RELATIVE EFFICIENCY EVALUATION OF DRIP AND BASIN METHODS OF IRRIGATION IN BANANA

By

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THESIS

submitted in partial fulfilment of
the requirement for the degree

Master of Science in Agricultural Engineering

Faculty of Agriculture
Kerala Agricultural University

Department of Agricultural Engineering
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1985

DECLARATION

I hereby declare that this thesis entitled "Relative Efficiency Evaluation of Drip and Basin Methods of Irrigation in Banana" 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,
11th December, 1985

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CERTIFICATE

Certified that this thesis entitled "Relative Efficiency Evaluation of Drip and Basin Methods of Irrigation in Banana" is a record of research work done independently by Shri Koshy Varghese under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned, members of the Advisory Committee of Shri Koshy Varghese, a candidate for the degree of Master of Science in Agricultural Engineering, agree that the thesis entitled "Relative Efficiency Evaluation of Drip and Basin Methods of Irrigation in Banana" may be submitted by Shri Koshy Varghese in partial fulfilment of the requirements for the degree.

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ACKNOWLEDGEMENT

I had the good fortune to come across many helpful people and it is to them that I want to pay my homage.

I am grateful to Professor T.P. George, Chairman of my Advisory Committee and Head, Department of Agricultural Engineering for his guidance in all aspects since the time I joined this University and during the preparation of this thesis.

I am indebted to Professor K. John Thomas, Department of Agricultural Engineering for his valuable advice and guidance.

Thanks are also due to Shri P.A. Varkey, Associate Professor, Agricultural Research Station, Mannuthy and Shri Jippu Jacob, Assistant Professor, Department of Agricultural Engineering, the other members of my Advisory Committee, for their help and valuable suggestions.

I am also greatly indebted to Dr. A.N. Remadevi, Professor, Department of Agricultural Engineering for the help rendered.

I express my sincere gratitude to the staff members of the Agricultural Engineering Workshop, Mannuthy and to the staff members and labourers of the Banana Research Station, Kannara, for their help during the experiment.

I also thank Mr. Sivaswamy, Mr. Ganesan, Mr. T.R. Gopalakrishnan, Mr. P.K. Rajeevan, Assistant Professors, Mr. T.D. Raju, Mrs. K.P. Visalakshi, Jr. Asst. Professor and Mr. Hajilal M.S., Research Associate for their friendly help during this time.

I thank the Kerala Agricultural University for enabling me to do my Masters programme as a part time student.

Finally, I extend my sincere and heartfelt gratitude to my parents and relatives, especially to Miss Mary John and Dr. E. John for their loving encouragement which brought me up to this level.

(KOSHY VARGHESE)

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ABBREVIATIONS

Agric.	Agricultural
ASAE	American Society of Agricultural Engineers
cc	Cubic centimetre(s)
Cd	Coefficient of discharge
C.D.	Critical difference
cm	Centimetre(s)
Dept.	Department
Div.	Division
et al.	and others
FAO	Food and Agriculture Organisation
Fig.	Figure
g	Gram(s)
Ha	Hectare(s)
HP, hp	Horse power
hr	Hours
ICAR	Indian Council for Agricultural Research
IRRI	Indian Rice Research Institute
ISAE	Indian Society of Agricultural Engineers
J.	Journal
Kg.	Kilogram(s)
l	Litre(s)
m	Metre(s)
min.	Minute(s)
mm	Millimetre(s)

M.S.	Mild Steel
No.	Number
P	Page
pp	pages
Proc.	Proceedings
Res.	Research
Rs.	Rupees
S.S.	Sum of squares
Sec.	Second(s)
Sl.	Serial
/	Per
%	Per cent
Σ	Sum of

Introduction

INTRODUCTION

Irrigation in many countries is an old art - as old as civilization - but for the whole world it is a modern science - the science of survival. The pressure of survival and the need for additional food supplies are necessitating a rapid expansion of irrigation throughout the world. Proper management of water resources which is becoming progressively scarce is of utmost importance in this context. Methods to increase productivity per unit area using less water is a basic need of the day. Drip irrigation system has been recognised as a promising technology to achieve this objective. This system is gaining momentum among researchers and farmers. The drip irrigation system, by name, is found to have been originated in the 1960s in Israel. But, even before that, shortly after the World War II, irrigation systems were developed for frequent slow application of water to soil through mechanical devices called emitters located at selected points along pipe lines for experimental crops and greenhouses. This kind of system has been used in countries like Israel, Australia, South Africa, United States, France and Soviet Union.

The demand for water is increasing day by day. But the allocation of water to agriculture will be reduced as more water is to be given for industries and for the growing population. To feed this population, more area should be brought under cultivation. Therefore, considering our present situation regarding the availability of water, the aspect of efficient use of water carries much importance. Out of the efficient methods of irrigation, drip method is by far superior without any doubt.

Drip irrigation is comparatively new to the people of our country. Though the work on drip irrigation commenced in our country in the 1960s, the information base has not been exposed to any appreciable extent.

Wild flooding, border strip, furrow and basin are the common surface methods of irrigation in our country. At present water use efficiencies of these surface irrigation systems can be placed at 45 to 50 per cent. Drip or trickle irrigation method is a step further towards sophistication in irrigation and economy in the use of water. It has a very high water use efficiency of over 90 per cent as it supplies water at the right place in the correct amount at the right time. It requires less water and less labour in comparison to the other methods. In our country, this system has started on a limited scale in Tamil Nadu, Karnataka and Kerala mainly for coconut, coffee and some other high value crops. Drip irrigation holds considerable potential where irrigation wells deliver extremely small quantities of water and it offers the hope of sizable irrigated acreage using small wells.

In drip irrigation, plants are irrigated frequently with a volume of water equal to the consumptive use of plants and thereby minimising the losses of water. Water is delivered in drops at the soil surface near the base of the plants. The slow application of water keeps the soil always at the optimum condition of moisture for plant growth.

The initial cost of conventional drip irrigation equipment which comes to about Rs.40,000/- per hectare is the limiting factor for its large scale adoption. Skill required in the installation, operation and maintenance of the pressure feed system pressure control system, filter units etc. are the other difficulties encountered in this system.

Considering these problems in the feasibility of the system under Indian conditions, the Kerala Agricultural University at its Agronomic Research Station, Chalakudy, in the year 1977 developed a low cost drip irrigation system made of locally available materials which requires no special skill in its fabrication, installation or operation. This equipment works on low pressure while the conventional system works on high pressure. The total head required for working this system is only about one metre. Water is pumped into a tank having an elevation of one metre above the field level and is conveyed from the tank to the field through a main pipe. Laterals of smaller diameter pipes depending on the area are connected on both sides of the main pipe at suitable intervals. Distributors are connected to the laterals through micro-tubes. Water flows into the distributor at the rate of 6 to 10 litres per hour. From the distributor four micro-tube outlets are taken out which acts as "drippers" emitting water at the rate of 1 to 2 litres/hour. The micro-tubes are connected to the laterals and distributors by drilling holes having smaller diameter than the external diameter of the micro-tube and pushing the tubes into these holes for a tight fit. These joints are leak proof because the system works on low pressure. The connections are very easy. The rate of flow of each dripper can be controlled by varying the length of the micro-tube.

The total initial cost of the equipment is about Rs.18,000/- to Rs.20,000/- per hectare. The equipment will last at least for 8 to 10 years. Once installed, additional labour is not necessary to operate the system compared to the basin method of irrigation where the labour requirement is high for controlling and diverting the irrigation water.

The relative advantages and disadvantages of this low cost drip irrigation system is tested in this study over the conventional basin method of irrigation in banana.

Review of Literature

REVIEW OF LITERATURE

Several scientists have conducted various experiments in drip irrigation considering different aspects related to it including comparative studies with conventional and other methods. The works done so far on these aspects are briefly reviewed under the following heads:

1. Drip in general
2. Drip in relation to conventional and other methods of irrigation
3. Effect of drip irrigation on different crops

1. Drip in general

One of the most recent introductions to agriculture, the drip irrigation system, also called trickle irrigation is fast becoming popular especially in hot arid areas of the world. (Hiler *et al*., 1973; Booher 1974; Gustafson *et al*., 1974; Panjab Singh, 1978; Sivanappan, 1979).

An experiment was laid out to compare the efficiency of drip irrigation over conventional furrow method of irrigation. Initial observations indicated that vegetables like amaranthus and bhindi respond well to drip irrigation (Annon, 1977-'78).

The results of the various experiments conducted in the recent years have brought forth the following advantages of drip irrigation over other methods of irrigation.

a. The method in general, results in increased crop yield per unit of water.

b. Drip irrigation usually results in substantial saving of water by limiting the wetted area to the crop root zone and reducing the loss of water through surface run-off and deep percolation.

c. Weed growth is substantially reduced in the case of widely spaced crops irrigated by the drip system, since irrigation is confined to the crops' root zone.

d. Drip irrigation is specially suited for deep sandy soils where other methods of irrigation often results in low irrigation efficiency.

e. The method does not necessitate extensive land levelling and is applicable to undulating topography.

f. Labour cost is considerably reduced by adopting drip system of irrigation.

g. Yound plants mature faster due to absence of moisture stress.

h. Crop diseases are reduced since water does not come into contact with the leaves.

i. Decreased interculture is another advantage noted in drip irrigated plots.

j. Saline water can be used in drip irrigation system to a certain extent without causing damage to the crop.

Drip irrigation is mainly a technique whereby water and fertilizers can be placed at the direct disposal of the root zone with the help of a specially designed emitter, by a network of pipes, to the exact requirements of crops. The acreage under trickle irrigation in the whole world is steadily increasing.

Goldberg _et al_. (1976) defined the drip irrigation as a new agro-technical approach for growing crops under highly controlled conditions of soil moisture, fertilization, salinity & pest control. It has significant effect on crop response, timing of harvest and yield.

Goldberg _et al_. (1976) states that under drip irrigation, the soil moisture level does not drop much beyond field capacity. In terms of moisture stress, it means that matric tension do not exceed 30 to 50 centibars. Such low tensions are difficult to maintain with any other form of application, since water application at short intervals both by sprinkler and under gravity are impracticable. The low matric tension with drip irrigation allows the use of higher salinity levels. High salinity concentrations at the edge of trickle wetting patterns have led to many investigations into what has been as a potential salinity problem with this method of irrigation. However, in all the work reported in the literature, there is no instance where plant growth has been poorer or chloride content of the plant tissue has been significantly higher under trickle than under sprinklers. on the contrary, there are references to poorer plant growth and higher leaf chloride contents when poorer quality water is applied by sprinkler rather than trickle.

The work done by Kumar (1979) showed that by applying saline water by drip method did not affect the economic yield. However, he found that whatever be the case, less salt water always resulted in better yield. The nozzle type emitters performed well under these conditions due to their ability to spread the water on the soil surface and thereby increasing the wetted area. That is, enlarged water spread area in comparison with the micro-tubes, holes and socket type emitters.

One of the explanations offered for the beneficial effect of trickling has been the prevention of leaf scorch through the elimination of leaf wetting. This effect is especially pronounced when irrigation water is saline. But its importance in the case of non-saline water has not yet been conclusively established (Gornat et al., 1973).

To maximise production in the Southern regions of Texas with the appropriated water, automated irrigation is increasing in popularity. Citrus producers in the region tend towards drip irrigation (Ivan, 1984).

2. Drip in relation to conventional and other methods of irrigation

Abrol and Dixit (1971) compared the drip or trickle method with conventional basin irrigation in India for onions and bhindi. They found significant yield and water use efficiency increases for the drip method which were ascribed to increased availability of soil moisture at low tensions and reduced surface evaporation.

Trickle irrigation has resulted in considerable increase in water use efficiency over furrow and sprinkler irrigation (Cole, 1971; Bernstein and Francois, 1973; Hiler and Howell, 1973; Black and West, 1974; Cho et al., 1974; Freeman et al., 1976).

Much water saving can be achieved by restricting the water supply to the most efficient root zone (Dasberg and Steinhardt, 1974). On steep hills and/or under strong wind conditions, furrow and sprinkler methods are very inefficient while drip method can be very effectively practiced (Seginer, 1967 and 1969).

The experiments conducted with the vegetables and other cash crops at TNAU, Coimbatore for the past four years have shown that the water used in drip method is only about 1/2 to

1/5 of the control (surface method) and at the same time, yield is increased by 10 to 40 per cent in many crops (Sivanappan et al., 1974; Sivanappan, 1975; 1977a; 1977b; Sivanappan and Nataraj, 1976; Sivanappan and Palaniswamy, 1978).

Drip irrigation resulted in significant increase in production and water use efficiency of onion, sugarbeat and potato at Hissar and of potato at Jobner in comparison with surface irrigation (AICSRWMSS, 1975). In the case of vegetables, at Jodhpur in loamy sand, drip irrigation resulted in higher yield and water use efficiency compared to sprinkler and furrow irrigation. Only 50 per cent water applied through drip in comparison to furrow, yielded similar amount of potato tuber. Thus the water use efficiency is doubled (Singh, 1974).

Drip was superior to sprinkler irrigation, as expressed in greater annual leaf and bunch production, fruit size and total yield in date palms (Reuveni, 1974). Compared with furrow irrigation, drip irrigation gave an increased yield of 67 per cent under Sao Paulo conditions in brinjal (Vieria et al., 1974).

Sivanappan et al. (1976) reported the response of banana to drip irrigation at Coimbatore and compared it to check basin method. Analysis of data showed no significant difference in the yield of banana between the check basin method and drip irrigated plots. However, the quantity of water used in the drip irrigated plot was only one-fourth of check basin method.

Chennappa (1977) studied the response of banana to drip irrigation and compared to check basin irrigation at Hebbal, Bangalore. The results were identical to those obtained by Sivanappan et al. (1976).

No significant difference in yield of cucumber was noticed due to methods of irrigation or due to irrigation schedules (IW/CPE ratio) or their interaction, in an experiment conducted at Agronomic Research Station, Chalakudi (Annon, 1979-'80). But drip irrigation was as effective as basin irrigation. Even though the irrigation water applied in each treatment widely varied, both yield of fruits and water use efficiency had not differed significantly. It was presumed that the high amounts of precipitation received during the cropping period in comparison with irrigated water applied might have contributed to this anomaly.

The experimental results in 1981-'82 revealed that response of ash gourd to different methods of irrigation was very poor. The interaction between levels and methods of irrigation was significant. The fruit yield increased with increase in the ratio under drip whereas it increased upto 0.7 ratio (IW/CPE) and then declined under basin method. Further, the yield under basin method was higher than drip upto 0.7 ratio and at 1.0 ratio, there was a substantial reduction (Annon, 1981-'82).

Muthukrishnan et al. (1983) reported that no adverse effect on bunch weight in banana was observed although the water applied was only one-fourth of the conventional system.

According to John (1984) drip irrigation system is much less expensive to install, running about 1000 dollars an acre, compared to the over-head sprinklers which comes to about 3000 dollars an acre. There is also a difference in power requirement. Felxibility in moving the line either closer to or away from the trees to prevent excess watering is another advantage especially for young trees, grafting etc. Gravity drip system reduces energy cost.

3. Effect on different crops

This system is being adopted to almost all types of crop production (Goldferg and Shmueli, 1970; Goldgerg et al., 1971; Boaz, 1973; Gornat et al., 1973; Halevy et al., 1973; Hiler and Howell, 1973; Waterfield, 1973; Yager and Charesh, 1974; William and William, 1974).

Abrol and Dixit (1971) on irrigating onion and bhindi with drip irrigation found significant yield and water use efficiency increase which were ascribed to increased availability of soil moisture at low tensions and reduced surface evaperation.

The experiments conducted with the vegetables and other cash crops at TNAU, Coimbatore have shown an increased yield by 10 to 40 per cent (Sivanappan et al., 1974; Sivanappan, 1975; 1977a; 1977b; Sivanappan and Nataraj, 1976; Sivanappan and Palaniswamy, 1978).

Sugarbeet, potato and onion under drip irrigation at Hissary resulted in significant increase in production and water use efficiency (AICSRWMSS, 1975). Vegetable crops under drip irrigation at Jodhpur on loamy sand soil resulted in higher yield and water use efficiency (Singh, 1974).

Working on fine textured soils at Phoenix, Bucks et al. (1974) observed that maximum production of cabbage was almost identical under drip. They were of the view that drip irrigation has the potential to reduce irrigation water requirements, but not consumptive use under many field conditions.

Maize developed more rapidly and gave higher yields in drip irrigation (Goldberg et al., 1976).

Studies by Krishnan (1977) in banana showed that total leaf area and total number of leaves per plant at shooting increased significantly with increase in the available soil moisture level. Sucker production was not significantly increased by the different soil regimes. Length, weight of bunch, number of hands, number of fingers, weight of fingers etc. were significantly increased with increase in soil moisture availability. Weight and volume of fruits were also significantly increased with frequent irrigation. The total crop duration was extended with decrease in soil moisture availability. The net profit was more from the plants under frequent irrigation.

Drip system of irrigation has been found to produce better grapes and better wine. Also the system is found to be much more cost effective than other methods of irrigation as the water bills have been cut down by 35 per cent. Drip system was found to be the most ideal method for supplying the accurate quantity of water for each variety of vine (Ivan, 1983).

Muthukrishnan et al. (1983) did not observe any adverse effect on bunch weight in different methods of irrigation in banana.

Materials and Methods

MATERIALS AND METHODS

The evaluation studies were done under field conditions in a carefully laid out irrigation experiment at varying levels of water supply, using banana as the indicator crop. The whole fabrication work was done with the cheapest and locally available materials tailored to suit an ordinary farmers capacity. This system was designed for a low hydraulic head of 1 to 3 metres.

3.1 Principle of the system

Water is needed only in the root zone of crops and this is achieved through the drip irrigation system. This system avoids unnecessary wetting of soil zones not having any roots in them and minimises losses due to evaporation and deep percolation. Conveyance of water through open channels is avoided in this system which could cause a loss of 20% of water in a 100 metres long open channel under garden land conditions. Hydraulic head of one to three metres has been found to be sufficient for most areas. If the area to be irrigated is large, it should be divided into number of smaller units.

3.2 Location

The site for conducting the experiment was selected at the Banana Research Station of the Kerala Agricultural

University at Kannara. A suitable area of 75 cents was selected after studying the topography of the land in the area.

The Manali river was used as the primary source of water supply for irrigation. The static head from the source to the field was 6.3 metres. A 10 H.P. engine pumpset was used for pumping the irrigation water.

The entire area was first of all, cleaned of tall growing weeds like Chromolaena oderata Linn., Mimosa pudica Linn. etc. The soil was then ploughed and pulverised using tractor.

3.3 Field capacity and wilting percentage

Field capacity and wilting percentage of the soil in the experiment area were estimated using pressure plate apparatus. The apparatus consisted of ceramic pressure plates of high air entry values, contained in air tight metallic chamber strong enough to withstand high pressure. The porous plates were saturated first. The saturated soil samples were filled in rubber rings and they were placed on the plates. Then the plates were transferred to the metallic chamber. The plate outlet tube leaving the diaphram was connected to the outlet of the chamber. The chamber was closed using special wrenches to tighten the nuts and bolts with required torque for sealing it.

Pressure was applied from a compressor through control valves which maintained the desired pressures of 1/3 and 15 bars for determining the field capacity and wilting percentage respectively. Water started flowing out from the saturated soil samples through outlet and continued to trickle till equilibrium against the applied pressure was achieved. After that, the soil samples were taken out and oven dried and the moisture contents were determined. They were found to be 15.78% at 0.3 atmosphere and 9.2% at 15 atmosphere.

3.4 Schedule of irrigation

There was reasonable rainfall till the end of October. Life saving irrigation was given once in four days at the rate of 3 litres per plant from the middle of November. This dose was increased to 5 litres per plant for the month of December.

From the first of January, regular schedule of irrigation as per treatments was started. In the drip method, plants were irrigated every day whereas, in the basin method, the plants were irrigated once in four days. That is, a plant in treatment number one which received irrigation water at the rate of five litre per plant per day was given 20 litres once in four days. Details of quantity of water given for different treatments in basin method of irrigation are given in Table 2.

Table 1. Quantity of water applied in different treatments

Treatments	Method of irrigation	Quantity of Water/plant/day
T_1	Basin method	5 litres
T_2	Basin method	10 litres
T_3	Basin method	15 litres
T_4	Basin method	20 litres
T_5	Drip method	5 litres
T_6	Drip method	10 litres
T_7	Drip method	15 litres
T_8	Drip method	20 litres

Table 2. Quantity of water applied per irrigation in basin method

Treatments	Quantity of water/irrigation	Irrigation interval
T_1	20 litres/plant	Four days
T_2	40 litres/plant	Four days
T_3	60 litres/plant	Four days
T_4	80 litres/plant	Four days

Table 3. Schedule of life saving irrigation given during the month of November in litres

Method of irrigation	Basin				Drip			
Treatments / Dates	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15	12	12	12	12	12	12	12	12
16								
17								
18								
19	12	12	12	12	12	12	12	12
20								
21								
22								
23	12	12	12	12	12	12	12	12
24								
25								
26								
27	12	12	12	12	12	12	12	12
28								
29								
30								

Table 4. Schedule of life saving irrigation given during the month of December in litres

Method of irrigation	Basin				Drip			
Treatments / Dates	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1	20	20	20	20	20	20	20	20
2								
3								
4								
5	20	20	20	20	20	20	20	20
6								
7								
8								
9	20	20	20	20	20	20	20	20
10								
11								
12								
13	20	20	20	20	20	20	20	20
14								
15								
16								
17	20	20	20	20	20	20	20	20
18								
19								
20								
21	20	20	20	20	20	20	20	20
22								
23								
24	16.2 mm of rainfall							
25	15.6 mm of rainfall							
26								
27								
28	20	20	20	20	20	20	20	20
29								
30								
31								

Table 5. Schedule of irrigation for the month of January in litres

Method of irrigation	Basin				Drip			
Treatments / Dates	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1	20	40	60	80	5	10	15	20
2					5	10	15	20
3					5	10	15	20
4					5	10	15	20
5	20	40	60	80	5	10	15	20
6					5	10	15	20
7					5	10	15	20
8					5	10	15	20
9	20	40	60	80	5	10	15	20
10					5	10	15	20
11					5	10	15	20
12					5	10	15	20
13	20	40	60	80	5	10	15	20
14					5	10	15	20
15					5	10	15	20
16					5	10	15	20
17	20	40	60	80	5	10	15	20
18					5	10	15	20
19					5	10	15	20
20					5	10	15	20
21	20	40	60	80	5	10	15	20
22					5	10	15	20
23					5	10	15	20
24					5	10	15	20
25	20	40	60	80	5	10	15	20
26					5	10	15	20
27					5	10	15	20
28					5	10	15	20
29	20	40	60	80	5	10	15	20
30					5	10	15	20
31					5	10	15	20

Table 6. Schedule of irrigation for the month of February in litres

Method of irrigation	Basin				Drip			
Treatments / Dates	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1								
2	20	40	60	80	5	10	15	20
3					5	10	15	20
4					5	10	15	20
5					5	10	15	20
6	20	40	60	80	5	10	15	20
7					5	10	15	20
8					5	10	15	20
9					5	10	15	20
10	20	40	60	80	5	10	15	20
11					5	10	15	20
12					5	10	15	20
13					5	10	15	20
14	20	40	60	80	5	10	15	20
15					5	10	15	20
16					5	10	15	20
17					5	10	15	20
18	20	40	60	80	5	10	15	20
19					5	10	15	20
20					5	10	15	20
21					5	10	15	20
22	20	40	60	80	5	10	15	20
23					5	10	15	20
24					5	10	15	20
25					5	10	15	20
26	20	40	60	80	5	10	15	20
27					5	10	15	20
28					5	10	15	20
29					5	10	15	20

Table 7. Schedule of irrigation for the month of March in litres

Method of irrigation	Basin				Drip			
Treatments / Dates	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1	20	40	60	80	5	10	15	20
2					5	10	15	20
3					5	10	15	20
4					5	10	15	20
5	20	40	60	80	5	10	15	20
6	11.2 mm rainfall				5	10	15	20
7								
8								
9	20	40	60	80	5	10	15	20
10					5	10	15	20
11					5	10	15	20
12					5	10	15	20
13	20	40	60	80	5	10	15	20
14					5	10	15	20
15					5	10	15	20
16					5	10	15	20
17	20	40	60	80	5	10	15	20
18					5	10	15	20
19					5	10	15	20
20					5	10	15	20
21	20	40	60	80	5	10	15	20
22					5	10	15	20
23					5	10	15	20
24					5	10	15	20
25	20	40	60	80	5	10	15	20
26					5	10	15	20
27					5	10	15	20
28					5	10	15	20
29	20	40	60	80	5	10	15	20
30					5	10	15	20
31					5	10	15	20

Table 8. Schedule of irrigation for the month of April in litres

Method of irrigation	Basin				Drip			
Treatments / Dates	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1					5	10	15	20
2	20	40	60	80	5	10	15	20
3					5	10	15	20
4	12.8 mm rainfall				5	10	15	20
5	10.9 mm rainfall							
6	25.0 mm rainfall							
7								
8								
9								
10	20	40	60	80	5	10	15	20
11					5	10	15	20
12					5	10	15	20
13					5	10	15	20
14	20	40	60	80	5	10	15	20
15					5	10	15	20
16	18.8 mm rainfall				5	10	15	20
17								
18								
19								
20	20	40	60	80	5	10	15	20
21					5	10	15	20
22					5	10	15	20
23	52.1 mm rainfall				5	10	15	20
24								
25								
26								
27	20	40	60	80	5	10	15	20
28					5	10	15	20
29					5	10	15	20
30					5	10	15	20

Table 9. Schedule of irrigation for the month of May in litres

Method of irrigation / Treatments / Dates	Basin				Drip			
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1	20	40	60	80	5	10	15	20
2					5	10	15	20
3					5	10	15	20
4					5	10	15	20
5	20	40	60	80	5	10	15	20
6					5	10	15	20
7					5	10	15	20
8					5	10	15	20
9	20	40	60	80	5	10	15	20
10					5	10	15	20
11					5	10	15	20
12					5	10	15	20
13	20 15.2 mm rainfall	40	60	80	5	10	15	20
14					5	10	15	20
15					5	10	15	20
16					5	10	15	20
17	20	40	60	80	5	10	15	20
18					5	10	15	20
19					5	10	15	20
20					5	10	15	20
21	20	40	60	80	5	10	15	20
22					5	10	15	20
23					5	10	15	20
24					5	10	15	20
25	20	40	60	80	5	10	15	20
26					5	10	15	20
27					5	10	15	20
28					5	10	15	20
29	20 1.2 mm rainfall	40	60	80	5	10	15	20
30								
31								

There were a few showers during the month of April and May. It was scheduled in such a way that 5 mm of rainfall substituted a days irrigation with a maximum limit of 4 days gap before the next irrigation. The details can be seen in Tables 3 to 9.

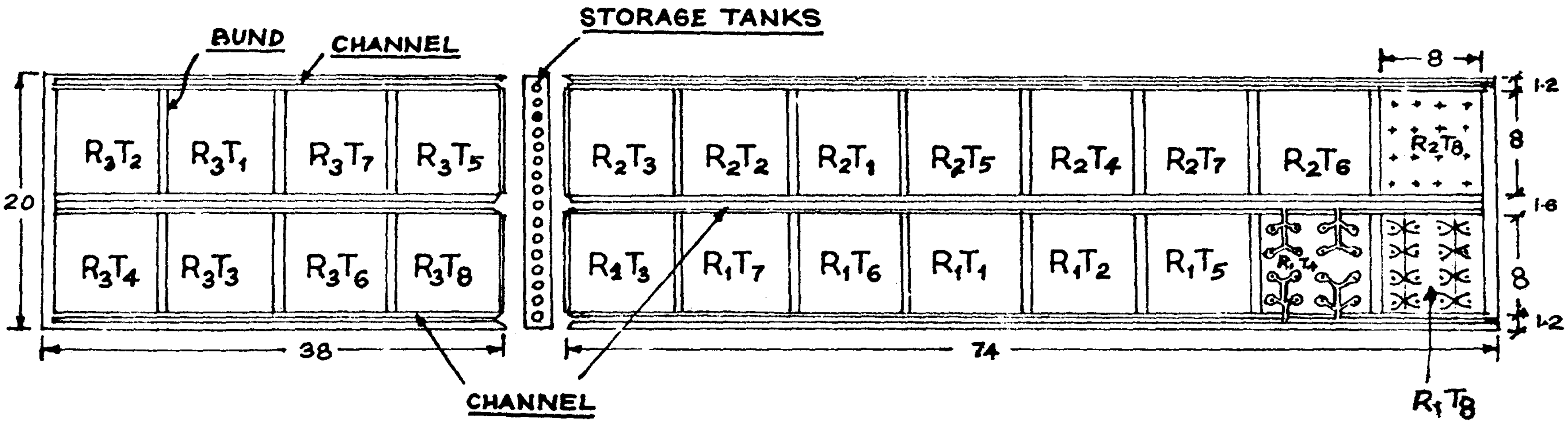
Irrigation was given till the end of May after which there was sufficient rainfall.

3.5 Layout

There were altogether 8 treatments and 3 replications. Treatments were laid out by randomised block design. Detailed layout is given in Fig. 1.

Optimum plant to plant distance of 2 metres was given. There was a total distance of 3 metres between plants in two different treatments.

Nendran variety of banana was selected for the experiment. 384 uniform suckers were selected and planted. The uniformity of the suckers were ensured by calculating the weight girth index of each of them and selecting the suckers coming within the middle range. Very big and small suckers were rejected. Manurial application, weeding, plant protection measures etc. were carried out according to the package of practices. Few plants were affected by kokkan disease for which there was no preventive or curative measure. Fortunately they were not the treatment plants.



ALL DIMENSIONS IN METRES

SCALE 1:500

LAY-OUT OF THE EXPERIMENTAL FIELD

FIG. 1

There were altogether 16 plants in a plot, out of which, the 4 plants in the centre were the experimental plants and the rest served as buffers, thus constituting a total number of 384 plants in 24 plots.

The suckers were planted on the 10th of October, 1983. Biometric observations like the length of leaves, breadth of leaves, height of plants, girth of plants etc. were taken just before the commencement of the irrigation season, at the time of flowering and at harvest. The weight of bunches, number of hands and number of fingers were also noted during harvest.

The leaf area for banana was calculated using the formula developed at the Banana Research Station itself based on the work done there. The formula is,

$$A = 0.825 \times L \times B$$ (Rajeevan et al., 1985)

A = area of the leaf (cm^2)

L = length of the leaf (cm)

B = breadth of the leaf (cm)

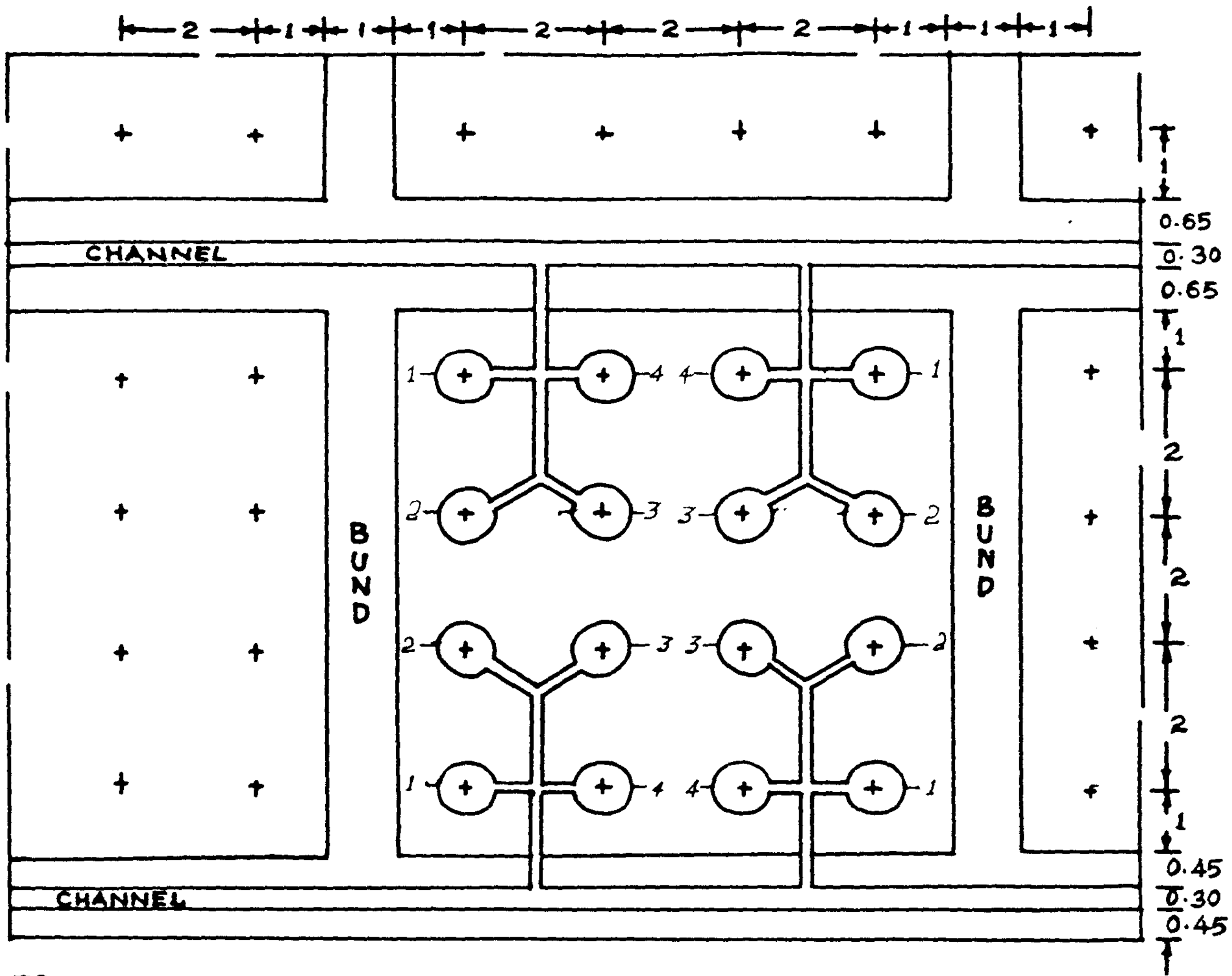
3.6 Irrigation channels

Irrigation channels of 30 cm width were made on either sides of the treatment plots. 45 cm wide bunds were provided on either sides of these channels. The outer ends of the channels were left open to allow the excess water to flow out.

Flexible hose pipe connected to the main pumping line was used to discharge water into each main channel.

As shown in the figure the sub-channel conveying water from the main channel to the basin were so designed as to give exact quantity of water to the experimental plants. Each treatment in a replication contained 16 plants of which four were experimental plants and 12 were buffer plants receiving the same quantity of water as the experimental plants. Even if there was slight variation in the quantity of water applied to the buffer plants, it was very important that the treatment plants received the exact quantity of water. In order to achieve this objective, the sub-channels and main channels were laid out in the following manner. Main channels ran on both sides of each treatment. As can be seen from Fig. 2 eight plants received irrigation from one main channel while the other eight plants in the same treatment received irrigation from the main channel on the other side. From the main channel, two sub-channels conveyed water to the basin of eight plants in each treatment, one sub-channel catering to the needs of four plants.

The location of the measuring device, the orifice plate, in all the cases were in the main channel, a little above the sub-channel. The sub-channels would be dry at the beginning of each irrigation and a considerable quantity of water would be lost by infiltration. This would cause error in the quantity of water applied to each basin. In order to



1, 2 & 4 – BUFFER PLANTS.

3 - TREATMENT PLANT.

SCALE 1:100

ALL DIMENSIONS IN METRES

FIG. 2. DETAILS OF A CHECK BASIN PLOT

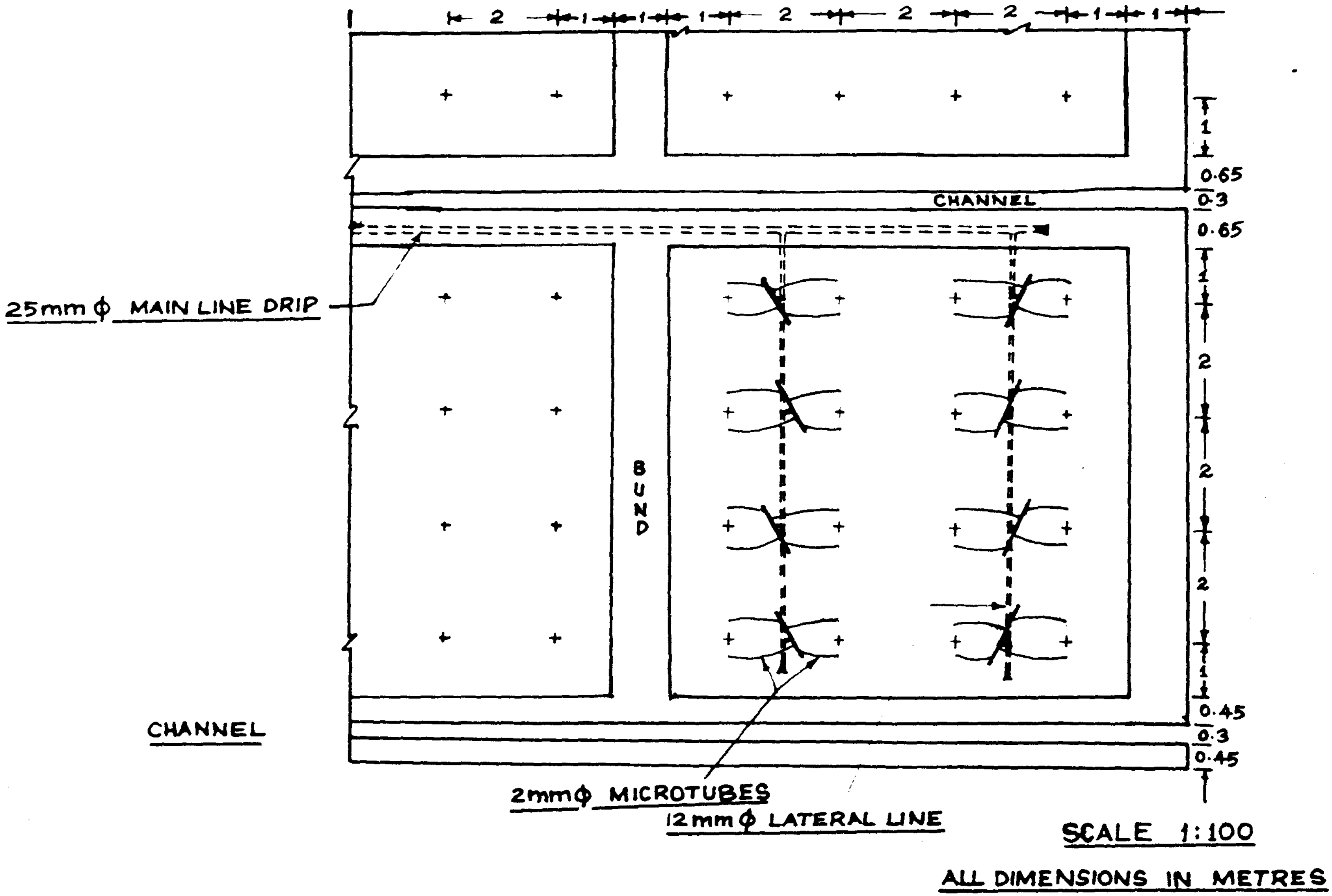


FIG 3. DETAILS OF A DRIP PLOT

minimise this error, the following sequence of irrigation was followed.

Plant No.1 which was a buffer plant was irrigated first. Then plant No.2 which again was a buffer plant was irrigated. The time taken to irrigate these two plants was sufficient to saturate the sub-channel surface and thereby minimising the losses due to infiltration. Then the treatment plant was irrigated by metering the exact quantity of water. The fourth plant was then irrigated and the sub-channel was closed. There would always be some water left in the sub-channel which would go into the basin of the fourth plant and cause some error in the quantity of water. The above sequence of operation minimised the error in the quantity of water applied to the experimental plant.

Water was diverted into the main channel from the pumping line. Keeping all the sub-channels closed, water was allowed to flow out from the other end of the channel. After attaining a constant rate of flow in the channel, each sub-channel was opened one by one placing the orifice plate across the main channel on the upstream side of the sub-channel. The head on the orifice plate was noted and each of the four basins to be irrigated by this sub-channel was opened one by one for the required time. The required time was calculated for each head depending on the treatment.

The required time for each treatment calculated for different heads is given in Appendix-II.

3.7 Measurement of irrigation water

Circular orifice plates were used to measure the flow into the individual basins of the banana plant. Orifice plate is a simple device to measure comparatively small flows accurately.

The orifice plate consisted of a small iron sheet of 20 gauge thickness with accurately machined circular orifices or openings of 4.7, 6.6 and 9 cm in diameter. Fig. 4 shows the construction details of the orifice plate. This orifice plate was capable of accurately measuring any flow between 0.5 and 4.3 litres per second within a head loss range of 1.2 to 6.6 cm. The edge of the openings were not sharpened as this was a thin walled orifice plate. Plastic scales were fixed directly on the upstream and downstream faces with their zero readings coinciding with the centre of the orifice. The formula used is given below:

$Q = CA\sqrt{2gh}$, which for litres per second can be written as

$$Q = 0.0443\ Cd.a.\ \sqrt{h}$$

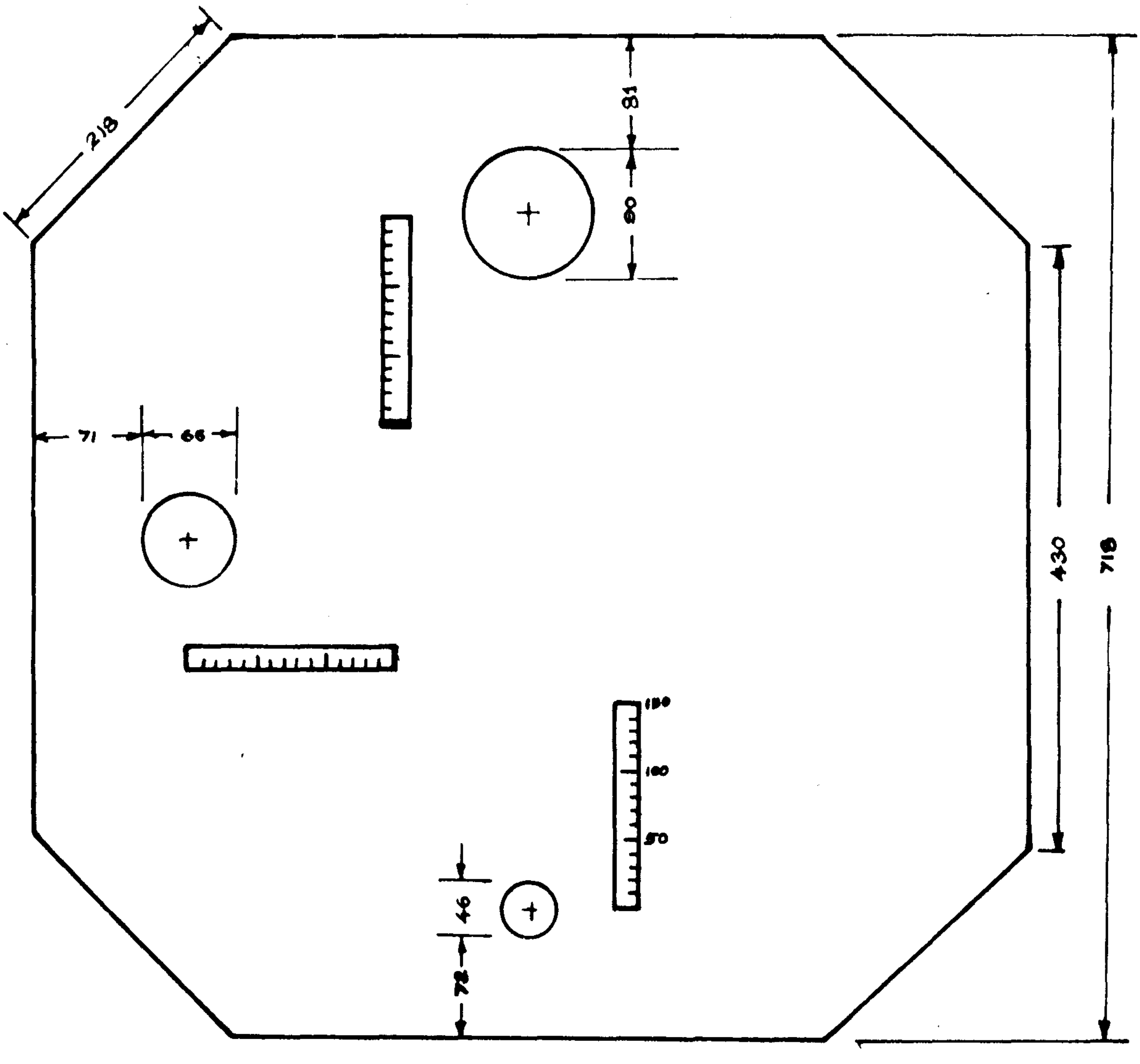


FIG. 4. ORIFICE PLATE

Q = Discharge through orifice in litres/second

Cd = Coefficient of discharge which is 0.61 when thin plates of about 20 gauge thickness is used

a = Area of cross-section of the orific in cm^2

g = Acceleration due to gravity in cm/sec^2

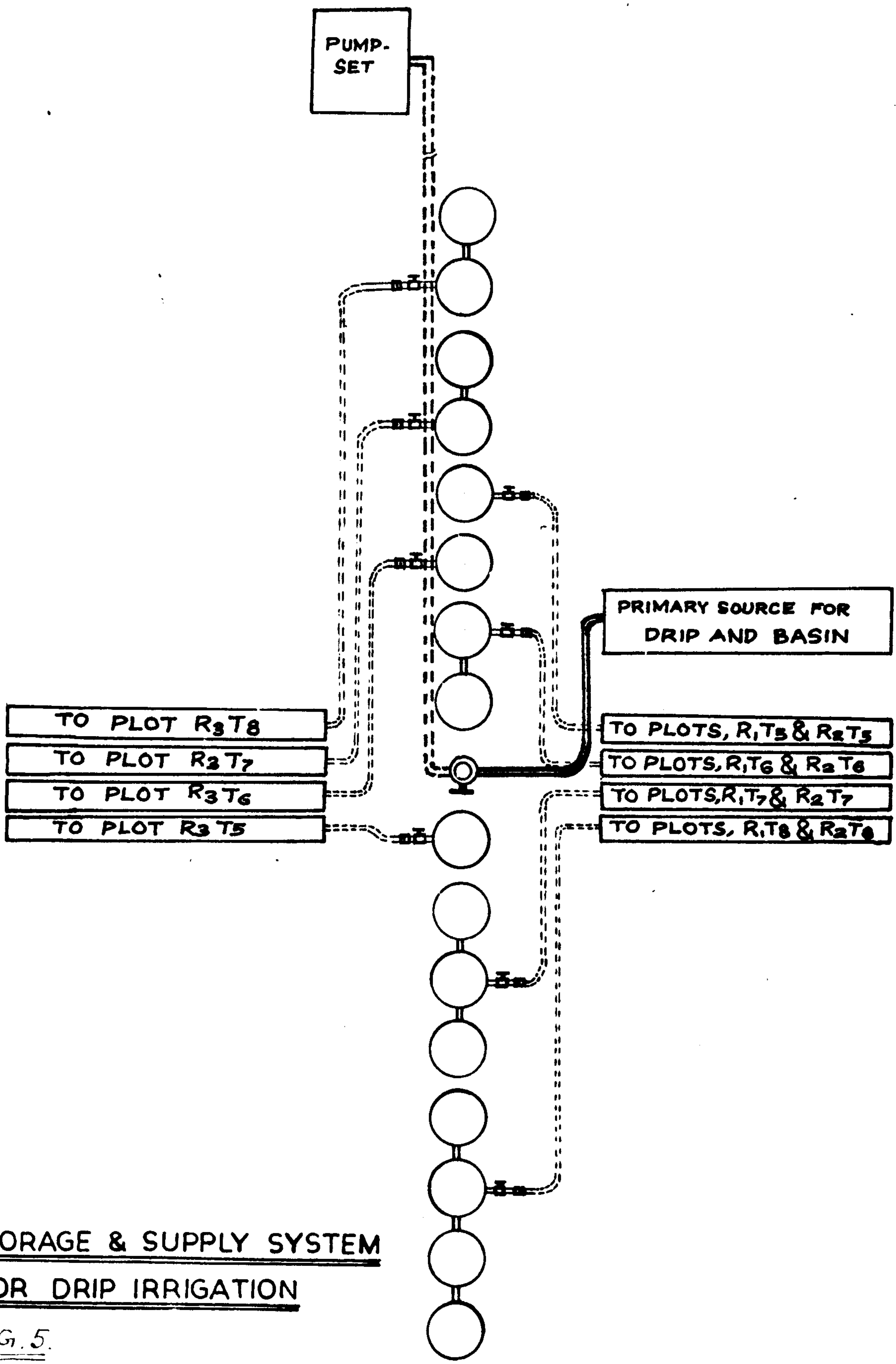
H = Head differential measured in centimetres

Appendix-II directly gives the time of flow required for irrigation of different treatments under different heads.

These orifice plates have several advantages. They are simple, inexpensive, and easy to install. Small streams can be measured with a minimum head differential or restriction to flow, thereby minimising the increase in the wetted perimeter of the furrow above the measuring point and the probability of overtopping. With reasonable care in setting and reading, the margin of error in the measurements will not exceed 5 per cent.

3.8 Storage tank

Oil drums of 200 litres capacity were used as storage tanks for the drip irrigation system. Since two replications were on one location and the third replication was on the opposite side of the pumping main line, two sets of drums were required to irrigate each treatment. In treatment number eight where 20 litre of water was applied for each



STORAGE & SUPPLY SYSTEM FOR DRIP IRRIGATION

FIG. 5.

Table 10. Number of drums used for each treatment in replications I, II and III for the drip system

Treatments	R_I and R_{II}		R_{III}	
	Total quantity of water stored/day	No.of drums used	Total quantity of water stored/day	No.of drums used
T_5	160 litres	One	80 litres	One
T_6	320 litres	Two	160 litres	One
T_7	480 litres	Three	240 litres	Two
T_8	640 litres	Four	320 litres	Two

plant per day, a total quantity of 320 litres of water was required to irrigate the 16 plants in it. As two replications were at the same site, 640 litres of water was required to be stored for irrigating the plants in these two replications. For storing 640 litres of water, four drums were required. For interconnecting the four drums, 25 mm threaded G.I. pipes were welded to the drums 3 cm above the bottom. The drums were connected together using unions. 3 cm space above the bottom was given to allow the suspended impurities to settle down and thus protecting the system from clogging by particles of dust and suspended impurities. The drums were filled in the evening and the valves were opened only the next day morning for irrigation, thus giving a settling time of 12 hours. This gave sufficient time for the settlement of all the larger suspended particles which would clog the system. The drums were given two coatings of rust proof water resistant paint. Covers made of G.I. sheets were also provided for the drums to prevent leaves and other foreign particles falling inside them.

The outlet from the drum was controlled by a wheel valve connected to a 20 cm long, threaded 25 mm G.I. pipe welded to the drum 3 cm above its bottom. About 5 cm length of this pipe extended into the drum for attaching the plastic wire mesh filter for preventing larger floating impurities getting into the pipe when the water level in the drum came

PLATE 1

Storage tanks for the drip irrigation

PLATE 2

Layout of the experimental field with the main channel in between two replications

PLATE 3
Drip irrigated plot

PLATE 4
Main channel for basin irrigation

in level with the outlet pipe at the end of irrigation. Fine mesh filter made of plastic was used for this purpose. As this system worked on low pressure, any small air lock in the system would stop the flow of water. To prevent this, an air vent was provided in the system. The air vent was fabricated by connecting a 25 mm x 12 mm Tee joint immediately after the wheel valve. Through a hose collar a 12 mm plastic pipe was connected to the Tee joint and the outlet of this pipe was kept 15 cm above the top of the drum. When the valve was opened, air in the system escaped through this air vent. Till all the air escaped, water could be seen spurting out of the air vent. It took about 2 to 3 minutes for expelling all the air in the system. The drums were placed on an elevated bund, 1.5 metres high, thus providing a minimum head of 1.5 metres even when the drums were nearly empty. This head was found to be sufficient for the satisfactory working of the system.

3.9 Mains and laterals

25 mm and 12 mm black low density polyethylene pipes were used for main and lateral pipes respectively. The laterals were connected to the main pipe by using 25 mm x 12 mm G.I. Tees. 25 mm hose collars were connected to the 25 mm hose pipe wherever laterals were to be taken out. The threaded side of the hose collar was connected to the G.I. Tee. 12 mm hose collars connected to the G.I. Tee provided

the connections for the laterals. The main line was extended by providing another hose collar of 25 mm diameter on the other side of the Tee joint. In places where laterals were to be taken out on both sides of the main line, one more additional joint of the similar type was provided. The main line and laterals were embedded at a depth of 20 cm below the ground. This was to prevent the black pipes from absorbing and transmitting heat to the irrigation water. This arrangement also prevented damages to the pipes during cultural operations.

3.10 Micro-tubes

In this system, micro-tubes without any additional attachment functioned as the drippers or emitters. The micro-tubes were connected to the laterals by drilling holes having slightly lesser diameter than the external diameter of the micro-tubes, and pushing the micro-tube into these holes for a tight fit. These joints were leak proof as the system worked on low pressure. The micro-tubes attached to the lateral was connected to a distributor.

3.11 Distributor

The heart of this drip irrigation system was the distributor developed at the Agronomic Research Station, Chalakudy in the year 1977. The rate of discharge of the micro-tube connected to the lateral was about 10 to 12 litres

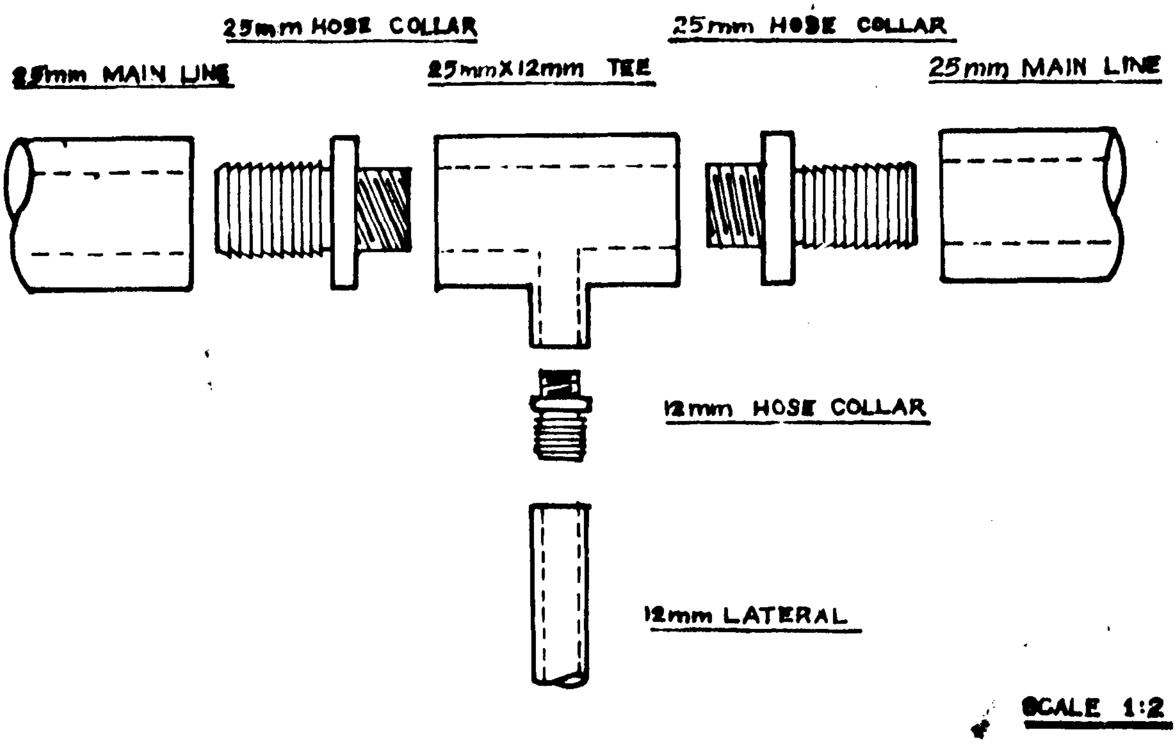


FIG. 6. TEE ASSEMBLY FOR MAIN TO LATERAL CONNECTION

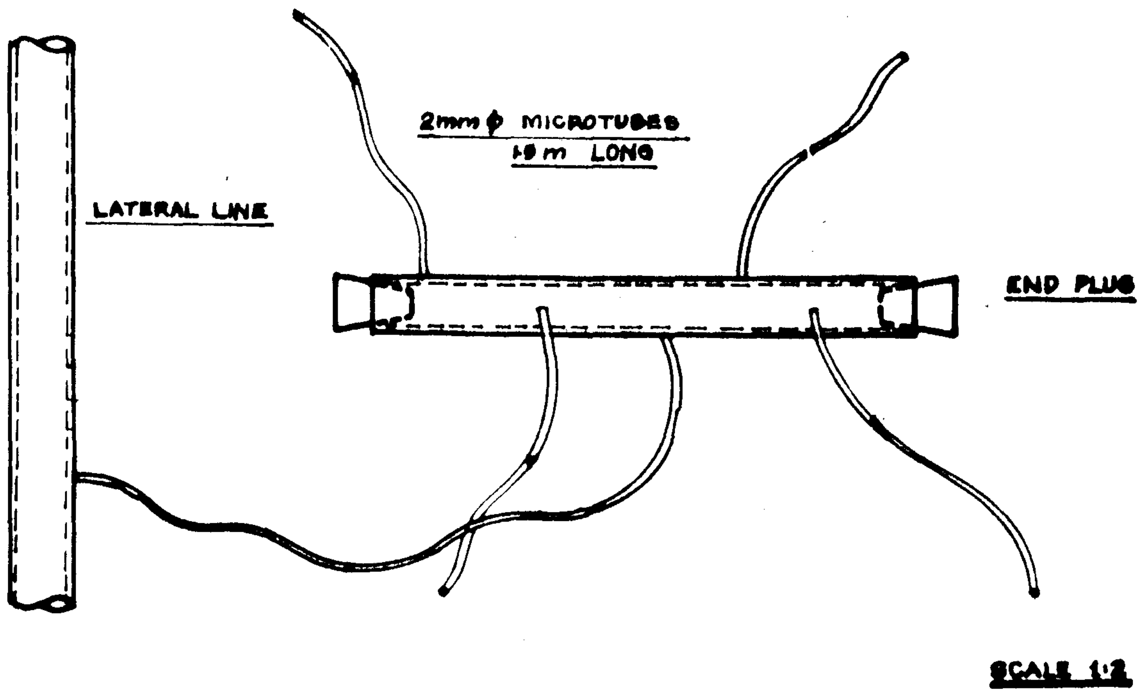


FIG. 7. DISTRIBUTOR

per hour. This rate of discharge was on the higher side. The average discharge of a conventional drip irrigation system is 1.5 to 3 litres per hour. The function of the distributor was to reduce this high discharge of 10 to 12 litres per hour to about 1 to 2 litres per hour. The disadvantage of the high discharge was that a larger surface area would be wetted and thereby increasing the evaporation loss and reducing the efficiency of system. Distributor was made from a 15 cm long, 12 mm diameter polyethylene pipe plugged at both ends with cork or wood. The micro-tubes were connected to the distributor in the same manner as they were connected to the lateral. From the distributor, four micro-tubes, about 1½ metre long, were taken out, which functioned as the drippers. The discharge from each dripper was about 2 litres per hour. One banana plant was irrigated by two micro-tube drippers positioned 50 cm away from the plant stem on both sides. Water leak at joints, displacement of laterals, non-functioning of the drip holes, improper fittings etc. were rectified then and there. The tips of the microtubes were kept raised above the ground surface by tying to stakes fixed on the ground. This was done to prevent clogging caused by soil particles or small insects entering the microtubes and blocking the exit. Another advantage of keeping the dripper above the ground was that any clogging in any micro-tube could be immediately noticed.

The height of the micro-tube tips, tied to the stakes were raised or lowered to get the final accurate discharge and to maintain uniformity. The discharge from the micro-tube were very sensitive to the variation in height.

3.12 Discharge of micro-tubes

The discharge from the micro-tubes were maintained at 2 litres per hour. The discharge could be varied by

1. Changing the hydraulic head by raising or lowering the storage tank
2. Varying the length of micro-tubes by which the frictional head is changed
3. Changing the diameter of the micro-tubes
4. Raising or lowering the microtube tips on the stakes

Results and Discussion

RESULTS AND DISCUSSION

4.1 Initial soil characteristics

The physical characteristics of the soil were determined

4.1.1 Bulk density:

The bulk density of the soil was found to be 1.3 gm/cc as given in Table 11.

4.1.2 Field capacity and wilting point:

The average field capacity and wilting percentage were observed to be 15.78% at 0.3 amosphere and 9.2% at 15 atmosphere respectively. The data are shown in Table 12 and Table 13.

4.2 Uniformity of suckers planted

The weight girth index of the suckers planted were statistically analysed and there was no significant difference among them.

4.3 Flowering

No significant difference in the number of days taken for flowering was observed among the treatments in either drip or basin method of irrigation. However treatment T_8 with 20 litre per plant per day in drip method on an average flowered earlier than the other treatments in all

Table 11. Estimation of bulk density of soil

Weight of core sampling cylinder (Kg)	Weight of cylinder + moist soil (Kg)	Weight of cylinder + dry soil (Kg)	Weight of dry soil (3) - (1) (Kg)	Volume of cylinder (cc)	Bulk density $\frac{(4)}{(5)}$x100 (gm/cc)
(1)	(2)	(3)	(4)	(5)	(6)
1.45	2.65	2.35	0.90		1.358
1.45	2.71	2.17	0.72	$\frac{\pi}{4} \times 7.5^2 \times 15$ = 662 cc	1.086
1.45	2.32	2.42	0.97		1.464

Mean bulk density = 1.302 gm/cc

Table 12. Determination of field capacity

Weight of moisture can (gm)	Weight of can + wet soil (gm)	Weight of can + dry soil (gm)	Weight of dry soil (3) - (1) (gm)	Weight of moisture (2) - (3) (gm)	Moisture content $\frac{(5)}{(4)} \times 100$ (gm)
(1)	(2)	(3)	(4)	(5)	(6)
48.20	80.50	76.05	27.85	4.45	15.98
46.40	78.50	74.25	27.85	4.25	15.26
46.80	75.20	71.27	24.47	3.94	16.10

Mean field capacity = 15.78 per cent

Table 13. Determination of wilting point

Weight of moisture can (gm)	Weight of can + wet soil (gm)	Weight of can + dry soil (gm)	Weight of dry soil (3) - (1) (gm)	Weight of moisture (2) - (3) (gm)	Moisture content $\frac{(5)}{(4)} \times 100$ (gm)
(1)	(2)	(3)	(4)	(5)	(6)
42.80	72.85	70.40	2.45	27.60	8.88
45.25	77.20	74.36	2.84	29.11	9.75
43.25	76.49	73.75	2.74	30.50	8.98

Mean wilting point = 9.2 per cent

replications. Treatment T_1, with 5 litresper plant per day in basin method was the last to flower in all replications.

4.4 <u>Weight of bunches on harvest</u>

The weights of bunches harvested from T_3, T_4, T_7, and T_8 treatments which received 15 and 20 litres per plant per day by both basin and drip methods were significantly higher than the treatments T_1, T_2, T_5 and T_6 which received only 5 and 10 litres per plant per day. The 15 and 20 litres per plant treatments in both the methods of irrigation were on par.

4.5 <u>Number of days between planting and harvest</u>

Plants in T_7 and T_8 treatments which received 15 litres and 20 litres per day by drip method of irrigation were harvested first. These two treatments were significantly different from the rest. Treatments T_1 and T_5 were harvested last. T_2, T_3, T_4 and T_6 were on par as far as the days to harvest were concerned.

4.6 <u>Height of plants at harvest</u>

T_3 and T_4 treatments were the tallest and they were significantly different from the rest. T_7 and T_8 treatments which received 15 and 20 litres per plant per day by drip method were the second tallest and were on par with the plants which received 10 litres per plant in the basin

Table 14. Weight-girth index of suckers planted

Treatments	Replications		
	R_1	R_2	R_3
T_1	152.0	161.5	67.8
T_2	149.4	193.3	60.3
T_3	255.3	204.5	87.9
T_4	130.4	146.7	81.8
T_5	137.6	158.4	97.5
T_6	168.0	124.1	102.9
T_7	181.0	142.2	91.2
T_8	112.1	117.2	109.4

C.D. = 52.8481

S.E.M. = 17.4216

Table 15. Observation on the number of days taken for flowering

Treatments	Replications			Mean
	R_1 (Days)	R_2 (Days)	R_3 (Days)	(Days)
T_1	289	278	296	287.7
T_2	263	276	269	269.3
T_3	247	263	259	256.3
T_4	264	272	255	263.7
T_5	281	279	249	269.7
T_6	259	260	296	271.7
T_7	254	259	260	257.7
T_8	241	253	264	252.7

C.D. = 21.7995

S.E.M. = 7.1863

Table 16. Weight of bunches

Treatments	Replications			Mean
	R_1 (Kg)	R_2 (Kg)	R_3 (Kg)	(Kg)
T_1	2.1	3.2	3.5	2.9
T_2	3.4	3.1	2.8	3.1
T_3	7.5	8.1	5.5	7.0
T_4	6.5	7.9	8.0	7.5
T_5	1.7	2.3	2.8	2.3
T_6	3.3	2.9	5.0	3.7
T_7	7.4	7.3	6.3	7.0
T_8	8.2	7.1	7.0	7.4

C.D. = 1.5451

S.E.M. = 0.5094

Table 17. Number of days between planting and harvest

Treatments	Replications			Mean
	R_1 (Days)	R_2 (Days)	R_3 (Days)	(Days)
T_1	355	351	358	354.7
T_2	338	350	348	345.33
T_3	347	350	348	348.33
T_4	346	340	338	341.33
T_5	358	358	351	355.67
T_6	336	342	348	342.00
T_7	332	335	328	331.67
T_8	328	332	332	330.67

C.D. = 7.6353

S.E.M. = 2.5170

Table 18. Height of plants at harvest

Treatments	Replications			Mean
	R_1 (cm)	R_2 (cm)	R_3 (cm)	(cm)
T_1	243	228	239	236.7
T_2	279	309	264	284.0
T_3	340	324	338	334.0
T_4	329	317	340	328.7
T_5	230	224	240	231.3
T_6	254	249	281	261.3
T_7	302	307	283	297.3
T_8	312	271	291	291.3

C.D. = 26.5731

S.E.M. = 8.7599

Table 19. Girth of plants at harvest

Treatments	Replications			Mean
	R_1 (cm)	R_2 (cm)	R_3 (cm)	
T_1	60	59	58	59.0
T_2	59	56	60	58.7
T_3	61	60	62	61.0
T_4	61	59	63	61.0
T_5	56	58	57	57.0
T_6	54	56	57	55.7
T_7	57	63	61	60.0
T_8	63	59	60	60.7

C.D. = 3.4157

S.E.M. = 1.1260

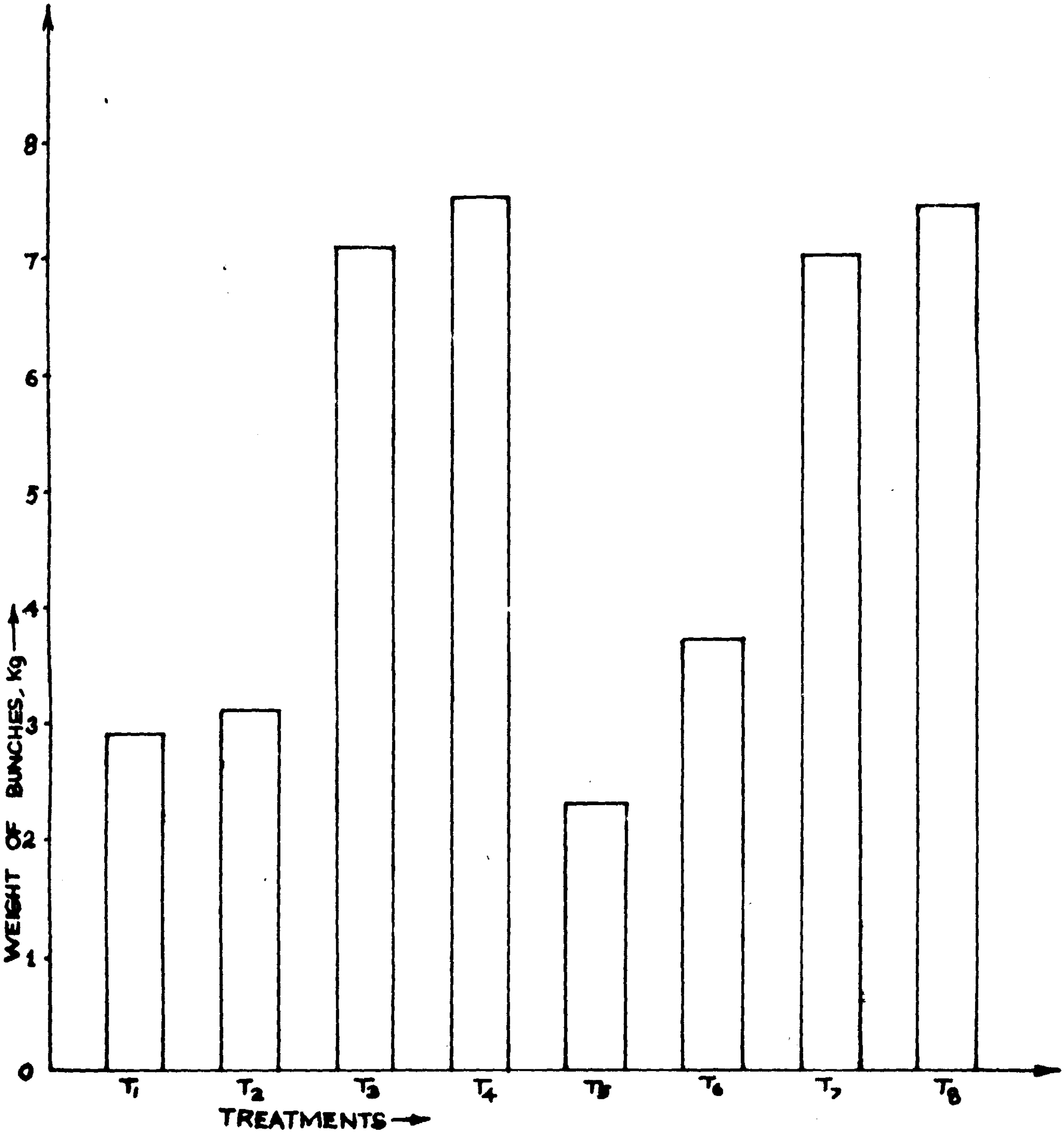


FIG.8. SCALE 2cm = 1 unit (Y axis)

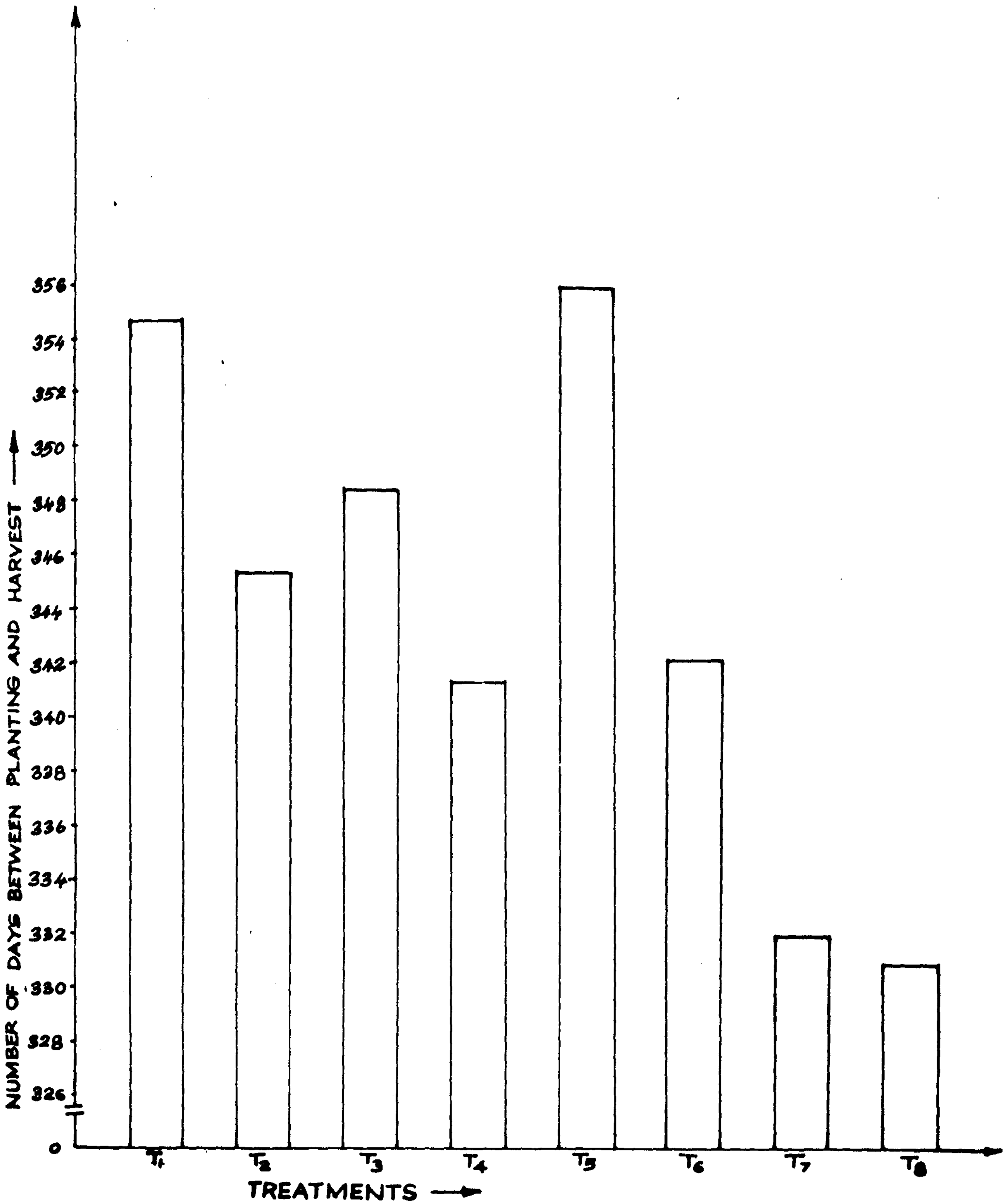


FIG.9. SCALE 1cm = 2 days (Y-axis)

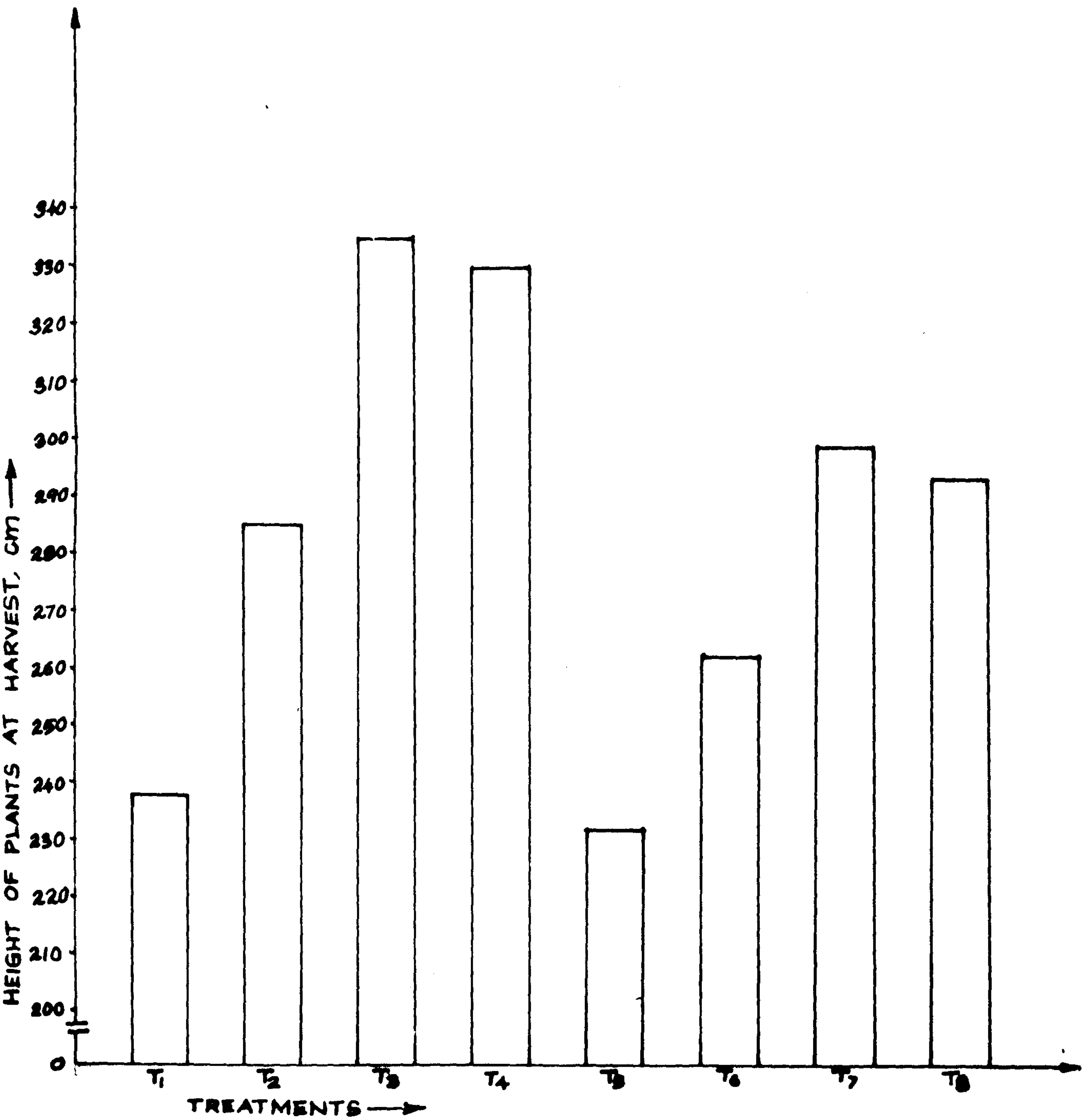


FIG. 10 SCALE 1:10 (Y-AXIS)

method. The plants which received 10 litres per plant per day were on par in both the methods of irrigation. The treatments T_1 and T_5 were significantly inferior to other treatments.

4.7 Girth of plants at harvest

Plants which received 15 and 20 litres of irrigation water in both the methods showed the maximum girth though the difference was not significant.

There was no significant difference in the leaf area of plants in different treatments.

The drip irrigation system installed for the experiment worked very well throughout the irrigation period. Clogging was not at all a serious problem as in the case of drip nozzles or emitters and wherever clogging occured, they were cleared by gently tapping the micro-tubes three or four times. Expensive filter units were thus eliminated in this system.

It was seen that there was very little weed growth in the drip irrigated plots compared to the basin irrigated plots as the wetted surface area was lesser in the former case. This would considerably reduce the labour cost incurred for weeding operations in the plots irrigated by drip method.

All the materials required for this system were purchased locally and could be assembled by an ordinary labourer without any difficulty. No adhesives were required as this system worked on los pressure and the micro-tubes were connected by the push fit method as explained in the earlier chapter.

From the results obtained in the yield or bunch weight of banana, it was observed that there was no significant difference between the basin method of irrigation and drip method of irrigation. Results obtained in the other parts of the country and elsewhere in the world revealed that the drip method of irrigation is superior to the other surface methods of irrigation both in the case of vegetative growth and yield. This has been observed both in perennial and annual crops. However, experiments conducted on banana by Sivanappan et al. (1976) showed no significant difference in the yield, between the check basin method and drip irrigated plots. Chennappa (1977) studied the response of banana to drip irrigation and compared to check basin irrigation at Hebbal, Bangalore. The results were identical to those obtained by Sivanappa et al. (1976). But Muthukrishnan et al. (1983) reported that no adverse effect on bunch weight in banana was observed although the water applied was only one-fourth of the conventional system.

The results of this study agreed with the results obtained by the above workers. Drip irrigation was in no way superior to the conventional basin method of irrigation as far as yield was concerned at least in the case of banana. The reason for this could be the high frequency of irrigation of banana even in the conventional method. The moisture content of the soil is kept high throughout the growing season even in the conventional method.

During irrigation in a hectare of land there will be on an average 100 metres of wetted irrigation channel at a time. The observations taken in the channel at two points 100 metres apart gave a loss of 0.372 litre per second in that length. This was 18.6 per cent of the original discharge. The total quantity of water required for a hectare of 2500 plants at the rate of 15 litres per plant is 37,500 litres and the loss at the rate of 18.6 per cent from this is 6,975 litres. An additional number of 465 plants can be irrigated using this quantity of water.

As given in the appendix, the yearly expenditure in operating a drip irrigation system for irrigating one hectare of banana during one irrigation season consisting of about 150 days comes to Rs.4,098. This includes both fixed costs and variable costs.

The total expenditure for irrigating one hectare of banana by basin method of irrigation comes to Rs.8,400. The details of this are given in Appendix-I(b).

By adopting drip method of irrigation, there is a net saving of Rs.4,302 per year per hectare.

The advantages of drip irrigation observed during the experiment were:

1. In drip irrigation system, practically no water is lost in conveyance. It was found that the average loss of water in the basin method of irrigation while irrigating one hectare of land was 18.6 per cent. In other words this means that if drip irrigation is adopted, additional area can be brought under irrigation with the same quantity of water.

2. Weed growth was found to be less in the plots irrigated by drip method. The reason for this was that only a small percentage of the surface area was wetted by drip and only in this wetted area, there was weed growth. In the basin method of irrigation, the entire surface area was wetted and this caused weed growth in the whole area.

3. Since only a small area was wetted, surface evaporation was considerably restricted.

4. Small quantities of water available in shallow wells and tanks during dry season could be effectively utilised for raising crops which would not be possible in the other surface methods of irrigation because large amount of water would be lost in conveyance.

5. By adopting drip irrigation, there would be a saving of Rs.4,302 per year per hectare as explained earlier.

The special advantages of K.A.U. drip irrigation system over the conventional drip irrigation system are:

1. Special skill is not required for the fabrication, installation, maintenance and operation of K.A.U. drip irrigation system.

2. All materials required for the fabrication of the system are readily available in the local market.

3. Repair and rectification of faults can be done in the field itself.

4. Clogging was not a serious problem in this system, while in the conventional system, clogging of the drippers is a serious problem.

5. Since this system works ov very low pressure, the pipes and tubings used would last longer than in the case of conventional system.

6. As the K.A.U. drip irrigation system is considerably cheaper than the conventional system, the cost benefit ratio would be high in this case.

The disadvantage of the K.A.U. drip irrigation system is that, unlike in the conventional drip irrigation system which can cover a large area and can be fully automated, this can cover only a small area of one to two hectares as this system works on low head. If the head is increased, it may cause leaks at joints.

Hydraulics of K.A.U. drip irrigation system may be taken up in the future line of work. Relative efficiency evaluation of this drip system with the conventional method of irrigation with respect to other crops may also be studied at a later stage.

Summary

SUMMARY

Water being a limited resource, its efficient use is basic to the survival of the ever increasing population of the world. Land and water are the two basic needs for progress in agriculture and economic development of any country. The demand for these resources are increasing day by day. Therefore, scientists are on the look out for new techniques for maximising the efficiency in water use. This is where the drip irrigation system has a vital part to play.

The main principle of the drip irrigation system is that water is needed only in the root zone of crops. This system avoids unnecessary wetting of soil zones not having any roots in them and minimises losses due to evaporation and deep percolation.

The evaluation studies of the drip and basin methods of irrigation were done under field conditions at varying levels of water supply in Nendran variety of banana. There were 8 treatments and 3 replications. The experiment was laid out by randomised block design. Adequate spacing between plants and channels were provided to avoid the seepage of irrigation water from one treatment to another. Each treatment in a replication contained 16 plants of which 4 were experimental plants.

Circular orifice plates were used in the main channel to measure the flow into the basins of each plant.

The whole fabrication work of the drip irrigation system was done with the cheapest and locally available materials. Oil drums of 200 litres capacity were used as storage tanks for the drip system. 25 mm and 12 mm black low density polyethylene pipes were used for main and lateral lines respectively. These lines were embedded at a depth of 20 cm below the ground surface to prevent the absorption and transmission of heat to the irrigation water.

Micro-tubes of 2 mm diameter were used as drippers or emitters. The micro-tubes were connected to the laterals by drilling holes having slightly lesser diameter than the external diameter of the micro-tubes and pushing the micro-tubes into these holes for a tight fit. These joints were leak proof as the system worked on low pressure. The micro-tube attached to the lateral was connected to a distributor.

The heart of this drip irrigation system was the distributor developed at the Agronomic Research Station, Chalakudy in the year 1977. The distributor reduced the discharge per emitter to about 1 to 2 litres per hour. It distributed water to 4 micro-tube emitters.

The micro-tube tips were tied to stakes fixed at about 50 cm from the stem of the plant, the height of which were adjusted to get the required discharge. The discharge could also be varied by, changing the length of the micro-tubes, changing the diameter of the micro-tubes and also by varying the hydraulic head. Two micro-tubes supplied water to each plant in this experiment

Drip irrigated plots were irrigated every day and the basin irrigation was given, once in four days. In both the methods, plants were irrigated at the rate of 5,10,15 and 20 litres per plant per day.

The physical characteristics of the soil in the experimental field were studied and the bulk density was found to be 1.3 gm/cc. The average field capacity and wilting percentage were 15.78 and 9.2 respectively.

There was no significant difference in the number of days taken for flowering between different treatments.

Plants irrigated with 15 and 20 litres of water per day in both the treatments gave significantly higher yield at harvest.

Plants in T_7 and T_8 treatments which received 15 and 20 litres per day by drip method of irrigation were harvested first. The difference was statistically significant. There was no significant difference in the girth and leaf area of plants in different treatments.

The results of this study agreed with the results obtained by the other research workers in India. Drip irrigation was in no way superior to the conventional basin method of irrigation as far as yield was concerned at least in the case of banana. The reason for this could be the high frequency of irrigation of banana even in the conventional method. The moisture content of the soil is kept high throughout the growing season even in the conventional method. However, there was considerable saving of water in drip method compared to basin method of irrigation, because conveyance losses were minimised.

The yearly expenditure in operating a drip irrigation system for irrigating one hectare of banana comes to Rs.4098.

The total expenditure for irrigating one hectare of banana by basin method comes to Rs.8400.

By adopting drip method of irrigation, there is a net saving of Rs.4302 per year per hectare.

In drip irrigation system, practically no water is lost in conveyance. This means that additional area can be brought under irrigation with the same quantity of water by adopting drip irrigation.

Special skill is not required for the fabrication, installation, maintenance and operation of the K.A.U. drip irrigation system. All the materials required for the fabrication of the system are readily available. Repair and rectification of faults can be done in the field itself. Clogging was not a serious problem in this system. Since this system works on low pressure, the pipes and tubings used would last longer than in the case of conventional system.

The drip irrigation system installed for the experiment worked very well throughout the irrigation period.

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Appendices

Appendix-I(a) Cost of installing K.A.U. drip irrigation system for banana in one hectare (Rs.)

Item	Qty.	Unit	Rate	Amount
1. Main line 50 mm black polyethylene pipe	100	Metre	12.00	1,200.00
2. Lateral line 12 mm black ployethylene pipe	2500	Metre	1.00	2,500.00
3. G.I. Tee 50 mm x 12 mm	50	No.	35.00	1,750.00
4. C.I. Hose collar 50 mm	100	No.	8.00	800.00
5. C.I. Hose collar 12 mm	50	No.	2.00	100.00
6. Wheel valve 50 mm	1	No.	150.00	150.00
7. Micro-tube 2 mm dia	7500	Metre	0.15	1,125.00
8. Laying cost	20 Labourers	No.	25.00	500.00
9. Miscellaneous expenses				375.00
Total				8,500.00
10. Cost of tank for 40 m^3 capacity				10,000.00
Grand total				18,500.00

Reasonable life period of materials like pipes, Tees etc. is 8 years. The depreciation on these items will be $\frac{(8500)}{8}$ = 1063 per year. The salvage value of these materials at the end of 8 years will be practically insignificant and hence ignored.

Appendix-I(a) (Contd.)

Assuming that the life of tank is 20 years, the depreciation will be Rs.500 per year.

Interest on the capital at the rate of 11 per cent for the total amount of Rs.18,500 will be Rs.2,035. Therefore, the annual fixed cost is Rs.3,598.

Once the system is laid out, practically no labour is required to operate the system. However, for supervision, pumping water into the tank and removal of clogging, about one hour's work will be required per day. For an irrigation season of 150 days, 150 man hours will be required. This is approximately equal to 20 man days, which will involve a recurring expenditure of Rs.500 per year.

The details of expenditure for operating the drip irrigation system is given below:

<u>Fixed cost</u>

1.	Depreciation of pipes, Tees etc.	Rs.1,063.00
2.	Depreciation on tank	Rs. 500.00
3.	Interest on capital	Rs.2,035.00
	Total	Rs.3,598.00

<u>Variable cost</u>

1.	Labour for operating the system	Rs. 500.00
	Total operating cost	Rs.4,098.00

Appendix-I(b) **Cost of irrigating one hectare of banana by basin method**

About 40 labourers will be required to layout the irrigation channels and basins in one hectare.

One person can divert water into the basins of about 275 to 325 banana plants. In a hectare, there are 2,500 plants and about 8 labourers will be required for irrigating one hectare of banana. If the irrigation schedule is once in four days, for an irrigation season of 150 days, 37 irrigation will be required.

The detailed cost for irrigating one hectare of banana by basin method is given below:

1.	Number of labourers required for the layout of channels and basins		= 40
2.	Number of persons required for irrigating the basin crop during one irrigation season	= 37 x 8	= 296
3.	Total number of labourers required	= 296 + 40	= 336
	Cost at the rate of Rs.25 per labourer	= 336 x 25	= 8,400.00

The fixed and variable costs involved in operation of the pumping system has not been taken into account while calculating the above operating costs as this is common to both the methods.

Appendix-II(a) **Time of flow required for different treatments under different heads using the 4.7 cm diameter orifice of the plate**

Head (cm)	Discharge Lit/Sec	Time of flow for different treatment plots					
		20 Lit/ plant	40 Lit/ plant	60 Lit/ plant		80 Lit/ plant	
				Min.	Sec.	Min.	Sec.
2.0	0.67	29.85 Sec	59.7 Sec	1	30	2	00
2.1	0.68	29.41 Sec	58.8 Sec	1	30	2	00
2.2	0.70	28.60 Sec	57.2 Sec	1	26	1	54
2.3	0.71	28.20 Sec	56.4 Sec	1	25	1	53
2.4	0.73	27.40 Sec	54.8 Sec	1	22	1	50
2.5	0.74	27.00 Sec	54.0 Sec	1	21	1	48
2.6	0.76	26.30 Sec	52.6 Sec	1	19	1	45
2.7	0.77	26.00 Sec	52.0 Sec	1	18	1	44
2.8	0.78	25.77 Sec	51.4 Sec	1	17	1	43
2.9	0.80	25.00 Sec	50.0 Sec	1	15	1	40
3.0	0.81	24.70 Sec	49.4 Sec	1	14	1	39
3.1	0.83	24.00 Sec	48.0 Sec	1	12	1	36
3.2	0.84	24.00 Sec	48.0 Sec	1	12	1	36
3.3	0.85	23.50 Sec	47.0 Sec	1	11	1	34
3.4	0.86	23.30 Sec	47.0 Sec	1	10	1	33
3.5	0.87	23.00 Sec	46.0 Sec	1	9	1	32
3.6	0.90	22.20 Sec	44.4 Sec	1	7	1	29
3.7	0.90	22.00 Sec	44.0 Sec	1	6	1	28
3.8	0.91	22.00 Sec	44.0 Sec	1	6	1	28
3.9	0.93	21.50 Sec	43.0 Sec	1	5	1	26
4.0	0.94	21.30 Sec	42.6 Sec	1	4	1	25

Appendix-II(a) (Contd.)

Head (cm)	Discharge Lit/Sec	Time of flow for different treatment plots 20 Lit/ plant	40 Lit/ plant	60 Lit/ plant Min.	Sec.	80 Lit/ plant Min.	Sec.
4.1	0.95	21.0 Sec	42.0 Sec	1	3	1	24
4.2	0.96	20.8 Sec	41.6 Sec	1	2	1	23
4.3	0.97	20.6 Sec	41.2 Sec	1	2	1	22
4.4	0.98	20.4 Sec	40.8 Sec	1	1	1	22
4.5	0.99	20.2 Sec	40.4 Sec	1	1	1	21
4.6	1.00	20.0 Sec	40.0 Sec	1	0	1	20
4.7	1.00	20.0 Sec	40.0 Sec	1	0	1	20
4.8	1.03	19.4 Sec	39.0 Sec	0	58	1	18
4.9	1.04	19.2 Sec	38.4 Sec	0	58	1	17
5.0	1.05	19.0 Sec	38.0 Sec	0	57	1	16
5.1	1.06	18.7 Sec	37.4 Sec	0	56	1	15
5.2	1.07	18.7 Sec	37.4 Sec	0	56	1	15
5.3	1.08	18.5 Sec	37.0 Sec	0	56	1	14
5.4	1.10	18.2 Sec	36.0 Sec	0	56	1	13
5.5	1.10	18.0 Sec	36.0 Sec	0	54	1	12
5.6	1.11	18.0 Sec	36.0 Sec	0	54	1	12
5.7	1.12	18.0 Sec	36.0 Sec	0	53	1	11
5.8	1.13	17.7 Sec	35.0 Sec	0	53	1	10
5.9	1.14	17.5 Sec	35.0 Sec	0	52	1	9
6.0	1.15	17.3 Sec	35.0 Sec	0	52	1	9
6.1	1.16	17.2 Sec	34.4 Sec	0	51	1	8
6.2	1.17	17.0 Sec	34.0 Sec	0	51	1	8

Appendix-II(a) (Contd.)

Head (cm)	Discharge Lit/Sec	Time of flow for different treatment plots					
		20 Lit/ plant	40 Lit/ plant	60 Lit/ plant		80 Lit/ plant	
				Min.	Sec.	Min.	Sec.
6.3	1.18	16.9 Sec	33.8 Sec	0	51	1	7
6.4	1.19	16.8 Sec	33.6 Sec	0	50	1	7
6.5	1.20	16.6 Sec	33.3 Sec	0	50	1	6
6.6	1.20	16.5 Sec	33.0 Sec	0	49	1	6
6.7	1.20	16.4 Sec	32.6 Sec	0	49	1	5
6.8	1.21	16.3 Sec	32.2 Sec	0	48	1	4
6.9	1.23	16.0 Sec	32.0 Sec	0	48	1	4

Appendix-II(b) Time of flow required for different treatments under different heads using the 6.6 cm diameter orifice of the plate

Head (cm)	Discharge Lit/Sec	Time of flow for different treatment plots			
		20 Lit/ plant	40 Lit/ plant	60 Lit/ plant	80 Lit/ plant
3.0	1.6	12.5 Sec	25.0 Sec	37.5 Sec	50.0 Sec
3.5	1.7	11.6 Sec	23.1 Sec	34.7 Sec	46.3 Sec
4.0	1.8	10.8 Sec	21.6 Sec	32.5 Sec	43.3 Sec
4.5	1.9	10.2 Sec	20.4 Sec	30.6 Sec	40.8 Sec
5.0	2.0	9.7 Sec	19.4 Sec	29.0 Sec	38.7 Sec
5.5	2.2	9.2 Sec	18.5 Sec	27.7 Sec	37.0 Sec
6.0	2.3	8.8 Sec	17.7 Sec	26.5 Sec	35.3 Sec
6.5	2.4	8.5 Sec	17.0 Sec	25.5 Sec	34.0 Sec
7.0	2.4	8.2 Sec	16.5 Sec	24.5 Sec	32.7 Sec
7.5	2.5	7.9 Sec	15.8 Sec	23.7 Sec	31.6 Sec

Appendix-III Observation on the day the irrigation started - height of the plants

Treatments	Replications			Mean
	R_1 (cm)	R_2 (cm)	R_3 (cm)	
T_1	107.3	114.0	104.5	108.6
T_2	130.0	129.0	109.3	122.8
T_3	154.5	149.0	128.0	143.8
T_4	115.8	127.0	112.8	118.5
T_5	111.3	101.5	110.8	107.9
T_6	131.0	117.8	125.0	124.6
T_7	134.5	109.3	95.3	113.0
T_8	116.8	128.3	114.5	119.9

Appendix-IV Observation on the day the irrigation started - girth of the plants (cm)

Treatments	Replications R_1 (cm)	R_2 (cm0	R_3 (cm)	Mean (cm)
T_1	29.0	30.5	29.5	29.7
T_2	35.3	33.8	29.8	33.0
T_3	40.8	40.5	30.0	37.1
T_4	32.5	34.8	32.3	33.2
T_5	31.8	30.3	32.5	31.5
T_6	38.8	38.3	36.3	37.8
T_7	37.8	32.5	26.3	32.2
T_8	36.5	36.8	34.0	35.8

Appendix-V Observation on the day the irrigation started - length of leaves (cm)

Treatments	Replications			Mean
	R_1 (cm)	R_2 (cm)	R_3 (cm)	(cm)
T_1	93	93	95	93.7
T_2	130	106	97	111.0
T_3	122	126	105	117.7
T_4	105	108	112	108.3
T_5	111	95	105	103.7
T_6	115	104	111	110.0
T_7	115	103	93	103.7
T_8	108	113	113	111.3

Appendix-VI Observation on the day the irrigation started - breadth of the leaves (cm)

Treatments	Replications			Mean
	R_1 (cm)	R_2 (cm)	R_3 (cm)	(cm)
T_1	43	48	44	45.0
T_2	50	49	45	48.0
T_3	54	56	52	54.0
T_4	46	50	48	48.0
T_5	49	46	48	47.7
T_6	53	50	52	51.7
T_7	55	47	45	49.0
T_8	51	54	49	51.3

Appendix-VII Observation on the day the irrigation started - number of functioning leaves

Treatments	Replications			Mean
	R_1	R_2	R_3	
T_1	12	13	12	12.3
T_2	13	13	12	12.7
T_3	13	14	12	13.0
T_4	13	13	11	12.3
T_5	13	14	13	13.3
T_6	14	13	12	13.0
T_7	14	13	13	13.3
T_8	13	14	12	13.0

Appendix-VIII Observation on the day the irrigation started - total number of leaves

Treatments	Replications			Mean
	R_1	R_2	R_3	
T_1	13	18	17	16.0
T_2	18	19	16	17.7
T_3	18	20	17	18.3
T_4	17	18	17	17.3
T_5	18	19	18	18.3
T_6	18	18	19	18.3
T_7	19	18	18	18.3
T_8	18	19	18	18.3

Appendix-IX Observation on the day of flowering - height of the plant

Treatments	Replications R_1 (cm)	R_2 (cm)	R_3 (cm)	Mean (cm)
T_1	232	218	224	224.7
T_2	253	279	255	262.3
T_3	309	213	321	281.0
T_4	304	310	309	307.7
T_5	211	207	227	215.0
T_6	241	235	272	249.3
T_7	289	285	266	280.0
T_8	288	252	271	270.3

Appendix-X Observation on the day of flowering - girth of the plant

Treatments	Replications			Mean
	R_1 (cm)	R_2 (cm)	R_3 (cm)	(cm)
T_1	56	62	54	57.3
T_2	64	62	59	61.7
T_3	63	57	66	62.0
T_4	64	62	62	62.7
T_5	52	53	56	53.7
T_6	54	57	50	53.7
T_7	60	57	54	57.0
T_8	58	57	62	59.0

Appendix-XI Observation on the day of flowering - number of leaves

Treatments	Replications			Mean
	R_1	R_2	R_3	
T_1	13	14	12	13.0
T_2	15	14	13	14.0
T_3	14	15	16	15.0
T_4	13	16	13	14.0
T_5	13	13	14	13.3
T_6	14	13	13	13.3
T_7	15	14	15	14.7
T_8	13	15	14	14.0

Appendix-XII Observation on the day of flowering - length breadth and area of leaves

Treatments	R_1			R_2			R_3			Mean area (cm^2)
	Length (cm)	Breadth (cm)	Area (cm^2)	Length (cm)	Breadth (cm)	Area (cm^2)	Length (cm)	Breadth (cm)	Area (cm^2)	
T_1	188	60	9306	187	58	8948	144	48	5702	7985.3
T_2	200	54	8910	183	55	8304	185	54	8242	8485.3
T_3	183	50	7549	170	50	7013	201	60	9950	8170.7
T_4	163	56	7531	203	53	8876	200	63	10395	8934.0
T_5	146	50	6023	149	56	6884	158	60	7821	6909.3
T_6	157	44	5699	166	49	6711	150	55	6806	6405.3
T_7	180	57	8465	175	55	7941	145	48	5742	7382.7
T_8	185	31	4731	162	51	6816	196	64	10348	7298.3

C.D. = 2903.35

S.E.M. = 957.1

Appendix-XIII Observations at the time of harvest - number of functioning leaves

Treatments	Replications			Mean
	R_1	R_2	R_3	
T_1	2	1	1	1
T_2	2	2	2	2
T_3	2	2	3	2
T_4	2	3	2	2
T_5	1	2	2	2
T_6	1	2	2	2
T_7	1	2	2	2
T_8	2	3	2	2

Appendix-XIV Observations at the time of harvest - number of hands per bunch

Treatments	Replications			Mean
	R_1	R_2	R_3	
T_1	4	5	5	5
T_2	5	5	4	5
T_3	5	5	5	5
T_4	5	5	5	5
T_5	4	4	5	4
T_6	4	4	5	4
T_7	5	4	5	5
T_8	4	4	5	4

Appendix-XV Observations at the time of harvest - number of fingers per bunch

Treatments	Replications R_1	R_2	R_3	Mean
T_1	30	33	27	30.0
T_2	44	26	28	26.0
T_3	44	53	49	48.7
T_4	48	53	50	50.3
T_5	30	32	36	32.7
T_6	30	30	32	30.7
T_7	48	53	41	47.3
T_8	40	38	34	37.3

RELATIVE EFFICIENCY EVALUATION OF DRIP AND BASIN METHODS OF IRRIGATION IN BANANA

By

KOSHY VARGHESE

ABSTRACT OF A THESIS

submitted in partial fulfilment of
the requirement for the degree

Master of Science in Agricultural Engineering

Faculty of Agriculture
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COLLEGE OF HORTICULTURE
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1985

ABSTRACT

Well planned and efficiently utilised irrigation systems help to keep the food production in pace with the increasing population. Hence it is essential to design and adopt an efficient low cost economic irrigation system tailored to fit the local potential and needs.

Out of the efficient methods of irrigation, drip method is the most promising. Drip irrigation is comparatively new to our country and needs popularisation.

The relative efficiency and feasibility of a low cost drip irrigation system fabricated with the cheapest and locally available materials in relation to the conventional basin method of irrigation is tested in this experiment taking banana as the indicator crop.

Plants were irrigated at the rate of 5, 10, 15 and 20 litres per day in both the methods of irrigation.

Oil drums of 200 litres capacity were used as storage tanks for the drip irrigation system. 25 mm and 12 mm (dia) black low density polyethylene pipes were used for main and lateral lines respectively which were embedded at a depth of 20 cm below the ground surface.

Micro-tubes of 2 mm diameter were used as drippers or emitters.

The heart of this drip system was the distributor developed in K.A.U. which could deliver irrigation water at a slow rate of 1 to 2 litres per hour from each micro-tube.

Physical characteristics of the soil and bio-metric observations of the plants were taken during the experiment.

It was observed that there was no significant difference in the yield of plants under the drip and basin methods of irrigation. Similar results were obtained by Sivanappan et al. (1976) and Chennappa, (1977).

The economy of the system was studied and it was found that, by adopting drip method of irrigation, there is a net saving of Rs.4302 per year in one hectare.

Weed growth was found to be less in the plots irrigated by drip method. Special skill is not required for the fabrication, installation, maintenance and operation of the K.A.U. drip irrigation system.