FORMS OF WATER LOSS AND WATER REQUIREMENT OF RICE IN KOLE LANDS

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Science in Agricultural Engineering

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1988

DECLARATION

I hereby declare that this thesis entitled "Forms of water loss and water requirement of rice in Kole lands" 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.

Vellanikkara,
1988.

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CERTIFICATE

Certified that this thesis entitled "Forms of water loss and water requirement of rice in Kole lands" is a record of research work done independently by Smt. LISSY DEVID CHIRAYATH under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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LISSY DEVID CHIRAYATH

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SYMBOLS AND ABBREVIATIONS

Agric	Agricultural
Cm	Centimetre (s)
°C	Degree centigrade
Co	Company
Dept	Department
Devl	Development
Div	Division
e.g.	Example
et al.	and others
°F	Degree fahren.heit
Fig.	Figure
FAO	Food and Agricultural Organisation
ft	feet
G.I.	Galvanised iron
g	gram(s)
ha	hectare(s)
hr	hour
ICAR	Indian Council of Agricultural Research
in	inch(es)
IRRI	International Rice Research Institute
J	Journal
kg/ha/mm	Kilogram per hectare per millimetre
Ltd	Limited
m	metre (s)
min	minute
mm	millimetre (s)
No	Number

p	page
pp	pages
proc	proceedings
Res	Research
sec	Second
temp	temperature
%	per cent
/	per
°	degree (s)
'	minute (s)
"	second (s)

Introduction

INTRODUCTION

Agriculture is the back bone of Indian Economy and nearly two-third of the population depends on it for its living. Fifty per cent of the gross national income comes from agriculture and ancillary industries. The production of food in India has to be kept in pace with the needs of the ever increasing population. Since new areas that can be brought under plough is limited the only alternative is to increase the productivity of land. Placed in this situation there is no choice but to make the best possible use of the available natural resources namely soil and water and to produce maximum from unit area to meet ever increasing demand for food.

Rice is the most important and extensively cultivated food crop in Kerala. In India it is grown in an area of nearly 40.19 million hectares with an annual production of 53.8 million tonnes contributing about 40 per cent of the total food grain output in the country. Rice yield in India remains to be low and variable because of the widely varying soil and agroclimatic conditions under which rice is grown, inadequate fertilization, inefficient utilization of applied nitrogen, limited scope for optimum water management and susceptibility to incidence of pests and diseases. Nearly 13.9 million hectares under rice receives supplementary irrigation. About 45 per cent of irrigation water in the country is being diverted for this crop alone. Irrigation experiments in rice have revealed that the system of irrigation depends upon phenological stage of crop growth, soil characteristics, water table depth, climatic pattern and intensity of evaporative demand.

Rice is unique among the cereals in being able to establish and thrive under submerged conditions which help to keep down most of the weeds by providing unfavourable environment for their growth (Jones 1933). Such conditions benefit the crop as they prevent the fall in soil temperature which is likely to occur in temperate regions during the winter season.

Water constitutes one of the principal constraints for increasing food production in our hungry world. Efficient use of water for crop production has been a major concern for centuries. Today this concern is greater than ever because of the rising needs of food and fibre, coupled with the decreasing supplies of water in several major irrigation regions.

Though nearly 40 to 50 per cent of the water available for irrigation is diverted to rice crop, the yield per unit quantity of water is very low. The production of grain measured in kg/ha/mm of water is only 3.7 in the case of rice. The water requirement of rice ranges between 1500 and 2500 mm of water (Hukkeri and Pandey, 1977). Agricultural production has to be increased for the growing population in years to come. This is possible only by means of using the available water resources more judiciously and economically.

As the water need of rice is many times more than other crops, a precise knowledge of water requirement of crop attains importance not only for affecting economy in water use, but also for increasing production.

With the prospect of attaining self sufficiency in food production, the demand for quality grain depending upon consumer preferences will be increasingly felt. Production of better quality grains through improved varieties and manipulation of management practices are the line of development in rice production. 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.

The Kole areas are reclaimed lake beds below sea level and lying parallel to sea coast. The area is subject to inundation which keeps these under submerged condition for nearly seven months in the year. The cultivation of Kole lands is done by pumping out the water after the cessation of heavy rains. At present paddy is the only crop cultivated in these lands.

Kole land in general is an area where good management practices can be adopted successfully except a few pockets where salinity, severe acidity and salt problems are noticed. A map of Trichur Kole development project is given in Appendix. The Kole lands of Trichur and Malappuram districts extending over an area of 11534 hectares is an important rice growing tract of Kerala. The Kole lands in Trichur district are situated in Mukundapuram, Trichur, Chavakkad and Talappally Taluks. The main source of irrigation water is from the water available in Peechi dam.

The Kole lands in Trichur district are broadly classified into three zones. In Zones I and II, a single crop of paddy (Punja rice) is raised whereas in the Zone III two crops of paddy are taken (Mundakan and Punja).

The Kerala Land Development Corporation is undertaking the construction of bunds and in the near future the entire area under Zone I and II also will be converted into double crop lands.

Shortage of orrigation water is a serious problem in most of Kole area during 'Punja' season. After commissioning of Chimmeny Mulpli irrigation system this could be solved. Knowledge of water requirement of rice in Kole lands will greatly help in efficient utilisation of the limited water available in the reservoirs. The present investigation was taken up to estimate the losses through evaporation, transpiration and percolation and to assess the total water requirement of a medium duration rice in Punja season in Kole lands which has not been assessed so far.

Percolation losses that occur in ordinary paddy field has been estimated under various situations. In the Kole lands cultivation is done below mean sea level. Under such a situation so far no study has been conducted to estimate the percolation losses. The objective of the present study is to estimate the various forms of water losses that occur in the Kole lands.

Review of Literature

REVIEW OF LITERATURE

In this chapter an attempt is made to clarify the important concepts relevant to the study in the light of major studies undertaken in the past.

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

In water management studies for rice in Thailand, Peter kung et al. (1965) reported that water requirements vary from 800 mm to 1200 mm and the daily consumptive use was from 6 mm to 10 mm. With reference to similar studies in Japan, the same authors reported that the amount of water required by the early crop was 1000 mm, medium crop 1200 mm and late crop 1400 mm. From a water requirement study Iwarkri and Tommena (1965) reported that maximum evapotranspiration from irrigation water was 3.5 mm per day in early crop and 5.7 mm per day in the normal cultivation seasons.

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

In Coimbatore it was reported that 1673 mm of water was required for main crop, while at Pettukottai 2000 mm for Kuruvai crop and 2650 mm during Samba crop were found to be optimum (Chandra Mohan, 1970). Choudhry et al. (1963) reported that 1 to 6 cm depth of standing water was optimum for rice. Dastana (1970) reported that a depth range of 0 to 4 cm of water seemed 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.

At Dhanuri, for Kharif rice percentages of evaporation, transpiration and percolation were found to be 23.0, 37.6 and 39.4 and at Chakuli (Orissa), the corresponding percentages were 14.0, 30.0 and 56.0. It may be seen that percolation forms the major component of different forms of water losses (Sharma et al., 1972). They also stated that at Siruguppa (Mysore) in black Clayey soil, percolation loss (19.8 mm/day) was found to be 2-3 times higher than that due to evapotranspiration (7.8 mm/day) in the case of kharif rice and 18.4 mm/day for summer rice.

According to Sharma and Battacharya (1972) at Kharagpur, in lateritic soil, details of losses during 1969-71 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

Studied conducted in Punja season in the agronomic research station in 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).

Sen (1936) reported that optimum water requirement for maximum yield was found to be different for different varieties. Nojima et al. (1962) concluded that constant relation was not always found between water depth and rice yields since it varies with climate, soil and cultural conditions. Peter Kung et al. (1965) stated that the Japanese Scientists have found that crops with higher yields consume more water requirement. A normal crop of 4.5 tonnes per hectare with an irrigation period of 100 days consumes 6.3 mm of water per day by transpiration. The figure declines to 1.4 mm when the yield decreases to 1.0 tonnes per hectare. It increases to 10.5 m when the yield reaches 7.5 tonnes. They have concluded that transpiration rate depends on varieties growth rate, crop yield and climate and that evaporation depends on climate and density of plant growth.

Choudhry and Pandey (1968) while reviewing the water requirement of some of high yielding varieties of rice, have reported that the water requirement appeared to be a varietal character and was not necessarily governed by the duration of the variety.

According to Sharma and Battacharya (1972) in West Bengal best results were obtained by an application of 41.91 cm in 9 doses giving the highest yield of 37.65 quintals per hectare. At the Rice Research Station, Chinsurah, it was indicated that different levels should be maintained at different stages of plant growth and development i.e. 5.08 to 7.62 cm (2-3 inch) for two weeks after transplanting followed by drainage and maintenance of the soil in the saturated condition for five to eight weeks and then standing water at the grain filling stage. Bhattacharya reported that experiments conducted at the Tarsus irrigation Research Institute, Turkey indicated that watering was needed most at flowering and dough stages, for which water requirements were 2 litre per second per hectare, while for the remaining period of vegetation, the corresponding figure was 1 litre per second per hectares. Highest yield of 80 quintals per hectare was recorded with total water use of 4.3 m.

Some measures for reducing percolation losses have been suggested by Dastane (1970) as below:-

1. Selection of heavy soils or those with hard pans and shallow depths.

2. Growing crops in large blocks instead of isolated pieces. The seepage is proportional to perimeter of the area, e.g. the losses are five times greater per hectare, in one hectare field than in 25 hectares block field.

3. Scrupulous land levelling. Unlevelled lands involve more application of water.

4. Puddling to reduce permeability.
5. Light or shallow depth of land submergence to reduce percolation rate by minimising hydrostatic pressure.

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

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

Shahu and Rout (1969) reported that the total consumptive use of water by rice from transplanting to harvest was 1560 mm under submergence, 812 mm at field capacity level and 200 mm at 75 per cent available moisture. Under 15 cm submergence, consumptive use was 1.2 cm per day during vegetative phase, 1.5 cm per day during the reproductive phase, 0.65 mm per day during dough stage and yellow ripe stage of the crop growth.

Pande and Mittra (1970) found that among the three levels of submergence of 0.5 cm, 5 cm and 10 cm depth, water requirement of rice was maximum at 10 cm, depth but crop performance was similar to that of 5 cm with medium and high level of fertilization.

According to Michael (1978) experiments conducted at various locations in India on low land rice reveal that practice of keeping soil under shallow depth of submergence about (5 ± 2) cm throughout the crop growth period is conducive to higher yields.

Bhattacharya (1968) reported that an experiment conducted at the Indian Agricultural Research Institute, New Delhi indicated that irrigation at field capacity with measures for weed control gave yields which compared favourably with those with submergence of 6 and 12 cm. Lower soil moisture regimes invariably reduced yields. It was indicated that rice could not stand moisture depletion below field capacity. Submergence had a beneficial role in controlling weeds, one of the main retardants in crop yields for rice. In Mysore, studies at the Engineering Research Station showed that the application of water for only five days in a week gave better yield than continued submergence. Variations were also noticed in water requirements of different varieties of rice.

According to Battacharya (1968), in the Philippines, it was found that there was no significant difference in yields by continuous submergence of 5 to 20 cm and intermittent flooding and drainage. In the latter method, rice fields were flooded and drained two to three times upto the tillering stage, the duration of drainage varying from 5 to 10 days. Fields were again submerged from the tillering stage to the final drainage, ten to fifteen days before harvest. The same author reported that United States Department of Agriculture, advocates submergence for two reasons (i) for controlling weeds (ii) for arresting the drop of temperature below 70°F. California recommends 15.24 cm to 20.32 cm (6-8 inch), depth of submergence, while the corresponding depth is 10.16 cm to 15.24 cm (4-6 inch) for the states of Louisiana and Texas. Irrigation practices have been classified in accordance with climatic conditions varying with temp. For cold climates, recommendations have been made regarding irrigation methods such as deep water irrigation, dispersion irrigation which may raise the soil or water temp. In hot or warm areas flowing irrigation is recommended to alleviate high temperature damage along with drainage for preventing soil reduction caused by high temp. In the temperate areas a warm or cold type irrigation is practiced in accordance with the prevailing temperatures in a particular season.

According to Battacharya (1968) at Kharagpur, in laterite acid soils with PH 5-4, it was found in 1970-71 that economy in water use was possible by maintaining submergence with 5 $\pm$ 2 cm depth at active vegetative and reproductive phases. In 1971-72, submergence irrigation, whether deep or shallow, gave practically the same yield as that with saturation during rainy season in which evaporative demand is low. But submergence gave significantly higher yield than saturation during summer. At Coimbatore it was found by the same author in 1970-71 that the yield of IR-20, during Kharif season, did not show any differential response in three irrigation treatments, viz. 5 cm depth applied daily, 5 cm depth applied on alternate days and submergence irrigation, at three phases viz., vegetative, tillering and reproductive. Water use was 2,077 mm and 1801 mm for irrigation with 5 cm depth daily and on alternate days, indicating a 15 per cent saving in water use by irrigation on alternative days.

Battacharya (1968) reported that detailed studies have been carried out by a number of workers, in India, in Japan and in United States of America on the aspects of submergence irrigation with drainage. Some of the benefits of submergence are listed below.

(a) Control of growth of weeds, particularly dicots, one of the major inhibitors of plant growth.

(b) Control of temperature of soil and the plant, as temperature below 27°C is considered to be harmful.

(c) Aid in some growth processes, particularly photosynthesis in lower leaves due to reflection of light from water which normally suffer from lack of adequate light due to shad#ing by upper leaves.

(d) Protection against wind damage

(e) Fixation of atmospheric nitrogen due to favourable conditions for growth of blue green algae.

(f) Dissipation of excessive solar energy by vaporisation of water and development of favourable microclimate in rice field.

(g) Control of some pests and diseases.

(h) Increased availability of plant nutrients, namely, phosphorus, iron, manganese and silicon in early stages of plant growth.

Drainage is found to be useful for

(a) Soil aeration

(b) Protection against lodging by preventing over assimilation of water and nitrogen.

(c) Control of the setting in of reductive processes, at the soil water interface.

(d) Control against some diseases.

Experiments were conducted in 1968 by the Madras Department of Agriculture. Best yield was obtained with continued submergence with 5.04 cm (2 in) depth of water for which the yield was the same as that recorded with applications of 5.04 cm (2 in) depth at intervals of 3 days and 10.18 cm (4 in) in 6 days (Battacharya, 1969).

At International Rice Research Institute, Philippines, it was reported that during wet season (1962) there were no significant differences among yields obtained with continuous flooding, alternate flooding or drained surface. The drained surface treatment was good as the continuous flooding (Anon, 1962). The report of IRRI (Anon, 1968) indicated that deep flooding condition increased the height of IR 8 but decreased tillers. The efficiency of water use (grain per litre of water applied) was greater with shallow than with deep water. Shallow continuous flooding (2.5 cm) gave consistently better grain yield, good weed control and lower water loss. Helm (1967) reported that the level of water above the surface of the soil did not influence the growth of rice and that there was no difference between saturated and submerged water regime. Rao et al. (1971) found that irrigation whenever soil just starts cracking or keeping the soil under saturated condition till flowering and maintaining 5 to 8 cm water thereafter was found to save 40 to 50 per cent water as compared to continuous submergence.

Pandey and Mittra (1970) showed that land submergence was the best practice for obtaining maximum yield per unit area. Response of rice per unit water decreased with depth of water and duration of land submergence. It was reported at IRRI (Anon, 1965) that grain production efficiency in terms of amount of grain per unit water was the maximum at shallow continuous treatment. Kim and Yoo (1970) stated that flooding will affect the young seedlings and flooding of rice plants at the stage of ear primodrium initiation resulted in an yield decrease of 40 per cent when flooded for more than 48 hours and 20 per cent in case of flooding for 24 hours.

According to Sharma and Battacharya (1972) rice differs from other crops, which can stand some depletion below the field capacity. Two experiments carried out at Cuttack showed that water requirements and water management practices vary at different stages of plant growth in accordance with the variety of the crop taken up. The same author reported that incomparative studies of different irrigation practices at Dhenauri, it has been shown that irrigation at field capacity is not superior to the existing irrigation practice with fixed depths and intervals. But irrigation at field capacity results in a saving of 40 per cent in water use.

Kalyanikutti *et al.* (1970) observed that irrigation to maintain 120 per cent moisture once in three days recorded the highest yield of grain and straw. Mane and Dastane (1971) in a field investigation with rice concluded that irrigating the land at 0.2 to 0.5 atmosphere soil moisture tension was as good as irrigating it at 4 cm depth. There were no significant differences found in the paddy grain yield.

According to Sahu and Rout (1969) manuring enhances the total water requirement but increases water use efficiency. Choudhry and Pandey (1968) reported that water requirement of the crop decreases when manured. The decrease in water requirement was found to be conspicuous when manured with ammonium sulphate. Experiments conducted at the Central Rice Research Institute, Cuttack during the years 1953-54, 1958-59, 1959-60 gave indications that water requirements of rice decreased with manurial applications. A combination of ammonium sulphate, farm yard manure and superphosphate gave the best yield. Bhattacharya (1968) reported that in Gujarat, three varieties of paddy were experimented upon. Eight waterings gave the best results. For manuring, it was found that the yield went on increasing upto 89.67 kg of nitrogen per hectare, although a economic dose was 44.83 kg of nitrogen per hectare.

Enyi (1965) reported that the efficiency of nutrient utilisation of nitrogen and phosphorus for dry matter production was less in plants grown on flooded soil then under dry soil. The levels of water over the soil surface have no difference with respect to uptake of nutrients and all the nutrients are absorbed constantly upto flowering period. The depth of water has been found to have an influence over the yield and yield attributes. Baba (1961) reported that 1000 grain weight showed no definite relation to nitrogen supply. Flowering was earlier in shallow water, but lodging was greater and total nitrogen in the straw was lower than in the other system.

Bhattacharya (1968) reported that, in West Bengal experiments with pot culture technique were conducted on watering needs of rice in the Department of Agriculture, Calcutta University in 1937. Best results were obtained with a treatment which was dry germination, saturation during pretillering, submerged during tillering and preflowering, saturated again during flowering and dry finally during post flowering.

Materials and Methods

MATERIALS AND METHODS

This chapter describes the materials used and methods adopted for the investigation. A field experiment to estimate the losses through evaporation, transpiration and percolation and to assess the total water requirement of a medium duration rice was conducted during 1986 in Punja season in Kanjany Kole lands. A general view of Kanjany Kole land is given in Plate 1.

1 Location

The experiment was conducted in the Kole lands at Kanjany in Trichur district. It is situated at 10° 28' North latitude and 76° 7' East longitude. Trichur district has a total geographical area of 2,99,390 hectares. Out of which total cropped area comes to 2,29,739 hectares. The cultivated area can be divided into three distinct geographical parts namely:

1. The Coastal belt.
2. The Midland area
3. The Eastern High ranges

In the garden land, along the coastal belt mono-cropping with coconut is the practice. In the wet land of the coastal belt, paddy is the main crop. Midland region, again is classified into garden land and wet land. In the garden land crops like coconut, arecanut, tapioca, pulses, vegetables etc. are mainly cultivated. In the high ranges rubber is extensively cultivated.

Kole lands in Trichur district are broadly classified into three zones. The three zones are described below.

Zone 1 - There are 22 numbers of separate fields (named as padavu) comprising an area of 1870 hectares. The cultivation commences by middle of November and the sowing/planting will be completed by the first week of December.

Zone II - In this zone there are 26 numbers of separate fields (padavu) comprising an area of 1974 hectares. The work commences by third week of December and sowing completed by middle of January.

Zone III - There are 33 numbers of separate fields (padavu) in this zone. The total area is 4064 hectare. This zone forms the double cropped area. The crop is raised during Mundakan season. The cultivation is adjusted in such a way that the crop is harvested by end of December. Later this zone is flooded, and dewatering started by the end of January for summer crop, and planting of this crop is completed by first week of February.

An appreciable paddy area comes under Kole lands. The entire Kole area is below the mean sea level. In many areas it is one metre or more below mean sea level. Before commencement of cultivation water is pumped out from the field for land preparation. During extreme dry season, when the water level is very low, pumping has to be resorted to for irrigation.

2 Soil

The soil is sandy clay loam in texture comprising of 27.05 per cent coarse sand, 25.35 per cent fine sand, 17.40 per cent silt and 30.2 per cent clay.

.3 Climate

The area receives rainfall mainly from the south west monsoon and a certain extent from north east monsoon.

.4 Season and weather conditions

The experiment was conducted during the Punja season of 1986. The details of the meteorological data recorded at District Agricultural Farm, Mannuthy during the crop periods are presented in Table 1 and Fig.1.

Table 1. Meteorological data during the experimental period

Standard week	Period	Mean maximum temperature °C	Mean minimum temperature °C	Relative humidity %
	FEBRUARY			
6	5 - 11	34.6	24.8	56
7	12 - 18	32.9	22.3	69
8	19 - 25	34.7	23.4	55
9	26 - 4th	35.4	24.6	52
	MARCH			
10	5 - 11	36.6	24.3	51
11	12 - 18	36.1	24.6	64
12	19 - 25	35.7	24.9	70
13	26 - 1st	36.5	25.4	65
	APRIL			
14	2 - 8	35.8	25.6	65
15	9 - 15	36.1	25.7	65
16	16 - 22	36.1	24.6	68
17	23 - 29	35.4	25.0	72
18	30 - 6th	34.5	25.0	73

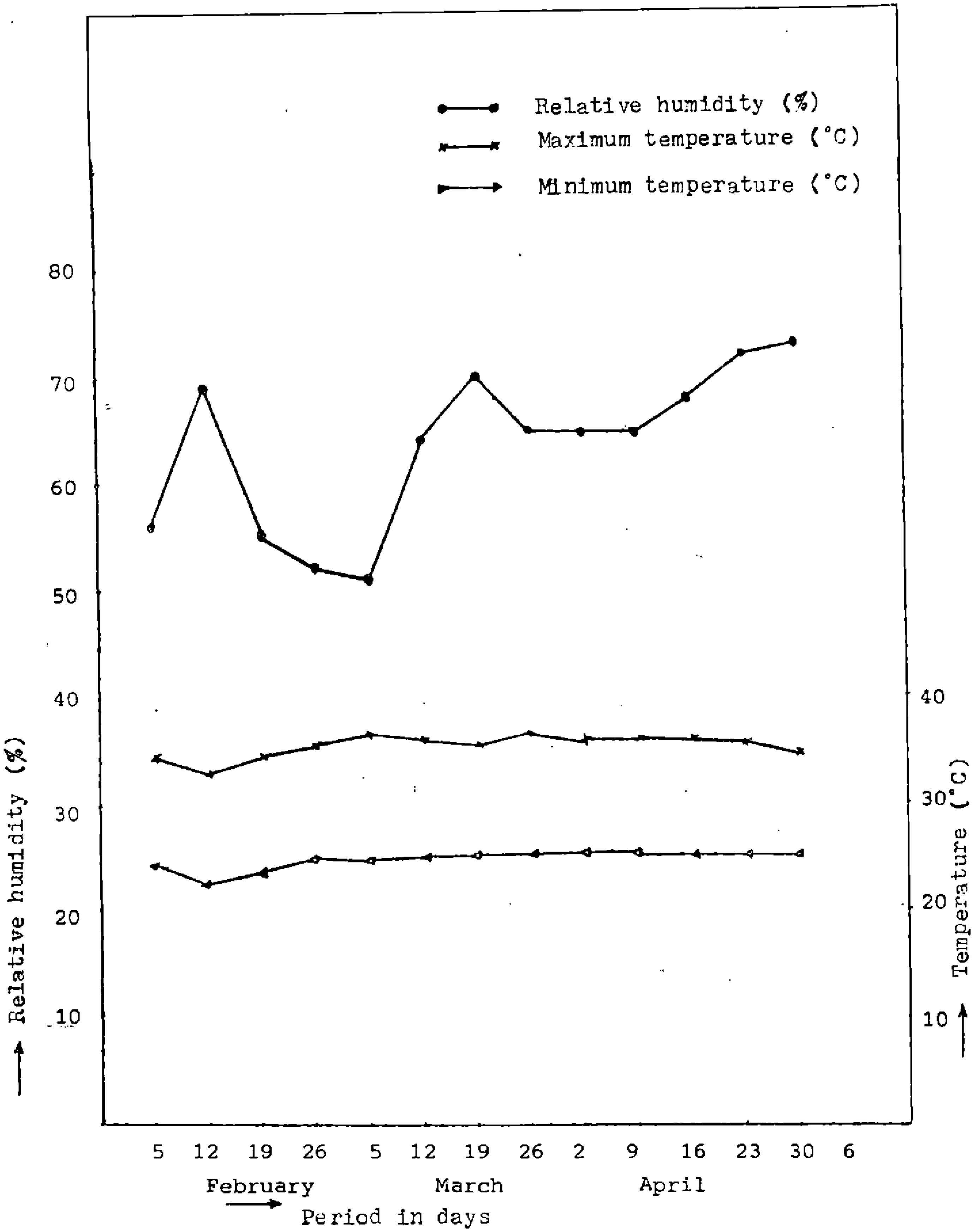


Fig.1 Meteorological data during the experimental period

5 Experimental technique

Estimations of evaporation, transpiration and percolation were done on the principle of drum culture technique using the following field equipments (Anon, 1975). The experiment was replicated four times in four plots of area one cent. The plan of layout and an individual plot are given in Fig.2a and Fig.2b 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 0.5 mm. The height of hook gauge was designed so as to read the scale by squatting on the bund without parallax error. There was a frame made of angle iron at the bottom for giving perfect seating to the equipment in the field. The diagram of field hook gauge is given in Fig.3 and also in plate II. 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 a 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

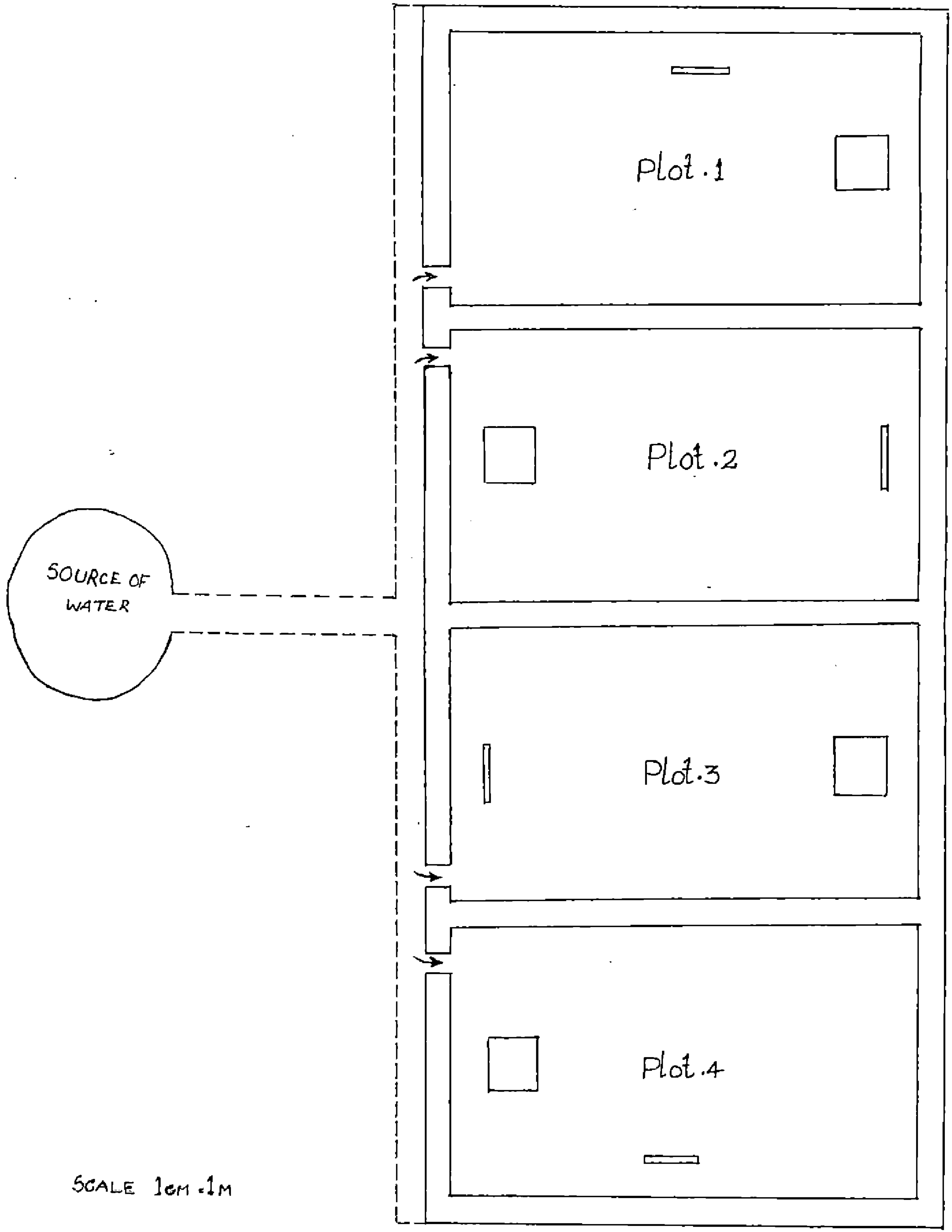
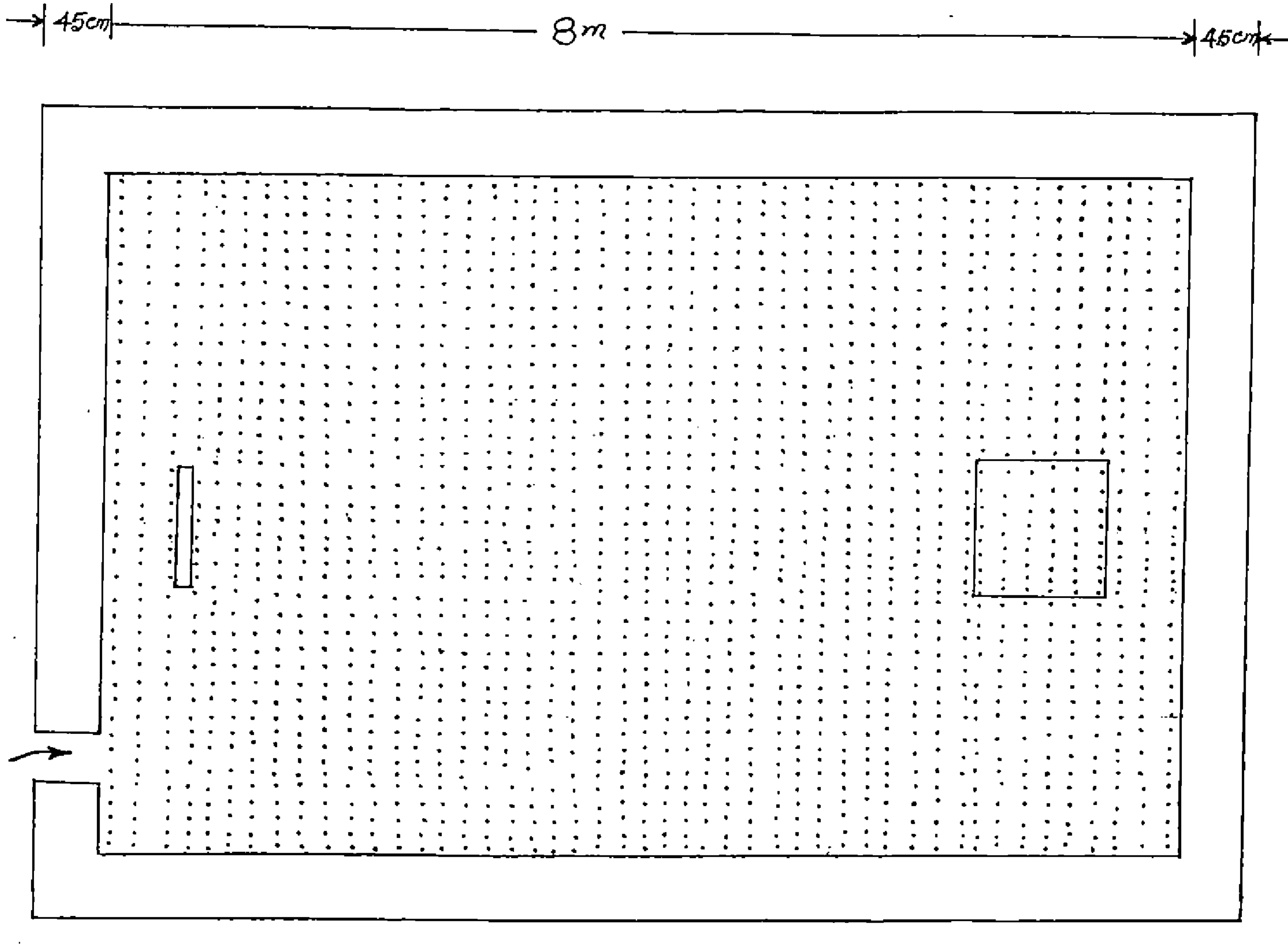


Fig.2a. PLAN OF LAYOUT



SCALE 1cm=50cm

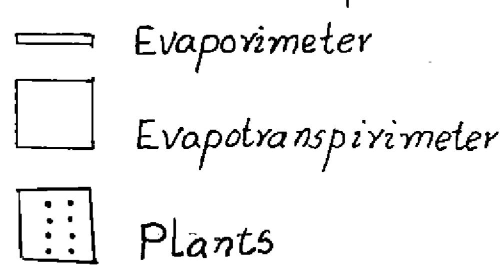


Fig.2b AN INDIVIDUAL PLOT

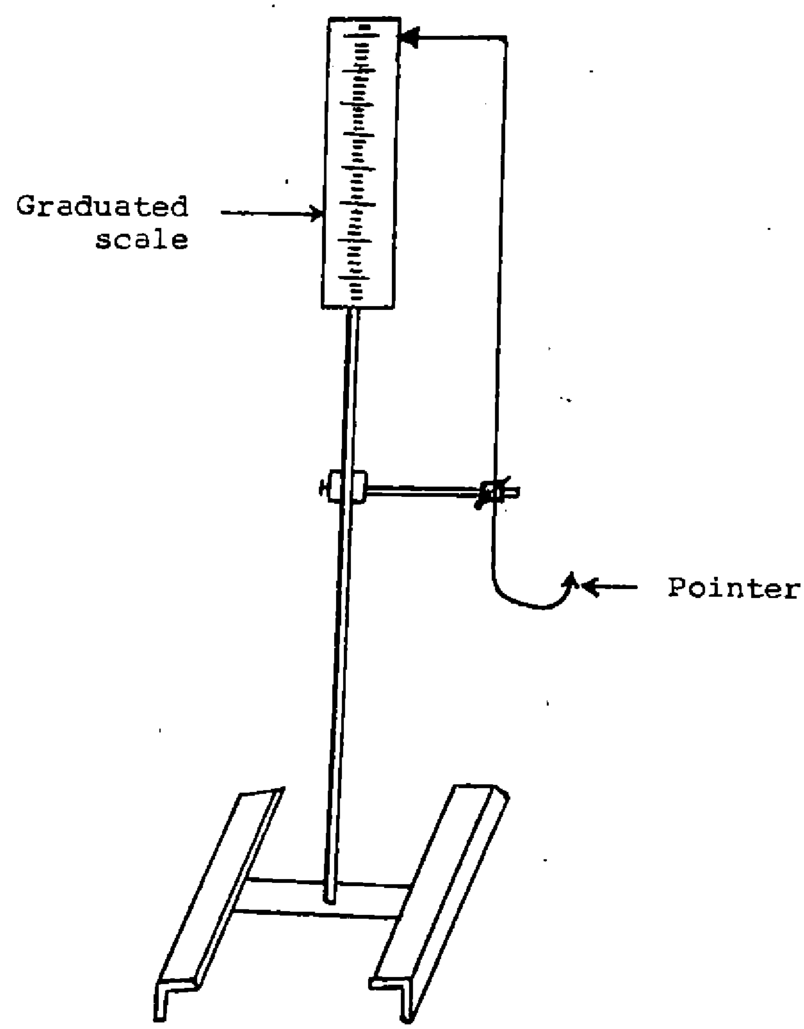


Fig.3 Field hook gauge

5 cm of its height above the field level. Water was let into the field till it coincided with the tip of the pointer. This made the water in the field excatly 5 cm. The screw of the hook gauge was loosened the pointer of the hook geuge 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 hours 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 height made of 18 gauge galvanised iron sheet. The diagram of the evaporimeter is given in Fig.4 and also in Plate III. Evaporation is the process during which a liquid changes into gas. The process of evaporation of water in nature is one of the fundamental components of hydrologic

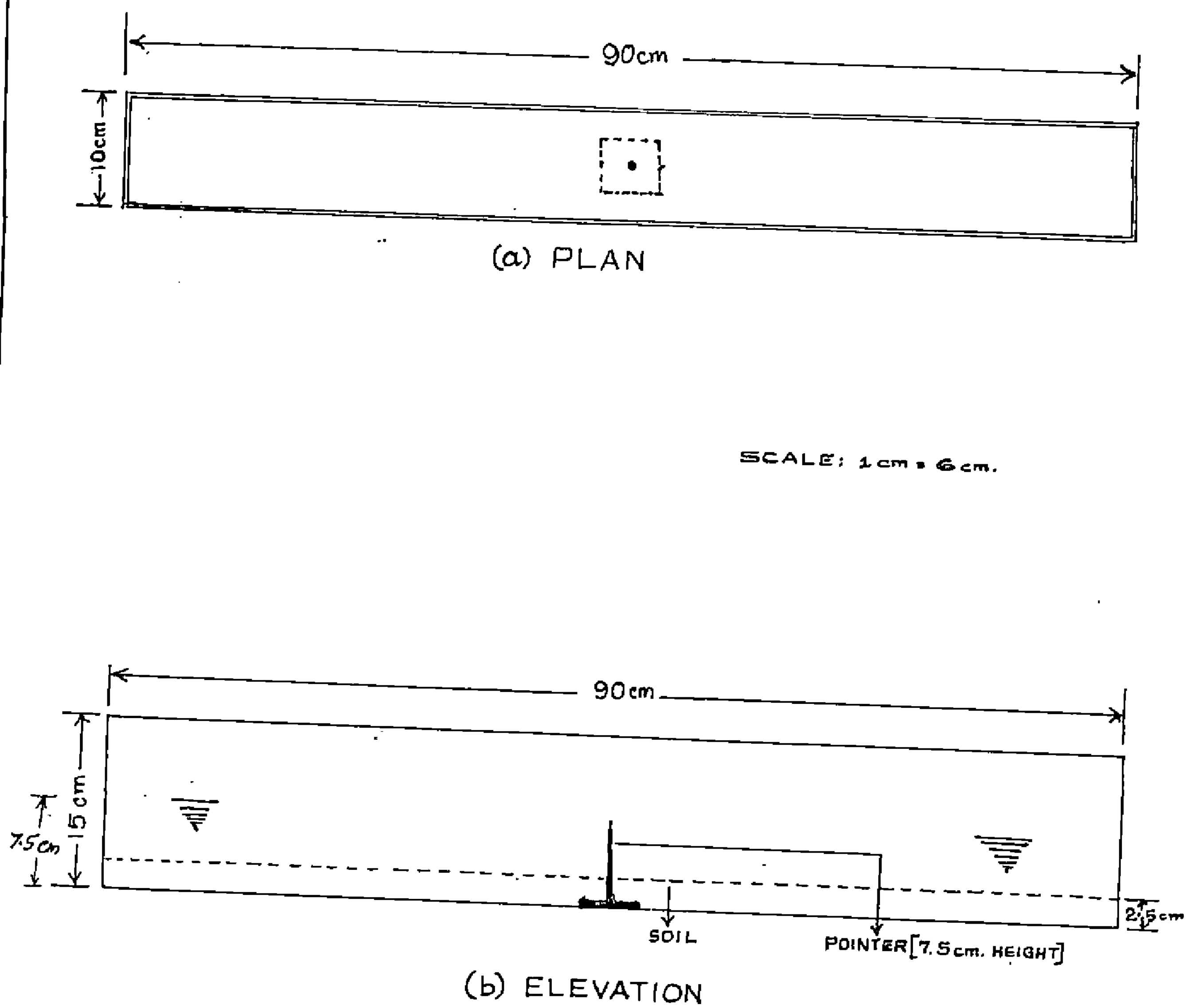
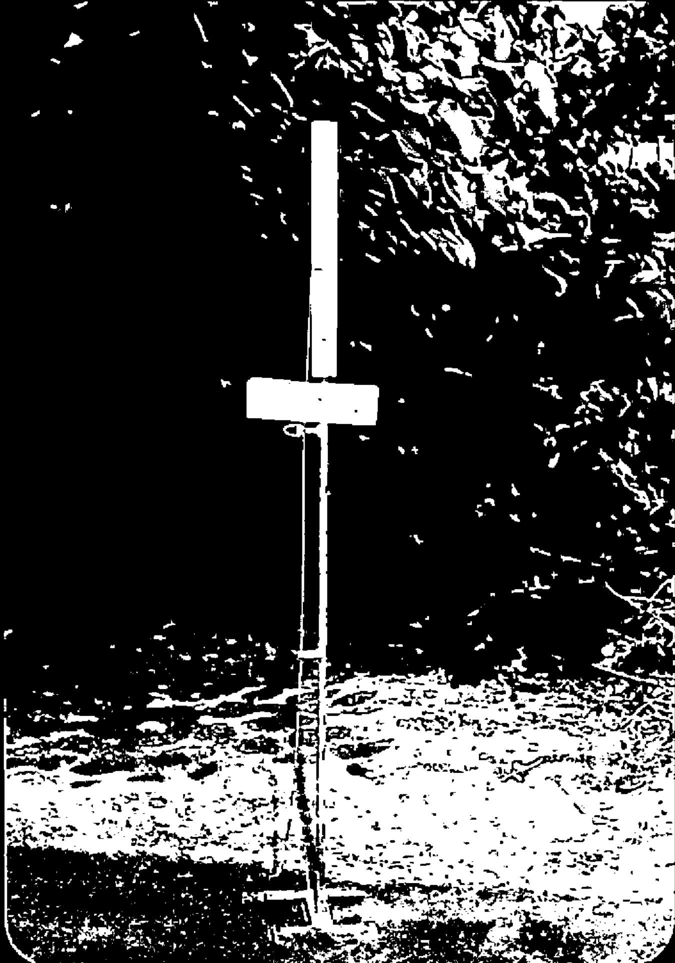
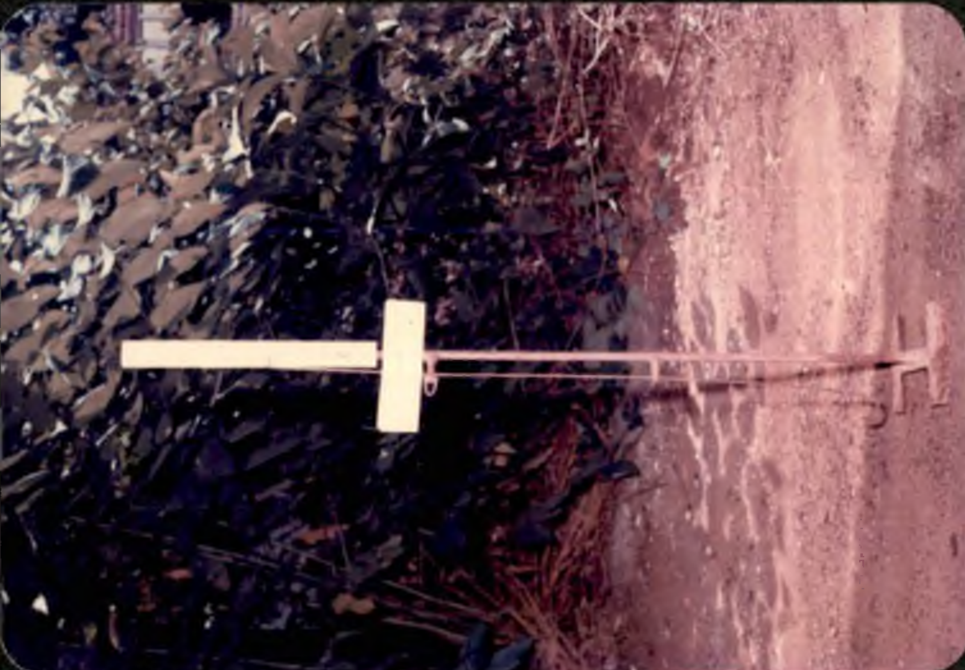


FIG.4. EVAPORIMETER





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 coincided exactly with the tip of the pointer. Then the hook gauge was raised by exactly by 2 cm. Then measured quantities of water was added till the water level coincided exactly with the tip of the pointer. After obtaining the quantity of water required for raising the water level inside the evaporimeter by 2 cm, a calibration chart was prepared and the same is given in Table 2. 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 that 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

Table 2. Evaporimeter calibration

Plots	Quantity of water for raising level of water by 2 cm height in cm^3				Quantity of water for raising the level of water by	
	1	2	3	Mean	1 mm height in cm^3	0.1 mm height in cm^3
1	1900	1900	1900	1900	95.00	9.500
2	1880	1883	1880	1881	94.05	9.405
3	1860	1860	1860	1860	93.00	9.300
4	1880	1880	1883	1881	94.05	9.405

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.

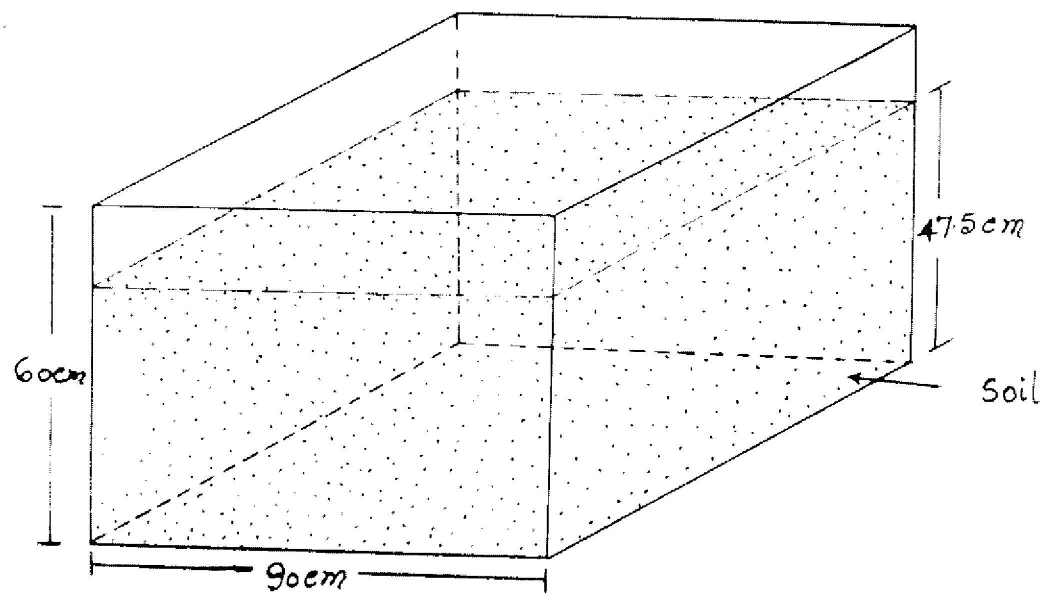
A pointer having 7.5 cm height fixed on a flat plate was placed inside the evaporimeter. The evaporimeter was filled with soil to a height of 2.5 cm from the bottom. The evaporimeter was placed inside the field with its bottom 2.5 cm below the ground surface so as to make the level of soil in the field 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 converted into millimeters using the calibration table. The water lost from 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.5 and also in Plate IV, 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.

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 when 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.



Scale 1cm : 15cm

Fig.5 Evapotranspirimeter

Plate III Evaporimeter

Plate IV Evapotranspirimeter


EVAPORI—METER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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 in 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 also calibrated. Water level in the evapotranspirimeter was brought to about 3 cm above the soil surface. Then the pointer of hook gauge installed inside the evapotranspirimeter was made to coincided exactly with the level of water in the evapotranspirimeter. The reading on the scale of hook guage 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 a calibration chart was prepared. Volume occupied by the plants increased as they grow and this would vitiate the calibration values. In order to overcome this, calibration of evapotranspirimeter was done once in every tendays interval and corresponding calibration charts were prepared and they are given in Table 3. 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 pointer. Water lost by evapotranspiration in every day was replenished by adding measured quantities of water. The mean value of two consecutive calibrations was 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 3. Evapotranspirimeter calibration

No.	Date of calibration	Plot No.	Quantity of water for raising level of water by 2 cm height in cm^3				Quantity of water for raising level of water	
			1	2	3	Mean	1 mm height in cm^3	0.1 mm height in cm^3
1	2	3	4	5	6	7	8	9
1	4.2.1986	1	15945	15960	15945	15950	797.50	79.750
		2	15920	19930	15925	15925	796.25	79.625
		3	15880	15875	15870	15875	793.75	79.375
		4	15830	15825	15835	15830	791.50	79.150
2	14.2.1986	1	15755	15750	15745	15750	787.50	78.750
		2	15695	15700	15705	15700	785.00	78.500
		3	15645	15660	15645	15650	782.50	78.250
		4	15625	15635	15630	15630	781.50	78.150
3	24.2.1986	1	15370	15380	15375	15375	768.75	76.875
		2	15355	15350	15345	15350	767.50	76.750
		3	15275	15280	15270	15275	763.75	76.735
		4	15285	15280	15275	15280	764.00	76.400

Table 3 (Contd.)

1	2	3	4	5	6	7	8	9
4	6.3.1986	1	14970	14980	14975	14975	748.75	74.875
		2	14950	14945	14955	14950	747.50	74.750
		3	14905	14900	14895	14900	745.00	74.500
		4	14905	14900	14910	14905	745.25	74.525
5	16.3.1986	1	14670	14680	14675	14675	733.75	73.375
		2	14625	14630	14620	14625	731.25	73.125
		3	14605	14600	14595	14600	730.00	73.000
		4	14600	14605	14595	14600	730.00	73.000
6	26.3.1986	1	14390	14410	14400	14400	720.00	72.000
		2	14340	14345	14335	14340	717.00	71.700
		3	14320	14325	14330	14325	716.25	71.625
		4	14350	14355	14345	14350	717.50	71.750
7	5.4.1986	1	14295	14300	14305	14300	715.00	71.500
		2	14250	14255	14245	14250	712.50	71.250
		3	14240	14245	14235	14240	712.00	71.200
		4	14245	14255	14250	14250	712.50	71.250

Table 3 (Contd.)

1	2	3	4	5	6	7	8	9
8	15.4.86	1	14245	14250	14255	14250	712.50	71.250
		2	14200	14205	14195	14200	710.00	71.000
		3	14205	14195	14200	14200	710.00	71.000
		4	14205	14200	14210	14205	710.25	71.025
9	25.4.1986	1	14245	14235	14240	14240	712.00	71.200
		2	14175	14170	14180	14175	708.75	70.875
		3	14180	14175	14170	14175	708.75	70.875
		4	14180	14175	14185	14180	709.00	70.900

5.4 Crop raising

The experiment was laid out in Kanjany Kole lands in the month of February and continued up to April 1986 which is the Punja 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 channels and distributaries were also provided to facilitate irrigation to individual plots. The source of irrigation water was a pond water near the plots.

Pure seeds of a medium duration variety 'Jaya' were used for the experiment. Fertiliser application, weeding and all other practices were done as per the recommendations in the package of practice and are given in Appendix Ia. After the layout and preparation of the plots, evapotranspirimeter was installed in the field and the seedlings were transplanted as described before. The daily loss due to evapotranspiration was measured by refilling method. Evaporimeter was placed in between the seedling rows. Water level in the field was brought to 5 cm back every day by letting in water. Daily total loss of water during 24 hour was measured by using hook guage in the field.

Thus evaporation loss from standing crop of paddy field was got from evaporimeter, evapotranspiration from evapotranspirimeter and total loss from the field. From the above data losses due to evaporation, transpiration and percolation were calculated separately.

The crop was transplanted in the field on 4.2.1986 and harvested on 30.4.1986. Water loss was estimated for 86 days i.e. till the date of harvest.

After harvest root and shoot including grain of the plants from evapotranspirimeters were collected. Oven dry weight of these were determined and by adding up, the total dry matter weight was obtained. Transpiration ratio and consumptive use ratio were calculated as

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

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

The observations and calculations are given in Chapter IV.

Results and Discussion

RESULTS AND DISCUSSION

A field experiment to estimate the losses through evaporation, transpiration and percolation and to assess the total water requirement for a medium duration variety rice was conducted in Kenjany Kole lands. The experiment was replicated four times.

Estimation of daily evaporation was made on the basis of measurements using evaporimeter which was described in Chapter 3. Before installing the equipment in the field, it was calibrated by using the field hook gauge. Calibration chart is given in Table 2. The calibration chart was used to convert the volume in litres into height in millimetres. Evapotranspirimeter was installed in the field as described in Chapter 3 and it was calibrated periodically. The calibration was done once in every ten days and the details are given in Table 3. Daily evapotranspiration was estimated from evapotranspirimeter 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 millimeters.

Daily total loss of water from the field was measured by using a field hook gauge. Subtracting daily evaporation from daily evapotranspiration, rate of transpiration was obtained. Percolation was obtained by subtracting evapotranspiration from total loss of water from the field. Mean of daily evaporation, evapotranspiration, total water loss, transpiration and percolation from the field of four plots are given in Table 4. The above readings obtained from four individual plots are given in Appendix-I. There were three rainy days during the cultivation season. As there was no rain gauge in the immediate vicinity various forms of water losses on these days could not be estimated. However these losses on the rainy days were estimated by taking the mean values of different forms of water losses for the ten days interval in which the rain occurred. For each ten days interval the evaporation, evapotranspiration, total loss of water, transpiration and percolation was calculated and the mean of four plots is given in Table 5. The above readings of four individual plots are given in Appendix 2.

For each ten day interval daily average of evaporation, evapotranspiration, total loss of water, transpiration and percolation were calculated and mean of four plots is given in Table 6. The above readings obtained from four individual plots separately are given in Appendix-3. The crop period was classified into different growth stages.

Table 4. Mean of daily evaporation, evapotranspiration, total water requirement, transpiration and percolation of four plots

Date	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1	2	3	4	5	6
4/2/86	3.960	4.020	16.00	0.060	11.980
5/2	3.960	4.025	16.00	0.065	11.975
6/2	3.950	4.040	16.00	0.090	11.960
7/2	3.990	4.055	15.75	0.065	11.695
8/2	4.022	4.038	16.50	0.036	12.462
9/2	3.975	4.025	15.75	0.050	11.725
10/2	4.015	0.037	16.00	0.022	11.963
11/2	4.002	4.053	15.75	0.051	11.697
12/2	4.013	4.055	16.50	0.042	12.445
13/2	4.013	4.080	16.00	0.067	11.920
14/2	4.028	4.175	17.00	0.147	12.825
15/2	4.040	4.233	17.75	0.193	13.517
16/2	4.027	4.300	18.50	0.273	14.200
17/2	4.053	4.398	20.50	0.340	16.102
18/2	4.060	4.483	21.50	0.423	17.017
19/2	4.030	4.670	23.50	0.640	18.830
20/2	4.040	4.790	24.50	0.750	19.710
21/2	4.030	4.880	25.50	0.850	21.120
22/2	0.465	5.255	28.50	1.190	23.245
23/2	4.065	5.325	31.00	1.260	25.675
24/2	4.015	5.558	32.00	1.543	26.442
25/2	3.990	5.670	32.50	1.680	26.830
26/2	3.95	5.830	32.50	1.880	26.670
27/2	3.92	5.910	33.50	1.990	27.590
28/2	3.88	6.023	33.75	2.143	27.729

Table 4. (Contd.)

1	2	3	4	5	6
1/3/86	3.855	6.160	34.75	2.305	28.590
2/3	3.803	6.230	33.50	2.427	27.270
3/3	3.670	6.320	32.75	2.650	26.430
4/3	3.618	6.425	32.50	2.807	26.075
5/3	3.560	6.470	33.50	2.907	27.030
6/3	3.563	6.795	31.75	3.232	27.960
7/3	3.480	6.988	30.00	3.508	23.020
8/3	3.403	7.243	31.00	3.840	23.757
9/3	3.350	7.423	31.00	4.073	23.577
10/3	3.280	7.735	30.75	4.455	23.015
11/3	rainyday	-	-	-	-
12/3	"	-	-	-	-
13/3	3.243	8.448	30.75	5.205	22.302
14/3	3.175	8.540	29.75	5.365	21.210
15/3	3.163	8.588	29.75	5.425	21.162
16/3	3.098	8.888	30.50	5.740	21.662
17/3	3.030	8.858	30.50	5.828	21.642
18/3	3.005	8.888	30.00	5.883	21.112
19/3	2.965	8.913	29.75	5.948	20.837
20/3	rainy day	-	-	-	-
21/3	2.910	9.028	29.75	6.118	20.722
22/3	2.870	9.033	29.75	6.163	20.717
23/3	2.845	9.033	30.00	6.188	20.967
24/3	2.817	9.053	30.00	6.236	20.947
25/3	2.773	9.055	29.00	6.882	19.945
26/3	2.738	9.275	28.00	6.537	18.725
27/3	2.675	9 178	27.00	6.503	17.822
28/3	2.618	9.118	26.00	6.500	16.890
29/3	2.603	9.015	26.50	64.12	17.485
30/3	2.580	9.015	26.00	6.435	16.985
31/3	2.540	9.015	26.00	6.475	16.985

Table 4 (Contd.)

1	2	3	4	5	6
1/4/86	2.528	9.075	26.00	6.547	16.925
2/4	2.473	8.983	25.00	6.510	16.017
3/4	2.443	8.930	24.00	6.478	15.070
4/4	2.400	8 898	24.00	6.498	15.102
5/4	2.365	8.925	25.00	6.560	16.075
6/4	2.338	8.903	24.00	6.565	15.097
7/4	2.315	8.868	24.00	6.553	15.132
8/4	2.280	2.820	23.50	6.560	14.680
9/4	2.245	8.785	23.80	6.540	14.715
10/4	2.205	8.783	22.50	6.578	13.717
11/4	2.190	8.780	22.50	6.590	13.720
12/4	2.155	8.788	22.50	6.603	13.742
13/4	2.115	8.733	21.50	6.618	12.767
14/4	2.085	8.753	21.50	6.648	12.767
15/4	2.085	8.753	21.50	6.668	12.747
16/4	2.100	8.725	21.50	6.653	12.747
17/4	2.153	8.783	21.50	6.622	12.725
18/4	2.165	8.780	21.50	6.618	12.717
19/4	2.195	8.785	21.50	6.585	12.720
20/4	2.208	8.785	21.50	6.577	12.715
21/4	2.208	8.785	21.50	6.577	12.715
22/4	2.208	8.793	20.75	6.505	11.957
23/4	2.220	8.793	21.25	6.573	12.457
24/4	2.245	8.795	21.00	6.550	12.205
25/4	2.195	8.770	20.60	6.575	11.730
26/4	2.143	8.770	20.50	6.627	11.730
27/4	2.100	8.743	20.50	6.430	11.759
28/4	2.058	8.720	19.50	6.662	10.780
29/4	2.008	8.710	19.00	6.702	10.290
30/4	2.033	8.628	19.00	6.595	10.372

Table 5. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval - Mean of four plots

Days		Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10		39.90	40.40	160.30	0.50	119.90
11 - 20		40.50	46.50	222.30	6.00	175.80
21 - 30		38.30	60.50	331.30	22.20	270.80
31 - 40 (2 rainy days)		33.30	77.20	305.90	43.90	228.70
41 - 50 (1 rainy day)		29.20	89.70	299.50	60.50	209.80
51 - 60		25.60	90.40	258.50	64.80	168.10
61 - 70		22.30	88.10	224.00	65.80	135.90
71 - 80		21.80	87.80	213.50	66.00	125.70
81 - 86 (only 6 days)		12.54	52.32	118.92	39.78	66.60
Total	86	263.44	632.92	2134.22	369.48	1501.30

Table 6. Daily average of evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval - Mean of four plots

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	3.99	4.04	16.03	0.05	11.99
11 - 20	4.05	4.65	22.23	0.60	17.58
21 - 30	3.83	6.05	33.13	2.22	27.08
31 - 40 (2 rainy days)	2.33	2.72	30.59	4.39	22.87
41 - 50 (1 rainy day)	2.92	8.87	28.85	6.05	20.98
51 - 60	2.56	9.04	25.85	6.48	16.81
61 - 70	2.23	8.81	22.40	6.58	13.59
71 - 80	2.18	8.78	21.35	6.60	12.57
81 - 86 (only 6 days)	2.09	8.72	19.82	6.63	11.10
Daily mean	3.02	7.42	24.58	4.40	17.17

Transplanting

30 days

Maximum tillering or
panicle initiation

16 days

Booting

10 days

Flowering
(50% emergence)

Milk stage

30 days

Dough stage

Mature grain stage

Evaporation, evapotranspiration, total loss of water, transpiration and percolation for the days between each stage were calculated and the mean of four plots is given in Table7. The above readings of four plots are separately given in Appendix 4.

Daily average mean of evaporation, and transpiration are graphically represented in Fig.6. In the graphical representation the growth stages are marked. Considering the rate of evaporation curve, during the first twenty days it was almost horizontal. The rate was constant as there was

Table 7. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation during different growth stages - Mean of four plots

Growth stages	Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
Transplanting to Maximum tillering or panicle initiation	30	118.70	147.40	713.90	28.70	566.50
to Booting	16	50.82	131.02	485.60	80.20	354.58
to Flowering (50% emergence)	10	27.04	90.12	274.90	63.08	184.78
milk stage Dough stage Mature grain stage	30	66.88	264.38	659.82	197.50	395.44
Total	86	263.44	632.92	2134.22	369.48	1501.30

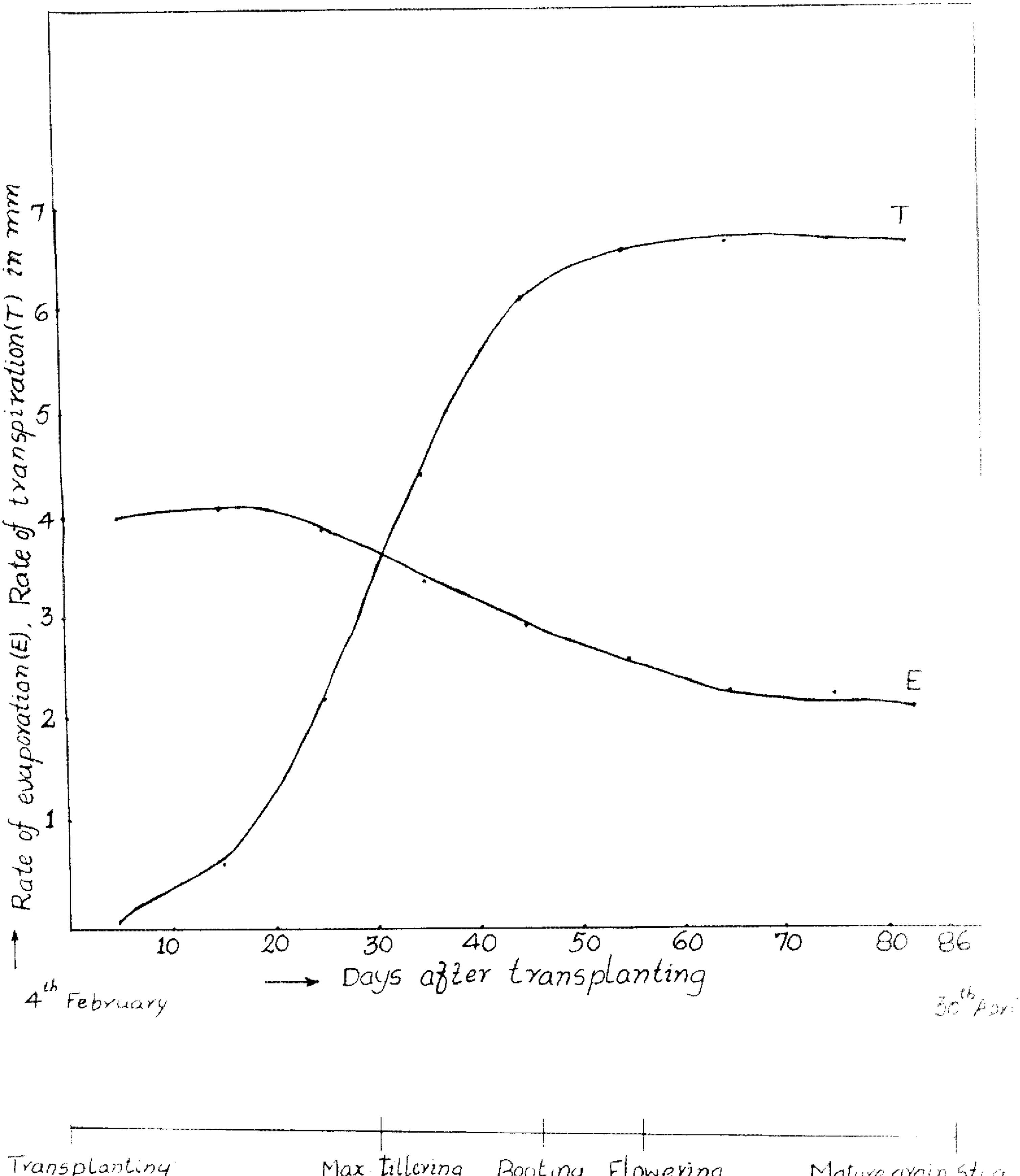

Fig. 6 Rate of evaporation curve and rate of transpiration curve

practically very little shade from the plants. Then it started decreasing continuously up to 69 days because the shade from the plants increased as the crop grew. The vegetative growth of plants ceased at that stage and the shade did not increase any further. And then onwards rate of evaporation curve was almost constant. The minor variation in rate of evaporation could be due to climatological factors like temperature, wind velocity, relative humidity, etc. In the normal case rate of evaporation in last stages should have increased because the mature leaves during this stage would have withered which in turn would have decreased the shaded area. However, in the present case the leaves remained green till harvest.

Considering the rate of transpiration it remained almost constant during first ten days as this was the rooting period and as there was practically very little growth. Then it increased at a faster rate up to fifty days i.e. up to the booting stage. This was because up to the booting stage plants grew at a faster rate than in the initial stage. Afterwards, transpiration curve was almost horizontal up to the final stage. Usually, after reaching maximum rate of transpiration at the booting stage, there should have been a gradual decrease in the final stage. But in the present experiment it was almost constant during the final stage because the leaves remained green till harvest. Another reason for the above was the higher mean temperature during this period.

Daily average mean of evapotranspiration and total loss of water are graphically represented in Fig.7. In the graphical representation the growth stages are marked. Considering the evapotranspiration curve during first twelve days it was almost horizontal. The initial stage was the rooting period and during this period there was practically very little shade from plants. Then it was increasing up to forty eight days i.e. up to booting stage. During this period rate of evaporation decreased, as the shade increased, but transpiration increased at a faster rate, as the plant foliage increased. Afterwards it was slowly decreasing up to seventy days and then the rate became almost constant. In the final stage evaporation and transpiration were almost constant. Evapotranspiration curve was the summing up of evaporation curve and transpiration curve.

Considering the total loss of water curve it was increasing from transplanting and reached a maximum of 34.8 mm/day after 26 days. One reason for the above was that the transpiration rate was increasing in the initial

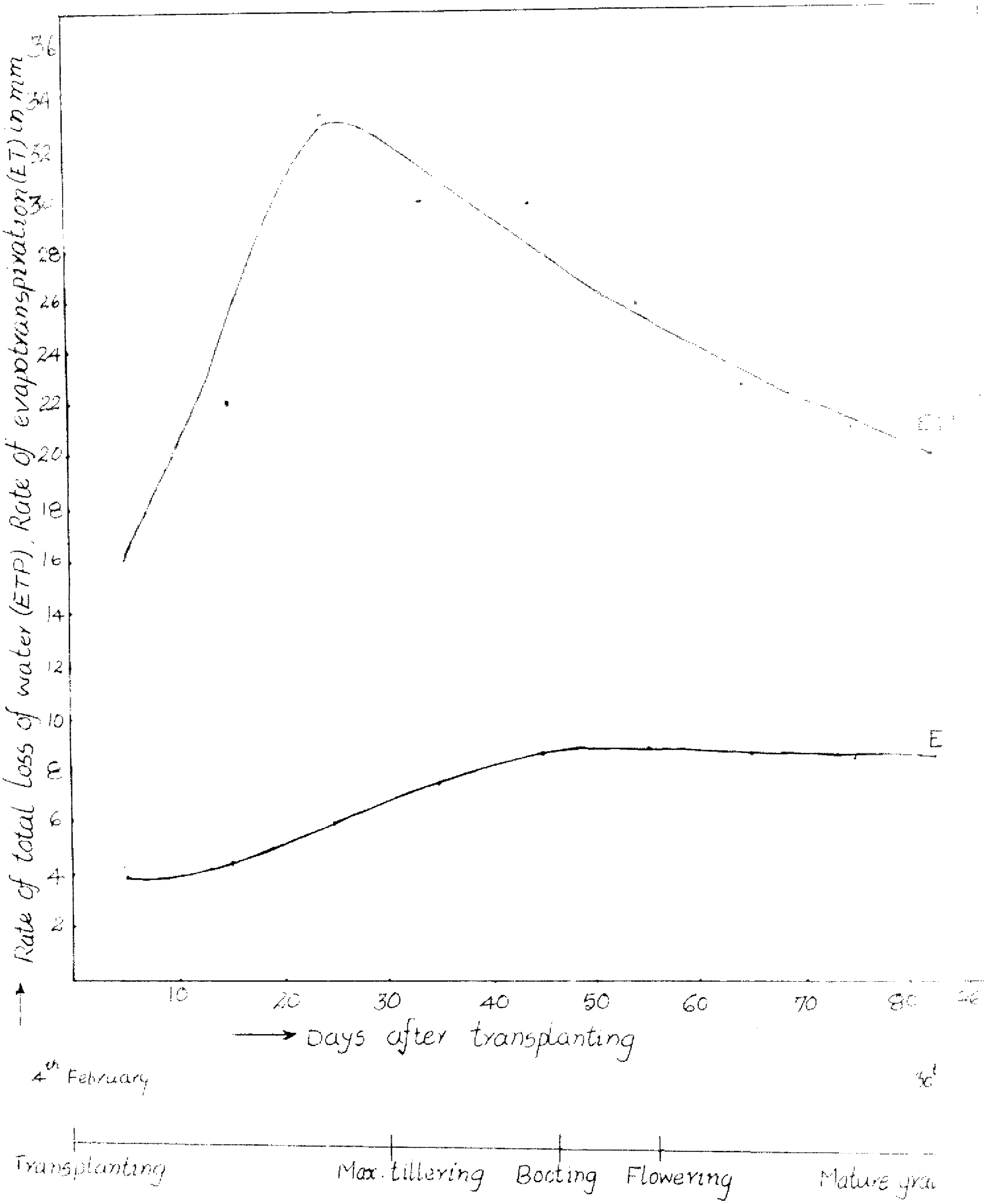

Fig.7 Rate of total loss of water curve and rate of evapotranspiration curve

stage. The more important reason was that the daily rate of percolation increased considerably because the level of water in the canal during this period was decreasing. This in turn decreased the general water table of the area. Then the rate of total loss started decreasing in a faster rate up to 67 days and reached a value 22 mm/day. This was because the level of water in the canal was rising as water was let out into the Kole area from Peechi reservoir during this period. As the level of water rose in the canal, total loss of water decreased from a maximum 34 mm/day to 22 mm/day. Then the total loss of water curve was decreasing slowly up to the final stage.

Experimental field was located in the middle between the upper lands and the lower lands. Hence the values obtained from the field for different forms of water losses can be considered as the mean value for the region.

Percolation will depend upon water table in the field which in turn depended on the water level in the canal. Thus by maintaining water level in the canal we can decrease the percolation rate and thus total loss of water.

Open pan evaporation during the crop period was collected from meteorological observatory at College of Horticulture, Vellanikkara, in Trichur district. Various forms of water loss and total water requirement of rice during Punja season were elculated and mean of four plots is given in Table 8. The above readings of four plots separately are given in Appendix-V. Ratio of evapotranspiration to open pan evaporation were calculated and are given in the above Tables. Ratio of cumulative evapotranspiration to total pan evaporation was calculated and it was found to be 1.026.

Average daily water used, totel water used and percentage of evapotranspiration, evaporation, transpiration, percolation and total water requirement were calculated and are given in Table 9. Total dry matter weight of the plants in the evapotranspirimeters were determined and are given in Table 10. Transpiration ratio and consumptive use ratio were calculated as mentioned in Chapter 3 and given in the above Table. Percentage of water lost by percolation, transpiration and evaporation were calculated and represented in pie diagram in Fig.8.

In Kole lands cultivation is done below mean sea level as mentioned earlier. During second crop season

Table 8. Mean of four plots of various forms of water loss and total water requirement of rice during Punja season on a medium duration variety 'Jaya'.

Period in days	Total water requirement (mm)		Total percolation (mm)		Total evapotranspiration (mm)		Total transpiration (mm)		Total evaporation (mm)		Total pan evaporation		Evapotranspiration (mm)
	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	Open pan evaporation
1 - 10	160.30	160.30	119.90	119.90	40.40	40.40	0.50	0.50	39.89	39.89	75.6	75.6	0.53
11 - 20	222.30	382.60	175.80	295.70	46.50	86.90	6.00	6.50	40.50	80.39	57.9	133.50	0.80
21 - 30	331.30	713.90	270.80	566.50	60.50	147.40	22.20	28.70	38.30	118.69	79.1	212.60	0.76
31 - 40 (2 rainy days)	305.90	1019.80	228.70	795.20	77.20	224.60	43.90	72.60	33.33	152.02	79.6	292.20	0.97
41 - 50 (1 rainy day)	299.50	1319.30	209.81	1005.00	89.70	314.30	60.50	133.10	29.20	181.22	63.4	355.60	1.41
51 - 60	258.50	1577.80	168.10	1173.10	90.40	404.70	64.80	197.90	25.60	206.82	75.60	431.20	1.19
61 - 70	224.00	1801.80	135.90	1309.00	88.10	492.80	65.80	263.70	22.30	229.12	73.20	504.40	1.20
71 - 80	213.50	2015.30	125.70	1434.70	87.80	580.60	66.00	329.70	21.80	250.92	73.70	578.10	1.19
81 - 86	118.92	2134.22	66.60	1501.30	52.32	632.92	39.78	369.48	12.52	263.44	38.80	616.90	1.34

$$\frac{\text{Cumulative evapotranspiration}}{\text{Total pan evaporation}} = 1.026$$

Table 9. Different forms of water loss and water requirement of medium duration variety Jaya in Punja season - Mean of four plots

		Average daily water used (mm)	Total water used (mm)	Percentage
1(a)	Evapotranspiration	7.42	632.92	29.66
(b)	Evaporation	3.02	263.44	12.34
(c)	Transpiration	4.40	369.48	17.32
2	Percolation	17.17	1501.30	70.34
3	Total water requirement	24.59	2134.22	100.00

Table 10. Calculation of transpiration ratio and consumptive use ratio

Plot No.	Total dry matter weight in evapotranspirimeter (gms)	Weight of water transpired from evapotranspirimeter (gms)	Weight of water lossed by evapotranspiration from evapotranspirimeter (gms)	Transpiration ratio	Consumptive use ratio
1	1005	288044	493128	286.61	490.67
2	998	287801	493452	288.38	494.44
3	993	286383	492399	288.40	495.87
4	945	286497	492318	303.17	520.97

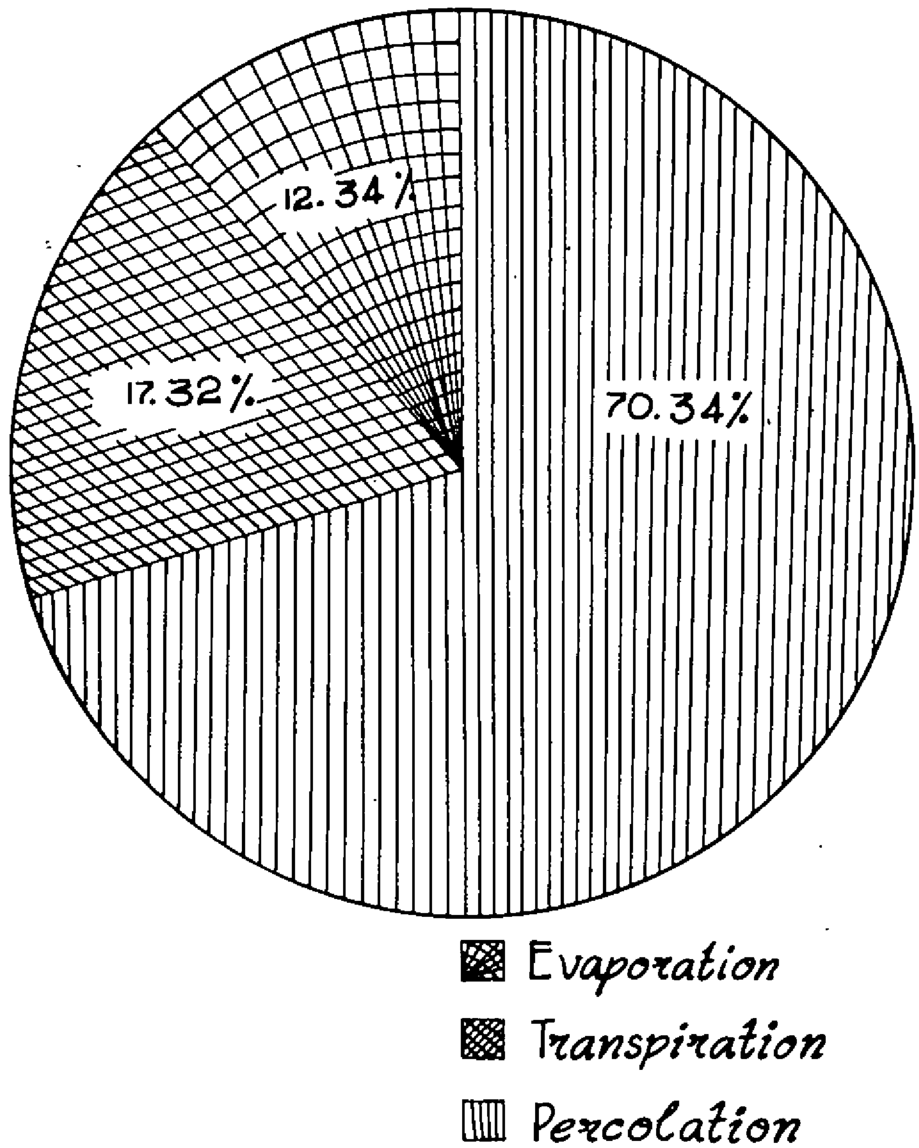

Fig.8 Pie diagram showing the losses due to Percolation, transpiration and evaporation

the water level in the canal will be very high and in many cases more than one metre above the field level. Because of this high water level in the canal there will be an upward movement of water in the Kole lands and there will be no percolation. However during summer season water level in the canal will be low and percolation will take place. When the level of water in the canal is very low, this study has shown that the percolation loss in Kole lands could be as high as 28.6 mm/day. Hence it is imperative to keep the water level in the canal very high to save wastage of water due to deep percolation.

Summary

SUMMARY

Rice is the most important and extensively cultivated food crop in Kerala. Water constitutes one of the principal constraints increasing food production in our hungry world. Efficient use of water for crop production has been a major concern for centuries. As the water needs of rice is many times greater than other crops, a precise knowledge of water requirement of crop attains importance not only for effecting economy in water use, but also for increasing production. The present investigation was taken up to estimate the losses through evaporation, transpiration, percolation and to assess the total water requirement of a medium duration rice in Punja season in Kanjany Kole lands in Trichur District which has not been assessed so far. The Kole areas are reclaimed lake beds below mean sea level and lying parallel to sea coast. The area is subject to inundation which keeps these under submerged condition for nearly seven months in the year. At present paddy is the only crop cultivated in these lands. The Kole lands in Trichur district are situated in Mukundapuram, Trichur, Chavakkad and Talappally Taluks. The main source of irrigation water to the Kole lands is from the Peechi irrigation system.

Studies conducted in Punja season, in the Agronomic Research Station in 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.

The experiment was conducted during Punja season of 1986 in the Kanjany Kole lands situated at 10° 28' north latitude and 76° 7' East longitude in Trichur district. The soil in the experimental field was sandy clay loam in texture comprising of 27.05 per cent coarse sand, 25·35 per cent fine sand, 17.40 per cent silt and 30.2 per cent clay. Estimations of evaporation, transpiration and percolation were made on the basis of measurement using simple field equipments namely evaporimeter, evapotranspirimeter and field hook guage. Pure seeds of a medium duration variety 'Jaya' was used for the experiment. Fertiliser application, weeding and all other practices were done as per the recommendations in the package of practice. Different forms of daily losses were measured by refilling method and by adding up the cumulative values during the crop period was obtained.

Experimental field was located in the middle between the upper lands and the lower lands. Hence the values obtained from the field for different forms of water losses can be considered as the mean value for the region. From the study we got total water requirement was 2134.22 mm. Percentages of water lost by percolation, transpiration and evaporation were 70.34, 17.32 and 12.34 respectively. Rate of evaporation was almost horizontal during first twenty days, then started decreasing continuously up to 69 days and then onwards was almost constant. The rate of transpiration remained almost constant during first ten days, then increased at a faster rate up to fifty days i.e. up to the booting stage. Afterwards rate of transpiration was almost constant up to final stage.

During the summer season the water level in the canal would be low. When the level of water in the canal is very low, this study has shown that the percolation loss in Kole lands could be as high as 28.6 mm. The rate of percolation will depend upon the water table in the field, which in turn will depend upon the water level in the canal. Thus by maintaining water level in the canal, we can save wastage of water due to deep percolation. Shortage of irrigation water is a serious problem in most of Kole area during the Punja season. After commissioning of the Chimmeny

Mupli irrigation system the situation is expected to improve considerably. Knowledge of water requirement of rice in Kole lands will greatly help in efficient utilisation of the limited water available in the reserviors.

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Appendices


PERUMPUZHA
PULLA THODU
TRICHUR

Appendix. 1a. Recommendations for rice in the package of practice
(Kerala Agricultural University)

Rice variety	:	Jaya
Duration	:	120 - 125
Grain colour	:	White
Special charactors	:	Very high yield potential - highly susceptible to brown plant hopper and other pests
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 20-25 days after sowing.
Transplanting	:	Transplant 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 fertilisers	:	Apply organic manures in the form of farm yard manure or compost or green leaf at the rate of 5 t/ha and incorporate into the soil while ploughing. Fertilisers to be applied at 90 kg/ha of N, 45 kg/ha of P_2O_5 and 45 kg/ha of K_2O
Weed control	:	Keep the field free of weeds up to 45 days.

Appendix I_b Daily evaporation, evapotranspiration, total water requirement, transpiration and percolation of plot No.1

Date	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1	2	3	4	5	6
4/2/86	3.94	4.01	17	0.07	12.99
5/2	3.94	4.01	16	0.07	11.99
6/2	3.94	4.01	17	0.07	12.89
7/2	4.00	4.07	16	0.07	11.93
8/2	4.00	4.07	17	0.07	12.93
9/2	3.94	4.01	16	0.07	11.99
10/2	4.00	4.01	17	0.01	12.99
11/2	4.00	4.06	16	0.06	11.94
12/2	3.94	4.07	17	0.13	12.93
13/2	3.94	4.11	17	0.17	12.89
14/2	4.00	4.19	18	0.19	13.81
15/2	4.05	4.25	18	0.20	13.75
16/2	4.00	4.38	19	0.38	14.62
17/2	4.05	4.51	21	0.46	16.49
18/2	4.05	4.66	22	0.61	17.34
19/2	4.00	4.82	24	0.82	19.18
20/2	4.05	4.93	25	0.88	20.07
21/2	4.00	5.04	26	1.04	20.96
22/2	4.05	5.27	29	1.22	23.73
23/2	4.05	5.35	32	1.30	26.65
24/2	4.00	5.59	33	1.59	27.41
25/2	4.00	5.72	33	1.72	27.28
26/2	3.95	5.85	33	1.90	27.15
27/2	3.95	5.92	34	1.97	28.08
28/2	3.89	6.05	24	2.16	27.95

I. (Contd.)

1	2	3	4	5	6
1/3/86	3.84	6.18	35	2.34	28.82
2/3	3.79	6.24	34	2.45	27.76
3/3	3.68	6.37	33	2.69	26.63
4/3	3.63	6.44	33	2.81	26.56
5/3	3.58	6.48	34	2.90	27.52
6/3	3.58	6.81	32	3.23	25.19
7/3	3.47	7.01	31	3.54	23.99
8/3	3.42	7.28	31	3.86	23.72
9/3	3.37	7.48	32	4.11	24.52
10/3	3.26	7.45	32	4.49	26.25
11/3	rainy day	-	-	-	-
12/3	"	-	-	-	-
13/3	3.21	8.48	32	5.28	23.52
14/3	3.15	8.55	30	5.40	21.45
15/3	3.15	8.61	30	5.46	21.39
16/3	3.05	8.84	30	5.79	21.16
17/3	3.05	8.85	30	5.80	21.15
18/3	3.00	8.89	31	5.89	22.11
19/3	2.94	8.96	31	6.02	22.04
20/3	rainy day	-	-	-	-
21/3	2.89	9.02	30	6.13	20.98
22/3	2.84	9.03	31	6.19	21.97
23/3	2.84	9.04	31	6.20	21.96
24/3	2.84	9.05	31	6.21	21.95
25/3	2.78	9.06	30	6.28	20.94
26/3	2.73	9.20	29	6.47	19.80
27/3	2.68	9.19	28	6.51	18.81
28/3	2.63	9.09	27	6.46	17.91
29/3	2.63	9.03	27	6.40	17.97
30/3	2.58	9.02	27	6.44	17.98
31/3	2.53	9.02	27	6.49	17.98

I. (Contd.)

1	2	3	4	5	6
1/4/86	2.53	9.01	27	6.48	17.99
2/4	2.47	8.92	25	6.45	16.99
3/4	2.47	8.92	25	6.45	11.08
4/4	2.42	8.88	25	6.46	16.12
5/4	2.36	8.92	26	6.56	17.08
6/4	2.36	8.89	25	6.53	16.11
7/4	2.32	8.87	25	6.55	16.13
8/4	2.26	8.81	24	6.55	15.19
9/4	2.26	8.78	23	6.58	14.22
10/4	2.20	8.78	23	6.58	14.22
11/4	2.20	8.77	23	6.57	14.23
12/4	2.16	8.74	23	6.58	14.26
13/4	2.11	8.71	22	6.60	13.29
14/4	2.05	8.70	22	6.65	13.30
15/4	2.05	8.70	22	6.65	13.30
16/4	2.05	8.70	22	6.65	13.30
17/4	2.10	8.75	22	6.65	13.25
18/4	2.10	8.75	22	6.65	13.25
19/4	2.16	8.75	22	6.59	13.25
20/4	2.21	8.77	22	6.56	13.23
21/4	2.21	8.77	22	6.56	13.23
22/4	2.21	8.77	22	6.56	13.23
23/4	2.21	8.79	22	6.58	13.21
24/4	2.26	8.77	22	6.51	13.23
25/4	2.16	8.76	21	6.60	12.24
26/4	2.11	8.74	21	6.63	12.26
27/4	2.05	8.71	21	6.66	12.29
28/4	2.05	8.71	20	6.66	11.29
29/4	2.00	8.69	20	6.69	11.31
30/4	2.00	8.57	20	6.57	11.43

3. Daily evaporation, evapotranspiration, total water requirement, transpiration and percolation of plot No.2

Date	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1	2	3	4	5	6
4/2/86	3.99	4.01	16	0.02	11.09
5/2	3.99	4.02	17	0.03	12.98
6/2	3.99	4.08	16	0.09	11.92
7/2	3.99	4.08	16	0.09	11.92
8/2	4.04	4.06	16	0.02	11.94
9/2	3.99	4.02	16	0.03	11.98
10/2	4.04	4.07	16	0.03	11.93
11/2	3.99	4.08	16	0.09	11.92
12/2	4.04	4.08	16	0.04	11.92
13/2	4.04	4.09	16	0.05	11.91
14/2	4.04	4.19	17	0.15	12.81
15/2	6.04	4.24	18	0.20	13.76
16/2	4.04	4.27	18	0.23	13.73
17/2	4.09	4.45	20	0.36	15.55
18/2	4.09	4.55	21	0.46	16.45
19/2	4.04	4.69	23	0.65	18.31
20/2	4.04	4.78	24	0.74	19.22
21/2	4.04	4.84	25	0.80	20.16
22/2	4.09	5.26	28	1.17	22.74
23/2	4.04	5.33	31	1.29	25.67
24/2	4.04	5.58	32	1.54	26.42
25/2	3.99	5.67	32	1.68	26.33
26/2	3.99	5.84	32	1.85	26.16
27/2	3.93	5.89	33	1.96	27.17
28/2	3.88	6.03	33	2.15	26.97

2. (Contd.)

1	2	3	4	5	6
1/3/86	3.88	6.15	35	2.27	28.85
2/3	3.80	6.23	33	2.43	26.77
3/3	3.67	6.32	32	2.65	25.68
4/3	3.62	6.41	32	2.79	26.52
5/3	3.56	6.48	33	2.90	26.52
6/3	3.56	6.80	32	3.22	25.20
7/3	3.51	6.97	30	3.46	23.03
8/3	3.40	7.22	31	3.62	23.78
9/3	3.35	7.38	31	4.03	23.62
10/3	3.29	7.73	31	4.44	23.27
11/3	rainy day	-	-	-	-
12/3	"	-	-	-	-
13/3	3.14	8.59	30	5.45	21.41
14/3	3.09	8.84	31	5.75	22.16
15/3	3.03	8.87	31	5.84	22.13
16/3	3.07	0.89	30	5.86	21.11
17/3	2.98	0.88	30	5.90	21.12
18/3	2.93	9.04	30	6.11	20.96
19/3	2.92	9.05	30	6.13	20.95
20/3	rainy day	-	-	-	-
21/3	2.82	9.06	30	6.24	20.94
22/3	2.76	9.07	29	6.31	19.93
23/3	2.71	9.24	28	6.52	18.76
24/3	2.66	9.21	27	6.55	17.79
25/3	2.60	9.12	26	6.52	16.88
26/3	2.83	9.04	26	6.41	16.96
27/3	2.61	9.05	26	6.44	16.95
28/3	2.50	9.85	26	6.55	16.95

2. (Contd.)

1	2	3	4	5	6
1/4/86	2.50	9.04	26	6.54	16.96
2/4	2.45	8.89	25	6.54	16.01
3/4	2.45	6.93	24	6.48	15.07
4/4	2.39	8.91	24	6.52	15.09
5/4	2.34	8.94	25	6.60	16.06
6/4	2.34	8.91	24	6.57	15.09
7/4	2.29	8.87	24	6.58	15.13
8/4	2.23	8.81	23	6.58	14.19
9/4	2.23	8.79	23	6.56	14.21
10/4	2.18	8.79	22	6.61	13.21
11/4	2.18	8.79	22	6.61	13.21
12/4	2.13	8.77	22	6.64	13.23
13/4	2.07	8.72	21	6.66	12.27
14/4	2.07	8.72	21	6.65	12.28
15/4	2.07	8.76	21	6.69	12.24
16/4	2.13	8.77	21	6.64	12.23
17/4	2.18	8.79	21	6.61	12.21
18/4	2.18	8.80	21	6.62	12.20
19/4	2.18	8.79	21	6.61	12.21
20/4	2.18	8.79	21	6.61	12.21
21/4	2.18	8.79	21	6.61	12.21
22/4	2.18	8.80	20	6.62	11.20
23/4	2.18	8.80	21	6.62	12.20
24/4	2.23	8.80	21	6.57	12.20
25/4	2.18	8.79	20	6.61	11.21
26/4	2.13	8.76	20	6.65	11.22
27/4	2.07	6.76	20	6.69	11.24
28/4	2.02	6.75	19	6.73	10.25
29/4	2.02	8.73	18	6.71	9.27
30/4	2.02	8.61	18	6.59	9.39

3. Daily evaporation, evapotranspiration, total water requirement, transpiration and percolation of Plot No.3

Date	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1	2	3	4	5	6
4/2/86	3.98	4.03	15	0.05	10.97
5/2	3.98	4.03	15	0.05	10.97
6/2	3.92	4.03	15	0.11	10.07
7/2	4.03	4.06	75	0.03	10.94
8/2	3.98	4.03	16	0.05	11.97
9/2	3.98	4.03	15	0.05	10.97
10/2	4.03	4.07	15	0.04	10.93
11/2	3.98	4.03	15	0.05	10.97
12/2	4.03	4.08	16	0.05	11.92
13/2	4.03	4.06	15	0.03	10.94
14/2	4.03	4.17	16	0.14	11.83
15/2	4.03	4.22	17	0.19	12.78
16/2	4.03	4.28	18	0.25	13.72
17/2	4.03	4.32	20	0.29	15.68
18/2	4.03	4.37	21	0.34	16.63
19/2	4.03	4.60	23	0.57	18.40
20/2	4.03	4.75	24	0.72	19.25
21/2	4.03	4.83	25	0.80	20.17
22/2	4.08	5.24	28	1.16	22.74
23/2	4.08	5.32	30	1.24	24.68
24/2	4.03	5.56	31	1.53	25.44
25/2	3.98	5.66	32	1.68	26.34
26/2	3.93	5.83	32	1.91	26.14
27/2	3.87	5.89	33	2.02	27.11
28/2	3.87	6.02	34	2.33	27.85

3. (Contd.)

1	2	3	4	5	6
1/3/86	3.82	6.15	34	2.33	27.85
2/3	3.76	6.22	33	2.46	26.78
3/3	3.66	6.28	32	2.62	25.72
4/3	3.60	6.42	32	2.82	25.58
5/3	3.55	6.44	33	2.89	26.56
6/3	3.55	6.78	31	3.23	24.22
7/3	3.49	6.97	29	3.48	22.02
8/3	3.39	7.22	30.	3.83	22.78
9/3	3.33	7.38	30	4.05	22.62
10/3	3.28	7.72	29	4.44	21.28
11/3	rainy day	-	-	-	-
12/3	"	-	-	-	-
13/3	3.28	8.43	29	5.15	20.57
14/3	3.17	8.52	29	5.35	20.48
15/3	3.17	8.56	29	5.39	20.44
16/3	3.12	8.83	30	5.71	21.17
17/3	3.01	8.85	30	5.84	21.15
18/3	3.01	8.88	29	5.87	20.12
19/3	2.90	8.90	28	6.00	19.10
20/3	rainy day	-	-	-	-
21/3	2.90	9.01	29	6.11	19.99
32/3	2.85	9.01	29	6.16	19.99
22/3	2.79	9.05	29	6.26	19.95
34/3	2.79	9.05	29	6.26	19.95
25/3	2.79	9.04	28	6.25	18.96
26/3	2.74	9.20	27	6.46	17.80
27/3	2.69	9.18	26	6.49	16.82
28/3	2.63	9.13	25	6.50	15.87
29/3	2.58	8.99	26	6.41	17.01
30/3	2.58	8.99	25	6.41	16.01

3. (Contd.)

1	2	3	4	5	6
1/4/86	2.53	8.00	25	6.47	16.00
2/4	2.47	8.98	24	6.51	15.02
3/4	2.62	8.85	23	6.53	14.05
4/4	2.42	8.90	23	6.48	14.10
5/4	2.37	8.83	24	6.56	15.07
6/4	2.31	8.90	23	6.48	14.10
7/4	2.31	8.86	23	6.55	14.14
8/4	2.26	8.83	23	6.57	14.17
9/4	2.26	8.78	23	6.52	14.22
10/4	2.26	8.79	22	6.53	13.21
11/4	2.20	8.79	22	6.58	13.21
12/4	2.15	8.76	22	6.61	13.24
13/4	2.15	8.75	21	6.60	12.25
14/4	2.15	8.75	21	6.60	12.25
15/4	2.15	8.77	21	6.62	12.23
16/4	2.15	8.77	21	6.62	12.23
17/4	2.20	8.79	21	6.58	12.21
18/4	2.20	8.80	21	6.60	12.20
19/4	2.26	8.80	21	6.54	12.20
20/4	2.26	8.80	21	6.54	12.20
21/4	2.26	8.80	21	6.54	12.20
22/4	2.26	8.80	20	6.54	11.20
23/4	2.26	8.80	21	6.54	12.20
24/4	2.26	8.80	21	6.54	12.20
25/4	2.26	8.79	20	6.51	11.23
26/4	2.15	8.79	20	6.44	11.21
27/4	2.15	8.76	20	6.61	11.24
28/4	2.09	8.75	18	6.66	10.25
29/4	2.04	8.72	18	6.68	10.28
30/4	2.09	8.68	19	6.58	10.32

4. Daily evaporation, evapotranspiration, total water requirement, transpiration and percolation of Plot No.4

Date	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1	2	3	4	5	6
4/2/86	3.99	4.03	16	0.04	11.97
5/2	3.94	4.04	16	0.10	11.96
6/2	3.94	4.04	16	0.10	11.96
7/2	3.94	4.04	16	0.10	11.96
8/2	3.99	4.03	17	0.04	12.97
9/2	3.99	4.04	16	0.05	11.96
10/2	3.99	4.04	16	0.05	11.96
11/2	4.04	4.08	16	0.04	11.92
12/2	4.04	4.07	17	0.03	12.93
13/2	4.04	4.06	16	0.02	11.94
14/2	4.04	4.15	17	0.11	12.85
15/2	4.04	4.22	18	0.10	13.78
16/2	4.04	4.27	19	0.23	14.73
17/2	4.04	4.31	21	0.27	16.29
18/2	4.04	4.35	22	0.31	17.65
19/2	4.04	4.58	24	0.51	19.42
20/2	4.04	4.73	25	0.69	20.27
21/2	4.04	4.80	26	0.76	21.20
22/2	4.04	5.25	29	1.19	23.75
23/2	4.09	5.30	31	1.21	25.70
24/2	3.99	5.50	32	1.51	26.50
25/2	3.99	5.63	33	1.64	27.37
26/2	3.93	5.80	33	1.87	27.20
27/2	3.93	5.92	34	1.99	28.08
28/2	3.88	5.89	34	2.11	28.01

4. (Contd.)

1	2	3	4	5	6
1/3/86	3.88	5.99	34	2.11	28.01
2/3	3.78	6.23	34	2.45	27.77
3/3	3.67	6.31	34	2.64	27.69
4/3	3.62	6.43	33	2.81	26.57
5/3	3.56	6.48	34	2.92	27.52
6/3	3.56	6.79	32	3.23	25.21
7/3	3.45	7.00	30	3.55	23.00
8/3	3.40	7.28	32	3.89	24.72
9/3	3.35	7.45	31	4.10	23.55
10/3	3.29	7.74	31	4.45	23.26
11/3	rainy day	-	-	-	-
12/3	-	-	-	-	-
13/3	3.24	8.45	31	5.21	22.55
14/3	3.19	8.55	30	5.36	21.45
15/3	3.19	8.59	30	5.40	21.41
16/3	3.13	8.84	31	5.71	22.16
17/3	3.03	8.84	31	5.71	22.16
18/3	2.98	8.91	30	5.93	21.09
19/3	2.98	8.91	30	5.93	21.09
20/3	rainy day	-	-	-	-
21/3	2.92	9.04	30	6.12	20.96
22/3	2.87	9.04	29	6.17	19.96
23/3	2.82	9.04	30	6.22	20.96
24/3	2.81	9.05	30	6.23	20.95
25/3	2.76	9.05	29	6.29	19.95
26/3	2.77	9.19	28	6.42	18.81
27/3	2.71	9.18	27	6.47	17.82
28/3	2.61	9.13	26	6.52	16.87
29/3	2.60	9.00	27	6.40	18.00
30/3	2.55	9.00	26	6.45	17.00
31/3	2.55	8.99	26	6.44	17.01

4. (Contd.)

1	2	3	4	5	6
1/4/86	2.55	8.98	26	6.43	17.02
2/4	2.50	8.99	26	6.45	17.05
3/4	2.49	8.92	26	6.47	17.08
4/4	2.39	8.80	24	6.51	15.10
5/4	2.39	8.91	25	6.52	16.09
6/4	2.34	8.91	24	6.57	15.09
7/4	2.34	8.87	24	6.53	15.13
8/4	2.29	8.83	24	6.60	15.17
9/4	2.23	8.79	24	6.56	15.21
10/4	2.18	8.77	23	6.58	14.23
11/4	2.18	8.77	23	6.59	14.23
12/4	2.18	8.77	23	6.58	14.23
13/4	2.13	8.74	22	6.61	13.26
14/4	2.07	8.76	22	6.69	13.24
15/4	2.07	8.18	22	6.11	13.72
16/4	2.07	8.77	22	6.70	13.23
17/4	2.13	8.77	22	6.64	13.23
18/4	2.18	8.78	22	6.60	13.22
19/4	2.18	8.78	22	6.60	13.22
20/4	2.18	8.78	22	6.60	13.22
21/4	2.18	8.78	22	6.60	13.22
22/4	2.18	8.80	21	6.62	12.20
23/4	2.23	8.80	21	6.57	12.20
24/4	2.23	8.80	20	6.57	11.20
25/4	2.19	8.76	21	6.68	12.24
26/4	2.18	8.77	21	6.69	12.23
27/4	2.13	8.74	21	6.61	12.26
28/4	2.07	6.67	20	6.60	11.33
29/4	1.97	6.70	19	6.73	10.30
30/4	2.02	6.63	19	6.61	10.37

Appendix 2. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.1

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	39.64	40.43	166.00	0.79	125.57
11 - 20	40.30	47.40	234.00	7.10	186.60
21 - 30	38.31	60.24	336.00	21.93	275.76
31 - 40 (2 rainy days)	33.30	77.50	312.50	44.20	235.00
41 - 50 (1 rainy day)	29.10	89.70	306.70	60.60	217.00
51 - 60	25.67	90.37	268.00	64.70	177.63
61 - 70	22.28	87.98	211.60	65.69	123.02
71 - 80	21.56	87.60	220.00	65.96	132.40
81 - 86 (only 6 days)	12.31	52.18	123.00	39.87	70.82
Total 86	262.47	633.40	2177.20	370.84	1543.80

2. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.2

Days		Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10		40.10	40.55	161.00	0.45	120.45
11 - 20		40.55	46.60	225.00	6.05	178.40
21 - 30		38.44	60.60	327.00	22.16	266.40
31 - 40 (2 rainy days)		33.40	77.10	307.50	43.70	230.40
41 - 50 (1 rainy day)		29.40	89.70	301.10	60.30	211.40
51 - 60		25.47	90.58	268.00	65.11	167.42
61 - 70		22.06	88.12	227.00	66.06	138.88
71 - 80		21.69	87.89	209.00	66.20	121.11
81 - 86 (only 6 days)		12.44	52.42	115.00	39.98	42.58
Total	86	263.55	633.56	2130.60	370.01	1497.04

3. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.3

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	39.94	40.33	152.00	0.39	111.67
11 - 20	40.40	46.10	198.00	5.70	151.90
21 - 30	38.06	60.47	326.07	22.41	265.60
31 - 40 (2 rainy days)	33.30	77.00	295.00	43.70	218.00
41 - 50 (1 rainy day)	29.10	89.50	290.00	60.40	200.50
51 - 60	25.64	90.32	249.06	64.68	158.74
61 - 70	22.42	88.16	224.08	65.72	135.92
71 - 80	22.26	87.99	209.00	65.68	121.01
81 - 86 (only 6 days)	12.78	52.49	117.07	39.69	64.58
Total 86	263.90	632.36	2060.28	368.37	1427.92

4. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.4

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	39.90	40.40	162.00	0.50	121.60
11 - 20	40.95	45.96	232.00	5.01	186.04
21 - 30	38.23	60.45	336.00	22.22	275.55
31 - 40 (2 rainy days)	33.30	77.30	308.80	44.00	231.50
41 - 50 (1 rainy day)	29.30	89.70	300.00	60.40	210.30
51 - 60	25.68	90.24	259.00	64.56	168.76
61 - 70	22.33	88.13	234.00	65.80	145.87
71 - 80	21.63	87.89	216.00	66.26	128.11
81 - 86 (only 6 days)	12.55	52.29	121.00	39.74	68.71
Total 86	263.87	632.36	2168.8	368.49	1536.44

Appendix 3.

1. Daily average of evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.1

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	3.96	4.04	16.60	0.08	12.56
11 - 20	4.03	4.74	23.40	0.71	18.66
21 - 30	3.83	6.02	33.60	2.19	27.58
31 - 40 (2 rainy days)	3.33	7.75	31.25	4.42	23.50
41 - 50 (1 rainy day)	2.91	8.97	30.67	6.06	21.69
51 - 60	2.57	9.04	26.80	6.47	17.76
61 - 70	2.23	8.79	21.10	6.56	12.30
71 - 80	2.14	8.75	22.00	6.59	13.25
81 - 86 (only 6 days)	2.05	8.69	20.50	6.64	7.08
Daily mean	3.00	7.42	25.10	4.41	17.15

2. Daily average of evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.2

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	4.01	4.06	16.10	0.05	12.04
11 - 20	4.06	4.66	22.50	0.60	17.84
21 - 30	3.84	6.06	32.70	2.22	26.64
31 - 40 (2 rainy days)	3.34	7.71	30.75	4.37	23.04
41 - 50 (1 rainy day)	2.94	8.97	30.11	6.03	21.14
51 - 60	2.55	9.06	25.80	6.51	16.74
61 - 70	2.21	8.81	22.70	6.60	13.89
71 - 80	2.70	8.79	20.90	6.09	12.11
81 - 86 (only 6 days)	2.07	8.74	19.17	6.67	10.43
Daily mean	3.08	7.43	24.53	4.35	17.09

3. Daily average of evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.3

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	3.99	4.03	15.20	0.04	11.17
11 - 20	4.04	4.61	19.80	0.57	15.19
21 - 30	3.81	6.05	32.60	2.24	26.55
31 - 40 (2 rainy days)	3.33	7.70	29.50	4.37	21.80
41 - 50 (1 rainy day)	2.91	8.95	29.00	6.04	20.05
51 - 60	2.56	9.03	24.90	6.47	15.87
61 - 70	2.24	8.81	22.40	6.57	13.59
71 - 80	2.23	8.79	20.90	6.56	12.11
81 - 86 (only 6 days)	2.13	8.75	19.50	6.62	10.75
Daily mean	3.03	7.41	23.76	4.38	16.35

8. Daily average of evaporation, evapotranspiration, total water requirement, transpiration and percolation for each ten day interval of Plot No.4

Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
1 - 10	3.99	4.04	16.20	0.05	12.16
11 - 20	4.05	4.59	23.20	0.55	18.60
21 - 30	3.82	6.05	33.60	2.22	27.56
31 - 40 (2 rainy days)	3.33	7.73	30.88	4.40	23.15
41 - 50 (1 rainy day)	2.93	8.97	30.00	6.04	21.03
51 - 60	2.57	9.02	25.90	8.48	18.88
61 - 70	2.33	8.81	23.40	6.58	14.59
71 - 80	2.18	8.78	21.60	8.62	12.82
81 - 86	2.09	8.71	20.10	3.97	6.87
Daily mean	3.02	7.41	24.99	4.39	17.58

Appendix 4.

1. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation during different growth stages of Plot No.1

Growth stage	Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
Transplanting to Maximum tillering or panicle initiation	30	118.25	148.07	736.00	29.82	587.93
to Booting	16	50.76	131.32	496.52	80.56	365.20
to Flowering (50% emergence)	10	27.06	90.10	283.48	63.07	193.38
milk stage Dough stage Mature grain stage	30	66.40	263.82	661.20	197.39	397.38
Total	86	262.47	633.31	2177.20	370.84	1543.89

2. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation during different growth stages of Plot No.2

Growth stage	Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
Transplanting to	30	119.09	147.75	713.00	28.66	565.25
Maximum tillering or panicle initiation to	16	51.04	130.92	488.16	79.88	357.24
Booting to	10	27.04	90.23	275.24	63.19	185.01
Flowering (50% emergence) milk stage Dough stage Mature grain stage	30	66.38	264.66	654.20	198.37	389.56
Total	86	263.55	633.54	2130.60	370.10	1497.06

3. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation during different growth stages of Plot No.3

Growth stage	Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
Transplanting to	30	118.40	146.90	676.00	28.50	519.10
Maximum tillering or panicle initiation to	16	50.76	130.70	467.00	79.94	338.30
Booting to	10	27.02	89.99	267.40	62.97	177.41
Flowering (50% emergence) Milk stage Dough stage Mature grain stage	30	67.72	264.68	649.60	196.96	392.92
Total	86	263.90	632.27	2060.00	368.37	1427.73

4. Total evaporation, evapotranspiration, total water requirement, transpiration and percolation during different growth stages of Plot No.4

Growth stage	Days	Evaporation (mm)	Evapotranspiration (mm)	Total water requirement (mm)	Transpiration (mm)	Percolation (mm)
Transplanting to	30	118.08	146.84	730.00	28.47	583.16
Maximum tillering or panicle initiation to	16	50.88	131.12	488.80	80.24	357.68
Booting to	10	28.13	90.02	275.40	62.69	185.38
Flowering (50% emergence) Milk stage Dough stage Mature grain stage	30	66.78	264.29	874.60	197.00	410.31
Total	86	263.87	632.27	2168.80	368.40	1536.53

Appendix 5. Various forms of water losses and total water requirement of rice during Punja season on a medium duration variety 'Jaya' of plot No.1.

Period in days	Total water requirement (mm)		Total percolation (mm)		Total evapotranspiration (mm)		Total transpiration (mm)		Total evaporation (mm)		Total pan evaporation (mm)		Evapotranspiration / (Open pan evaporation)
	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	
1 - 10	166	166	125.57	125.57	40.43	40.43	0.49	0.49	39.64	39.64	75.6	75.6	0.53
11 - 20	234	400	186.60	312.17	47.40	87.33	7.10	7.59	40.30	79.94	57.9	133.5	0.82
21 - 30	336	736	275.76	587.73	60.24	148.07	21.93	29.52	38.31	118.25	79.1	212.6	0.76
31 - 40	312.50	1048.50	235.00	822.93	77.50	225.57	44.20	73.72	33.3	151.55	79.6	292.2	0.97
41 - 50	306.70	1355.20	216.90	1039.83	89.70	315.27	60.60	134.32	29.10	180.65	63.4	355.6	1.41
51 - 60	268.00	1623.20	177.63	1217.46	90.37	405.64	64.70	199.02	25.67	206.32	75.6	431.2	1.19
61 - 70	211.00	1834.20	123.03	1340.49	87.97	493.61	65.69	264.71	22.28	228.60	73.2	504.4	1.20
71 - 80	220.00	2054.20	132.48	1472.97	87.52	581.13	65.96	330.61	21.56	250.16	73.7	578.1	1.19
81 - 86	123.00	2177.20	70.82	1543.89	52.18	633.31	39.87	370.84	12.31	262.47	38.8	616.9	1.34

$$\frac{\text{Cumulative Evapotranspiration}}{\text{Total pan Evaporation}} = 1.0266$$

2. Various forms of water losses and total water requirement of rice during Punja season on a medium duration variety 'Jaya' of Plot No.2

Period in days	Total water requirement (mm)		Total percolation (mm)		Total evapotranspiration (mm)		Total transpiration (mm)		Total evaporation (mm)		Total pan evaporation (mm)		Evapotranspiration
	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	Open pan evaporation
1 - 10	161.0	161.0	120.45	120.45	40.55	40.55	0.45	0.45	40.10	40.10	75.6	75.6	0.54
11 - 20	225.0	386.0	178.40	298.85	46.66	87.15	6.50	6.50	40.55	80.65	57.9	133.5	0.81
21 - 30	327.0	713.0	266.40	565.25	60.60	147.75	22.16	28.66	38.44	119.09	79.1	212.6	0.77
31 - 40	307.5	1020.5	230.40	795.65	77.10	224.85	43.70	72.36	33.40	152.49	79.6	292.2	0.97
41 - 50	301.1	1321.6	211.40	1007.05	89.70	314.55	60.30	132.66	29.40	181.89	63.4	355.6	1.41
51 - 60	258.0	1579.6	167.42	1174.47	90.58	405.13	65.11	197.77	25.47	207.36	75.6	431.2	1.20
61 - 70	227.0	1806.6	138.88	1313.35	88.12	493.25	60.06	263.83	22.06	229.42	73.2	504.4	1.20
71 - 80	209.0	2015.6	121.11	1434.46	87.89	581.14	66.20	330.03	21.69	251.11	73.7	578.1	1.19
81 - 86	115.0	2130.6	62.58	1497.04	52.42	633.56	39.98	370.01	12.44	263.55	38.8	616.9	1.35

$$\frac{\text{Cumulative Evapotranspiration}}{\text{Total pan Evaporation}} = 1.0269$$

3. Various forms of water losses and total water requirement of rice during Punja season on a medium duration variety 'Jaya' of Plot No.3

Period in days	Total water requirement (mm)		Total percolation (mm)		Total evapotranspiration (mm)		Total transpiration (mm)		Total evaporation (mm)		Total pan evaporation (mm)		Evapotranspiration / Open evaporation
	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	
1 - 10	152.00	152.00	111.67	111.67	40.33	40.33	0.39	0.39	39.94	39.94	75.6	75.6	0.53
11 - 20	198.00	350.00	151.90	263.67	46.10	86.43	5.70	6.09	40.40	80.34	57.9	133.5	0.79
21 - 30	326.07	676.07	265.60	529.17	60.47	146.90	22.41	28.50	38.06	118.40	79.1	212.6	0.76
31 - 40	295.00	971.07	218.00	747.17	77.00	223.90	43.70	72.20	33.30	151.70	79.6	292.2	0.77
41 - 50	290.00	1261.07	200.50	947.67	89.50	313.40	60.40	130.60	29.10	180.80	63.4	355.6	1.27
51 - 60	249.06	1510.13	158.74	1106.41	90.32	403.72	64.68	197.28	25.64	206.44	75.6	431.2	1.19
61 - 70	224.08	1734.21	135.92	1242.33	88.16	491.88	65.72	263.00	22.42	228.86	73.2	504.4	1.20
71 - 80	209.00	1943.21	121.01	1363.34	87.99	579.87	65.68	328.68	22.26	251.12	73.7	578.1	1.19
81 - 86	117.07	2060.28	64.58	1427.92	52.49	632.36	39.69	368.37	12.78	263.90	38.8	616.9	1.35

$$\frac{\text{Cumulative Evapotranspiration}}{\text{Total pan evaporation}} = 1.025$$

4. Various forms of water losses and total water requirement of rice during Punja season on a medium duration variety Jaya of Plot No.4

Period in days	Total water requirement (mm)		Total percolation (mm)		Total evapotranspiration (mm)		Total transpiration (mm)		Total evaporation (mm)		Total pan evaporation (mm)		Evapotranspiration
	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	For the period	Cumulative	Open evaporation
1 - 10	162.0	162.0	121.60	121.60	40.40	40.40	0.50	0.50	39.90	39.90	75.6	75.6	0.53
11 - 20	232.0	394.0	186.04	307.64	45.96	86.36	5.51	6.01	40.45	80.35	57.9	133.5	0.79
21 - 30	336.0	730.00	275.55	583.19	60.45	146.81	22.22	28.23	38.23	118.58	79.1	212.6	0.76
31 - 40	308.8	1038.80	231.50	814.69	77.30	224.11	44.00	72.25	33.30	151.88	79.6	292.2	0.97
41 - 50	300.0	1338.8	210.30	1024.99	89.70	313.81	60.40	132.63	29.30	181.18	63.4	355.6	1.41
51 - 60	259.0	1597.8	168.76	1193.75	90.24	404.05	64.56	197.19	25.68	206.86	75.6	431.2	1.19
61 - 70	234.0	1831.8	145.87	1339.62	88.13	492.18	65.80	262.99	22.33	229.19	73.2	504.4	1.20
71 - 80	216.0	2047.8	128.11	1467.73	87.89	580.07	66.26	329.25	21.63	250.82	73.7	578.1	1.19
81 - 86	121.0	2168.8	68.71	1536.44	52.29	632.36	39.74	368.49	12.75	263.87	38.8	616.9	1.34

$$\frac{\text{Cumulative Evapotranspiration}}{\text{Total pan Evaporation}} = 1.025$$

FORMS OF WATER LOSS AND WATER REQUIREMENT OF RICE IN KOLE LANDS

By

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ABSTRACT OF A THESIS

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ABSTRACT

Rice is the most important and extensively cultivated food crop in Kerala. Efficient use of water for crop production has been a major concern for centuries. As the water needs of rice is many times greater than other crops, a precise knowledge of water requirement of crop attains importance for increasing production. The present investigation was taken up to estimate the losses through evaporation, transpiration, percolation and to assess the total water requirement of a medium duration rice variety Jaya, in Punja season in Kanjany Kole lands in Trichur district, which has not been assessed so far. The Kole areas are reclaimed lake beds below mean sea level. The main source of irrigation water to the Kole lands is from the Peechi irrigation system.

The experiment was conducted during Punja season of 1986 in Kanjany Kole lands. Estimations of evaporation, transpiration and percolation were made on the basis of measurements, using evaporimeter, evapotranspirimeter and field hook gauge. From the study it was revealed that the total water requirement was 2134.22 mm. Percentages of water lost by percolation, transpiration and evaporation

were 70.34, 17.32 and 12.34 respectively. Rate of evaporation was almost constant during first twenty days, then started decreasing up to 69 days and then onwards was almost constant during the final stage. Rate of transpiration remained almost constant up to ten days, then started increasing up to fifty days and then remained almost a constant up to final stage. Rate of total loss of water was increasing from transplanting, reached a maximum of 28.6 mm after 26 days, then started decreasing up to final stage.

When the level of water in the canal is very low, this study has shown that the percolation loss in Kole lands could be as high as 28.6 mm. So by maintaining water level in the canal, we can save wastage of water due to deep percolation. Shortage of irrigation water is a serious problem in most of Kole area during Punja season. Knowledge of water requirement of rice in Kole lands will greatly help in efficient utilisation of the limited water available in the reservoirs.