EVALUATION OF DRIP AND CONVENTIONAL METHODS OF IRRIGATION IN AMARANTHUS AND BRINJAL

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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Kelappaji College of Agricultural Engineering and Technology, Tavanur

1988

DECLARATION

I hereby declare that this thesis entitled "Evaluation of Drip and Conventional Methods of Irrigation in Amaranthus and Brinjal" 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.

Sheela E V N

Vellanikkara,
March 1983.

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CERTIFICATE

Certified that this thesis entitled "Evaluation of Drip and Conventional Methods of Irrigation in Amaranthus and Brinjal" is a record of research work done independently by Smt. Sheela, E.V.N. 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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ACKNOWLEDGEMENTS

I express my deep sense of gratitude to Professor T.P. George, Chairman of my advisory committee and Dean in-charge, Kelappaji College of Agricultural Engineering and Technology, Kerala Agricultural University, Tavanur, for his valuable guidance and constant encouragement since I joined this University and during the preparation of this thesis.

I am greatly indebted to Shri. K. John Thomas, Professor and Head, Department of Irrigation and Drainage Engineering; Shri. C.P. Mohammed, Professor and Head; Shri Jippu Jacob, Associate Professor (on deputation), Department of Farm Power Machinery and Energy, Kelappaji College of Agricultural Engineering and Technology, Tavanur for their valuable help and suggestions as members of advisory committee.

I am specially indebted to Dr. K.V. Peter, Professor and Head, Department of Olericulture, College of Horticulture, Vellanikkara for his valuable advice and guidance as member of advisory committee.

I am highly grateful to Shri. M.P. Sankaranarayanan and Mrs. K.P. Visalakshi, Assistant Professors, College of Horticulture, Vellanikkara and Shri. M.S. Hajilal, Junior Assistant Professor, Kelappaji College of Agricultural Engineering and Technology and post-graduate scholars of the

Department of Agricultural Engineering, College of Horticulture, Vellanikkara for their whole-hearted help rendered during the course of this project.

I express my sincere gratitude for the help extended by the staff members of the Agricultural Engineering Workshop, Mannuthy.

I thank the Kerala Agricultural University for the award of Junior Fellowship during my post-graduate programme.

The timely help and loving encouragements extended by friends and relatives, especially Mrs. and Dr.P.A. Peethambaran is highly cherished.

Finally, I extend my sincere and heartfelt gratitude to my family members, especially to my husband Sri. P.B. Devadas who has been a guiding force throughout my studies.

SHEELA, E.V.N.

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ABBREVIATIONS

Agric.	Agricultural
ASAE	American Society of Agricultural Engineers
cc	Cubic centimetre(s)
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)
hr	hour
ICAR	Indian Council of Agricultural Research
IRRI	International Rice Research Institute
ISAE	Indian Society of Agricultural Engineers
J	Journal
kg	Kilogram(s)
l	Litre(s)
min	Minute(s)
mm	Millimetre(s)
MS	Mild Steel
MSS	Mean sum of squares
No.	Number
pp	pages
Proc.	Proceedings
Res.	Research
Rs.	Rupees
SS	Sum of squares
sec	Second(s)
Sl.	Serial
/	per
%	Per cent

Introduction

INTRODUCTION

Irrigation is an age old art, as old as civilisation. The increasing need for crop production for the growing population demands the rapid expansion of irrigation systems throughout the world. Water, being a limited resource, its efficient use is very vital for the survival of the ever increasing population of the world. Economic and social development depend upon increased agricultural production. Land and water are the two basic needs for progress in agriculture. Since there is no scope for expanding the extent of cultivable land appreciably, the productivity of the land has to be increased by some means. Presently the availability of water being limited for irrigation purposes, the efficiency of utilisation of water has to be increased by adopting modern methods of irrigation. Out of the efficient methods of irrigation, drip method is by far superior without any doubt. Drip irrigation has proven to be a promising technique for providing precise application of water without wastage. This system is gaining momentum among researchers and farmers. The drip irrigation system, by name is found to have originated in the 1960's in Israel.

From time immemorial, gravity irrigation by way of flooding in furrows and various forms of basins have been practised all over the world. Under the surface systems, water infiltrates into the soil while traversing and also while standing in the furrows, borders or basins, which depends on the quantity, duration and rate of stream flow, the gradient, soil texture and structure. The overall irrigation efficiency in the surface method on an average comes to only 25 to 60 per cent. Loss of water occurs due to seepage, evaporation and deep percolation. Additionally it leads to problems such as erosion, salination and water logging which ultimately reduce the productivity of land.

In recent years advanced methods of water application like drip irrigation have received attention throughout the world. In this system water is delivered to each plant at its root zone through a net work of tubes. It works under low or medium pressure and only the required quantity of water is provided daily in order to avoid water stress to the plant. The basic principle used in developing the system was the maintenance of plants under minimum moisture stress by keeping the soil at or near field capacity by application of water at frequent intervals. The efficiency of drip irrigation is very high as it supplies water at the right place in the correct quantity at the right time.

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 for the installation, operation and maintenance of the pressure feed system, pressure control system and filter units are the other bottlenecks encountered in this system.

Considering these problems, the Kerala Agricultural

University at its Agronomic Research Station, Chalakudy, in the year 1977 developed a low cost drip irrigation system. In this system locally available materials are used. It requires no special skill in its fabrication, installation or operation. This system works on very 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. The distributors developed at the Agronomic Research Station, Chalakudy are connected to the laterals through the microtubes. Water flows into the distributor at the rate of 10 to 20 litres per hour. The function of the distributor is to reduce the high discharge. From the distributor four microtube outlets are taken out which acts as 'drippers' emitting water at the rate of 1 to 5 litres/hour. The microtubes are connected to the laterals and distributors by drilling holes having smaller diameter than the external diameter of the microtube 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 can be made very easily. The rate of flow of each dripper can be controlled by varying the length of the microtube.

The total initial cost of the equipment is only 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 amaranthus and brinjal.

Review of Literature

REVIEW OF LITERATURE

A brief review of literature on studies conducted in drip and other methods of irrigation are summarised below:

Drip or trickle irrigation can be defined as the daily maintenance of an adequate section of the root zone of a plant at or near field capacity during the growing and productive cycle. Drip irrigation is the fore-runner of a soil-less culture system which uses the soil as an anchorage only and not as a food reservoir (Barry Larkman, 1971). Drip irrigation is a multidisciplinary agricultural practice and has enormous potential and possibilities (Goldberg, 1971).

The basic principle of drip irrigation is to replace water and sometimes nutrients used by plants during the previous day and to supply these requirements without wastage or stress to the plant (Swan and Coffman, 1971).

Drip or trickle irrigation is one of the recent methods of irrigation, becoming increasingly popular in areas with water scarcity and salt problems. In this method, irrigation is accomplished through a net-work of tubes. The system applies water slowly to keep the soil moisture within the desired range for plant growth. Experiments conducted to compare drip irrigation with conventional surface irrigation showed that the former saves upto 80% water, reduces weed growth, improves germination and gives the same or sometimes more yield (Sivanappan, 1977a). Four drip irrigation treatments with moisture levels 35, 50, 65 and 80% of available water produced 20 to 40% more marketable yield than furrow irrigation and 80% more than the non-irrigated control (Lin et al., 1983). Drip irrigation with an automatic controller saved 80% of water and nutrients compared with sprinkler fertilization (Hildman et al., 1985). Drip irrigation resulted in considerable increase in water use efficiency over furrow and sprinkler irrigation (Cole, 1971; Bernstein and Francois, 1973; Miller and Newell, 1973; Black and West, 1974; Freeman et al., 1976).

Much water saving is achieved by restricting the water supply to the extent of the most efficient root zone (Dasberg and Steinhardt, 1974). On steep hills, furrow irrigation and under strong wind condition, sprinkler irrigation are very ineffective with respect to water saving (Seginer, 1967 and 1969). An experiment was laid out to compare the efficiency of drip irrigation. Initial observations indicated that vegetables like amaranthus and bhindi respond well to drip irrigation (Anon., 1977-78). 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, Chalakudy (Anon., 1979-80). But drip irrigation was as effective as basin irrigation. Eventhough 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 contributed to this anomaly.

Cucumbers were drip irrigated to evaluate the water requirement and effect of silver coated plastic mulch on crop performance. The moist treatment gave significant increase in crop yield compared to wet and dry treatments. The use of plastic mulch further enhanced production by 4.6 t/ha (Goyal and Allison, 1983). The experimental results during 1981-82 revealed that response of ash gourd to different methods of irrigation was not significant. 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 Iw/CPE ratio 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 substantial reduction under basin method (Anon., 1981-82). Yields of tomatoes under drip irrigation were double that of sprinkler irrigation. Apart from this, the fruit was more uniform which meant less grading and sorting (Grobellaar, 1971).

Tomato crop at Coimbatore yielded 9 t/acre under drip system as compared to the corresponding control yield of 7 t/acre. The savings in water obtained by drip irrigation for different crops vary from 60 to 80%. From the results obtained, it was seen that drip method saved not only the water but yield was also increased. At present, the economy of adopting the drip method does not attract the average farmer as it comes to nearly Rs.3000/acre (Sivanappan and Padmakumari, 1980). Abrol and Dixit (1971) compared the drip method with conventional basin irrigation in India for onion and Bhindi. They found significant yield and water use efficiency increase for the drip method, ascribed to increased availability of soil moisture at lower tensions and reduced surface evaporation.

Drip irrigation resulted in significant increase in production and water use efficiency of onion, sugar beet and potato at Hissar in comparison with surface irrigation (AICSRWM83, 1973-1978). One carrot and two onion varieties were drip and sprinkler irrigated. Drip yields were greater than sprinkler yields when equal gross amounts of water were used. Drip irrigated onion and carrots were larger on an average than the sprinkler irrigated onions and carrots (Melstad and De Boer, 1983).

Working on fine textured soil at Phoenix, Bucks et al. (1974) observed that maximum production of cabbage was almost identical under drip and furrow irrigation. They viewed that drip irrigation has the potential to reduce irrigation water requirements but not consumptive use of water under many field conditions. In case of vegetables at Jodhpur on loamy sand soil, drip irrigation resulted in higher yield and water use efficiency than sprinkler and furrow irrigation. Only 50% water applied through drip in comparison to furrow yielded similar amount of potato tuber. Thus the water use efficiency was doubled (Singh, 1974). The experiments conducted with vegetables and cash crops at Tamil Nadu Agricultural University, Coimbatore for the past three years showed that the water used in drip method was only 1/2 to 1/5 of the control (surface method) and at the same time yield was increased by 20 to 40% in many crops (Sivanappan et al., 1974; Sivanappan, 1975; 1977a; 1977b; Sivanappan and Natarajan, 1976; Sivanappan and Palaniswamy, 1978).

The work done by Koshy Varghese at Kerala Agricultural University (1985) showed that there was no significant difference in the yield of banana under drip and basin methods of irrigation. The number of days taken for flowering were not significant between different treatments in the above study. The trial on banana conducted at Coimbatore showed that eventhough the yield was reduced by 2 kg/plant, the water saving was 3/4th of the control system. It was also noticed that plants in the plot irrigated by drip method flowered earlier than those in control (Sivanappan et al., 1976).

An observational trial conducted on pappaya at Tamil Nadu Agricultural University, with drip and control methods showed the yield in drip plot was increased by 69%. The use of water in this case was only 73.35 cm while in control method water used was 228.5 cm excluding rainfall in both the cases (Sivanappan and Padmakumari, 1980). Field trials demonstrated a response to drip irrigation in terms of plant growth and yields of a range of fruits, vegetables and forest trees in comparison with other methods. While the root development of tomato was reduced under drip irrigation, that of other crops was greater in comparison with traditional methods. Drip irrigation had no adverse effect on soil structure (Zerbig and Chiaranda, 1979). In a field study in Maryland, U.S.A., drip and travelling gun sprinkler irrigation system were compared on six fruit crops. The total initial cost of the trickle irrigation system was 50% of the cost of sprinkler system. The trickle system used 54% less water and 74% less energy than the sprinkler in supplying the same amount of water to the same crop (Funt et al., 1978).

The drip irrigated apple orchard produced 81.8 % more total yield than during the previous season when it was flood irrigated (Grobellaar, 1971). In case of drip irrigated grapes for wine production, a tremendous yield increase (190%) was obtained compared to the production of previous years which was flood irrigated. The drip irrigated guavas contained 3% more suger than the sprinkler irrigated guavas.

An experimental area of drip irrigation on wine grapes at Great Western Victoria gave 30% more fruit yield (Smart, 1971). Experiments conducted in Hen River Valley grapes showed that drip irrigation increased yield by 62.6% as that in sprinkler irrigated fields. Field trials were carried out in 1976-1981 to compare the drip irrigation of rasoberries with sprinkler irrigation. Drip irrigation increased yield by 10.8% in comparison to sprinkler irrigation, but fruit quality (mean fruit weight, solids and sugar content) improved only slightly. Drip irrigation of raspberries compared to sprinkler irrigation resulted in a 10.4% reduction in water requirement and 10.9% less production cost/100 kg fruit. Drip irrigation at 3 days intervals and a 90% of Etm (maximum evapo transpiration) produced good results. Drip irrigation requires higher capital investment than sprinkler irrigation (Ivanov, 1984).

Work done with strawberries in South California showed that in drip irrigation, water used is less than 50% of that used in control. The salt content of the bed decreased by 40% under standard drip system. Standard furrow irrigation produced a salt built up leaf burn. The number of plants/ acre can be increased by 50% with equal plant performance thus increasing yield by atleast that amount using the drip system of irrigation (Remor, 1971).

Drip was superior to sprinkler irrigation as expressed in greater annual leaf and bunch production, fruit size and total yield in palms compared with furrow irrigation (Reuveni, 1974). Drip irrigation increased yield by 67% under Saopaulo conditions in brinjal (Vioria and Manfrinato, 1974). Maize developed more rapidly and gave higher yields in drip irrigation (Goldberg et al., 1976). Trials on drip irrigation in sugarcane conducted in Hawai showed equal or better yields than with furrow irrigation (Gibson, 1975). In 1983, a little difference in yields occurred when drip irrigation was applied by a single drip line/one or two cotton rows, although yields decreased drastically for a single drip line/three cotton rows (Bucks *et al.*, 1974).

Evapotranspiration, a crop coefficient and a water use efficiency curve were developed for drip irrigated cotton. For maximum yield, 600 ± 50 mm of water is required for evapotranspiration. When water supply is limited, drip irrigation is more efficient than furrow irrigation for producing unit cotton (Phene *et al.*, 1984). The work done by Krishnan (1977) showed that application of saline water by drip method did not affect 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 microtubes, holes and socket type emitters.

Conversion to drip irrigation resulted in substantially lowering the operating costs and improving water and nutrient application efficiencies (Bui and Kinoshita, 1985).

The review of literature revealed that studies on evaluation of drip and basin irrigation in vegetables under tropical conditions are limited and scarce. The study was conducted to evaluate the merits and demerits of drip irrigation over basin irrigation in vegetables under tropical conditions.

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. The whole fabrication work was done with the cheapest and locally available materials tailored to suit an ordinary farmer's capacity. This system was designed for a low hydraulic head of 1 to 3 metres.

3.1. Principles of the system

Drip irrigation is an advanced method of applying water to the plant at its root zone through a network of tubes. It works under low or medium pressure and only the required quantity of water is given daily in order to avoid water stress to the plant. The criteria used in developing the system were minimum moisture stress which could be maintained on substantial part of the root zone and this would be achieved at minimum capital and labour cost.

In this system, water is applied to a point through microtubes. The microtubes are connected to the lateral pipes which in turn are connected to submains or mains. The main pipe is connected to storage tank. The system is designed to work on low pressure. The rate of discharge of the microtubes varies from 1.0 to 3.0 l/hr. The water applied maintain the soil always at or near field capacity and thus maintaining moisture level in the fields at the optimum levels.

3.2. Location

Experimental plot was located in the instructional farm of College of Horticulture, Vellanikkara (Plates III to VI).

3.3. Field capacity and wilting percentage

Field capacity and wilting percentage were estimated by the pressure plate apparatus available at College of Horticulture, Vellanikkara. 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 those were placed on the plates. Then the plates were transferred to the metallic chambers. The plate outlet tube leaving the diaphragm was connected to the outlet of the chamber. The chamber was closed with special wrenches to tighten the nuts and bolts with the required torque for sealing it.

Pressure was applied from a compressor through a control system which maintained the desired pressure. Pressure of 1/3 and 15 bars were applied for determining field capacity and wilting point respectively. Water started flowing from the saturated soil samples through the 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 by gravimetric method.

3.4. Mechanical analysis of the soil

Mechanical analysis was done to determine the various soil separates - coarse sand, fine sand, silt and clay in the soil of the experimental plot. The pipette method was used for this analysis. The procedure adopted was as follows:

Twenty g of air dried soil was weighed and the same was transferred to 500 ml beaker. Fifty ml of 6% hydrogen peroxide was added and placed on a water bath with occasional stirring by means of a rubber tipped glass rod. Care was taken to avoid frothing. The process was repeated till no effervescence occurred on addition of hydrogen peroxide. The contents were allowed to cool and 25 ml 2 N hydrochloric acid was added to remove the presence of carbonates. Loss due to frothing was avoided. Contents were allowed to stand for 2 hours with occasional stirring and then filtered through Whatman No.50 in a burner funnel under suction. The entire soil was transferred without loss into burner funnel and the washing continued till the washings were free of chloride. The acid free soil left as a residue on the filter paper was transferred with jet of distilled water into the stirrer cup. The total volume was limited between 400 to 450 ml. Enough normal sodium hydrochloride was added to the bottle to make the contents distinctly alkaline. The contents were stirred for 20 to 25 minutes till dispersion was complete. The contents of cup were transferred to a 0.2 mm sieve placed on a funnel, the filterate being collected in a 1000 ml spoutless measuring cylinder. The filterate was made upto 1000 ml mark by adding distilled water. The residue left on the sieve was transferred without loss into a weighed China-dish. It was dried in an oven at 105°C. and weighed to constant weight. This was the weight of the coarse sand in the soil and from this, the percentage of coarse sand was calculated.

The temperature of soil water suspension in the spoutless measuring cylinder was noted. It was covered with a rubber stopper and was shaken thoroughly with repeated inversion. The rubber stopper was removed and the stop watch was started. The suspension was allowed to stand undisturbed for the specified time corresponding to the temperature of the suspension for silt (4 minutes). A sample of suspension was taken just at the expiry of the time from 10 cm depth using a Robinson's pipette. The suspension was transferred into a weighed China-dish. It was dried first on a water bath and then in an oven at 105°C and weighed to constant weight. This was the weight of silt and clay fraction contained in the sample of suspension. From this the percentage of silt and clay fraction was calculated.

The soil water suspension in the spoutless measuring cylinder was shaken once again for a minute and kept undisturbed for the specific time for the clay separation (6 hours and 40 minutes). At the end of the period a sample of suspension was taken at 10 cm depth using the pipette. This fraction was dried and weight found out. From this, the percentage of clay was calculated.

After sampling of the clay fraction, the bulk of suspension was thrown away leaving the fine sand fraction at bottom of the jar. It was transferred without loss to a beaker using distilled water and water was added to make suspension to stand at a height of 10 cm. The contents of the beaker were stirred with a rubber tipped glass rod and then allowed it to stand for the time required for fine sand sedimentation (4 minutes). At the expiry of the time, the supernatant liquid was poured off. The process was repeated till the poured off liquid was as clear as the water added. The residue at the bottom of the beaker (which is the fine sand) was transferred to a weighed China dish. It was dried in an oven at 105°C and weighed to constant weight. From this weight, the percentage of fine sand in the given soil sample was calculated.

3.4. Bulk density

The bulk density of the soil was determined by using standard core cutter. The core cutter was driven into the soil and an uncompacted core was obtained. The sample was carefully trimmed at both ends of the core and its weight taken. The sample was dried in an oven at 105°C until the moisture was removed and it was again weighed. Volume of the soil core was the same as the inside volume of the core cylinder. Weight of the dry soil divided by the volume of the soil core gave the bulk density of the soil.

3.5. Lay out

Lay out of the experiment was done in the vegetable garden of the College of Horticulture. The experiment was laid out in a randomised block design. Two crops, amaranthus and brinjal were tested. Same lay out and design were adopted for testing both the crops. There were six treatments (2 methods x 3 rates). The rates of irrigation were based on Iw/CPE ratio i.e., the ratio of the irrigation water applied to cumulative pan evaporation. The treatments were labelled as follows:

Treatments	Methods of Irrigation	Iw/CPE
T1	Drip	1.00
T2	Drip	0.75
T3	Drip	0.50
T4	Basin	1.00
T5	Basin	0.75
T6	Basin	0.50

Each treatment was replicated four times and replications were labelled R1, R2, R3 and R4. Each replication containing all the treatments was laid out in a block. Treatments within the block were selected at random. Altogether there were four replications and six treatments for each crop making a total of 24 plots. The net size of individual plot was 6 x 3.75 m. The net area of experimental plot was 540 m^2. Each plot was separated by a bund having 45 cm width at bottom and 30 cm width at top. The gross area of the experimental plot was 837.9 m^2 for each crop.

After the completion of land preparation of experimental plot for planting, the seedlings of both the crops (brinjal and amaranthus) which were grown in nursery were transplanted.

The spacing of brinjal was 60 cm x 75 cm and that of amaranthus was 20 cm x 25 cm. The fertiliser (N,P,K) and the plant protection practices followed were as per the recommendations in the package of practice. Nitrogen was applied as urea, phosphorus as superphosphate and potasium as muriate of potash. Cowdung was applied as basal dose at the rate of 20 t/ha. Brinjal was harvested in four pickings. In the case of amaranthus two cuttings were taken during the experimental period. The border plants were treated as buffer plants to minimise border effects. The inner plants were treated as experimental plants.

The diagramatic representation of lay out and individual plot are given in Fig. 1 to 3.

3.6. Schedule of irrigation

Irrigation schedule was based on open pan evaporation value that is Iw/CPE ratios in both the methods viz., drip and basin irrigation. Irrigation based on treatments was given after common irrigation to all plots before planting.

Drip irrigation was given on every day depending on the evaporation value of the previous day. For example, if evaporation value of the previous day was 8 mm in treatment T1 (Iw/CPE = 1) the depth of irrigation water given was 8 mm. Similarly for the treatment T2 (Iw/CPE = 0.75) the depth of irrigation water given was 6 mm and for the treatment T3 (Iw/CPE = 0.5) the depth of irrigation water given was 4 mm.

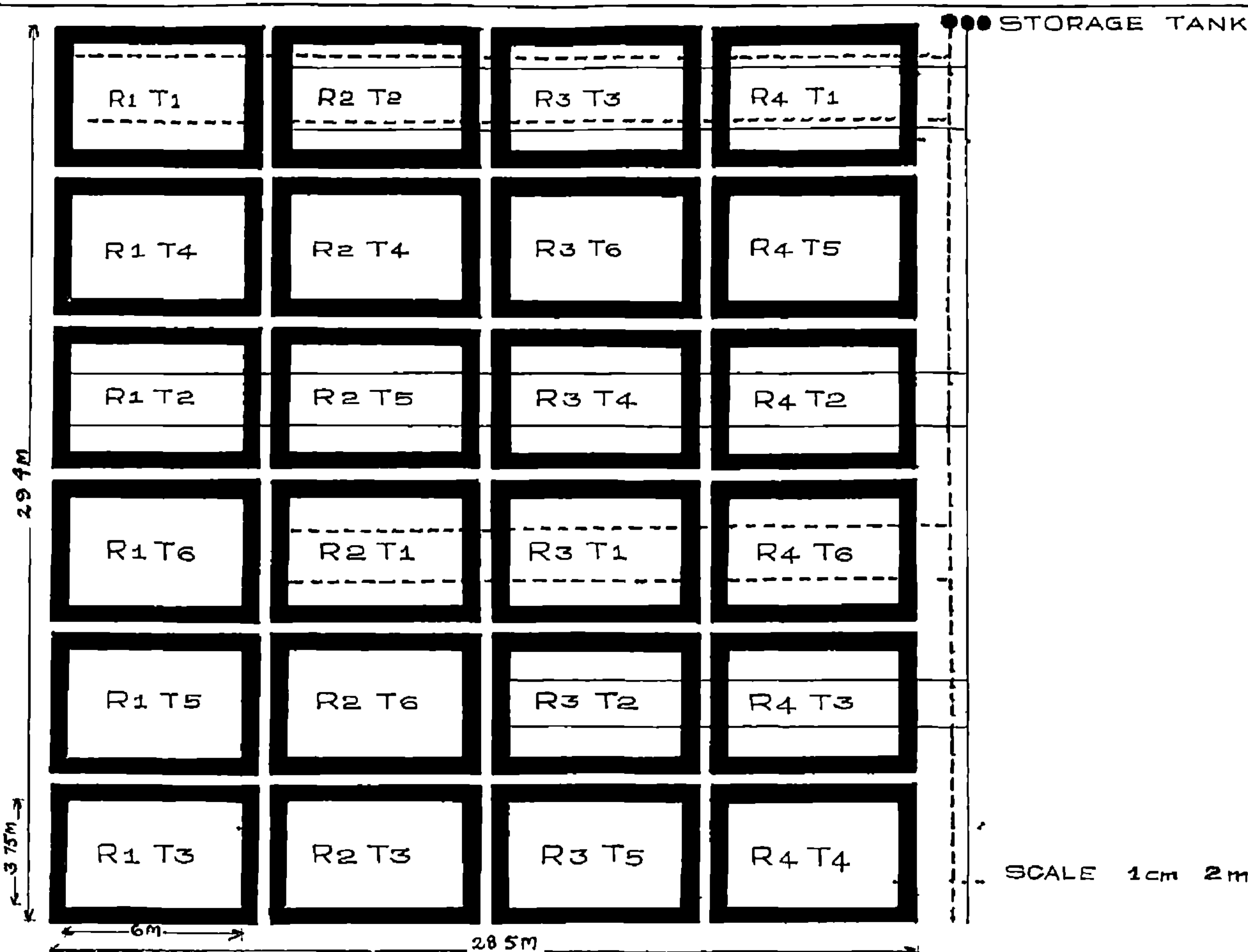

FIG. 1. LAY OUT OF THE FIELD

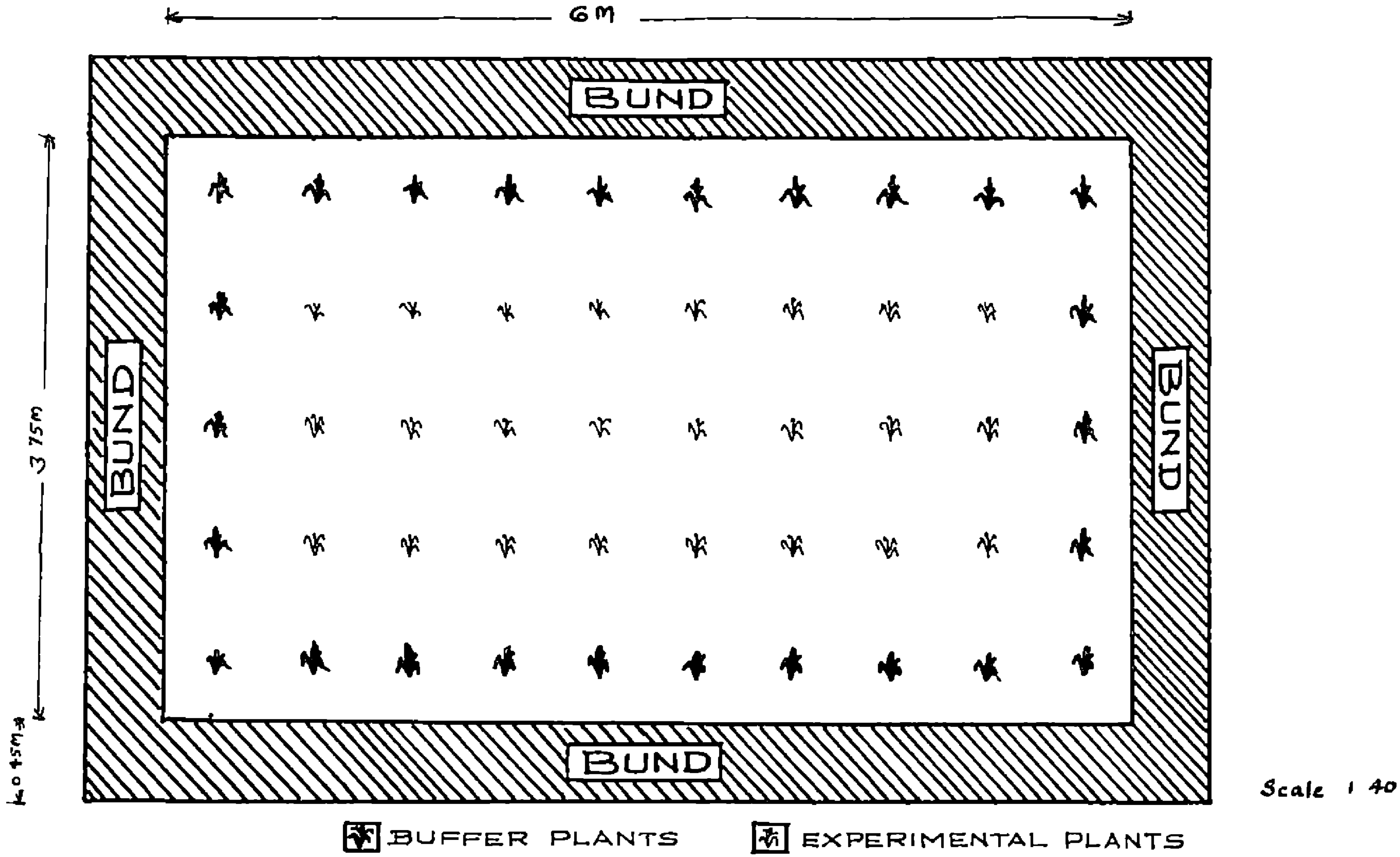

FIG_2. AN INDIVIDUAL BRINJAL PLOT

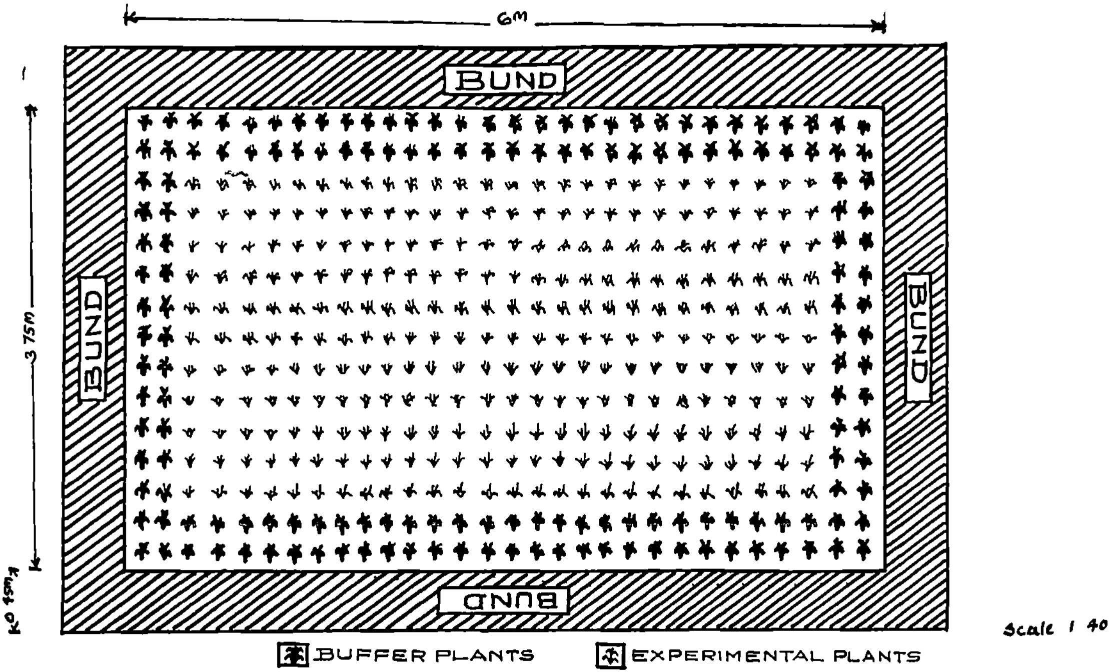

FIG_3. AN INDIVIDUAL AMARANTHUS PLOT

In basin method, the depth of irrigation water given for one irrigation was 30 mm. The quantity of water applied was 675 l/plot/irrigation. The irrigation frequency for each treatment was based on cumulative pan evaporation values. The treatment T4 (Iw/CPE = 1) was irrigated when cumulative pan evaporation value equalled to 30 mm. The treatment T5 (Iw/CPE = 0.75) was irrigated when cumulative pan evaporation value equalled 40 mm. The treatment T6 (Iw/CPE = 0.5) was irrigated when cumulative pan evaporation value equalled to 60 mm.

The details of irrigation for each treatment are given in Tables 1 to 3. Irrigation was given till the middle of May after which there was rainfall and the experiment was discontinued.

3.7. Irrigation channels

The water was pumped from the pond near the main gate of the University. The water was pumped from the main source into the main channel which was located on the longitudinal side of the experimental plot. From the main channel, water was diverted to subchannels. The sub-channel was located in between each replication which was the transverse side of the experimental plot. From the sub-channel, water was diverted to the individual plot after careful measurement by using orifice plate.

During irrigation in a hectare of land there will be

Table 1. Schedule of irrigation for the month of March (in litres)

Dates	Evaporation mm	Rainfall cm	Methods of irrigation (Treatments): Drip T1	Drip T2	Drip T3	Basin T4	Basin T5	Basin T6
9	8.0	-	-	-	-	-	-	-
10	8.5	-	180.00	135.00	90.00	-	-	-
11	8.6	-	191.25	143.44	95.63	-	-	-
12	8.8	-	193.50	145.13	96.75	-	-	-
13	6.8	-	198.00	148.50	90.00	675	-	-
14	7.0	-	153.00	114.75	76.50	-	675	-
15	7.7	-	157.50	118.13	78.75	-	-	-
16	7.6	-	173.25	129.94	86.63	-	-	-
17	5.6	-	171.00	128.25	85.50	-	-	675
18	6.4	-	126.00	94.50	63.00	675	-	-
19	6.7	-	144.00	108.00	72.00	-	-	-
20	5.2	1.0	150.75	113.06	75.38	-	675	-
21	5.9	6.6	117.00	87.75	58.50	-	-	-
22	5.7	-	-	-	-	-	-	-
23	6.4	-	128.25	96.19	64.13	-	-	-
24	6.7	-	144.00	108.00	72.00	675	-	-
25	7.2	-	150.75	113.06	75.38	-	-	-
26	7.4	-	162.00	121.50	81.00	-	-	-
27	7.0	-	166.50	124.88	83.25	-	675	675
28	9.6	-	157.50	118.13	78.75	675	-	-
29	10.0	-	216.00	162.00	108.00	-	-	-
30	6.0	-	225.00	168.75	112.50	-	-	-
31	6.3	-	135.00	101.25	67.50	-	-	-

Table 2. Schedule of irrigation for the month of April (in litres)

Dates	Evaporation mm	Rainfall mm	Methods of irrigation (Treatments)					
			Drip			Basin		
			T1	T2	T3	T4	T5	T6
1	7.1	-	141.75	106.31	70.88	675	675	-
2	7.2	-	159.75	119.81	79.88	-	-	-
3	8.2	-	162.00	131.50	81.00	-	-	-
4	8.1	-	184.50	138.38	92.25	-	-	675
5	7.1	-	182.25	136.69	91.13	675	-	-
6	7.7	-	159.75	119.81	79.88	-	675	-
7	7.2	-	173.25	129.94	86.63	-	-	-
8	7.7	-	162.00	121.50	81.00	-	-	-
9	8.0	-	173.25	129.94	86.63	-	-	-
10	6.1	-	112.50	84.38	56.25	675	-	-
11	9.0	-	137.25	102.94	68.63	-	-	-
12	6.6	-	202.50	151.88	101.25	-	675	-
13	7.6	-	148.50	111.38	74.25	-	-	675
14	7.7	-	171.00	128.25	85.50	675	-	-
15	9.2	-	173.25	129.94	86.63	-	-	-
16	7.0	-	207.00	155.25	103.50	-	-	-
17	7.3	-	157.50	118.13	78.75	-	675	-
18	6.1	-	164.25	123.19	82.13	675	-	-
19	7.2	-	137.25	102.94	68.63	-	-	-
20	8.8	-	162.00	121.50	81.00	-	-	-
21	7.0	-	198.00	148.50	99.00	-	-	675
22	9.0	-	157.50	118.13	78.75	675	675	-
23	4.6	-	202.50	151.88	101.25	-	-	-
24	8.5	-	103.50	77.63	51.75	-	-	-
25	6.1	0.8	123.75	92.81	61.88	-	-	-
26	6.0	-	137.25	102.94	68.63	-	-	-
27	7.1	-	135.00	101.25	67.50	675	-	-
28	4.0	12.0	159.75	119.81	79.88	-	-	-
29	4.4	-	-	-	-	-	-	-
30	6.4	-	99.00	74.25	49.50	-	-	-

Table 3. Schedule of irrigation for the month of May(in litres)

Dates	Evaporation mm	Rainfall mm	Methods of irrigation (Treatments) Drip T1	T2	T3	Basin T4	T5	T6
1	6.0	-	144.00	108.00	72.00	-	675	-
2	4.9	-	135.00	101.25	67.50	-	-	-
3	5.7	22.6	110.25	82.69	55.13	-	-	675
4	3.8	-	-	-	-	-	-	-
5	4.9	-	85.50	64.13	42.75	-	-	-
6	5.2	-	110.25	82.69	55.13	-	-	-
7	4.9	-	117.00	87.75	58.50	-	-	-
8	5.5	-	110.25	82.69	55.13	-	-	-
9	6.1	-	123.75	92.81	61.88	675	-	-
10	7.1	-	137.25	102.94	68.63	-	-	-
11	7.7	-	159.75	119.81	79.88	-	-	-
12	6.2	-	173.25	129.94	86.63	-	675	-
13	4.9	-	139.50	104.63	139.50	-	-	-
14	5.1	-	110.25	82.69	55.13	675	-	-

on an average 100 metres of wetted irrigation channel at a time. To measure the seepage losses in a channel, a 100 m straight channel was selected. Two orifices were placed at inlet and outlet and the rate of inflow and outflow measured.

3.8. Measurement of irrigation water

Irrigation water was measured using circular orifice plate. The details of construction of orifice plate are given in Fig. 4. It is made of 18 mm gauge M.S. sheet with accurately machined circular openings or orifices having diametres of 2.5 cm, 5 cm and 7.5 cm. The edges of the orifice plates were sharpened so that it could easily be fixed on the channel for measurement. A plastic scale was fixed directly to the plate on the upstream and downstream face of the orifice plate with its zero reading coinciding with the centre of the orifice.

The discharge through the orifice was calculated by the formula

$Q = 0.61 \times 10^{-3} a \times \sqrt{2gH}$ in which

Q = discharge through orifice (l/second)

a = area of cross section of orifice (cm^2)

g = acceleration due to gravity (cm/sec^2) (981 cm/sec^2)

H = Depth of water over the centre of the orifice in case of free flow orifice or the difference in elevation between the water surface at upstream and downstream faces of the orifice plate in case of submerged orifices (cm).

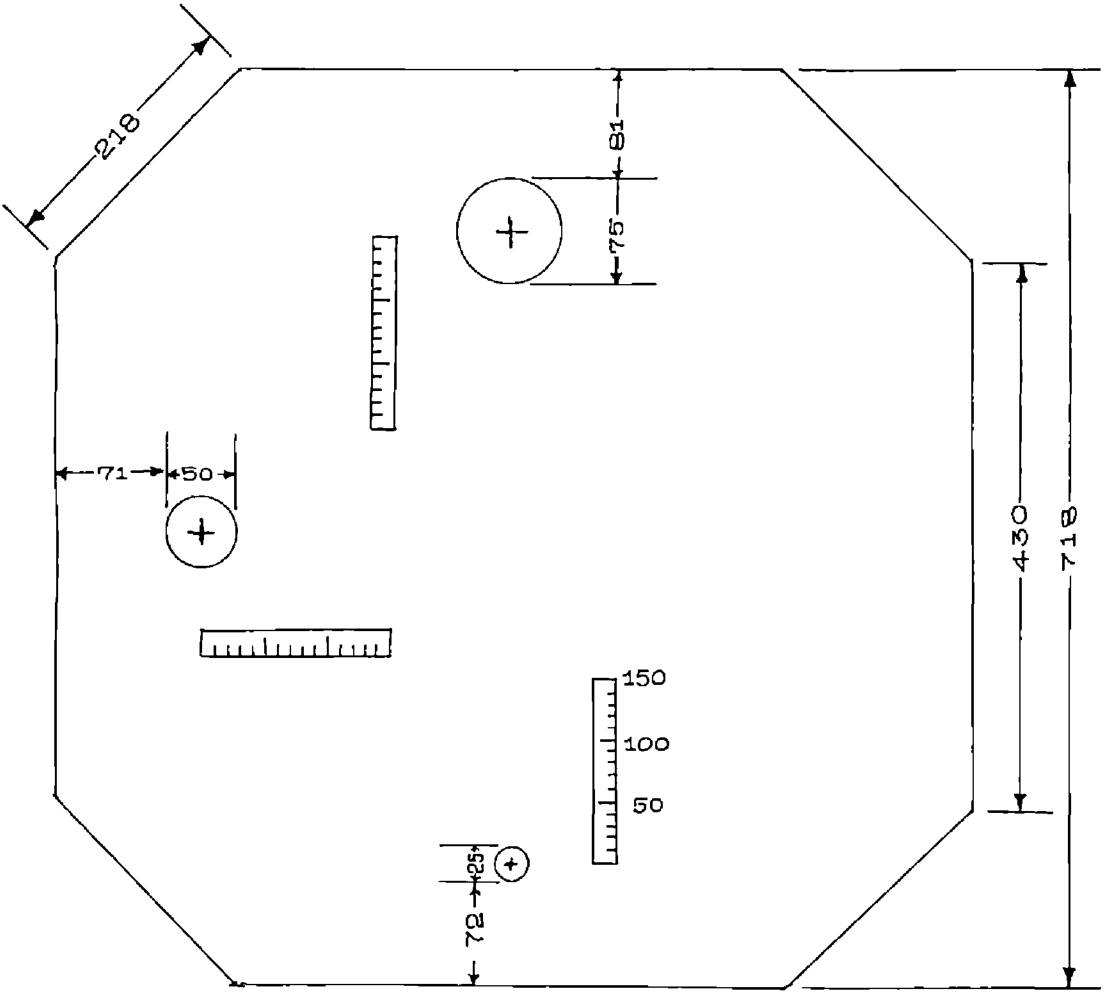

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FIG 4 ORIFICE PLATE

Quantity of irrigation water was measured by placing the orifice plate in the subchannel just above the plot which was to be irrigated. The water was allowed to flow through the submain channel until a steady flow was obtained and then it was diverted into the plot by cutting open the field bund. The flow in the submain channel beyond the opening was blocked simultaneously using the earth removed from the field bund. At the time of opening of the plot bund, a stop watch was started. The head of water over the orifice plate was noted and the discharge was computed. The time required for supplying the required quantity of water was computed and the plot bund was closed after the required quantity of water was delivered to the field. In order to determine quickly the time required to supply 675 litres of water for various heads through 7.5 cm diameter orifice, a ready reckoner was prepared. This is given in appendix 1.

3.9. Storage tanks

Oil drums having 200 l capacity were used as storage tanks for drip irrigation. The drums were placed above the earthen embankment. Height of the embankment was about 1 m. Then the minimum head available was 1 m, i.e., when the water level was at the bottom of the drum. The maximum daily evaporation at Vellanikkara was about 8 mm. For an evaporation of 8 mm, the quantity of water required for irrigating one T1 plot having a net area of 22.5 m^2 was 180 litres. One drum was required for storing the water required for irrigating one T1 plot because the capacity of one drum was 200 l. Since there were four T1 plots, one each in one replication, four drums were used for storing the irrigation water for treatment T1. Three drums were used for T2, as the quantity of water was 3/4th of that of T1 and two drums for treatment T3 as the quantity of water was 1/2 of that of T1. The drums were connected by 25 mm G.I. pipe. For each crop there were three sets of drums; one set with four drums, one set with three drums and one set with two drums. The top of the drum was closed with cloth to prevent the entry of dust from air through wind (Plates I and II). 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 G.I. pipe was extended into the drum for attaching the plastic wire mesh filter from inside for preventing floating impurities getting into the pipe when the water level in the drum came in level with the outlet pipe at the end of irrigation. Plastic fine wire mesh filter was used for this purpose. As this system worked on a low pressure, a small air lock in the system would stop the flow of water. To prevent this, airvents were provided at the beginning and end of main pipes.

3.10. Main and laterals

Black polyethylene pipes of 25 mm diameter were used as main pipe. As the systems worked on a low pressure, the cheapest polyethylene pipes available locally was used. Main pipe was attached to the outlet of the drum through 25mm hose collar. Main pipe was laid along the transverse side of the experimental plot. One main line for each treatment for each crop was laid out. There were three main lines for each crop because there were three rates of irrigation. As the system worked on low pressure, trapped air inside the pipe would obstruct the flow and to avoid this, airvents were provided at both the ends of the main line. Near the storage tank, airvent was provided through a 25 mm x 12 mm Tee joint connected at the beginning of the pipe. A 12 mm polyethylene pipe was connected to the 'Tee' joint and the other end of this pipe was kept above the water level in the drum. Airvent was also provided at the tail end of the main pipe by keeping that end open and above the water level in the main drum. This end was kept above the water level by tying that end to a pole fixed on the ground. At the time of opening the wheel valve, air and water could be seen bubling out of the airvents for a few minutes till all the trapped air escaped.

A 12 mm black polyethylene pipe was used as laterals. The laterals were connected to the main pipe by means of 'Tee' joints fabricated using PVC pipes.(Fig.5). The PVC 'Ts' were fabricated because they were considerably cheaper than the commercially available 'T' joints. As in the case of main line, in order to avoid air blocks the tail ends of laterals were also kept above the water level in the drum by tying that end to a pole fixed on the ground. Two laterals for

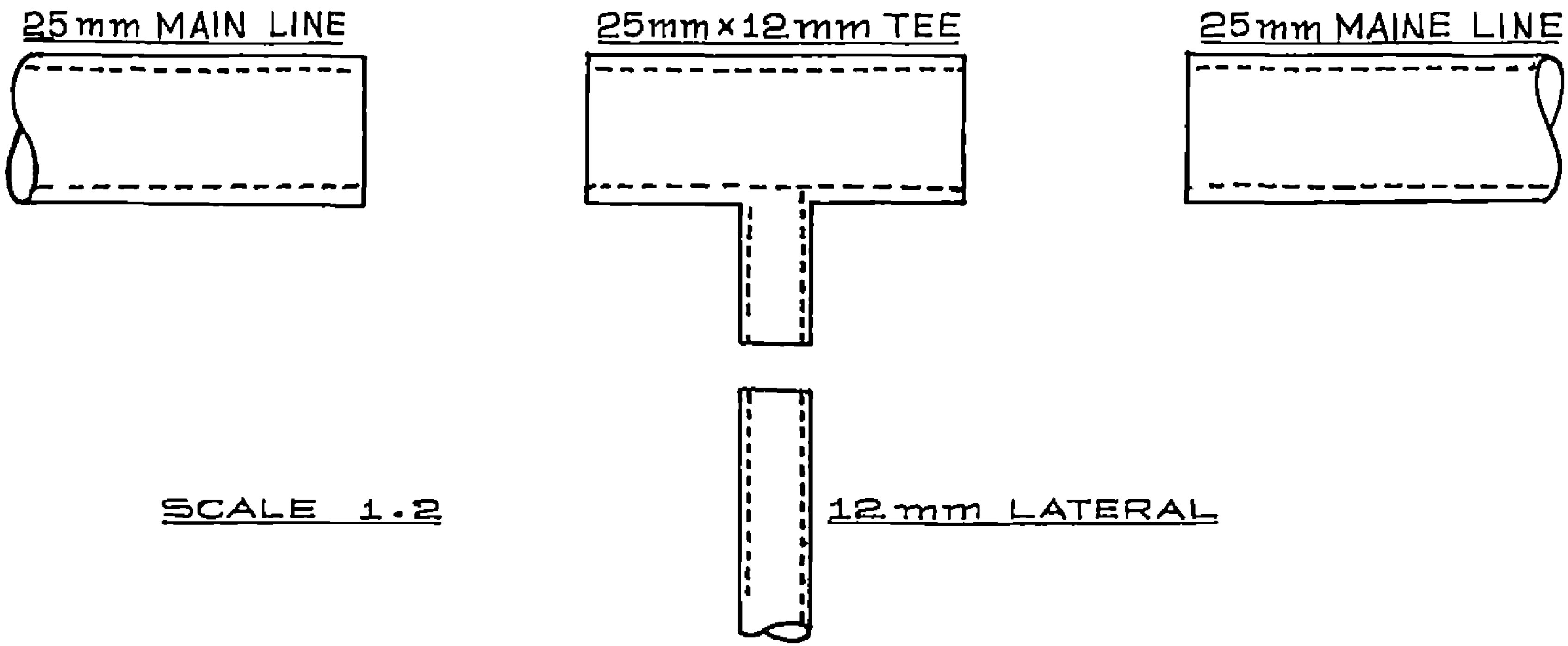

FIG_5: TEE ASSEMBLY – MAIN TO LATERAL CONNECTION each plot were laid along the longitudinal side. Three separate sets of laterals were used for three different treatments for each crop. As these pipes were made of black polyethylene, they absorbed considerable amount of heat which in turn raised the temperature of irrigation water substantially. In order to avoid this, both laterals and main lines were buried at a depth of 15 cm under the soil excepting their tail ends. The tail end of both the mains and laterals were protected by tying fine grade wire mesh at the ends. This was to prevent the entry of foreign materials into these pipes, at the same time facilitate the expulsion of air. Laterals were laid at a distance of 0.9375 m from the boundary bund.

3.11. Micro tubes

Commercially available 2 mm PVC pipes were used as microtubes which functioned as drippers or emitters. Microtubes of three different colours were used for three levels of irrigation for easy identification. The microtubes were connected to the laterals by making holes having slightly lesser diameter than the external diameter of the microtubes and pushing the microtube into these holes for tight fit. These joints were leak proof as the system worked on low pressure. The microtube attached to the lateral was connected to a distributor. The lay out of laterals and microtubes in the experimental field are given in Fig.5.

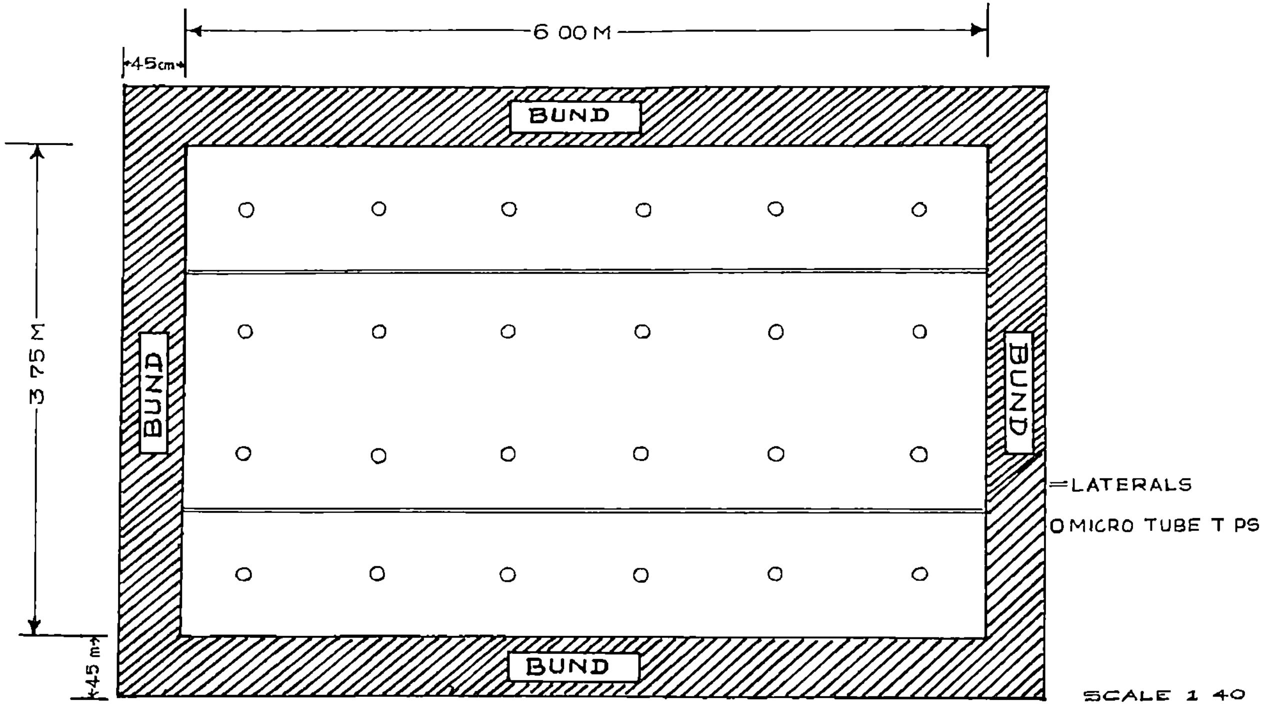

FIG_6 : DETAILS OF DRIP IRRIGATED PLOT

3.12. Distributor

The 'heart' of this drip irrigation system was the distributor developed at the Agronomic Research Station, Chalakudy in the year 1977 (Fig.7). The rate of discharge of the microtube connected to the lateral was about 10 to 20 litres/hour. The accepted discharge for a conventional drip irrigation system was 1 to 5 litres/hour which depends upon diameter of microtube. The function of the distributor was to reduce this high discharge of 10 to 20 litres/hour to about 1 to 5 litres/hour. The disadvantage of the high discharge was that a larger surface area would be wetted and this would increase the evaporation loss and reduce the efficiency of the system. Distributor was made from a 15 cm long 12 mm diameter polyethylene pipe plugged at both ends with commercially available 1/2" PVC plugs. The microtubes were connected to the distributor in the same manner as they were connected to the lateral. From the distributor, four microtubes of 1.5 m long were taken out which functioned as the drippers. The discharge from each dripper was about 2.5 litres/hour. There were six distributors in each drip irrigated plot. Water leak at joints, non-functioning of the dripper, improper fittings, etc. were rectified then and there. The tips of the microtubes were kept raised about 20 cm 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

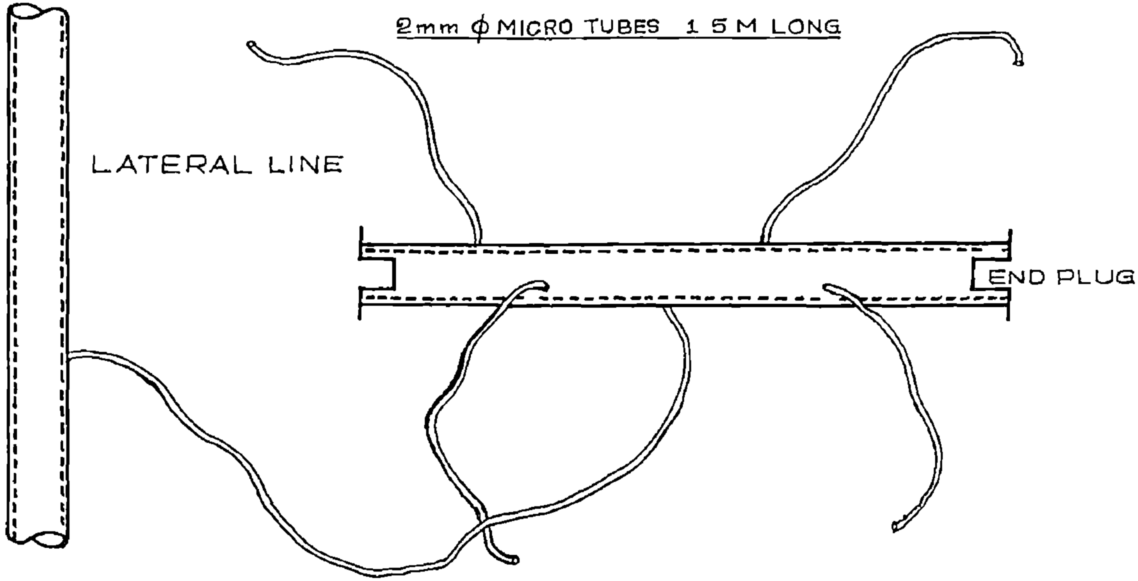

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FIG_7: DISTRIBUTOR

advantage of keeping the dripper above the ground was that any clogging in microtube could be immediately noticed. The height of the microtubes tips tied to the stakes were raised or lowered to get the final accurate discharge and to maintain uniformity. The discharges from the microtube were very sensitive to the variation in height.

3.13. Discharges of Microtubes

The discharge from the microtubes were maintained at about 2.5 litres/hour. The discharge could be varied by:

1. Changing the hydraulic head by raising or lowering the storage tank.
2. Varying the length of microtubes which change head loss due to friction.
3. Changing the diameter of the microtube.
4. Raising or lowering the microtube tips on the stakes.

Plate I. Storage tanks for Drip Irrigation

Plate II. Layout of a microtube tip for Drip Irrigation

Plate III. Basin irrigated Amaranthus Plot

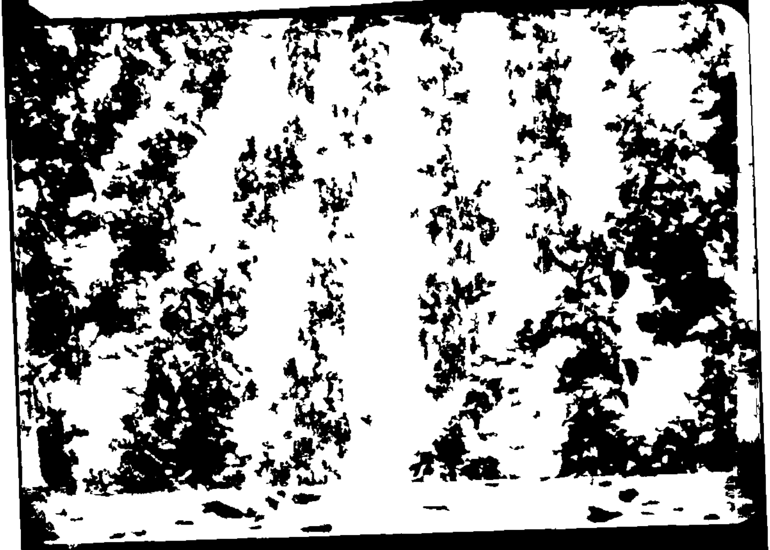

Plate IV. Drip irrigated Amaranthus Plot

Plate VI. Drip irrigated Brinjal Plot

Results and Discussion

RESULTS AND DISCUSSION

4.1. Initial soil characteristics

The physical characteristics of the soil were determined.

4.1.1. Field capacity and wilting percentage.

The average field capacity and wilting percentage of the soil in the experimental field were 15.5% and 9.6% respectively. The data are given in Tables 4 and 5.

4.1.2. Mechanical analysis of the soil.

Results of mechanical analysis showed that the soil was sandy loam. The percentage of coarse sand, fine sand, silt and clay obtained are 43.00%, 17.00%, 24.23% and 15.75% respectively (Table 6).

4.1.3. Bulk density.

The bulk density of the soil was 1.44 g/cc and the details are given in Table 7.

4.2. Biometric observations

Results of biometric observations taken on both the crops are given in Tables 8 to 16. The diagramatic representations are given in Figures 8 to 16. Analysis of variance Tables are shown in Appendices 2 to 10.

4.3. Amaranthus

4.3.1. Plant height.

Plant height was statistically analysed and no significant differences among the treatments were observed.

Table 4. Determination of field capacity

Weight of moisture Can	Weight of Can + wet soil	Weight of Can + dry soil	Weight of dry soil	Weight of moisture	Moisture content
(g)	(g)	(g)	(3)-(1) (g)	(2)-(3) (g)	$\frac{(5)}{(4)} \times 100$ (%)
(1)	(2)	(3)	(4)	(5)	(6)
42.0	61.70	59.0	17.0	2.7	15.8
34.0	53.70	51.0	17.0	2.5	14.7
34.5	56.70	53.5	19.0	3.2	16.0

Mean field capacity = 15.5 per cent

Table 5. Determination of wilting point

Weight of moisture Can (g)	Weight of Can + wet soil (g)	Weight of Can+dry soil (g)	Weight of dry soil (3)-(1) (g)	Weight of moisture (2)-(3) (g)	Moisture content $\frac{(5)}{(4)} \times 100$ (%)
(1)	(2)	(3)	(4)	(5)	(6)
42.0	59.0	57.5	15.5	1.5	9.6
34.0	51.8	50.2	16.2	1.6	9.8
34.5	55.8	54.0	19.5	1.8	9.4

Mean wilting point = 9.6 per cent

Table 6. Mechanical analysis of soil

Percentage of coarse sand	=	43.00
Percentage of fine sand	=	17.00
Percentage of silt	=	24.23
Percentage of clay	=	15.75

Table 7. 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 (kg) (3)-(1)	Volume of cylinder (cc)	Bulk density $\frac{(4)}{(5)} \times 100$ (g/cc)
(1)	(2)	(3)	(4)	(5)	(6)
1.45	2.77	2.47	1.02	$\frac{\pi}{4} \times 7.5^2 \times 15$ = .662	1.54
1.45	2.86	2.32	0.87		1.32
1.45	2.81	2.41	0.96		1.45

Mean bulk density = 1.44 g/cc

Table 8. Plant height of amaranthus (cm)

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	12.72	16.16	16.78	14.61	15.07
T2	12.83	16.05	16.22	13.39	14.62
T3	13.33	13.61	15.89	13.33	14.04
T4	14.94	19.44	20.28	13.83	17.12
T5	12.05	16.17	14.33	15.61	14.54
T6	14.40	15.27	16.06	14.06	14.95

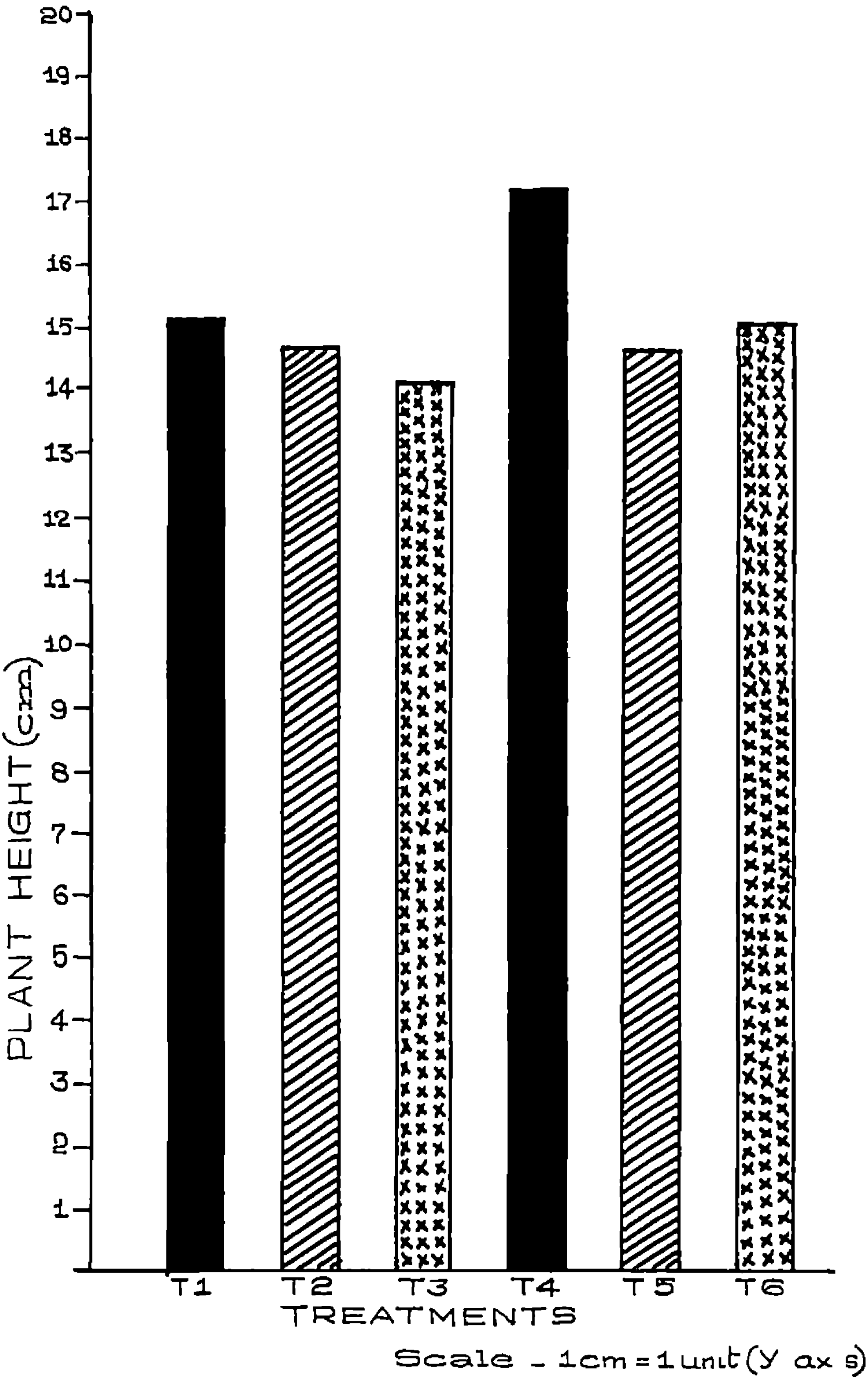

FIG 8. PLANT HEIGHT OF AMARANTHUS (cm)

4.3.2. Yield at each harvest.

The yield at first harvest was statistically analysed. There was significant difference between the treatments. The drip method of irrigation was significantly superior to basin method. The maximum yield was obtained from treatment T1 in drip method which was on par with T2 and T3, the other treatments in drip method.

On statistical analysis of the second harvest, drip method gave significantly higher yield than basin method. Maximum yield in basin method was obtained from treatment T4 which received the maximum quantity of water.

Total yield obtained in the two harvests were pooled and analysed statistically. In this analysis also the yield difference in drip method showed significant difference. Treatment T3 which received minimum quantity of water in drip method was significantly superior to treatment T4 which received maximum quantity of water in basin method of irrigation. Maximum yield was obtained from treatment T1 which received maximum quantity of water in drip method. The maximum yield in basin method was obtained in T4 which received maximum quantity of water in basin method. However this was on par with T5 and T6, the other treatments in basin method.

4.3.3. Dry matter percentage.

Dry matter percentage was statistically analysed and no significant difference between the treatments was observed.

Table 9. Yield of amaranthus at first harvest (kg/14.3 m^2)

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	4.34	4.60	4.02	4.58	4.43
T2	4.34	4.66	3.94	4.78	4.33
T3	4.16	3.68	3.58	4.38	3.95
T4	3.34	3.14	3.10	3.96	3.39
T5	3.50	3.35	3.12	3.50	3.36
T6	3.94	2.58	3.48	3.76	3.44

Table 10. Yield of amaranthus at second harvest (kg/14.3 m^2)

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	7.00	4.82	4.34	1.98	4.54
T2	5.20	4.42	4.76	3.48	4.47
T3	5.48	6.00	4.56	3.62	4.92
T4	4.24	4.10	3.08	1.06	3.11
T5	3.74	4.44	1.30	1.62	2.70
T6	2.20	3.40	3.30	0.83	2.45

Table 11. Total yield of amaranthus (kg/14.3 m^2)

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	11.34	9.42	8.36	6.56	8.92
T2	9.54	9.08	8.70	8.26	8.89
T3	9.64	9.68	8.14	8.00	8.86
T4	7.56	7.24	6.18	4.96	6.49
T5	7.24	7.79	4.42	5.12	6.14
T6	6.14	5.98	6.78	4.64	5.88

Table 12. Dry matter percentage in amaranthus

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	16.00	21.36	21.50	20.50	19.84
T2	15.25	22.50	19.50	20.50	19.44
T3	15.50	22.70	20.00	20.20	19.70
T4	13.60	20.56	19.40	21.66	18.81
T5	14.80	26.00	25.00	20.83	21.66
T6	15.75	22.85	22.08	25.00	21.42

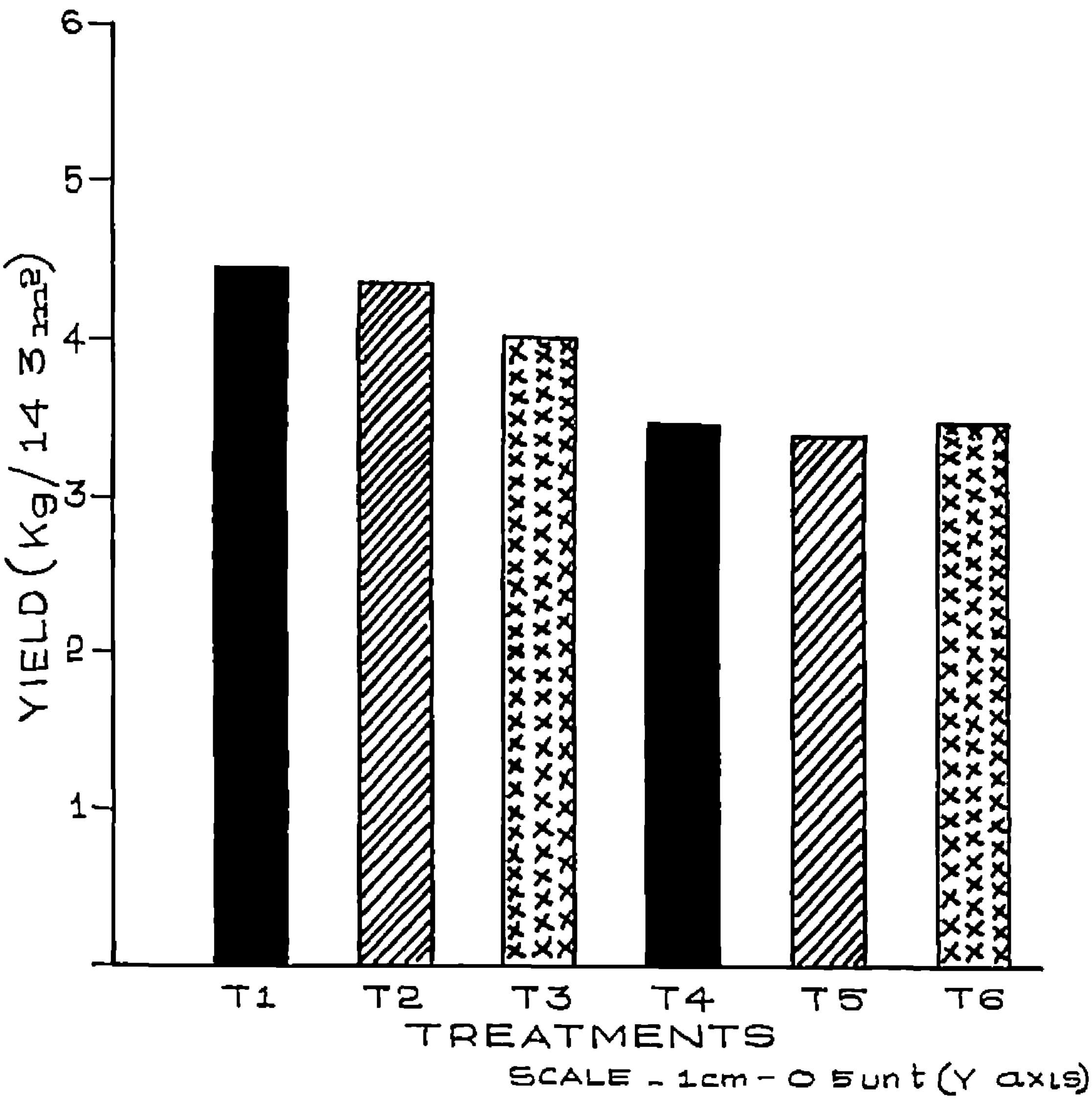

FIG. 9. YIELD OF AMARANTHUS IN FIRST HARVEST (Kg/14.3 m²)

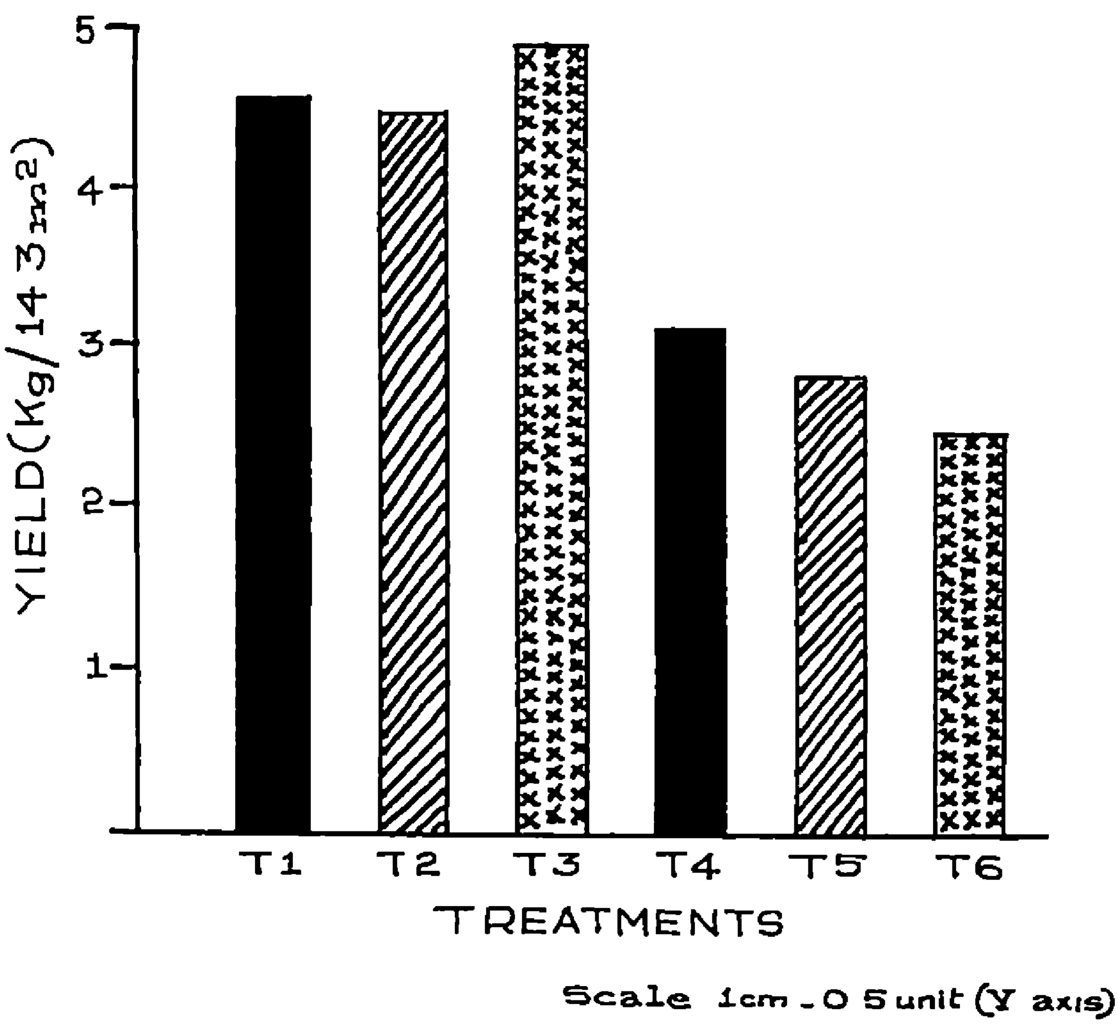

FIG. 10. YIELD OF AMARANTHUS IN 2nd HARVEST (Kg/14 3m²)

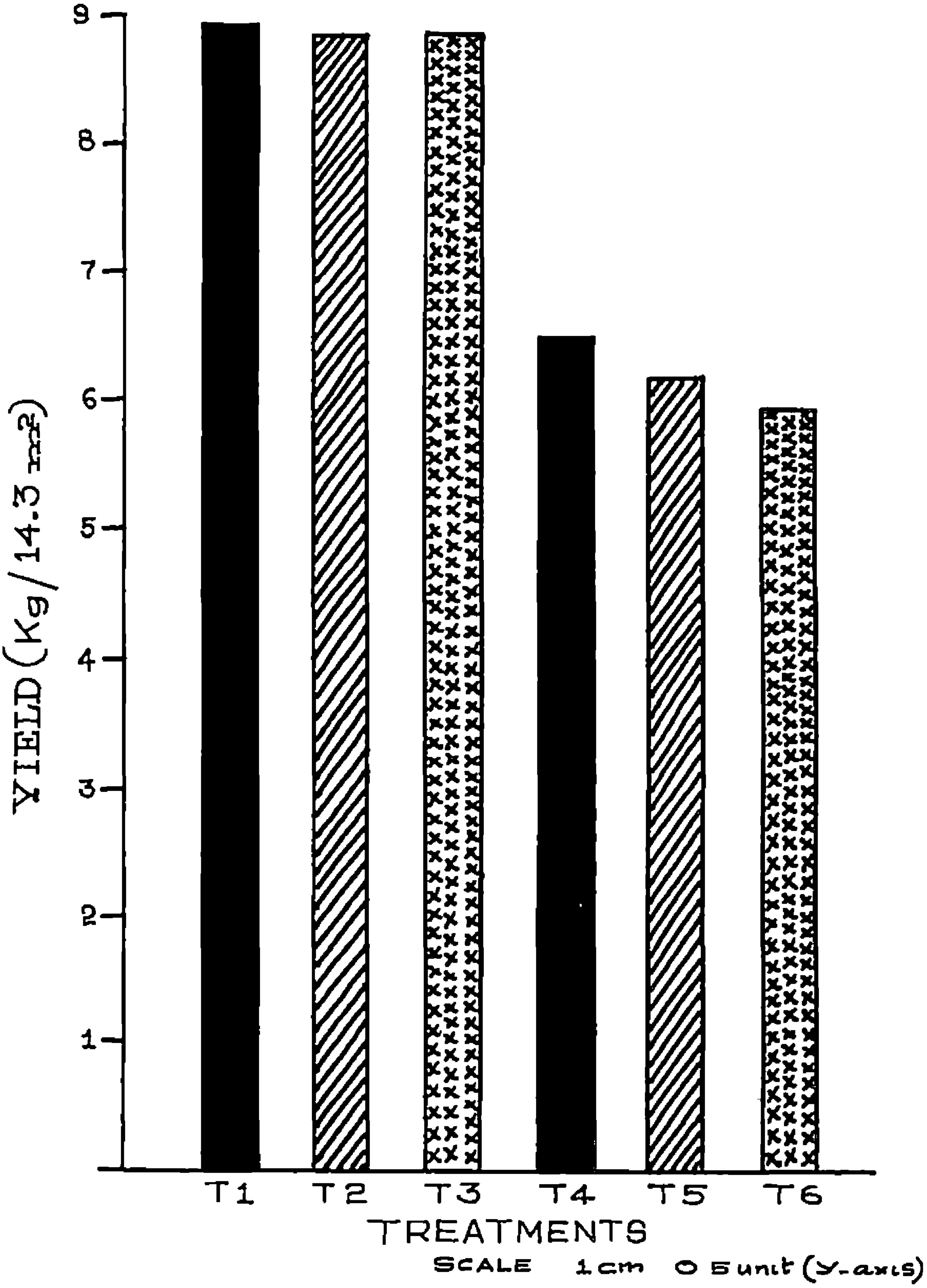

FIG_11. TOTAL YIELD OF AMARANTHUS
(Kg/14.3m²)

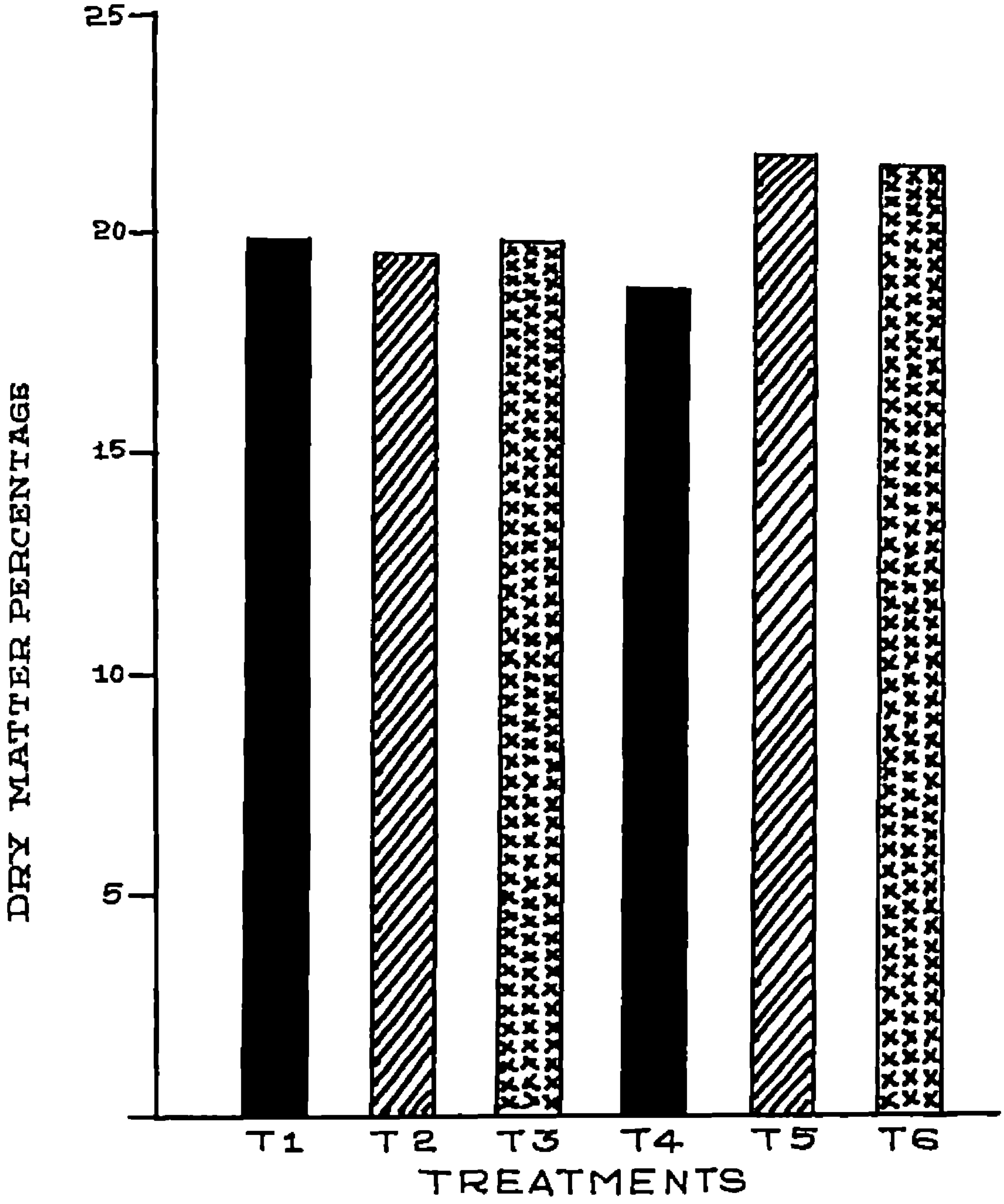

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FIG 12 : DRY MATTER PERCETAGE IN AMARANTHUS

4.4. Brinjal

4.4.1. Plant height.

Maximum plant height was noticed for the treatment T1 i.e., drip method with Iw/CPE = 1. The plant height in treatment T3 was on par with plant height in T4, T5 and T6.

4.4.2. Flowering.

No significant difference in number of days taken for flowering was observed among the treatments in either drip or basin method of irrigation.

4.4.3. Fruits/plant.

Fruits/plant showed no significant difference between the treatments in either drip or basin method of irrigation.

4.4.4. Total yield.

As in amaranthus, on statistical analysis, brinjal yield showed significant difference between the drip method and the basin method. Treatment T3 which received minimum quantity of water in drip method was significantly superior to treatment T4 which received maximum quantity of water in basin method of irrigation.

Experiments conducted on vegetables by Sivanappan et al. (1974) reported that the water used in drip method was only 1/2 to 1/5 of the surface method. Abrol and Dixit (1971) obtained significant increase in the yield and water use efficiency in drip method of irrigation. At Hissar, drip

Table 13. Plant height of brinjal (cm)

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	32.75	25.45	28.50	25.85	28.14
T2	28.70	27.50	27.10	27.45	27.69
T3	26.95	26.15	25.65	25.75	26.13
T4	27.10	25.95	24.30	24.50	25.43
T5	26.90	25.25	23.75	22.55	24.61
T6	25.30	27.25	23.90	22.90	24.84

Table 14. Number of days to flower (Brinjal)

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	104	115	111	114	111.00
T2	110	114	112	112	112.00
T3	111	115	113	114	113.25
T4	109	115	113	116	113.25
T5	110	112	115	118	113.75
T6	110	115	114	118	114.25

Table 15. Fruits per plant in Brinjal/10.8 m^2

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	169	89	121	95	118.50
T2	110	91	62	78	85.25
T3	115	94	94	96	99.75
T4	112	148	164	105	132.25
T5	130	107	111	74	105.50
T6	87	110	124	81	100.50

Table 16. Yield of Brinjal/10.8 m^2
in kg

Treatments	Replications				Mean
	R1	R2	R3	R4	
T1	5.64	5.16	4.48	5.26	5.14
T2	5.54	5.06	4.52	5.08	5.05
T3	5.16	4.78	4.58	5.18	4.93
T4	4.24	4.04	3.99	4.66	4.23
T5	3.90	3.65	3.72	3.90	3.79
T6	4.24	3.08	3.78	4.06	3.79

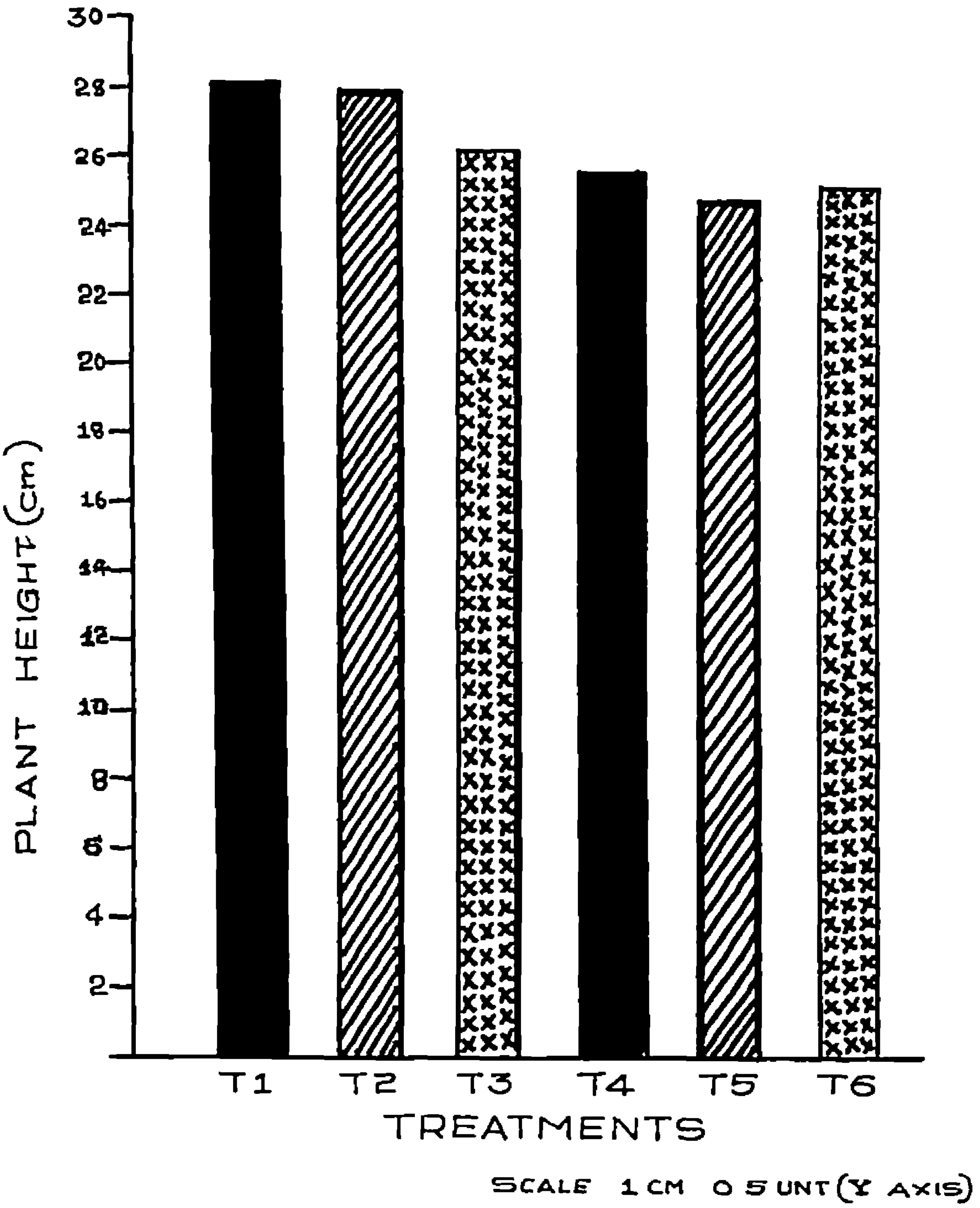
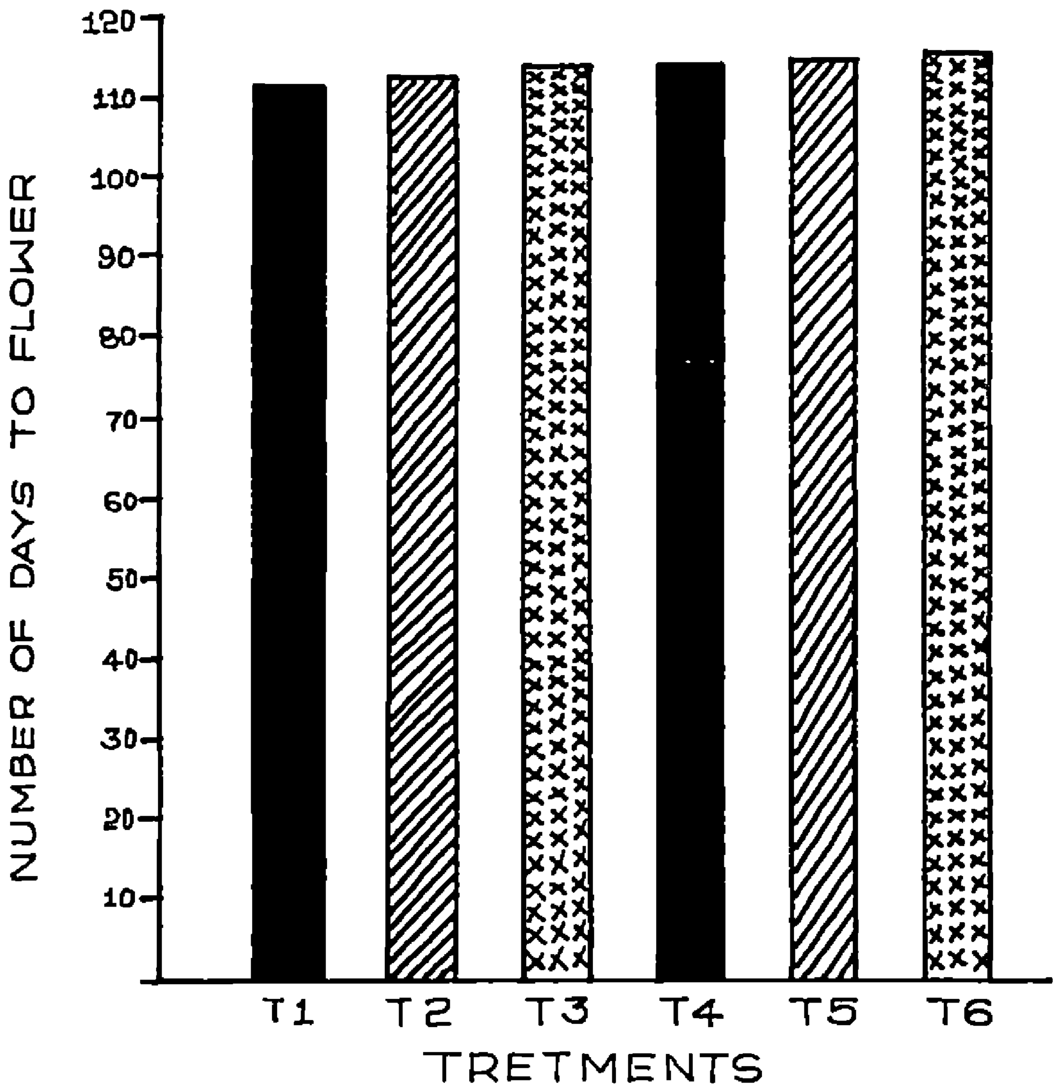


FIG.13. PLANT HEIGHT IN BRINJAL (cm)



Scale 1cm - 10units (Y-axis)

FIG-14: NUMBER OF DAYS TO FLOWER(BRINJAL)

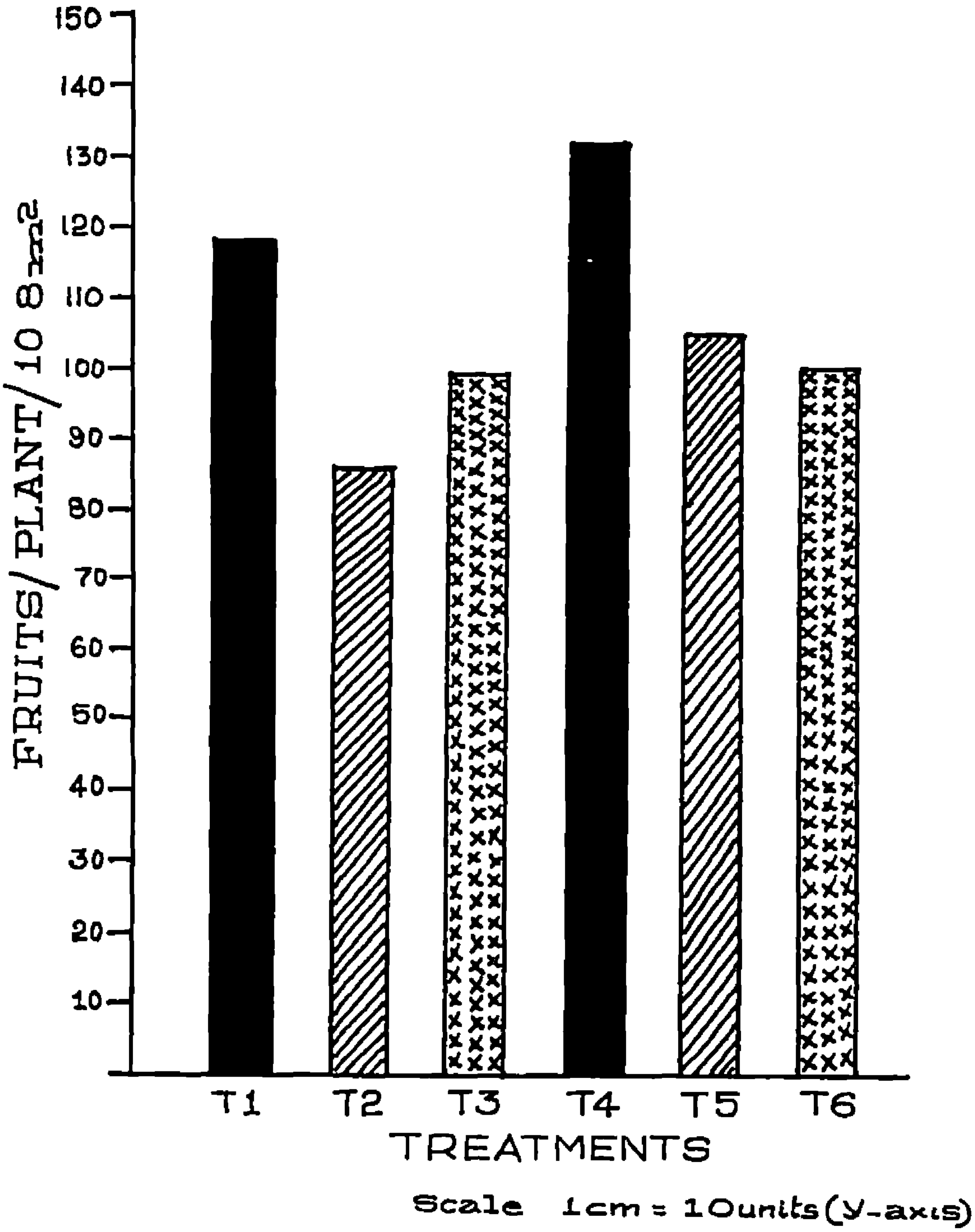
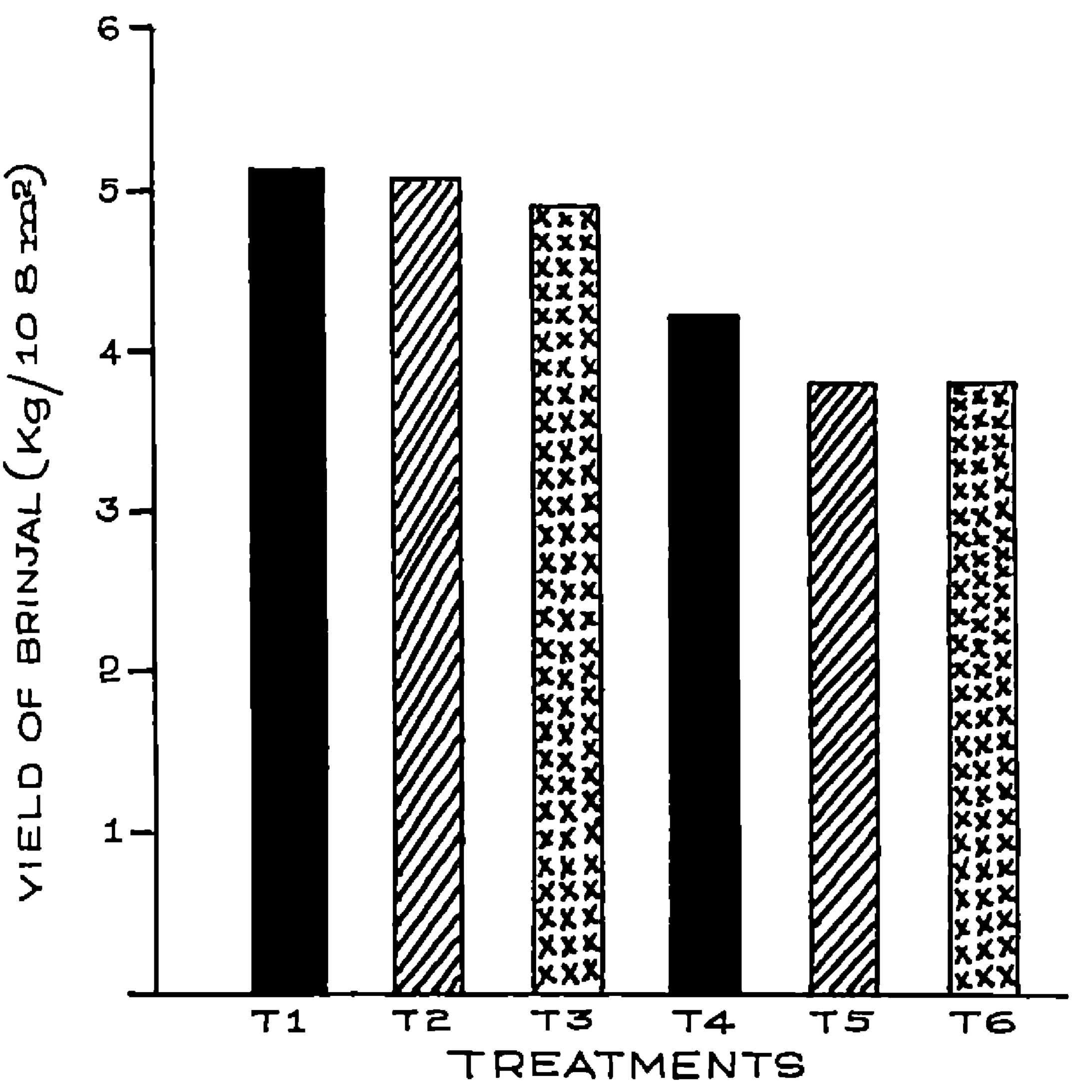


FIG-15: FRUITS PER PLANT IN BRINJAL (10.8m²)



SCALE 1cm = 0 5 unit (y axis)

FIG.16: YIELD OF BRINJAL (Kg/10.8 m^2)

irrigation resulted in significant increase in production and water use efficiency in crops viz., onion, sugar beet and potato in comparison with surface irrigation (AICRPWMS, 1975). Experiments conducted at Agronomic Research Station, Chalakudy (Anon., 1977-78) showed that vegetables like amaranthus and bhindi responded well to drip irrigation. The results of the present study agreed with the results obtained by the above workers. However, Kochy Varghese (1985) did not obtain any significant difference in yield of banana under drip and basin methods of irrigation.

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 occurred, they were cleared by gently tapping the microtubes 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 ordinary labourers without any difficulty. No adhesive was required as this system worked on low pressure and the microtubes were connected by the push fit method.

During irrigation by ordinary surface methods in a hectare of land there will be on an average 100 metres of wetted irrigation channel at a time. The measured loss due to lateral seepage in a 100 m channel was 27.7 %.

As explained earlier, with only half the quantity of water applied in basin method, the drip method of irrigation gave significantly superior yield than basin method. In addition to this, practically there was no conveyance loss in the drip method. This means that the water required to irrigate one hectare of vegetables by ordinary surface methods would be sufficient to irrigate more than 2.5 hectares of the same vegetables by drip method and better yield could be obtained.

Advantages

1. Drip method of irrigation gave higher yields both in amaranthus and brinjal.

2. Half the quantity of water applied by drip method of irrigation gave significantly superior yield than basin method of irrigation. In drip method, only a portion of surface area was wetted and evaporation took place only from that area. The component of evaporation in evapotranspiration was considerably reduced in drip method. Further in the case of drip method, only the root zone was wetted and percolation losses to a large extent eliminated. The higher yield obtained in drip method with half the quantity of water might be due to the reasons stated above.

3. Practically no water was lost in conveyance. The average loss of water in the basin method of irrigation while irrigating one hectare of land was 27.7%. And it was further noticed that half the quantity of water applied by drip method of irrigation gave significantly superior yield than basin method of irrigation. This means, the water required to irrigate one hectare of vegetables can be used to irrigate more than 2.5 hectares of the same vegetables by drip method and better yield could be obtained.

4. Weed growth was less in plots irrigated by drip method. The reason 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 basin method of irrigation, the entire surface area was wetted and this caused weed growth in the whole area.

5. 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 and evaporation.

The special advantages of KAU drip irrigation system over the conventional drip irrigation system are,

1. Special skill is not required for the fabrication, installation, maintenance and operation of KAU 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 is 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 on very low pressure, the pipes and fittings used would last longer than in the case of conventional system.

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

The disadvantage of the KAU 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 pressure. If the pressure is increased, it may cause leaks at joints.

The relative efficiency of KAU drip system with the conventional method of irrigation with respect to other crops, especially perennial crops is an important area for future line of work.

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 role to play.

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

The evaluation of the drip and basin methods of irrigation were carried out under field conditions at varying levels of water supply in amaranthus and brinjal. There were 6 treatments each having 4 replications. The experiment was laid out on randomised block design. The spacing of amaranthus was 20 cm x 25 cm and that of brinjal was 60 cm x 75 cm. All plots were surrounded by bunds. The border plants were treated as buffer plants to minimise border effects. The inner plants were treated as 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 using 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 embeded at a depth of 15 cm below the ground surface to prevent absorption of heat by the pipes and its consequent transmission to irrigation water.

Microtubes of 2 mm diameter were used as drippers or emitters. The microtubes were connected to the laterals by making holes having slightly lesser diameter than the external diameter of the microtubes and pushing the microtubes into these holes for a tight fit. These joints were leak proof as the system worked on low pressure. The microtube 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 5 litres per hour. It distributed water through 4 microtube emitters.

The tips of the microtubes were kept raised about 20 cm above the ground surface by tying to stakes fixed on the ground. The discharge from the microtubes could be varied by changing the length of the microtubes, raising or lowering the microtube tips on the stakes, changing the diameter of the microtubes and also by varying the hydraulic head.

Irrigation schedule was based on IW/CPE ratios of 1.0, 0.75 and 0.5 in both the methods of drip and basin irrigation. In drip method, plots were irrigated every day and the depth of irrigation water was based on the pan evaporation value of the previous day. In basin method, the depth of irrigation water was 30 mm and the frequency of irrigation was based on pan evaporation values and IW/CPE ratios.

The physical characteristics of the soil in the experimental field were studied and the soil texture was found to be sandy loam. The bulk density was found to be 1.44 gm/cc. The average field capacity and wilting percentage were 15.5 and 9.6 respectively.

Drip method of irrigation gave higher yields both in amaranthus and brinjal. In the case of amaranthus there were no significant differences in plant height and dry matter percentages, between treatments. In the case of brinjal, no significant differences were noticed in number of days taken for flowering and number of fruits per plant, between the treatments. There was significant difference in plant height between treatments.

With half the quantity of water given in basin method, drip method of irrigation gave significantly superior yield than basin method of irrigation. Practically no water was lost in drip irrigation system. The average loss of water due to conveyance in the field channel in the basin method of irrigation while irrigating in one hectare of land was found

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to be 27.7%. This means that the water required to irrigate one hectare of vegetables by basin method can be used to irrigate more than 2.5 hectares of the same vegetables by drip method and better yield could be obtained.

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 could be done in the field itself. Clogging was not a serious problem in this system. Since this system worked on low pressure, the pipes and tubes 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 1. Time required to flow 675 litres of water using the 7.5 cm diameter orifice of the plate

Head of water over centre of Orifice, in cm	Discharge l/sec	Time required to flow 675 l. in seconds
1.0	1.2	562.5
1.5	1.4	480.0
2.0	1.7	397.0
2.5	1.8	375.0
3.0	2.1	321.4
3.5	2.2	306.8
4.0	2.4	281.3
4.5	2.5	270.0
5.0	2.7	250.0
5.5	2.8	241.0
6.0	2.9	233.8
6.5	3.0	225.0
7.0	3.1	217.7
7.5	3.3	204.5
8.0	3.4	198.5
8.5	3.5	193.0
9.0	3.6	187.5
9.5	3.7	182.0
10.0	3.8	171.5

Appendix 2. Analysis of variance table for plant height of amaranthus (cm)

Sources	DF	SS	MSS	F
Treatments	5	23.08	4.62	2.85
Replications	3	42.88	14.29	8.82
Error	15	24.33	1.62	
Total	23	90.29		

Appendix 3. Analysis of variance table for yield in amaranthus at first harvest (kg/14.3 m^2)

Sources	DF	SS	MSS	F
Treatments	5	4.99	0.998	11.09
Replications	3	1.39	0.463	5.14
Error	15	1.36	0.09	
Total	23	7.74		

C.D. = 0.4518

Appendix 4. Analysis of variance table for yield of amaranthus at second harvest (kg/14.3 m^2)

Sources	DF	SS	MSS	F
Treatments	5	22.17	4.434	6.23
Replications	3	25.02	8.34	11.71
Error	15	10.68	0.712	
Total	23	57.87		

C.D. = 1.27

Appendix 5. Analysis of variance table for total yield in amaranthus (kg/14.3 m^2)

Sources	DF	SS	MSS	F
Treatments	5	45.164	9.0328	13.77
Replications	3	20.124	6.708	10.225
Error	15	9.836	0.656	
Total	23	75.124		

C.D. = 1.22

Appendix 6. Analysis of variance table for dry matter percentage in amaranthus

Sources	DF	SS	MSS	F
Treatments	5	26.02	5.204	2.32
Replications	3	206.37	68.790	30.70
Error	15	33.64	2.240	
Total	23	266.03		

Appendix 7. Analysis of variance table for plant height of brinjal (cm)

Sources	DF	SS	MSS	F
Treatments	5	43.4947	8.70	4.25
Replications	3	32.1928	10.73	5.20
Error	15	30.6791	2.045	
Total	23	106.3666		

C.D. = 2.15

Appendix 8. Analysis of variance table for number of days to flower Brinjal

Sources	DF	SS	MSS	F
Treatments	5	29.00	5.80	1.75
Replications	3	139.33	46.44	14.03
Error	15	49.67	3.31	
Total	23	218.00		

Appendix 9. Analysis of variance table for fruits per plant in Brinjal/ 10.8 m^2

Sources	DF	SS	MSS	F
Treatments	5	5359.71	1071.942	1.78
Replications	3	3415.79	1138.59	2.3
Error	15	7353.46	490.23	
Total	23	16128.96		

Appendix 10. Analysis of variance table for yield of Brinjal (kg/10.8 m^2)

Sources	DF	SS	MSS	F
Treatments	5	7.85	1.57	23.43
Replications	3	1.58	0.527	7.86
Error	15	1.01	0.067	
Total	23	10.44		

C.D. = 0.339

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 suit 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 evaluation of a low cost drip irrigation system fabricated with the cheapest and locally available materials in relation to the conventional basin method of irrigation was done in this experiment taking amaranthus and brinjal as indicating crops. The irrigation schedule was based on IW/CPE ratios of 1.0, 0.75 and 0.5 in both the methods viz., drip and basin irrigation. In drip method, plots were irrigated every day and the depth of irrigation water given was based on the pan evaporation value of the previous day. In basin method, the depth of irrigation water given was 30 mm.

Oil drums of 200 litres capacity were used as storage tanks for the drip irrigation system. 25 mm and 12 mm diameter black low density polyethylene pipes were used for main and lateral lines respectively which were embedded at a depth of 15 cm below the ground surface.

Microtubes 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 5 litres per hour from each microtube.

Physical characteristics of the soil and biometric observations of the plants were taken during the experiment. With half the quantity of water given in basin method, drip method of irrigation gave significantly superior yield than basin method of irrigation. Practically no water was lost in drip irrigation system. The average loss of water due to conveyance in the field channel in the basin method of irrigation in one hectare of land was 27.7%. This means that the water required to irrigate one hectare of vegetables by basin method can be used to irrigate more than 2.5 hectare of the same vegetables by drip method and better yield could be obtained.

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.