DESIGN, FABRICATION AND TESTING OF AN EQUIPMENT TO MEASURE DEEP PERCOLATION

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Technology in Agricultural Engineering

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Tavanur, Malappuram

1990

DECLARATION

I hereby declare that this thesis entitled "Design, fabrication and testing of an equipment to measure deep percolation" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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19-11-1990.

CERTIFICATE

Certified that this thesis entitled "Design, fabrication and testing of an equipment to measure deep percolation" is a record of research work done independently by **Smt. Jolly Kutty Eapen** under my guidance and supervision and that it has not previously formed the basis for the award for any degree, fellowship or associateship to her.

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We, the undersigned members of the Advisory Committee of **Smt. Jolly Kutty Eapen,** a candidate for the degree of Master of Technology in Agricultural Engineering agree that the thesis entitled "Design, fabrication and testing of an equipment to measure deep percolation" may be submitted to Smt. Jolly Kutty Eapen in partial fulfilment of the requirement of the degree.

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Jolly Kutty Eapen
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Dedicated to my mother

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SYMBOLS AND ABBREVIATIONS

Agric	-	Agricultural
Agron	-	Agronomy
cm	-	centimetre(s)
Co	-	Company
Dept	-	Department
_et al._	-	and others
Fig	-	Figure
Fmg	-	Farming
G.I	-	Galvanised Iron
g	-	gram(s)
ha	-	hectare(s)
hr	-	hour
ICAR	-	Indian Council of Agricultural Research
J	-	Journal
KCAET	-	Kelappaji College of Agricultural Engineering and Technology
kg/ha	-	kilogram per hectare
Ltd	-	Limited
l/s	-	litre(s) per second
mgt	-	management
mm	-	millimetre(s)
No.	-	Number
p	-	page
Proc.	-	Proceedings
PVC	-	Poly Vinyl Chloride
Res	-	Research
Symp	-	Symposium
t/ha	-	tonne per hectare
Univ	-	University
%	-	per cent

Introduction

INTRODUCTION

Water is essential for every living biological system Since ancient times, mankind took water as a gift of God and also recognised its importance as one of the basic elements of life. It is estimated that out of a total quantity of 370 million hectare meters of water received as annual rainfall over the Indian Sub-continent, about 170 million hectare meters go as run off, while 120 million hectare meters of water infiltrate into soil The net available water, if properly managed would cover a much larger area for irrigation than what is being covered at present.

Agriculture is tne backbone of Indian economy and nearly two third of the population depends on it for living. Rice is the most important and extensively cultivated food crop of Kerala The State of Kerala has a total area of 21 84 lakh hectares under cultivation, of which 7.4 lakh hectares are covered by rice. The production of rice was 12.56 lakh tonnes in the year 1984-'85 (The Directorate of Economics and Statistics, Trivandrum). Rice yield in Kerala remains to be low and variable due to the widely varying soils and agroclimatic conditions under which rice is grown.

Rice is a semi aquatic plant and hence its water requirements are many times more than most of the other food crops It is therefore a major consumer of the water resources of the country and thus needs careful water mangement in order to increase its efficiency for water use.

With the prospect of attaining self sufficiency in food production, the demand for quality grain depending upon consumer preference will be increasingly felt. Production of better quality grains can be achieved through improved varieties and manipulation of management practices. Thus, the concept of rice farming is gradually undergoing a revolution not only to keep pace with green revolution taking place in our country with regard to increase in yield per unit area, but also to satisfy the consumer demands to a greater degree with regard to quality.

To achieve the goal to increase the area under irrigation without any additional increase in the quantity of irrigation water is by reducing the different losses of water in the paddy fields to the least possible level. There are mainly three important losses of water in the paddy cultivation. They are

1. Conveyance losses
2. Percolation losses
3. Evapotranspiration losses

The loss of water which occurs while conveying water from the source of irrigation water to the field is termed as conveyance loss. Percolation is the downward movement of water through saturated or nearly saturated soil in response to force of gravity

The losses of water by percolation constitute the major portion of the water in submerged field conditions. Percolation can be divided into two types (1) Vertical and (2) Horizontal. It has been shown that about 40 to 60 per cent of the water required by rice is lost by percolation. Percolation is affected by the texture and structure of the soil to a greater extent.

The measurement or prediction of deep percolation losses in field condition is of great practical significance for efficient irrigation and also for the determination of nutrient losses. Percolation losses that occur in the paddy fields have been estimated by the drum culture technique under various situations. All these studies give values of total percolation measured at the surface only. In this study an attempt is made to find the percolation losses below the root zone of paddy that is deep percolation losses. When the water percolates down through the soil, the nutrients in the fertilizer especially cationic forms get fixed in the soil As it goes down though the soil into deeper layers more and more nutrients get fixed in the soil profile. Information on the quantitative losses of nutrients below the root zone through deep percolation is scanty A study on the above aspect will provide valuable information for the quantitative assessment of the nutrients lost through deep percolation. Standard equipment is not readily available to assess the deep percolation losses. The main objective of the study is

1. to design, fabricate and test an equipment to measure deep percolation

2. to quantify the deep percolation losses

3. to assess the nutrient losses in the percolation water

Review of Literature

REVIEW OF LITERATURE

An attempt is made to give a brief review of the literature relevant to the topic of the study undertaken in the past.

In Kerala, paddy can be grown as transplanted or direct sown crop during three seasons depending upon the availability of water and other local conditions. They are

Virippu	-	First crop (Autumn) April-May to September-October
Mundakan	-	Second crcp (Winter) September-October to December-January
Punja	-	Third crop (Summer) December-January to March-April

The water required to produce optimum yield in rice not only include the water required to satisfy the evapotranspiration needs of the crop but also the water required to replenish the losses due to deep percolation.

The different components of water losses in paddy field are

1. Percolation
2. Evaporation
3. Transpiration
4. Conveyance
5. Surface run off

1 Total water requirement

Pande and Mittra (1969) and Sahu and Rout (1969) showed that water needs of rice ranged from 950 to 2150 mm depending upon the place, season and duration of crop.

Chandra Mohan (1970) reported in Coimbatore that 1673 mm of water was required for main crop, while at Pattukottai 2000 mm for Kuruvai crop and 2650 mm during Samba crops were found to be optimum.

Rao et al. (1971) found that 200 mm water was needed for nursery and another 200 mm for puddling and 600 to 800 mm during the rest of crop growth depending upon duration.

2 Evaporation, transpiration and percolation losses

According to Sharma and Bhattacharya (1972) at Kharagpur, in lateritic soil details of losses during 1969-1971 were as follows.

For kharif rice

	Submergence	
	Shallow	Deep
Evaporation, mm	140	141
Transpiration, mm	197	204
Percolation, mm	935	1707

For summer rice

	Submergence	
	Shallow	Deep
Evaporation, mm	389	402
Transpiration, mm	362	370
Percolation, mm	1114	1794

Studies conducted in Punja season in the Agronomic Research Station (1976) on a medium duration variety showed that evaporation is 10.4 per cent, transpiration is 16.69 per cent and percolation is 72.89 per cent (Anon, 1976).

Chirayath Lissy Devid (1988) estimated the various forms of water loss that occurs in Kole lands of Trichur District with lysimeter and evaporimeter. The water lost by evaporation is 12.34 per cent and transpiration loss is 17.32 per cent and that of percolation loss is 70.34 per cent. The total water requirement of the crop was 2134.22 mm measured by using a field hook gauge.

Percolation

Vamadevan and Dastane (1968) found out the limits of percolation rates which can be utilized in irrigated rice culture in Central Rice Research Institute, Cuttack and classified soils into the following categories by the drum culture technique.

Percolation losses from different class of land

Class	Percolation rate (mm/day)
Excellent	1.0 to 2.5
Fair	2.5 to 5.0
Marginal	5.0 to 7.5
Unsuitable	>7.5

If the soil percolation rate is greater than 7.5 mm/day, it may be rejected for growing rice crop. Soil selected for rice culture should have low percolation value.

Dastane (1969) and Shanmugham (1971) reported that nearly 60 to 70 per cent of applied water is lost by percolation.

Dastane (1970) reported that a depth range of 0 to 4 cm of water seemed to be optimum and also suggested some measures for reducing percolation losses are given below.

1. Selection of heavy soils or those with hard pans and shallow depth
2. Scrupulous land levelling, unlevelled lands involve more application of water
3. Puddling to reduce permeability
4. Light or shallow depth of land submergence to reduce percolation rate by minimising hydrostatic pressure

5. Intermittent drying of field at proper stages in long duration varieties

6. Compacting of soil, embedding polythene sheets and application of chemicals such as bitumen, asphalt etc. at about 30 cm below the surface. High costs involved in such practices, however do not yet permit their wide usage

7. Growing crops in large blocks instead of isolated pieces

Pande and Mittra (1971) from Kharagpur reported that percolation loss was 64 mm and 84 mm for Aus and Boro Paddies.

Sharma et al. (1972) stated that at Mysore, in black clayey soil, a percolation loss of 19.8 mm/day was found. The percolation loss was found 2-3 times higher than that of evapotranspiration. For summer rice the percolation loss was 18.4 mm/day.

Gupta (1972) observed that deep percolation was of the order 25 to 50 per cent in sandy soil, 15 to 25 per cent on sandy loam, 10 to 20 per cent in fine sandy loam and 5 to 15 per cent in heavy clay soils of Uttar Pradesh.

Vamadevan et al. (1974) conducted studies at Central Rice Research Institute, Cuttack, indicated that the horizontal (lateral) seepage was major fraction in the different components of water loss Th s loss was two to five times to that of vertical percolation.

Sivanappan *et al.* (1974) evaluated the two important losses of water in paddy cultivation viz., conveyance and percolation losses by the modified drum culture technique. It is reported that 40 to 50 per cent of the water required by the rice is lost by percolation. The average vertical percolation in

Sandy loam soil is 3-6 mm/day

Loamy soil is 2-3 mm/day

Clay loam soil is 1-2 mm/day

Morachan and Iruthayaraj (1974) carried out experiments for minimising water losses in rice fields of T.N.A.U., Coimbatore. The percolation losses and seepage losses can be minimised by suitable agronomic and water management practices as follows

1. Reduction of losses by soil fillings such as tank silt, fire ash etc.
2. Use of water saving devices, like turn-out gates, diversion boxes etc. to have rotational irrigation
3. Compaction of soil
4. Irrigation at different stages of plant growth
5. Manipulation of soil by different tillage implements
6. Use of barriers, like cement, asphalt, polythene sheets etc.

George et al. (1976-1977) conducted studies on various forms of water loss and total water requirement of rice in Mundakan, Virippu, and Punja season in Agronomic Research Station, Chalakkudy The loss of water due to evaporation in the field was maximum immediately after transplanting and the loss was 4.8 mm/day The maximum rate of transpiration was 6.3 mm/day. The percolation loss was 76.40 per cent of the total water requirement.

Yadav (1977) reported from the results of All India Co-ordinated Project for Research on Water Management and salinity that at Siruguppa (Mysore) on heavy soils in the Kharif season, about 72 per cent of the water required for rice was lost through percolation and only 28 per cent of water was used consumptively.

Jung and Gschwind (1979) and Lyon et al. (1930) reported that the loss of water by percolation in cropped area is generally less than that of bare areas, unless surface run off in excessively high form the bare soil.

George et al. (1985) evaluated different methods for reducing percolation loss of water in rice fields of Agronomic Research Station, Chalakudy for five years 1974 to 1980. The study showed that puddling with different implements like power tiller, country plough and wet land puddler, soil dressing with lateritic loam and subsoil compaction at 30 cm depth did not effectively reduced the water loss nor influence the grain yield in sandy loam soil.

Yadav _et al._ (1987) conducted field studies at Experimental Station, G.B. Pant University of Agriculture and Technology, Pantnagar. The studies were conducted in loamy soil with wheat crop to find the effect of area and discharge on percolation losses in check basin. Percolation loss was determined by the formula

$$P = \frac{(d_a - d)}{d} \quad 100$$

where,

P - percolation loss in percentage

d - depth of water needed

da - depth of water applied (cm)

The results indicated that for 10 l/s, 14 l/s and 28 l/s discharge, the check basin should not exceed 200 m^2, 300 m^2 and 500 m^2 respectively in loamy soil if percolation losses are to be kept to a level of 10 per cent or less and percolation losses increased with decrease in stream size.

Singh _et al._ (1988) compared percolation loss of packed clay soil found by lysimeter and tensiometer methods. The percolation and evaporation plus percolation fluxes of packed Ashutia clay soil determined under prevented evaporation and free evaporation condition respectively using tensiometric techniques, matched with profile water losses from lysimeter measurements. The error ranged between 0 01 and 0.82 mm/day with high correlation coefficient indicating that water loss from a soil profile can be estimated from tensiometer readings.

3 Nutrient losses

Buckman and Brady (1969) found out the average annual loss of nutrients by percolation through soils from four different areas using Monolith type of lysimeter. The loss of nitrogen from Dunkirk, bare and rotation conditions are 77 and 9 kg/ha/yr. And from Volusia, bare and rotation conditions are 48 and 7 kg/ha/yr. Similarly the loss of potassium for the Dunkirk, bare and rotation conditions are 81 and 64 kg/hr/yr. And from Volusia, bare and rotation conditions are 72 and 64 kg/ha/yr. The loss of phosphorus can be neglected.

Padmaja and Koshy (1978) conducted an experiment at the Kerala Agricultural University Campus at Vellayani during the Kharif season of 1975-1976 using a laterite clay loam soil for the run off losses of major plant nutrients in water logged rice soil. The experiment was conducted in 10 kg pots and were filled with air dried soil and a basal application was given. Water was added and rice seedlings were planted. Surface water was removed by run off method and samples were analysed for NPK. It was observed that about 70 per cent of applied nitrogen was lost when water was removed by run off on the same day of manuring. The loss was reduced by 44 per cent after 48 hrs and negligible after the fifth day of fertilizer application. The losses were reduced after two days and were negligible after second day. Losses of phosphorus were negligible and a maximum loss of 2 per cent occurred on third day of fertilizer application.

Patel and Ghildyal (1982) conducted glass house and lysimeter experiments with Jaya and Bala varieties of rice to study the leaching losses of nitrogen and potassium under different drainage conditions and under flooding. It was reported that concentration of nitrogen in drainage water decreased with advancement of crop growth and reached to a minimum value at har vest. The total loss of nitrogen ranged from 46.2 kg/ha for Jaya, 45.2 kg/ha for Bala under high drainage to 24.7 kg/ha for Jaya and 25 kg/ha for Bala under low drainage. Potassium content in percolation water decreased from 0.371 m eq/l to zero after 34 days of crops growth.

Armstrong (1989) reported that the leaching losses on drained plots are higher than on the undrained. A careful consideration of the supply of both water and nitrogen can do much to reduce these losses. Nitrogen loss can be reduced by applying nitrogen fertilizers at the time of maximum requirement.

Goss Mike (1989) conducted an experiment of leaching of nitrate under arable crops at Brimstone Farm. It was reported that the average annual loss of nitrogen from drained ploughed plots was 40 kg N/ha equivalent to 23 per cent of the applied fertilizers.

Materials and Methods

MATERIALS AND METHODS

The design details, materials used and methods adopted for the investigation are discussed in this chapter. A field experiment to estimate the losses through percolation and to assess the nutrient losses of a short duration rice was conducted during 1989-'90 in Mundakan Season.

1 Location

The experiment was conducted in the paddy field of K.C.A.E.T., Tavanur. It is situated at 10° 52' 30" latitude and 76° east longitude. K.C.A.E.T. has a total area of 40.99 ha, out of which total cropped area is 29.65 ha.

In the wetlands paddy is the main crop. Crops like coconut, arecanut, pulses, vegetables are mainly cultivated in the garden lands.

2 Soil

Surface soil (60 cm) is sandy loam in texture comprising of 10 per cent gravel, 65 per cent sand, 12.5 per cent silt and 12.5 per cent clay.

3 Climate

Agroclimatically the area falls within the border line of northern zone and central zone. The area receives rainfall mainly from the southwest monsoon and to a certain extent from the northeast monsoon. The annual rainfall is in between 2500 mm and 2900 mm.

4 Season and weather conditions

The experiment was conducted during the Mundakan Season of 1989-'90. The details of meteriological data recorded at Instructional Farm of K.C.A.E.T., Tavanur during the crop period are presented in the Table 1. The crop was transplanted on 19.10.1989 and harvested on 11.1.1990.

5 Experimental technique

Estimations of evaporation, transpiration and percolation were done on the principle of drum culture technique using the following field equipments. The experiment was replicated four times in four plots of area 40 m^2. The plan of layout and an individual plot are given in Fig.1a and Fig.1b, respectively.

5.1 Field hook gauge

Field hook gauge consisted of a pointer bent upwards, which was sliding over a 6 mm iron rod to which a graduated scale was fitted. Least count of the scale was 0.50 mm. The height of hook gauge was designed so as to read the scale without parallax error by squatting on the bund. A frame made of angle iron was provided at the bottom for giving perfect seating to the equipment in the field. The diagram of field hook gauge is given in Fig.2 and also in

Table 1 Meteorological data during the experimental period

Period	Mean maximum temperature °C	Mean minimum temperature °C	Mean of temperature	Sunshine hours
October				
19 - 25	31.42	24.07	27.75	6 77
26 - 1st	31.00	24.42	27.71	5.59
November				
2 - 8	31.85	25.29	28.57	8 57
9 - 15	31.93	25.79	28.86	6.86
16 - 22	32.43	25.43	28.93	9.56
23 - 29	30.50	24.07	27.28	10.20
30 - 6	30.36	25.29	27.83	10.20
December				
7 - 13	31.86	25.29	28.58	9.10
14 - 20	32.14	27.57	29.85	9.36
21 - 27	32.07	23.57	27.82	9.27
28 - 3	32.50	24.71	28.60	8.06
January				
4 - 10	31.36	24.00	27.68	8.59

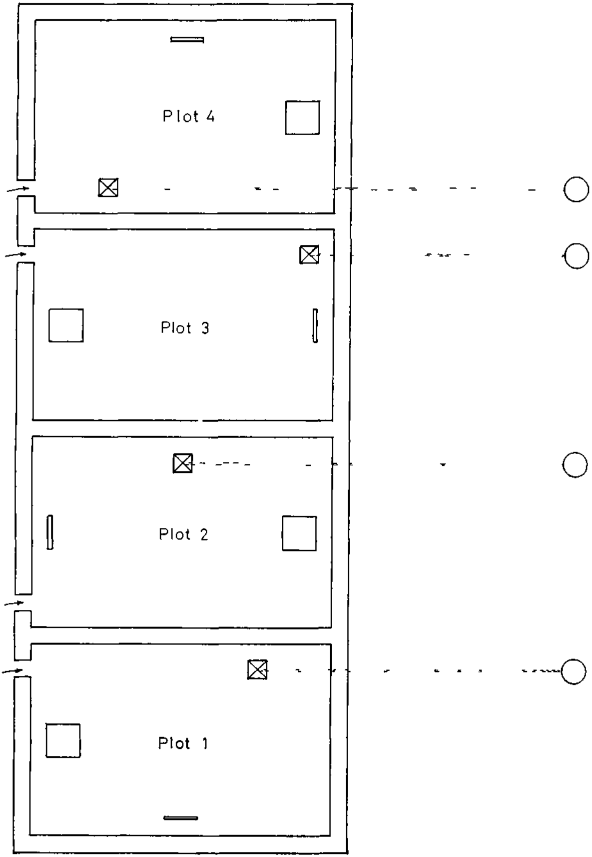
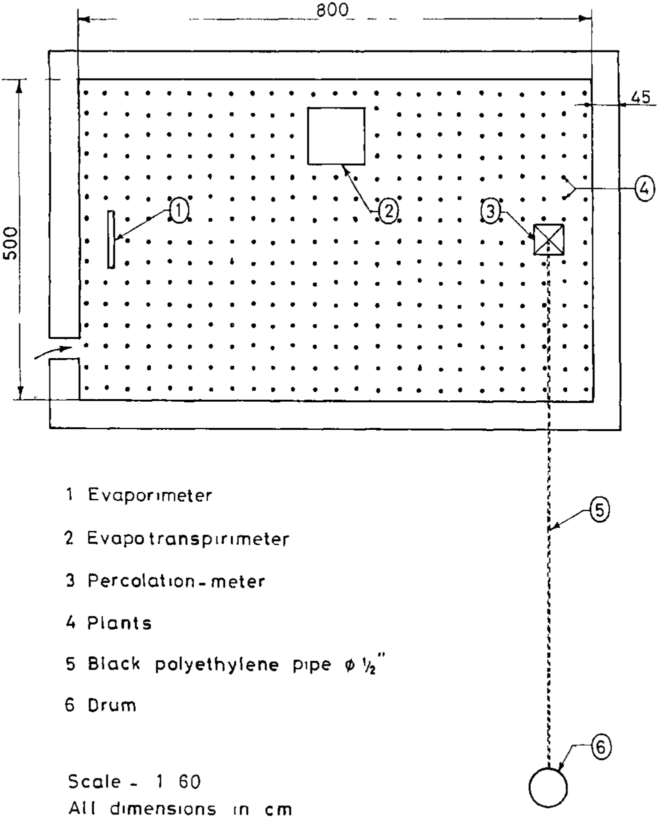


Fig 1a LAYOUT OF PLOTS



1 Evaporimeter

2 Evapotranspirimeter

3 Percolation-meter

4 Plants

5 Black polyethylene pipe ϕ ½"

6 Drum

Scale - 1 60
All dimensions in cm

Fig. 1b AN INDIVIDUAL PLOT

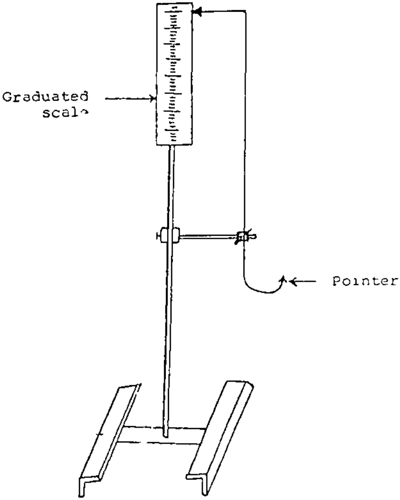


Fig:2 FIELD HOOK GAUGE

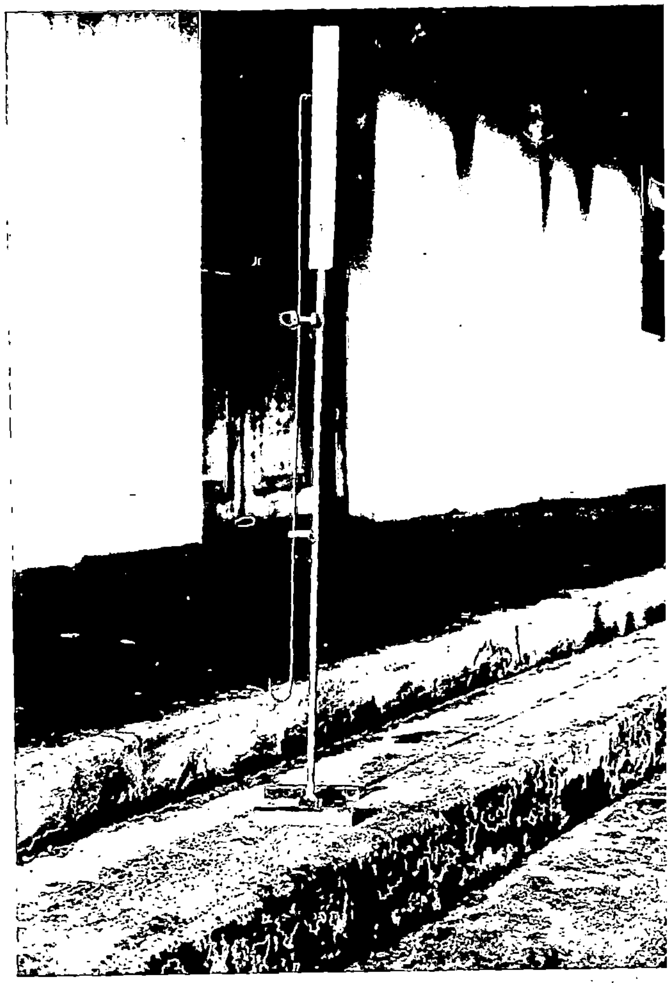
Plate I. Field hook gauge was firmly installed in the field to avoid movement due to wind or any other reason.

Hook gauge was installed in the field at the distance of 45 cm from the bund so as to enable one to take reading without entering into the cropped field. A pointer 7.5 cm high fixed on a flat plate was also embedded with exactly 5 cm of its height above the field level. Water was let into the field till it coincide with the tip of the pointer. This made the depth of water in the field exactly 5 cm. The screw of the hook gauge was loosened and the pointer of hook gauge was brought in level with the water in the field. Then the screw was tightened and the reading of the scale was noted. After 24 hrs the drop in the level of water in the field was measured by using the hook gauge. The drop in water level included water lost due to percolation, transpiration and evaporation or in other words it was the total water requirement in 24 hours. Water was again let into the field till it coincided with the tip of the pointer. The hook gauge was also reset to coincide with the level of water in the field. Repeated the process every day and by adding up daily loss, the total loss of water for the crop period was obtained.

5.2 Evaporimeter

Evaporimeter is a box 90 cm long, 10 cm wide and 15 cm high made of 18 gauge galvanised iron sheet. The diagram of the evaporimeter is given in Fig.3 and also in Plate II. Evaporation is the process during which a liquid changes into gas. The process of

Plate I Field hook gauge



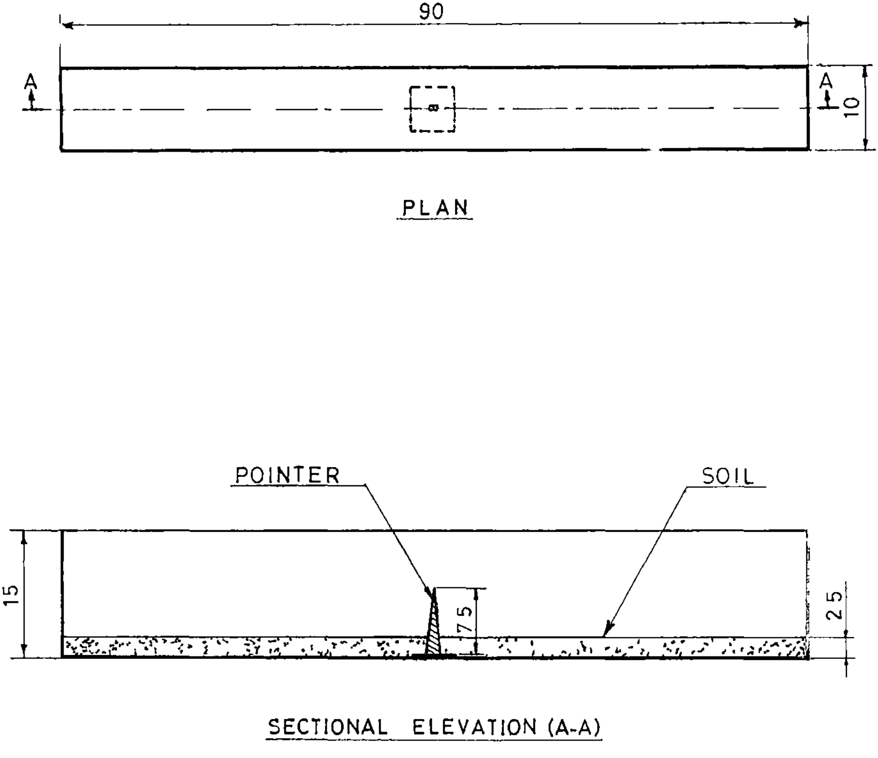
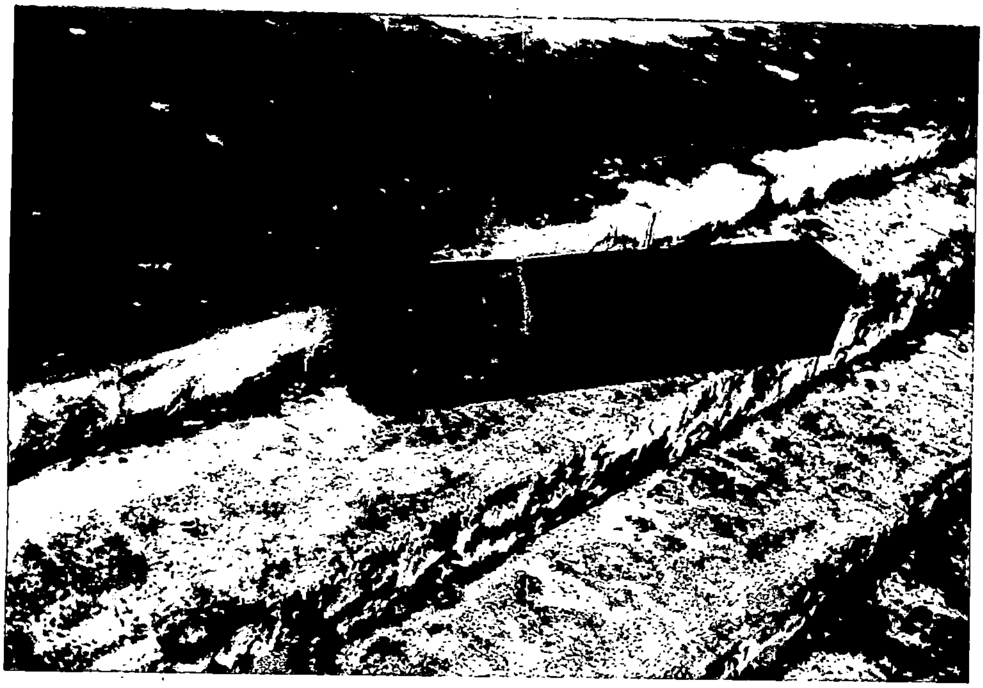


Fig.3 EVAPORIMETER



evaporation of water in nature is one of the fundamental components of hydrologic cycle by which water changes into vapour through the absorption of heat energy from the field.

Before installing the evaporimeter in the field, the equipment was calibrated as described below.

A field hook gauge was fixed on the ground. The evaporimeter to be calibrated was kept very close to the hook gauge in such a way that the pointer of the hook gauge moved inside the evaporimeter. The pointer was kept about 9.5 cm below the top of the evaporimeter. Then water was poured into the evaporimeter till the water level coincide exactly with the tip of the pointer. Then the hook gauge was raised exactly by 2 cm. Then measured quantities of water was added till the water level coincided exactly with the tip of the pointer. The quantity of the water required for raising the water level inside evaporimeter by 2 cm, was found out. All the four evaporimeters were separately calibrated using the same procedure. This was done to take care of the minor variation in the sizes of evaporimeters which might have occurred during their fabrication.

The width of evaporimeter was designed as 10 cm in order to keep it between the paddy rows, which was 15 cm wide. This equipment was kept at a distance of about 45 cm from the bund leaving three crop rows so as to facilitate pouring the water into the evaporimeter, without actually entering into the cropped field. This arrangement also gave sufficient shade to the evaporimeter.

A pointer having 7.5 cm height fixed on a flat plate was placed inside the evaporimeter. The evaporimeter was filled with soil to a height of 2.5 cm from the bottom. The evaporimeter was placed inside the field with its bottom 2.5 cm below the ground surface so as to make the level of soil in the field and in the evaporimeter same. The four evaporimeters were randomly placed in each plot.

Evaporimeter was filled with water till it coincided with tip of the pointer. After 24 hours drop in the level of water was measured by refilling method. The water required to refill the evaporimeter was due to evaporation only, because there was no plant in the evaporimeter. This would be the amount of water that would be lost from the field also due to evaporation, because the water in the evaporimeter received the same amount of shade from the plants as the water in the field. This process was repeated every day and by adding up the cumulative evaporation during the crop period was obtained.

5.3 Evapotranspirimeter

Evapotranspirimeter is a G.I. tank having 90 cm length, 90 cm width and 60 cm height. The diagram of the equipment is given in Fig.4 and also in Plate III. 18 gauge galvanised iron sheet was used for the fabrication of the equipment. Daily loss due to evapotranspiration was measured from the evapotranspirimeter. Evapotranspiration or consumptive use represents the quantity of water lost to the atmosphere from a well irrigated field by transpiration from the crop plus evaporation directly from the soil or water surface.

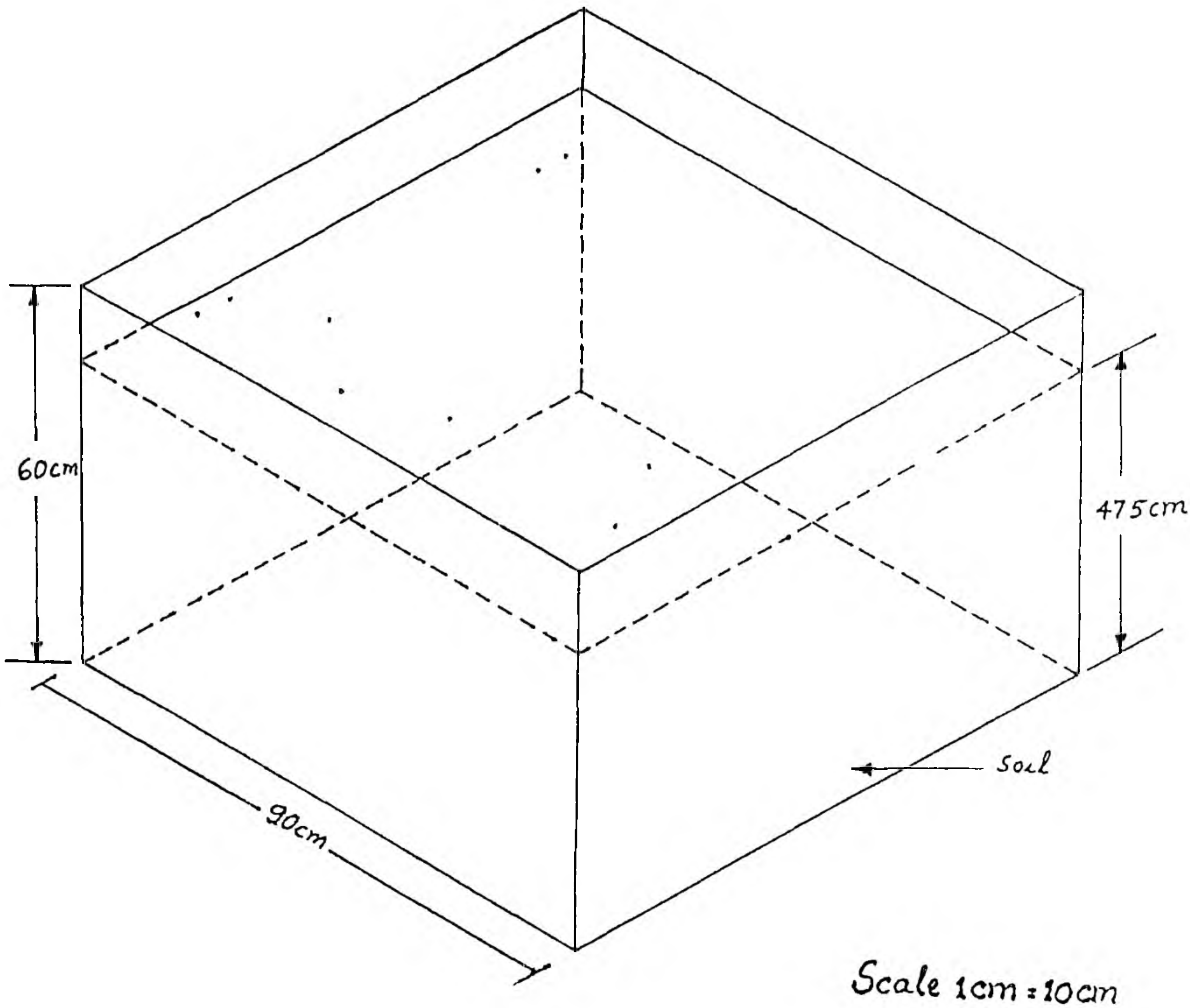


Fig 4 EVAPOTRANSPIRIMETER

Plate III Evapotranspirimeter


K.A.U.T-2

Evapotranspirimeter was a tank with a closed bottom. The water lost in the evapotranspirimeter would represent the evapotranspiration only as there was no percolation from the tank. Galvanised iron was used for fabricating the equipment to avoid rusting. It was installed in the field about 47.5 cm below the ground surface with its top about 12.5 cm above the ground surface.

5.4 Installation of the equipment

For installing the equipment in the field first a square pit of 1 m^2 area and 47.5 cm depth was made. As there was water in the pit the evapotranspirimeter floated on the water. Soil was put in the equipment so as to make it sink into the pit. Just enough soil was added to make it settle on the bottom of the pit. A spirit level was used for levelling the tank. After levelling the tank, soil was added till the evapotranspirimeter was filled with soil to a height of 47.5 cm from the bottom. This made the level of soil in the tank and that in the field the same. Then the level was finally checked using the spirit level and the gap around the evapotranspirimeter was filled carefully. The young seedlings were transplanted at a spacing of 15 x 10 cm in the field as well as in the evapotranspirimeter. This equipment was installed at a distance of 45 cm from the bund, leaving three crop rows as in the case of evaporimeter. This facilitated taking reading by squatting on the bund without stepping into the cropped field.

Evapotranspirimeter was calibrated. Water level in the evapotranspirimeter was brought to about 3 cm above the soil surface. Then the pointer of the hook gauge installed inside the evapotranspirimeter was made to coincide exactly with the level of water in the evapotranspirimeter. The reading on the scale of hook gauge was noted. The level of hook gauge was raised exactly by 2 cm Measured quantities of water was added to raise the water level to the new position of the hook gauge. The volume of water required to raise the water level by 2 cm was obtained. From this calibration chart was prepared. Volume occupied by the plants increased as they grew and this would affect the calibration values. In order to overcome this, calibration of evapotranspirimeter was done once in every ten days interval and corresponding calibration chart was prepared and they are given in Table 2. Each evapotranspirimeter was calibrated separately.

A pointer of height 7.5 cm with a flat bottom was installed inside the equipment with the pointer 5 cm above the soil surface. Water was poured into the evapotranspirimeter till it coincided with the tip of the pointer. Water lost by evapotranspiration every day was replenished by adding measured quantities of water. The mean values of two consecutive calibrations were used for converting the measured volume into height. This process was repeated during the crop period and cumulative evapotranspiration was got by adding the daily loss.

Table 2 Evapotranspirimeter calibration

Sl. No.	Date of calibration	Plot No.	Quantity of water for raising level of water by 2 cm height in cm^3			
			1	2	3	Mean
1	19.10.1989	1	15000	14500	15500	14860
		2	14500	14500	14500	14500
		3	15000	16000	15500	15500
		4	15000	15500	15250	15250
2	30.10.1989	1	14990	14500	14900	14790
		2	14400	14450	14300	14380
		3	14900	15000	14800	14900
		4	14500	14900	14600	14660
3	10.11.1989	1	14755	14695	14645	14690
		2	14380	14350	14280	14336
		3	14745	14705	14645	14690
		4	14375	14350	14275	14330
4	20.11.1989	1	14370	14380	14375	14375
		2	14355	14345	14245	14315
		3	14695	14700	14760	14685
		4	14340	14320	14310	14320

Contd

Table 2 (contd.)

Sl. No.	Date of calibration	Plot No.	Quantity of water for raising level of water by 2 cm height cm^3			
			1	2	3	Mean
5	1.12.1989	1	14295	14300	14305	14300
		2	14320	14310	14305	14311
		3	14670	14680	14675	14675
		4	14320	14326	14310	14318
6	11.12.1989	1	14250	14255	14245	14250
		2	14305	14310	14300	14305
		3	14625	14630	14620	14625
		4	14295	14315	14305	14305
7	22.12.1989	1	14240	14250	14230	14240
		2	14305	14245	14235	14261
		3	14600	14600	14600	14600
		4	14250	14240	14250	14246
8	1 1.1990	1	14200	14205	14195	14200
		2	14255	14240	14110	14201
		3	14500	14575	14575	14550
		4	14235	14170	14175	14193

5.5 Percolation measuring equipment

Materials required

Sl.No.	Quantity	Materials	Specification
1.	2	20 gauge mild steel sheet	8' x 4'
2.	4	G.I. Pipe	3/4"
3.	4	Reducer	3/4" x 1/2"
4.	4	Hose Collar	1/2"
5.	1	1/2" Black polyethylene pipe	40 m
6	1	3/4" PVC Pipe	40 m
7.	1	2mm Wiremesh	2 m x 1 m
8.	1	1 mm nylon mesh	2 m x 1 m
9.	4	Drums	200 lit.
10.	4	Bucket	10 lit.
11.	4	Rope	5 m

a. Fabrication

An equipment for measuring deep percolation was designed and fabricated. This device shall be hereinafter referred to as percolation-meter.

The percolation-meter consisted of a square box of size 50 x 50 x 20 cm. It was made with a 20 gauge mild steel sheet. A square pyramid with a base of 50 cm and height 15 cm was fabricated with 20 gauge mild steel sheet and welded to the bottom of the square box. At the apex of the square pyramid a hole of diameter 25 mm was made. A V-cut was made on 20 mm, G.I. pipe, 17 cm long at 5 cm from one end and the pipe was bent at this line of cut to the desired angle. The resulting groove was welded and filled. This pipe then was welded to the apex of the square pyramid with a downward slope of 10° for easy flow of water. A 20 mm x 12 mm G.I. reducer was fixed to the G.I. Pipe. A hose collar of size 12 mm was connected to the reducer. Polyethylene pipe of 12 mm was connected to the hose collar. The other end of the polyethylene pipe was connected to the drum. As the highly flexible polyethylene pipe were to be laid underground, a protective outer cover to the pipe was provided with 20 mm PVC Pipe. The other end of the pipe was connected to a metallic drum of 60 cm diameter and 110 cm height The pipe was connected to the drum at 30 cm from the bottom of the drum. A hole of 12 mm was made at 30 cm and the polyethylene pipe was passed through this hole. For the collection of percolation water bucket with 10 litres capacity was placed inside the drum. The percolation-meter and drums were made leak proof before installation

A 2 mm size wiremesh was fixed on a frame size 48 x 48 cm The frame was made to the correct measurement so that the sides of the frame fitted snugly to the sides of the box. Another 1 mm size nylon mesh was placed over this wiremesh. These meshes were kept inside the percolation-meter at the bottom of the square box, just above the pyramid. This prevented the flow of soil below the meshes.

b. **Installation of percolation-meter**

The diagram of percolation-meter is given in Fig 5 and also in the Plate IV. The instrument was installed in the paddy field of K.C A.E.T, Tavanur. For installing the percolation-meter, a square pit of size litter bigger than the size of the percolation-meter was made. The depth of the pit was 75 cm. The percolation-meter was placed below the soil surface with its top 30 cm below the ground surface. This would enable the percolation-meter to collect deep percolation water i.e., the water that would go below the root zone of paddv. For installation of the percolation-meter a spirit level was used for levelling.

A trench was cut from the percolation-meter to the collecting drum. The depth of the trench was 75 cm near percolation-meter and was 85 cm near the drum. The polyethylene pipe which was connected to the percolation-meter was laid in the trench. The metallic drum was installed 5 m away from the experimental plot and in the next field which was lower in elevation than the experimental plot The difference In elevation of the experimental plot and the field in which metallic durm was installed was 20 cm. For installing the drum, a circular pit of 60 cm diameter and depth of 90 cm was made The drum was Installed with its top 15 cm above the ground surface. This was done in order to prevent the flow of surface water into the drum. The other end of the polyethylene pipe was inserted through the hole into the drum with about 10 cm of the pipe projecting into the

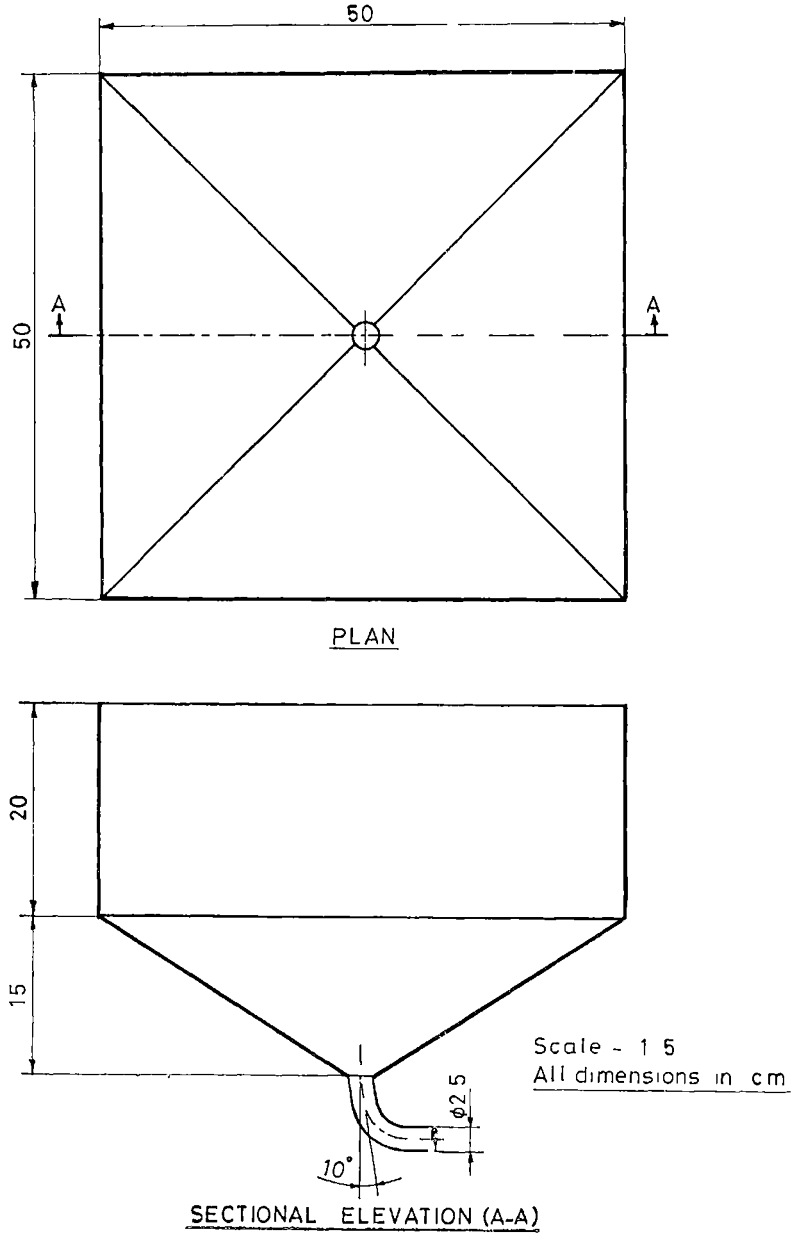
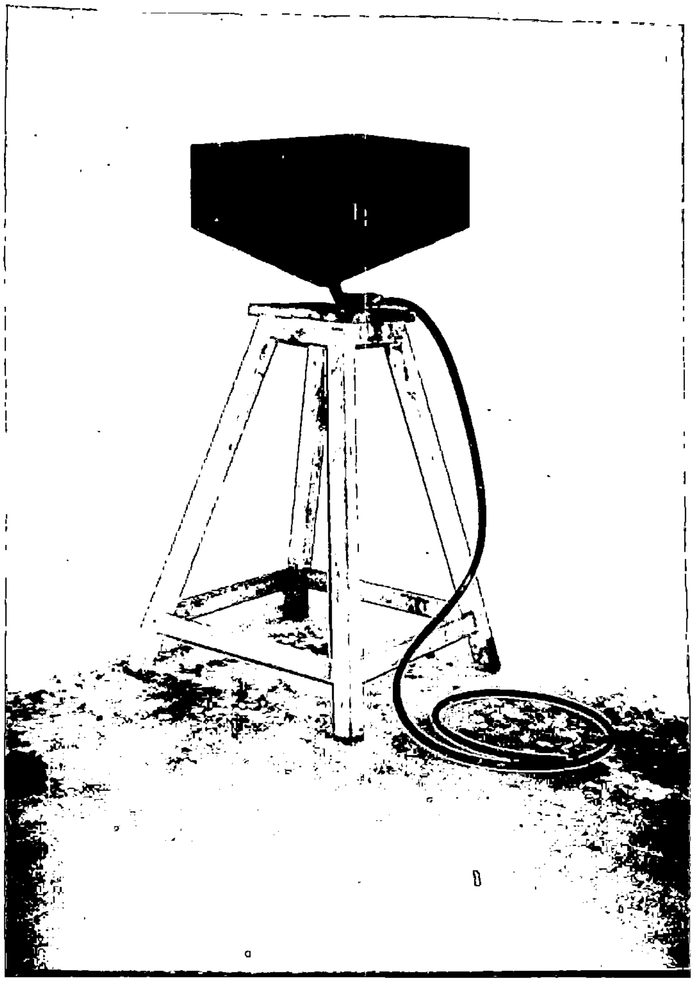
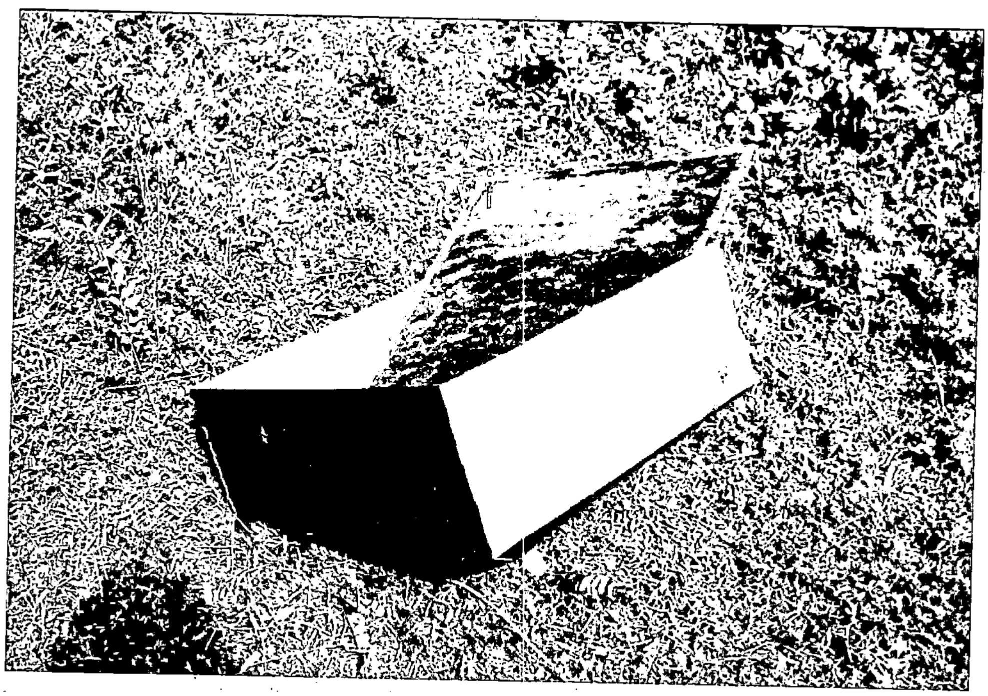


Fig 5 PERCOLATION-METER

Plate IV a Percolation-meter

Plate IV b Percolation-meter with sieves





drum. The gap between the pipe and drum was made leak proof by using synthetic adhesive. To collect the percolation water a bucket was placed inside the drum. A rope was tied to the handle of the bucket to facilitate easy lifting of the bucket.

5.6 Crop raising

The experiment was laid out in the Instructional Farm of KCAET in the month of October and continued upto January 1990 which was the Mundakan season. The experimental area was ploughed with a tractor and the field was levelled and four plots were laid out. The size of each plot was 8 m x 5 m. Irrigation channel and distributaries were also provided to facilitate irrigation to individual plots. The source of irrigation water was filter-point tube well

Pure seeds of short duration variety 'Triveni was used for the experiment. Fertilizer application and weeding, were done as per the recommendations in the package of practice and are given in Appendix I. After the layout and preparation of the plots percolation-meter, evaporimeter and evapotranspirimeter were installed in the field. Evaporimeter was placed in between the seedling rows Seedlings were transplanted in the evapotranspirimeter as well as in the plots as described before. The daily losses due to evapotranspiration and evaporation were measured by refilling method. Water level in the field was brought to 5 cm back every day by letting in water. Daily total loss of water during 24 hours was measured by using a field hook gauge in the field.

Evaporation loss from the paddy field with standing crop was obtained from the evaporimeter and the evapotranspiration from the evapotranspirimeter. The total loss was measured using a field hook gauge. Deep percolation losses were obtained by means the water collected in the bucket each day. Total percolation losses were also computed by subtracting the evapotranspiration from the total water loss.

For the determination of nutrients lost through percolation, samples of percolation water were collected one day prior to the application of fertilizer and also ten subsequent days till the loss is negligible. The water samples were analysed for NPK losses by the standard methods. Nitrogen was estimated by the micro Kjeldahl method. The percentage of nitrogen was calculated as follows

$$\%\ \text{N in water sample} = \frac{\text{Burette reading (ml)} \times \text{Normality of Sulphuric Acid}}{\text{Volume of sample (ml)}} \times 1.4$$

$$\text{ppm of N present} = \%\ \text{N} \times 10^4$$

$$\text{N loss in g/ha} = \frac{\text{ppm of N} \times \text{Vol. of percolated water in lit}}{1000}$$

Phosphorus was determined by the colorimetric method. The ppm loss of phosphorus was obtained from the standard curve.

Flame photometer method was used for the estimation of potassium.

The crop was transplanted in the field on 19.10 1989 and harvested in 11.1.1990. Percolation loss was estimated for 84 days till the date of harvest.

After harvest root and shoot including grain of the plants from evapotranspirimeters were collected. Oven dry weight of total dry matter was obtained. Transpiration ratio and consumptive use ratio were calculated.

$$\text{Transpiration ratio} = \frac{\text{Weight of water transpired}}{\text{Weight of total dry matter}}$$

$$\text{Consumptive use ratio} = \frac{\text{Weight of water lost by evapotranspiration}}{\text{Weight of total dry matter}}$$

Results and Discussion

RESULTS AND DISCUSSION

The results of experimental studies conducted for estimating the percolation loss and the nutrient losses in the water which percolated below the root zone for a short duration rice are presented in this chapter.

Vertical percolation was obtained by measuring the water collected in the bucket, and converting the measured volume into its height. The total water requirement of rice was measured by using a field hook gauge. Estimation of daily evapotranspiration and evaporation were made by using evapotranspirimeter and evaporimeter respectively.

Evapotranspirimeter was installed in the field as described in the chapter III and it was calibrated periodically. The calibration was done once in every 10 days and the details are given in Table 2. Daily evapotranspiration was estimted by replenishing the water lost during the previous day by measured quantity of water and the calibration chart was used to convert volume in litres into height in millimetres. Before installing the evaporimeter in the field, it was calibrated by using the field hook gauge.

The total percolation loss was obtained by subtracting evapotranspiration from total loss of water from the field Vertical percolation was measured by the instrument fabricated. This was installed in the field as described in Chapter III. By measuring the water collected in the bucket, vertical percolation was obtained and lateral percolation was obtained by subtracting vertical percolation loss from the total percolation loss. By subtracting evaporation from evapotranspiration rate of tanspiration was obtained.

Mean of daily evapotranspiration, evaporation, transpiration total water requirement, total percolation, vertical and lateral percolation loss from the four plots are given in Table 3. The above readings obtained from four individual plots are given in Appendix II. For each ten days interval in which the evapotranspiration, evaporation, transpiration, total water requirement, total percolation, vertical and lateral percolation loss were calculated and the mean values of four plots are given in Table 4.

For each ten day interval daily average of evapotranspiration, evaporation, transpiration, total water requirement, total percolation, vertical and lateral percolation were calculated and the mean values of four plots are given in Table 5. The crop period was classified into different growth stages.

Transplanting

↓

30 days

↓

Maximum tillering or
panicle initiation

↓

Table 3 Mean of daily total water requirement, evapotranspiration, evaporation, transpiration, total percolation, vertical percolation and lateral percolation of four plots

Date	Total water requirement (mm)	Evapotranspiration (mm)	Evaporation (mm)	Transpiration (mm) (3-4)	Total percolation (mm) (2-3)	Vertical percolation (mm)	Lateral percolation (mm) (6-7)
1	2	3	4	5	6	7	8
19/10/1989	8.38	2.00	2.00	0.00	6.38	5 77	0 61
20/10	8.38	2 00	2.00	0.00	6.38	5.77	0.61
21/10	8.50	2.00	2.00	0.00	6.50	5.60	0.90
22/10	9.38	2.55	2.06	0.49	6.83	6.25	0.58
23/10	9.98	2.59	2.08	0.51	7.38	6.43	0.95
24/10	10.05	2.60	2.13	0.48	7.44	6.25	1.19
25/10	10.56	2.65	2.15	0.50	7.91	5.95	1.96
26/10	10.68	2.65	2.20	0.45	8.03	5.73	2.30
27/10	10.61	2.71	2.30	0.41	7.90	5.53	2.42
28/10	10.98	2.75	2.23	0.52	8.23	5.59	2.64
29/10	11.40	2 90	2.43	0.47	8.50	5.03	3 48
30/10	10.87	3.00	2.55	0.45	7.87	5.58	2.29
31/10	10.85	3.19	2.65	0.54	7.66	5.55	2.11

Table 3 (contd.)

Date	Total water requirement (mm)	Evapotranspiration (mm)	Evaporation (mm)	Transpiration (mm) (3-4)	Total percolation (mm) (2-3)	Vertical percolation (mm)	Lateral percolation (mm) (6-7)
1	2	3	4	5	6	7	8
1/11/1989	10.80	3 30	2.60	0.70	7.50	5.48	2.03
2/11	11.10	3.65	2.66	0.99	7.50	4.33	3.18
3/11	11.48	3 80	2.91	0.89	7.69	4.35	3.34
4/11	11.70	4.13	2.99	1.14	7.58	5.23	2.36
5/11	11.33	4.95	3.18	1.77	6.38	5.08	1.31
6/11	12.20	5.54	3.05	2.49	6.66	4.93	1.74
7/11	12.75	6.23	3.50	2.73	6.53	5.02	1.51
8/11	13.25	7.53	3.75	2.78	6.73	5.20	1.54
9/11	13.38	6.25	3.73	2.52	7.13	5.20	1.93
10/11	13.58	6.13	3.75	2.38	7.25	5.00	2.25
11/11	13.25	6 63	4.13	2.50	6.63	5.24	1.39
12/11	13.08	6.68	4.03	2.65	6.40	5.10	1.30
13/11	13.33	6 63	4.08	2.55	6.70	5.10	1.60
14/11	13.38	6.50	4.13	2.37	6.88	5.09	1.79

Contd.

Table 3 (contd)

Date	Total water requirement (mm)	Evapotran-spiration (mm)	Evaporation (mm)	Transpiration (mm) (3-4)	Total percolation (mm) (2-3)	Vertical percolation (mm)	Lateral percolation (mm) (6-7)
1	2	3	4	5	6	7	8
15/11/1989	14.13	7.13	2.50	4.63	7.00	4.87	2 14
16/11	14.15	7.50	2.88	4.63	7.00	4.94	2 06
17/11	14.88	7.95	2.62	5.32	6.93	4.92	2.00
18/11	14.50	7.00	2.67	4.32	7.50	4.80	2.70
19/11	15.63	7.75	2.67	5.08	7.88	4.85	3.03
20/11	16.38	7.08	3.00	4.38	9.00	4.67	4.32
21/11	16.75	8.50	2.50	6.00	8.25	4.60	3.60
22/11	17.25	8.62	2.13	6.50	8.63	4.73	3.90
23/11	17.25	9.00	2.06	6.93	8.25	5.15	3.10
24/11	17.13	9.13	2.05	7.08	8.00	4.93	3.07
25/11	17.38	8.75	2.05	6.70	8.63	5.08	3.55
26/11	19.50	8.38	2.00	6.38	11.13	5.25	5 88
27/11	17.38	8 75	2-.05	6.70	8.63	5.08	3.55
28/11	19.50	8.00	1.69	6.31	11.50	5.75	5 75

Contd

Table 3 (contd)

Date	Total water requirement (mm)	Evapotranspiration (mm)	Evaporation (mm)	Transpiration (mm) (3-4)	Total percolation (mm) (2-3)	Vertical percolation (mm)	Lateral percolation (mm) (6-7)
1	2	3	4	5	6	7	8
29/11/1989	21.50	8.75	1.60	7.15	12.75	6.15	6.60
30/11	26 00	925	1.48	7 78	16.75	6.18	10 57
1/12	28.25	9.75	1 50	8.25	18.50	6.00	12 50
2/12	13.25	10.50	1.78	8.73	19.75	6.00	13.75
3/12	31.25	11.00	2.25	8.75	20.25	5.30	14.95
4/12	30.25	11.00	2.30	8.70	19.25	5.25	14.00
5/12	27.75	10.00	2.23	7.78	17.75	5.43	12.32
6/12	27.75	9.50	1.98	7.52	18.25	5.40	12.85
7/12	27.00	10 75	1.95	8.80	16.25	5.40	10.85
8/12	24.00	8.50	1.93	6.58	15.50	5.38	10.12
9/12	16.75	8 00	1.43	6.57	8.75	5.50	3.25
10/12	16 75	8.12	1.15	6.97	8.63	5.00	3.63
11/12	16.50	8.25	1.10	7.15	8.25	5.00	3 25
12/12	16 25	9 00	1 16	7.83	7 25	4.50	2 75
13/12	16 50	10 00	1.20	8.80	6.50	4.50	2 00

Contd

Table 3 (contd.)

Date	Total water requirement (mm)	Evapotran- spiration (mm)	Evaporation (mm)	Transpiration (mm) (3-4)	Total percolation (mm) (2-3)	Vertical percolation (mm)	Lateral percolation (mm) (6-7)
1	2	3	4	5	6	7	8
14/12/1989	16.30	10.42	1.20	9.22	5.88	4.25	1.63
15/12	15.88	9.75	1 18	8.57	6.13	4.38	1.75
16/12	15.25	9.00	1.09	7.91	6.25	4.18	2.07
17/12	15.63	8.50	1.10	7.40	7.13	4.60	2.53
18/12	15.63	8.25	1 15	7.10	7.38	4.30	3.08
19/12	15.25	8.00	1.20	6 80	7.25	4.35	2.90
20/12	15.25	8.00	1.10	6.90	7.25	4.63	2.65
21/12	15.25	8.00	1.08	6.92	7.25	4.65	2.60
22/12	14.75	7.75	1.10	6.65	7.00	4.63	2.37
23/12	15.00	7.50	1.15	6.35	7.50	5.10	2.40
24/12	14.75	7.12	1.08	6.04	7.63	4.83	2.00
25/12	14 75	7.00	1 08	5.92	7.75	4.43	3.32
26/12	14.50	7 00	1 10	5.90	7.50	4.00	3.50
27/12	14.0	6.87	1.05	5.82	7.13	4.50	2.63

Contd.

Table 4 Total of total water requirement, evapotranspiration, evaporation, transpiration, total percolation, vertical percolation and lateral percolation for each ten days intervals - mean of four plots

Days	Total water requirement (mm)	Evapotranspiration (mm)	Evaporation (mm)	Transpiration (mm)	Total percolation (mm)	Vertical percolation (mm)	Lateral percolation (mm)
1 - 1	97.50	24.50	21.14	3.36	72.98	58.86	14.16
11 - 20	114.48	40.69	28.51	12.17	73.87	50.54	23.32
21 - 30	136.56	67.93	35.57	32.33	68.65	50.65	17.99
31 - 40	171.27	82.88	23.01	59.86	88.40	49.51	38.83
41 - 50	269.50	98.50	18.73	79.77	171.00	56.86	114.14
51 - 60	169.81	89.54	12.53	77.0	80.27	47.29	32.92
61 - 70	149.13	75.49	11.09	64 40	73.64	45.42	28.25
71 - 80	118 00	64 30	14 58	49.77	53.67	42 03	11.65
81 - 84 (only 4 days)	44 00	23.89	8.90	14.99	20.11	16.15	3.96
Total	1270.25	567.72	174 06	393.64	702.53	417.31	285.22

Table 5 Daily averge of total water requirement, evapotranspiration, evaporation, transpiration, total percolation, vertical percolation and lateral percolation for each ten day interval mean of four plots

Days	Total water requirement (mm)	Evapotran-spiration (mm)	Evaporation (mm)	Transpiration (mm)	Total percolation (mm)	Vertical percolation (mm)	Lateral percolation (mm)
0 - 10	9.75	2.45	2.11	0.33	7.29	5.88	1.41
11 - 20	11.44	4.06	3.85	1.21	7.38	5.05	2.33
21 - 30	13.65	6.70	3.55	3.23	6.86	5.06	1.79
31 - 40	17.12	8.12	2.30	5.98	8.84	4.95	3.88
41 - 50	26.95	9.85	1.87	7.79	17.10	5.68	7.41
51 - 60	15.98	8.95	1.25	7.70	8.27	4.72	3.29
61 - 70	14.91	7.54	1.10	6.44	7.36	4.54	2.80
71 - 80	11.80	6 43	1.45	4.97	5 37	4 20	1.16
81 - 84 (only 4 days)	11.00	5.97	2.22	3.74	5.03	4.03	0.99
Daily mean	15.12	6.75	2 07	4.68	8.36	4.97	3.39

16 days

↓

Booting

↓

10 days

↓

Flowering
milk stage

↓

30 days

↓

Dough stage

↓

Mature

↓

Grain stage

Evapotranspiration, evaporation, transpiration, total water requirement, total percolation, vertical and lateral percolation loss between each stage were calculated and the mean values of four plots are given in Table 6. Daily average mean of evapotranspiration, evaporation, transpiration, total water requirement, total percolation, vertical and lateral percolation are graphically represented in Fig.6, 7 and 8, respectively. In the graphical representation, the different growth stages are also marked.

Considering the rate of evaporation during the initial stage, there was a gradual increase in evaporation and it reached a maximum of 3.6 mm. This was due to the increase in temperature.

Table 6 Total of total water requirement, evapotranspiration, evaporation, transpiration, total percolation, vertical percolation and lateral percolation during different growth stages - mean of four plots

Growth stages	Days	Total water requirement (mm)	Evapotranspiration (mm)	Evaporation (mm)	Transpiration (mm)	Total percolation (mm)	Vertical percolation (mm)	Lateral percolation (mm)
Transplanting to Maximum tillering or panicle initiation	30	384.54	133.12	85.22	47.86	215.50	160.05	55.47
to Booting	16	328.02	140.13	33.30	106.83	187.90	84.89	102.90
to Flowering (50% emergence)	10	219.50	93.12	16.41	76.90	126.32	51.36	75.01
milk stage dough stage mature grain stage	28	374 19	201.35	39.13	162.25	172.81	121 01	5.84
Total	84	1270.25	567.72	174.06	393.84	702.53	417.31	285 22

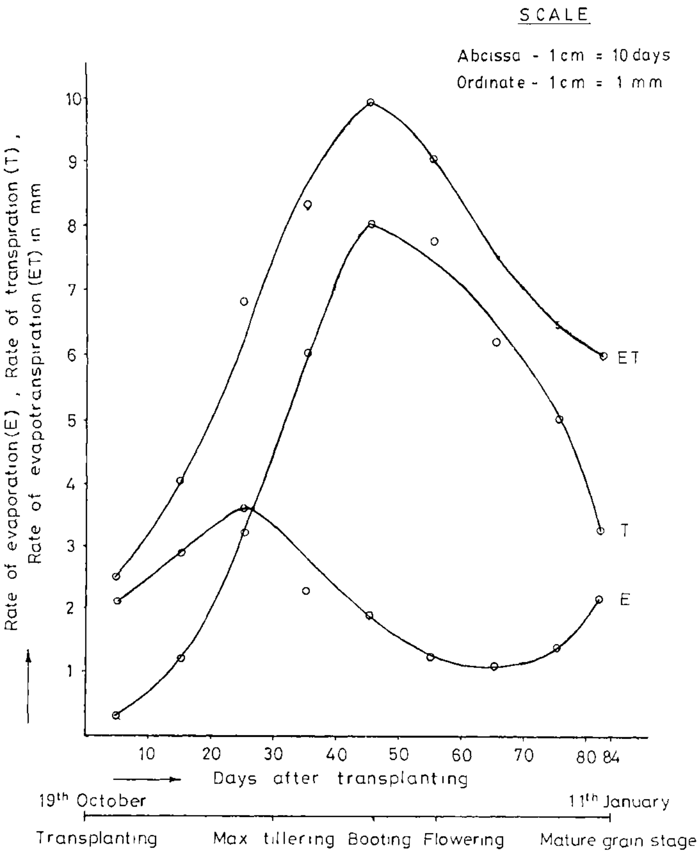


Fig 6 RATE OF EVAPORATION CURVE, RATE OF TRANSPIRATION CURVE & RATE OF EVAPOTRANSPIRATION CURVE.

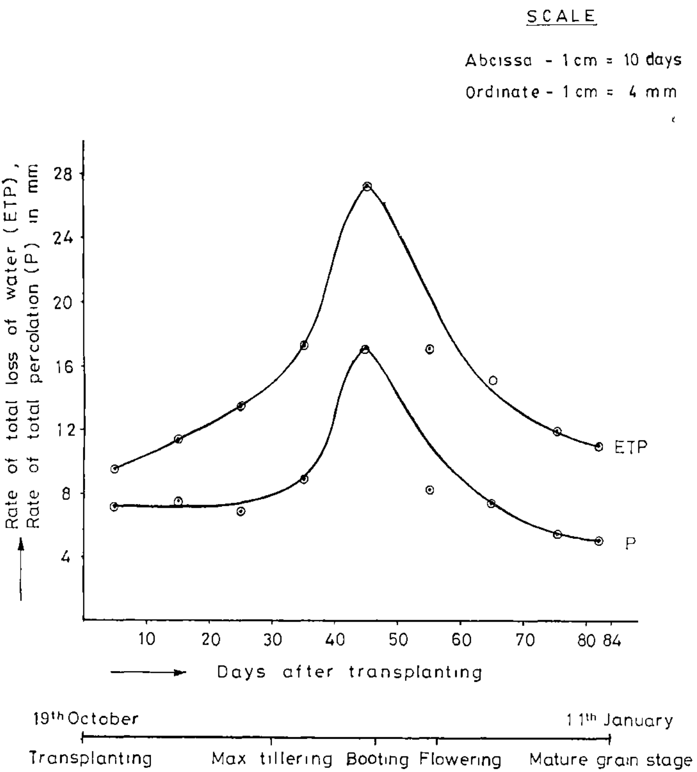


Fig 7 RATE OF TOTAL LOSS OF WATER CURVE AND RATE OF TOTAL PERCOLATION CURVE

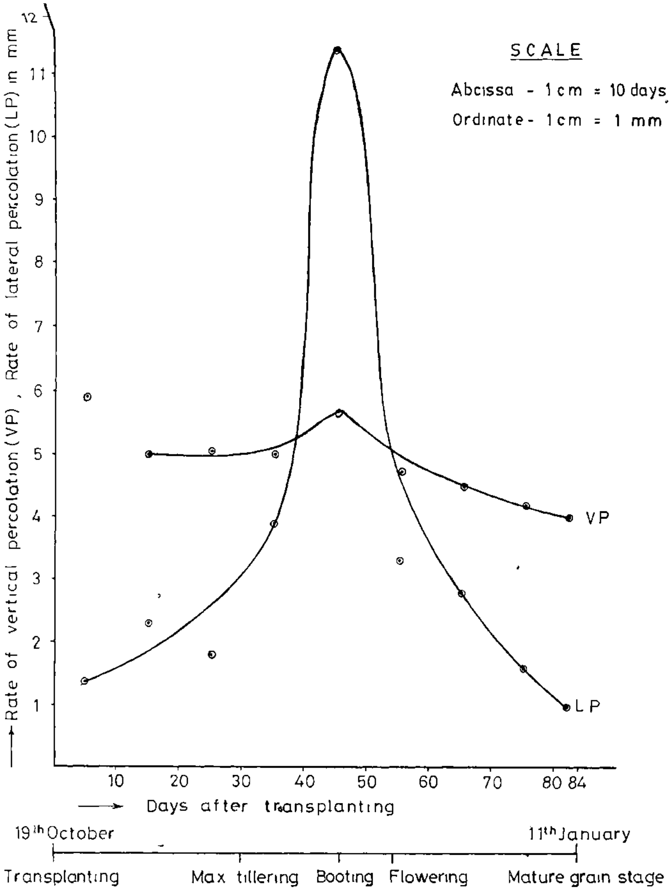


Fig 8 RATE OF VERTICAL PERCOLATION CURVE AND RATE OF LATERAL PERCOLATION CURVE

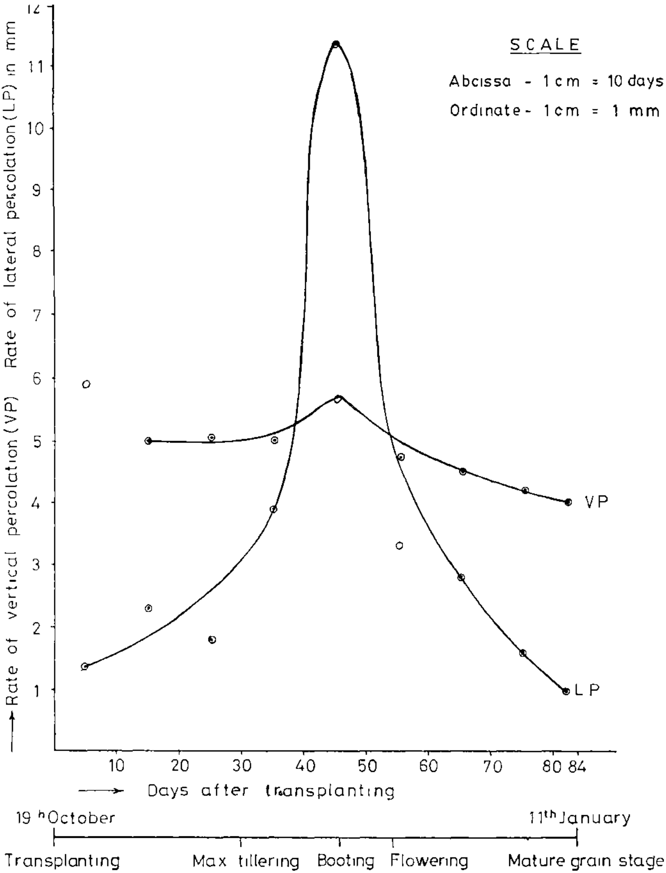


Fig 8 RATE OF VERTICAL PERCOLATION CURVE AND RATE OF LATERAL PERCOLATION CURVE

Then it started decreasing upto 65 days because the shade from the plants increased as the crop grew. The vegetative growth of plants ceased at that stage and the shade of the crop, the rate of evaporation increased because the mature leaves during this stage withered which inturn decreased the shaded area.

Considering the rate of transpiration, during the first 10 days there was only little increase in the rate of transpiration as this was the rooting period and there was practically very little growth. Then the rate slowly increased as the crop grew. After maximum tillering, the rate of transpiration increased at a faster rate upto the booting stage. The reason for this is that upto booting stage plants grew at a faster rate than in the initial stage. After the booting stage, the rate of transpiration remained constant till flowering. Then there was a gradual decrease in the rate of transpiration in the final stage as the mature leaves withered

In the case of total percolation, the average daily value was 8.36 mm. The rate of total percolation was almost constant during the crop period except in the 6th week after transplanting 55.3 per cent of the total water was lost by percolation.

Two components of total percolation, the vertical percolation and lateral percolation were compared. During the initial stage, vertical percolation rate was higher than in the subsequent periods and reached a maximum value of 5.88 mm/day, while the average value was only 4.97 mm. For installing the percolation-meter the soil was disturbed upto 75 cm for making the pit and the trench. It took some days for settlement and this could be the reason for the higher vertical percolation rate during the initial stage. After 10 days the vertical percolation rate remained almost constant and there was only little variation. The vertical percolation rate ranged from 4 03 to 5.05 mm/day. 32.8 per cent of total water was lost as vertical percolation and it was 59.4 per cent of the total percolation.

Considering the lateral percolation the daily average value was 3.39 mm. It reached a maximum value of 11.41 mm/day in the sixth week after transplanting. Both in the preceding and succeeding weeks the rate was almost constant. The rate of vertical percolation in the sixth week after transplanting remained constant and the variation in total percolation was due to lateral percolation alone. The reason for this is unexplainable and a detailed study is needed to describe this phenomenon. 22.45 per cent of total water was lost by lateral percolation and it was 40.6 per cent of the total percolation.

From the above results, it can be concluded that more than 50 per cent of the applied water is lost through percolation and vertical percolation is more than the lateral percolation. This significant water loss through vertical percolation is due to the sandy nature of the soil with very little collodial material.

Average total percolation is 8.36 mm/day and average vertical percolation is 4.97 mm/day. In Tamil Nadu Agricultural University, Sivanappan et al. reported that for a sandy loam soil, the vertical percolation rate is 3-6 mm/day.

Average daily water used, total water requirement and percentage of evapotranspiration, evaporation, transpiration, total percolation, vertical and lateral percolation are given in Table 7. Total dry matter weights of plants in each evapotranspirimeter were determined and are given in Table 8. Transpiration ratio and consumptive use ratio were calculated as mentioned in Chapter III and given in the above table. Mean of transpiration ratio and consumptive use ratios are 295.92 and 426.32. The equipment fabricated for the measurement of deep percolation losses worked satisfactorily.

Nutrient losses due to deep percolation

a. Percolation loss of nitrogen

The comparative percolation loss of nitrogen at two different split doses of fertilizer are given in Appendix IIIa and the progress of vertical percolation loss of nitrogen after basal dressing and top dressing are represented graphically in Fig.9. It was found that 0.47 per cent of the applied nitrogen was lost on the first day of basal application. The loss was reduced by 0.33 per cent and 0.05 per cent on the second and third day respectively. It became

Table 7 Different forms of water loss and water requirement of short duration variety Triveni in Mundakan season - Mean of four plots

			Average daily water used (mm)	Total water used (mm)	percentage
I	(a)	Evapotranspiration	6 75	567.72	44 69
	(b)	Evaporation	2.07	173.88	13 69
	(c)	Transpiration	4.68	393.84	31.00
II	(a)	Total percolation	8.36	702 53	55 30
	(b)	Vertical percolation	4 97	417.31	32.85
	(c)	Lateral percolation	3.39	285 22	22 45
III		Total water requirement	15.12	1270.25	100.00

Table 8 **Calculation of transpiration ratio and consumptive use ratio**

Plot No.	Evapotranspiration (cm)	Evapotranspiration (cm^3)	Evapotranspiration (kg)	Total dry matter weight in evapotranspirimeter (kg)	Weight of water transpired from evapotranspirimeter (kg)	Transpiration ratio	Consumptive use ratio
1	53.22	431082	431.08	1.05	294.52	280 49	410.55
2	56.85	460485	460.49	1.13	317.84	281.28	407.51
3	57.25	463725	463.72	1.13	323.19	284.74	410.38
4	59.75	483975	483.97	1.02	342.46	337.17	476.82
Mean						295.92	426.32

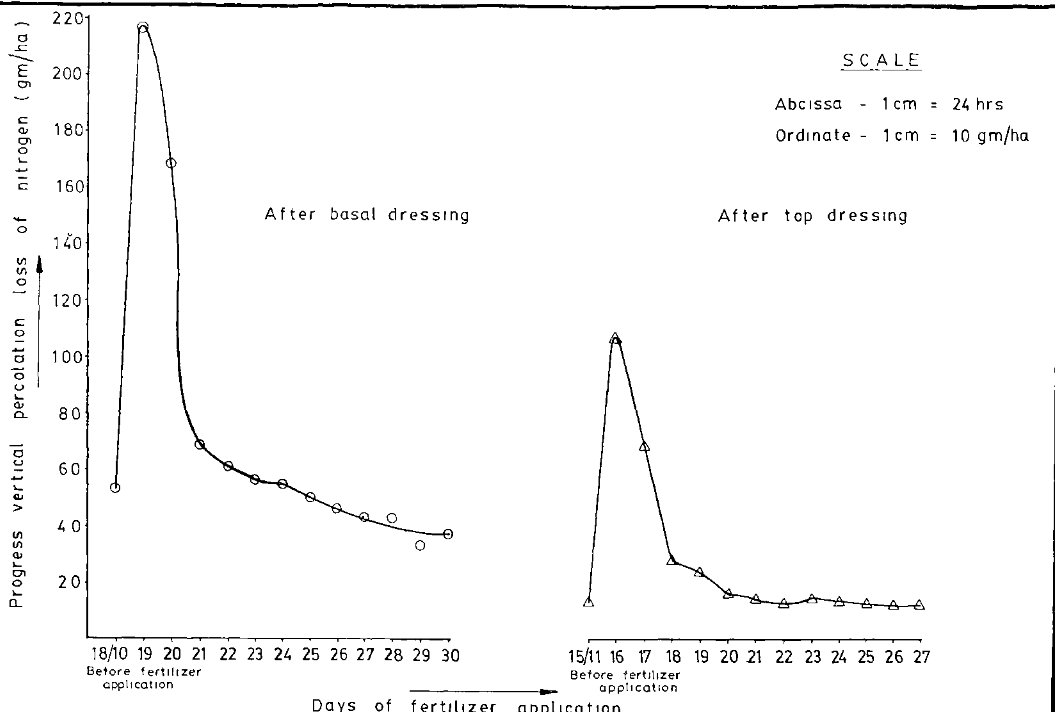


Fig 9 PROGRESS VERTICAL PERCOLATION LOSS OF NITROGEN AFTER BASAL DRESSING AND TOP DRESSING

trace on the fourth day. The observed reduction in percolation loss of nitrogen with time is due to the water soluble urea nitrogen used The total nitrogen lost through vertical percolation in six days is 0.88 per cent. This amounts to 0.62 kg of applied nitrogen as urea.

Top dressing was done on the 18th day of planting. It was found that 0.27 per cent of the applied nitrogen was lost on the first day of top dressing. The loss was reduced by 0.16 per cent and 0 07 per cent on the second and third day respectively. The total loss of nitrogen in six days is 0.53 per cent. This amounts to 0.19 kg of applied nitrogen. This reduced percolation loss is due to the compaction of the soil made by the progressive growth stages of crop.

b. Percolation loss of phosphorus

The comparative percolation loss of phosphorus after basal dressing is given in Appendix IIIb and the progress of vertical percolation loss is represented graphically in Fig. 10.

It was found that 0.03 per cent of applied phosphorus was lost on the first day and 0.02 per cent on the second day of basal application. However the maximum loss of phosphorus within six days was only 0.12 per cent. This amounts to 0.04 kg of applied phosphorus. As far as percolation loss of phosphorus is concerned the losses were negligible when compared to nitrogen and potassium. The lower loss of phosphorus found in this study in due to the high rate of absorption of phosphorus during early growth phases

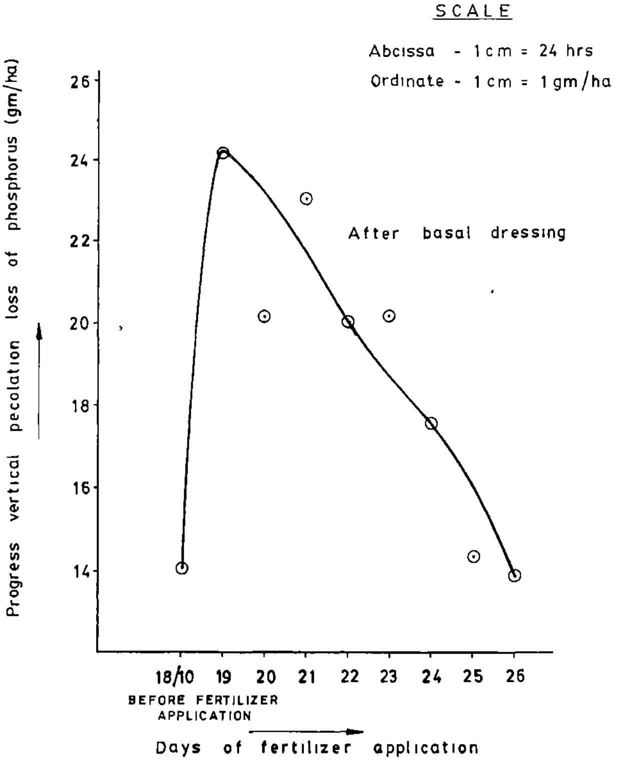


Fig 10 PROGRESS VERTICAL PERCOLATION LOSS OF PHOSPHORUS AFTER BASAL DRESSING

c. **Percolation loss of potassium**

The comparative percolation loss of potassium at two different split doses are given in Appendix IIIc and are represented graphically in Fig.11.

On the first day, 0.24 per cent of applied potassium was lost and 0.04 per cent was lost on second day of basal application. Maximum loss occurred during the first two day and there was only trace in the following days. The total loss of potassium for the two days was 0.28 per cent. This amounts to loss of 0.05 kg of applied potassium.

0.15 per cent and 0.02 per cent of applied potassium was lost on the first and second day of top dressing. The total loss was 0.17 per cent only. This amounts to 0.03 kg of applied potassium.

The results showed that 0.81 kg of nitrogen out of 70 kg/ha, 0.04 kg phosphorus out of 35 kg/ha and 0.08 kg potassium out of 35 kg/ha was lost through deep percolation. The maximum percolation losses of applied nitrogen, phosphorus and potassium occurred on the first day of application and became trace on the fourth day. The percentage loss of NPK are represented in the Table 9.

Padmaja and Koshy (1978) reported in the lateritic alluvium soils of Vellayani, that the maximum run off loss of 70 per cent of applied nitrogen and 26 per cent of applied potassium occur on the same day of application. The loss of phosphorus is negligible and is about two per cent.

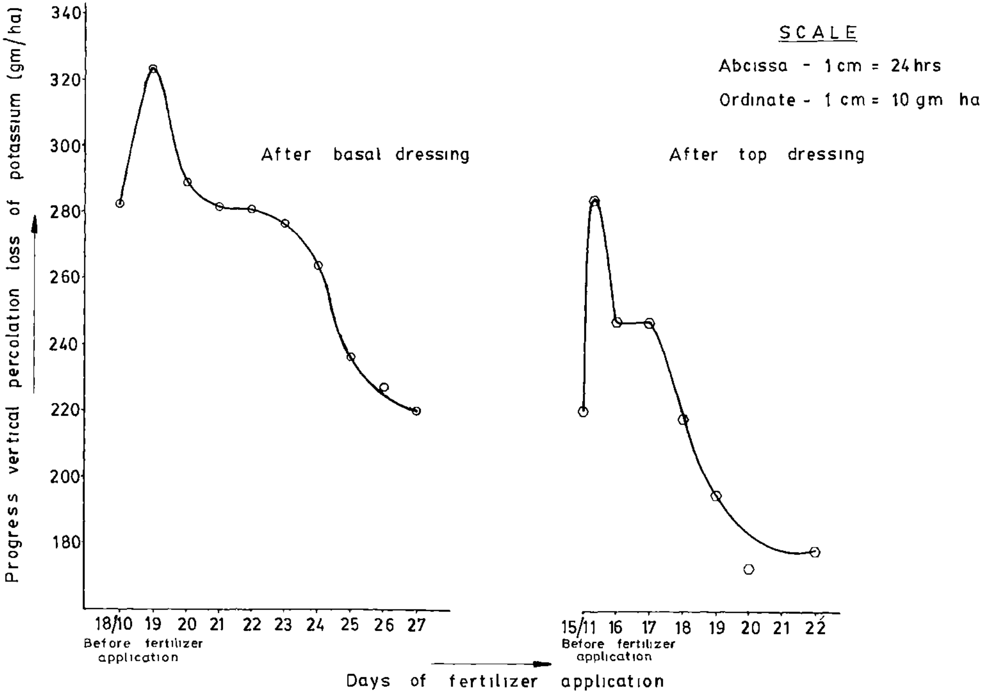


Fig. 11 PROGRESS VERTICAL PERCOLATION LOSS OF POTASSIUM AFTER BASAL DRESSING AND TOP DRESSING

Table 9 Percentage loss of NPK after basal dressing and top dressing

Days	Vertical percolation of				
	Nitrogen		Phosphorus		Potassium
	Basal dressing (%)	Top dressing (%)	Basal dressing (%)	Basal dressing (%)	Top dressing (%)
1st	0.47	0.27	0.03	0.24	0 15
2nd	0.33	0.16	0.02	0.04	0 02
3rd	0.05	0.17	Trace	Trace	Trace
Total	0.85	0.50	0.05	0 28	0.17

From the above, it can be concluded that NPK losses due to deep percolation is not much when compared to the run off losses This may be due to the fact that the NPK content in the solution gets fixed in the soil, as it percolate down through the soil. As it goes down through the soil into deeper layers, more NPK gets fixed in the soil. So the water that goes beyond the root zone will contain only very little NPK.

But the quantity of fertilizer lost through lateral percolation may be much more than this because most of the lateral percolation takes place in the upper regions of the soil. The concentration of the fertilizer in the lateral percolation water is likely to be somewhere in between the quantity of fertilizer lost in the run off water and that is lost in deep percolation. About 70 per cent of applied nitrogen and 26 per cent of applied potassium is lost through surface run off on the same day of application. About 0.47 per cent nitrogen and 0.24 per cent potassium is only lost on the same day through deep percolation. The loss of nutrients in the water that is lost in lateral percolation could not be assessed in this study. As these losses are likely to be substantial, a more detailed study is recommended.

SUMMARY

In India nearly 50 per cent of the total quantity of irrigation water is utilised for growing rice crops alone. Water constitutes one of the principal constraints increasing food production It is possible to increase the area under irrigation without any additional increase in the quantity of irrigation water by reducing the different losses of water in the field. To achieve this goal, the quantitative analysis of the different losses of water is essential. The present investigation was taken up to design, fabricate and test an equipment to measure deep percolation losses in the paddy field. The crop raised was a short duration variety rice in 'Mundakan' season. The soil in the experimental field was sandy loam in texture comprising of 10 per cent gravel, 65 per cent sand, 12.5 per cent silt and 12.5 per cent clay. The main source of irrigation water was filter-point tubewell.

The estimations of evaporation, transpiration and percolation were made on the basis of measurement using field equipments namely evaporimeter, evapotransperimeter and percolation-meter. The percolation-meter consisted of a square box of size 50 x 50 x 20 cm. A square pyramid with a base 50 cm and height 15 cm was fabricated and welded to the bottom of the square box. At the apex of the square pyramid, a hole of diameter 25 mm was made. A V-cut was made on a G.I. pipe at 5 cm from one end and the pipe was bent at this line of cut to desired angle. This pipe then was welded to the

apex of the square pyramid, with a downward slope for easy flow of water. A reducer was fixed to the G.I. pipe and a hose collar was connected to the reducer. One end of the polyethylene pipe was connected to the hose collar and the other end was connected to the drum. For the collection of percolation water a bucket was placed inside the drum. Meshes of 1 mm and 2 mm sizes were fixed on a frame and kept inside the percolation-meter.

Pure seeds of a short duration variety 'Triveni' was used for the experiment. Fertilizer application weeding and all other practices were done as per the recommendations in the package of practices. Different forms of daily losses were measured by refilling method and by adding daily losses the cumulative values during the crop period were obtained. Samples of percolation water were collected one day prior to the application of fertilizer and also in the subsequent days till the loss became negligible. The water samples were analysed for NPK losses by the standard methods.

This study reveals that total water requirement was 1270.25 mm percentages of water lost by evaporation, transpiration, total percolation, vertical and lateral percolation were 13.7, 31.0, 55.3, 32.85, 22.45 respectively. During the initial stages there was a gradual Increase In the rate of evaporation. Then it started decreasing upto 65 days and towards the last stages, the rate of evaporation increased as the mature leaves withered which inturn decreased the shaded area. The rate of transpiration remained constant during the first 10 days. Then increased at a faster rate upto the booting stage. Afterwards the rate of transpiration was almost constant.

The rate of total percolation was almost constant during the crop period except in the 6th week after transplanting. More than 50 per cent of the applied water is lost through percolation. During the initial stage vertical percolation rate was higher than in the subsequent periods. For installing the percolation-meter, the soil was disturbed for making the pit and trench. It took some days for settlement and this could be the reason for the higher vertical percolation. After 10 days the vertical percolation rate remained almost constant and the average value was 4.97 mm Vertical percolation is more than the lateral percolation. This significant water loss through vertical percolation is due to the sandy nature of the soil with very little colloidal material.

The NPK losses due to deep percolation is not much when compared to the run off losses. This may be due to the fact that the NPK content in the solution gets fixed in the soil as it percolates down through the soil. The maximum percolation losses of applied NPK occurred on the first day of application and there was only traces on the fourth day onwards. As far as phosphorus is concerned, the losses are negligible when compared to nitrogen and potassium. The equipment fabricated for the measurement of deep percolation losses worked satisfactorily.

Following suggestion is made for further study

1. To device methods for assessing lateral percolation and nutrient losses through lateral percolation.

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Originals not seen

Appendices

Appendix - I

Recommendations for rice in the package of practices

(Kerala Agricultural University)

Rice variety		Triveni
Duration		95-105 days
Grain colour	·	White
Special characters		Tolerant to brown plant hopper, susceptible to blast and sheath blight diseases
Seed rate	·	60-85 kg/ha
Age of seedlings	:	Seedlings are ready to be pulled out when these attain the 4-5 leaf stage, about 18 days after sowing
Transplanting	:	Thransplant seedlings of the appropriate age for the variety at 2-3 seedlings per hill in rows at a spacing of 15 cm x 10 cm
Manures and fertilizers		Apply organic manures in the form of farmyard manure or compost or green leaf at the rate of 5 t/ha and incorporate into the soil while ploughing. Fertilizers to be applied at 70 kg/ha of N, 35 kg/ha of P_2O_5 and 35 kg/ha of K_2
Weed control	:	Keep the field free of weeds upto 45 days

Append x II

Da y total water requ rement evapotranspirat on evaporat on transp rat on to percolat on ver ca percolat on and lateral percolat on of P ot No 1

Date	Total water requ rement (mm)	Evapotran-sp rat on (mm)	Evaporat on (mm)	Transp rat on (mm)	Total perco at on (mm)	Vert cal perco at on (mm)	La era percolat on (mm)
1	2	3	4	5	6	7	8
19/10/1989	8 00	2 00	2 00	0	6 00	5 60	0 40
20/10	8 00	2 00	2 00	0	6 00	,5 60	0 40
21/10	8 00	2 00	2 00	0	6 00	5 40	0 60
22/10	8 00	3 10	2 10	0	4 90	4 80	0 10
23/10	8 50	3 15	2 10	0 05	5 35	5 00	0 35
24/10	8 50	3 15	2 10	0 05	5 53	5 20	0 15
25/10	8 75	3 20	2 10	0 10	5 55	5 30	0 25
26/10	8 75	3 00	2 20	0 80	5 75	5 20	0 55
27/10	8 75	3 10	2 30	0 80	5 65	5 00	0 65
28/10	9 00	3 20	2 20	1 00	5 80	5 20	0 60
29/10	10 00	3 21	2 25	0 96	6 79	5 50	1 29
30/10	10 00	3 22	2 50	0 72	6 78	6 00	0 78
31/10	10 00	3 25	2 50	0 75	6 75	6 00	0 75
1/11	10 00	3 00	2 20	0 80	7 00	6 50	0 50
2/11	10 10	3 10	2 25	0 85	7 10	5 80	1 30
3/11	10 50	3 16	2 75	0 41	7 34	4 30	3 04
4/11	11 00	3 20	3 00	0 20	7 80	5 80	2 00
5/11	10 00	4 00	2 50	1 50	6 00	5 80	0 20
6/11	12 00	4 05	2 75	1 30	7 95	4 80	3 15
7/11	12 00	6 50	4 00	2 50	5 50	4 20	1 30
8/11	12 00	6 50	4 00	2 50	5 50	4 28	1 22
9/11	12 00	6 00	4 00	2 00	6 00	4 30	1 70
10/11	11 00	6 00	4 00	2 00	5 00	4 00	1 00
11/11	11 00	6 50	4 00	2 50	4 50	3 96	0 54
12/11	11 50	6 70	4 00	2 70	4 80	4 40	0 40
13/11	11 50	6 50	4 00	2 50	5 00	4 00	1 00
14/11	12 00	6 00	2 00	4 00	6 00	3 96	2 04
15/11	14 00	6 50	2 00	4 50	7 50	3 96	3 54
16/11	14 00	8 00	2 50	5 50	6 00	3 76	2 24
17/11	14 00	8 00	2 50	5 50	6 00	3 80	2 20
18/11	14 00	6 50	3 00	3 50	7 50	3 60	3 90
9/11	13 50	7 00	3 00	4 00	6 50	3 50	3 00
20/11	13 50	6 50	3 00	3 50	7 00	3 40	3 60
21/11	14 00	7 00	2 00	5 00	7 00	3 60	3 40
22/11	14 00	7 50	2 00	5 50	6 50	3 80	2 70
23 11	15 00	8 00	2 00	6 00	7 00	5 00	2 00
24/11	14 00	8 50	2 00	6 50	5 50	4 50	1 00
25/11	14 00	8 00	2 00	6 00	6 00	4 00	2 00
26/11	16 00	8 00	2 00	6 00	8 00	5 00	3 00
27/11	17 00	9 00	1 50	7 50	8 00	6 00	2 00
28/11	17 00	8 00	1.00	7 00	9 00	6 00	3 00
29/11	22 00	9.00	1 00	8 00	13 00	8 00	5 00
30/11	27 00	9 00	1 00	8 00	18 00	8 00	10 00
1/12	26 00	10 00	1 00	9 00	16 00	8 00	8 00
2/12	28 00	11 00	1 00	10 00	17 00	8 00	9 00
./12	32 00	11 00	3 00	8 00	21 00	6 00	15 00
4/12	30 00	12 00	3 00	9 00	18 00	6 00	12 00
5/12	28 00	10 00	3 00	7 00	18 00	6 00	12 00

Contd

Append x II (contd)

Date	Total water requirement (mm)	Evapotranspiration (mm)	Evaporat on (mm)	Transpiration (mm)	Total percolat on (mm)	Vertical percolation (mm)	Lateral percolation (mm)
1	2	3	4	5	6	7	8
6/12/1989	27 0	10 0	2 0	8 0	18 0	6 0	11 0
7/12	26 0	11 0	2 0	9 0	15 0	7 0	9 0
8/12	21 0	8 0	2 0	6 0	13 0	6 0	7 0
9/12	14 0	8 0	1 0	7 0	6 0	6 0	0 0
10/12	14 0	8 0	1 0	7 0	6 0	4 0	2 0
11/12	14 0	8 0	1 0	7 0	6 0	4 0	2 0
12/12	15 0	9 0	1 0	8 0	6 0	4 0	2 0
13/12	16 0	10 0	1 0	9 0	6 0	5 0	1 0
14/12	16 0	10 0	1 0	9 0	6 0	5 0	1 0
15/12	14 0	8 0	1 0	7 0	7 0	5 5	0 5
16/12	14 0	8 0	1 0	7 0	6 0	4 5	1 5
17/12	15 0	8 0	1 0	7 0	7 0	5 0	2 0
18/12	14 0	8 0	1 0	7 0	6 0	4 0	2 0
19/12	14 0	8 0	0 0	7 0	6 0	4 2	1 8
20/12	15 0	8 0	1 0	7 0	7 0	5 0	2 0
21/12	15 0	8 0	1 0	7 0	7 0	4 5	2 5
22/12	15 0	7 0	1 0	6 0	8 0	4 5	3 5
23/12	15 0	6 0	1 0	5 0	9 0	6 0	3 0
24/12	15 0	5 0	1 0	4 0	10 0	6 0	4 0
25/12	13 0	5 0	1 0	4 0	8 0	4 0	4 0
26/12	14 0	5 0	1 2	3 8	9 0	4 0	5 0
27/12	14 0	6 0	1 2	4 8	8 0	6 0	2 0
28/12	13 0	6 0	1 3	4 7	7 0	6 0	1 0
29/12	12 0	5 0	1 0	4 0	7 0	6 0	1 0
30/12	12 0	5 0	1 0	4 0	7 0	6 0	1 0
31/12	11 0	5 0	1 0	4 0	6 0	6 0	0 0
1/1/1990	11 0	5 0	1 5	3 5	6 0	4 0	2 0
2/1	12 0	5 5	1 5	4 0	6 5	4 5	2 0
3/1	11 0	5 3	1 5	3 8	5 7	4 6	1 1
4/1	11 0	5 1	2 0	3 1	5 9	4 2	1 7
5/1	10 0	5 5	2 0	3 5	4 5	4 1	0 4
6/1	11 0	5 6	2 0	4 6	5 4	4 0	1 4
7/1	11 0	4 8	2 0	2 8	6 2	4 2	2 0
8/1	10 0	5 0	2 0	3 0	5 0	4 0	1 0
9/1	11 0	5 0	2 0	3 0	6 0	4 0	2 0
10/1	11 0	5 0	2 0	3 0	6 0	4 0	2 0

Append x II (contd)

Da y otal water requ rement evapotransp rat on evaporat on transp rat on total percolat on vert ca percolat on and lateral percolat on of Plot No 2

Date	Total water requ rement (mm)	Evapotran sp rat ion (mm)	Evaporat on (mm)	Transp rat on (mm)	Total percolat on (mm)	Vert cal percolat on (mm)	Lateral percolat on (mm)
1	2	3	4	5	6	7	8
19/10/1969	8 0	2 0	2 0	0 0	6 0	5 5	0 5
20/10	8 0	2 0	2 0	0 0	6 0	5 5	0 5
21/10	8 0	2 0	2 0	0 0	6 0	5 4	0 6
22/10	11 0	2 1	2 0	0 1	8 9	7 0	1 9
23/10	11 2	2 2	2 1	0 1	9 0	7 0	2 0
24/10	10 5	2 2	2 1	0 1	8 3	6 8	1 5
25/10	11 0	2 3	2 2	0 1	8 7	6 5	2 2
26/10	12 0	2 35	2 3	0 05	9 65	5 0	3 65
27/10	12 0	2 35	2 3	0 05	9 65	6 2	3 45
28/10	12 5	2 3	2 1	0 2	10 2	6 0	4 2
29/10	13 0	2 9	2 8	0 1	10 1	6 1	4 0
30/10	11 0	3 0	2 9	0 1	8 0	6 0	2 0
31/10	10 0	3 2	3 1	0 1	6 8	6 0	0 8
1/11	10 0	3 3	3 0	0 3	6 7	5 0	1 7
2/11	11 0	5 0	2 9	2 1	6 0	4 0	2 0
3/11	12 0	5 0	3 0	2 0	7 0	5 0	2 0
4/11	12 0	4 0	3 0	1 0	8 0	6 0	2 0
5/11	11 0	6 0	4 0	2 0	5 0	5 0	0 0
6/11	12 0	6 2	3 0	3 2	5 8	5 0	0 8
7/11	13 0	6 5	3 0	3 5	6 5	6 0	0 5
8/11	13 0	6 0	4 0	2 0	7 0	5 5	1 5
9/11	12 5	6 0	4 5	1 5	6 5	5 5	1 0
10/11	12 5	6 0	4 0	2 0	6 5	5 0	1 5
11/11	13 0	6 0	4 5	1 5	7 0	6 0	1 0
12/11	13 0	5 5	4 0	1 5	7 5	5 0	2 5
13/11	14 0	6 0	4 0	2 0	8 0	6 0	2 0
14/11	13 0	6 0	2 0	4 0	7 0	6 0	1 0
15/11	13 0	6 5	2 0	4 5	6 5	5 0	1 5
16/11	13 0	7 0	3 0	4 0	6 0	5 5	0 5
17/11	15 0	8 3	8 0	5 3	6 7	5 0	1 7
18/11	14 0	6 0	3 0	3 0	8 0	5 0	8 0
19/11	14 0	7 0	3 0	4 0	7 0	5 0	2 0
20/11	16 0	6 5	3 0	2 5	9 5	5 5	4 0
21/11	18 0	9 0	2 09	7 0	9 0	5 8	3 2
22/11	15 0	8 5	1 5	7 0	7 5	5 6	1 9
23/11	16 0	9 0	1 75	7 25	7 0	5 6	1 4
24/11	16 0	9 0	2 0	7 0	7 0	5 4	1 4
25/11	16 0	9 0	2 0	7 0	7 0	5 5	1 5
26/11	19 0	8 5	2 0	6 5	10 5	5 2	5 3
27/11	19 0	8 5	2 0	5 5	10 5	4 0	6 5
28/11	19 0	8 0	1 75	6 25	11 0	5 0	6 0
29/11	19 0	9 0	1 5	7 5	10 0	5 2	4 8
30/11	24 0	9 0	1 0	8 0	15 0	5 3	9 7

Contd

Appendix I (contd)

Date	Total water requirement (mm)	Evapotranspiration (mm)	Evaporation (mm)	Transpiration (mm)	Total percolation (mm)	Vertical percolation (mm)	Lateral percolation (mm)
1	2	3	4	5	6	7	8
1/12/1989	26 0	10 0	1 0	9 0	16 0	5 5	10 5
2/12	32 0	10 0	1 0	9 0	22 0	5 6	16 4
3/12	33 0	12 0	2 0	10 0	21 0	5 2	15 8
4/12	31 0	11 0	2 0	9 0	20 0	5 3	14 7
5/12	25 0	10 0	2 0	8 0	15 0	5 4	9 6
6/12	25 0	10 0	2 0	8 0	15 0	5 5	9 5
7/12	25 0	11 0	2 0	9 0	14 0	5 5	8 5
8/12	22 0	8 0	2 0	6 0	14 0	5 6	8 4
9/12	17 0	8 0	2 0	6 0	9 0	5 4	3 6
10/12	17 0	8 5	1 0	7 5	8 5	5 2	3 3
11/12	17 0	9 0	1 0	8 0	8 0	5 2	2 8
12/12	15 0	9 0	1 25	7 75	7 0	5 0	2 0
13/12	15 0	11 0	1 5	9 5	4 0	4 0	0 0
14/12	15 0	11 0	1 5	9 5	4 0	4 0	0 0
15/12	14 0	10 0	1 5	8 5	4 0	4 0	0 0
16/12	14 0	10 0	1 25	8 75	4 0	4 0	0 0
17/12	14 5	8 0	1 3	6 7	6 5	5 0	1 5
18/12	14 5	8 0	1 4	6 6	6 5	5 0	1 5
19/12	15 0	8 0	1 5	6 5	7 0	5 0	2 0
20/12	140	8 0	1 2	6 8	6 0	5 1	0 9
21/12	14 0	8 0	1 1	6 9	6 0	5 0	1 0
22/12	14 0	8 0	1 1	6 9	6 0	5 2	0 8
23/12	15 0	8 0	1 1	6 9	7 0	5 5	1 5
24/12	14 0	8 5	1 0	7 5	5 5	5 0	0 5
25/12	14 0	8 0	1 0	7 0	6 0	5 1	0 9
26/12	13 0	8 0	1 0	7 0	5 0	4 0	1 0
27/12	12 0	8 0	1 0	7 0	4 0	4 0	0 0
28/12	11 0	8 0	1 0	7 0	3 0	3 0	0 0
29/12	12 0	6 0	1 0	5 0	6 0	4 0	2 0
30 12	12 0	6 0	1 0	5 0	6 0	4 0	2 0
31/12	11 0	6 0	1 0	5 0	5 0	4 0	1 0
1 1/1990	11 0	5 9	1 5	4 4	5 1	4 5	0 6
2/1	12 0	6 0	2 0	4 0	6 0	4 6	1 4
3/1	12 0	5 9	2 0	3 9	5 1	4 6	0 5
4/1	12 0	6 2	2 0	4 2	5 8	4 5	1 3
5/1	11 0	6 0	2 0	4 0	5 0	4 2	0 8
6/1	11 0	5 8	2 0	3 8	5 2	4 1	1 1
7/1	10 0	5 6	2 5	3 1	4 4	4 0	0 4
8/1	11 0	5 8	2.0	3 8	5 2	4 2	1 0
9/1	10 0	5 5	2 0	3 5	4 5	4 0	0 5
10/1	11 0	5 5	3 0	2 5	5 5	4 0	1 5

Append x II (contd)

Da ly total water requ rement evapotranspiration evaporat on transp rat on total percolat on vertical percolat on and lateral percolat on of Plot No 3

Date	Total water requ rement (mm)	Evapotran-sp ration (mm)	Evaporation (mm)	Transpirat on (mm)	Total perco at on (mm)	Vert cal percolat on (m m)	Latera percolat on (mm)
1	2	3	4	5	6	7	8
19 0/1989	8 5	2 0	2 0	0 0	6 5	5 6	0 9
20/10	8 5	2 0	2 0	0 0	6 5	5 6	0 9
21/10	9 0	2 0	2 0	0 0	7 0	5 4	1 6
22/10	9 5	2 5	2 05	0 45	7 0	6 8	0 2
23 10	10 0	2 5	2 05	0 45	7 5	6 9	0 6
24 10	11 0	2 6	2 1	0 5	8 4	6 5	1 9
25/10	12 0	2 6	2 1	0 5	9 4	6 0	3 4
26 10	11 0	2 6	2 1	0 5	8 4	6 2	2 4
27/10	10 5	2 7	2 3	0 4	7 8	6 4	1 4
28/10	11 0	2 7	2 3	0 4	8 3	7 0	1 2
29/10	11 0	2 8	2 25	0 55	8 2	6 5	1 7
30 10	11 0	3 0	2 4	0 6	8 0	6 3	1 7
31 10	12 0	3 5	2 5	1 0	8 5	6 2	2 3
11	11 8	4 0	2 6	1 4	7 8	6 0	d
? 1	11 9	3 5	2 7	0 8	8 4	4 0	4 4
3 11	11 8	3 5	2 8	0 7	8 3	4 0	3 8
4 11	11 8	3 4	2 75	0 65	8 4	4 5	3 9
5 11	11 8	3 8	3 0	0 8	8 0	4 8	3 2
6/11	12 0	6 0	3 25	2 75	6 0	5 0	0
7/11	12 0	6 0	3 5	2 5	6 0	5 0	1 0
8/11	13 0	10 0	3 5	3 5	6 0	5 0	1 0
9/11	13 0	6 5	3 2	3 3	6 5	5 0	1 5
10/11	14 0	6 5	3 8	2 7	7 5	5 0	2 5
11/11	14 0	7 0	4 0	3 0	7 0	5 0	2 0
1? 1	13 0	7 5	4 1	3 4	5 5	5 0	0 5
1ɜ/11	13 0	6 0	4 3	1 7	7 0	5 5	2 0
14/11	14 0	6 0	4 5	1 5	8 0	5 5	2 5
15/11	15 0	6 5	3 0	3 5	8 5	5 5	3 0
16/11	16 0	6 5	3 0	3 5	9 5	5 5	4 0
17/1	15 5	7 0	2 5	4 5	8 5	5 7	2 8
18/11	16 0	7 0	2 2	4 8	9 0	5 4	3 6
19/11	19 0	8 0	2 2	5 8	11 0	5 4	5 6
20/11	20 0	8 0	3 0	5 0	12 0	4 8	7 2
21/11	19 0	8 0	3 0	5 0	11 0	5 0	6 0
22/11	20 0	9 0	2 0	7 0	11 0	5 5	5 5
23/11	19 0	9 0	2 0	7 0	10 0	6 0	4 0
24/11	19 5	9 0	2 2	6 8	10 5	5 8	4 7
25/11	19 5	8 0	2 2	5 8	11 5	5 8	5 7
26/11	20 0	8 0	2 0	6 0	12 0	5 8	6 2
27/11	20 0	8 0	2 0	6 0	12 0	6 0	6 0
28 11	20)	9 0	2 0	7 0	11 0	6 0	5 0
29/11	23 0	9 0	2 0	7 0	14 0	6 0	8 0
30/11	27 0	10 0	2 0	8 0	17 0	6 0	11 0

Contd

Append x II (contd)

Date	Total water requ rement (mm)	Evapotran-sp ration (mm)	Evaporation (mm)	Transpirat on (mm)	Total percolat on (mm)	Vert cal percolat on (mm)	Latera percolat on (mm)
1	2	3	4	5	6	7	8
1/12/1989	31 0	10 0	2 0	8 0	21 0	6 0	15 0
2/12	32 0	11 0	2 1	8 9	21 0	6 0	15 0
3/12	30 0	11 0	2 0	9	19 0	6 0	13 0
4/12	30 0	10 0	21 0	7 9	20 0	5 8	14 2
5/12	29 0	10 0	1 9	8 1	19 0	5 8	13 2
6/12	29 0	9 0	1 9	7 1	20 0	5 6	14 4
7/12	28 0	8 0	1 8	6 2	20 0	5 6	14 4
8/12	26 0	9 0	1 7	7 3	17 0	5 4	11 6
9/12	17 0	8 0	1 7	6 3	9 0	4 8	4 2
10/12	17 0	8 0	1 6	6 4	9 0	4 8	4 2
11/12	17 0	8 0	1 4	6 6	9 0	4 8	4 2
12/12	16 0	9 0	1 4	7 6	7 0	5 0	2 0
13/12	17 0	10 0	1 3	8 7	7 0	5 0	2 0
14/12	17 0	11 0	1 3	9 7	6 0	4 0	2 0
15/12	17 0	10 0	1 2	8 8	7 0	4 0	3 0
16/12	16 0	10 0	1 1	8 9	6 0	4 0	2 0
17/12	16 0	10 0	1 1	8 9	6 0	4 0	2 0
18/12	16 0	8 0	1 1	6 9	8 0	4 2	3 8
19/12	16 0	8 0	1 1	6 9	8 0	4 2	3 8
20/12	16 0	8 0	1 0	7 0	8 0	4 2	3 8
21/12	16 0	8 0	1 0	7 0	8 0	4 2	3 8
22/12	15 0	8 0	1 0	7 0	7 0	4 8	2 2
23/12	14 0	8 0	1 1	6 9	6 0	4 4	1 6
24/12	15 0	7 0	1 0	6 0	8 0	4 2	3 8
25/12	16 0	7 0	1 0	6 0	9 0	4 4	4 6
26/12	15 0	7 0	1 0	6 0	8 0	4 0	4 0
27/12	15 0	6 0	1 0	5 0	9 0	4 0	5 0
28/12	14 0	6 0	1 1	5 0	8 0	4 0	4 0
29/12	13 0	7 0	1 0	6 0	6 0	4 0	2 0
30/12	13 0	7 0	1.0	6 0	6 0	4 0	2 0
31/12	14 0	7 0	1 0	6 0	7 0	4 0	1 0
1/1/1990	12 0	7 0	1 5	5 5	5 0	4 0	1 0
2/1	12 0	7 0	1 5	5 5	5 0	4 0	1 0
3/1	11 0	7 0	1 5	5 5	4 0	3 8	0 2
4/1	12 0	7 2	2 0	5 2	4 8	4 0	0 8
5/1	11 0	6 8	2 0	4 8	4 2	4 0	0 2
6/1	10 0	7 0	2 0	5 0	3 0	2 8	0 2
7/1	11 0	6 5	2 0	4 5	4 5	4 0	0 5
8/1	12 0	6 5	2 5	4 0	5 5	4 5	1 0
9/1	10 0	6 7	2 5	4 2	3 3	3 0	0 3
10/1	11 0	6 5	2 5	4 0	4 5	4 0	0 5

App nd x I (contd)

Da ly total water requ rement evapotransp rat on evaporat on transp rat on total percolat on vert cal percolat on and lateral perco at on of Plot No 4

Date	Total water requ rement (mm)	Evapotran-spiration (mm)	Evaporat ion (mm)	Transp rat on (mm)	Total percolat ion (mm)	Vert cal percolat on (mm)	Lateral percolat on (mm)
1	2	3	4	5	6	7	8
19/10/1989	9 0	2 0	2 0	0 0	7 0	6 4	0 6
20/10	9 0	2 0	2 0	0 0	7 0	6 4	0 6
21/10	9 0	2 0	2 0	0 0	7 0	6 2	0 8
22/10	9 0	2 5	2 1	0 4	6 5	6 4	0 1
23/10	10 2	2 5	2 1	0 4	7 7	6 8	0 9
24/10	10 2	2 5	2 2	0 3	7 7	6 5	1 2
25 10	10 5	2 5	2 2	0 3	8 0	6 0	2 0
26/10	11 0	2 7	2 2	0 5	8 3	5 5	2 8
27/10	11 2	2 7	2 3	0 4	8 5	4 5	4 0
28/10	11 4	2 8	2 3	0 5	8 6	4 14	4 46
29/10	11 6	2 8	2 4	0 4	8 8	4 0	4 8
30/10	11 5	2 8	2 4	0 4	8 7	4 0	4 7
31/10	11 4	2 8	2 5	0 3	8 6	4 0	4 6
1/11	11 4	3 0	2 6	0 4	8 4	4 4	4 0
2/11	11 4	3 0	2 8	0 2	8 4	3 5	4 9
3/11	11 6	3 5	3 1	0 4	8 1	3 6	4 5
4/11	12 0	5 9	3 2	2 7	6 1	4 6	1 5
5/11	12 5	6 0	3 2	2 8	6 5	4 7	1 8
6/11	12 8	5 9	3 2	2 7	6 9	4 9	2 0
7/11	14 0	5 9	3 5	2 4	8 1	5 0	3 1
8/11	15 0	6 6	3 5	3 1	8 4	6 0	2 4
9/11	16 0	6 5	3 2	3 3	9 5	6 0	3 5
10/11	16 0	6 0	3 6	2 8	10 0	6 0	4 0
11/11	15 0	7 0	4 0	3 0	8 0	6 0	2 0
12/11	14 8	7 0	4 0	3 0	7 8	6 0	1 8
13/11	14 8	8 0	4 0	4 0	6 8	4 9	1 9
14/11	14 5	9 0	4 0	5 0	5 5	4 9	0 6
15/11	14 5	9 0	3 0	6 0	5 5	5 0	0 5
16/11	15 0	9 0	3 0	6 0	6 5	5 0	1 5
17/11	15 0	8 5	2 5	6 0	6 5	5 2	1 3
18/11	14 0	8 5	2 5	6 0	5 5	5 2	0 3
19/11	16 0	9 0	2 5	6 5	7 0	5 5	1 5
20/11	16 0	8 5	3 0	5 5	7 5	5 0	2 5
21/11	16 0	10 0	3 0	7 0	6 0	4 0	2 0
22/11	19 0	10 0	3 0	7 0	9 0	4 0	5 0
23/11	19 0	10 0	2 5	7 5	9 0	4 0	5 0
24/11	19 0	10 0	2 0	8 0	9 0	4 0	5 0
25/11	20 0	10 0	2 0	8 0	10 0	5 0	5 0
26 11	23 0	9 0	2 0	7 0	14 0	5 0	9 0
27/11	22 0	6 0	2 0	6 0	14 0	5 8	8 2
28/11	22 0	8 0	2 0	6 0	14 0	6 0	8 0
29/11	22 0	8 0	1 9	6 4	14 0	5 4	8 6
30/11	26 0	9 0	1 9	7 1	17 0	5 4	11 6

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Append x II (contd)

Date	Total water requirement (mm)	Evapotran-spiration (mm)	Evaporation (mm) ♦	Transpiration (mm)	Total percolation (mm)	Vertical percolation (mm)	Lateral percolation (mm)
1	2	3	4	5	6	7	8
1/12/1969	30 0	9 0	2 0	7 0	21 0	4 5	16 5
2/12	29 0	10 0	2 0	8 0	19 0	4 4	14 6
3/12	30 0	10 0	2 0	8 0	20 0	4 0	16 0
4/12	30 0	11 0	2 0	9 0	19 0	3 9	15 1
5/12	29 0	10 0	2 0	8 0	19 0	4 5	14 5
6/12	30 0	9 0	2 0	7 0	21 0	4 5	16 5
7/12	29 0	9 0	2 0	7 0	20 0	4 5	15 5
8/12	27 0	9 0	2 0	7 0	18 0	4 5	11 5
9/12	19 0	8 0	1 0	7 0	11 0	6 0	5 0
10/12	19 0	8 0	1 0	7 0	11 0	6 0	5 0
11/12	18 0	8 0	1 0	7 0	10 0	6 0	4 0
12/12	18 0	9 0	1 0	8 0	9 0	4 0	5 0
13/12	18 0	9 0	1 0	8 0	8 0	4 0	5 0
14/12	18 5	11 0	1 0	10 0	7 5	4 0	3 5
15/ 2	18 5	11 0	1 0	10 0	7 5	4 0	3 5
16/12	17 0	8 0	1 0	7 0	9 0	4 2	4 8
17/12	17 0	8 0	1 0	7 0	9 0	4 4	4 6
18/12	17 0	8 0	1 1	6 9	9 0	4 0	5 0
19/12	16 0	8 0	1 2	6 8	8 0	4 0	4 0
20/12	16 0	8 0	1 2	6 8	8 0	4 2	3 8
21/12	16 0	8 0	1 2	6 8	8 0	4 3	3 7
22/12	15 0	8 0	1 3	6 7	7 0	4 0	3 0
23/12	16 0	8 0	1 4	6 6	8 0	4 5	3 5
24/12	15 0	8 0	1 3	6 7	7 0	4 1	2 9
25/12	16 0	8 0	1 3	6 7	8 0	4 2	3 8
26 12	16 0	8 0	1 2	6 8	8 0	4 0	4 0
27/12	15 0	7 5	1 0	6 5	7 5	4 0	3 5
28/12	15 0	7 5	1 0	6 5	7 5	4 0	3 5
29 12	13 0	8 0	1 0	7 0	5 0	4 0	1 0
30 12	13 0	7 5	1 0	6 5	5 5	4 0	1 5
31/12	13 0	7 5	1 0	6 5	5 5	4 0	1 5
1/1/1990	12 0	7 5	1 5	6 0	4 5	4 0	0 5
2/1	11 0	7 0	1 5	5 5	4 0	4 0	0 0
3/1	12 0	7 3	1 5	5 8	4 7	4 2	0 5
4/1	11 0	7 5	1 5	6 0	4 5	4 0	0 5
5/1	10 0	7 0	2 0	5 0	3 0	2 8	0 2
6/1	11 0	6 8	2 0	4 8	4 2	4 0	0 2
7/1	12 0	7 0	2 0	5 0	5 0	4 0	1 0
8/1	13 0	7 0	2 0	5 0	6 0	4 5	1 5
9/1	11 0	7 0	2 5	4 5	4 0	4 0	0 0
10/1	11 0	6 5	2 5	4 0	4 5	4 2	0 3

Appendix - IIIa

Comparative percolation loss of nitrogen after basal application of fertilizers

Date	Volume of sample (m	Loss of nitrogen (ppm)	Average loss (ppm)	Vertical percolated water (lit/ha)	Loss of nitrogen in percolated water (gm/ha)	Actual loss of nitrogen (gm/ha)
1	2	3	4	5	6	7
18 10 1989	25	0 89	0 89	$5\ 87 \times 10^4$	52 6	(Check) 0
19 10 1989	10	4 20 3 92 3 36 3 64	3 78	$5\ 77 \times 10^4$	218 10	165 46
20 10 1989	10	2 80 3 08 3 08 2 80	2 94	$5\ 70 \times 10^4$	167 58	114 98
21 10 1989	20	1 26 1 40 1 12 1 12	1 22	$5\ 60 \times 10^4$	68 3[illegible]	15 72
22 10 1989	20	0 84 1 12 0 84 1 12	0 98	$6\ 25 \times 10^4$	61 25	8 65
23 10 1989	20	0 98 0 84 0 84 0 84	0 88	$6\ 43 \times 10^4$	56 26	3 66
24 10 1989	20	0 98 0 84 0 84 0 84	0 88	$6\ 25 \times 10^4$	54 68	2 08
5 10 1989	20	0 84 0 84 1 12 0 56	0 84	$5\ 95 \times 10^4$	9 96	Trace
26 10 1989	20	0 70 0 84 0 84 0 84	0 81	$5\ 73 \times 10^4$	46 12	Trace
27 10 1989	20	0 56 0 84 1 12 0 56	0 77	$5\ 53 \times 10^4$	42 58	Trace
28 10 1989	20	0 84 0 84 0 56 0 84	0 77	$5\ 58 \times 10^4$	42 96	Trace
29 10 1989	20	0 70 0 84 0 56 0 56	0 67	$5\ 02 \times 10^4$	33 63	Trace
30 10 1989	20	0 56 0 56 0 70 0 84	0 67	$5\ 57 \times 10^4$	37 31	Trace

To a

Append x IIIa

Comparat ve percolation loss of n trogen after top dress ng

Date	Volume of sample (ml)	Loss of nitrogen (ppm)	Average loss (ppm)	Vertical percolated water (lit/ha)	Loss of n trogen n percolated water (gm/ha)	Actual oss of nitrogen (gm/ha)
1	2	3	4	5	6	7
15 11 1989	50	0 22 0 33 0 22 0 33	0 27	4 86 x 10^4	13 51	0 (Check)
16 11 1989	50	1 96 2 52 2 24 1 96	2 17	4 94 x 10^4	107 19	94 07
17 11 1989	50	1 45 1 34 1 34 1 45	1 40	4 92 x 10^4	68 70	55 58
18 11 1989	50	0 78 0 67 0 78 0 89	0 78	4 80 x 10^4	37 63	24 51
19 11 1989	50	0 44 0 33 0 44 0 33	0 49	4 85 x 10^4	24 00	10 88
20 11 1989	50	0 33 0 39 0 28 0 36	0 33	4 67 x 10^4	15 70	2 58
21 11 1989	50	0 39 0 28 0 28 0 22	0 29	4 60 x 10^4	13 52	0 40
22 11 1989	50	0 33 0 28 0 28 0 22	0 27	4 73 x 10^4	13 19	Trace
23 11 1989	50	0 28 0 28 0 33 0 28	0 29	5 15 x 10^4	15 08	Trace
24 11 1989	50	0 22 0 28 0 33 0 22	0 26	4 93 x 10^4	13 06	Trace
25 11 1989	50	0 28 0.28 0 22 0 22	0 25	5 08 x 10^4	12 80	Trace
26 11 1989	50	0 22 0 28 0 22 0 22	0 23	5 25 x 10^4	12 49	Trace
27 11 1989	50	0 22 0 22 0 22 0 22	0 22	5 45 x 10^4	12 20	Trace

Comparative percolation loss of phosphorus after basal application of fertilizer

Date	Volume of sample (ml)	Loss of phosphorus (ppm)	Average loss (ppm)	Vertical percolated water (lit/ha)	Loss of phosphorus in percolated water (gm/ha)	Actual loss of phosphorus (gm/ha)
18.10.1989	25	0.24	0.24	5.87×10^4	14 08	0 (Check)
19 10.1989	25	0.48 0.40 0.48 0.32	0.42	$5\ 77 \times 10^4$	24 23	10 15
20 10.1989	25	0.48 0.40 0.24 0.32	0.36	5.70×10^4	20.52	6 44
21.10.1989	25	0.32 0.40 0.58 0.32	0.41	5.60×10^4	22.96	8 88
22 10.1989	25	0.24 0.32 0.32 0.40	0.32	$6\ 25 \times 10^4$	20.00	5 92
23 10.1989	25	0.32 0.24 0.40 0.32	0.32	6.43×10^4	20.56	6.48
24.10.1989	25	0.24 0.24 0.32 0.32	0.28	6.25×10^4	17 5	3 42
25.10.1989	25	0.24 0.24 0.24 0.24	0.24	5.95×10^4	14.28	0 20
26.10.1989	25	0.24 0.24 0.24 0.24	0.24	5.73×10^4	13.75	Trace

Append x IIIc

Comparat ve percolat on loss of potass um after basal applicat on of fert l zer

Date 1	Loss of potassium (ppm) 2	Average loss (ppm) 3	Vertical percolated water (lit/ha) 4	Loss of potass um n percolated water (gm/ha) 5	Actua loss of potass um (gm/ha) 6
18 10 1989	4 8	4 80	5 87 x 10^4	281 80	0 (Check)
19 10 1989	5 9 5 0 5 8 5 7	5 60	5 77 x 10^4	323 12	41 32
20 10 1989	5 2 5 0 4 8 5 3	5 07	5 70 x 10^4	288 99	7 19
21 10 1989	5 2 4 6 5 3 5 0	5 03	5 60 x 10^4	281 16	Trace
22 10 1989	4 0 5 3 4 7 4 0	4.50	6 25 x 10^4	281 25	Trace
23 10 1989	4 0 5 0 5 0 4 0	4 50	6 43 x 10^4	276 49	Trace
24 10 1989	4 2 4 5 4 2 4 0	4 23	6 25 x 10^4	264 38	Trace
25 10 1989	3 8 4 2 4 0 4 0	4 00	5 95 x 10^4	236 00	Trace
26 10 1989	4 1 4 2 4 3 4 0	4 15	5 73 x 10^4	237 80	Trace
27 10 1989	3 9 4 2 3 8 4 0	3 98	5 53 x 10^4	220 09	Trace
28 10 1989	4 0 4 1 4 2 4 0	4 08	5 58 x 10^4	227 67	Trace
Total					48 51
			After top dressing		
15 11 1989	4 5 4 6 4 4 4 6	4 53	4 86 x 10^4	220 16	
16 11 1989	5 2 5 0 4 8 5 0	5 00	4 94 x 10^4	247 00	26 84
17 11 1989	4 4 4 4 4 8 4 6	4 55	4 93 x 10^4	224 32	4 16
18 11 1989	4 4 4 8 4 6 4 4	4 55	4 80 x 10^4	218 40	Trace
19 11 1989	4 2 4 4 4 3 4 0	4 23	4 85 x 10^4	205 16	Trace

DESIGN, FABRICATION AND TESTING OF AN EQUIPMENT TO MEASURE DEEP PERCOLATION

By

JOLLY KUTTY EAPEN

ABSTRACT OF A THESIS

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ABSTRACT

Rice is the most important and extensively cultivated food crop in Kerala Because of the semi-aquatic nature, the water requirement of rice is 2-3 times greater than other crops The measurement or prediction of percolation losses in field situation is of great practical significance for efficient irrigation and also for the determination of the nutrient losses. A precise knowledge of water requirement of crop attains importance for increasing production The present investigation was taken upto design, fabricate and test an equipment to collect deep percolation water, quantify it and to assess the nutrient losses in the percolation water The study was undertaken in Mundakan' season and the variety was 'Triveni' The location was the Instructional Farm of KCAET, Tavanur The main source of irrigation water was filter point tubewell.

The experiment was conducted during the Mundakan season of 1989 Estimations of evaporation, transpiration and percolation were made on the basis of measurements, using evaporimeter, evapotranspirimeter and field hook gauge Vertical percolation was assessed using percolation-meter which was designed and fabricated for this study. Lateral percolation was obtained by subtracting vertical percolation from total percolation The study revealed that the total

water requirement was 1270.25 mm The percentages of water lost by evaporation, transpiration, and total percolation are 13.69, 31.0 and 55.3. The water which is lost by vertical and lateral percolation are 59 4 and 40 6 per cent of the total percolation respectively.

There was a gradual increase in the rate of evaporation during the initial stage Then it decreased upto 65 days and then again increased upto the final stage. Rate of transpiration remained almost constant upto 10 days and then the rate slowly increased as the crop grew. The rate increased upto the booting stage There was a gradual decrease in the rate of transpiration in the final stage

The rate of total percolation remained almost constant during the crop period. More than 50 per cent of the applied water is lost through percolation During the initial stage, vertical percolation rate was higher than in the subsequent days. After 10 days, the vertical percolation rate remained almost constant. The rate of lateral percolation was constant during the crop period except in the sixth week after transplanting. The samples of percolation water were collected and the NPK losses due to deep percolation were analysed by the standard methods The maximum percolation losses of applied NPK occurred on the first day of application and there was only traces on the fourth day onwards. Nitrogen and potassium losses were higher than the loss of phosphorus which was negligible. The NPK losses due to deep percolation is not much when compared to the run off losses. This may be due to the fact that the NPK content in the solution gets fixed in the soil as it percolates down through the soil. So the water that goes beyond the root zone will contain only very little NPK. The equipment fabricated for the measurement of deep percolation losses worked satisfactorily.

Knowledge of water requirement of rice will greatly help in the efficient utilisation of available water.