IRRIGATION MANAGEMENT RELATED TO SUB - SURFACE MOISTURE CONSERVATION TECHNIQUES IN ORIENTAL PICKLING MELON

(Cucumis melo Var. Canomon (L.) *makino)*

By

R. VEERAPUTHIRAN

THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture

KERALA AGRICULTURAL UNIVERSITY

Department of Agronomy

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680654

KERALA, INDIA.

1996

DECLARATION

I hereby declare that this thesis entitled "Irrigation management related to sub-surface moisture conservation techniques in oriental pickling melon (*Cucumis melo* var. canomon (L.) makino)" is a bonafide record of research work done by me during the course of research and that this 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.

College of Horticulture
Vellanikkara
Date : 25.9.96.

R. VEERAPUTHIRAN

Dr. P.A. JOSEPH
Asst. Professor (Agronomy)

Communication Centre
Directorate of Extension
Kerala Agricultural University
Mannuthy, Thrissur

CERTIFICATE

Certified that this thesis entitled **"Irrigation management related to sub-surface moisture conservation techniques in oriental pickling melon (*Cucumis melo* var. canomon (L.) makino)"** is a record of research work done by **Mr. R. VEERAPUTHIRAN** 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.

Place : Mannuthy
Date :

Joseph, P.A.
Dr. P.A. JOSEPH
Chairman
Advisory Committee

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Mr. R. VEERAPUTHIRAN** a candidate for the Degree of **Master of Science in Agriculture**, agree that this thesis entitled **"Irrigation management related to sub-surface moisture conservation techniques in oriental pickling melon (*Cucumis melo* var. canomon (L.) makino)"** may be submitted by **Mr. R. VEERAPUTHIRAN** in partial fulfilment of the requirement for the Degree.

DR. P.A. JOSEPH
(Chairman, Advisory Committee)
Assistant Professor (Agronomy)
Communication Centre
Directorate of Extension
Kerala Agrl. University
Mannuthy, Thrissur

DR. R. VIKRAMAN NAIR
(Member, Advisory Committee)
Professor & Head
Dept. of Agronomy
College of Horticulture
Kerala Agrl. University
Vellanikkara, Thrissur

DR. U. JAIKUMARAN
(Member, Advisory Committee)
Associate Professor & Head
Agricultural Research Station
Kerala Agrl. University
Mannuthy, Thrissur

Sri. V.K.G UNNITHAN
(Member, Advisory Committee)
Associate Professor
Dept. of Agrl. Statistics
College of Horticulture
Kerala Agrl. University
Vellanikkara, Thrissur

EXTERNAL EXAMINER

"TIME IS GOD"

Dedicated to

The God
My beloved parents and
V. Rathinasamy

ACKNOWLEDGEMENT

I express my deep sense of gratitude and indebtedness to **DR. P.A. JOSEPH**, Assistant Professor (Agronomy), Communication Centre, Directorate of Extension, Kerala Agricultural University, Mannuthy and Chairman of my Advisory Committee for his inspiring guidance, keen interest, sustained encouragement, constructive criticism and affectionate advices during the course of my study, research work and preparation of the thesis.

I am fortunate in having **DR. R. VIKRAMAN NAIR**, Professor and Head, Department of Agronomy, College of Horticulture as a member of my Advisory Committee for his unwearied attention, constant inspiration, inestimable and everwilling help rendered throughout the study and this investigation.

My heartfelt gratitude is due to **DR. U. JAIKUMARAN**, Associate Professor and Head, Agricultural Research Station, Mannuthy and member of my Advisory Committee for his ardent interest, valuable suggestions and timely help at various stages of this experiment.

I am very much obliged to Sri. **V.K.G. UNNITHAN**, Associate Professor, Department of Agricultural Statistics and member of my Advisory Committee for his help in designing the experiment and the statistical analysis of the results.

I am also extremely grateful to **DR. V.V. RADHAKRISHNAN**, Assistant Professor, Agricultural Research Station, Mannuthy for the immense help during the analysis of the data.

The constant encouragement, whole hearted co-operation and affectionate advices of **DR. N.N. POTTY, DR.C.T. ABRAHAM, DR. P.V. BALACHANDRAN, DR. K.E. SAVITHRI, DR. MERCY GEORGE** and other staff members, students, Sri. Thulasi and Smt. Sosamma and my friends has come a long way in helping me complete this investigation and I shall ever be grateful to them.

My heartfelt gratitude is due to **DR. G.R. PILLAI**, Associate Director of Research for the help during the preparation of thesis.

The help and assistance rendered by Miss. **G. IRINE** throughout this investigation is gratefully remembered.

The help provided by the Department of Agricultural Meteorology and Department of Olericulture is gratefully acknowledged.

The help and assistance rendered by the staff members and labourers of Agricultural Research Station and Information and Sales Centre, Mannuthy are gratefully remembered.

The help, whole hearted co-operation and assistance offered by Joshi, Manojkumar, Suja Thomas, Sudheesan, Sreekala, Nimmy Jose, Vandana, Sudheesh, Livi, Mini, Liji, Uthaman, Sathian, Manoj, Vasudevan, John, Kochappan and Santhosh are greatefully acknowledged.

I express my special gratitude to Senthil Vinayagam, Edwin Prem, Binu John Sam, Asha, Ravichandran, Mohan and Thavamani for their constant encouragement, affectionate support throughout the course of my study and this research work.

The award of **ICAR Junior Fellowship** is greatefully acknowledged.

My heartful thanks to Sri. **R. Noel** for the neat typing and prompt service.

I lovingly thank my parents, brothers, sisters and relatives whose inspiration, timely persuasion and warm blessings were very vital for successful completion of this work.

Above all I bow my head before **GOD, THE ALMIGHTY** whose blessings and '**POWER**' enabled me to complete my carrier successfully.

R. VEERAPUTHIRAN

CONTENTS

ABBREVIATIONS

Cu	:	Consumptive use
DAS	:	Days after sowing
ET	:	Evapotranspiration
IW/CPE	:	Irrigation water/ Cumulative pan evaporation
LAI	:	Leaf area index
MCT	:	Moisture conservation techniques
PET	:	Potential evapotranspiration
WUE	:	Water use efficiency

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Introduction

INTRODUCTION

Among the vegetables grown in India, cucurbits are the largest group of vegetables. They belong to the family Cucurbitaceae and are grown for their ripe and unripe fruits. They are used as salad and pickle and also as cooked vegetable. Cucurbits are good sources of carbohydrates, vitamin-A, vitamin-C and minerals (Yawalker, 1980). The seeds of cucumber are used in ayurvedic preparations. The oil extracted from seed is good for brain and body (Shanmughavelu, 1989). In South India, cucumber is the most economical cucurbit for cultivation in rice fallows (Rajamony *et al.*, 1985).

Growing of cucurbitaceous vegetables in summer rice fallows from September to April is a common practice in Kerala. This period coincides with the dry spell experienced in the state and the vegetable crops are exclusively grown with irrigation. The full potential of vegetable crop grown during summer months can be exploited only with judicious water management practices. Summer vegetables cannot be grown if proper irrigation facilities are not available. When water is a premium, vegetables of all types will usually get first priority. This is because they give high returns.

The water requirements of any crop during summer vary according to the variation in the evaporative demand of the atmosphere. Evapotranspiration rates varies from place to place and from season to season. Since climate is a major component that determines its rate, scheduling of irrigation based on evaporation values is more practicable and measurements are simple as compared to other methods.

Most of the vegetable crops require frequent irrigations. The cost of vegetable cultivation in the summer months is high due to too frequent irrigations practised by the growers and also due to expensive means of making the water available for irrigation through pumping or lifting with the help of country devices. Water use efficiency in summer vegetables is also very less due to enormous loss of water through evaporation, seepage and deep percolation from frequent irrigations. Therefore, there is a need to develop a suitable water management practice for summer vegetable which eliminate the necessity for frequent irrigations by integrating with viable sub-soil moisture conservation practices. This practice will definitely be highly acceptable to the growers as it can greatly reduce the cost of cultivation of summer vegetables and increase water use efficiency. Exploring the possibility of reducing the need for frequent irrigation through enhancement of sub-soil moisture retention is a new line of research in the field of water management of vegetables. As cucurbits are the main vegetable crops grown in the summer rice fallows oriental pickling melon has been selected for this study.

With these considerations in view, investigations on the "Irrigation management related to sub-surface moisture conservation techniques in oriental pickling melon *Cucumis melo* var. canomon (L.) makino)" was initiated. The study was conducted at the Agricultural Research Station, Mannuthy during the summer season of 1996, with the following objectives.

1. To study the effect of irrigation and moisture conservation techniques on growth and yield of oriental pickling melon

2. To compare the levels of irrigations and to compare the different moisture conservation practices on growth and yield
3. To study the interaction between levels of irrigation and moisture conservation techniques
4. To workout the moisture extraction pattern, consumptive use and water use efficiency.
5. To understand to what extent the incorporation of moisture retaining ameliorants in the root zone depth of vegetable crops can enhance moisture conservation ability of the soil and if so to what extent scheduling of irrigation can be modified for better water economy for vegetables
6. To work out the economics of cultivation.

Review of Literature

REVIEW OF LITERATURE

Vegetables have not received as much attention as that of field crops with respect to the studies on water management. Available literature however emphasizes the importance of moist regimes by frequent irrigations where water table is low. Meagre specific research on water management aspect and very little specific research on moisture conservation aspects have been reported in the case of cucurbits. Attempts have therefore been made to review the works conducted in India and abroad on cucurbits, a group of vegetables to which oriental pickling melon belongs.

The literature reviewed are classified under the following sections.

2.1 Effect of irrigation

2.2 Consumptive use and water requirement

2.3 Irrigation scheduling based on evaporation data

2.4 Methods of irrigation

2.5 Importance of moisture conservation in vegetables

2.6 Effect of moisture conservation techniques

2.7 Comparison of moisture conservation techniques

2.8 Effect of interaction of irrigation and moisture conservation techniques

2.9 Soil moisture depletion pattern

2.10 Critical stages of growth

2.11 Soil moisture and nutrient uptake

2.12 Chemical composition and nutrient uptake

2.13 Economics

2.1 Effect of irrigation

2.1.1 Effect of irrigation on growth attributes

An adequate water supply throughout the growing season is one of the important requirements for the successful cultivation of cucurbits. In the studies of Belik (1961), it was revealed that the optimum condition for cucumber development during the early growth phase was 80-90 per cent of full moisture capacity. Flocker *et al.*, (1965) reported that frequent and heavy irrigation increased the vine growth and succulence in melons. Results of the studies of Borna (1969) have proved that irrigation during the entire growing season was more effective in cucumber.

In Mexican squash, Escobar and Gausman (1974) noticed that the leaves of the plants under higher water stress were thicker and smaller, containing less water than under lower water stress. Leaf area in cucumber was greatly reduced under water stress (Cummins and Kretchman, 1974).

The highest plant growth of cucumbers at a medium soil moisture level of p^F 2.0 was reported by Tomitaka (1974). Michael (1978) revealed that the soil moisture at about 15 cm depth should not be allowed to drop below 70 per cent of total available moisture for better growth of vegetable crops. Studies conducted by Pai and Hukkeri (1979) revealed that for good growth of vegetables the soil moisture should be maintained at or above 75 per cent of availability in the active root zone.

Experiments conducted with pickling cucumbers (variety Premier) Ortega and Kretchman (1982) noticed that a reduction in the rate of vine growth and the number of nodes when the plants were subjected to stress for a period of one week. Growth was found to be completely inhibited after two weeks of stress.

In the studies conducted at Agronomic Research Station, Chalakudy, it was found that bittergourd responded well to irrigations and frequent irrigation at low depletion of available soil moisture was congenial for growth and development of cucurbits. However, heavy irrigations at frequent intervals were found to be detrimental for crop growth (Thomas, 1984).

The highest water melon growth was recorded when the plants were irrigated at IW/CPE ratio of 1.0 (Desai and Patil, 1984). Bhella (1988) recorded the greatest stem growth and early and total yield from plants grown with polyethylene mulch in combination with trickle irrigation.

In green house cucumber studies, Heissner *et al.* (1987)found that the experimental and linear phases of leaf growth were unaffected by soil moisture tension in the upper layers, but from 70 days after planting, the leaf area decreased more rapidly with higher moisture tension.

Studies conducted by Hegde (1988) indicated that for watermelon frequent irrigation, when the soil matrix potential at 15 cm depth reached -25 KPa, resulted in maximum drymatter accumulation and distribution, leaf area index, leaf area duration and net assimilation rate, leading to higher fruit yield compared with irrigation at -50 and -70 KPa.

Experiments conducted during the summer season of 1991 at Bangalore, Prabhakar and Naik (1993) found that 60, 90 and 120 per cent pan evaporation replenishment had significant effect on vine length and number of branches while it had no marked effect on number of leaves.

2.1.2 Effect of irrigation on yield and yield attributes

Adequate soil moisture enhances the number of female flowers, fruitset, fruit number and size of the fruits in cucumber.

2.1.2(a) Effect on number of female flowers and fruit set

Studies of Abolina *et al.* (1963) showed that the melon plants watered regularly produced greater number of female flowers.

Trial conducted by Pew and Gardner (1983) on muskmelon showed that earlier fruit set and earlier maturity was obtained by irrigation when soil moisture tensions at the 25 cm depth reached 50 75 KPa compared with 25 KPa.

Experiment conducted at Agricultural Research Station, Mannuthy revealed that the total number of female flowers produced increased progressively with higher levels of irrigation in watermelon grown in summer rice fallow (Siby, 1993).

2.1.2(b) Effect on fruit size and weight

Studies of Flocker *et al.* (1965) indicated that yield increase by irrigation in cucumber was due to fruit size. Studying the cultural practices requirements of summer squash, Bradley and Rhodeo (1969) concluded that the fruit weight was significantly increased by weekly irrigation compared with fortnightly irrigation.

The drip irrigation trial conducted by Singh and Singh (1978) revealed that the yield increase of cucurbitaceous crops by irrigation was associated with increase in the fruit weight.

Work done in ashgourd at Agronomic Research Station, Chalakudy indicated that the weight of fruits increased with increase in the level of irrigation (ICAR, 1982).

Trials conducted by Pew and Gardner (1983) on muskmelon showed that larger fruit size and earlier maturity were obtained by irrigating when soil moisture tensions at the 25 cm depth reached 50 or 75 KPa compared with 25 KPa.

In the field trials conducted in the summer season of 1990-91 at Bangalore showed that highest yield of cucumber (36 t ha^{-1}) was obtained due to higher fruit number per vine coupled with greater average fruit weight (Prabhakar and Naik, 1993). Yingjajaval and Markmoon (1993) found that in cucumber the yield increase by irrigation was due to fruit number rather than fruit size. Nerson *et al.* (1994) reported that increasing the water supply from a dry regime to a weekly irrigation regime significantly increased the mean fruit weight.

2.1.2(c) Effect on number of fruits

The drip irrigation trial conducted by Singh and Singh (1978) revealed that the yield increase of cucurbitaceous crops by irrigation was associated with number of fruits per plant.

According to Hayness and Herring (1980), irrigation at 0.7 bar produced the highest yields of marketable squash. However the number of marketable fruit was maximum with irrigation at 0.3 bar. Henriksen (1980) found that 60 per cent more fruits were produced with irrigation than without irrigation in ridge cucumbers.

Work done in ashgourd at Agronomic Research Station, Chalakudy revealed that the number of fruits per plant increased with increase in the level of irrigation (ICAR, 1982).

The field trial during the summer season of 1990-91 at Bangalore showed that the highest yield of cucumber (36 t ha^{-1}) was due to higher fruit number per vine coupled with greater average fruit weight (Prabhakar and Naik, 1993). Studies of Yingjajaval and Markmoon (1993) showed that in cucumber increasing the irrigation rate increased the total yields and it was due to fruit number rather than fruit size. Nerson *et al.* (1994) reported that increasing the water supply from a dry farming regime to a weekly irrigation regime had only a small effect on fruit number.

2.1.2(d) Effect on yield

Studies of Flocker *et al.* (1965) indicated that the yields of melon was increased by irrigation when soil moisture tension at the 45 cm depth reached three bars.

The sprinkler irrigation studies by Downes (1966) revealed that the average yield of melon was increased when irrigation at frequent intervals was practised. In the studies of Dunkel, (1966), the highest yield of cucumber was obtained when the soil moisture did not go below 70 per cent of field capacity.

In the cultural practices studies on summer squash, Bradley and Rhodeo (1969) concluded that irrigation at 7, 14 and 21 days interval made very little difference to the yield harvested frequently, but at the 21 days interval the ones over yield was markedly reduced. The fruit weight and fruit yield of muskmelon significantly increased by weekly irrigation compared with fortnightly irrigation (Jassal *et al.*, 1970).

The drip irrigation trial conducted by Singh and Singh (1978) indicated that the yield increase of cucurbitaceous crops by irrigation was associated with increased number of fruits per plant and increased fruit weight. Abreu *et al.* (1978) obtained highest average yield of melon (13.02 t ha^{-1}) when irrigation was applied at 0.7 atmosphere.

According to Hayness and Herring (1980), irrigation at 0.7 bar produced the highest yields of marketable squash. Chernovel (1980) observed that the night irrigated plants gave highest yield followed by evening, morning and mid-day irrigation. According to Katayal (1980), during dry weather weekly irrigation should be given to pumpkin and cucumber for maximum yield.

With muskmelons, Kashi (1981) obtained maximum yield with irrigation intervals of six and eight days. Green house cucumber studies by Mannini and Roncuzzi (1983) showed that irrigation at an interval of three to six days did not affect cucumber yield, but the volume of water applied was important. Tau *et al.* (1983) reported that irrigation at 60 per cent available soil moisture was ideal for multiharvest and at 25 per cent for once over harvest for highest yield in cucumber.

Trial conducted by Pew and Gardner (1983) on muskmelon showed that higher yield was obtained by irrigating when soil moisture tensions at the 25 cm depth reached 50 or 75 KPa compared with 25 KPa.

Experiment conducted at Agricultural Research Station, Mannuthy revealed that there was no significant difference in yield between irrigating at 25, 50 and 75 per cent depletion of available soil moisture for pumpkin, oriental pickling melon and ashgourd (Radha, 1985).

Irrigation studies on fluted pumpkin by Asoegwu (1988) showed that irrigating every six days produced significantly higher number of seeds while irrigating every three days gave the best leaf yield and pod yield. Pulekar and Patil (1988) found that the yield of watermelon was significantly increased due to irrigation scheduling at 10 mm CPE (3 days interval).

According to Stansell and Smittle (1989) the marketable fruit yield of summer squash was greatest when the plants were irrigated at 25 KPa of soil water tension.

The field trial during the summer season of 1990-91 at Bangalore revealed that the highest yield of cucumber (36 t ha^{-1}) was obtained with most frequent irrigation scheduled to replenish 120% of panevaporation (Prabhakar and Naik, 1993). Yingjajaval and Markmoon (1993) found that in cucumber increasing the irrigation rate from 100 to 150 or 200% potential evapotranspiration increased the total yields by 12 and 31 per cent respectively.

2.1.2(e) Effect on quality of fruits

Irrigation lowered the fruit dry matter, Vitamin C and sugar content in both fresh and processed cucumber (Krynska *et al.*, 1976). Elkner and Radzikowska (1976) found that irrigation particularly in years of low rainfall increased firmness, improved the taste and reduced percentage of hollow cucumbers, but decreased drymatter, total N and NO_3^-N in the fruit.

With muskmelons, Kashi (1981) obtained maximum yield and enhanced solid content with irrigation intervals of six and eight days.

Water management and method of irrigation studies by Neil and Zunio (1972) revealed that higher irrigation rate improved the flavour and decreased firmness in melon.

It can be thus concluded from the above review that irrigation on cucurbits increase the number of female flowers, early fruitset, fruit size and weight, number of fruits per plant, fruit quality and ultimately the yield.

2.2 Consumptive use and water requirement

In designating water use by the crops, the term consumptive use includes all the water consumed by the plants plus the water evaporated from the bare land and water surfaces in the area occupied by the crop.

Whitaker and Davis (1962) studied the irrigation water requirement of cucurbits and they found that the irrigation requirement of watermelon and cucumber was 150 hamm each and that for pumpkins and summer and winter squashes was 180 hamm each. Dunkel (1966) showed that optimal yields of cucumber could be obtained, when 600-750 mm of water was applied.

Water requirement study conducted by Neil and Zunio (1972) showed that the maximum evapotranspiration in irrigated cantaloups was 60 per cent of potential evapotranspiration and between flowering and fruit formation it was 55 per cent of potential evapotranspiration. The water uptake increased during fruit enlargement. At harvest, water uptake was 85 per cent of potential evapotranspiration which declined to 55 per cent by mid-day harvest. The water uptake at successive growth stage of melon crop was 560 m^3ha^{-1} between germination and fruitset, 1008 m^3ha^{-1} upto fruit enlargement, 882 m^3ha^{-1} upto pre-maturity and 280 $m^3 ha^{-1}$ to harvest.

In an investigation to find out the relationship between development and water utilisation in cucumber, Cselotel and Varga (1973) reported that during the period upto the beginning of flowering, the water uptake was small, amounting to five litres per plant. In a 30 days period following the beginning of flowering, the water uptake amounted to 30-31 litres per plant. In the subsequent 30 days period corresponding to full development of the fruits and the beginning of seed maturity, water uptake was 10-20 litre per plant.

In a trial to find out the amount and nature of water consumption in muskmelon, Konishi (1974) found that the total water consumption by a fruit bearing plant with a leaf area of about 11000 cm^2 was 85-90 litres. As the plant grows the ratio of water consumption per plant to panevaporation increased to a maximum at the netting stage and then declined with aging. He also observed that young leaves transpired faster than old leaves and water consumption was less by the plants without fruit.

Tomitaka (1974) in a study with cucumber observed that the evapotranspiration rate declined with a decrease in the soil moisture level. Pavlov (1976) observed that the highest yield of cucumber (26.6 kg m^{-2}) was obtained when 70-100 lm^{-2} of water was applied during the plant growing phase in 20-23 individual irrigations, followed by 480-570 lm^{-2} during fruiting in 92-94 individual irrigations.

The consumptive use of cucumber increased during flowering and early fruiting and then levelled off during late harvest (Loomis and Crandall, 1977). They also found that the total amount of water used during the later two months period of crop growth ranged from 300-400 mm over each of the four years of experiment.

The ratio of consumptive use to evaporation from a pan evaporimeter (Kc) increased to a maximum of 1.5 during the early harvest season.

The water requirement of water melon for the total growing period for a 100 day crop ranged from 400-600 mm (Doorenbos and Kassan, 1979). The consumptive use of watermelon increased as the irrigation levels increased from 0.6 to 1.2 IW/CPE ratios. The increased irrigation levels also increased the water requirement from 360 to 580 mm. The optimum water requirement for the highest yield was 540 mm (Desai and Patil, 1984).

Experiments conducted at Agronomic Research Station, Chalakudy revealed that the consumptive use increased with increase in the level of irrigation in the case of bittergourd (Thomas, 1984). Experiments conducted at Agricultural Research Station, Mannuthy revealed that the treatments which received frequent irrigation showed higher values of consumptive use throughout the crop growth period in the case of cucumber and other cucurbits like pumpkin and ashgourd (Radha, 1985). This was supported by Jacob (1986) and Thankamani (1987). Hegde (1987) reported that field water use efficiency increased with decrease in irrigation frequency.

The water consumption of winter squash at three different soil moisture tensions of 30, 50 and 80 KPa was 12.79, 12.75 and 12.44 cm respectively. The corresponding values for the spring crop were 15.18, 13.98 and 14.97 cm (Safadai, 1987).

In a heated greenhouse studies with cucumber Eliades (1988) observed that the average water requirement during the whole growing period was equivalent to 0.7 x pan evaporation. Maeda and Martinez (1988)found that for the greenhouse cucumber (Hybrid Monara) the average water consumption per plant per day was 360 ml during the period from transplanting to flowering, 800 ml from flowering to the start of fruiting, 1600 ml from the start of fruiting to 50 per cent fruiting and 1200 ml during ripening stage.

Studies in watermelon by Yadav *et al.* (1989) showed that water use efficiency was higher with irrigation at 83 mm cumulative pan evaporation and it was lowest with 62.5 mm cumulative pan evaporation. In a drip and perforated pipe irrigation study in green house cucumber in Japan showed that the average consumptive use was (1.5-2.8 mm day^{-1}) nearly equal to the evaporation (Komamura *et al.*, 1990).

The seasonal consumptive use for cucumber and squash was 267.0, 242.4 and 226.0 mm under a soil moisture tension of 0.35, 0.45 and 0.55 bar. The calculated reference evapotranspiration values were 363.1, 325.9, 370.6 and 275.3 mm per season by Blanny-Criddle, radiation. modified Penman and Pan evaporation methods (El-Gindy *et al.*, 1991).

Prabhakar and Naik (1993) found that with increase in the level of replenishment of pan evaporation from 60 to 120 per cent, the seasonal evapotranspiration of cucumber increased from 282 mm to 360 mm with corresponding increase in water use efficiency from 64 to 101 kg $ha^{-1}mm^{-1}$.

Experiments conducted at Agronomic Research Station, Chalakudy revealed that the consumptive use and the ratio of evapotranspiration to the pan evaporation (Et/Eo) values of bittergourd increased progressively with levels of nitrogen and irrigation. At higher moisture regimes the variation in consumptive use and Et/Eo values did not reflect in crop yield. Water use efficiency of the crop maintained a positive relation with levels of nitrogen and negative relation with levels of irrigation (Thampatti *et al.*, 1993).

Studies in ashgourd by Menon and Marykutty (1993) showed that field water use efficiency increased with decrease in IW/CPE ratio. An increase of 51.61 per cent field water use efficiency could be observed when irrigation level shifted from 0.75 to 0.25 IW/CPE ratio. The amount of water used is about one half that used at 0.75 ratio. This might be the reason for significant increase in field water use efficiency at 0.25 IW/CPE ratio.

It can thus be seen that consumptive use depends on the physiological stages of crop, evaporative demand of atmosphere and duration of the crop. The consumptive use increased with increasing levels of irrigation and the water use efficiency decreased with increasing levels of irrigation. Cucurbitaceous vegetable crops require about 500-600 mm of water through frequent irrigations.

2.3 Irrigation scheduling based on evaporation data

An evaporimeter is an instrument which integrates the effect of all the different climatic elements furnishing them their natural weightage (Dastane, 1967). Evaporation values measured from a standard USWB class-A open pan evaporimeter are extensively used for scheduling of irrigation using a suitable IW/CPE ratio (Sharma and Dastane, 1969; Sharma *et al.*, 1975; Vamadevan, 1980).

The applicability of different irrigation scheduling methods were critically reviewed by Prihar *et al.* (1975) and they observed that under Indian conditions, where instrumentation is limited, irrigation scheduling based on application to a fixed depth after the lapse of a given evaporation value from the USWB pan evaporimeter holds great promise.

Consumptive use of water which is the main part of water requirement of a crop is governed primarily by meteorological parameters. The high correspondence between water loss from an evaporimeter and potential evapotranspiration makes this approach attractive for irrigation scheduling, as the evaporation is easy to monitor and necessary equipment is simple and easy to maintain (Doorenbos and Pruitt, 1977).

Singh and Singh (1978) recorded high total yields with drip irrigation, at 65 per cent of the evaporation from a class-A pan evaporimeter in crops like bottlegourd, roundground and watermelon in loamy sandy soils of hot arid regions. Studies on scheduling irrigation to bittergourd and cucumber at the

Agronomic Research Station, Chalakudy indicated that 3 cm irrigation at IW/CPE ratio of 0.4 was optimum for both the crops in summer rice fallows (ICAR, 1981). Similar studies in ashgourd recorded the highest yield at IW/CPE ratio of 1.0 which was on par with the IW/CPE ratio of 0.7. Both these were significantly superior to the IW/CPE ratio of 0.4 (ICAR, 1982). The crops were however raised under shallow water table conditions.

An irrigation and date of sowing study conducted by Desai and Patil (1984) revealed that of the four irrigation ratios (IW/CPE 0.6, 0.8, 1.0 and 1.2) good plant growth, fruit quality and the highest yield of watermelon was obtained from irrigation at IW/CPE ratio of 1.0. Srinivas *et al.* (1984) studied the effect of four (25, 50, 75 and 100%) levels of evaporation replenishment under drip and furrow irrigation and indicated that replenishment of 25 per cent evaporation losses under drip and 50 to 70 per cent evaporation losses under furrow irrigation were optimum for realizing higher yields of watermelon.

In the studies conducted at the Agronomic Research Station, Chalakudy, it was found that IW/CPE ratio of 1.2 was the most ideal for cucurbits (Thomas, 1984). The results of the trial conducted during the summer season of 1986 using bittergourd and snakegourd at Agricultural Research Station, Mannuthy revealed that irrigation at IW/CPE ratio of 1.0 gave the highest yield on both the crops (Jacob, 1986; Thankamani, 1987).

Mannini and Gallinga (1987) compared the three irrigation rates (50, 100 and 150% x maximum evapotranspiration) (ETM) in an unheated greenhouse with cucumber. They recorded the highest yield, number and individual fruit weight with irrigation at 150% x ETM. In a greenhouse cucumber study, Eliades (1988) reported that the yield was highest in the 1.0 x potential evapotranspiration and significantly lower in the 0.6 x potential evapotranspiration.

In watermelon cultivar Sugarbaby, Yadav *et al.* (1989) recorded the maximum number of edible fruits per plant, total soluble solids and yield with frequent irrigations at 83 mm cumulative pan evaporation. In melons, Musard and Yard (1990) found that vitreous flesh disorder might be due to too much of water during fruit ripening and he also suggested that irrigation must be reduced to 40-50 per cent of evapotranspiration during the last week before harvest.

In a field trial at Bangalore, during the summer season of 1990-91 using cucumber revealed that irrigation scheduled to replenish 120 per cent of pan evaporation recorded the highest yield. This treatment also resulted in 25 per cent more of early harvestable yield (Prabhakar and Naik, 1993).

In an irrigation and fertilizer trial at Thailand, Yingjajaval and Markmoon (1993) found that increasing the irrigation rate from 100 to 150 or 200 per cent potential evapotranspiration increased the total yield of cucumber by 12 and 13 per cent respectively.

It is clear from the above review that scheduling of irrigation to cucurbitaceous vegetables based on evaporation data and more particular with IW/CPE ratio is reliable and that scheduling irrigation at an IW/CPE ratio of 1 to 1.2 best suits to cucurbits.

2.4 Methods of irrigation

Cucurbits are generally irrigated by furrow or basin methods.

The root development in the field grown cucumber was better with flood irrigation than sprinkler irrigation or no irrigation. Sharma and Dastane (1969) emphasized that to achieve high irrigation frequency, uniform water distribution and uniform high yields check basin should be microlevelled. Drip irrigation produced yields of melon twice as high as sprinkler irrigation (Goldberg and Shamueli, 1970).

Furrow irrigation increased the yield and mean fruit weight but did not affect the number of fruits per plant (Caro and Linsalata, 1977). Henriksen (1980) found that for ridge cucumbers there was no significant difference in yield and quality between drip irrigation and overhead manual watering.

The comparative effect of pitcher irrigation and pot watering in cucumber was studied by Balakumaran *et al.* (1982). They reported that yields were slightly higher in pot watering plants, but water economy was appreciably greater under pitcher irrigation. Reddy and Rao (1983) worked on the response of bittergourd to pitcher and basin systems of irrigation. They found that the yield was highest in plots with pitcher filled every 4th day and lowest in plots with basin filled every 5th day. Jacob (1986) found that in bittergourd pitcher irrigated plots have the lowest yield.

Studies conducted by Mannini and Gallinga (1987) revealed that irrigation methods had no effect on the yield of cucumber grown in unheated green house.

The comparative study between sub-surface and sprinkler irrigation in cucumber showed that sub-surface irrigation produced better yields than sprinkler irrigation. Srinivas *et al.* (1989) observed that drip irrigation gave higher yield than furrow irrigation in watermelon. The water use efficiency of watermelon was higher in surface irrigation followed by sprinkler and drip irrigation.

2.5 Importance of moisture conservation in vegetables

Moisture conservation is one of the important cultural practices in the growing of vegetable crops. Both surface and sub-surface moisture conservation techniques are practised. Surface moisture conservation techniques are more common than sub-surface moisture conservation techniques.

Moisture conservation techniques have several advantages like reduction of tillage operations, reduction of weed growth, reduction of evaporation from soil, increasing the water absorption by soil, regulation of soil temperature, inducing better root growth and nutrient availability and increasing the organic matter content of soil etc.

Generally irrigation methods have to be properly devised to get maximum profit from the moisture conser-vation techniques. The literature on the effect of soil moisture conservation techniques on crops more particularly on vegetables are reviewed below.

2.6 Effect of moisture conservation techniques

Numerous type of materials have been tried from rocks and to stones to slowly decomposing materials like sawdust and wood shavings, alfalfa and bean straw, hay and manures for their effect on soil moisture conservation (Lamb and Chapman, 1943).

Soil water characteristics and hydraulic conductivity functions were determined for the surface and sub-surface horizons were studied by Hapmans and Van Immerzeel (1988). They found that degree of reduction in evapotranspiration was governed by capacity of subsoil to transport water from the ground water to the rootzone.

2.6.1 Effect on water economy

Mulches are used for various reasons. However water conservation and erosion control are the most important for agriculture in dry season (Unger, 1971; Black and Siddoway, 1979 and Subbaiah *et al.*, 1978).

Crop residues and other plant waste products like straw, stover, leaves, corn cob, saw dust, wood chips etc. acted as cheap source of organic material readily available permitting water to enter the soil readily. When maintained at adequate levels, these materials reduced evaporation and increased water content in soil (Guptha, 1975).

In England, Goode and White (1958) compared the effects of clean cultivation and permanent straw mulch on soil moisture. They found that under the mulch, soil moisture remained close to the field capacity throughout the summer. Similarly in the relatively dry conditions of South West Finland, Vuorinen (1958) reported that mulching with straw reduced from four to two the number of irrigations needed to prevent the soil moisture tension raising to 700 mm Hg. Soczek (1958) observed that mulching with sawdust, peat and straw increased the levels of moisture in a polish cherry orchard.

An experiment with mulches in tropical soil stated that water conservation characteristics of soil was improved by mulches. He also observed that mulched plots had a higher soil moisture content throughout the growing season than the unmulched plots for both 0-10 and 10-20 cm depth. He also noticed that mulching indirectly influenced the waterholding capacity and moisture release characters of soil (Lal, 1972).

According to Raghothama (1981), paddy husk and coir dust were most effective in conserving soil moisture and reducing the number of irrigations required for cardamom. Mandal and Ghosh (1983) opined that the consumptive use was lowest with straw mulch and highest with no mulch.

Study on plastic house tomatoes by Suwwan and Judah (1985) indicated that compared with bare soil 15.15 and 25.76 per cent of water applied were saved by the white and black mulch treatments respectively.

They also found that water use efficiency was similar for the two mulch treatments but considerably higher than that of bare soil.

An experiment on turmeric was conducted at Punjab Agricultural University, Ludiana, using paddy husk and wheat straw as mulch. The results revealed that the mulches changed the microclimate by conserving more moisture, modifying soil temperature, controlling weeds and thus economising the use of irrigation water. It also showed that response of irrigation was much higher with the application of mulch as compared to no mulch (Mahey *et al.*, 1986).

In a laboratory study, Voorhes (1986) found that spoil that had been amended with sawdust had absorbed more water at 2,24 and 48 hours after initial wetting respectively than the spoil that had not been amended with sawdust. Kalaghatagi *et al.* (1990) found that total water use was lowest and water use efficiency was highest by using rice straw and black polythene as mulch in maize.

The moisture status under paddy husk, water hyacinth and paddy straw mulched plots were found to be higher in comparison to control plots in banana (Kotoky and Bhattacharya, 1991). Wang and Zhao (1991) observed that mulching with 3.75 to 4.5 t ha^{-1} of straw found to be an effective measure to reduce the inter-plant evaporation from a wheat paddock. The experiments showed that water consumption was reduced and the reduction in ineffective evaporation was approximately 35 per cent which was equal to the irrigation requirement of one watering (750 m^3ha^{-1}). Channabasavanna *et al.* (1992) recorded an increase of soil moisture level of 10.4 percent in straw mulch and 29.6 percent in polyethylene mulch over control.

Usefulness of coir pith as a moisture conserving agent in rainfed agriculture has been reported by Ramaswamy and Kothandaraman (1991) and Veerabadran (1991). The moisture content of the subsoil upto 60 cm depth was consistently higher in the coir waste mulch treatment in the cotton and cotton green gram cropping system (Rajendran, 1991). It was also reported that waterholding capacity of the soil increased by 40 percent due to coir pith addition.

Waterholding capacity of cinnamon lands of Srilanka was increased in direct proportion to the amount of coir pith incorporated into the soil (Santhirasegaram, 1965). Liyanke (1989) reported that in coconut gardens coirdust can be burried instead of coconut husks as a moisture conservation practice. Maximum benefit can be obtained by burying coir dust in layers of 8 cm thick alternated with 5 cm thick soil layers.

Mulching in pineapple plot with wood shavings, rice husk and sawdust enhanced soil moisture retention compared with no mulch control (Asoegwu, 1991).

In situ moisture conservation study conducted at Banglore revealed that incorporation of maize residue @ 4 t ha^{-1} continuously for three years had its good effects on water retention. The moisture content at sowing time in residue incorporated plots was 11.24 and 14.03 per cent in 0-15 and 15-30 cm depths compared to 8.85 and 13.39 per cent respectively in plots without residue (Channappa, 1994).

It is clear from the above review that application of organic materials either on the surface or sub-surface increase the moisture content of the soil and increase the water use efficiency of the crops.

2.6.2 Effect on growth and yield

Sawdust at 30 or 60 per cent of soil volume added to greenhouse soil two weeks before planting and incorporated to a depth of 25 cm increased the cucumber yield by 10-14.7 per cent (Ivonova and Ivonova, 1976). Mavrodii (1979) reported that adding chopped straw or saw dust in combination with fertilizers, increased the yields of cucumbers by 3.3-3.5 kg m^{-2}.

When pearl millet grain husks were incorporated with bentonite at 2.5-3.0 kg per pit they increased the yields in cucurbits. Bentonite alone did not give any result (Singh *et al.*, 1979). Iapichino and Gagliand (1984) observed the greater growth of water melon and earlier appearance of first female flowers in polythene mulched plots.

In pickling cucumbers mulching with polythene increased the yields by 149 per cent, vine length by 183 per cent, leaf number by 163 per cent and main root length by 128 per cent (Cerne, 1984).

Studies on the effect of mulches on coconut seedling establishment revealed that coir pith laid at 10 cm thickness recorded a highest plant survival of 86.7 per cent (Uthaiah and Lingaiah, 1989). Vani *et al.* (1989) observed that use of yellow polythene, transparent polythene and straw mulch reduced the levels of mosaic disease incidence in muskmelon and increased the plant growth and yield by 36, 74 and 51 per cent respectively.

In sandy soil, coir pith application at 10 t ha^{-1} resulted in increased pod yield of peanut (Arunachalam, 1987). Beside this, its usefulness in increasing the yield of number of crops viz., sorghum, pearlmillet, fingermillet, maize and cotton under rainfed condition to the tune of 10-30 per cent over control was reported by many workers (Anabayan, 1988); Athmanathan, 1988; Veerabadran, 1991). In irrigated crops also the trend of results observed for number of crops revealed that the performance of coir pith is on par with that of FYM for rice (Savithri *et al.,* 1991) and Nagarajan *et al.* (1989). However, the response of turmeric and sunflower to coir pith was better than FYM (Nagarajan *et al.*, 1989).

Incorporation of chicken manure, sugarcane bagasse and sawdust into the soil of the plant bed significantly increased the leaf area, flowering rate and yield in sweet pepper (Corrales *et al.*, 1990). Clark and Moore (1991) found that using of pine sawdust and woodchips to a depth of six inches as mulch increased the yield in rabbit eye and high bush blue berry compared with control although the differences were not significant.

According to Devaraj and Chockalingam (1991), coir pith mulching along with ridges and furrows in sugarcane produced highest cane yields of 82.5 t ha^{-1} c mpar d with 71.3 t ha^{-1} for no mulch. Asoegwu (1991) found that applying rice husk, sawdust as mulch produced significantly more leaf area in pineapple.

The best rubber seedling development was observed in an 80:20 sawdust : soil moisture (Reis, 1991). Abdel-Galil (1992) recorded the higher percentage of germination of mango seeds sown in 2 inches deep in sawdust. Experiments conducted at Banglore with potatoes cv. Kufrijyothi revealed that drymatter accumulation, tuber yield were highest with plastic mulching followed by rice straw mulching (Khalak and Kumaraswamy, 1992).

Experiments conducted with cucumbers grown in 50 cm deep trenches filled with rice straw covered with a 10 cm layer of clay or sand showed that straw media gave higher yields than sand or clay alone. Rice straw covered with sand gave higher plant fresh weight and drymatter content (Abou-El-Hassan *et al.*, 1993).

Incorporation of acid sphagnum peat or mixed pine hard wood sawdust increased plant growth, spread and vigour of "Erntedank" and "Korella" lingenberry (Stang *et al.*, 1993). Sari *et al.* (1994) found that cultivation of squash and cucumber under 2 m high polyethylene tunnels with clear polyethylene mulches raised the early and total yield of squash by 29 per cent and 30 per cent respectively and those of cucumbers by 51 per cent and 25 per cent respectively. Mulch tended to produce shorter and fatter cucumbers but had no effect on squash size or shape.

Sawdust mulch consistently depressed the yield and yield components of onion more than millet stover and groundnut shell mulch (Adetunji, 1994).

The mean plant height, leaf area, number of flowers per plant, mean number of branches per plant, root length, drymatter production and yield of fruits of egg plant were all the highest in plants grown with banana trash mulch @ 15 t ha^{-1} compared to other mulches and without mulch control (Saravanababu, 1994).

It could be seen from the above review that moisture conservation techniques significantly increase the growth, yield and yield attributes of many crops.

2.6.3 Effect of nutrient status

Because of the change in atmosphere of rhizosphere due to moisture concentration practices, it influences the mobility of nutrients within the soil rhizosphere and plays a significant role in determining the extent of nutrient uptake.

Use of plastic mulch increased the N, P and K uptake in cucumber and gherkins (Kromer, 1982; Zhang and Wang, 1986). Karbe (1984) observed that, sawdust mulch increased the N content of *Spiraea japanica* cv. Little Princess, decreased the P content, but K and Mg remain unchanged.

In a field trial conducted at Palampur, Himachalpradesh indicated that incorporation of chopped rice straw increased the N uptake of wheat (Verma and Dixit, 1989). Sandhu *et al.* (1992) found that rice straw mulching at the rate of 4 t ha^{-1} increased the nitrate N in wheat.

In guava plantations application of paddy husk and paddy straw as mulch increased the level of organic matter content of soil (Borthakur and Bhattacharya, 1992).

A field study was conducted on mulching and spacing on yield and quality of tomato under rainfed condition. The study revealed that there was a significant increase in P uptake by 33 per cent in straw mulching and 153 per cent in polyethylene mulch over no mulch (Channabasavanna *et al.* 1992). Cai *et al.* (1993) found that plastic film mulch in cucumber increased the N, P, K, Mg and Ca uptake by 79.2 percent.

Experiment conducted by Adetunji (1994) showed that there was no significant difference in N, P and K uptake of onion between groundnut shell and millet straw mulch. The least nutrient uptake was observed under sawdust mulch.

It can be summed up that the influence of moisture conservation techniques on nutrient uptake depends on the nature of material used and the type of crop.

2.7 Comparison of moisture conservation techniques

Experiments conducted at the Agronomic Research Station, Chalakudy revealed that mulching with dried leaves recorded the highest yield of amorphophallus followed by that with paddy waste and coir dust (Mathew *et al.*, 1988). Shajari *et al.* (1990) found that groundnut and rice husk could give efficient water savings and good yields of pineapple than white translucent and black coloured plastic mulches.

The results of a field experiment on sugarcane cv. CoC-771 showed that commercial cane sugar percent and content were not affected by either sugarcane trash or coir pith mulching applied along the furrows or ridges or on both (Devaraj and Chockalingam, 1993).

According to Asoegwu (1991), rice husk and sawdust mulch produced significantly more leaf area than wood shavings and without mulch in pineapple plots. Among the mulches viz. rice husk, sawdust and wood chips mulched to a depth of 5 cm recorded the highest yield in pineapple (Obiefuna, 1991).

Experiments conducted at Bangalore with potatoes cv. Kufrijyothi revealed that drymatter accumulation, tuber yield were highest with plastic mulching followed by rice straw mulch (Khalak and Kumaraswamy, 1992). Ashutosh Mandal and Chattopadhyay (1994) recorded the highest shoot growth of custard apple for the straw mulch treatment followed by black plastic, sawdust, coarse sand mulches and control. The yield of highbush blue berry was highest in bark mulched plots than peat and sawdust mulch (Mercik and Smolarz, 1995).

The above review clearly shows that the materials used for moisture conservation techniques have varying effectiveness on crop yield.

2.8 Effect of interaction of irrigation and moisture conservation technique

An interaction occurs when the response of one factor is modified by the effect of another factor. A positive interaction occurs when the response of two or more inputs used together is greater than the sum of their individual responses. The interaction effect of irrigation and moisture conservation practices on vegetable growth and yield are discussed below.

Irrigation and mulching studies by Suryanarayana and Venkateswaralu (1981) revealed that rice straw mulching with irrigation once in 15 days gave the highest fruit yield.

Experiment conducted at Punjab Agricultural University, Ludhiana showed that interaction effect of irrigation and mulching was significant on rhizome yield of turmeric. Paddy husk and wheat straw mulches where irrigation was scheduled at 40 mm CPE increased the rhizome yield at a greater magnitude as compared to those when irrigation was applied either 60 or 80 mm CPE (Mahey *et al.,* 1986).

Experiments conducted at Regional Agricultural Research Station, Pilicode revealed that practice of daily irrigation along with paddy straw mulching had given more yield in cucumber than other treatments (KAU, 1991).

Sprinkler irrigation study conducted by Tindall *et al.* (1991) showed that irrigation increased the tomato yield with a straw mulch along while adopting daily or twice weekly irrigation.

Although the interaction effects of irrigation and mulching were not significant, the number of flower buds per cluster and percentage fruit retention in ber were higher in pitcher irrigation with sugarcane trash or sawdust mulch, while per cent fruitset and yield were more in normal irrigation with sawdust and sugarcane trash (Jagtap and Wavhal, 1993).

Studies conducted at the College of Agriculture, Vellayani revealed that there was a significant effect on yield by the interaction between irrigation and mulching. Dry leaf mulch with 20% depletion gave highest yield followed by sawdust mulch with 40% depletion. This was superior than paddy husk or paddy straw mulches with either 20% or 40% depletion (Jayasree, 1987).

The above review indicates that presence of a moisture conservation technique may modify the effect of irrigation.

2.9 Soil moisture depletion pattern

The percentage of moisture use by the crop from different layers refers to the soil moisture depletion pattern.

The root system of all economic cucurbits is extensive but shallow (Whitaker and Davis, 1962). They also found that root growth often equals or exceeds vine length laterally and is very rapid and extensive in the upper 12-18 inches of soil. Vittum and Flocker (1967) pointed out that cucurbits are with medium or deep root systems that require large amount of water. Belik and Veselovskii (1975) reported that under irrigation, the main root mass of watermelon was in the 8.5 - 17 cm soil layer.

Water consumption study by Loomis and Crandall (1977) indicated that cucumbers extracted 50 per cent of the total amount of water consumed from the upper 30 cm of the soil profile, 30 per cent from the next 30 cm and 10 per cent from the next 30 cm.

In irrigated cucumbers, the root distribution at bearing was 64.5 per cent at 0-10 cm depth, 28.5 cm per cent at 10-20 cm depth and 6.2 per cent at 20-30 cm depth. In the case of unirrigated cucumbers the figures were 53.7 per cent at 0-10 cm, 29 per cent at 10-20 cm and 14.9 per cent at 20-30 cm (Zabara, 1978).

The field study conducted at Agronomic Research Station, Chalakudy by Thomas (1984) revealed that bittergourd depleted 42-48 per cent of total soil moisture from the top 15 cm soil layer. The moisture use from the 15 to 30 cm layer was as high as that from the next 30 cm soil layer below. The top 30 cm layer contributed about 66.71 per cent of total water use. Moisture depletion decreased rapidly with soil depth. He also observed that in comparison with wet regions, dry regions extracted more soil water from the lower soil layer. Similar observations were made by Radha (1985).

In a four year study on scheduling irrigation for cucumber by Ells *et al.* (1989) showed that the best combination of high yield, high water use efficiency was obtained by irrigating when 40 per cent of the available water was depleted. Thampatti *et al.* (1993) found that bittergourd extracted major part of the water from upper layers of soil irrespective of the irrigation treatments. More than 60 per cent of the squash roots were located in the top six inches of soil throughout the season (Ells *et al.*, 1994).

These works reveal that most part of cucurbits roots are located in the top layer of soil and the moisture extraction is found to be the highest from the upper layer of the soil profile.

2.11 Critical stages of growth

While scheduling irrigation the concept of critical stages of the crop has also to be taken into consideration. Critical stage refers to the stage of the crop growth when soil water stress will have a lasting effect on crop growth and yields.

In the studies of Varga (1973) it was found that in cucumbers the period between flowering and fruit ripening was critical for fruit development. During this period, it was necessary to supply the crop with 40 mm of water. However excessive water was found to be deleterious. Hammett *et al.* (1974) found that a constant supply of moisture is necessary during the growth of cucumbers especially during flowering and fruiting. Ware and McCollum (1980) found that the most critical period occurs at the time of flowering.

In gherkin cucumber, Riley (1990) found that there was a marked reduction in the total and saleable crop when water was not available during early flowering and particularly during fruiting stage.

Irrigation from the start of flowering and at full bloom is particularly beneficial. Fruit enlargement also requires large supply of water. Drought during flowering results in deformed, nonviable pollen grains leading to poor yield (Hegde, 1993).

It can be seen from the above review that preflowering, flowering and fruit development are the critical stages for cucumbers.

2.12 Soil moisture and nutrient uptake

Nutrient absorption is directly affected by the level of soil moisture, as well as indirectly by the effect of water on the metabolic activity of the plant, soil aliation and the salt concentration of the soil solution.

The absorption of N, P and K by cotton and soybeans increase linearly in response to increase in the soil moisture level from the wilting point to field capacity (Brown *et al.*, 1960).

According to Sharma and Prasad (1973), N uptake of bhindi was higher with irrigation of soil moisture tension of 0-0.5 atm as compared to 0-0.25 and 0-0.75 atm, respectively. They also reported that irrigation had failed to produce any significant effect on N content in plant parts.

Singh (1975) studied the effect of different soil moisture regimes along with graded doses of fertilizers on berseen fodder and he found that the percentage of N, P and K decreased with increase in moisture level from 25 per cent to 75 per cent. An increase in soil moisture level increased the total uptake of N significantly. The uptake of P and K also increased with water regimes, but did not reach the level of significance.

While evaluating the effect of soil moisture regimes of 25, 50 and 100 per cent available moisture on greengram, Varma and Subha Rao (1975) observed that a moisture regime of 50 per cent to be optimum for maximum N content in plant parts.

In cotton and sorghum, the K uptake was increased with increase in the soil moisture upto a certain level beyond which it decreased (Kharkar and Deshmukh, (1976). Reports from Carraso and Puente (1979) showed that water stress in strawberries increased the leaf N concentration but decreased the P and K concentration.

While studying the effects of irrigation, Gamayun (1980) observed that a moisture regime of 80 per cent of the field capacity was ideal for the maximum uptake of N, P and K by tomato than 60 and 70 per cent of field capacity. Balasubramaniam and Yayock (1981) observed that moisture stress during peg and pod development stages in groundnut at 9 to 13 weeks after sowing lowered the uptake of N.

In brinjal, N, P and K content of leaves and uptake become reduced as the soil water deficit increased (Panchalingam, 1983). Swiader (1985) found that irrigated pumpkins accumulated more N, P and K than dryland pumpkins.

The studies conducted at Agronomic Research Station, Chalakudy, revealed that N and P content of bittergourd leaves and stems were not affected by water management practices during any of the growth stages. However the leaves on the 55th day recorded a significantly higher value which was not visible at the final harvest. N, P and K uptake followed the trend more or less similar to that of dry matter production at all the growth stages (Thomas, 1984).

Irrigating watermelon when the soil matric potential at 15 cm depth reached -25 KPa compared with -50 and -75 KPa resulted in the highest mineral uptake of 51.82, 9.67, 50.28, 30.67 and 8.17 kg of N, P, K, Ca and Mg per ha respectively (Hegde, 1987a). Srinivas *et al.* (1989) found that frequent irrigations with 100 per cent panevaporation replenishment resulted in the highest N, P, K, Ca and Mg uptake in watermelon.

From this review, we can know that in general, higher soil moisture content leads to higher mineral uptake by plants.

2.13 Chemical composition and nutrient uptake

The leaf K content of cucumber decreased sharply with increasing yield, but the leaf N content was not affected (Fiskell and Breland, 1967).

The N, P and K contents of cucumber and tomato leaves during different phases of growth were determined by Grozdova (1970). He found that cucumber required higher N dose from the time of flower bud formation until the end of growth. The need for P increased during flower and bud formation, decreased slightly during flowering and rose again during cropping. Potassium was readily absorbed during early growth, declined during flower bud formation and then rose again.

The total uptake of N, P and K by pickling cucumbers was 90, 12 and 145 lb per acre respectively and the nutrients removed by the harvested fruits was 40, 6 and 55 lb per acre respectively (Mc Collum and Miller, 1971). Jessal *et al.,* 1972 reported that the percentage of N and P in the plant tissues were highest after maximum application of the respective nutrients irrespective of the irrigation frequency.

Wilcox (1973) determined the leaf N content and related it to yield. Optimum leaf total N composition in relation to yield was 4.5 per cent and the optimum petiole nitrate N composition was over 1500 ppm during plant growth and fruit formation stage.

The characterisation of nutrient uptake by muskmelon grown in hydrophonic culture was studied by Kagohaski *et al.* (1978). They found that the rates of N uptake rose gradually before pollination, increased rapidly after pollination, remained high for about 15 days and then suddenly fell to pre-pollination levels. Total uptake of nitrate N was higher during the early stages while that of K was lower during the later stages of the plant cycle.

The trials with domestic cucumbers, Laske (1979)recorded the crop removal of 500 kg ha^{-1} N during the growing season. He noted that when N = 1, the removal of N : P_2O_5 : K_2O was 1.0 : 0.4 : 2.0. Tesi *et al.* (1981) observed that nutrient requirements were greatest during fifteen days preceding the first harvest and during the subsequent fifteen days.

The N, P and K uptake of the crop followed a trend more or less similar to that of dry matter production at all the growth stages (Thomas, 1984). Swiader (1985) found that the concentration of N, P and K in foliage generally decreased as pumpkin age increased. Hegde (1987b) observed that the concentration of all nutrients decline with fruit maturity in watermelon.

The K concentration of summer grown cucumber leaves and the corresponding soil samples were lower than the optimum level (Choliaras and Mavromatis, 1991). Roppongi (1991) found that with the rapid growth of cucumbers, the optimum levels of nitrate N in petioles were 800-1200 ppm at the mid harvest and 100-300 ppm during the late stage of the harvest, while slower growth the optimum level was 1000-2000 ppm for all the stages.

In the studies conducted at Northern Territory, Australia using watermelon, Smith (1991) observed that the peak N uptake occurred around 46 days after planting coinciding with fruitset and rapid increase in ground cover. According to Drews and Fisher (1992), the standard press sap composition of cucumber nitrate N was 1000-1600 mgl^{-1} and for K it was 4000-5500 mgl^{-1}. The N concentration of petiole sap of cucumber increased with leaf age (Schacht and Schenk, 1994).

A nutrient uptake study was conducted in muskmelon cv. Galia-71 in cold greenhouse by Petsas and Lulakis (1995). They observed that for the production of approximately 5.2 kg frit per plant, 10.97 g N, 2.67 g P, 21.20g K, 15.06 g Ca and 4.68 g Mg per plant were taken up by the plant. They also found that N, P and K uptake was most intense between 10 and 12 weeks after planting, when fruit production was maximum but Ca and Mg uptake was most intense between four to six weeks after planting when vegetative growth was greatest. Schacht and Schenk (1995) observed that P and K uptake of greenhouse cucumbers were in a constant ratio to N uptake during the whole growing period and there was no constant relationship between water and N uptake.

2.14 Economics

One of the main objective of scheduling of irrigation is to reduce the cost involved in the cultivation as low as possible and to increase the economic product as high as possible. Therefore, getting maximum benefit from each unit of water applied to crop is important. Calculation of cost-benefit ratio will be highly useful in determining the irrigation scheduling.

In the studies conducted at Agronomic Research Station, Chalakudy on bittergourd grown in summer rice fallow revealed that irrigation at the IW/CPE ratio of 1.2 recorded the maximum net return per rupee invested followed by IW/CPE ratio of 0.8 (Thomas, 1984).

The results of experiments by Jayakrishnakumar (1986) indicated that bhindi needed daily irrigation at Chalakudy condition for maximum yield, however, maximum profit was recorded when it was irrigated as attaining CPE values of 30 mm.

Water management and fertilizer studies conducted at the College of Agriculture, Vellayani showed that scheduling irrigation (5 cm depth) when the CPE values reached 25 mm was the most economic management practice for cucumber raised in summer rice fallows (KAU 1991).

Experiments conducted in watermelon and cucumber grown in summer rice fallows at the Regional Agricultural Research Station, Pilicode, revealed that irrigation at IW/CPE ratio 0.5 had the maximum cost:benefit ratio for both the crops (Rajagopalan *et al.*, 1989).

In sandy soil coir waste application at 10 t ha^{-1} resulted in higher cost:benefit ratio over mulching with sugarcane trash, groundnut husk, maize cob pith, pearlmillet straw and nonmulched control (Arunachalam, 1987)

According to Channabasavnna *et al.* (1989), the use of polyethylene mulch in tomato cultivation caused a loss of Rs.1,443/- per ha where as the use of straw mulch gave a profit of Rs.2,986/- per ha over no mulch.

Results of the studies of Singh and Suraj Bhan (1993) revealed that maximum return of Rs.7,501/- per ha obtained by the use of plastic mulch in cotton was closely followed by maize stover mulch (Rs.7,188/- per ha), but from the consideration of mulch gave maximum return, being Rs.1.25 rupee invested.

Materials and Methods

MATERIALS AND METHODS

The details of the materials used and the techniques adopted during the course of this investigation are presented in this chapter.

3.1 Experimental site

The experiment was conducted in the rice fallow of the Agricultural Research Station, Mannuthy, Thrissur, Kerala. Geographically the area is situated at 10° 32 N latitude and 76° 10 E longitude and at an altitude of 22.5 m above the mean sea level.

3.2 Climate and weather conditions

The experiment was conducted during the summer season of 1996. The weekly weather data for the cropping period obtained from the Department of Agricultural Meteorology, College of Horticulture, Vellanikkara are presented in Table 1 and Fig.1.

The crop received 220.2 mm rainfall during its last stages of growth period. Mean evaporation was 6.4 mm/day during the growth period.

3.3 Cropping history

The experimental site is a double crop paddy wet land where every year a semidry crop during April-May to August-September and a wet crop during September-October to December-January were regularly cultivated. The land is usually left fallow during the summer season.

Table 1 Mean weekly weather parameters for the crop growth period

Standard Week No.	Month and date	Maximumm temperature (°C)	Minimum temperature (°C)	Sunshine (hours)	Relative humidity(%)	Wind speed (Kmh^{-1})	Mean evaporation (mm/day)	Total rainfall (mm)
4	Jan 22 - Jan 28	33.3	21.7	9.9	45	7.5	7.9	-
5	Jan 29 - Feb 04	33.6	22.0	10.2	50	8.5	8.3	-
6	Feb 05 - Feb 11	34.1	23.1	10.1	51	7.2	6.8	-
7	Feb 12 - Feb 18	34.8	23.3	9.6	51	5.5	6.6	-
8	Feb 19 - Feb 25	35.2	24.2	9.7	58	4.5	7.0	-
9	Feb 26 - Mar 04	35.9	23.5	10.4	50	5.6	7.5	-
10	Mar 05 - Mar 11	37.1	22.1	10.4	45	4.3	8.0	-
11	Mar 12 - Mar 18	37.4	24.8	7.9	63	2.9	6.8	-
12	Mar 19 - Mar 25	36.5	25.6	9.0	67	3.2	6.7	-
13	Mar 26 - Apr 01	35.0	25.0	6.6	72	3.1	5.5	-
14	Apr 02 - Apr 08	36.1	25.4	8.0	71	2.8	5.8	9.0
15	Apr 09 - Apr 15	34.6	24.6	7.8	70	3.1	5.5	8.6
16	Apr 16 - Apr 22	33.6	24.4	8.1	75	3.0	4.7	119.2
17	Apr 23 - Apr 29	34.1	25.5	9.6	76	2.6	5.0	15.2
18	Apr 29 - May 06	32.0	25.4	6.3	80	2.6	3.9	68.2

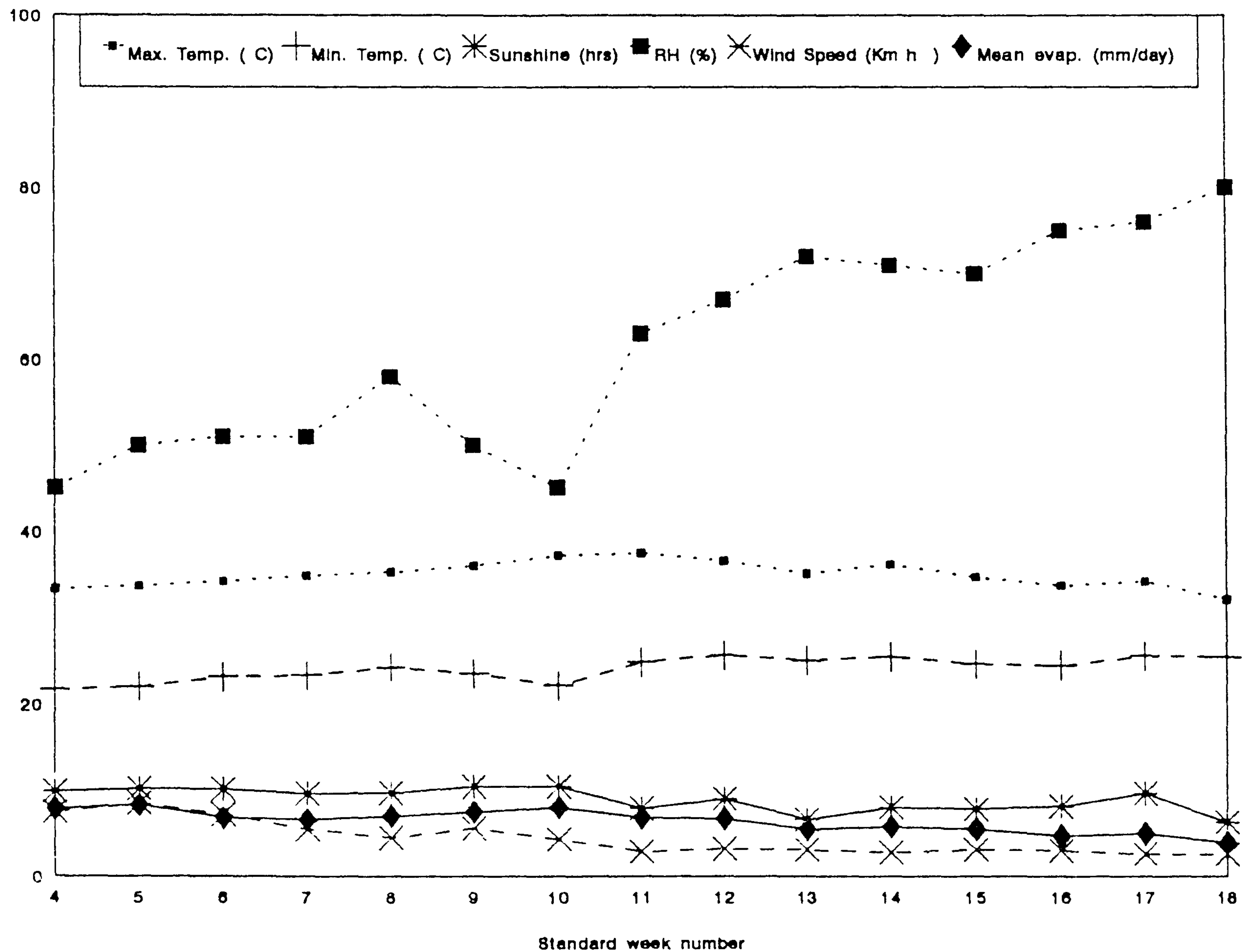
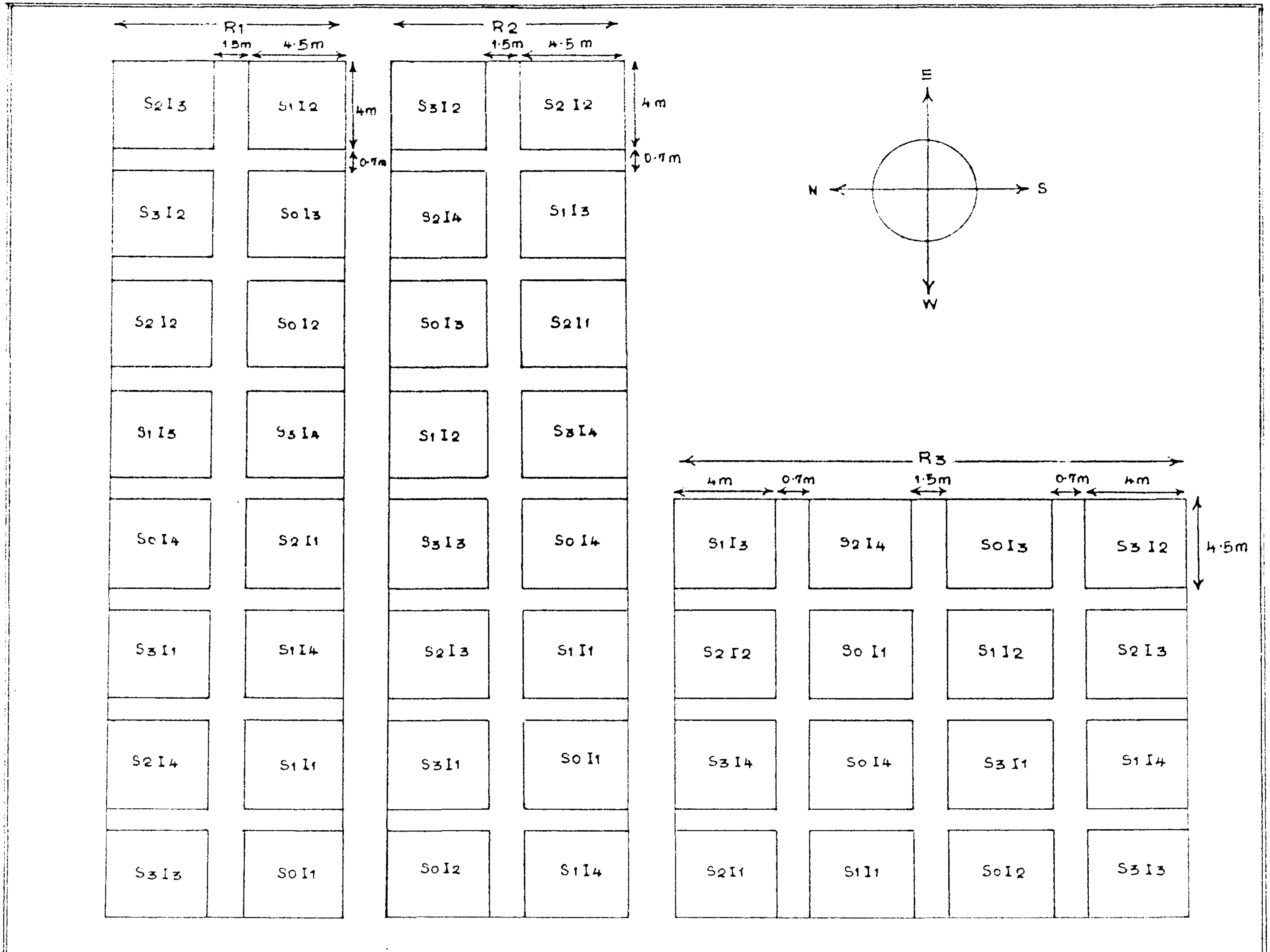


Fig.1 Meteorological data (weekly) during the crop period

Fig. 2 Layout plan of the experiment



3.4 Soil characteristics

Composite soil samples from 0-60 cm depth taken before commencement of the experiment were used for the determination of the physio-chemical properties. The data are presented in Table 2.

3.5 Crop and variety

Oriental pickling melon, variety Mudikkode local was used for this study. The plants have green pubescent angular stem. The leaves are orbicular with slightly serrated margin and blunt tip. The fruits are long and oval, golden yellow in colour.

3.6 Experimental technique

3.6.1 Layout

The layout plan of the experiment is given in Fig.2 The details are presented below:

Design	:	Randomised Block Design
Replications	:	Three

Treatments

Moisture conservation techniques	Notations
Control - No moisture conservation technique	S_0
Applying sawdust @ 1/3rd pit volume	S_1
Applying paddy waste @ 1/3rd pit volume	S_2
Applying coconut pith @ 1/3rd pit volume	S_3

Irrigation

Irrigation at IW/CPE ratio 0.4	I_1
Irrigation at IW/CPE ratio 0.8	I_2
Irrigation at IW/CPE ratio 1.2	I_3
Irrigation at critical growth stages of branching, flowering and fruit development (3 numbers)	I_4

Number of treatments - Sixteen (consisted of combinations of four moisture conservation techniques and four levels of irrigation)

S_0I_1	S_1I_1	S_2I_1	S_3I_1
S_0I_2	S_1I_2	S_2I_2	S_3I_2
S_0I_3	S_1I_3	S_2I_3	S_3I_3
S_0I_4	S_1I_4	S_2I_4	S_3I_4

IW = 33 mm (50% of the available water of the rootzone taking the effective rootzone depth as 60 cm and effective radius of wetting as 75 cm).

Plot size	:	4.5 x 4 m
Spacing	:	2 x 1.5 m
Number of pits per plot	:	Six pits having four plants in each pit

Table 2 Soil characteristics of the experimental field

A. Mechanical composition

Particulars	Per cent composition	Method employed
Coarse sand	26.58	Robinson's International Pipette method (Piper, 1950
Fine sand	24.04	
Silt	22.39	
Clay	27.31	
Textural class	Sandy clay loam	I.S.S.S. system

B. Physical constants of soil

Constant	Value	Procedure adopted
Field capacity (0.3 bars)	19.08	Pressure plate apparatus (Richard, 1947)
Permanent wilting point (15 bars)	10.82	Pressure plate apparatus (Richard, 1947)
Bulk density	1.34	Core method (Blake, 1965)
Particle density	2.16	Pycnometer method (Blake, 1965)

Contd.....

Table 2 contd...

c. Chemical properties

Procedure	Value	Method employed
Organic carbon	0.372%	Walkley and black rapid titration method (Jackson, 1958)
Available N	242.8 kg ha^{-1}	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available P	122.6 kg ha^{-1}	Chlorostannous reduced molybdophosphorus blue colour method in hydrochloric acid system (Jackson, 1958)
Available K	71.82 kg ha^{-1}	Flame photometry, Neutral normal ammonium acetate extraction (Jackson, 1958)
pH	5.4	1 : 2.5 Soil : Water suspension using pH meter (Jackson, 1958)
Electrical conductivity	0.41 mmhos cm^{-1}	Supernatant of 1 : 2.5 Soil : Water suspension using EC bridge (Jackson, 1958)

3.7 Cultural practices

3.7.1 Land preparation

The experimental area was ploughed well and then levelled. Plots of 4.5 m x 4 m size were taken leaving the buffer stripes of 70 cm with all around the plot. Pits of 45 cm depth and 60 cm diameter were taken. Recommended quantity of farm yard manure and moisture retaining ameliorants @ 1/3rd pit volume were thoroughly mixed with top soil and the pits were filled fully. Finally the basal dose of fertilizers were applied in each pit and incorporated into the soil.

3.7.2 Sowing

The seeds were sown on January 27th, 1996. The seedlings were thinned to four plants per pit, 20th day after sowing.

3.7.3 Manures and fertilizer application

Dried and powdered farm yard manure at the rate of 20 t ha^{-1} was applied uniformly to all the plots as basal dose. Urea, mussoriephos and muriate of potash were used for supplying the nutrients. Fertilizers were applied as per package of practices recommendation of Kerala Agricultural University (1993) @ 70:25:25 kg N, P_2O_5 and K_2O ha^{-1} respectively. Half of nitrogen and full doses of phosphorus and potassium were applied as basal dose at the time of sowing. the remaining dose of nitrogen was applied in two equal split doses at the time of vining and at the time of full blooming.

3.7.4 Irrigation

A presowing irrigation with two pots of water (16 litres) was given uniformly to all pits. Thereafter two pots of water were given uniformly to all the pits upto 19th day after sowing. Irrigation according to the treatments was started from the 20th day after sowing, when the plants were well established.

The quantity of water applied per pit was calculated by taking the effective radius of wetting and depth of rootzone as 75 cm and 60 cm respectively. Based on these values, the volume of water to be applied to bring the soil to field capacity was calculated (It was 58 litres per pit per irrigation). Irrigations were scheduled when the cumulative pan evaporation values attained 27.5 mm, 41.25 mm and 82.5 mm respectively for the IW/CPE ratios 1.2, 0.8 and 0.4. For the treatment I_4, three irrigations were given at the critical growth stage of the crop viz. branching, flowering and fruit development. Pot watering was adopted in all the cases. The details of irrigation given are presented in Table 3.

3.7.5 After cultivation

The basins were kept free of weeds throughout the crop growth period. When the plants started to vine, the interspaces between the plants were mulched with dried coconut leaves.

Table 3 Details of the irrigation treatments

Treatments	Total number of Irrigation	Interval of irrigation (days)	Quantity of water applied (mm)	Pre-treatment irrigation (mm)	Effective rainfall (mm)	Total quantity of water applied (mm)
I_1	4	12-17	132	91.0	59.5	282.5
I_2	8	6-9	264	91.0	110.0	465 .0
I_3	13	4-6	429	91.0	127.7	647.7
I_4	3	-	99	91.0	93.0	283.0

3.7.6 Plant protection

Furadon was applied 15-20 days after sowing as a prophylactic measure against the attack of red pumpkin beetle. Leafminor was controlled by applying Dimethoate @ 0.2%. At the fruit development stage attack of mites was noticed and the same was brought under control by spraying Kelthane @ 0.2%.

3.7.7 Harvesting

Fruits were harvested when they were fully mature. The maturity was judged by visual appearance. Totally three harvesting were done on 01-04-1996, 12-04-1996 and 02-05-1996.

3.8 Soil moisture studies

3.8.1 Soil sampling

Soil samples were collected by using a screw auger. Sampling was done at a distance of 10-15 cm away from the base of the plant from three depths viz.0-15 cm, 15-30 cm and 30-45 cm. The soil samples were dried inside the hot air oven at 105°C for 24-26 hrs. After taking the weights of dry soil, the loss of moisture was estimated and expressed as percentage of oven dry soil.

3.8.2 Consumptive use

The consumptive use of water by the crop under different treatments was worked out using the formula described by (Michael, 1978).

$$u = \sum_{i=1}^{n} \frac{M1i - M2i}{100} Ai\ Di$$

where,

u	=	water use from the rootzone for successive sampling periods or within one irrigation cycle, mm
n	=	number of soil layers sampled in the rootzone depth D
M1i	=	soil moisture percentage at the time of the first sampling in the i^{th} layer
M2i	=	soil moisture percentage at the time of the second sampling in the i^{th} layer
A	=	Apparent specific gravity of the i^{th} layer of the soil
D	=	Depth of i^{th} layer of soil, mm

Following each irrigation, soil moisture determination was done after 48 hours. For this period potential evapotranspiration obtained by multiplying pan evaporation value with crop factor 0.6 was taken for the calculation of consumptive use (Dastane, 1972). The effective rainfall determined based on the soil moisture content and the potential evapotranspiration were also taken into account for computing consumptive use. Seasonal consumptive use was calculated by summing up the consumptive use values for each sampling interval. The daily moisture depletion was worked out by dividing the total consumptive use by the duration of the crop in days.

3.8.3 Soil moisture depletion pattern

The average relative soil moisture depletion from each soil layer in the rootzone was worked out upto 45 cm for each irrigation interval. The potential evapotranspiration values for the 48 hours after each irrigation, extrapolated from the class-A pan evaporation data were added to the depletion in the first layer and total loss from each layer was determined on percentage basis at the end of the period.

3.8.4 Water use efficiency

Field WUE and crop WUE were computed using the following formulae and are expressed as kg $hamm^{-1}$.

$$\text{Field WUE} = \frac{\text{Fruit yield kg ha}^{-1}}{\text{Consumptive use (mm)}}$$

$$\text{Crop WUE} = \frac{\text{Fruit yield (kg ha}^{-1})}{\text{Total water applied (mm)}}$$

3.8.5 Crop coefficient (Kc)

The Kc was worked out by dividing the consumptive use during a given period by the pan evaporation values during that period.

3.9 Biometric observations

3.9.1 Length of vine

The length of vine was recorded from four plants per plot at 45, 75 DAS and at the time of harvest. The length of main vine was measured from the base to the growing tip of the vine and the mean length of vine per plant were worked out.

3.9.2 Number of leaves per vine

The total number of leaves of the main vine from three plants per pit was recorded at 45, 75 DAS and at the time of harvest of the crop. The mean number of leaves per vine was worked out.

3.9.3 Drymatter production

Drymatter content of the vegetative parts was recorded at the time of harvest. Two plants per plot were randomly chosen and cut close to the ground and kept in an oven at 80±5°C to a constant weight. The drymatter content was expressed as g $plant^{-1}$.

3.9.4 Leaf area

Since destructive sampling was not possible, on the spot determination of leaf area was done. A set of leaves of varying maximum width was picked and measured in a leaf area meter. For each maximum width of leaves, leaf area was worked out by averaging five leaves. By considering the maximum width, the leaves were grouped into three or four categories. The average leaf area for each category was worked out and multiplied by the number of leaves to get the leaf area of that category. Total leaf area was found by adding the leaf areas of all categories and which was divided by total number of leaves per plant to get the average leaf area. The average leaf area were worked out at 3 stages viz., 45, 75 DAS and at harvest.

3.9.5 Leaf area index

Leaf area index was found by dividing the total leaf area by the land area occupied by the plant (Watson, 1947). Leaf area index were worked out at 3 stages viz., 45, 75 DAS and at harvest.

3.9.6 Mean length of fruit

The length of five fruits harvested from each plot was recorded in cm and the mean length was worked out.

3.9.7 Mean girth of fruit

The girth at the centre of the fruit was recorded from five fruits per plot and the mean girth for a fruit was calculated.

3.9.8 Mean weight of fruit

Weight of fruits harvested from each plot from the various harvests was recorded and the mean weight was determined.

3.9.10 Yield of fruits

Total weight of fruits harvested from each plot from the various harvests was recorded and the yield in tonnes per hectare and yield in kg $plant^{-1}$ were worked out.

3.9.11 Number of fruits per plant

Total number of fruits harvested from each plot was recorded and divided by number of plants per plot to get the number of fruits per plant.

3.10 Plant analysis

Leaf samples collected for chemical analysis were oven dried at $80\pm5^{\circ}C$, ground and used for analysis. The N, P and K contents in leaves were determined at three stages of crop growth viz., 45^{th} DAS, 75^{th} DAS and at final harvest.

a) Nitrogen content

The total nitrogen content of leaf samples was determined by Microkjeldahl method (Jackson, 1958).

b) Phosphorus content

The phosphorus content of the samples was determined using di-acid extract (Jackson, 1973). A Klett-Summerson Photoelectric colorimeter was used for reading the colour intensity developed by Vanadomolybdo phosphoric yellow colour method.

c) Potassium content

The potassium content of samples was determined with di-acid extract, reading in an EEL flame photometer (Jackson, 1973).

3.11 Statistical analysis

Data relating to each character was analysed by applying the analysis of variance technical and significance was tested by 'F' test (Snedecor and Cochran, 1967).

Results

RESULTS

The results of the experiment on the "Irrigation management related to subsurface moisture conservation techniques in oriental pickling melon *Cucumis melo* canomon (L.) makino" are furnished in this chapter.

4.1 Growth attributes

4.1.1 Vine length

The mean values of the length of main vines recorded at 45, 75 days after sowing (DAS), and at harvest are presented in Table 4 and its analysis of variance in Appendix I.

The main effects of irrigation and moisture conservation techniques along with their interaction were found to be significant.

As evident from the table, MCT (moisture conservation techniques) had a significant influence on vine length. At 45 DAS, among the treatments, moisture conservation with coir pith (S_3) recorded significantly the highest value and the effects of other moisture conservation techniques were at par and significantly inferior to the moisture conservation with coir pith. At 75 DAS also coir pith incorporated plots recorded the maximum vine length, but was at par with the incorporation of sawdust (S_1) and paddy waste (S_2). The lowest value was recorded by the control plots (S_0) and was significantly inferior to the other treatments. At harvest also the

Table 4 Length of vines (cm) as influenced by MCT (moisture conservation techniques) and levels of irrigation

Treatments	45 DAS	75 DAS	Harvest
MCT			
S_0	115.792	146.750	157.750
S_1	114.458	158.438	162.188
S_2	116.750	161.813	165.625
S_3	125.542	164.979	171.563
Irrigation			
I_1	98.646	143.854	148.833
I_2	130.792	166.667	171.146
I_3	145.646	192.208	208.229
I_4	97.458	129.250	134.521
SEM±	2.80	3.24	3.10
CD	8.09	9.34	8.96
Interaction	Sig.	Sig.	NS

MCT - Moisture conservation technique
DAS - Days after sowing

vine length was maximum with coir pith incorporation plots. Its effect was at par with paddy waste incorporation but significantly superior to sawdust incorporation and control. Though control plots recorded lowest vine length, its effect was at par with sawdust and paddy waste incorporation. At all the three stages of observation highest vine growth was observed in coir pith incorporated plots followed by paddy waste incorporation.

Among the irrigation treatments, at 45 days after sowing, irrigation at IW/CPE ratio 1.2 (I_3) recorded the highest value and was significantly superior to other treatments, followed by irrigation at IW/CPE ratio 0.8 (I_2). The effect of irrigation at IW/CPE ratio 0.4 (I_1) and at critical stages (I_4) were at par but were significantly inferior to irrigation at IW/CPE ratio of 1.2 and 0.8. At 75 DAS and at harvest maximum vine length was observed with I_3 and was significantly superior to the rest of the treatments. The lowest value was recorded by I_4 and its effect was significantly inferior to the other treatments at both the above stages. The results have clearly indicated that vine growth is significantly highest when irrigation was undertaken at close intervals ie, IW/CPE ratio of 1.2.

At 45 DAS, incorporation of coir pith and irrigation at IW/CPE ratio 1.2 produced the maximum vine length. Moisture conservation with coir pith produced significantly the highest vine length when irrigation was given at IW/CPE ratio 1.2. This was significantly followed by paddy waste incorporation. Significant effect of adding moisture conserving materials on vine length was evident only with irrigation

Table 4(a) Mean length of vines (cm) at 45 DAS under MCT and irrigation treatments

Treatments	I_1	I_2	I_3	I_4
S_0	98.750	130.583	131.00	100.833
S_1	99.333	129.167	132.500	96.833
S_2	98.583	123.417	149.250	95.750
S_3	97.917	138.000	169.833	96.417
SEM±	5.79			
CD	16.18			

Table 4(b) Mean length of vines (cm) at 75 DAS under MCT and irrigation treatments

Treatments	I_1	I_2	I_3	I_4
S_0	136.417	160.417	177.500	118.667
S_1	142.083	168.750	191.667	126.250
S_2	144.167	170.417	197.083	135.583
S_3	153.750	167.083	202.583	136.500
SEM±	6.48			
CD	18.68			

at IW/CPE ratio 1.2. The vine length of control plots was statistically at par with that of sawdust and the effects of these two treatments were significantly inferior to that of paddy waste and coir pith incorporation when irrigation was scheduled at the same level. Among the irrigation treatments, irrigation at IW/CPE ratio 1.2 recorded the maximum vine length which was at par with that of irrigation at IW/CPE ratio 0.8, when no MCT and sawdust incorporation were done. However when coir pith and paddy waste were added, the vine lengths were significantly higher with I_3 than I_2. At all the moisture conservation treatments, the effects of I_1 and I_4 were at par and significantly inferior to that of I_2 and I_3.

At 75 DAS also, moisture conservation with coir pith produced the highest vine length at irrigation at IW/CPE ratio 1.2 which was at par with that of coir pith and sawdust, but was significantly superior to control. Though the vine length of incorporation of paddy waste was at par with that of sawdust, it was significantly superior to control at the same irrigation frequency level. Though the vine length of control plots was at par with that of sawdust incorporation, it was significantly inferior to that of coir pith and paddy waste incorporation at the same irrigation frequency level. But in the case of irrigation at IW/CPE ratio 0.8, o.4 and at critical stages, the moisture conservation techniques did not significantly influence the vine length. Among the irrigation treatments, irrigation at IW/CPE ratio 1.2 recorded the maximum value and was at par with that of irrigation at IW/CPE ratio 0.8, when no MCT was done. However when coir pith, paddy waste and sawdust were added the vine length were significantly higher with I_3 than I_2. At all the moisture conservation treatments, the effects of I_1 and I_4 were at par and significantly inferior to that of I_2 and I_3.

The interaction effect due to moisture conservation and irrigation on vine length was however not significant at the time of harvest. The interaction effect clearly shows that MCT produce significant effect on vine length only at closer intervals of irrigation, ie., at IW/CPE ratio 1.2 and the effects are more pronounced at 75 DAS.

4.1.2 Number of leaves per vine

The data relating to the number of leaves of the main vine are given in Table 5 and the analysis of variance in Appendix II.

Number of leaves per vine was significantly influenced by both the moisture conservation techniques and irrigation schedules. With respect to MCT, at 45 DAS, incorporation of coir pith recorded the maximum value and was at par with that of incorporation of paddy waste. Though the moisture conservation with sawdust, paddy waste and control were at par, control and moisture conservation with sawdust were significantly inferior to the MCT with coir pith. At 75 days after sowing paddy waste incorporation recorded the highest value and was at par with coir pith incorporation. Both were significantly superior to control and sawdust incorporation which were at par. Control plots recorded the minimum number of leaves per vine. At the time of harvest, MCT had no significant influence on the number of leaves per vine.

Table 5 Number of leaves per main vine as affected by MCT and levels of irrigation

Treatments	45 DAS	75 DAS	Harvest
MCT			
S_0	14.83	15.75	14.36
S_1	15.19	16.00	14.88
S_2	15.44	19.22	16.33
S_3	16.28	18.00	15.78
Irrigation			
I_1	13.83	14.97	16.69
I_2	16.22	18.45	16.56
I_3	18.42	21.14	14.49
I_4	13.28	14.41	14.61
SEM±	0.35	0.49	0.59
CD	1.01	1.43	NS
Interaction	NS	Sig.	Sig.

Among the irrigation treatments, at 45 DAS, irrigation at IW/CPE ratio 1.2 recorded the maximum number of leaves and was significantly superior to the other treatments. Though the effects of irrigation at IW/CPE ratio 0.4 and at critical stages were at par, they were significantly inferior to irrigation at IW/CPE ratio 0.8 and 1.2. But at the time of harvest no significant difference on number of leaves per vine was observed among the irrigation treatments.

The interaction between MCT and irrigation was not significant at 45 DAS, but was significant at 75 DAS and at harvest. At 75 DAS, the highest value was recorded by the moisture conservation using paddy waste with irrigation at IW/CPE ratio 1.2 and was significantly superior to all other treatments. The effects of moisture conservation with coir pith, paddy waste and sawdust were significantly superior to control when irrigation was given at IW/CPE ratio 1.2 and the effects of incorporation of coir pith and sawdust were at par at the same IW/CPE ratio of 1.2. Incorporation of paddy waste (S_2) was significantly superior to control (S_0) and sawdust (S_1) and was at par with that of coir pith (S_3) when irrigation was given at IW/CPE ratio 0.8. The effects of control, coir pith and sawdust were at par at the same irrigation frequency level. The effect of moisture conservation with coir pith was significantly superior to control and sawdust incorporation when irrigation was given at IW/CPE ratio 0.4 also, but was at par with paddy waste. When irrigation was scheduled at critical stages, the effects of moisture conservation materials and control were at par.

Table 5(a) Mean number of leaves per vine under MCT and irrigation treatments at 75 DAS

Treatments	I_1	I_2	I_3	I_4
S_0	13.78	16.89	17.22	13.11
S_1	13.11	16.78	20.78	13.33
S_2	15.67	22.00	25.33	13.89
S_3	17.33	18.11	21.22	15.33
SEM±	0.99			
CD	2.87			

Table 5(b) Mean number of leaves per vine under MCT and irrigation treatments at harvest

Treatments	I_1	I_2	I_3	I_4
S_0	14.11	16.00	14.00	15.33
S_1	15.22	14.78	15.30	14.22
S_2	14.55	16.67	18.00	14.11
S_3	15.89	16.78	18.67	14.78
SEM±	1.18			
CD	3.41			

Among the irrigation schedules, irrigation at IW/CPE ratio 1.2 and 0.8 were at par and were significantly superior to other irrigation schedules which were at par when no MCT was done. But when incorporation of sawdust or paddy waste or coir pith were done, irrigation at IW/CPE 1.2 produced significantly the maximum number of leaves per vine followed by irrigation at IW/CPE ratio 0.8. Among the moisture conserving materials, the effect of paddy waste was significantly superior to others on the number of leaves per vine both at IW/CPE ratios of 1.2 and 0.8. Though the number of leaves per vine produced by the irrigation treatments at IW/CPE ratio 0.4 and at critical stages were at par, they were significantly inferior to that of I_2 and I_3 when moisture conservation materials were added.

At harvest, moisture conservation with coir pith produced highest number of leaves when irrigation was scheduled at IW/CPE ratio 1.2 and o.8, but significant difference was observed only when irrigation was scheduled at IW/CPE ratio of 1.2. The effects of paddy waste and coir pith were significantly superior to control at the same irrigation level. At all the other timings of irrigation, the effects of all the MCT were at par with control. The effects of all irrigation treatments were not significantly affected when no moisture conservation or MCT with sawdust was adopted. When incorporation of paddy waste or coir pith was done, irrigation at IW/CPE ratio 1.2 produced the maximum number of leaves per vine which was significantly superior to irrigation at critical stages only.

4.1.3 Leaf area

The data on the average leaf area are given in Table 6 and the analysis of variance in Appendix III.

Moisture conservation techniques as well as irrigation schedules significantly affected the leaf area. At 45 DAS, MCT did not exhibit any significant difference on leaf area. At 75 DAS, incorporation of coir pith recorded the maximum leaf area which was significantly superior to all other treatments, followed by incorporation of paddy waste which was at par with that of sawdust. The lowest value was recorded by the control and was significantly lower to the other treatments. At harvest, no MCT, incorporation of sawdust and coir pith were at par, but were significantly superior to that of paddy waste.

With respect to irrigation, irrigation at IW/CPE ratio 1.2 recorded the maximum leaf area at all the three stages of observation which was significantly superior to all the other scheduling at 45 DAS. The second highest leaf area was observed with irrigation at IW/CPE ratio 0.8 both at 45 and 75 DAS and its effect was also significantly superior to I_1 and I_4. At the above stages, the leaf area recorded from the irrigation at critical stages and at IW/CPE ratio 0.4 were at par, but were significantly inferior to irrigation at IW/CPE ratio 0.8 and 1.2. At harvest also I_3 recorded the maximum leaf area which was significantly superior to I_2 and I_4, but was at par with I_1. Though the treatments I_1 and I_2 were at par, they were significantly superior to I_4 which recorded the lowest value.

Table 6 Leaf area (cm^2) as influenced by MCT and levels of irrigation

Treatments	45 DAS	75 DAS	Harvest
MCT			
S_0	94.74	75.08	42.54
S_1	97.74	84.82	45.62
S_2	97.72	85.75	35.60
S_3	98.05	92.83	44.25
	NS		
Irrigation			
I_1	90.95	79.56	44.23
I_2	98.11	90.91	40.51
I_3	112.67	100.93	49.25
I_4	86.53	67.06	34.01
SEM±	2.48	1.73	2.61
CD	7.16	4.99	7.61
Interaction	NS	Sig.	Sig.

MCT - Moisture conservation technique
DAS - Days after sowing

The interaction effect was significant only at 75 DAS and at harvest. At 75 DAS, the effects of MCT on leaf area were not significantly different when irrigation was given at IW/CPE ratio 1.2. Incorporation of coir pith produced the highest leaf area which was at par with that of paddy waste and sawdust when irrigation was scheduled at IW/CPE ratio 0.8. Though the effect of control was at par with that of sawdust and paddy waste, it was significantly inferior to coir pith at the same IW/CPE ratio. Incorporation of coir pith produced the highest leaf area which was at par with that of paddy waste and sawdust when irrigation was scheduled at IW/CPE ratio 0.8. Though the effect of control was at par with that of sawdust and paddy waste, it was significantly inferior to coir pith at the same IW/CPE ratio. Incorporation of paddy waste and coir pith produced significantly more leaf area compared to control when irrigation was given at IW/CPE ratio 0.4. The effect of incorporation of sawdust was at par with control and paddy waste but was inferior to coir pith. But in the case of irrigation at critical stages, all the three moisture conservation techniques were significantly superior to control. Among the moisture conserving materials, the effects of coir pith and paddy waste were at par and significantly superior to that of sawdust also at the same irrigation schedule. At no MCT, I_3 recorded the highest leaf area which was at par with that of I_2 and both these were significantly superior to I_1 and I_4. Irrigation at critical stages recorded significantly the lowest leaf area when no MCT was done. In the cases of moisture conservation with paddy waste or sawdust or coir pith, the effects of irrigation at IW/CPE ratio 1.2 and 0.8 were at par and significantly superior to that of other irrigation schedules.

Table 6(a) Mean leaf area (cm^2) as influenced by MCT and irrigation treatments at 75 DAS

Treatments	I_1	I_2	I_3	I_4
S_0	67.83	87.52	97.36	47.62
S_1	74.07	91.27	98.44	65.17
S_2	83.33	95.77	103.66	79.93
S_3	93.02	99.08	104.27	75.54
SEM ±	3.25			
CD	9.98			

Table 6(b) Mean leaf area (cm^2) as influenced by MCT and irrigation treatments at harvest

Treatments	I_1	I_2	I_3	I_4
S_0	38.96	32.57	46.01	32.61
S_1	36.87	40.81	44.85	30.92
S_2	36.78	37.79	52.13	35.74
S_3	40.32	41.89	54.01	36.76
SEM ±	5.27			
CD	15.21			

At harvest, at all the irrigation levels, moisture conservation treatments did not influence the leaf area significantly. The irrigation treatments also did not influence the leaf area significantly when incorporation of sawdust and no MCT were done. But in the case of incorporation of paddy waste and coir pith, irrigation at IW/CPE ratio 1.2 produced highest leaf area which were at par with that of irrigation at IW/CPE ratio 0.8, but was significantly superior to that of irrigation at IW/CPE ratio 0.4 and at critical stages. The effect of irrigation at IW/CPE ratio 0.8, 0.4 and at critical stages were at par when incorporation of either coir pith or paddy waste was done.

4.1.4 Leaf area index

The leaf area index (LAI) worked out at 45 DAS, 75 DAS and at harvest are presented in Table 7 and the analysis of variance in Appendix IV.

The MCT as well as irrigation significantly influenced the LAI at all the stages. At 45 DAS, moisture conservation with coir pith recorded the highest LAI (0.754) but was at par with that of paddy waste and was significantly superior to sawdust and no MCT. The lowest value was recorded by control. At 75 DAS also incorporation of coir pith recorded the maximum LAI and was at par with that of incorporation of paddy waste and sawdust and was significantly superior to that of control. Though the LAI recorded by control was the lowest, it was at par with that of moisture conservation with sawdust. At harvest, the highest LAI was recorded by the plots incorporated with paddy waste and was significantly superior to the effects of other MCT which were at par among themselves and the control.

Table 7 Leaf area index as influenced by MCT and levels of irrigation

Treatments	45 DAS	75 DAS	Harvest
MCT			
S_0	0.602	0.582	0.327
S_1	0.662	0.611	0.347
S_2	0.686	0.693	0.485
S_3	0.754	0.766	0.357
SEM±	0.032	0.030	0.022
CD	0.091	0.087	0.065
Irrigation			
I_1	0.543	0.577	0.372
I_2	0.679	0.737	0.355
I_3	0.979	0.973	0.404
I_4	0.502	0.365	0.380
SEM±	0.032	0.030	0.022
CD	0.091	0.087	NS
Interaction	Sig.	Sig.	Sig.

MCT - Moisture conservation technique
DAS - Days after sowing

The leaf area index increased with increase in the frequency of irrigation both at 45 and 75 DAS. At both these stages irrigation at IW/CPE ratio 1.2 produced significantly more LAI than other irrigation schedules. The lowest LAI was recorded by the irrigation at critical stages, but it was at par with irrigation at IW/CPE ratio 0.4 at 45 DAS and was significantly inferior to I_1, I_2 and I_3 at 75 DAS. At harvest any significant effect of irrigation on LAI was not visible.

The interaction effect of MCT and irrigation was significant at all the three stages. At 45 DAS, incorporation of coir pith and irrigation at IW/CPE ratio 1.2 recorded the maximum LAI which was at par with that of paddy waste at the same irrigation frequency. The effects of moisture conservation with paddy waste and coir pith were significantly superior to that with sawdust and control which were at par when irrigation was given at the same irrigation frequency. There was no significant difference between the effect of moisture conservation techniques when irrigation was given at IW/CPE ratio of 0.8 and at critical stages. In the case of irrigation at IW/CPE ratio 0.4, moisture conservation with coir pith produced the highest LAI and it was significantly superior to control. Though the control plots recorded the LAI which was significantly inferior to that of moisture conservation with coir pith, it was at par with that of paddy waste and sawdust.

At 45 DAS, among the irrigation intervals, irrigation at IW/CPE ratio 1.2 produced significantly highest LAI than other irrigation levels irrespective of MCT or non moisture conservation. When sawdust was applied or no MCT was adopted, the

Table 7 Mean leaf area index under MCT and irrigation treatments at various crops stages of the crop growth

(a) 45 DAS

Treatments	I_1	I_2	I_3	I_4
S_0	0.425	0.588	0.893	0.503
S_1	0.593	0.674	0.898	0.589
S_2	0.510	0.690	1.103	0.429
S_3	0.646	0.765	1.129	0.477
SEM ±	0.064			
CD	0.182			

(b) 75 DAS

Treatments	I_1	I_2	I_3	I_4
S_0	0.545	0.678	0.799	0.304
S_1	0.580	0.643	0.889	0.333
S_2	0.468	0.666	1.194	0.444
S_3	0.716	0.960	1.010	0.379
SEM ±	0.061			
CD	0.154			

(c) Harvest

Treatments	I_1	I_2	I_3	I_4
S_0	0.378	0.264	0.244	0.320
S_1	0.336	0.287	0.365	0.387
S_2	0.382	0.503	0.656	0.397
S_3	0.390	0.266	0.417	0.353
SEM ±	0.044			
CD	0.138			

effects of I_1, I_2 and I_4 were at par. When incorporation of paddy waste or coir pith was done, the effect of irrigation at IW/CPE ratio 0.8 was at par with that of IW/CPE ratio 0.4 and was significantly superior to that of irrigation at critical stages.

At 75 DAS, moisture conservation with paddy waste recorded the highest LAI closely followed by that of coir pith at irrigation at IW/CPE ratio 1.2 and both these effects were significantly superior to control. Though the control recorded the lowest LAI, it was at par with that of sawdust at the same irrigation frequency level. At IW/CPE ratio 0.8, the effect of incorporation of coir pith was significantly superior to other MCTs and control. At IW/CPE ratio 0.4 also, addition of coir pith recorded the highest LAI which was significantly superior to control and paddy waste. But in the case of irrigation at critical stages, there was no significant difference between MCTs.

With respect to irrigation levels, irrigation at IW/CPE ratio 1.2 produced the highest LAI with all the moisture conserving materials and control. Its effect was at par with that of irrigation at IW/CPE ratio 0.8 and was significantly superior to I_1 and I_4 when coir pith was added or no moisture conservation was adopted. But when paddy waste or sawdust was applied the effect of I_3 was significantly superior to I_1, I_2 and I_4. Irrigation at critical stages recorded the lowest LAI values with irrespective of the moisture conservation techniques and control.

At harvest, the effect of moisture conservation with paddy waste was significantly superior to other moisture conservation techniques and control both at the IW/CPE ratios of 1.2 and 0.8. At IW/CPE ratio 1.2, the second best LAI was observed with coir pith whose effect was also significantly superior to control. However at the IW/CPE ratio 0.8, the effects of control, coir pith and sawdust were at par and also were significantly inferior to paddy waste. There was no significant difference among the moisture conservation techniques when irrigation was scheduled at IW/CPE ratio 0.4 or at critical stages.

The LAI was not significantly affected by irrigation frequencies when no MCT and incorporation of sawdust were practised. However LAI was significantly affected by paddy waste, coir pith by irrigation treatments. In the case of incorporation of paddy waste, I_3 recorded significantly the highest LAI followed by I_2. The effects of I_1, I_2 and I_4 were at par. In the case of moisture conservation with coir pith also irrigation at IW/CPE ratio 1.2 produced the highest LAI. This inturn was significantly superior to irrigation at IW/CPE ratio 0.8. The effects of I_1, I_2 and I_4 were at par when coir pith was incorporated.

4.1.5 Drymatter production

The drymatter production per plant worked out at the time of harvest is presented in Table 9 and the analysis of variance in Appendix VI.

The moisture conservation techniques did not produce any significant difference on drymatter production.

Irrigation treatments had a significant influence on drymatter production. The plants received irrigation at IW/CPE ratio 1.2 (I_3) produced significantly more drymatter compared to other irrigation treatments, followed by irrigation at IW/CPE ratio 0.8 (I_2) which was also significantly superior to irrigation at IW/CPE ratio 0.4 and at critical stages. The drymatter production with irrigation at critical stages and at IW/CPE ratio 0.4 were statistically at par and they were significantly inferior to I_2 and I_3. The interaction between MCT and irrigation on drymatter production was not significant.

4.2 Yield components and yield

The data on the yield components are presented in Table 8 and the analysis of variance in Appendix V.

4.2.1 Mean length of fruits

The effect of moisture conservation techniques on length of fruits was not significant. However irrigation had a significant influence on length of fruits. The irrigation at IW/CPE ratio 1.2 recorded significantly the highest fruit length followed by irrigation at IW/CPE ratio 0.8 which was significantly superior to irrigation at IW/CPE ratio 0.4 and at critical stages. Irrigation at critical stages recorded the lowest fruit length.

Table 8 Effect of MCT and levels of irrigation on yield components

Treatments	Length of fruits (cm)	Girth of fruits (cm)	Average fruit weight (kg)	Number of fruits per plant
MCT				
S_0	25.467	27.142	0.768	2.911
S_1	24.783	27.083	0.760	3.215
S_2	25.792	28.350	0.794	3.791
S_3	25.867	28.383	0.776	3.282
SEM±	0.41	0.38	0.016	0.18
CD	NS	1.09	NS	0.53

Treatments	Length of fruits (cm)	Girth of fruits (cm)	Average fruit weight (kg)	Number of fruits per plant
Irrigation				
I_1	23.908	26.650	0.724	2.663
I_2	26.375	28.592	0.798	3.305
I_3	29.242	30.633	0.928	4.617
I_4	22.383	25.083	0.658	2.617
SEM±	0.41	0.38	0.016	0.18
CD	1.17	1.09	0.046	0.53
Interaction	NS	NS	NS	NS

MCT - Moisture conservation technique
DAS - Days after sowing

The interaction effect between MCT and irrigation did not show any significant influence on length of fruits.

4.2.2 Mean girth of fruits

Moisture conservation techniques and levels of irrigation significantly influenced the girth of fruits. Among the MCT, incorporation of coir pith recorded the maximum girth of fruits (28.383 cm)and was at par with the effect of paddy waste, but significantly superior to the effect of sawdust and control which were at par.

With respect to irrigation treatments, irrigation at IW/CPE ratio 1.2 recorded the maximum girth and was significantly superior to the rest of the treatments, followed by irrigation at IW/CPE ratio 0.8. The least value was recorded by irrigation at critical stages which was significantly inferior to other treatments.

The interaction effect was found to be nonsignificant.

4.2.3 Fruit weight

The average fruit weight followed a similar trend as observed in length of fruits. Moisture conservation techniques had no significant influence on fruit weight. However irrigation treatments significantly influenced fruit weight. Among the irrigation treatments highest fruit weight of 0.928 kg was recorded with irrigation at IW/CPE ratio 1.2 which was significantly superior to all the other irrigation treatments. This was followed by irrigation at IW/CPE ratio 0.8. Its effect was also significantly superior to irrigation at IW/CPE ratio 0.4 and at critical stages. The lowest fruit weight was observed with irrigation at critical stages. The interaction effect was not significant.

4.2.4 Number of fruits per plant

The number of fruits per plant was significantly influenced both by the moisture conservation technique and levels of irrigation.

Among the MCT, the maximum number of fruits per plant (3.791) was recorded by paddy waste incorporation. Its effect was at par with coir pith incorporation (3.285), and was significantly superior to sawdust incorporation (3.215) and control (2.911). The lowest number of fruits per plant was produced by control and was significantly inferior to moisture conservation with paddy waste and at par with sawdust and coir pith incorporation. Increasing frequencies of irrigation had an increasing trend in the number of fruits produced per plant. Of the irrigation treatments, irrigation at IW/CPE ratio 1.2 produced significantly the highest number of fruits per plant (4.617), followed by irrigation at IW/CPE ratio 0.8 (3.305). Second best irrigation schedule was irrigation at IW/CPE ratio 0.8 and its effect was significantly superior to irrigation at IW/CPE ratio 0.4 (2.663) and at critical stages (2.617). The number of fruits produced by the plant by irrigation at IW/CPE ratio 0.4 and at critical stages were at par and were significantly inferior to irrigation at IW/CPE ratios 1.2 and 0.8.

4.2.5 Fruit yield per hectare

The data regarding the fruit yield per hectare and per plant are presented in Table 9 and the analysis of variance in Appendix VI.

The main effects of irrigation and moisture conservation techniques (MCT) as well as their interaction were significant on fruit yield.

Among the MCT, incorporation of paddy waste gave the highest yield (36.015 t ha^{-1}) and was at par with that of coir pith (33.168 t ha^{-1}), but was significantly superior to that of sawdust (31.395 t ha^{-1}) and control (28.432 t ha^{-1}). Though the yield from incorporation of coir pith (S_3) was statistically at par with that of sawdust (S_1), it was significantly superior to control. The lowest yield was recorded by control, but was at par with that of sawdust.

With respect to irrigation intervals, the irrigation schedule at IW/CPE ratio 1.2 gave significantly the highest yield (47.208 t ha^{-1}). Though the yield from irrigation at IW/CPE ratio 0.4 (25.336 t ha^{-1}) and at critical stages (22.035 t ha^{-1}) were at par, they were significantly inferior to that of irrigation at IW/CPE ratio 0.8 and 1.2.

The interaction between the moisture conservation techniques and intervals of irrigation was significant. When irrigation was given at IW/CPE ratio 1.2, moisture

Table 9 Effect of MCT and levels of irrigation on fruit yield and drymatter production

Treatments	Yield		Drymatter production g/plant
	t ha^{-1}	kg $plant^{-1}$	
MCT			
S_0	28.432	2.318	50.192
S_1	31.395	2.512	50.742
S_2	36.015	2.899	54.583
S_3	33.168	2.736	52.508
			NS
Irrigation			
I_1	25.336	2.107	38.600
I_2	34.432	2.790	58.700
I_3	47.208	3.793	72.375
I_4	22.035	1.776	34.508
SEM±	1.299	0.100	2.270
CD	3.751	0.289	6.57
Interaction	Sig.	Sig.	NS

MCT - Moisture conservation technique
DAS - Days after sowing

conservation with paddy waste (S_2) recorded the highest yield (54.513 t ha^{-1}) which was at par with that of coir pith (S_3) (51.541 t ha^{-1}) but was significantly superior to that of control (S_0) and Sawdust (S_1). Though the yield from incorporation of coir pith was at par with that of sawdust, it was significantly superior to control at the same irrigation frequency level. The yield from incorporation of sawdust and control were at par at the same irrigation frequency level. In the case of irrigation at IW/CPE ratio 0.8 paddy waste incorporation was significantly superior to control, but was at par with that of sawdust and coir pith.

But in the case of irrigation at IW/CPE ratio 0.4 and at critical stages, the moisture conservation techniques were not significantly different. Among the irrigation intervals, irrigation at IW/CPE ratio 1.2 (I_3) gave significantly higher yield than other irrigation treatments which were at par when no MCT was done. When incorporation of sawdust or paddy waste or coir pith were done, irrigation at IW/CPE ratio 1.2 produced the significantly highest yield, followed by irrigation at IW/CPE ratio 0.8 (I_2). Though the yield from irrigation at IW/CPE ratio 0.4 and at critical stages (I_4) were at par, they were significantly inferior to that of I_2 and I_3 when moisture conservation were done.

The interaction effect clearly shows that the effects of moisture conservation techniques were significantly effective only at closer irrigation frequency level.

Table 9(a) Mean fruit yield (t ha^{-1}) underMCT and irrigation treatments

Treatments	I_1	I_2	I_3	I_4
S_0	24.905	27.905	37.570	23.350
S_1	23.350	35.126	44.902	20.942
S_2	26.368	39.033	54.513	24.146
S_3	26.460	34.663	51.846	19.702
SEM±	2.597			
CD	7.501			

Table 9(b) Mean fruit yield (kg plant^{-1}) under MCT and irrigation treatments

Treatments	I_1	I_2	I_3	I_4
S_0	2.075	2.356	2.983	1.857
S_1	2.077	2.936	3.508	1.527
S_2	2.135	3.008	4.427	2.027
S_3	2.140	2.861	4.252	1.692
SEM±	0.200			
CD	0.576			

4.3 Soil moisture studies

4.3.1 Soil moisture content

The data regarding the gravimetric soil moisture content (% w/w) before and 48 hours after irrigation at depths of 0-15, 15-30 and 30-45 cm are given in Table 10.

As evident from the Table, incorporation of coir pith, sawdust and paddy waste increased the soil moisture content at all the depths irrespective of the irrigation treatments. Coir pith incorporation plots retained comparatively more moisture followed by paddy waste and sawdust compared to control. Irrespective of the MCT and irrigation levels, soil moisture content increased with depth.

4.3.2 Consumptive use

The mean seasonal consumptive use from 20 DAS to the end of crop growth is given in Table 11.

Consumptive use increased with increasing level of irrigation. The crop receiving irrigation at IW/CPE ratio 1.2 recorded maximum consumptive use (498.60 mm) followed by irrigation at IW/CPE ratio 0.8 (382.97 mm) and that of 0.4 (265.38 mm). Irrigation at critical stages recorded the lowest consumptive use (224.13 mm).

Table 10 Mean moisture content (% w/w) of soil before and after irrigation under different moisture conservation techniques and levels of irrigation

Treat-ments	Depth of soil					
	0-15 cm		15-30 cm		30-45 cm	
	BI	AI	BI	AI	BI	AI
S_0I_1	7.50	11.17	7.98	13.15	8.96	14.19
S_0I_2	9.35	13.36	10.66	14.46	11.09	15.96
S_0I_3	8.68	13.97	11.98	15.88	12.94	17.51
S_0I_4	3.41	11.92	8.42	13.51	9.17	14.99
S_1I_1	7.51	11.16	8.10	13.84	10.32	16.29
S_1I_2	8.80	14.26	9.15	15.79	11.43	16.08
S_1I_3	9.78	14.38	12.30	15.67	15.88	20.28
S_1I_4	5.16	12.26	9.37	14.18	11.52	15.39
S_2I_1	6.37	14.10	11.42	14.62	11.69	16.34
S_2I_2	10.04	14.55	12.01	16.85	11.53	17.59
S_2I_3	8.65	12.87	10.90	14.90	12.25	19.56
S_2I_4	4.60	13.83	8.64	16.57	11.77	16.67
S_3I_1	6.13	15.08	9.61	15.40	10.62	15.87
S_3I_2	10.13	15.38	11.18	16.30	11.83	18.72
S_3I_3	10.89	15.78	12.79	19.52	13.18	19.44
S_3I_4	3.47	13.38	8.80	14.10	11.71	16.04

BI - Before irrigation AI - 48 hours after irrigation

Among the moisture conservation treatments, consumptive use was maximum for the incorporation of coir pith (354.60 mm) followed by incorporation of sawdust (346.51 mm) and paddy waste (339.51 mm). The lowest consumptive use was recorded by he control (330.46 mm).

The variation in mean daily consumptive use at intervals of 15 days is given in Table 11(a).

At all the intervals, maximum daily consumptive use was recorded by irrigation at IW/CPE ratio 1.2, followed by irrigation at IW/CPE ratio 0.8 and irrigation at IW/CPE ratio 0.4. Irrigation at critical stages registered lowest daily Cu at all the intervals. The maximum daily Cu was observed to be the highest at the interval of 36-50 DAS in the case of irrigation at IW/CPE ratios 1.2, 0.8 and 0.4. However when the crop was irrigated at critical growth stages the period of maximum consumptive use was between 20-35 DAS.

4.3.3 Crop coefficient

The data on crop coefficient for different periods and overall average are presented in Table 11(a) and 11(b) respectively.

The crop coefficient values averaged over the intervals showed an increase with increasing levels of irrigation. Irrigation at IW/CPE ratio 1.2 recorded the maximum crop coefficient (0.80) followed by irrigation at IW/CPE ratio 0.8 (0.63) and

Table 11 Mean seasonal consumptive use (mm) as influenced by MCT and levels of irrigation

Treatments	I_1	I_2	I_3	I_4	Mean
S_0	253.21	378.32	472.66	217.61	330.46
S_1	278.32	405.18	494.09	208.45	346.51
S_2	521.08	368.26	496.87	241.81	339.51
S_3	278.89	380.12	530.76	228.64	354.60
Mean	265.38	382.97	498.60	224.13	

Table 11(b) Mean daily consumptive use (Cu), mean daily pan evaporation and average crop coefficient

Treatments	Mean daily Cu (mm)	Mean daily panevaporation (mm)	Crop coefficient
MCT			
S_0	3.41	6.40	0.53
S_1	3.62	6.40	0.57
S_2	3.53	6.40	0.55
S_3	3.71	6.40	0.58
Irrigation			
I_1	2.91	6.40	0.45
I_2	4.04	6.40	0.63
I_3	5.12	6.40	0.80
I_4	2.57	6.40	0.40

MCT - Moisture conservation technique

Table 11(a) Mean daily consumptive use in mm day^{-1} (Cu) and crop coefficient (Kc) at different periods of crop growth

Treatments	20-35 DAS		36-50 DAS		51-65 DAS		66-80 DAS		81-97 DAS	
	Cu	Kc	Cu	Kc	Cu	Kc	Cu	Kc	Cu	Kc
I_1	3.28	0.49	3.48	0.47	2.11	0.34	2.08	0.35	2.43	0.48
I_2	4.01	0.60	5.39	0.73	5.11	0.83	2.77	0.48	2.64	0.57
I_3	6.31	0.94	7.30	0.99	7.12	1.16	4.29	0.74	2.44	0.52
I_4	3.62	0.54	2.39	0.36	2.10	0.34	2.39	0.33	2.37	0.51

irrigation at IW/CPE ratio 0.4 (0.45). Irrigation at critical stages recorded the lowest Kc value (0.40). Among the MCT, the crop coefficients averaged over the intervals were higher for incorporation of coir pith and sawdust. The lowest crop coefficient was recorded by control.

The crop coefficient recorded during different intervals showed maximum value with irrigation at IW/CPE ratio of 1.2. This was followed by irrigation at IW/CPE ratio 0.8. The lowest values were observed with irrigation at critical stages. The period during which the crop coefficient values registered maximum values varied with the irrigation intervals. Maximum Kc value was observed between 51-65 DAS in the case of irrigation at IW/CPE ratio 1.2 and 0.8. For irrigation at IW/CPE ratio 0.4 and at critical stages the Kc values were maximum for the period of 20-35 DAS.

4.3.4 Water use efficiency

The data regarding both crop water use efficiency (WUE) and field WUE are given in Table 12.

The moisture conservation techniques had a remarkable influence on water use efficiency. Moisture conservation with paddy waste had more crop and field WUE (105.14 kg ha mm^{-1} and 86.69 kg $hamm^{-1}$) followed by that of coir pith and sawdust. The lowest WUE was recorded by the control.

Table 12 Effect of moisture conservation techniques and levels of irrigation on water use efficiency (kg hamm^{-1})

Treatments	Field WUE	Crop WUE
MCT		
S_0	72.32	89.92
S_1	76.14	91.10
S_2	86.69	105.14
S_3	79.46	91.38
Irrigation		
I_1	77.67	95.54
I_2	74.04	91.03
I_3	72.88	90.33
I_4	78.01	98.48

MCT - Moisture conservation technique

With respect to irrigation, WUE was found decreasing with increasing levels of irrigation. Irrigation at critical stages registered the highest field and crop WUE, followed by irrigation at IW/CPE ratio 0.4 and 0.8. Irrigation at IW/CPE ratio 1.2 recorded the lowest WUE.

4.3.5 Soil moisture depletion pattern

The mean values of soil moisture depletion pattern are given in Table 13. Irrespective of the MCT and levels of irrigation, the upper most soil layer (0-15 cm) depleted maximum soil moisture which ranged from 46.54 to 53.89%. The moisture depletion pattern from the 15-30 and 30-45 cm layers were almost identical and ranged from 21.90 to 28.11%. The difference between moisture depletion from 0-15 and 15-30 cm layers did not vary much between moisture conservation techniques. But a slight increase in moisture depletion ranging from 1.27 to 3.42% was observed from 30-45 cm when moisture conserving materials were incorporated. Moisture depletion was more from the deeper layer in the drier regimes.

4.4 Chemical composition of leaves

4.4.1 Nitrogen content

The data on the total nitrogen content of leaves at 45, 75 DAS and at harvest expressed as percentage on dry weight basis are presented in Table 14 and the analysis of variance in Appendix VII.

Table 13 Relative moisture depletion pattern from different soil layers in percentage as influenced by MCT and levels of irrigation

Treatments	Relative soil moisture depletion (%)		
	0-15 cm	15-30 cm	30-45 cm
MCT			
S_0	53.50	24.58	21.90
S_1	50.85	23.80	25.32
S_2	52.07	23.56	24.37
S_3	53.89	22.95	23.17
Irrigation			
I_1	47.55	25.26	27.20
I_2	49.97	24.02	26.01
I_3	51.58	23.62	24.72
I_4	46.54	25.35	28.11

MCT - Moisture conservation technique

Both moisture conservation techniques and levels of irrigation had significant influences on nitrogen content of leaves at all the stages. At all the three stages of observation N content of leaves was the highest in plants which received moisture conservation by the addition of paddy waste. At 45 DAS, the highest leaf N content (4.986%) with paddy waste incorporation was at par with that of coir pith (4.670%) and control (4.737%) but was significantly superior to that of sawdust (4.293). However at 75 DAS paddy waste incorporated plants which recorded the maximum leaf N content (3.343%) which was at par with that of sawdust (3.033%) and significantly superior to that of coir pith (2.905) and control (2.887). Though the N content of control plants was significantly inferior to paddy waste incorporation, it was at par with that of coir pith and sawdust incorporation. At harvest the effects of the treatments control (3.453%) sawdust (3.681%) and paddy waste (3.722%) were at par, but paddy waste recorded the highest value. Though the incorporation of coir pith was at par with control, it was significantly inferior to sawdust and paddy waste incorporation.

With regard to the effect of irrigation treatments on N content of leaves, no definite trend was seen repeated over the stages. Among the irrigation treatments, at 45 DAS, irrigation at IW/CPE ratio 1.2 recorded the maximum N content (5.143%) and the effect was significantly superior to that of other treatments which were at par. The lowest value was recorded by irrigation at critical stages (4.323%). Contradictory to this at 75 DAS and at harvest, leaf N content was minimum and significantly inferior to control in plants which received irrigation at IW/CPE ratio 1.2.

Table 14 Nitrogen content of leaves (%) as affected by MCT and levels of irrigation

Treatments	45 DAS	75 DAS	Harvest
MCT			
S_0	4.737	2.887	3.453
S_1	4.293	3.033	3.681
S_2	4.986	3.343	3.722
S_3	4.670	2.905	3.252
Irrigation			
I_1	4.553	3.284	3.891
I_2	4.667	3.027	3.343
I_3	5.143	2.794	3.211
I_4	4.323	3.062	3.663
SEM ±	0.122	0.118	0.125
CD	0.351	0.336	0.361
Interaction	NS	NS	NS

MCT - Moisture conservation technique
DAS - Days after sowing

At 75 DAS, the effects of irrigation at IW/CPE ratio 0.4 (3.284%), 0.8 (3.027%) and at critical stages (3.062%) were at par and significantly superior to irrigation at IW/CPE ratio 1.2 (2.794%) which was at par with I_2 and I_4. The lowest value was recorded by I_3. At harvest, irrigation at IW/CPE ratio 0.4 recorded the maximum N content (3.891%) and was at par with that of irrigation at critical stages (3.663%) which was at par with that of irrigation at IW/CPE ratio 0.8 (3.343%). The lowest N content of leaves was obtained by the irrigation at IW/CPE ratio 1.2 (3.211%) but was at par with that of irrigation at IW/CPE ratio 0.8.

The interaction effect between MCT and irrigation on N content of leaves was not significant.

4.4.2 Phosphorus content

The data pertaining the P content of leaves at 45, 75 DAS and at harvest are presented in Table 15 and the analysis of variance in Appendix VIII.

The effect of moisture conservation on P content of leaves was not significant at 45 and 75 DAS. At harvest, the treatments differed significantly each other. The P content in the plants which received incorporation of paddy waste (0.137%) was significantly the highest. The lowest P content was observed in control plants (0.120%) and was significantly inferior to other treatments.

Table 15 Effect of MCT and levels of irrigation on P content of leaves (%)

Treatments	45 DAS	75 DAS	Harvest
MCT			
S_0	0.219	0.184	0.120
S_1	0.219	0.206	0.128
S_2	0.240	0.189	0.137
S_3	0.217	0.196	0.122
SEM ±	±0.009	<0.001	<0.001
	NS	NS	<0.001
Irrigation			
I_1	0.202	0.186	0.129
I_2	0.243	0.204	0.118
I_3	0.254	0.206	0.115
I_4	0.196	0.179	0.135
SEM ±	0.009	<0.001	<0.001
CD	0.026	<0.001	<0.001
Interaction	Sig.	NS	NS

MCT - Moisture conservation technique
DAS - Days after sowing

Phosphorus content was significantly influenced by levels of irrigation at all the three stages. Irrigation at IW/CPE ratio 1.2 had the highest value (0.254%) at 45 DAS, and was at par with that of irrigation at IW/CPE ratio 0.8 (0.243%). Though the P content from irrigation at IW/CPE ratio 0.4 (0.202%) and at critical stages (0.196%) were at par, they were significantly inferior to I_2 and I_3. The lowest value was recorded by I_4. At 75 DAS, and at harvest also the treatments differed significantly each other. At 75 DAS, irrigation at IW/CPE ratio 1.2 recorded significantly the highest value (0.206%) where as irrigation at critical stages recorded significantly the highest value (0.135%) at harvest. At 75 DAS, the significantly lowest value was recorded by I_4, but it was by I_3 at harvest.

The interaction effect was significant only at 45 DAS. The highest P content was recorded by moisture conservation with paddy waste (0.264%) when irrigation was given at IW/CPE ratio 1.2. Irrespective of the irrigation levels, among the moisture conservation materials paddy waste recorded the highest value. At all the levels of irrigation the effects of moisture conservation treatments were not significant. However irrigation had a significant influence on P content when incorporation of paddy waste or saw dust or no MCT was done. Irrespective of the moisture conservation treatments, irrigation at IW/CPE ratio 1.2 recorded the highest value. The effect of irrigation at IW/CPE ratio 1.2 was at par with that of irrigation at IW/CPE ratio 0.8 and was significantly superior to that of irrigation at IW/CPE ratio 0.4 and at critical stages when incorporation of saw dust or no moisture conservation was adopted. In the case of moisture conservation with paddy waste, the effect of I_3

Table 15(a) Mean phosphorus content (%) under MCT and irrigation treatements at 45 DAS

Treatments	I_1	I_2	I_3	I_4
S_0	0.179	0.241	0.262	0.185
S_1	0.198	0.233	0.251	0.194
S_2	0.230	0.263	0.264	0.203
S_3	0.205	0.234	0.229	0.202
SEM ±	0.018			
CD	0.052			

was at par with that of I_1 and I_2 and was significantly superior to I_4. However when incorporation of coir pith was practised, the irrigation treatments did not influence the P content of leaves.

4.4.3 Potassium content

The data on the K content of leaves at 45, 75 DAS and at harvest are presented in Table 16 and the analysis of variance in Appendix IX.

The K content of leaves was significantly influenced by the moisture conservation techniques as well as levels of irrigation. At 45 DAS, the highest K content (2.600%) was recorded by the incorporation of paddy waste and was significantly superior to other moisture conservation treatments, followed by that of saw dust incorporation. The effects of moisture conservation with coir pith and control were at par and they were significantly inferior to that of saw dust and paddy waste at all the three stages of observation. At 75 DAS, moisture conservation with saw dust recorded the highest value (1.158%) though it was at par with that of paddy waste (1.158%) and these two treatments were significantly superior to coir pith and control.

No definite trend was seen repeated over the stages in the case of leaf potassium content as far as the irrigation treatments are concerned. At 45 DAS, among the irrigation treatments, irrigation at IW/CPE ratio 1.2 recorded the maximum value (2.471%) and was at par with irrigation at IW/CPE ratio 0.8 (2.346%) and these

Table 16 Potassium content of leaves (%) as influenced by MCT and levels of irrigation

Treatments	45 DAS	75 DAS	Harvest
MCT			
S_0	2.104	1.266	0.908
S_1	2.433	1.759	1.158
S_2	2.600	1.582	1.158
S_3	1.938	1.218	0.850
Irrigation			
I_1	2.092	1.638	1.108
I_2	2.346	1.331	0.900
I_3	2.471	1.193	0.846
I_4	2.167	1.663	1.221
SEM±	0.045	0.038	0.027
CD	0.129	0.109	0.079
Interaction	Sig.	Sig.	NS

MCT - Moisture conservation technique
DAS - Days after sowing

effects were significantly superior to other treatments. Irrigation at IW/CPE ratio 0.4 recorded the lowest value (2.092%) but was at par with irrigation at critical stages (2.167%). At 75 DAS, irrigation at critical stages recorded the highest value (1.663%) and was at par with irrigation at IW/CPE ratio 0.4 (1.638%) and was significantly superior to irrigation at IW/CPE ratio 0.8 and 1.2. Irrigation at IW/CPE ratio 1.2 recorded the lowest value at 75 DAS and at harvest. Both at 75 DAS and at harvest, irrigation at critical stages recorded significantly the highest values followed by irrigation at IW/CPE ratio 0.4.

The interaction effect was significant at 45 and 75 DAS only. At 45 DAS, irrespective of the irrigation levels, paddy waste recorded the maximum K content. The highest value was recorded by paddy waste incorporation and irrigation at IW/CPE ratio 1.2 (3.0%). Moisture conservation with paddy waste recorded the highest K content which was at par with sawdust incorporation and both these effects were significantly superior to control and moisture conservation with coir pith when irrigation was scheduled at IW/CPE ratios 1.2 and 0.8. The effects of moisture conservation with coir pith and no MCT were at par. In the case of irrigation at critical stages, the effect of paddy waste incorporation was significantly superior to other moisture conservation practices and control. Though the effects of control and coir pith were at par, they were significantly inferior to sawdust and paddy waste. However the effects of moisture conservation treatments were not significant when irrigation was scheduled at IW/CPE ratio 0.4.

Table 16(a) Mean K content of leaves (%) under MCT and irrigation treatments at 45 DAS

Treatments	I_1	I_2	I_3	I_4
S_0	2.083	2.083	2.267	1.983
S_1	2.117	2.633	2.783	2.200
S_2	2.167	2.733	3.000	2.500
S_3	2.000	1.933	2.133	1.983
SEM±	0.090			
CD	0.258			

Table 16(b) Mean K content of leaves (%) under MCT and irrigation treatments at 75 DAS

Treatments	I_1	I_2	I_3	I_4
S_0	1.120	1.400	1.127	1.527
S_1	1.930	1.553	1.493	2.060
S_2	1.827	1.587	1.243	1.670
S_3	1.577	0.993	0.910	1.393
SEM±	0.076			
CD	0.218			

Irrespective of moisture conservation treatments, irrigation at IW/CPE ratio 1.2 recorded the maximum value. The effect of irrigation at IW/CPE ratio 1.2 was at par with irrigation at IW/CPE ratio 0.4 and 0.8 and was significantly superior to irrigation at critical stages, when no moisture conservation was adopted. The effect of irrigation at IW/CPE ratio 1.2 was at par with irrigation at IW/CPE ratio 0.8 and was significantly superior to irrigation at IW/CPE ratio 0.4 and at critical stages, when incorporation of saw dust was practised. But in the case of moisture conservation with paddy waste, I_3 was significantly superior to other irrigation treatments. However the effects of all the irrigation levels were at par when incorporation of coir pith was practised.

At 75 DAS, among the MCT, incorporation of saw dust recorded the highest K content (1.493%) and this effect was significantly superior to the other moisture conservation treatments when irrigation was given at IW/CPE ratio 1.2. The effects of control and incorporation of paddy waste were at par at the same irrigation frequency. The lowest value was recorded by the coir pith incorporation. Moisture conservation with paddy waste recorded the highest value 1.587%) and was at par with saw dust incorporation when irrigation was given at IW/CPE ratio 0.8. The effect of sawdust was at par with control but was significantly superior to that of coir pith at the same irrigation frequency. At irrigation at IW/CPE ratio 0.4, saw dust recorded the highest value and was at par with that of paddy waste and both these effects were significantly superior to control and coir pith. The effect of coir pith was also significantly superior to control at the same irrigation frequency. The effect of incorporation of sawdust was significantly superior to other moisture conservation treatments, when irrigation was given at critical stages. Though the effects of control and moisture conservation with paddy waste were at par, they were significantly inferior to that of sawdust.

Among the irrigation treatments, irrigation at critical stages recorded the highest K content (1.527%) and was at par with irrigation at IW/CPE ratio 0.8 (1.40%) and both these effects were significantly superior to irrigation at IW/CPE ratio 0.4 and 1.2 when no MCT was done. Irrigation at critical stages also recorded the highest value (2.06%) when incorporation of sawdust was done. This effect was at par with that of irrigation at IW/CPE ratio 0.4 (1.93%) and both these effects were significantly superior to irrigation at IW/CPE ratios of 0.8 (1.553%) and 1.2 (1.493%). In the case of incorporation of paddy waste, irrigation at IW/CPE ratio 0.4 recorded the highest value (1.827%) which was at par with that of irrigation at critical stages (1.67%) and both these effects were significantly superior to that of irrigation at IW/CPE ratio 1.2 (1.243%). The effect of irrigation at IW/CPE ratio 0.4 recorded the highest value (1.577%) when coir pith was incorporated. Its effect was at par with that of irrigation at critical stages and both these treatments were significantly superior to that of the other two levels of irrigation.

4.5 Economics of different treatments

The economics of various treatments, mean net profit and mean net return per rupee invested are presented in Table 17, 17(a) and 17(b) respectively.

Table 17 Economics of different treatments

Treatments	Total cost of cultivation (Rs.)	Yield (kg ha^{-1})	Income (Rs.)	Net profit (y-x) (Rs)	Net return per rupee invested (Rs.)
MCT					
S_0	59088.02	28432	113728	40585.96	1.53
S_1	79479.05	31395	125580	44840.70	1.54
S_2	75776.04	36015	144060	68283.95	1.86
S_3	78126.04	33168	132672	54544.95	1.35
Irrigation					
I_1	63580.05	25336	101344	37562.95	1.60
I_2	80765.22	34432	137728	55918.78	1.68
I_3	102405.90	47208	188832	86434.96	1.85
I_4	59761.13	22035	88140	28388.13	1.48

1 kg fruit = Rs.4.00
Price of Farm Yard Manure = Rs.300 per ton
Mussoriephos = Rs.2.1/kg
Muriate of Potash = Rs.4.46/kg
Urea = Rs.3.5/kg
Labour charge = Rs.55 per women
Rs.90 per men

Among the moisture conservation techniques, the highest profit (Rs. 68,283.95) was recorded by incorporation of paddy waste, followed by incorporation of coir pith (Rs. 54,544.95) and incorporation of sawdust (Rs. 44,840.70). The lowest net profit (Rs. 40,585.96) was recorded by control. Paddy waste incorporation enhanced net profit by Rs. 27,697.99 over control.

The net profit increased with increase in the frequency of irrigation more or less similar to the trend observed with yield. The highest net profit of Rs. 86,434.96 was obtained when irrigation was given at IW/CPE ratio 1.2, followed by Rs. 55,918.78 for irrigation at IW/CPE ratio 0.8. The lowest net profit (Rs. 28,388.13) was obtained with irrigation at critical stages.

Among the treatment combinations, the highest net profit (Rs.1,16,498.21) was recorded by moisture conservation with paddy waste with irrigation at IW/CPE ratio 1.2, followed by incorporation of coir pith with irrigation at IW/CPE ratio 1.2 (Rs.1,03,480.21) and incorporation of paddy waste with irrigation at IW/CPE ratio 0.8 (Rs. 76,218.78). Next highest profit (Rs. 74,350.21) was recorded by incorporation of sawdust with irrigation at IW/CPE ratio 1.2. The lowest net profit (Rs.17,548.87) was with coir pith incorporation with irrigation at critical stages which was slightly lesser than that of incorporation of sawdust with irrigation at critical stages.

Table 17(a) Mean net profit (Rs.) as influenced by MCT and levels of irrigation

Treatments	I_1	I_2	I_3	I_4	Mean
S_0	39,576.95	34,179.78	51,411.21	37,175.87	40,585.96
S_1	26,968.95	56,887.78	74,350.21	21,155.87	44,840.70
S_2	42,743.95	76,218.78	1,16,498.21	37,674.87	68,283.95
S_3	40,761.95	56.388,78	1,03,480.21	17,548.87	54,544.95
Mean	37,562.95	55,918.78	86,434.21	28,388.87	

MCT - Moisture conservation technique

Table 17(b) Mean net return per rupee invested as influenced by MCT and levels of irrigation

Treatments	I_1	I_2	I_3	I_4	Mean
S_0	1.66	1.41	1.52	1.66	1.53
S_1	1.41	1.68	1.71	1.34	1.54
S_2	1.68	1.95	2.15	1.64	1.86
S_3	1.62	1.69	2.00	1.29	1.65
Mean	1.60	1.68	1.85	1.48	

With respect to net return per rupee invested, among the MCT, incorporation of paddy waste recorded the highest net return per rupee invested (Rs. 1.86), followed by incorporation of coir pith (Rs. 1.65). The lowest value was obtained by control (Rs. 1.53) which was slightly lesser than that of incorporation of sawdust (Rs. 1.54).

The net return per rupee invested was also increased with increase in the level of irrigation similar to the case observed in net profit. The highest net return per rupee invested (Rs. 1.85) was recorded by irrigation at IW/CPE ratio 1.2, followed by Rs. 1.68 for irrigation at IW/CPE ratio 0.8. The lowest value (Rs.1.48) was obtained with irrigation at critical stages.

Among the treatment combinations, moisture conservation with paddy waste with irrigation at IW/CPE ratio 1.2 recorded the highest net return per rupee invested (Rs. 2.15), followed by incorporation of coir pith with irrigation at IW/CPE ratio 1.2 (Rs. 2.00) which was slightly higher than that of paddy waste with irrigation at IW/CPE ratio 0.8 (Rs. 1.95). Next maximum value (Rs. 1.71) was by incorporation of sawdust with irrigation at IW/CPE ratio 1.2. The lowest value (Rs. 1.29) was with coir pith incorporation with irrigation at critical stages which was slightly lesser than that of sawdust with irrigation at critical stages (Rs.1.34).

Discussion

DISCUSSION

The results of the investigation on "Irrigation management related to sub-surface moisture conservation techniques in oriental pickling melon (*Cucumis melo* var. canomon (L.) makino)" given in the preceding chapter are briefly discussed below.

5.1 Crop growth

In the present investigation, the results clearly show that incorporation of moisture conservation materials increased the growth attributes like vine length, number of leaves per vine, leaf area and leaf area index (Table 4,5,6, 7 and Fig.3,5,7,9). Among them paddy waste and coir pith were found to be better than sawdust. The effect of coir pith on these parameters was significantly superior to the control at all the stages. The significant superiority of paddy waste over control on these attributes was seen after 45 DAS. The effect of sawdust was at par with control almost all the observations. The favourable effect of coir pith might be due to the relatively more soil moisture retention compared to control (Table 10) whereas that of paddy waste might be due to its higher soil moisture retention and the significantly higher nutrient absorbtion by the plants. The increased growth by the addition of soil conservation materials observed in this trial is in conformity with the observation of Cerne (1984); Corrales *et al.* (1990); Asoegwu (1991); Khalak and Kumaraswamy (1992); Stang *et al.* (1993) and Saravanababu (1994).

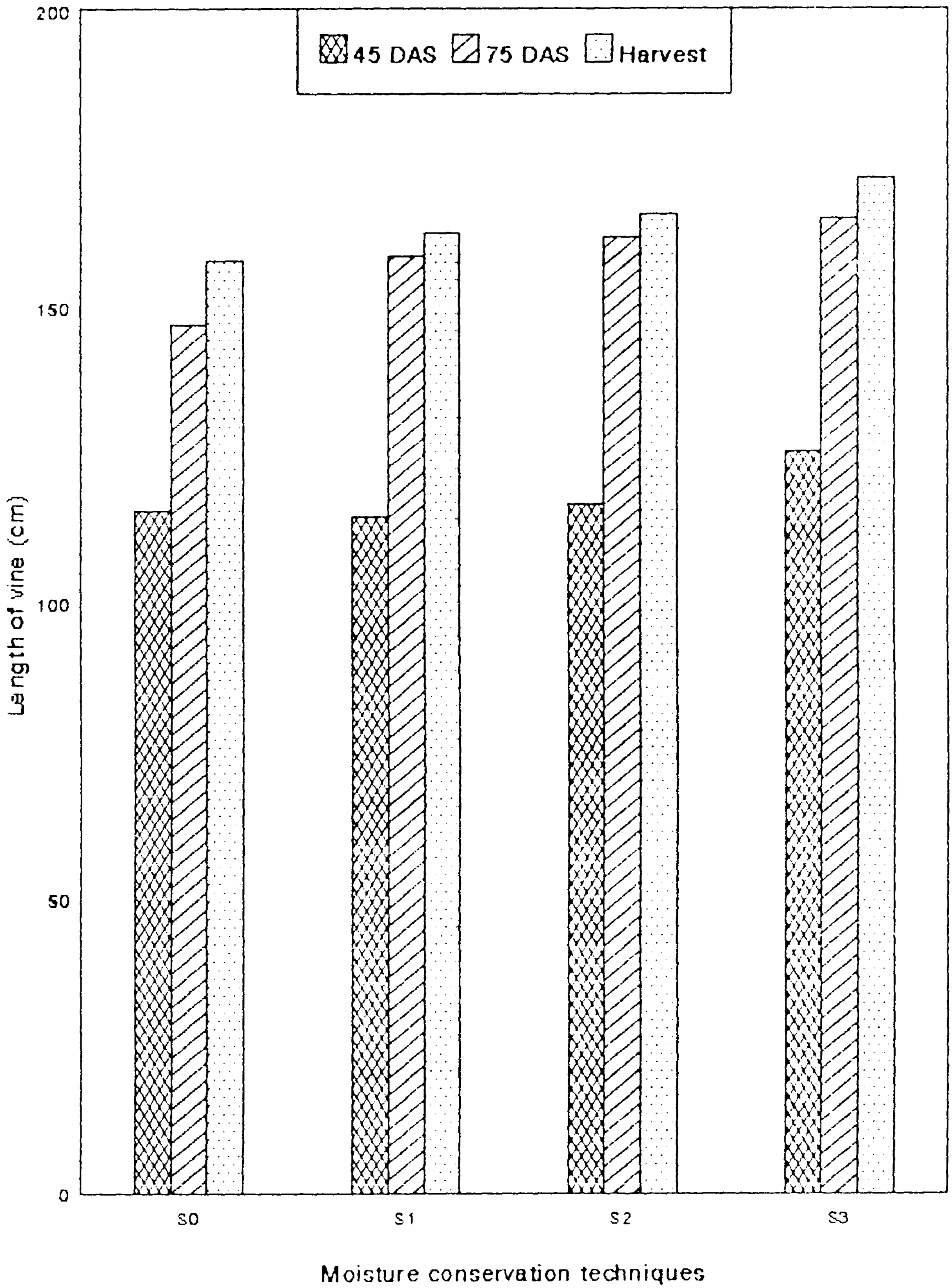


Fig.3 Effect of moisture conservation techniques on vine length (cm)

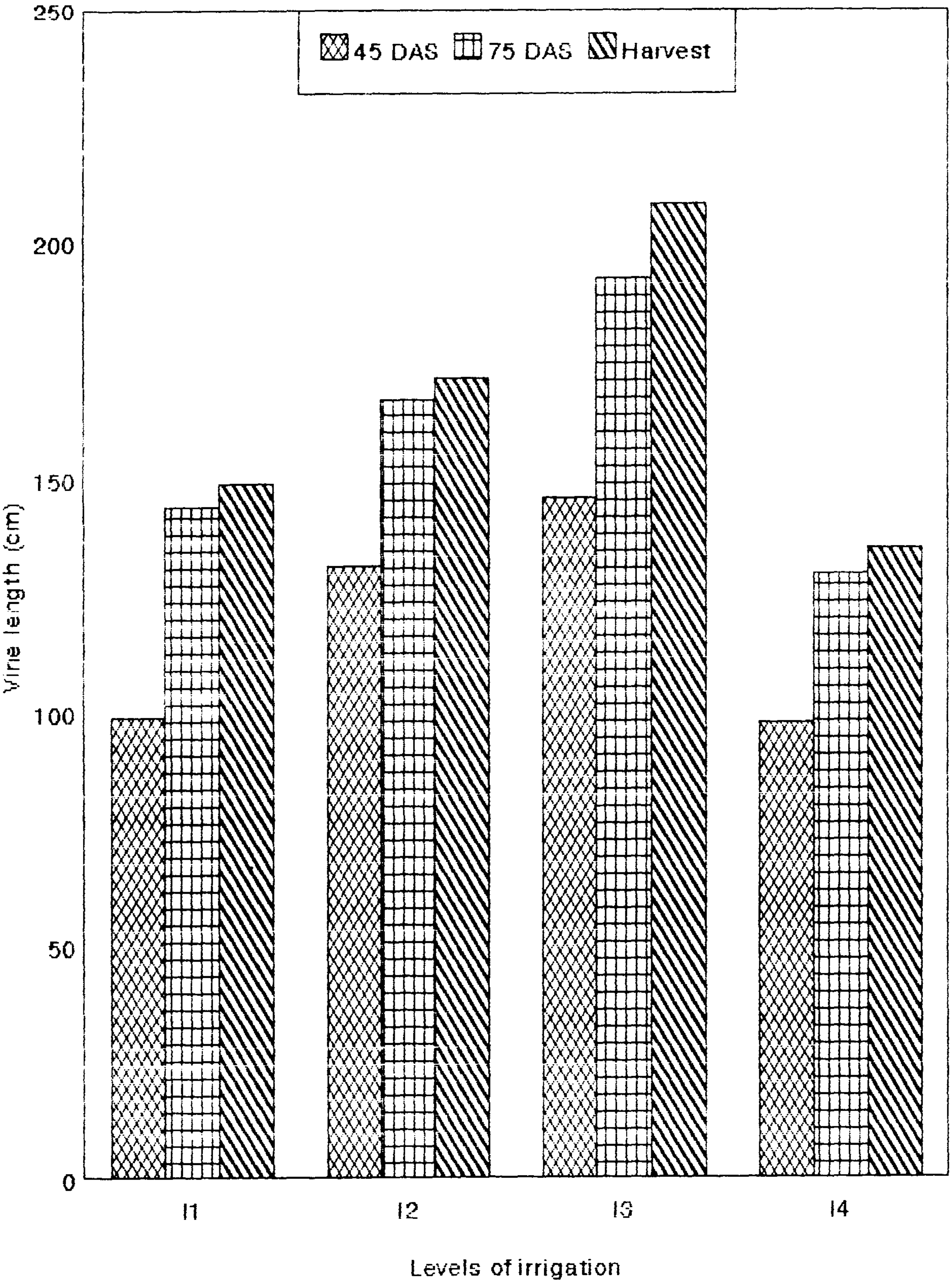


Fig.4 Effect of irrigation on vine length (cm)

The effect of irrigation in growth attributes was much significant. The treatment which received frequent irrigation (IW/CPE ratio 1.2) produced significantly the highest length of vine, number of leaves per vine, leaf area, leaf area index and dry matter production (Table 4, 5,6,7,9 and Fig.4,6,8,10). The results indicate that frequent irrigations (once in 4-6 days) based on irrigation schedule of IW/CPE ratio 1.2 is required for the best growth of cucumber.

Water deficit is likely to affect the two vital process of growth viz., cell division and cell enlargement resulting in poor growth with less number of irrigations observed with irrigation at IW/CPE ratio 0.4 and at critical stages. The favourable influence of higher levels of irrigation was attributed to stimulation of metabolic activities resulting in better growth of vines and production of more leaves on them.

Variation in leaf area and LAI may result from the changes in leaf number or in leaf size. Leaf number depends on the number of vines, the length of time during which leaves are produced, the rate of leaf production during the period and the life span of leaves. Leaf size is determined by the number and size of cells by which the leaf is built and is influenced by light, moisture regimes and the supply of nutrients (Arnon, 1975). Soil water supply was found to have a considerable influence on number of leaves produced and leaf size. Both these parameters were the highest where frequent irrigations were undertaken. The reduction in leaf area and LAI with lesser number of irrigations was due to lower number of leaves produced per vine and smaller size of leaves produced. Escobar and Gausman (1974) in mexican squash,

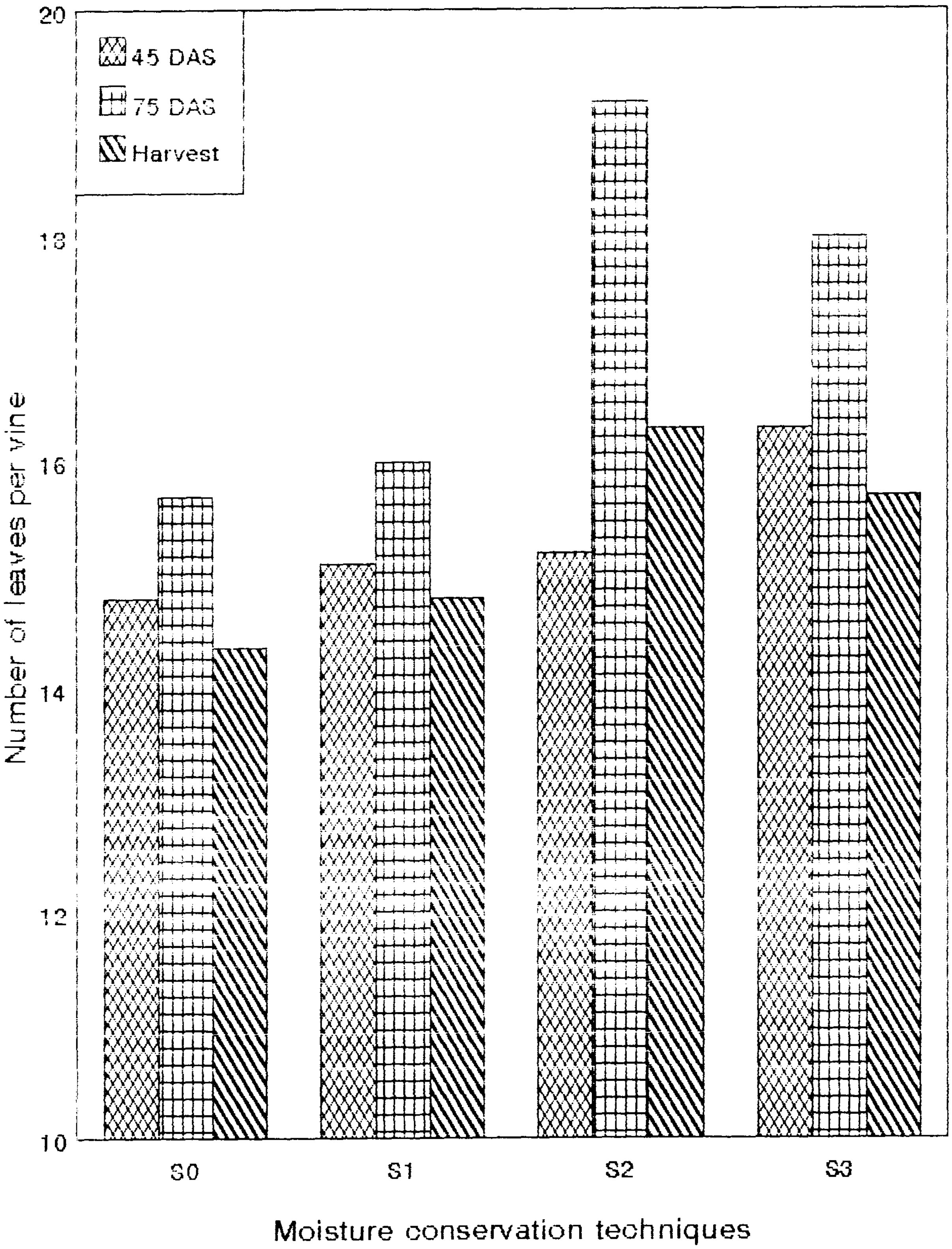


Fig.5 Effect of moisture conservation techniques on number of leaves per vine

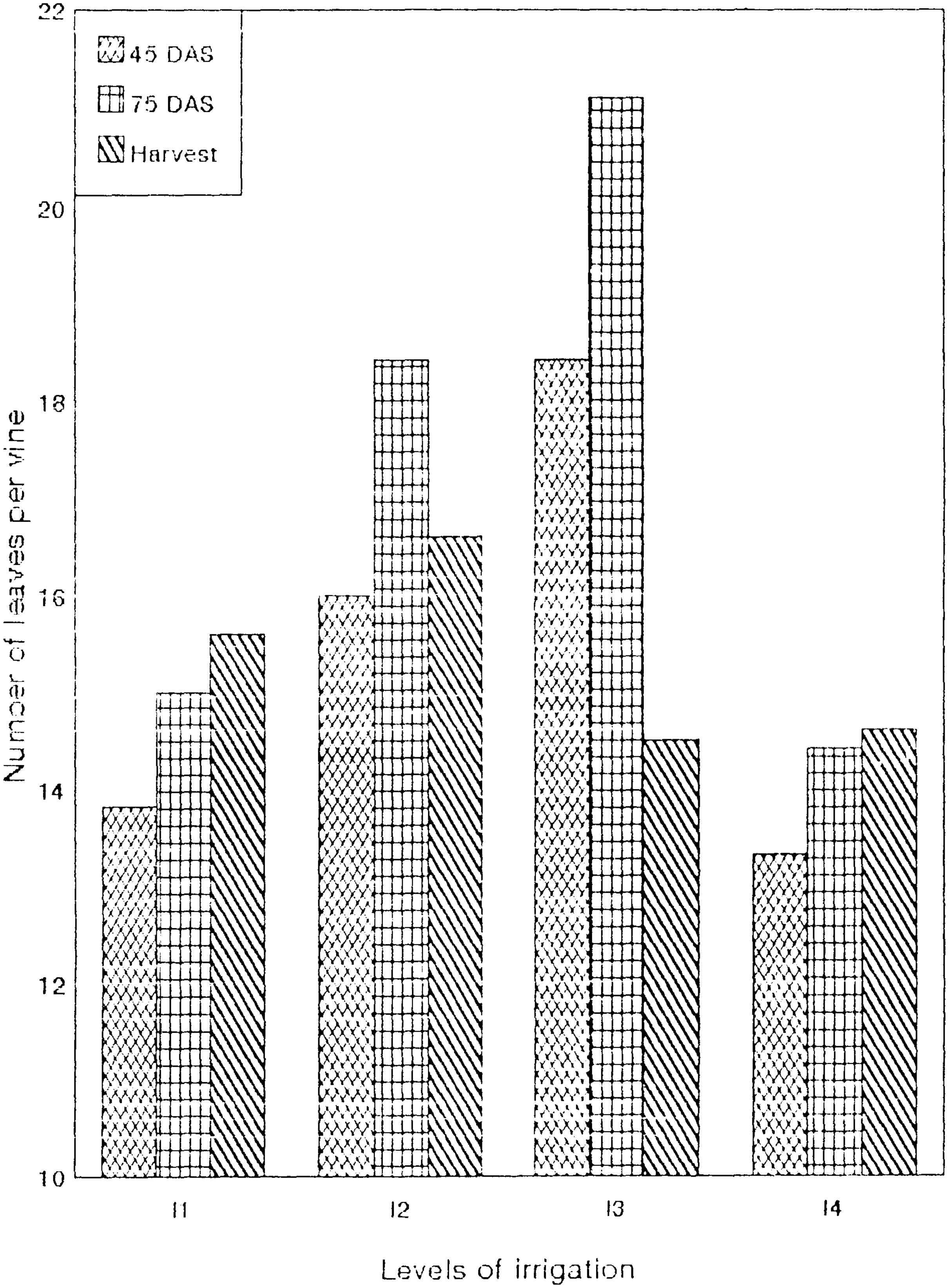


Fig.6 Effect of irrigation on number of leaves per vine

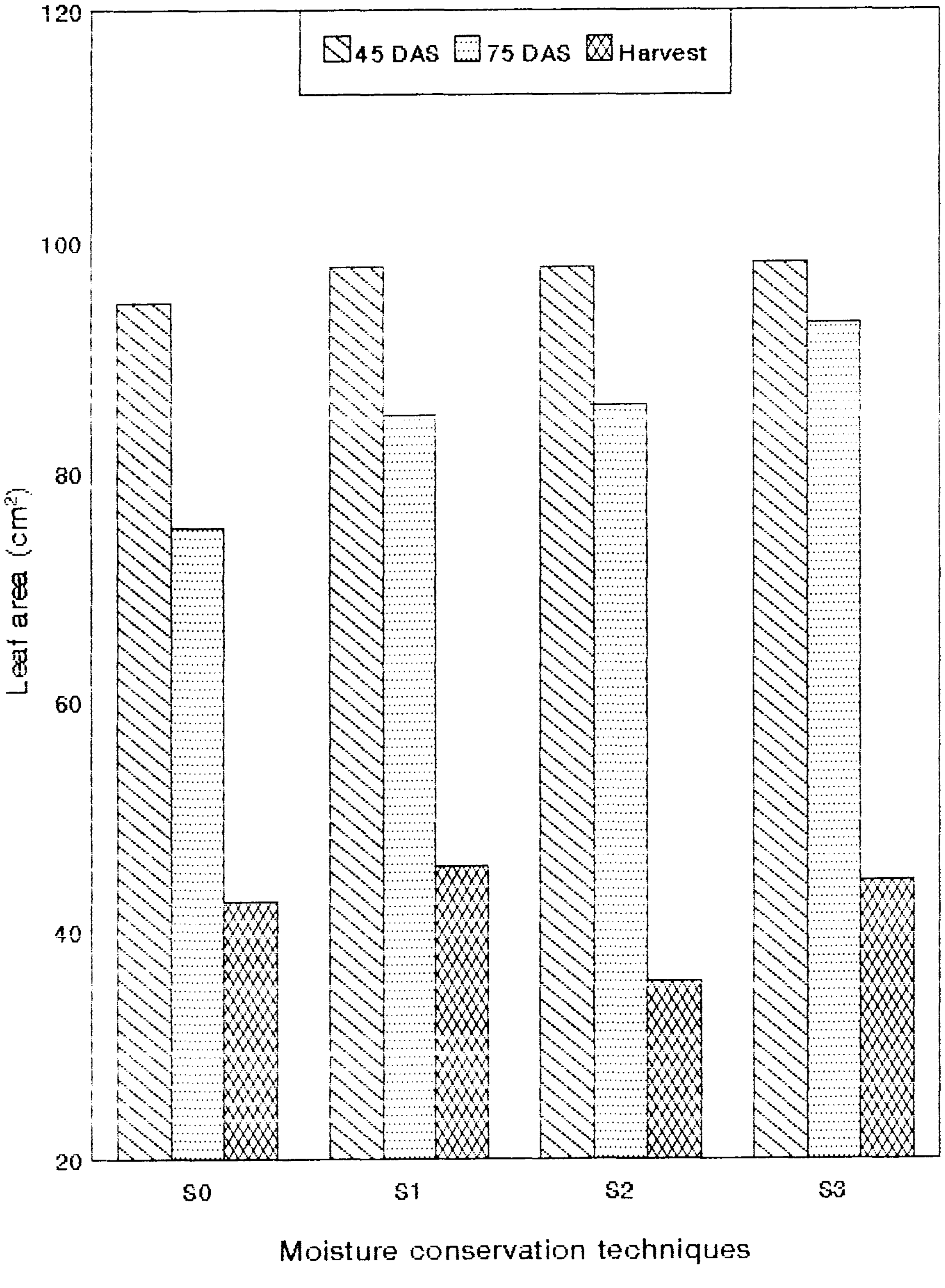


Fig. 7 Effect of MCT on leaf area (cm^2)

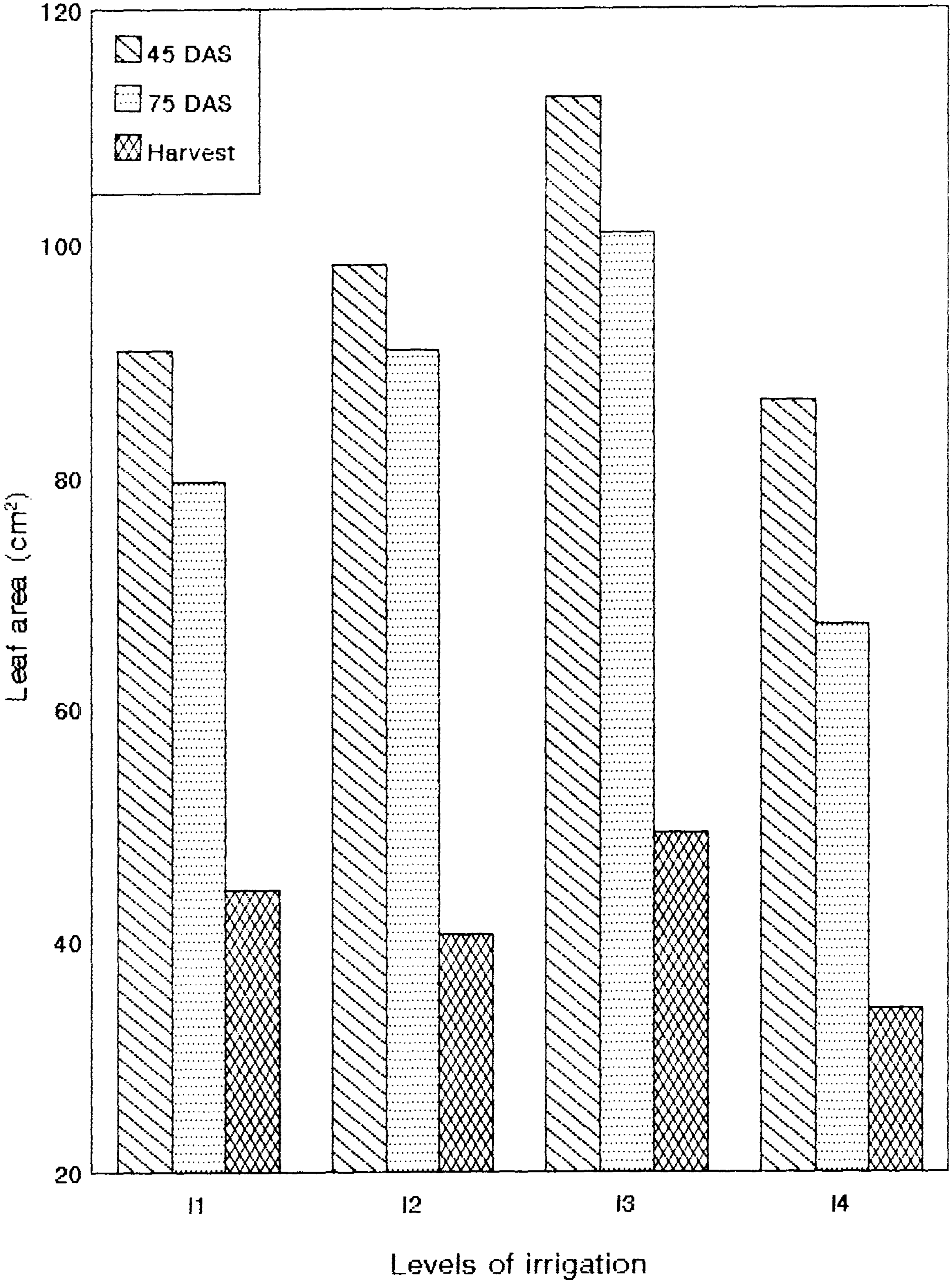


Fig.8 Effect of irrigation on leaf area (cm^2)

Cummins and Kretchman (1974) in cucumber and Radha (1985) in pumpkin, ashgourd and oriental pickling melon also reported reduction in leaf area and LAI (due to moisture stress) in lower level of irrigation.

As evident from Table 9, the drymatter production increased with increasing levels of irrigation. Photosynthesis is the basic process for build up of organic substances by the plants, for which sunlight provides the energy required for reducing Co_2 to sugar as the end product of the process. This sugar serves as the building material for all the other organic components of the plant. The amount of drymatter production will, therefore depend on the effectiveness of photosynthesis of the crop and further more on plants whose vital activities are functioning efficiently (Arnon, 1975). The leaves of a plant are the main organ of photosynthesis and LAI is the best measure of the capacity of a crop for producing drymatter. Lower photosynthetic efficiency which was evident from low LAI in less frequently irrigated plots might be a major reason for the poor growth and low drymatter production in those treatments.

The interaction effect clearly shows that moisture conservation materials produced significant effect on growth attributes only at closer intervals of irrigation (irrigation at IW/CPE ratio 1.2) and the effects were more pronounced at the actively growing stages of the crop after 45 DAS. The favourable effect of moisture conservation materials during the actively growing stages might be due to the fact that demand of water was more at that stage and the excess water consumed by these materials had been put to use at that stage only.

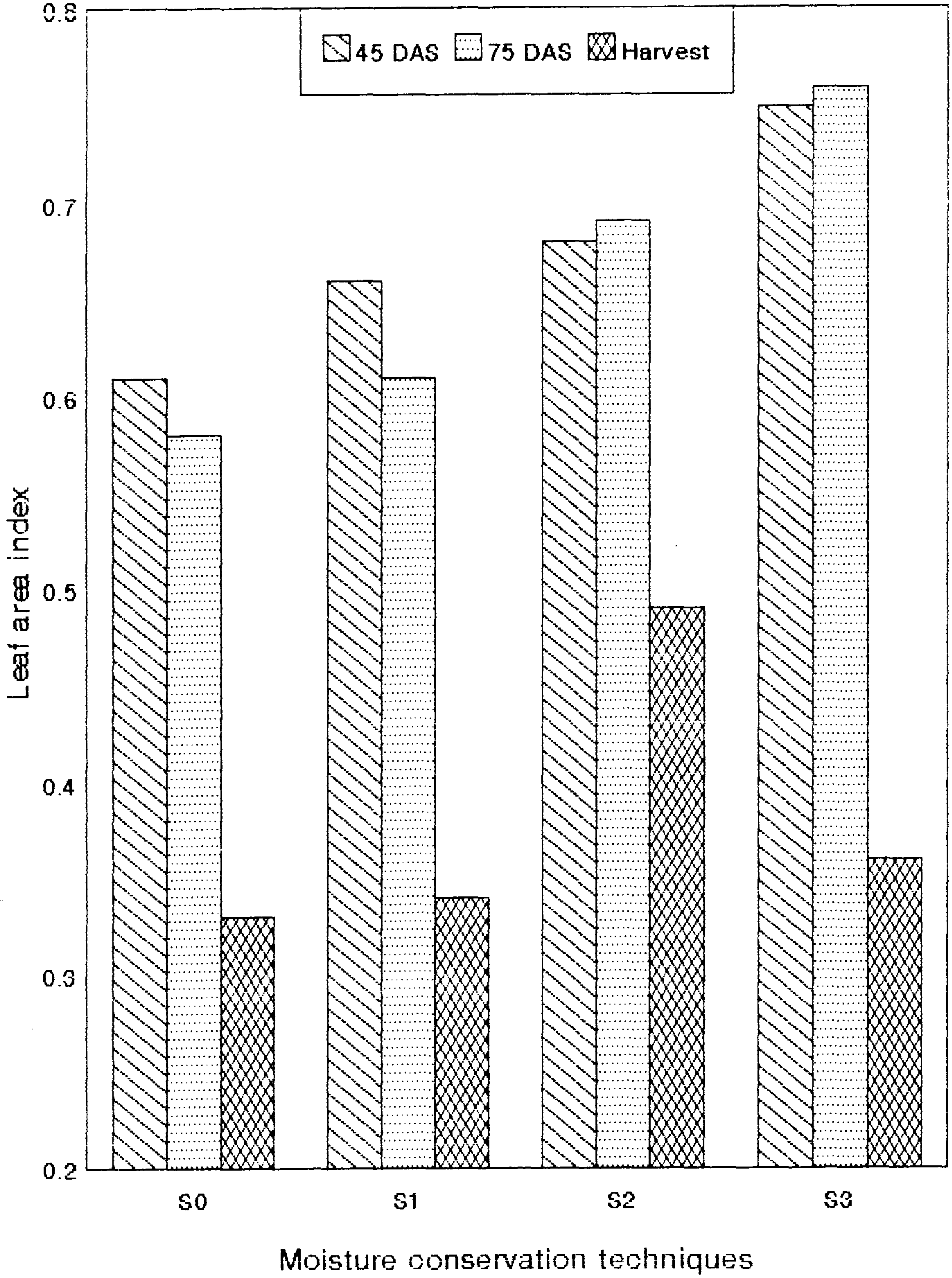


Fig.9 Effect of MCT on leaf area index

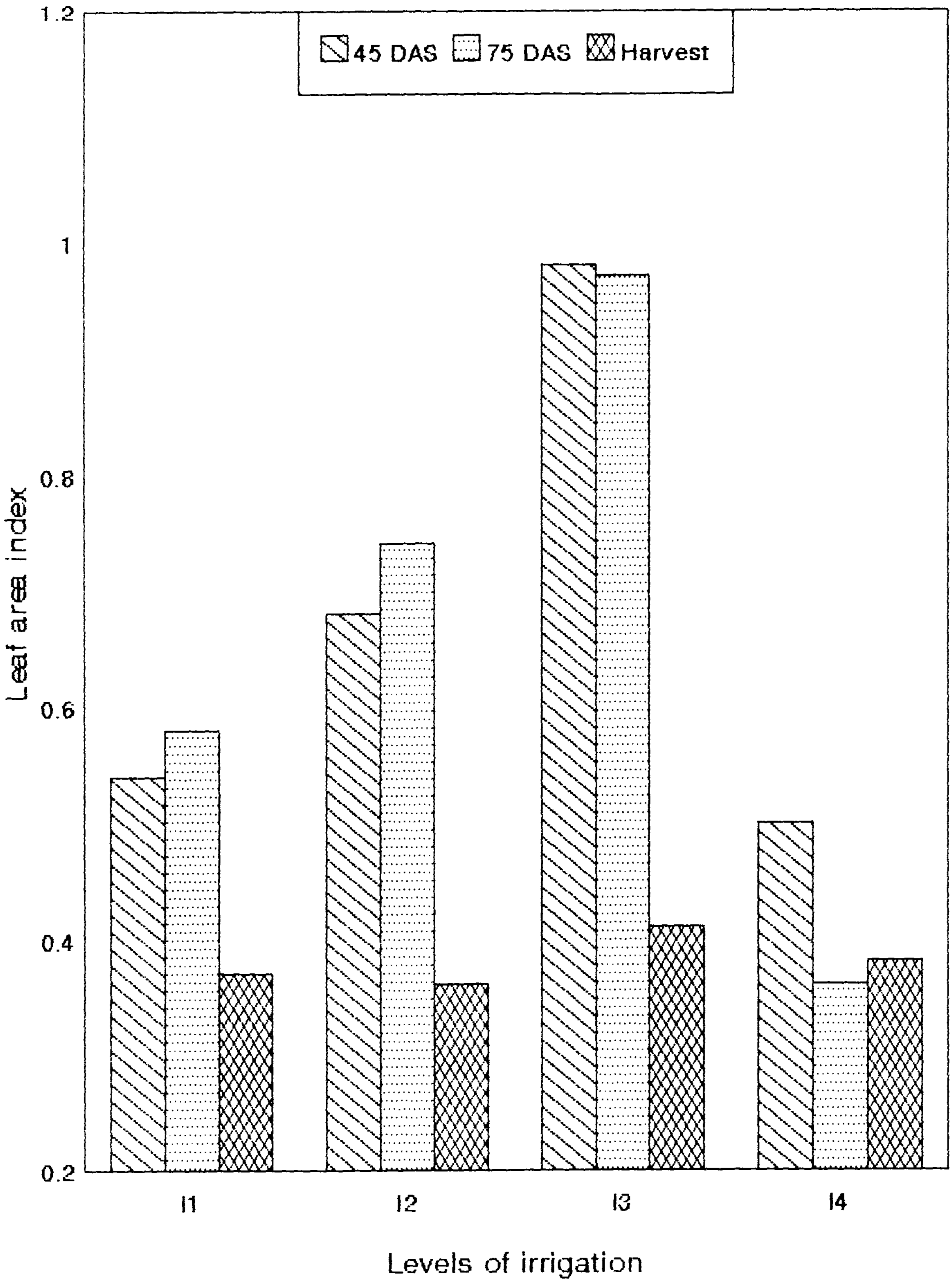


Fig.10 Effect of irrigation on leaf area index

5.2 Yield attributes

Among the yield attributes (Table 8), length and fruit weight were not significantly affected by the moisture conservation treatments. However incorporation of moisture conservation materials had a favourable effect on number of fruits per plant (Fig.11) and girth of fruits. Among the moisture conservation materials, paddy waste and coir pith significantly influenced the girth of fruits and number of fruits per plant. Incorporation of paddy waste and coir pith produced 30 and 13 per cent more number of fruits per plant respectively over control. This might be due to the significantly superior growth as a result of higher moisture availability to the plants which received the incorporation of paddy waste and coir pith.

All the yield components were substantially improved with increase in soil wetness associated with frequent irrigations (Table 8). The treatment which received frequent irrigation (IW/CPE ratio 1.2) recorded significantly the highest yield attributes. The effect of irrigation was more pronounced on fruit number and fruit weight. Irrigation at IW/CPE ratio 1.2 produced 76 and 41 per cent more number of fruits per plant and fruit weight respectively over that of irrigation at critical stages (Fig.11). Higher fruit number and better values of yield attributes in frequently irrigated plants was due to better growing of these plants associated with favourable soil moisture regimes. Favourable effect of frequent irrigation on yield attributes has been reported by Flocker *et al.* (1965) and Neil and Zunio (1972) in melons, Ortega and Kretchman (1982) in pickling cucumbers, Singh and Singh (1978) in bottlegourd, roundgourd and water melon, Thomas (1984) in bittergourd,

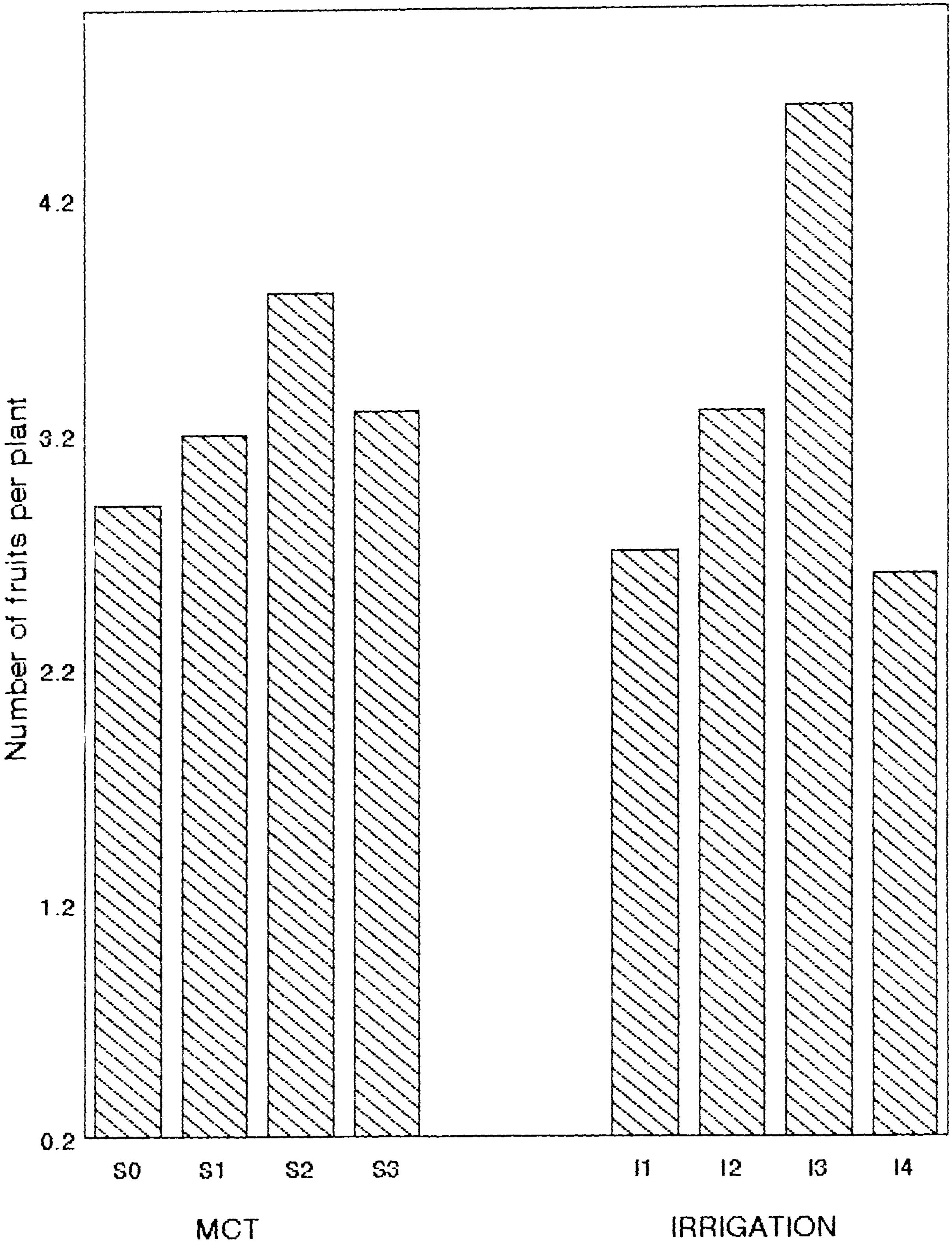


Fig.11 Number of fruits per plant as influenced by MCT and levels of irrigation

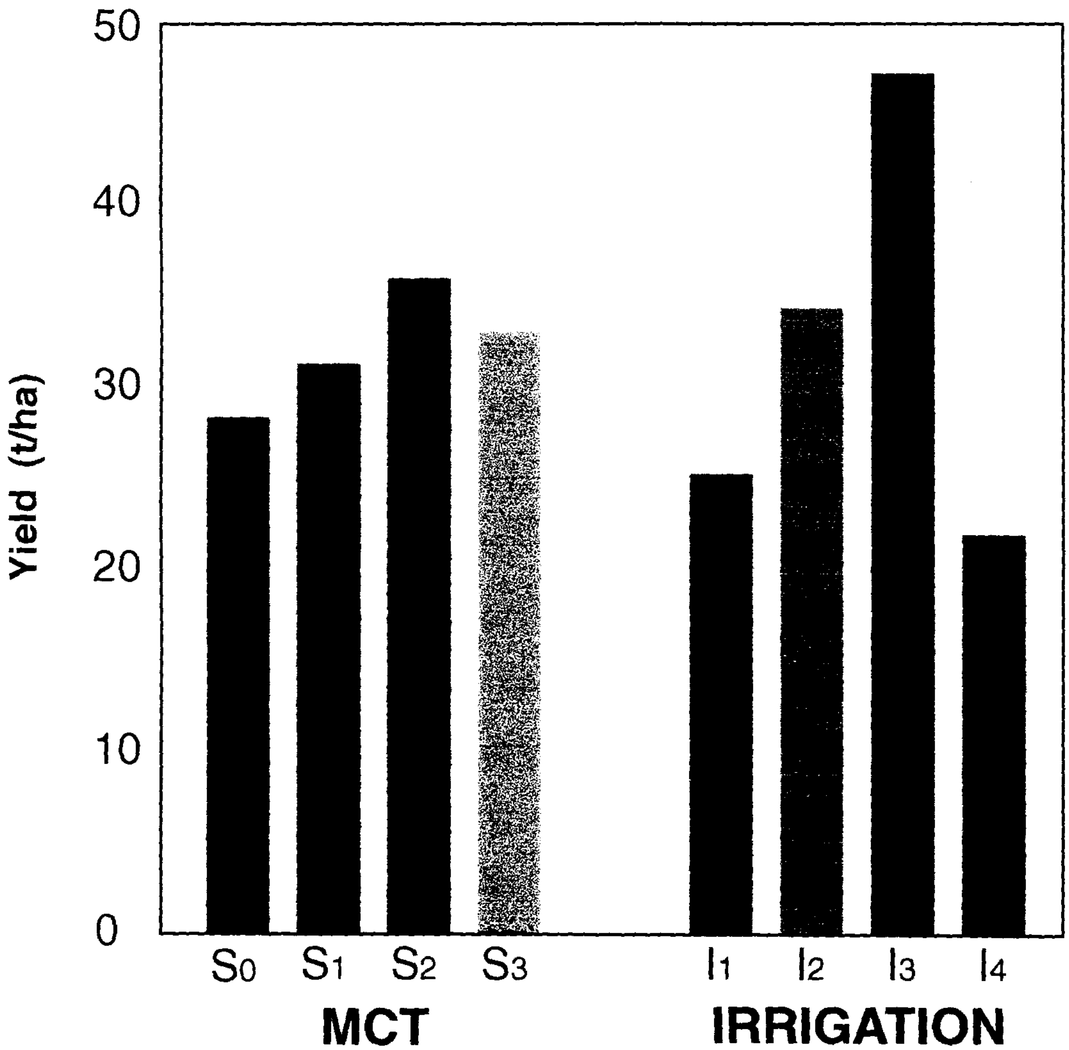
Loomis and Crandall (1977), Prabhakar and Naik (1993) and Yingjajaval and Markmoon (1993) in cucumber and Siby (1993) in watermelon. Kaufman (1972) stated that water deficit generally induced changes like retardation of floral primordia development, reduction in the number of flowers produced and fruitset, flower and fruit abscission etc. and all of these may lead to the decrease in the number of fruits produced. Frequent irrigations might have increased the availability and supply of plant nutrients resulting in better growth and translocation of photosynthates to fruits and thereby fruit weight increased. The period of fruit enlargement in the reproductive cycle of a plant is very critical during which considerable amounts of nutrient resources are transported into the fruit. Water deficit if any developed during this period may cause marked reduction in the size of the fruits (Kaufman, 1972). An increase in the length of fruit and girth of fruit explains the increased fruit weight at higher levels or irrigation.

The interaction effect on all the growth attributes were not significant.

5.3 Fruit yield

All the three moisture conservation materials increased fruit yield (Table 9 and Fig.12). However significant increase over control was observed only in the case of paddy waste and coir pith incorporation. Highest yield was recorded by paddy waste incorporation. The yield increase due to the incorporation of paddy waste, coir pith and sawdust over control was 27, 17 and 10 per cent respectively. Better plant growth associated with more moisture retention promoted more number of fruits and higher fruit weight in these treatments. The yield increase was due to increase in fruit

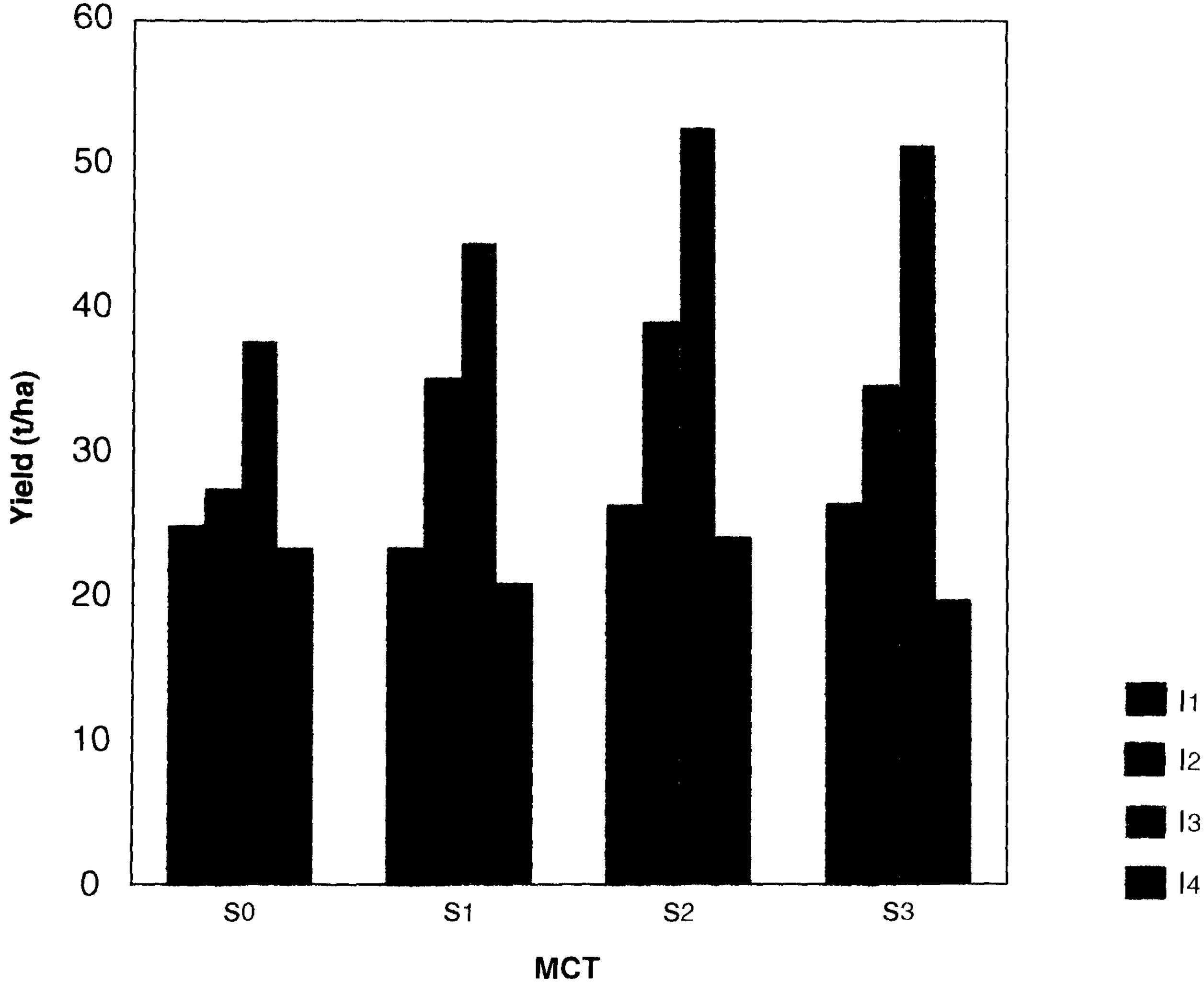
Fig. 12 Effect of MCT and levels of irrigation on fruit yield (t/ha)



number per plant and fruit weight observed in these treatments. This result is in conformity with the findings of Ivonova and Ivonova (1976); Mavrodii (1979); Singh *et al.* (1977); Arunachalam (1987); Anabayan (1988); Athmanathan (1988); Nagarajan *et al.* (1989); Veerabadran (1991); Clark and Moore (1991); Devaraj and Chockalingam (1991) and Saravanababu (1994) have stated that application of soil conservation materials increased the yield in many crops.

Number of irrigation had a better influence on fruit yield (Fig.12). The maximum yield was recorded by frequent irrigations scheduled by the IW/CPE ratio 1.2. This was significantly followed by irrigation at IW/CPE ratio 0.8. The yield from irrigation at IW/CPE ratio 0.4 and at critical stages were at par and significantly inferior to irrigation at IW/CPE ratios 1.2 and 0.8. The increase in yield by irrigation at IW/CPE ratio 1.2 over irrigation at IW/CPE ratio 0.8, 0.4 and at critical stages were 37, 86 and 114 per cent respectively. This clearly indicates the necessity for frequent irrigation in cucumber. The observed increase in yield with increase in the irrigation frequency is attributed to a more or less similar trend in yield attributes like length, girth and weight of fruits and number of fruits per plant. This is to be expected since fruit yield is the ultimate manifestation of the cumulative effect of these characters. This result is in conformity with findings of Jassal *et al.* (1970); Loomis and Crandall (1977); Kashi (1981); Desai and Patil (1984); Thomas (1984); Radha (1985); Jacob (1986); Thankamani (1987); Prabhakar and Naik (1993)' Yingjajaval and Markmoon (1993) and Siby (1993) who have found that cucurbitaceous crops require frequent irrigation for maximum yield.

Fig. 13 Interaction effect of MCT and levels of irrigation on fruit yield (t/ha)



The study clearly indicted that the interaction effect of moisture conservation techniques and irrigation was significant (Fig.13). Incorporation of paddy waste recorded significantly higher yield to control when irrigation was given at both IW/CPE ratio 0.8 and 1.2. The best combination was incorporation of paddy waste and irrigation scheduling at an IW/CPE ratio 1.2. However the effect of incorporation of coir pith was superior to control only when irrigation was scheduled to IW/CPE ratio 1.2. The increase in yield at this IW/CPE ratio due to the incorporation of paddy waste, coir pith and sawdust were 45, 38 and 20 per cent respectively over control.

From the studies it is clear that for higher yield cucumber needs frequent irrigation once in 4-6 days. Nevertheless the yield from irrigation at IW/CPE ratio 1.2 (13 irrigations) without any moisture conservation materials was at par with that of irrigation at IW/CPE ratio 0.8 (8 irrigations) with moisture conservation materials. This indicates that addition of moisture conservation materials can save five number of irrigations if an identical yield is expected compared to that with frequent number of irrigation scheduled at IW/CPE ratio of 1.2 without any moisture conservation techniques. However there has been tremendous increase in yield when we incorporate moisture conservation materials even when frequent irrigations are practised.

The results thus indicate that if less costly materials like paddy waste is available in the farm or materials like coir pith or sawdust are available nearby their incorporation will boost the yield of cucumber. This increase has been 45%, over control in the case of paddy waste, 38% with coir pith and 20% with sawdust.

If there is scarcity for irrigation, irrigation at an interval of 6-8 days (IW/CPE ratio 0.8) can also give reasonably high yield if proper moisture conservation materials are adopted. Irrigation at an interval dictated by the IW/CPE ratio of 0.8 (8 irrigations) with moisture conservation with paddy waste has given 40% increase over control at the same frequency and 4% over irrigation at IW/CPE ratio 1.2 (13 irrigations) without any moisture conservation practices.

5.4 Soil moisture studies

Soil moisture content from the moisture conservation materials incorporated plots were higher both before and after irrigation compared to control (Table 10). The increase in the soil moisture content over control due to the addition of coir pith, paddy waste and sawdust were 14.7, 10.8 and 6.8 per cent respectively at after irrigation and for before irrigation, these figures were 8.2, 7.8 and 7.3 per cent respectively. This result is in conformity with the findings of Vourinen (1958); Soczek (1958); Lal (1972); Ragothama (1981); Mahey *et al.* (1986); Voorhes (1986); Asoegwu (1991); Kotoky and Bhattarchrya (1991); Ramasamy and Kothandaraman (1991); Rajendran (1991); Veerabadran (1991) and Channappa (1994) who also observed the increase in the soil moisture content by the addition of paddy straw, paddy husk, sawdust, coir pith and other organic materials in various crops Among the moisture conservation materials, coir pith retained more moisture followed by paddy waste. This is in conformity with the results of Raghothama (1981) who found that paddy husk and coir pith were the most effective in conserving soil moisture and reducing the number of irrigations required for cardamom.

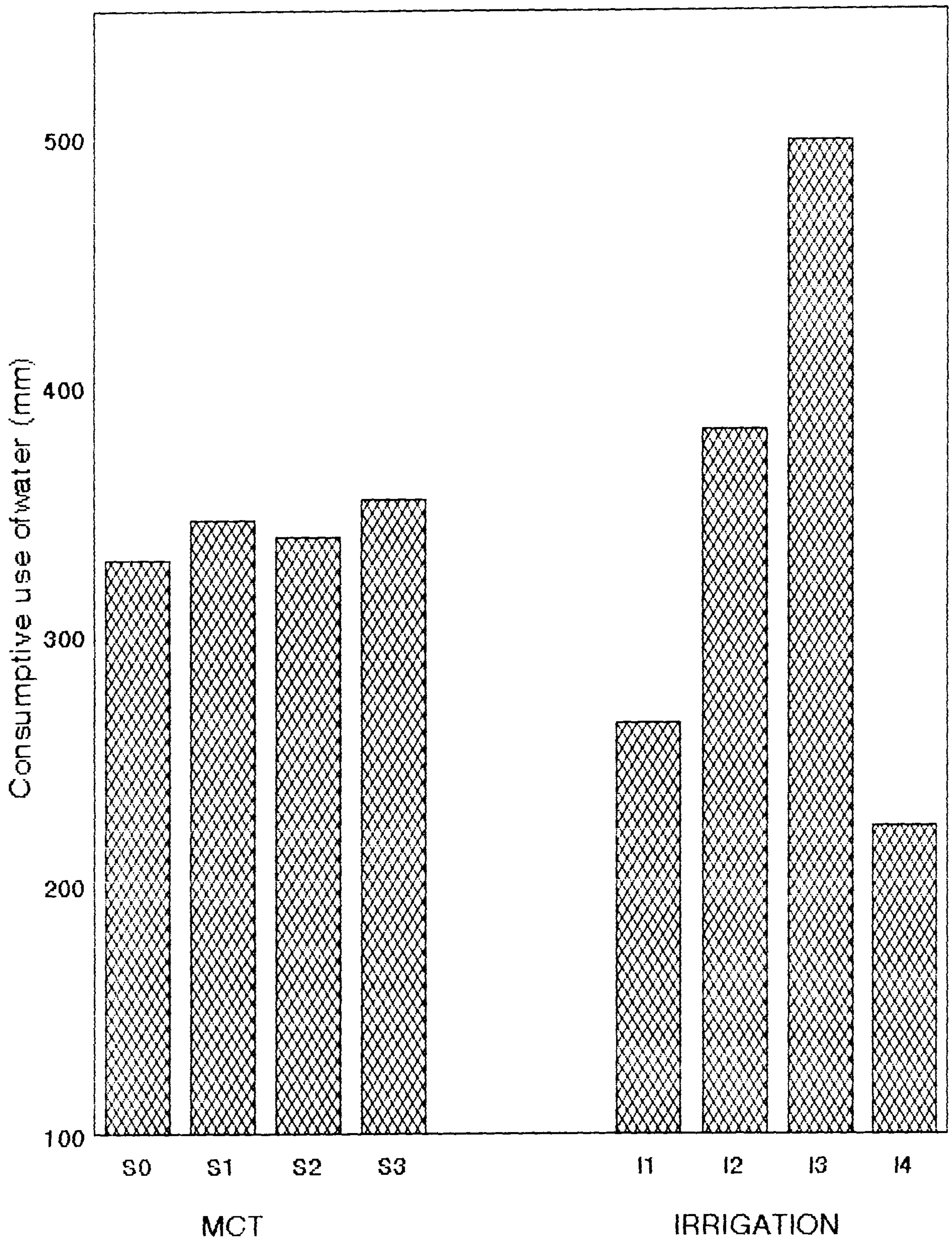


Fig.14 Consumptive use of water (mm) as influenced by MCT and levels of irrigation

With respect to consumptive use (Table 11, 11b and Fig.14) incorporation of moisture conservation materials increased the consumptive use compared to control. The increase in the consumptive use due to the addition of coir pith, sawdust and paddy waste over control was 7.3, 4.9 and 2.7 per cent respectively. This might be due to more moisture retention by the materials and higher growth attributes like length of vine, number of leaves per vine, leaf area and leaf area index.

The consumptive use increased with increase in the levels of irrigation (Fig.14). The highest value was recorded by frequent irrigation (irrigation at IW/CPE ratio 1.2). Frequent moisture supply created more favourable conditions for higher evapotranspiration. Similar reports were put forward by Tomitaka (1974); Desai and Patil (1984); Thomas (1984); Radha (1985); Jacob (1986); Thankamani (1987) and Siby (1993).

The mean consumptive use at various growth stages revealed that the peak consumptive use was reached maximum between 36-50 DAS for irrigation at IW/CPE ratio 1.2, 0.8 and 0.4 and for irrigation at critical stages it was between 20-35 DAS (Table 11a). This peak consumptive use coincides with the flowering and full canopy development stage of the crop. These factors together with the meteorological parameters like high wind speed, low humidity (Table 1) might have contributed to the high consumptive use during that period. The decrease in the consumptive use after this period may be attributed to the attainment of fruit maturity stage. Several workers have also reported that consumptive use increases during flowering and early fruiting and levels off during late harvest (Cselotel and Varga, 1973; Loomis and Crandall, 1977 and Radha, 1985).

With respect to crop coefficients [Table 11(a) and 11(b)], frequent irrigation (IW/CPE ratio 1.2) recorded the highest value and there was a decrease in the crop coefficient with decrease in the degree of wetness. The increase in the crop coefficient values with increase in wetness has to be expected as there was a similar increase in consumptive use with increase in the frequency of irrigation.

The variation in the crop coefficient values with the different growth stages was due to the corresponding changes in consumptive use. The maximum crop coefficient was between 51-65 DAS for irrigation at IW/CPE ratio 1.2 and 0.8 and for the irrigation at IW/CPE ratio 0.4 and at critical stages it was between 20-35 DAS. Later it declined. Similar trend was observed by Loomis and Crandall (1977) in Cucumber and Radha (1985) in pumpkin, ashgourd and oriental pickling melon. The subsequent decline in the crop coefficient values would probably due to the reduction in crop canopy as the crop was at its senescence stage.

The results revealed that addition of moisture conservation materials increased the water use efficiency. The increase in the field WUE due to the addition of paddy waste, coir pith and sawdust were 19.9, 9.9 and 5.3 per cent respectively and for crop

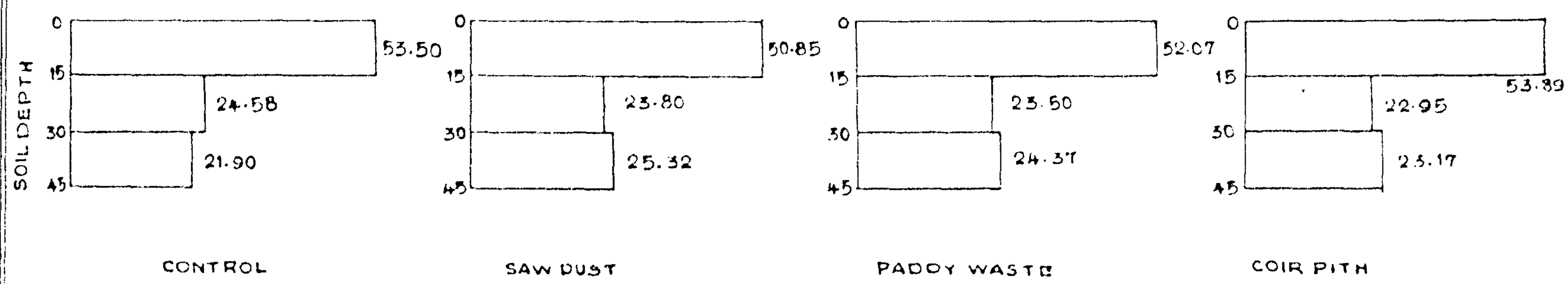
WUE these figures were 17.2, 1.9 and 1.5 per cent respectively over control. Addition of rice straw increase the WUE in maize was reported by Khera *et al.* (1976) and Kalaghatagi *et al.* (1990).

The water use efficiency decreased with increase in the level of irrigation (Table 12 and Fig.16). Water use efficiency is likely to increase with decrease in soil moisture supply until it reaches the minimum critical level because plants may actively try to economise water loss in the range from minimum critical to optimum moisture level. Water above the optimum level may be lost in the form of excessive evaporation, transpiration or even as deep percolation. These findings corroborate reports of Thomas (1984) and Thampatti *et al.* (1993) in bittergourd, Radha (1985) in pumpkin, ashgourd and oriental pickling melon, Thankamani (1987) in snakegourd and Siby (1993) in watermelon. Stress during any phase of growth and development considerably reduced WUE as there was a large decrease in yield components in relation to saving in the water used.

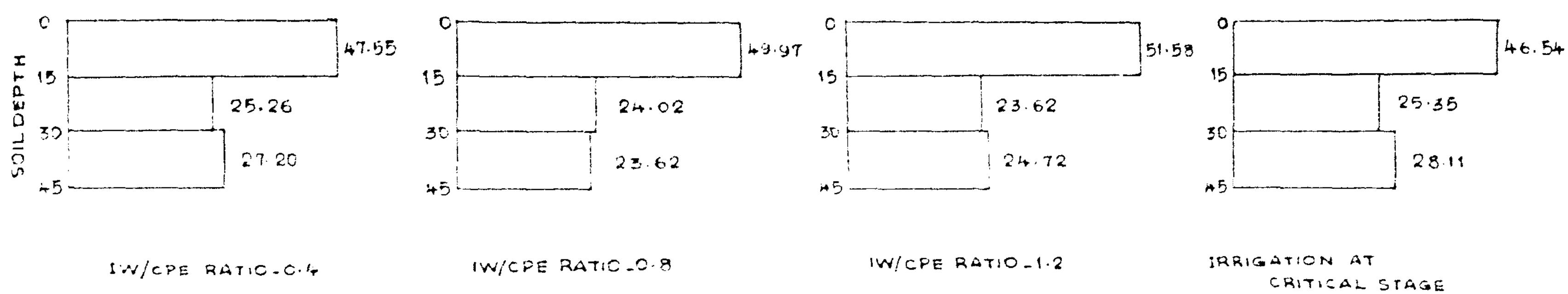
Maximum depletion of soil water was observed from the top 15 cm layer irrespective of the moisture conservation and irrigation treatments (Table 13 and Fig.15). Moisture depletion decreased with soil depth. This might be due to the fact that besides transpiration, losses from the soil surface were considerable and also the roots of the crop were mostly confined to the top surface layer. Another trend observed was that drier regimes of irrigation extracted more water from the lower soil layers (30-45 cm) when compared to wet regimes, possibly due to the extensive

FIG.15 SOIL MOISTURE EXTRACTION PATTERN (VALUES IN PERCENT) AS INFLUENCED BY MOISTURE CONSERVATION TECHNIQUES AND LEVELS OF IRRIGATION

MOISTURE CONSERVATION TECHNIQUES



LEVELS OF IRRIGATION



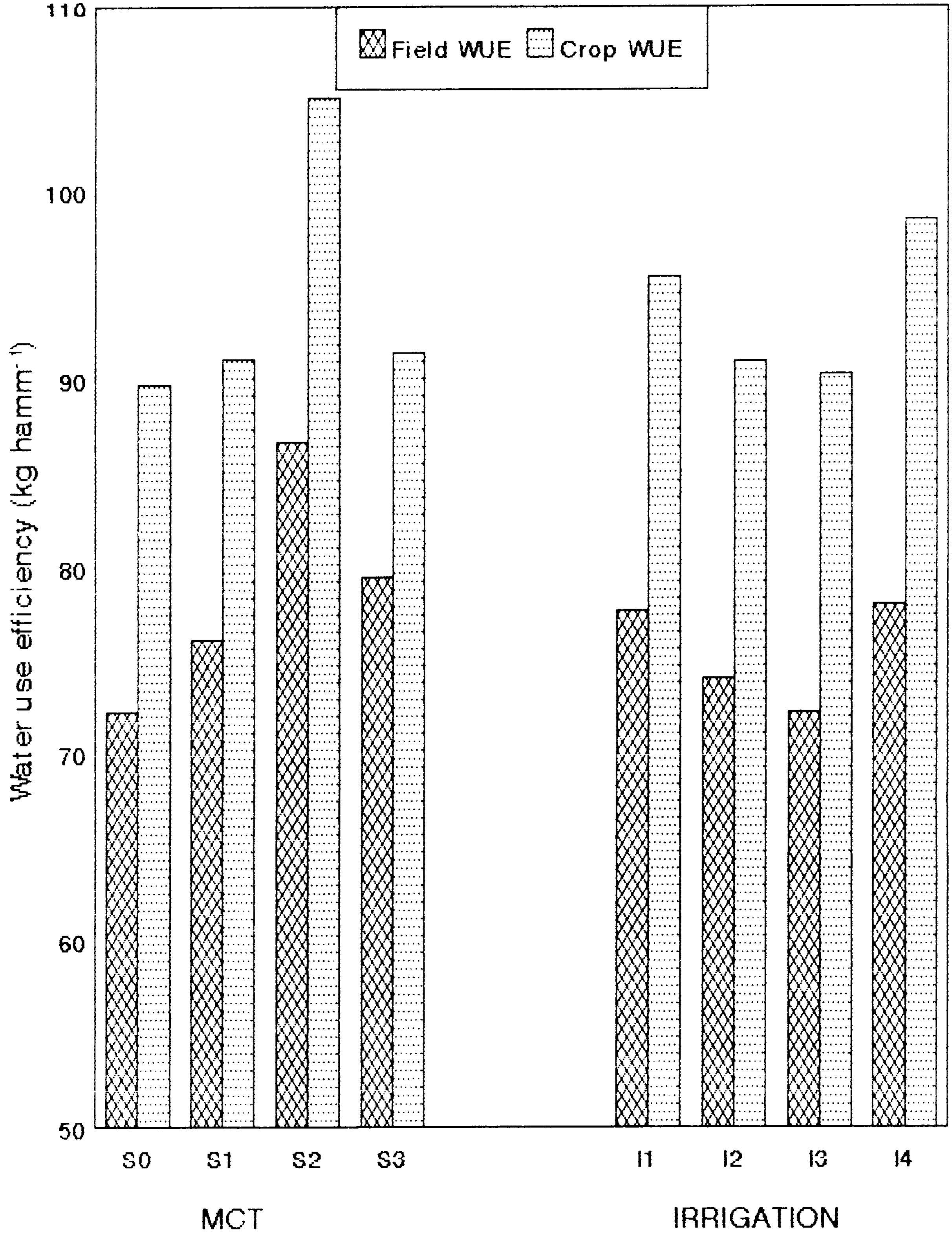


Fig.16 Effect of MCT and levels of irrigation on water use efficiency (kg $hamm^{-1}$)

proliferation of root system to utilize soil moisture from deeper layers. Similar observations were reported by Loomis and Crandall (1977) in cucumber, Thomas (1984) and Thampatti *et al.* (1993) in bittergourd, Radha (1985) in pumpkin, ashgourd and oriental pickling melon and Siby (1983) in watermelon.

The moisture depletion from 0-15 and 15-30 cm layers was more or less same for the moisture conservation techniques. But a slight increase in moisture depletion was observed from 30-45 cm when moisture conservation materials were incorporated. This increase over control was 3.42, 2.47 and 1.27 per cent for sawdust, coir pith, paddy waste respectively. This might be due to the loosening of soil by the incorporation of moisture conservation materials and thereby proliferation of more roots in the deeper layer.

5.5 Chemical composition of leaves

Moisture conservation techniques and levels of irrigation significantly affected the leaf nitrogen, phosphorus and potassium content at 45, 75 DAS and at harvest. The N, P and K content of leaves was higher in paddy waste incorporated plots at all the stages of observation (Table 14,15 and 16). Such an increase in the nutrient content might be due to the better moisture regimes created in the rootzone of the crop which enhanced better uptake of nutrients. Degradation of the moisture conservation materials also would have enriched the fertility status of the soil. This result is in conformity with the result of Chaudhary and Childyal (1970) and Jayashree (1987).

Higher levels of irrigation also markedly increased the N and K content of leaves upto 45 DAS and P content upto 75 DAS. Later the nutrient concentration of leaves decreased. The increase in the nutrient uptake with frequent irrigation might be attributed to a better uptake of nutrients with the favourable soil moisture regimes available at the rootzone of the crop in closely irrigated treatments. This result is in agreement with the findings of Brown *et al.* (1960) in Cotton, Tamaki and Naka (1971) in broad bean, Sharama and Prasad (1973) in Bhindi, Singh (1975) in berseem fodder, Cocueci *et al.* (1976) in squash and Thomas (1984) in bittergourd. From 45th day onwards, the N and K content of leaves decreased with increasing levels of irrigation. Similar results was observed by Thomas (1984). This might be due to dilution effect and this also evidently supports the view that N and K absorbed upto flowering accumulates in leaves and subsequently transported to fruits.

Tamaka *et al* (1964) pointed out that nutrient absorption by the plant is controlled by nutrient availability in the soil, nutrient absorption power of soil and the rate of increase in drymatter. The concentration and availability of various elements in the soil for the plant growth depends upon the soil solution phase which is controlled by the amount of soil water. So the availability of soil water is of great significance to plants need for and the ability to absorb nutrients and the soils ability to supply them (Black, 1973). Higher levels of irrigation produced favourable conditions and promoted root growth and rendered nutrients more available. The interaction effect shows that higher values of P & K content was recorded by paddy waste incorporation when irrigation was scheduled at IW/CPE ratio 1.2.

5.6 Economics of different treatments

The economic analysis clearly indicate that the superiority of incorporation of moisture conservation materials over control (Table 17 and Fig.17). The highest net profit was recorded by moisture conservation with paddy waste. The increase in the net profit due to the addition of paddy waste, coir pith and sawdust over control were Rs. 27,697.99 (68%), Rs. 13,958.99 (34%) and Rs. 4,254.74 (10%) respectively. Similar increase in net return per rupee invested in the order of 21.6, 7.8 and 0.01 per cent respectively over control. Therefore it is highly advantageous to incorporate paddy waste and coir pith as moisture conservation materials in the cultivation of oriental pickling melon.

Net profit as well as net return per rupee invested increased with increase in frequencies of irrigation and the highest values were recorded by frequent irrigations scheduled at IW/CPE ratio 1.2 (4-6 days interval) (Fig.17). The increase in the net profit by irrigation scheduled at IW/CPE ratio 1.2, 0.8 and 0.4 over irrigation at critical stages were 204, 97 and 32 per cent respectively. Therefore scheduling irrigation at an IW/CPE ratio of 1.2 (4-6 days interval) is the best irrigation practice for oriental pickling melon.

Considering the treatment combinations it emerged from the study that moisture conservation materials were economical only at higher frequencies of irrigation (IW/CPE ratio of 0.8 and 1.2) (Table 17b and Fig.18). The combination of paddy waste with irrigation was much more superior to other materials. The best combination was incorporation of paddy waste along with irrigation at IW/CPE ratio 1.2. The increase in net profit with the combination of paddy waste with irrigation at the IW/CPE ratio of 1.2 was 127% over control, 57% over sawdust and 13% over coir pith. At the irrigation frequency of IW/CPE ratio of 0.8 also incorporation of paddy waste recorded 123% over control, 34% over saw dust and 35% over coir pith. Incorporation of paddy waste recorded an increase of Rs. 40,279 (53%) more net profit when crop was irrigated at the IW/CPE ratio 1.2 over irrigation at IW/CPE ratio 0.8. Thus the results indicate that the incorporation of paddy waste at the irrigation frequency of IW/CPE ratio 1.2 is much superior or than other treatment combinations.

The results of the study clearly indicated that for best yielding, the crop is to be irrigated at closer interval of 4-6 days (at an irrigation interval dictated by IW/CPE ratio 1.2). The net profit obtained by crops irrigated at the IW/CPE ratio of 1.2 was Rs.51411. The results also have indicated that better net profit could be obtained even with lesser number of irrigations dictated by IW/CPE ratio 0.8 by the incorporation of moisture conservation materials. At this ratio, incorporation of paddy waste gave 48% (Rs.24807), sawdust 11% (Rs.5477) and coir pith 10% (Rs.4978) more net profit over irrigation alone at the IW/CPE ratio of 1.2.

The net return per rupee invested also followed the same trend in the combination of moisture conservation materials and irrigation schedules as that was seen in the case of net profit. Among the combination, the highest net profit of Rs.2.15 per rupee invested was observed in the combination of paddy waste and crops irrigated at the IW/CPE ratio of 1.2.

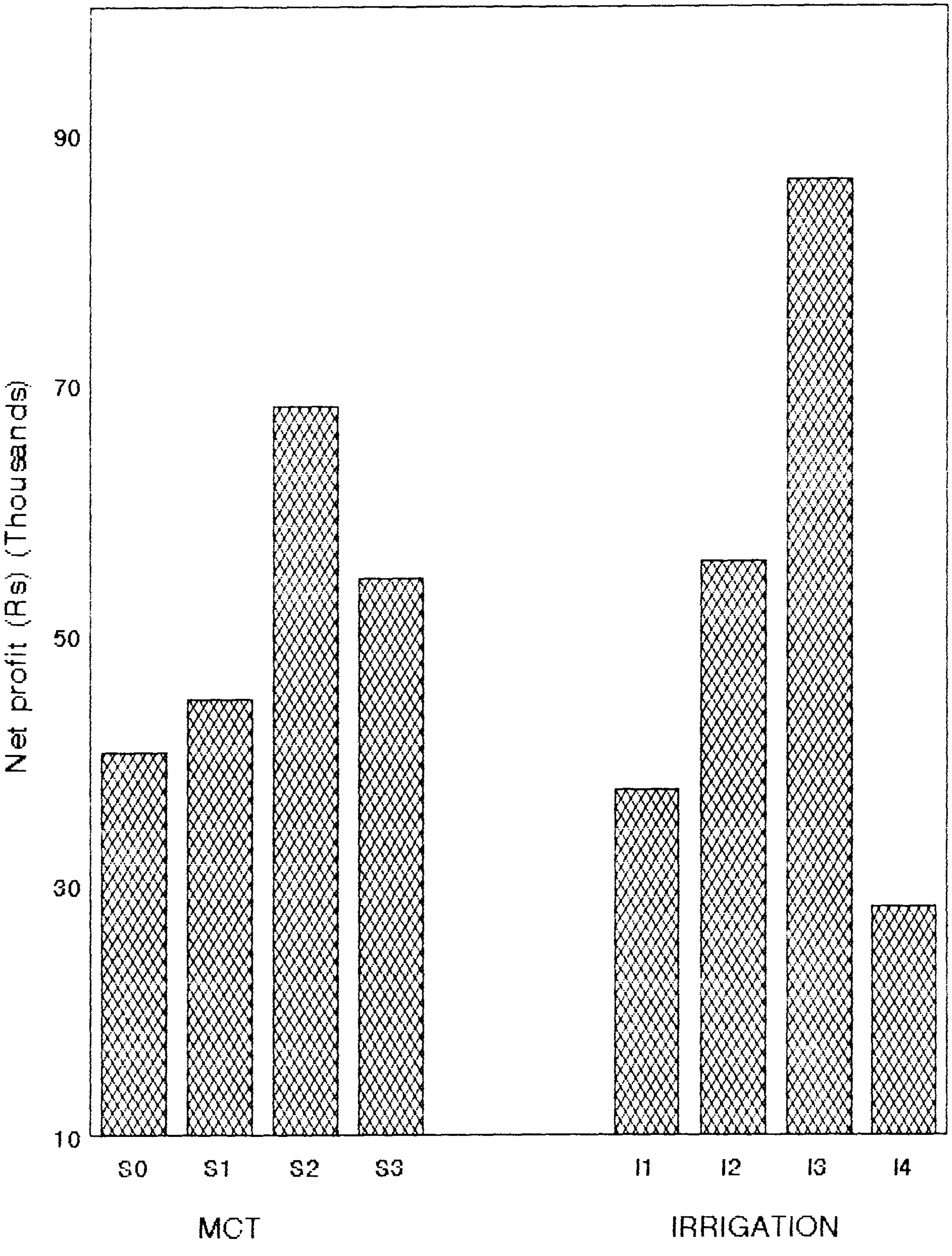


Fig.17 Effect of MCT and levels of irrigation on net profit (Rs)

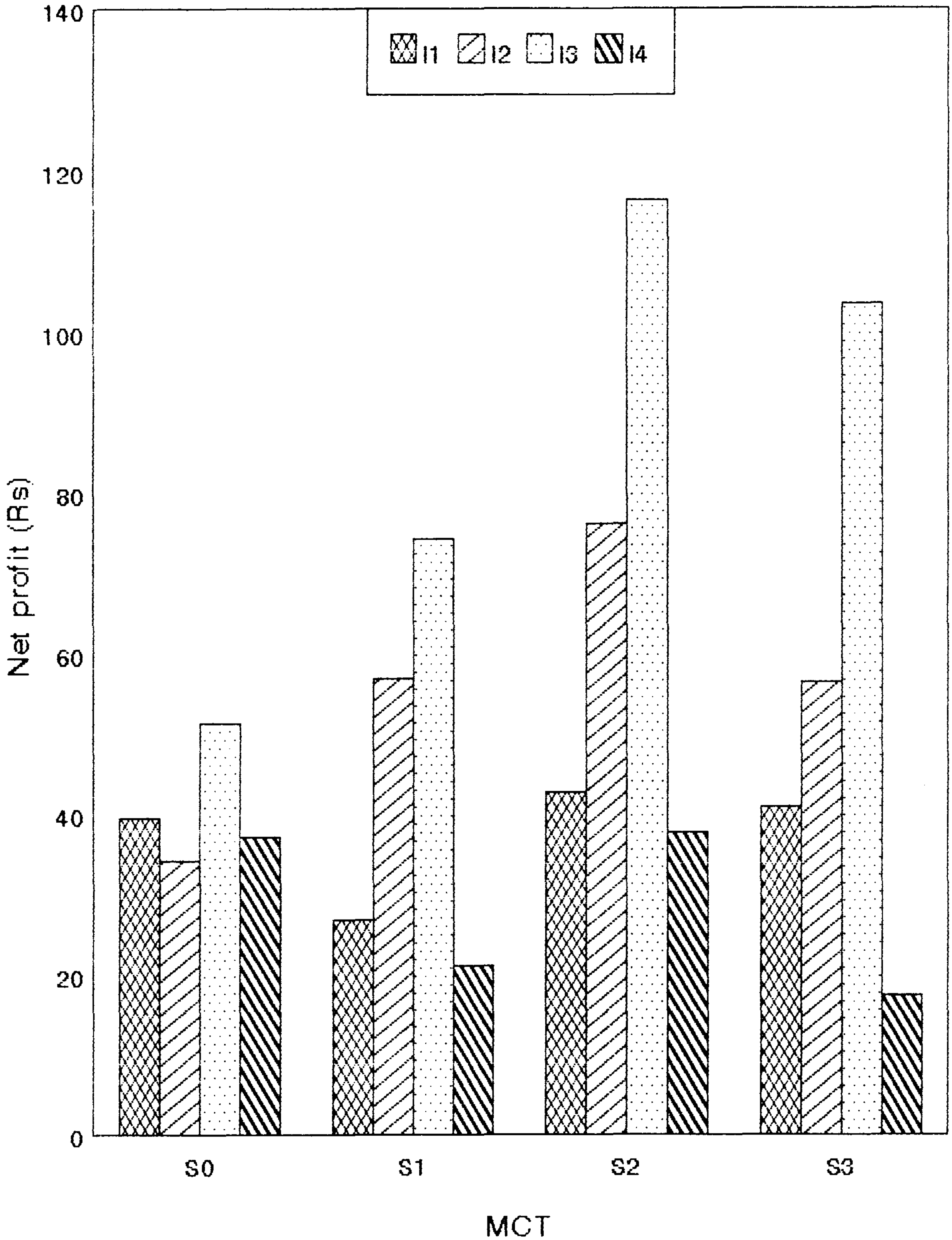


Fig.18 Interaction effect of MCT and levels of irrigation on net profit (Rs)

Summary

SUMMARY

A field experiment was conducted in the summer rice fallows during January to May 1996 at Agricultural Research Station, Mannuthy, Thrissur to study the "irrigation management related to sub-surface moisture conservation techniques in oriental pickling melon (*Cucumis melo* var. canomon (L.) makino)". The soil of the experimental field was sandy clay loam, bulk density 1.34 g cm^{-3}, acidic in reaction, medium in organic carbon and available nitrogen, low in available potassium and high in available phosphorus. The weather during the cropping period was almost normal with an average daily pan evaporation of 6.4 mm day^{-1} and 220.2 mm rainfall during the last stage of the crop.

The experiment was laid out in randomised block design with three replications. There were sixteen treatments consisting of combinations of four moisture conservation techniques (control, incorporation of sawdust, paddy waste and coir pith @ 1/3rd pit volume) and four levels of irrigation (IW/CPE ratio of 0.4, 0.8, 1.2 and at critical stages). Method of irrigation adopted was pot watering. The oriental pickling melon variety Mudikkode local was used for this study.

The salient results obtained during the course of investigation are summarised below:

1. Length of vine increased by the addition of moisture conservation materials and significantly higher vine length was observed by coir pith incorporation followed by paddy waste incorporation. Similarly the vine length increased with increase in the frequency of irrigation and significantly the highest value was obtained with irrigation undertaken at IW/CPE ratio of 1.2.

2. Addition of moisture conservation materials increased the number of leaves per vine. Significantly more number of leaves were produced by coir pith incorporation followed by paddy waste incorporation. The plants irrigated at IW/CPE ratio 1.2 produced significantly more number of leaves per vine than that irrigated under other irrigation treatments.

3. The plants incorporated with coir pith produced significantly maximum leaf area followed by paddy waste incorporation. The highest leaf area was recorded by the frequently irrigation treatment (IW/CPE ratio 1.2) and its effect was significantly superior to other intervals of irrigation.

4. The leaf area index was also significantly increased by the incorporation of coir pith and this effect was at par with that of paddy waste incorporation. There has been a substantial increase in leaf area index with increase in the frequency of irrigation and frequently irrigated plants (IW/CPE ratio 1.2) recorded significantly the highest LAI.

5. The interaction effect indicates that the significant effect of moisture conservation materials on these growth attributes were pronounced only at closer intervals of irrigation (IW/CPE ratio 1.2) and the effects were more pronounced after 45 DAS. The significant interaction effects were observed when coir pith or paddy waste were incorporated and irrigation undertaken at IW/CPE ratio 1.2.

6. Moisture conservation with paddy waste produced the highest drymatter followed by coir pith. The plants received frequent irrigations (IW/CPE ratio 1.2) produced significantly more dry matter.

7. Mean length of fruits was not significantly influenced by the moisture conservation techniques. However the mean length of fruits was significantly higher in plants which received frequent irrigations (IW/CPE ratio 1.2).

8. The girth of fruits were significantly higher in paddy waste and coir pith incorporated plots. Similarly the plants irrigated at IW/CPE ratio 1.2 produced significantly the highest girth of fruit.

9. Moisture conservation techniques had no significant influence on fruit weight. But irrigation schedules had a significant effect on fruit weight. The highest fruit weight was recorded by the plants received irrigation at IW/CPE ratio 1.2.

10. The maximum number of fruits per plant (3.791) was produced by paddy waste incorporation and was at par with that of coir pith incorporation (3.285). The plants received the incorporation of paddy waste and coir pith produced 30 and 13 per cent more number of fruits respectively over control. Increasing frequencies of irrigation had an increasing trend in the number of fruits produced per plant and plants irrigated at IW/CPE ratio 1.2 produced significantly the highest number of fruits (4.617) per plant compared to that under other irrigation treatments.

11. The highest fruit yield per ha and per plant was produced by paddy waste incorporation and was at par with that of coir pith incorporation. The plants received the incorporation of paddy waste and coir pith produced 27 and 17 per cent more yield respectively compared to control. Frequently irrigated plants (IW/CPE ratio 1.2) produced significantly the highest yield. Irrigation at IW/CPE ratio 1.2 and 0.8 produced 114 and 56 per cent more yield respectively over irrigation at critical stages. The moisture conservation techniques were significantly effective only at closer irrigation frequency. The best treatment combination was incorporation of paddy waste with irrigation at IW/CPE ratio 1.2.

12. Incorporation of coir pith, paddy waste and sawdust increased the soil moisture content 14.7, 10.8 and 6.8 per cent respectively over control at after irrigation and for before irrigation these figures were 8.2, 7.8 and 7.3 per cent respectively.

13. Incorporation of moisture conservation materials increased the consumptive use compared to control. The increase in consumptive use by paddy waste, sawdust and coir pith were 2.7, 4.9 and 7.3 per cent respectively over control. Consumptive use increased with increase in the level of irrigation and the plants which received irrigation at IW/CPE ratio 1.2 recorded the highest consumptive use.

14. The peak consumptive use was reached between 36-50 DAS for irrigation at IW/CPE ratio 1.2, 0.8 and 0.4 and it was 20-35 DAS for irrigation at critical stages.

15. The crop coefficient value was higher for incorporation of coir pith. Increasing levels of irrigation increased the crop coefficient and the highest was recorded by irrigation at IW/CPE ratio 1.2.

16. Maximum crop coefficient was observed between 51-65 DAS in the case of irrigation at IW/CPE ratio 1.2 and 0.8. For others it was between 36-50 DAS.

17. Incorporation of paddy waste, coir pith and sawdust increased the field WUE to the tune of 19.9, 9.9 and 5.3 per cent respectively over control and for crop WUE these increases were 17.2, 1.9 and 1.5 respectively. The plants irrigated at IW/CPE ratio 1.2 recorded the highest field WUE and crop WUE.

18. The soil moisture depletion was higher from the top 15 cm of the soil layer. There was relatively more depletion from the lower depths in drier regimes. A slight increase in the moisture depletion was observed from the deeper layer when moisture conservation materials were incorporated.

19. Nitrogen, phosphorus and potassium content of leaves were significantly higher in plants which received incorporation of paddy waste. Higher levels of irrigation also markedly increased the N and K content of leaves upto 45 DAS and P content upto 75 DAS.

20. Economic analysis indicated that incorporation of paddy waste, coir pith and sawdust could increase the net profit. The over all increase in net profit was Rs.27,697.99 (68%) for paddy waste, Rs.13,958.99 (34%) for coir pith and Rs.4,254.74 (10%) for sawdust over control. Similarly the over all increase in the net return per rupee invested was 21.6, 7.8 and 0.01 per cent over control respectively.

The highest net profit (Rs.86,434.96) and net return per rupee invested (Rs.1.85) were recorded by the frequent irrigation scheduled at IW/CPE ratio 1.2 (4-6 days interval). Among the treatment combinations, the best combination was incorporation of paddy waste with irrigation at IW/CPE ratio 1.2 followed by incorporation of coir pith at the same irrigation frequency. Incorporation of moisture conservation materials could give more net profit with lesser number of irrigations (interval 6-8 days - 8 irrigations) when the crop was irrigated at IW/CPE ratio of 0.8 than irrigation at the closer intervals of IW/CPE ratio 1.2 (interval 4-6 days - 13 irrigations) without any moisture conservation materials. Incorporation of paddy waste at irrigation at IW/CPE ratio 0.8 has given 48 per cent more net profit and 28 per cent more net return per rupee invested over irrigation at IW/CPE ratio 1.2 without any moisture conservation materials.

It may be concluded from the study that oriental pickling melon grown in summer rice fallows requires frequent irrigations for maximum yield. Scheduling of irrigation with 33 mm water at the IW/CPE ratio 1.2 (4-6 days intervals) was the most economic water management practice. Incorporation of paddy waste and coir pith @ 1/3rd of pit volume greatly increase the yield and net return.

The best net profit and net return per rupee invested were given by the combination of paddy waste and irrigation at IW/CPE ratio 1.2. But in places where water is scarce as in the case of irrigation at IW/CPE ratio 0.8 (once in 6-8 days), incorporation of both paddy waste and coir pith acted highly remunerative.

Incorporation of moisture conservation materials retained more moisture in the soil and thereby improved the growth and yield of oriental pickling melon.

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*Originals not seen

Appendices

APPENDIX I

Analysis of variance for length of vine

Sources	Degrees of freedom	Mean squares		
		45th DAS	75th DAS	Harvest
Replication	2	111.005	408.431	607.680
S	3	303.144*	759.991**	407.444*
I	3	6897.557**	9087.953**	13229.667**
S x I	9	270.400*	49.461	187.591
Error	30	99.505	125.507	115.577

APPENDIX II

Analysis of variance for number of leaves per vine

Sources	Degrees of freedom	Mean squares		
		45th DAS	75th DAS	Harvest
Replication	2	1.19	3.46	11.55
S	3	4.52*	33.03**	9.38
I	3	66.93**	119.12**	11.42
S x I	9	1.57	10.56**	11.13*
Error	30	1.48	2.96	4.18

* Significant at 5% level ** Significant at 1% level

APPENDIX III

Analysis of variance for leaf area

Sources	Degrees of freedom	Mean squares		
		45th DAS	75th DAS	Harvest
Replication	2	5.52	338.23	247.45
S	3	29.07	638.81**	237.25*
I	3	1572.56**	2557.66**	494.47**
S x I	9	71.85	191.96**	511.55**
Error	30	73.78	35.77	83.21

APPENDIX IV

Analysis of variance for leaf area index

Sources	Degrees of freedom	Mean squares		
		45th DAS	75th DAS	Harvest
Replication	2	0.018	0.004	0.009
S	3	0.047*	0.083**	0.063**
I	3	0.560**	0.791**	0.005
S x I	9	0.03*	0.038**	0.024**
Error	30	0.012	0.011	0.006

* Significant at 5% level ** Significant at 1% level

APPENDIX V

Analysis of variance for yield attributes

Sources	Degrees of freedom	Mean squares			
		Length of fruit	Girth of fruit	Weight of fruit	Number of fruits per plant
Replication	2	0.316	0.601	0.016	0.740
S	3	2.929	6.301*	0.0002	1.601*
I	3	108.042**	69.371**	0.161**	10.419**
S x I	9	3.247	1.164	0.004	0.850
Error	30	1.964	1.708	0.003	0.404

* Significant at 5% level ** Significant at 1% level

APPENDIX VI

Analysis of variance for drymatter production and yield

Sources	Degrees of freedom	Mean squares		
		Drymatter production	Yield t ha^{-1}	Yield kg plant^{-1}
Replication	2	455.86	1.51	0.118
S	3	79.08	121.29**	0.778**
I	3	3780.65**	1522.64**	9.519**
S x I	9	66.23	45.60*	0.326*
Error	30	62.14	20.24	0.120

APPENDIX VII

Analysis of variance for nitrogen content of leaves

Sources	Degrees of freedom	Mean squares		
		45th DAS	75th DAS	Harvest
Replication	2	2.052	0.207	0.780
S	3	0.987**	0.532*	0.571*
I	3	1.428**	0.483*	1.140**
S x I	9	0.184	0.188	0.205
Error	30	0.177	0.162	0.182

* Significant at 5% level   ** Significant at 1% level

APPENDIX VIII

Analysis of variance for phosphorus content of leaves

Sources	Degrees of freedom	Mean squares		
		45th DAS	75th DAS	Harvest
Replication	2	0.022	0.002	0.001
S	3	0.001	0.001	0.001*
I	3	0.010**	0.002**	0.002**
S x I	9	0.001**	0.000	0.000
Error	30	0.001	0.000	0.000

APPENDIX IX

Analysis of variance for potassium content of leaves

Sources	Degrees of freedom	Mean squares		
		45th DAS	75th DAS	Harvest
Replication	2	0.021	0.081	0.043
S	3	1.095**	0.801**	0.319**
I	3	0.354**	0.642**	0.371**
S x I	9	0.132**	0.58**	0.019
Error	30	0.024	0.017	0.009

* Significant at 5% level   ** Significant at 1% level

IRRIGATION MANAGEMENT RELATED TO SUB-SURFACE MOISTURE CONSERVATION TECHNIQUES IN ORIENTAL PICKLING MELON

(Cucumis melo Var. Canomon (L.) *makino)*

By

R. VEERAPUTHIRAN

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree

Master of Science in Agriculture

Faculty of Agriculture

KERALA AGRICULTURAL UNIVERSITY

Department of Agronomy

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680654

KERALA, INDIA.

1996

ABSTRACT

An experiment was conducted in the summer rice fallows during 1996 at Agricultural Research Station, Mannuthy to study the irrigation management related to sub-surface moisture conservation techniques in oriental pickling melon. The experiment was laid out in randomised block design with three replications. The treatments consisted of combinations of four moisture conservation techniques (control, incorporation of sawdust, paddy waste and coir pith @ 1/3rd pit volume) and four levels of irrigation (IW/CPE ratio of 0.4, 0.8, 1.2 and at critical stages).

The study revealed that incorporation of moisture conservation materials increased the growth attributes like length of vine, number of leaves per vine, leaf area, leaf area index and dry matter production and yield attributes like length, girth, weight of fruits and number of fruits per plant. Among the moisture conservation materials paddy waste was found to be the best for incorporation followed by coir pith. The increase in the number of fruits per plant and yield per hectare over control was 30 and 27 per cent respectively by paddy waste incorporation, whereas for coir pith incorporation this increase was 13 and 17 per cent respectively.

Oriental pickling melon responded very well to irrigation. Biometric characters (length of vine, number of leaves per vine, leaf area, leaf area index,

drymatter production) and yield attributing characters (length, girth, weight of fruits and number of fruits per plant) were favourably influenced by frequent irrigations. The fruit yield increased with increase in frequency of irrigation and was maximum at IW/CPE ratio of 1.2.

The interaction effect was found to be significant on growth attributes and yield. It also indicated that the significant effects of moisture conservation materials were pronounced only at closer intervals or irrigation (IW/CPE 0.8 and 1.2) and were more pronounced at the actively growing stages ie. after 45 DAS.

Incorporation of moisture conservation materials increased the soil moisture content, consumptive use and water use efficiency. Total consumptive use increased with increase in irrigation frequency. Drier regimes showed a tendency to extract more moisture from deeper layers. The peak consumptive use and crop coefficient were reached maximum between 36-50 and 51-65 DAS respectively. Soil moisture extraction pattern showed that oriental pickling melon on an average depleted 50.7 per cent of the total water use from the top 15 cm layer. Field and crop water use efficiency were higher in less frequently irrigated treatments.

N, P and K content of the leaves were enhanced by frequent irrigation and incorporation of paddy waste.

Incorporation of paddy waste and coir pith increased the net profit to the tune of 68 and 34 per cent respectively over control.

Scheduling irrigation at IW/CPE ratio 1.2 was economically better than other irrigation treatments. The combination of moisture conservation techniques and levels of irrigation further increased the net profit and net return per rupee invested over the individual effects. Best net profit was obtained when the crop was irrigated at the IW/CPE ratio of 1.2 with the incorporation of paddy waste. If water is scarce for irrigation, incorporation of paddy waste or coir pith and irrigation at IW/CPE ratio 0.8 was highly beneficial than crops at the closer interval of IW/CPE ratio 1.2 without any moisture conservation material.