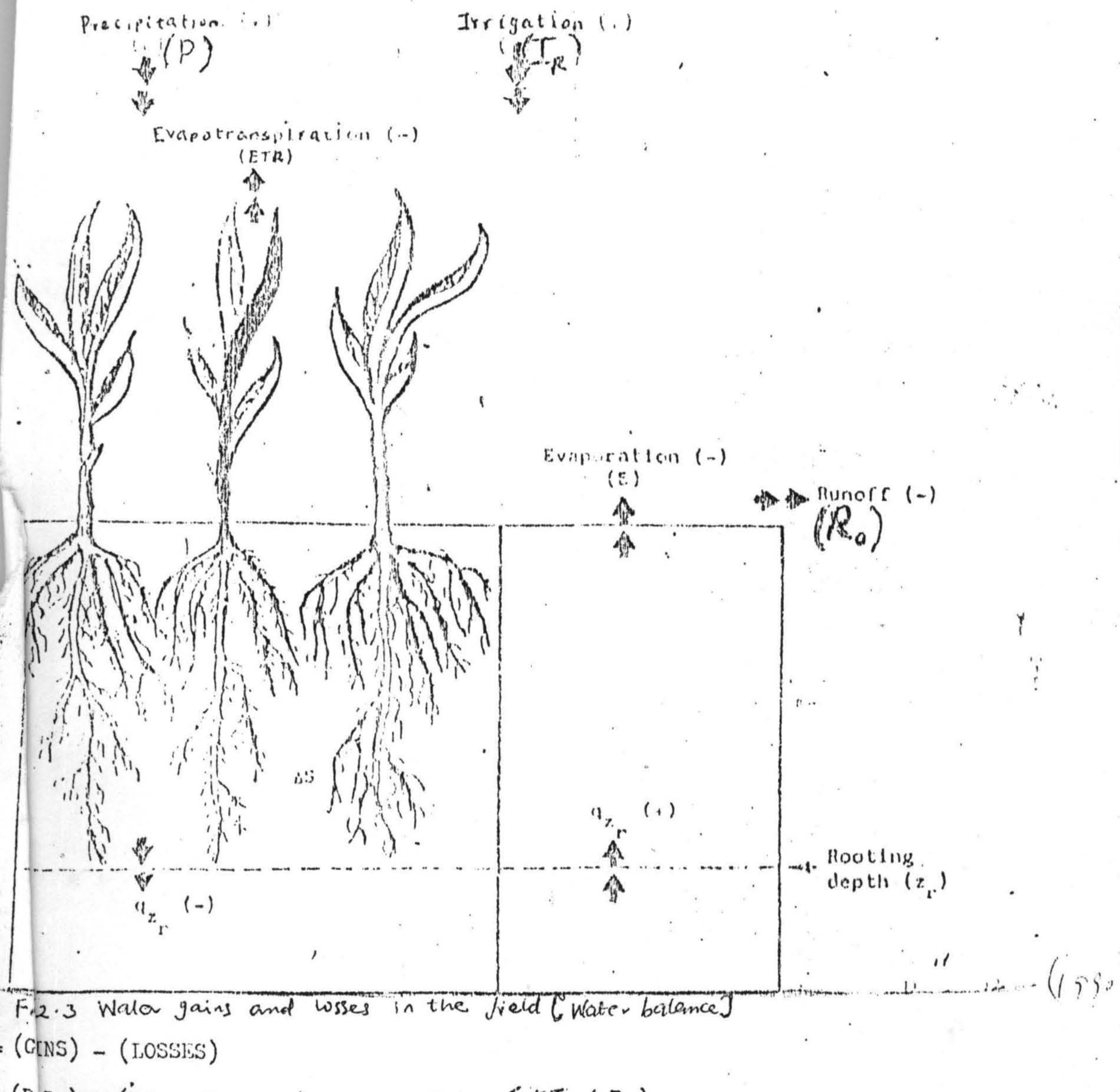


Fig 2.3 Water gains and losses in the field (Water balance)

= (GINS) - (LOSSES)

$= (P\ I_R) - (ETo + Pc + Ro) = P - R_o - (ET_o + P_C)$

= - D (i.e. G.W.C).

(i.e. NO. G.W.C)

P_E - N. W.R 2.1.7

$\% \text{ G.W.C} = \left(\frac{G.W.C}{N.W.R}; \text{ or } \frac{G.W.C}{E_T}\right) \times \frac{100}{1}$

Table 4.10 MOISTURE CONTENT, BULK DENSITY, AVAILABLE MOISTURE HOLDING CAPACITY

Depth (cm) 1	WT of wet soil(9) 2	WT of dry soil(9) 3	Moist cont(%) ((2-3/3)x 100) 4	Wet bulk Density (9/cm³) 5	Dry bulk density (g/cm³) 6	Porosity (%) 1-(6/5) 7	Available holding capacity (cm/m) 4 x 6 8	available moist holding capacity in root zone 9	Sample
0-20	351.38	300.20	17.05	2.25	1.89	16.00	32.22		A
20-40	320.79	288.14	11.33	2.02	1.82	9.90	20.62		B
40-60	322.85	290.88	10.99	2.04	1.83	10.29	20.11		C
60-80	341.03	302.92	12.58	2.15	1.91	11.16	24.03		D
								96.98	
0-20	330.40	283.14	16.69	2.08	1.79	13.94	29.88		A1
20-40	352.33	308.20	14.32	2.22	1.94	12.61	26.78		B1
40-60	321.74	292.12	10.14	2.03	1.84	9.06	18.66		C1
60-80	334.25	329.14	12.12	2.11	1.88	10.90	22.78		D1
								98.10	
0-20	339.49	297.82	13.99	2.14	1.88	12.15	26.30		A2
20-40	337.05	299.92	12.38	2.13	1.89	11.27	23.89		B2
40-60	323.06	286.40	12.80	2.04	1.81	11.27	23.17		C2
60-80	332.41	290.87	14.28	2.10	1.83	12.86	26.14		D2

99.00

Volume of core sample = $VT = \pi d^2 L/4 = (\pi(5.8)^2 \times 6)/4$

N.B. Volume of core sample = $158.52 cm^3$

APENDIX (C)

DETERMINATION OF EVAPOTRANSPIRATION (ET)
AND
SOIL MOISTURE BALANCE OF THE STUDY AREA
TABLE (1)

MONTH	RAINFALL	EVAPOTRANSPIRATION (ET)	RUN-OFF (SURPLUS)	IRRIGATIONS (DEFICIT)
JAN: 99	0.0	6.5 x 31 = 201.5	-	- 6.5
FEB: 99	2.8	6.5 x 29 = 182.7	-	- 3.7
MAR: 99	0.8	6.3 x 31 = 179.8	-	- 5.5
APR: 99	112.1	5.8 x 30 = 179.8	+ 106.3	-
MAY: 99	135.5	4.4 x 30 = 136.4	+ 131.1	-
JUNE: 99	196.8	3.5 x 31 =108.5	+ 193.3	-
JULY: 99	264.1	3.4 x 31 = 105.4	+ 260.7	-
AUG: 99	194.5	2.8 x 31 = 86.8	+ 191.7	-
SEPT: 99	153.7	2.9 x 31 = 89.9	+ 150.8	-
OCT: 99	98.0	3.8 x 31 = 117.8	+ 94.2	-
NOV: 99	.0.0	6.1 x 30 = 189.1	-	- 6.1
DEC: 99	0.0	6.2 x 31 = 192.2	-	- 6.2

NOTES :-

(i) RAINFALL = 1999 Rainfall Data was used (as attached)

(ii) EVAPOTRANSPIRATION (E_T) = Blarney-Morris-Nigeria (BMN) measured Data (Dry season) See Appendix G & H.

(iii) RUN-OFF = Surplus between Rainfall & E_T.

(iv) IRRIGATION = Dificit b/w Rainfall & E_T

fig 4.1

DATA ANALYSIS OF THE INFILITRATION TEST TAKEN AT THE FUT FARM PLOT BOSSO CAMPUS MINNA. PLOT 1

TIME (MIN)	INITIAL READING (CM)	FINAL READING (CM)	WATER INTAKE (CM)	ACCUMMULATED H_2O INTAKE (CM)	INFILTRATION (CM)	INFILTRATION RATE CM/HR.
0	-	-	-	-	-	-
1	6.0	10.9	4.9	4.9	4.9	294
2	10.9	14.3	3.4	8.3	4.15	124.5
3	2.7	7.3	4.6	12.9	4.3	86
5	7.3	15.3	8.0	20.9	4.18	50.16
10	15.3	23.1	7.8	28.7	2.87	17.22
15	2.0	14.8	12.8	41.5	2.76	11.04
20	1.8	15.2	13.4	54.9	2.57	8.25
25	0.5	15.4	14.9	69.8	2.79	6.70
30	3.0	17.1	14.1	83.9	2.79	5.58
35	2.1	17.5	15.4	99.3	2.84	4.86
40	6.3	17.8	11.5	110.8	2.77	4.15
45	2.2	17.7	15.5	126.3	2.81	3.74
50	2.1	17.6	15.5	141.8	2.84	3.41
55	1.0	16.8	15.8	157.6	2.86	3.12
60	1.5	15.7	14.2	171.8	2.86	2.86
65	1.8	16.8	14.2	186.0	2.86	2.64
70	1.5	14.2	14.3	200.3	2.86	2.45
75	1.3	14.2	12.9	213.2	2.84	2.27
80	0.8	14.5	13.7	226.9	2.84	2.13
85	1.3	14.9	13.6	240.5	2.83	1.99
90	1.9	13.8	11.9	252.4	2.80	1.86
95	0.5	12.8	12.3	264.7	2.78	1.75
100	2.3	13.0	12.3	277.0	2.77	1.66
105	0.7	0.7	13.0	290.0	2.76	1.57
110	0.7	11.3	10.6	300.6	2.73	1.48
115	1.2	12.8	11.6	312.2	2.71	1.41
120	2.1	17.5	15.5	327.7	2.73	1.36

fig 4.1.1

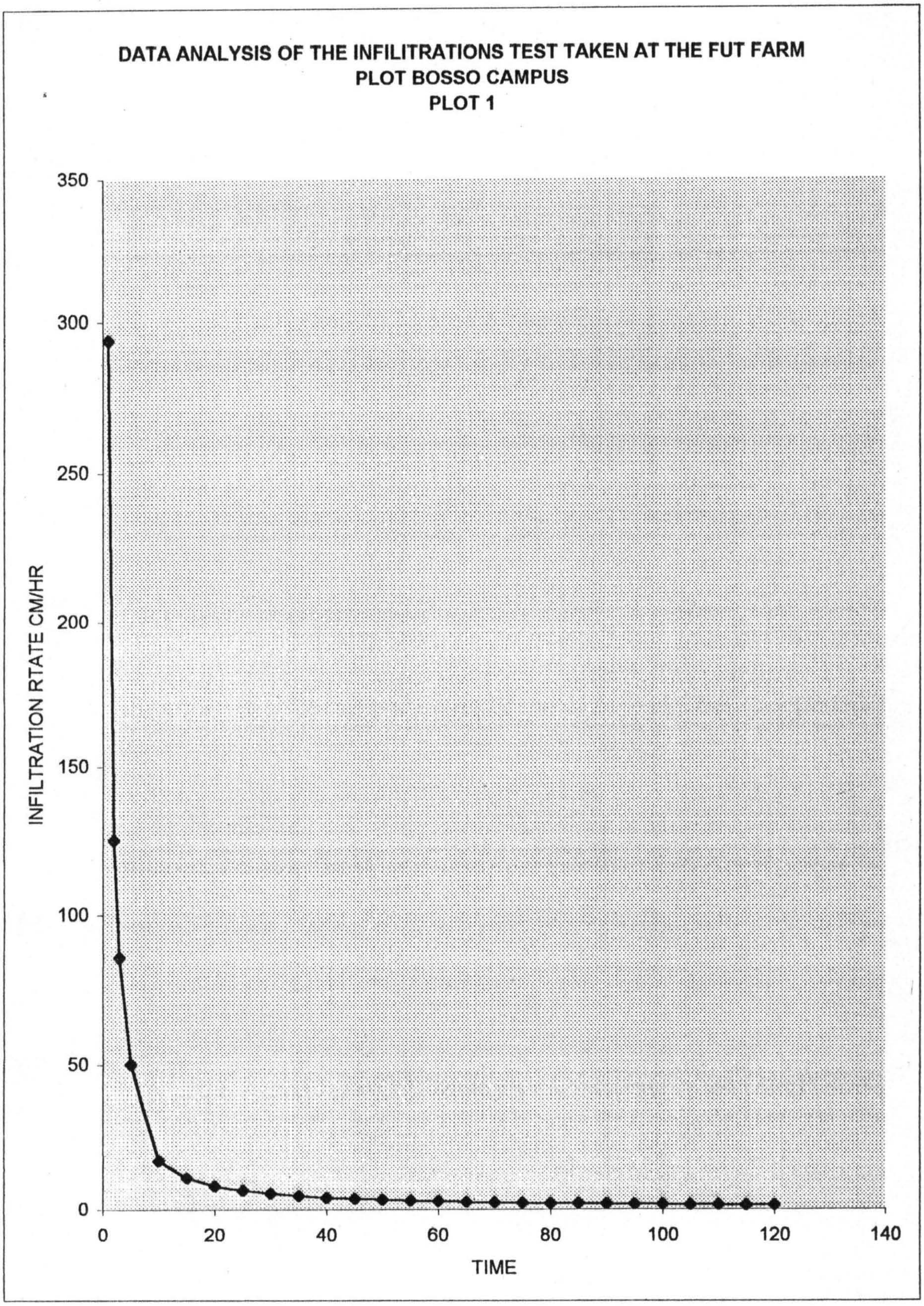

DATA ANALYSIS OF THE INFILITRATIONS TEST TAKEN AT THE FUT FARM
PLOT BOSSO CAMPUS
PLOT 1
INFILTRATION RTATE CM/HR
TIME
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140

fig 4:2

DATA ANALYSIS OF THE INFILTRATION TEST TAKEN AT THE FUT BOSSO CAMPUS FARM PLOTS MINNA PLOT2

TIME (MIN)	INITIAL READING (CM)	FINAL READING	WATER WTAKE (CM)	COMMULATIVE H_2O INTAKE (CM)	INFILITRATION (CM)	INFILTRATION RATE CM/HR
0	-	-	-	-	-	-
1	4.7	5.6	1.8	1.8	1.80	108
2	6.5	7.8	1.3	3.1	1.55	46.50
3	7.8	8.9	1.1	4.2	1.40	28.00
5	8.9	10.7	1.8	6.0	2.20	14.40
10	1.0	6.2	5.2	11.2	1.12	6.72
15	6.2	8.7	2.5	13.7	0.91	3.64
20	8.7	11.5	2.5	16.2	0.81	2.43
25	1.2	5.2	4.0	20.2	0.80	1.94
30	5.2	8.0	2.8	23.0	0.77	1.54
35	8.0	9.8	1.8	24.8	0.71	1.22
40	9.8	12.8	3.0	27.8	0.69	1.04
45	5.7	8.4	2.7	30.5	0.67	0.89
50	8.4	10.3	1.9	32.4	0.65	0.78
55	10.3	11.9	1.6	34.0	0.62	0.68
60	11.9	13.3	1.4	35.4	0.59	0.59
65	8.3	10.6	2.3	37.7	0.58	0.53
70	1.0	4.1	3.1	40.8	0.58	0.50
75	4.1	6.9	2.8	43.6	0.57	0.46
80	6.9	8.7	1.8	45.4	0.57	0.43
85	8.7	10.8	2.1	475	0.56	0.40
90	1.4	4.6	3.2	50.7	0.56	0.37
95	4.6	6.8	2.2	52.9	0.56	0.35
100	6.8	9.5	2.7	55.6	0.56	0.34
105	9.5	10.6	1.1	56.7	0.56	0.31
110	10.6	12.3	1.7	58.4	0.54	0.29
115	2.4	5.2	2.8	61.2	0.53	0.28
120	5.2	7.8	2.6	63.8	0.53	0.27

fig 4. 2. 1

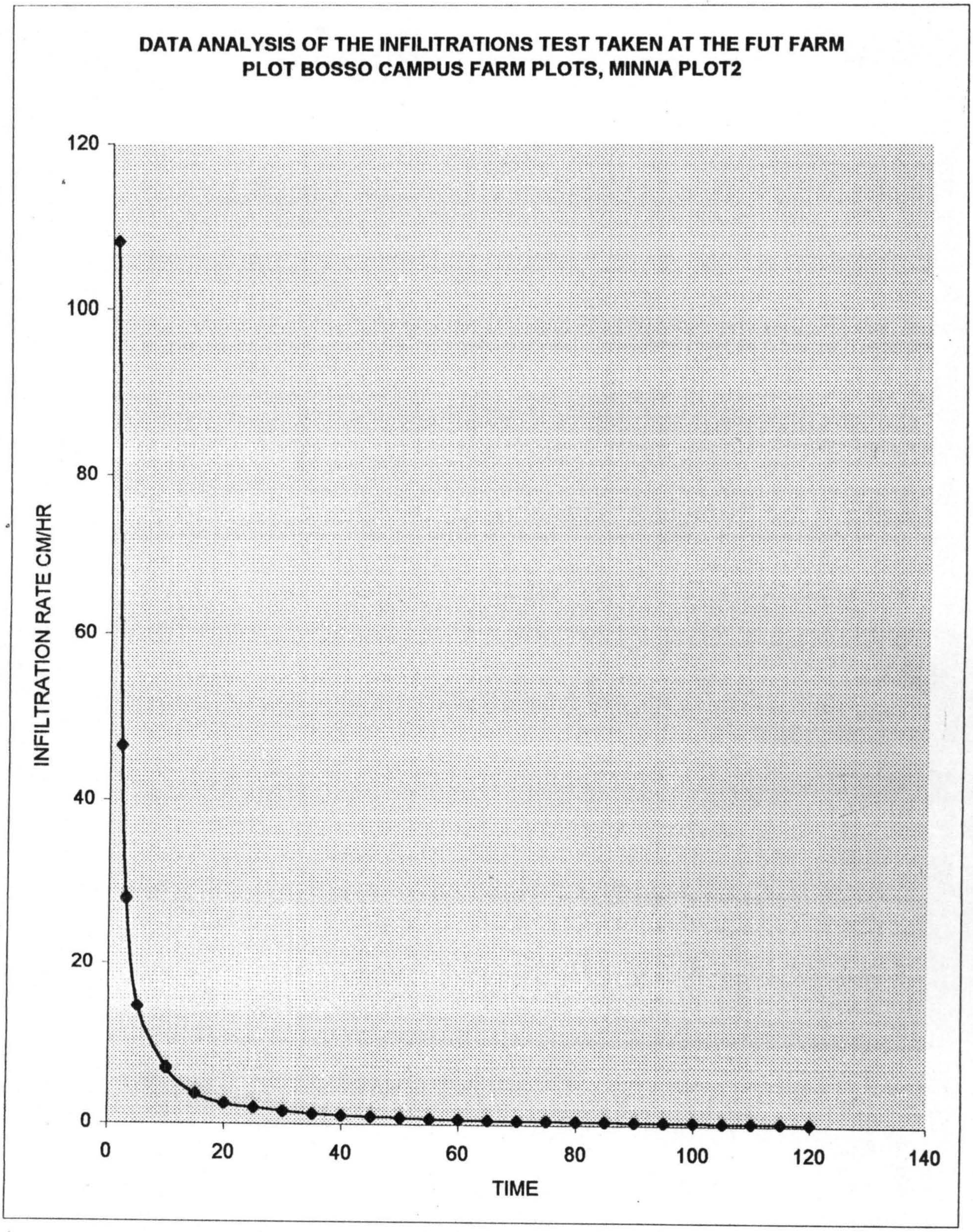
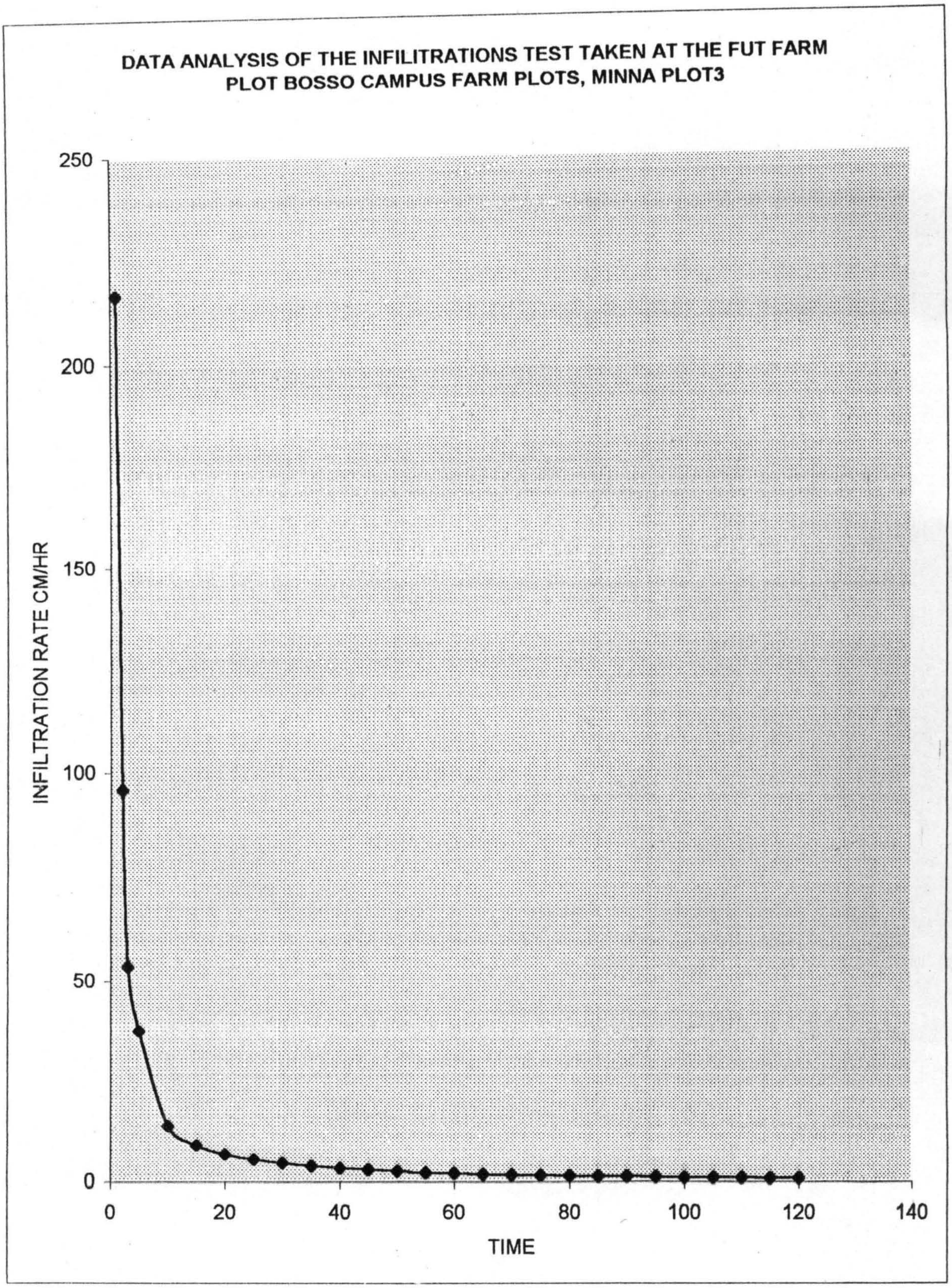

DATA ANALYSIS OF THE INFILITRATIONS TEST TAKEN AT THE FUT FARM PLOT BOSSO CAMPUS FARM PLOTS, MINNA PLOT2
INFILTRATION RATE CM/HR
TIME
0
20
40
60
80
100
120
140

Fig 4 : 3

DATA ANALYSIS OF THE INFILTRATION TEST TAKEN AT THE FUT BOSSO CAMPUS FARM PLOTS
MINNA PLOT 3

TIME (MIN)	INITIAL READING (CM)	FINAL READING	WATER WTAKE (CM)	COMMULATIVE H_2O INTAKE (CM)	INFILITRATION (CM)	INFILTRATION RATE CM)/HR
0	-	-	-	-	-	-
1	4.9	8.5	3.6	6.3	3.6	216
2	8.5	11.3	2.8	6.4	3.2	96
3	11.3	13.3	2.0	8.0	2.67	53.4
5	0.3	7.9	7.6	15.6	3.12	37.44
10	7.9	14.9	7.0	22.6	2.26	13.56
15	3.0	12.9	9.9	32.5	2.17	8.68
20	2.2	12.9	10.7	43.2	2.16	6.48
25	1.4	12.4	10.0	54.2	2.17	5.21
30	1.2	11.5	10.3	64.5	2.15	4.30
35	0.9	10.0	9.10	73.6	2.10	3.60
40	0.8	9.3	8.5	83.1	2.05	3.08
45	0.5	8.8	8.3	90.4	2.01	2.68
50	0.5	9.1	8.6	99.0	1.98	2.38
55	9.1	13.1	4.0	103.0	1.87	2.04
60	1.0	9.0	8.0	111.0	1.85	1.85
65	9.0	13.2	4.2	115.2	1.77	1.63
70	0.0	7.3	7.3	122.5	1.75	1.50
75	7.3	11.9	4.6	127.1	1.69	1.35
80	1.6	7.7	6.1	133.2	1.665	1.25
85	7.7	11.8	4.1	137.3	1.61	1.14
90	1.7	8.0	6.3	143.6	1.6	1.07
95	8.0	12.8	4.8	143.4	156	0.98
100	1.3	5.7	4.4	152.8	1.53	0.92
105	5.7	10.8	5.1	157.9	1.50	0.86
110	0.3	6.0	5.7	163.6	1.49	0.81
115	6.0	10.5	4.2	167.8	1.46	0.76
120	1.5	7.6	6.1	173.9	1.45	0.73

fig 4.3.1



DATA ANALYSIS OF THE INFILITRATIONS TEST TAKEN AT THE FUT FARM PLOT BOSSO CAMPUS FARM PLOTS, MINNA PLOT3
INFILTRATION RATE CM/HR
TIME
0
50
100
150
200
250
0
20
40
60
80
100
120
140

fig 4:4

DATA ANAYSIS OF THE INFILTRATION TEST TAKEN AT THE FUT BOSSO CAMPUS FARM PLOTS MINNA PLOT4

TIME (MIN)	INITIAL READING (CM)	FINAL READING	WATER WTAKE (CM)	COMMULATIVE H_2O INTAKE (CM)	INFILITRATION (CM)	INFILTRATION RATE CM/HR
0	-	-	-	-	-	-
1	4.4	5.7	1.3	1.3	1.3	78
2	5.7	6.8	1.1	2.4	1.2	36
3	6.8	7.7	0.9	3.3	1.1	22
5	7.7	9.0	8.3	11.6	1.320	27.84
10	0.8	6.0	5.2	16.8	1.680	10.08
15	6.0	7.2	1.2	18.0	1.200	4.800
20	7.2	8.9	1.7	19.7	0.985	2.955
25	8.9	9.9	1.0	20.7	0.828	1.987
30	9.9	11.0	1.1	21.8	0.726	1.452
35	1.9	5.1	3.2	53.8	1.537	2.635
40	5.1	6.1	1.0	54.8	1.370	2.055
45	6.1	7.5	1.4	56.2	1.248	1.664
50	7.5	8.3	0.8	57.0	1.140	1.368
55	8.3	9.2	0.9	57.9	1.052	1.147
60	9.2	10.3	1.1	59.0	0.980	0.983
75	2.4	7.0	4.6	63.6	0.848	0.678
90	7.0	9.4	2.4	66.0	0.733	0.488
105	1.7	6.1	4.4	70.4	0.670	0.304
120	6.1	8.6	2.5	72.9	0.607	0.304

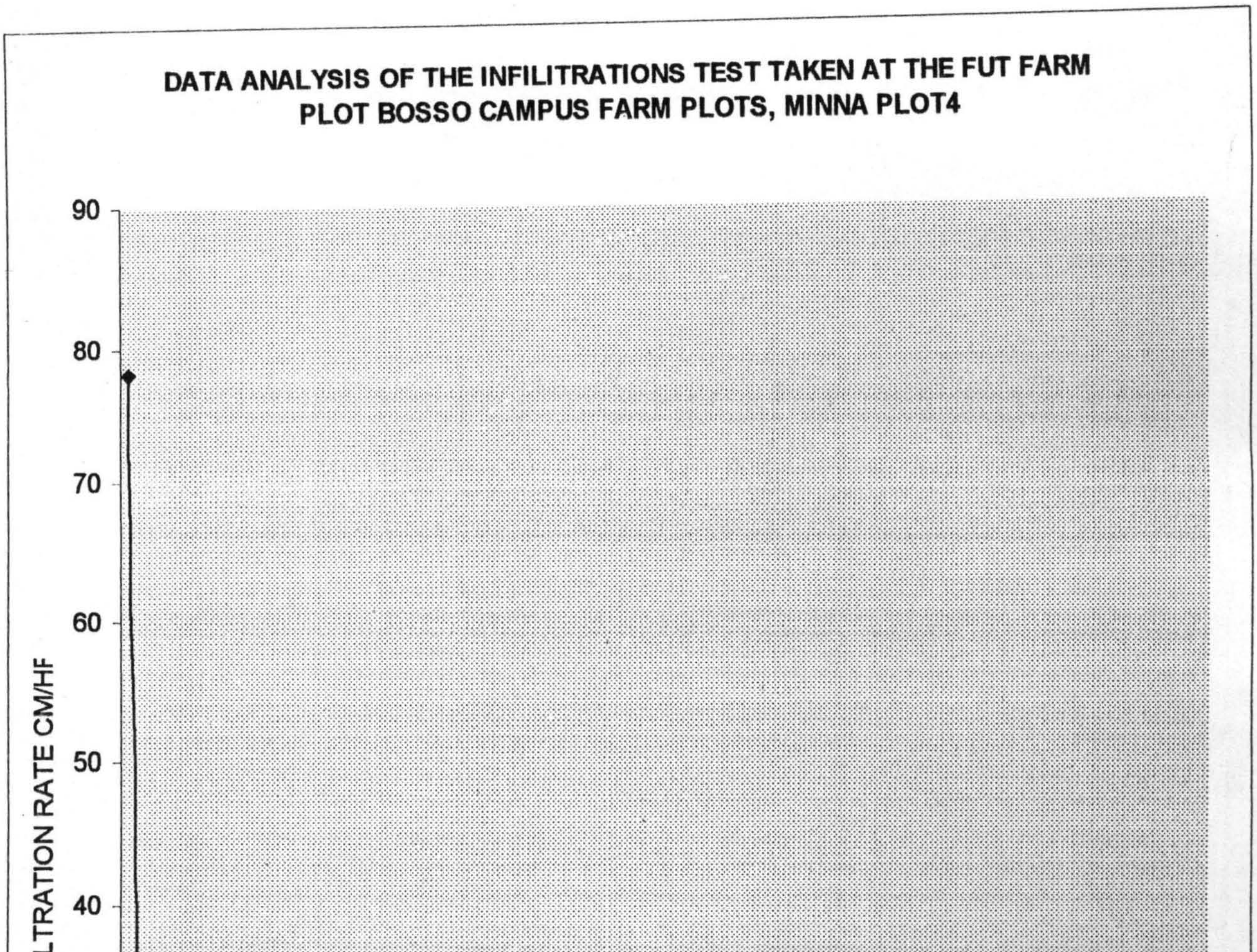

DATA ANALYSIS OF THE INFILITRATIONS TEST TAKEN AT THE FUT FARM PLOT BOSSO CAMPUS FARM PLOTS, MINNA PLOT4
INFILTRATION RATE CM/HF
TIME
0
10
20
30
40
50
60
70
80
90
0
20
40
60
80
100
120
140

fig 3.6.3

WATER TABLE MONITORING FIELD PLOT OF THE STUDY AREA

DATE	SHALLOW(THIGHER H_2O TABLE (A1) (A)	DEEP (LOWER) H_20 TABLE (M) (B)
3/7/2000	0.66	0.34
5/7/2000	0.66	0.45
7/7/2000	0.68	0.47
9/7/2000	0.64	0.45
11/7/2000	0.64	0.38
13/7/2000	0.59	0.33
15/7/2000	0.61	0.31
17/7/2000	0.63	0.34
19/7/2000	0.65	0.32
21/7/2000	0.65	0.31
23/7/2000	0.66	0.34
25/7/2000	0.45	0.32
27/7/2000	0.38	0.48
29/7/2000	0.29	0.52
31/7/2000	0.30	0.44
2/7/2000	0.38	0.42
4/8/2000	0.34	0.42
6/8/2000	0.32	0.45
8/8/2000	0.38	0.46
10/8/2000	0.38	0.40
12/8/2000	0.39	0.40
14/8/2000	0.40	0.40
16/8/2000	0.41	0.39
18/8/2000	0.42	0.43
20/8/2000	0.40	0.44
22/8/2000	0.40	0.46
24/8/2000	0.41	0.46

CHAPTER FIVE

5.0 SUMMERY, CONCLUSION AND RECOMMENDATION.

5.1 CONCLUSION

The aim and objective of the project was achieved, rainfall, weather, topographic soil Ground water table of the study area was considered, could be used to predict soil moisture balance of the particular area and designing good workable irrigation system. The area will be suitable for surface irrigation (gravity) system.

5.2 RECOMMENDATION

The major problem encountered during the course of my project work was no possible in the dry season. If is therefore, recommended that the installation of the piezometer pipe, that was not possible in the dry season. If is therefore, recommended that the installation of the piezometer pipe should be down before dry season or bigger instrument should be used to check or determine the round water table of the area for a given year.

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APPENDIX (A)

LIST OF SYMBOLS

P = Rainfall (mm)

Q = Runoff (mm)

S = Change in moisture storage (mm)

Et = Actual evaportansporation (mm)

L = Losses (Deep percolation) (mm)

B.S = End of storm.

INT = Internal

X= Loss factor L/P

S = Stage (f_l)

APPENDIX (B)

Grain size	Particle diameter
Gravel fine	2.0-1.0
Sand, coarse	1.0-0.5
Sand, medium	0.5-0.25
Sand, fine	0.25-0.10

C_u = D60/D10 Greater than 4

Well graded gravels, gravel-sand mixture, little or no fine.

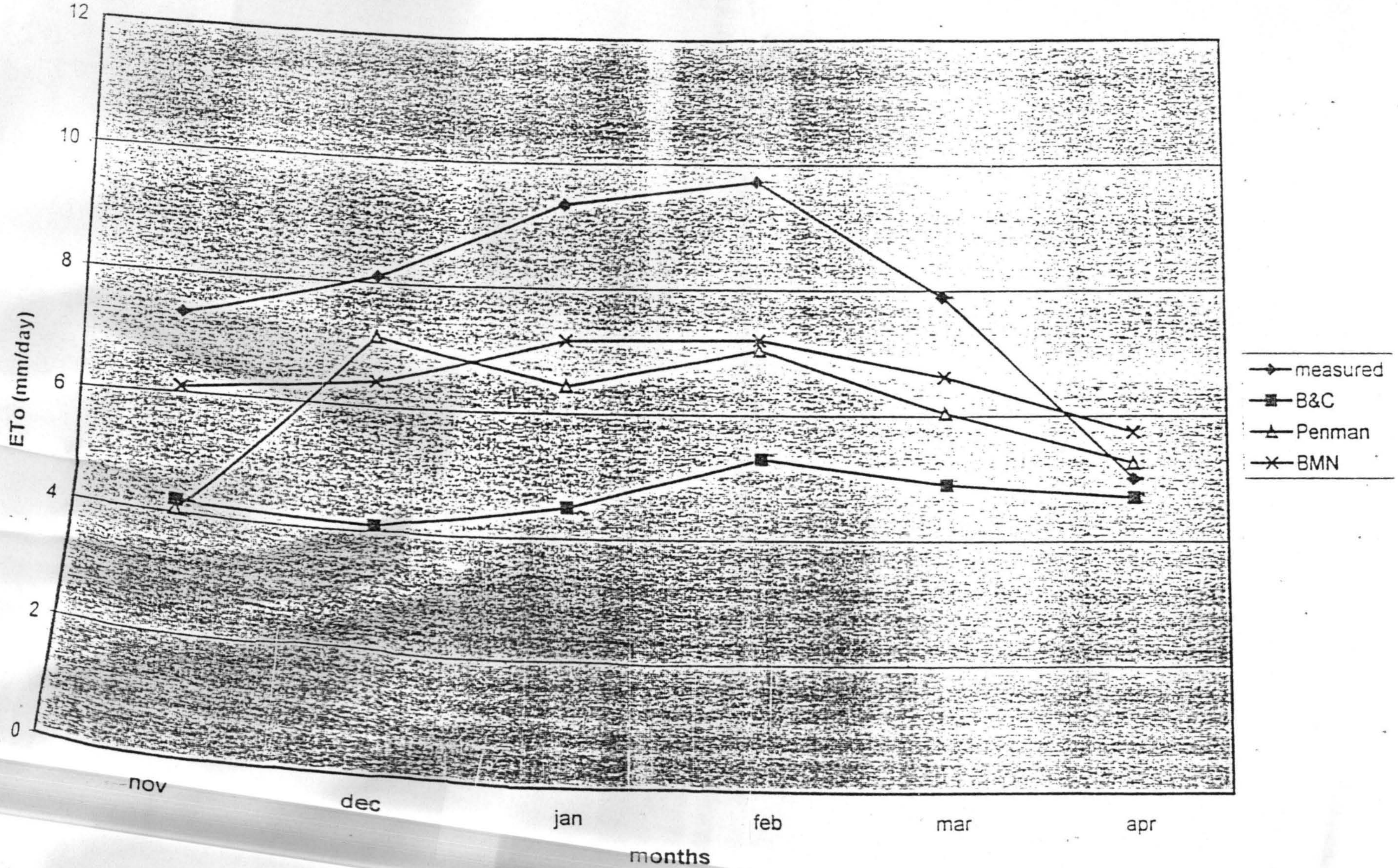
$C_c = (D30)^2/(D10 \times D60)$ Between 1 & 3

C_u = D60/D10 Greater than 6

Well graded sand, gravel sands little or no fine

$C_c = (D30)^2/(D10 \times D60)$ Between 1 & 3

Fig 2: BMN, modified penman and Blarney cradle models with measured data (dry season)



odels compared with measured data (wet season).