EVALUATION OF LOW COST TECHNIQUES IN POTTED VEGETABLES GROWN IN ROOF GARDENS

By

ROSHNI, G.C., B.Sc. (Ag.)

THESIS
SUMBITTED IN PARTIAL FULFILMENT
THE REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

Dedicated

to my

beloved parents

DECLARATION

I hereby declare that this thesis entitled "Evaluation of low cost techniques in potted vegetables grown in roof gardens", is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

College of Agriculture,
Vellayani,
10-12-1993.

ROSHNI. G.C.

CERTIFICATE

Certified that this thesis entitled "Evaluation of low cost techniques in potted vegetables grown in roof gardens", is a record of research work done independently by Smt. ROSHNI, G.C., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

College of Agriculture,
Vellayani,
10-12-1993

Dr. V.L. GEETHAKUMARI
Chairman,
Advisory Committee

APPROVED BY:

CHAIRMAN:

Dr. (Mrs.) V. L. GEETHAKUMARI

MEMBERS:

1. **Prof. P. CHANDRASEKHARAN** 27/1/94

2. **Dr. V. T. ALEXANDER**

3. **Dr. (Mrs.) S. PUSHKALA**

EXTERNAL EXAMINER:

ACKNOWLEDGEMENTS

The author wishes to express her deep sense of gratitude and sincere thanks to

Dr. (Mrs.) V.L. Geethakumari, Associate Professor of Agronomy, College of Agriculture, Vellayani and Chairman of Advisory Committee for her valuable guidance, critical suggestions and constant encouragement throughout the course of this study and in the preparation of the thesis.

Prof. P. Chandrasekharan, Professor and Head of Agronomy, College of Agriculture, Vellayani for his sustained interest in the conduct of this work.

Dr. V.T. Alexander, Professor of Agronomy, College of Agriculture, Vellayani for his encouragement, helpful suggestions and advice rendered during the course of the study.

Dr. (Mrs.) Pushkala, Associate Professor of Soil Science and Agricultural Chemistry for her valuable suggestions, critical scrutiny of the manuscript and for the keen interest shown throughout the study.

Dr. (Mrs.) P. Saraswathy, Head of Agricultural Statistics, Collge of Agriculture, Vellayani for valuable guidance in the statistical analysis of the data. Sri. C.E. Ajithkumar, Junior Programmer, Computer Centre, College of Agriculture, Vellayani for analysing the experimental data.

Sri. P. Raghunath, Associate Professor of Entomology, College of Agriculture, Vellayani for the guidance rendered at various stages of the study.

Sudha, Resmi, Rashmi, Rajasree, Sreelatha, Santhi, Suneetha, Leena, Jacob John, Sanjeev, Louis Joseph and all my colleagues for their sincere co-operation and assistance rendered during the course of this investigation.

to my beloved parents for their sincere help and inspiration given to me for the completion of the thesis.

to my husband for his inspiration in the timely completion of the thesis.

M/s. Athira Computers, Kesavadasapuram for neatly computing the thesis.

the Kerala Agricultural University for the award of fellowship for the Post Graduate Programme.

Above all, to God Almighty, for blessing me for the successful completion of the thesis.

ani,

10 -12-1993.

Roshni. G.C.

ROSHNI, G.C.

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS

mm	-	millimetre
cm	-	centimetre
mg	-	milligram
g	-	gram
kg	-	kilogram
l	-	litres
ha	-	hectare
N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
IW	-	Irrigation water
CPE	-	Cumulative pan evaporation
ET	-	Evapotranspiration
DAT	-	Days after transplanting
Fig	-	Figure
LAI	-	Leaf Area Index
DMP	-	Dry matter produciton
FC	-	Field Capacity
WUE	-	Water Use Efficiency
NAR	-	Net Assimilation Rate
RGR	-	Relative Growth Rate
K Pa	-	Kilo rascal
HI	-	Harvest Index
ASM	-	Available Soil Moisture

INTRODUCTION

1. INTRODUCTION

Our national food production programme, like any other developing country, has the twin objectives of fighting hunger and inadequate nutrition. While a fair degree of food self sufficiency at current levels of consumption capacity has been achieved, we are yet to stabilize a national nutrition security system. Vegetables being the cheap source of vitamins and minerals do a lot to combat with the problem of undernourishment and malnutrition. As per the allowance recommendations a minimum vegetable supply of 284 g day^{-1} $adult^{-1}$ is required. Hardly half of it is provided at present in our country. The annual requirement of vegetables at present is 52 m. tonnes of which only 16 m. tonnes is produced from an area of 1.3 m. ha. The low per capita consumption is mainly due to the low production level of vegetables. Hence vegetable production needs to be augmented on a large scale.

With the inexorable process of urbanisation and consequent pressure on land, it is becoming increasingly difficult to own and cultivate conventional type of vegetable gardens of even a few cents of land. Where little space is available vegetables can be profitably raised in pots.

Among the basic factors of agricultural productivity, adequate and timely provision of irrigation water is crucial. Water being a scarce resource, efficient use of available water has become extremely important. In this context drip irrigation has an important role to play. Drip irrigation has been recognised by researchers as the best and most efficient method of irrigation. But its high cost of installation limits its popularity. Hence, this study is aimed at the feasibility of using an indigenous autoirrigator fabricated with low cost materials for irrigating potted vegetables efficiently and economically.

The role of organic spreaders for economising water use is investigated in many crops. But the feasibility of using coir pith, a waste product of coir industry, as the mulch material is not much studied. Jalsakhti, a polymer was found to have the ability to absorb water and release it slowly to the crop for a longer time. This property of this hydrophilic amendment is not much studied for potted vegetables.

In the light of the above, the present study embodying the following objectives was taken up.

1. To assess the water requirement of vegetables grown in pots.

2. To compare the efficiency of different techniques for economising water use in vegetables.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

This investigation entitled "Evaluation of low cost techniques in potted vegetables grown in roof garden" was taken up with the objective of assessing the water requirement of vegetables grown in pots in terrace garden and to compare the efficiency of different techniques for economising water use in vegetables. Water being a scarce input of agriculture particularly during summer season, the need for increasing the efficiency of different methods for economising water use in summer vegetables is a long felt need of our vegetable growers. Since the information on the effect of irrigation and moisture conservation methods on chilli grown in pots are meagre, results of similar works on other related crops are reviewed. Only very scarce data on response of potted vegetables to irrigation are available. Hence response of vegetables to irrigation under field conditions is also reviewed. The present state of knowledge on these aspects with special reference to chilli are grouped under the following headings.

2.1. Effects of methods of irrigation on growth, yield and nutrient uptake of vegetables

2.2. Effects of levels of irrigation on growth, yield and nutrient uptake of vegetables

2.3. Effects of soil moisture conservation methods on growth, yield and nutrient uptake of vegetables

2.4. Water use efficiency and water requirement of vegetables

2.1. Effects of methods of irrigation on growth, yield and nutrient uptake of vegetables

Differences in the response of vegetable crops to various methods of irrigation were observed. The effects of methods of irrigation on various growth and yield attributes reported by various workers are reviewedhere under.

Shmucli and Goldberg (1971) observed rapid vegetative growth in muskmelon under drip irrigation in comparison with sprinkler and furrow irrigation. Early maturity and shortening of the growth phase without causing reduction in yield was observed in drip irrigated plants (Goldberg et al. 1976). Padmakumari and Sivanappan (1978) reported higher number of branches under drip irrigation in brinjal. Bar - Yosef et al. (1980) opined greater vegetative and root weight with high water application in trickle irrigated tomatoes. Vasanthakumar (1984) reported that height, number of branches plant^{-1}, days to 50 per cent flowering and setting per cent did not differ significantly in tomato for drip and furrow methods of irrigation. Bhella

(1988) observed that plant height increased in response to trickle irrigation. Sanders et al. (1989) reported increased plant height in drip irrigated tomatoes.

Shmucli and Goldberg (1971) attributed higher yields in muskmelon under drip irrigation to greater number of fruits $plant^{-1}$ which reached marketable size and in part to greater number of large sized fruits. Bernstein and Francois (1973) indicated fruit size increased with drip irrigation in bell pepper. Bar - Yosef et al. (1980) noted earlier fruit production in drip irrigated tomatoes. Hanna et al. (1985) reported drip irrigation increased fruit set and fruit size in tomatoes. The amount of fruits that matured early also increased.

Shmucli and Goldberg (1971) observed higher yields of muskmelon under drip irrigation compared to furrow and sprinkler irrigation. Bernstein and Francois (1973) indicated that in bell pepper daily drip irrigated plants, out yielded the furrow and sprinkler irrigated plants by 50 per cent. Halevy et al. (1973) opined that tomatoes, green pepper, cucumber, muskmelon and other melon varieties gave striking response to drip irrigation in terms of higher yields compared to other surface methods at equal or low volume of water. Borelli and Zerbi (1977) reported that drip irrigation increased total and marketable yields of sweet pepper and egg plant more than furrow irrigation. Padmakumari and Sivanappan (1978) observed higher yields of brinjal under drip irrigation using 30 per cent of the total water requirement of other surface methods. Sivanappan et al. (1978) reported that yield of chilli was significantly more in drip irrigation compared to conventional surface methods with a water saving of 62 per cent. Singh and Singh (1978) suggested that drip irrigation increased yield of long gourd by 48 to 49 per cent, round gourd by 21 to 38 per cent and water melon by 10 to 22 per cent compared to furrow and sprinkler irrigation. Sivanappan (1979) in a trial on chilli, brinjal, bhindi and tomatoes observed 10 to 40 per cent increased yield in drip irrigated crops compared to surface irrigation. Elmstorm et al. (1982) reported early yields of water melon in deep pine sandy soils of Lusberg under drip irrigation compared to sprinkler irrigation. Lin et al. (1983) noted that drip irrigation in tomatoes with moisture levels maintained above 25, 50, 65 and 80 per cent of available water produced 20 to 40 per cent more marketable yield than monthly furrow irrigation and 80 per cent more than unirrigated control. Vasanthakumar (1984) reported in tomatoes that fruit yield plant^{-1} was higher in drip irrigation than conventional surface irrigation systems. Younis (1986) observed early maturity, highest yield, highest net profit and least water consumption in tomatoes by drip and crop quality with drip irrigation compared to conventional methods. Gutal _et al_. (1990) reported in Capsicum that drip irrigation to wet 50 per cent of cropped area gave highest yield than when 100 per cent cropped area was wetted. Wivutvongvana _et al_. (1990) opined that marketable yields of sweet pepper were the same for furrow and drip irrigation.

Bernstein and Francois (1973) found that under drip irrigation more than half of the pepper roots were located within a depth of 5-15 cm. Vasanthakumar (1984) reported that root dry matter in drip irrigated plants was lower as compared to surface irrigation methods Randall and Locascio (1988) on studying the root growth of drip irrigated cucumber and tomato reported that water application rates did not influence root density distributions and high water quantity (0.5 times pan evaporation) resulted in high root density. In drip irrigation at different irrigation levels no significant difference with respect to vertical and horizontal roots was reported by Saffadi and Battikhi (1988).

Vertical roots reached maximum average of 27 cm. Sanders et al. (1989) reasoned increased yield in drip irrigated tomatoes as response to increased rooting due to higher soil moisture at the higher irrigation rates.

Bar - Yosef et al. (1980) noted in trickle irrigated tomatoes that application of 1.43 l plant^{-1} day^{-1} resulted in higher nitrogen and phosphorus uptake when compared to 0.73 l plant^{-1} day^{-1}. Kafkafi and Bar-Yosef (1980) had observed that drip irrigation of 642 mm. water resulted in higher nitrogen and phosphorus concentration compared to 404 mm in tomatoes. Bhella (1988) had reported that nutrient loss by leaching was reduced under drip irrigation.

Literature reviewed here shows that most of the vegetable crops like chilli, tomato, brinjal, bhindi and cucurbits performed better under drip irrigation compared to conventional methods of irrigation like furrow irrigation. Yield of almost all these crops increased by about 25 to 30 per cent by drip irrigation. This better yield was resulted from better expression of various growth and yield attributes. It is also observed that uptake of nutrients by vegetable crops was better under drip irrigation.

2.2. Effects of levels of irrigation on growth, yield and nutrient uptake of vegetables

Differences in response of crops to varying soil moisture were noted. Effect of different levels of irrigation on growth, yield and nutrient uptake of vegetables are reviewed here.

Shmueli and Goldberg (1971) reported linear response in plant growth with increase in the rate of water application. Tamaki and Naka (1971) opined that high soil moisture content (85 per cent field capacity) increased the number of branches, stem length, leaf number and dry weight of various aerial parts at later stages of growth in broad beans. Goldberg et al. (1976) reported that longer the soil moisture is maintained at field capacity the more vigorous is plant growth and greater the yield. Beese et al. (1982) in their study on chilli under drip irrigation found linear response to water application rates at 0.8, 1.0, 1.2 and 1.4 times of the control (applied at 25 cbr) in leaf area and DMP resulting in higher yields at higher regimes. George Thomas (1984) found that in bittergourd biometric characters like length of vine, LAI and DMP were favourably influenced by frequent irrigation. Wankhade and Morey (1984) reported in chilli a significant increase in leaf area and plant height due to higher levels of irrigation. Palled et al. (1985)

observed no significant difference in plant height in chilli irrigated at 25, 50 and 75 per cent depletion of ASM. Dirks and Tan (1988) found that chilli had a shallower root system with low root intensity below 50 cm. Chilli showed relatively little response to irrigation in terms of increased root distributions. Zhong and Kato (1988) in an experiment to study the effect of soil moisture (15 to 20, 23 to 28 and 30 to 35 per cent) on growth and yield of solanaceous fruits in pot reported that in all species dry weight and proportion of dry weight in stem increased with increasing soil moisture. The transpiration rate and apparent NAR decreased as soil moisture increased, but the difference between intermediate and high levels of soil moisture was not significant. Jagmail Singh et al. (1990) reported that a decrease in soil moisture content resulted in decrease in leaf area. Raja and Bishnoi (1990) suggested that root volume and dry weight increased while tap root and lateral root lengths decreased with increased irrigation frequency. Prabhakar and Srinivas (1990) has observed in bhindi an increase in plant height, LAI and DMP upon irrigation to meet 100 per cent compared to 50 per cent and 25 per cent pan evaporation. Length and girth of chilli fruits were favourably influenced under IW/CPE ratio of 0.6 with a little difference between medium and higher levels. (Wankhade and Morey 1984). Palled et al. (1985) reported in chilli that irrigation at 50 and 75 per cent depletion recorded significantly more mature fruits plant^{-1}. Gupta (1989) in a study on response of tomato to irrigation reported the moisture had significant effect on fruit size. Fruit size was the highest at 80 per cent ASM. Pulekar et al. (1990) in an experiment with five irrigation regimes on chilli (12, 24, 36, 48 or 60mm) reported the highest number of fruits plant^{-1}, weight of fresh fruits plant $^{-1}$ and yield when irrigation reached 36 mm. Kwapata (1990) observed in tomatoes that with increasing irrigation frequency, number of fruits plant $^{-1}$ and fruit size increased.

The highest yield in peppers was obtained at 80 to 90 per cent field capacity (Kartalov and Dimitrov, 1970). Bucks et al. (1974) reported that application of irrigation water less than optimum consumptive use reduced cabbage yield under drip irrigation. Bower et al. (1975) observed 17 per cent higher yields of tomato when soil moisture tension was maintained below 0.2 bar compared to 0.4 and 0.6 bar. Sadykov and Mikhael (1982) from a two year trial with capsicum reported that plants irrigated at 70 to 75 per cent field capacity gave higher yield. More frequent irrigations slightly decreased yield. Smittle and Threadgill (1982) compared two irrigation levels in a field trial with cucumber. They observed that highest marketable fruit yield was resulted from irrigation at 0.3 bar soil water tension. Lin et al. (1983) noted that drip irrigation in tomatoes with moisture levels maintained above 25, 60, 65 and 80 per cent of available water produced 20 to 40 per cent more marketable yield than monthly furrow irrigation and 80 per cent more than unirrigated control. Jayakrishnakumar (1986) reported that the highest yield of bhindi was obtained by irrigation at 85 per cent field capacity. Ferreyra et al. (1987) observed that in capsicum yield was the highest with 0.7 times pan evaporation. Narayana Rao and Kondap (1988) reported mean maximum green pod yield in chilli at 50 per cent ASM. Gupta (1989) in a study on response of tomato to irrigation reported the highest yield at 80 per cent ASM. Prabhakar and Srinivas (1991) has observed in bhindi an increase in yield on irrigation to meet 100 per cent pan evaporation compared to 50 per cent and 25 per cent pan evaporation.

Trouse (1971) reported that plants are unable to utilise plant nutrients in dry soil. According to Sharma and Prasad (1973) nitrogen uptake by bhindi was higher with irrigation at soil moisture tension of 0 to 0.5 atm. as compared to irrigation at 0 to 0.25 and 0 to 0.75 atm respectively. They reported that irrigation had failed to produce any significant effect on nitrogen content in plant parts. While studying the effects of irrigation at 60, 70 or 80 per cent of field capacity Gamayun (1980) observed a moisture regime of 80 per cent of field capacity to be ideal for the maximum uptake of nitrogen, phosphorus and potassium by tomato plants. George Thomas (1984) observed that levels of irrigation did not produce any significant influence on the content of nitrogen and phosphorus in plant parts of bitter gourd. Nitrogen, Phosphorus and Potassium uptake of crop was significantly increased by higher levels of irrigation. Karlen and Camp (1985) opined that irrigation significantly increased plant nitrogen and phosphorus concentration, but potassium concentration was not influenced by water management practices. Jayakrishnakumar (1986) reported maximum uptake of nitrogen, phosphorus and potassium in daily drip irrigated crops of bhindi. Ferreyra et al. (1987) observed that excessive water application (1.3 times pan evaporation) significantly reduced nitrogen, phosphorus and potassium absorption by capsicum plants. Hegde (1988) noted that high soil water potential either tended to decrease or failed to change the concentration of nitrogen, phosphorus and potassium in leaves and bulbs of onion plants, but the uptake of these nutrients generally increased due to higher DMP. In another experiment with bell pepper he reported that irrigation at 40 per cent ASM resulted in maximum nutrient uptake. Hegde and Srinivas (1990) reported that nitrogen concentration generally increased with decreased frequency of irrigation especially at -85 kPa. Concentration of phosphorus and potassium tended to decline with stress.

Suryanarayana *et al*. (1983) reported maximum chlorophyll content in chilli with irrigation at 6 days interval compared to 9 days and 12 days interval.

Results of works depicted here show that increase in soil water potential resulted in increase in various growth and yield attributes and most of the vegetable crops responded better at a soil water potential of about 70 to 90 per cent field capacity. In chilli maximum pod yield was obtained by maintaining soil moisture at 50 per cent ASM. Little response to irrigation was obtained in terms of increased root distribution. The tolerable limit of moisture depletion in chilli was found to be about 25 per cent of ASM. An increase in uptake of nutrients with increase in irrigation levels is seen in most of the vegetable crops. Increase in uptake was mainly due to increase in DMP.

2.3. Effects of soil moisture conservation methods on growth, yield and nutrient uptake of vegetables

Results of various works on effect of soil moisture conservation methods on growth, yield and nutrient uptake are reviewed.

Patil and Bansod (1972) observed significant increase in height, number of branches and leaves in tomato with mulching when compared to unmulched plots. Tumuhairwe and Gumbs (1982) reported that mean fresh weights and dry weights of cabbage in mulched plots was significantly higher than unmulched plots. Olasantan (1985) found that in tomato mulched plants grew taller and produce more number of branches. Balaswamy et al. (1986) reported that mulch treatment improved both vegetative and reproductive growth as compared to no mulch treatment. Carter and Johnson (1988) suggested significant increase in growth in brinjal with mulching when compared to unmulched plot. Earliness was also significantly influenced by mulching. Vanderwerken and Wilcox (1988) observed that mulching advanced flowering in bell pepper. Improved growth with respect to plant height and canopy spread was observed in mulched plots.

Patil and Bansod (1972) observed in tomato, increase in number of flower clusters by mulching. Olasantan (1985) reported that by mulching yield and yield components were significantly more in tomatoes. Fruit size was high in mulched plots. Kwapata (1990) reported increased fruit size with increasing mulch depth but the number of fruit plant^{-1} was not affected by changes in mulching depth. Negreiros et al. (1990) in an experiment to study the effect of mulching on capsicum with shredded leaves of Copernicia reported that mulched plants yielded more number of fruits than non mulched ones.

Isenberg and Odland (1950) reported in cucumber that mulching increased yield. White *et al*. (1959) reported higher yields of tomatoes when mulched with saw dust. Patil and Bansod (1972) observed significant increase in tomato yield by mulching. Srivastava *et al*. (1981) in their trial with various organic mulches in tomato reported that weed population was effectively checked and marketable yield was increased by hard mulches like orchard leaves, sugarcane leaves etc. Hankin *et al*. (1982) reported the greatest yield in vegetables when mulched with plastic. Olasantan (1985) opined increased yield by mulching in tomato. Subbha Reddy (1986) reported that increased yield under mulching was due to improved water intake, better aeration, increased water retention and uptake from soil. Straw mulching in tomato and okra increased yields by 100 and 400 per cent respectively (Gupta and Gupta, 1987). Suh Hyo-Duk (1990) had observed 42 per cent increase in red pepper yields by mulching.

Zheng and Wang (1986) reported increased absorption of nitrogen and potassium by mulching in cucumbers. Jayasree (1987) reported that soil temperature was lowered by 1.8 to $2^{0}C$ by mulching. Soil nitrogen and organic carbon contents were higher and uptake of nutrients like nitrogen, phosphorus and potassium were higher in mulched plots. Gupta and Gupta (1987) observed increased nitrogen availability with mulching. Loganathan (1990) reported increased availability of nitrogen, phosphorus and potassium on application of coir pith.

Tumuhairwe and Gumbs (1982) opined that mulching increased available water by 40 per cent with irrigation and 20 per cent without irrigation. Rivera and Goyal (1986) reported that soil moisture retention was better in mulched than in unmulched plots. Subba Reddy (1986) reported increased water intake, aeration, water retention and uptake from soil with mulching.

Flannery and Busscher (1982) in a trial with Permasorb, a water sorbing polymer reported that dry matter yield was not significantly affected by treatments. Roots were found to be thicker and numerous with increasing amount of Permasorb. Wallace et al. (1984) reported that addition of hydrophilic polymer improved root and shoot growth. Arvind Kumar et al. (1991) observed higher number of branches plant^{-1} and 1000 seed weight in Jalasakthi treated plants when compared to control. Woodhouse and Johnson (1991) reported that synthetic super absorbent starch co-polymer and polyacrylamide co-polymer increased dry matter production in lettuce.

Bandhopadhyay and Ray (1988) reported that addition of Jalsakhti to soil increased available water content to the maximum.

From the research works reviewed it is seen that mulching significantly increased yields in vegetables. Application of water sorbing polymers had promoted the growth and yield contributing characters.

2.4. Water use efficiency and water requirement

Differences in WUE was observed under different methods and levels of irrigation and soil moisture conservation methods. Research work on this aspect are reviewed.

Hanson and Peterson (1974) reported that WUE was the highest in onion under drip compared to sprinkle and furrow irrigation. Adoption of drip irrigation in bhindi resulted on a saving of 84.7 per cent of water used in conventional furrow irrigation (Sivanappan et al. 1974) This was later supported by Padmakumari and Sivanappan (1978). Bryon et al. (1976) observed that drip irrigation required 50 to 60 per cent less water than overhead irrigation in tomatoes. Sivanappan (1979) in his trial with chilli, brinjal, tomato and bhindi observed that about one third to one fifth of water is sufficient for drip plot as compared to surface irrigation. Lin et al. (1983) noted higher WUE under lower regimes in drip irrigation as degree of stress created was relatively low and decrease in yield was to a lesser extent compared to reduction in water use. Ramesh (1986) noted higher WUE of 20.86 kg ha mm^{-1} with drip irrigation at 0.6 times pan evaporation compared to 15.64 kg ha mm^{-1} with furrow irrigation at the same level. Kaniszewski and Dysko (1988) in tomatoes noted that water use in drip system was about 35 per cent lower than that with hand watering by hose. Water consumption per kilogram of fruit was lowest in drip systems (22-26 l) and highest in hand watering (41 l). Chartzoulakis et al. (1990) on comparing drip, furrow and microtube irrigation systems in cucumbers reported highest WUE for drip and lowest for furrow. Gutal et al. (1990) reported in capsicum that under drip irrigation 63.4 per cent less water was used. Singh (1990) opined increase in WUE with drip irrigation in watermelons and gourds. Wivutvongvana et al. (1990) reported that WUE was high for drip irrigation in sweet peppers.

Selvaraj (1976) opined that more the quantity of water supplied more would be reduction in WUE. Pai and Hukeri (1979) while studying the water requirement of vegetables suggested 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. Hedge (1988 a) indicated that irrigating capsicum at soil matric potential of -65 k Pa gave in maximum WUE compared to irrigation at -25, -45 and -85 k Pa. Hedge (1988 b) reported maximum WUE in bell peppers at 40 per cent ASM. Subba Rao (1989) showed that in cucumber field water use efficiency was high in the less frequently irrigated treatments. Raja and Bishnoi (1990) opined that increased irrigation frequency decreased WUE.

Gupta (1975) reported that mulching remarkably increased WUE by 25 per cent over no mulch. Patel and Singh (1979) reported marked reduction in water use by 12.6 per cent with mulching. Balaswamy et al. (1984) observed that mulch treatment resulted in higher crop water use efficiency. Wallace et al. (1984) observed that application of hydrophilic polymer reduced frequency of irrigation and decreased the plant water stress. Woodhouse and Johnson (1991) found increase in WUE with addition of hydrophilic polymer.

Research works narrated here indicated that WUE of most of the vegetables crops was higher under drip irrigation compared to other surface irrigation methods. It was observed that about 35 to 60 per cent water can be saved by adopting drip method of irrigation. Increase in irrigation frequency decreased WUE. Maximum WUE in bell pepper was observed at 40 per cent ASM. Significant increase in WUE was observed by mulching and application of Jalsakhti.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation was conducted as pot culture at College of Agriculture, Vellayani to assess the water requirement of chilli grown in pots and to compare the efficiency of different techniques for economising water use in chilli. The details of the materials used and methods adopted in this experiment are given in this chapter.

3.1. Location

The experiment was conducted in the net house attached to the Department of Agronomy, College of Agriculture, Vellayani. This location is situated 85^{o}N latitude and 76.9^{o}E longitude at an altitude of 29 m above mean sea level.

3.2. Season

The experiment was conducted during the summer season of 1992 - 1993. The details of weather data collected from the meteorological observatory attached to the College of Agriculture, Vellayani are given in Appendix-I and Fig. 1. Weekly averages of temperature, evaporation and relative humidity during the cropping period are presented.

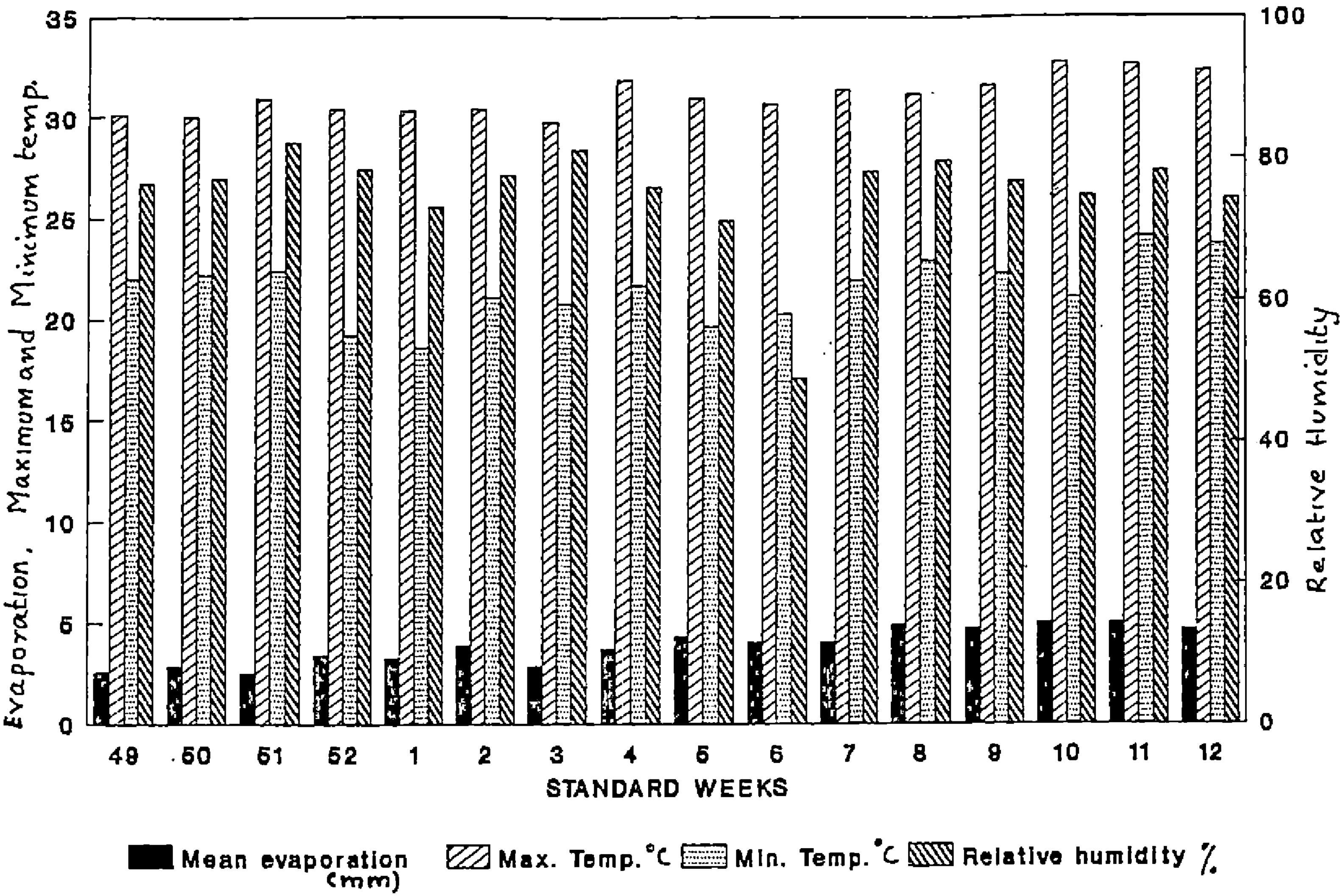

Fig. 1. Weather data during the crop period

Maximum temperature ranged between 32.64°C and 29.85°C and the minimum between 24.17°C and 18.62°C.

The relative humidity ranged from 71.23 to 84.92 per cent and pan evaporation values varied from 2.5 mm to 5 mm per day.

3.3. Materials

3.3.1. Potting mixture

The experiment was conducted with potting mixture prepared by mixing sand, red loam soil and farm yard manure in 1 : 1 : 1 proportion. The important physical and chemical properties of the potting mixture are given in Table 3.1.

Table 3.1. Important properties of the potting mixture

A. Physical properties

Particulars		Method used
Field capacity (%)	18.4	Pressure plate apparatus method (Richards, 1947)
Permanent wilting point (%)	7.4	Pressure plate apparatus method (Richards, 1947)
Bulk density (g cm^{-3})	1.3	Keen Raczkowski's method. (Karthikakutty Amma, 1977)

B. Chemical characteristics

Constituent	Content	Rating	Method used
Organic carbon (%)	0.2	Low	Walkley and Black rapid titration method (Jackson, 1973)
Available nitrogen (%)	0.0086	Low	Alkaline potassium permanganate method (Subbaiah and Asija, 1956)
Available P_2O_5 (%)	0.0025	High	Bray colorimetric method (Jackson, 1973)
Available K_2O (%)	0.0049	Low	Ammonium acetate method (Jackson, 1973)
pH	5.9	Acidic	1:2 soil solution ratio using pH meter (Jackson, 1973)

3.3.2. Cultivar

Chilli variety Jwalasakhi, a cross between local variety Vellanotchi and Pusa Jwala obtained from instructional farm, Vellayani was used for this study. This variety released from College of Agriculture, Vellayani have low pungent succulent fruits and is having a high yield potential of 19.6 t ha^{-1}.

3.3.3. Planting site

Earthern pots of 25 cm diameter and 30 cm height, filled with potting mixture at the rate of 8 kg pot^{-1} were used for raising the crop.

3.3.4. Mulch

Coirpith, a by-product of coir industry collected from Kovalam was used as mulch. Uniformly measured quantities of coir pith @ 20g pot^{-1} was applied in each pot to give a uniform thickness of 5 cm.

3.3.5. Hydrophilic amendment

Jalsakhti, a product of Indian Organic Chemicals Limited, Bombay which is capable of absorbing water hundreds of times of its weight of water and releasing water slowly for the use of plants was used for the study. It was applied @ 5 g pot^{-1}

3.3.6. Indigenous auto irrigator (modified drip system)

The holes of the garden pots were plugged with rubber corks provided with holes. Through the holes hospital drips were inserted. Water was stored in these pots and the flow was regulated @ 4 ml min^{-1} with the regulator attached to the hospital drip. These pots served as water source were placed at a level above plant height and plant were irrigated exploiting gravitational force. Pots were insulated from solar heating with thick coating of white paint on all exposed phases.

3.3.7. Pots for wick irrigation

Specially designed pots were used for wick irrigation. Water was stored at the bottom of the pot which was insulated. A hole was provided about 1/4 height from the base. A disc was placed above the hole to separate the potting mixture and water. A coir rope which served as wick inserted through the hole made at the centre of the disc supplied water to the crop by capillary action.

3.3.8. Manures and fertilizers

Cowdung was used for preparing the planting medium. The fertilizers used were Urea (45.8 % N) Superphosphate (16.1 % P_2O_5) and muriate of potash (59.5 % K_2O).

3.3.9. Source of irrigation water

Tap water with a pH of 5.9 was used for irrigation.

3.4. Methods

3.4.1. Design and treatments

The experiment was laid out in a factorial completely randomised design with 19 treatment combinations. Treatments consisted of three moisture regimes, two methods of irrigation, and three conservation methods and an absolute control (wick irrigation).

Treatments

A. Irrigation levels [I]

I_1 = Field capacity

I_2 = 80 per cent field capacity

I_3 = 60 per cent field capacity

B. Methods of irrigation [M]

M_1 = Indigenous auto irrigator (modified drip)

M_2 = Pot watering

C. Method of conservation [C]

C_o = Control

C_1 = Mulching with coir pith

C_2 = Hydrophilic amendment - Jalsakhti

D. Wick irrigation [W] = Absolute control

Treatment combinations - 18 + 1 = 19

1.	$I_1M_1C_0$	10.	$I_2M_1C_2$
2.	$I_1M_1C_1$	11.	$I_3M_1C_0$
3.	$I_1M_1C_2$	12.	$I_3M_1C_1$
4.	$I_2M_1C_0$	13.	$I_3M_1C_2$
5.	$I_1M_2C_0$	14.	$I_2M_2C_1$
6.	$I_1M_2C_1$	15.	$I_2M_2C_2$
7.	$I_1M_2C_2$	16.	$I_3M_2C_0$
8.	$I_2M_2C_0$	17.	$I_3M_2C_1$
9.	$I_2M_1C_1$	18.	$I_3M_2C_2$

Control Wick irrigation

Replications - 6

3.4.2. Layout

The pots were arranged in such a way that one pot served as the water source for four pots for the treatments that received irrigation through indigenous auto irrigator. (Plate 1).

3.4.3. Nursery

Seeds we

beds of size 1.2

PLATE I

to facilitate drainage of excess water. A basal dressing of powdered cattle manure at the rate of 1 kg m^{-2} was applied in nursery beds.

The seeds were sown on 13-11-1992. The seedlings were irrigated daily. Handweeding was done at weekly intervals. The seedlings were transplanted on 10-12-1992.

3.4.4. Transplanting

The seedlings were transplanted in earthern pots filled with potting mixture. Immediately after planting shade was provided for the seedlings.

3.4.5. Manures and Fertilizers

Farm yard manure analysing 0.4 per cent of N, 0.3 per cent P_2O_5 and 0.2 % K_2O was used for making potting mixture. Nitrogen, phosphorus and potash were applied to the pots in the form of urea, superphosphate and muriate of potash respectively. Uniform dose of nitrogen, phosphorus and potash at the rate of 75, 40 and 25 kg ha^{-1} respectively were applied to all pots. Fifty per cent nitrogen, full phosphorus and 50 per cent potash were applied as basal dose. The remaining 25 per cent nitrogen and 50 per cent potash were applied four weeks after transplanting and 25 per cent nitrogen one month thereafter.

3.4.6. Scheduling of irrigation

Irrigation was scheduled based on evaporation data. The evapotranspiration (ET) values were calculated by using the following relationship

$$ET = E_o \times \pi r^2 \times \text{crop factor } (0.8)$$

where r = radius of the pot in cm

E_o = evaporation in cm

Based on this, the quantity of water required for each irrigation was calculated.

3.4.7. Mulching and application of Jalsakhti

Mulching was done by spreading a 5 cm uniform thickness of coir pith over the soil surface.

Jalsakhti was applied in the soil in the root zone area prior to planting. Jalsakhti was mixed with soil at the rate of 5 g pot^{-1}.

3.4.8. Wick irrigation (Plate II and III)

Wick irrigation pots were prepared with coir rope wicks and earthern pots. Coir ropes of 1 inch thickness and 8 inch length were used as wicks. The lower half of the pots

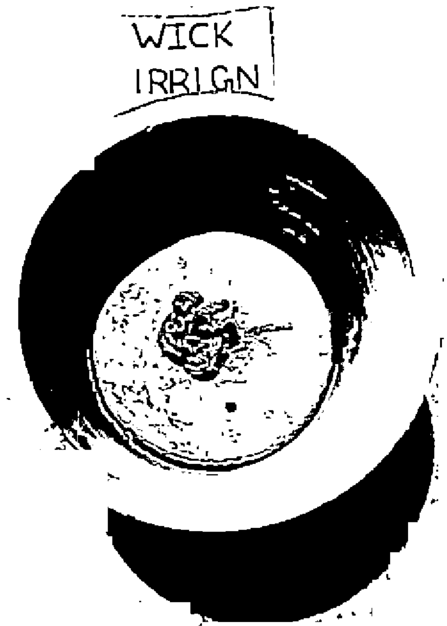

PLATE II

PLATE III

were filled with measured quantity of water prior to planting. Subsequent filling of pots were done at 4 days interval. On the day of last harvest, the quantity of water left over in the lower basins were measured. From these the total volume of water applied during the economic crop life was calculated. In wick irrigated pots moisture regimes were maintained near to field capacity throughout the growth period.

3.5. After cultivation

3.5.1. Gap filling

Gap filling was done on the fifth day after transplanting.

3.5.2. Weeding

The crop was handweeded thrice at 25 days interval.

3.5.3. Plant protection

Monocrotophos (0.05 %) was sprayed on crop to control thrips as a prophylactic measure.

3.5.4. Harvesting

The first harvest was on 9-2-93, about two months after planting and subsequent harvests were made at 8 days interval.

3.6. Observations

3.6.1. Growth characters

Observations were recorded at three growth stages viz. 35 DAT, 70 DAT and harvest.

3.6.1.1. Height of the plant

The height of plants were measured from the base to the growing tips.

3.6.1.2. Number of branches

The total number of branches per plant were counted, mean values were calculated and recorded.

3.6.1.3. Total dry matter production

Total dry matter production was worked out by recording the dry weight of shoot and pods after oven drying at 80^{o}C. Drying and weighing were repeated till constant weights were obtained.

3.6.1.4. Root studies

3.6.1.4.1. Root length

Roots were excavated carefully from each pot 70 DAT and harvest and length was recorded by measuring the longest tap root length.

3.6.1.4.2. Root area

Root area at 70 DAT and harvest were recorded by using graph paper and expressed in cm^2.

3.6.1.4.3. Root dry weight

Roots were oven dried at 80^oC and weights were recorded.

3.6.1.5. Time of 50 per cent flowering

The number of days taken for 50 per cent of the plant population to flower in each treatment was recorded.

3.6.1.6. Number of flowers per plant

Flower production on plants was recorded from the first flower opening till the last harvest.

3.6.1.7. Setting per cent

Setting per cent was computed from total number of fruits and flowers produced on the same plant.

3.6.1.8. Number of fruits per plant

The total number of fruits harvested from all the plants were counted and the averages were worked out for each treatment.

3.6.1.9. Length of fruits

Lengths of randomly selected fruits were measured and averages were worked out and expressed in cm.

3.6.1.10. Girth of fruits

Fruits used for measuring length were used for recording the girth. Girth was measured at the broadest part of the fruits and expressed in cm.

3.6.1.11. Hundred fruit weight

From each treatment 25 fruits were drawn at random and fresh weights were recorded. The values were quadrupled to get the hundred fruit weight.

3.6.1.12. Volume of fruits

From each treatment 10 fruits were drawn at random and volume measured by displacement method and expressed in cm^3.

3.6.1.13. Total fruit yield

Total fruit yield was computed by adding the weights of fruits of each harvest and is expressed in g $plant^{-1}$.

3.7. Computed parameters

3.7.1. Harvest Index (HI)

From the yield data, HI was calculated using the formula suggested by Donald (1962).

$$HI = \frac{\text{Economic Yield}}{\text{Biological Yield}}$$

3.7.2. Leaf area index (LAI)

Leaf area index was worked out at 35 DAT, 70 DAT and harvest. Area of all leaves produced per plant was recorded using LI-3100 leaf areameter and LAI was worked out using the formula suggested by William (1946).

$$LAI = \frac{\text{Leaf area}}{\text{Pot area}}$$

3.7.3. Relative growth rate (RGR)

The rate of increase in dry weight per unit dry weight per unit time expressed as mg day^{-1} was calculated by the following formula suggested by Blackmann (1919) and expressed as mg day^{-1}

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

3.7.4. Net Assimilation Rate (NAR)

The rate of increase in dry weight per unit leaf area per unit time was worked out by the following formula of William (1946).

$$NAR = \frac{(W_2 - W_1) \quad (\log_e L_2 - \log_e L_1)}{(t_2 - t_1) \quad (L_2 - L_1)}$$

L_1 and W_1 are the leaf area and dry weight of the plant at time t_1 and L_2 and W_2 are the leaf area and dry weight at time t_2. This was expressed as mg cm^{-2} day^{-1}.

3.7.5. Water use efficiency

Water use efficiency was calculated by dividing economic crop yield (Y) by the total amount of water used (WR). (Michael, 1985)

$$WUE = Y/WR$$

This was expressed as g $litre^{-1}$

3.8. Physical properties of soil

3.8.1. Soil water status

Moisture contents were recorded gravimetrically from soil samples collected from 15 cm depth before and after the experiment.

3.8.2. Soil temperature

Soil temperature at 15 cm depth was recorded at 8.30 and 14.30 hours at weekly intervals. The monthly means are presented.

3.9. Chemical properties of soil

3.9.1. Available nutrient status

Available nutrient status was determined before the experiment using standard procedures mentioned in Table 3.1.

3.10. Plant analysis

Plant samples were analysed for N, P and K at harvest by adopting standard procedures. The plants were chopped and dried in an air oven at 80 $\pm$ 5^{o}C separately till constant weights were achieved. Samples were then passed through a 0.5 mm mesh in a Wiley mill. Nitrogen content was estimated using Microkjeldahl method (Jackson, 1973), phosphorus content using vanadomolybdophosphoric yellow colour method (Jackson, 1973) and potassium content using flame photometer (Piper, 1966).

3.10.1. Nutrient uptake

The total uptake of N, P and K were calculated as the product of per cent content of nutrients in the plant samples and the dry weight and expressed as g plant^{-1}.

3.10.2. Chlorophyll content

The leaf samples were homogenised in cold 85 per cent acetone and centrifuged to get the clear extract. The absorbance of the extracts were measured at wavelengths of 645 and 663 nm for chlorophyll 'a' and 'b' in Spectronic 20 spectrophotometer. The amounts of total chlorophyll 'a' and 'b' were calculated using the formula of Starnes and Hadley (1965).

3.11. Economics of cultivation

Economics relating to methods of irrigation and conservation was worked out. Only the variable costs were considered in computing the economics. Labour charges were not included since family labour is utilised for irrigation in terrace gardens. Discarded hospital drips were utilised for the experiment. Thus variable costs for drip irrigation is that of rubber cork (Rs. 1.25 pot^{-1}) and Rs. 8 pot^{-1} for specially designed pots for wick irrigation. Considering the durability of cork and pots as 10 years, the cost involved per season comes to about 12 paise pot^{-1} and 80 paise pot^{-1} for modified drip and wick irrigation respectively. For conservation methods, the cost involved pot^{-1} comes to about 10 paise pot^{-1} for coir pith mulch and 52 paise pot^{-1} for Jalsakhti treated pots.

3.12. Statistical analysis

Data relating to each character was analysed by applying analysis of variance technique and significance tested by F test (Snedecor and Cochran, 1967). Significance was tested at 0.05 and 0.01 levels.

RESULTS

4. RESULTS

An investigation was conducted to determine the water requirement of chilli grown in pots and to compare the efficiency of different techniques for economising water use in chilli. The data on various observations were statistically analysed and presented in this chapter.

4.1. Growth Characters

The results on various growth characters recorded at 35 DAT, 70 DAT and harvest are presented below.

4.1.1. Plant-height

The data on plant height recorded at 35 DAT, 70 DAT and harvest is presented in Table 4.1. At all growth stages, significant influence of methods and levels of irrigation and conservation methods on height was observed. M_1 resulted in significantly higher plant height than M_2 at all stages. Plant height decreased with decrease in quantity of water applied and irrigation at I_3 level recorded the lowest height. The increase in heights due to I_1 over I_2 and I_3 and I_2 over I_3 were significant at all stages of growth. C_1 was significantly superior to C_2 and C_0. The increase in heights due to C_1 over C_2 and C_0 and C_2 over C_0 were significant at all the three stages.

Table 4.1. Effect of irrigation and conservation methods on height of plant^{-1}

Treatments	Height (cm)		
	35 DAT	70 DAT	Harvest
Methods of Irrigation			
M_1	24.50	46.40	52.60
M_2	22.50	44.70	50.60
F test	S	S	S
SE m$\pm$	0.28	0.22	0.18
CD (0.05)	0.81	0.64	0.52
Levels of Irrigation			
I_1	26.10	48.10	54.60
I_2	25.00	46.90	53.60
I_3	19.40	41.60	46.70
F test	S	S	S
SE m$\pm$	0.35	0.28	0.22
CD (0.05)	0.99	0.79	0.64
Methods of Conservation			
C_0	17.60	40.20	48.50
C_1	28.90	51.30	55.40
C_2	24.00	45.10	51.00
F test	S	S	S
SE m$\pm$	0.35	0.28	0.22
CD (0.05)	0.99	0.79	0.64
Control	31.73	53.00	60.10
Treatment VS Control	S	S	S
SE m$\pm$	1.4	1.2	0.94

S - Significant

Table 4.1a. Interaction effect of levels and method of irrigation and conservation methods on height of the plant

Treatments	70 DAT (cm)		
	C_0	C_1	C_2
M_1	41.3	52.6	45.2
M_2	39.2	50.2	45.0
F test	S	S	S
SE m ±	0.38	0.38	0.38
CD (0.05)	1.10	1.10	1.10
	Harvest		
I_1	51.5	58.7	53.7
I_2	50.8	57.8	52.1
I_3	43.1	49.7	47.4
F test	S	S	S
SE m ±	0.38	0.38	0.38
CD (0.05)	1.10	1.10	1.10

S - Significant

Wick irrigation was superior to all other treatments which recorded heights of 31.73 cm, 53.00 cm and 60.10 cm at 35 DAT, 70 DAT and harvest respectively.

M x I interaction was not significant at any stage. I x C interaction was not significant at 35 and 70 DAT. But significant differences were noticed at harvest. (Table 4.1a). I_1C_1 was the most superior (58.70 cm) and was on a par with I_2C_1 (57.80 cm) which was followed by I_1C_2 (53.70 cm). These three treatments were significantly superior to all other treatments. Lowest plant height (43.10 cm) was recorded by I_3C_0. At all levels of irrigation, C_1 recorded significantly higher plant height over other conservation methods. M x C interaction was not significant at 35 DAT and harvest, but was significant at 70 DAT. M_1C_1 recorded a plant height of 52.60 cm which was significantly superior to all other treatments. Lowest height was recorded at M_2C_0 (39.20 cm) (Table 4.1a). In both methods of irrigation, C_1 recorded significantly higher values compared to C_0 and C_2.

4.1.2. Number of branches

The data on number of branche
presented in Table 4.2.

Methods and levels of irrigation and conservation methods had significant influence on number of branches. M_1

Table 4.2. Effect of irrigation and conservation methods on branches plant $^{-1}$

Treatments	35 DAT	70 DAT	Harvest
Methods of irrigation			
M_1	15.60	37.50	53.10
M_2	13.90	35.60	50.50
F test	S	S	S
SE m±	0.22	0.25	0.22
CD (0.05)	0.62	0.72	0.63
Levels of irrigation			
I_1	17.70	41.10	59.80
I_2	16.50	40.20	58.10
I_3	10.00	28.40	37.50
F test	S	S	S
SE m±	0.27	0.31	0.27
CD (0.05)	0.76	0.88	0.77
Methods of conservation			
C_0	11.10	31.30	44.30
C_1	18.30	42.20	57.90
C_2	14.70	36.20	53.30
F test	S	S	S
SE m±	0.27	0.31	0.27
CD (0.05)	0.76	0.88	0.77
Control	22.30	49.70	69.00
Treatment VS Control	S	S	S
SE m±	1.12	1.30	1.14

S - Significant

Table 4.2a. Interaction effect of levels and method of irrigation and conservation methods on number of branches

Treatments	70 DAT			Harvest		
	C_0	C_1	C_2	C_0	C_1	C_2
I_1	34.5	48.3	40.5	50.2	67.9	61.5
I_2	33.5	47.7	39.5	48.2	65.7	60.5
I_3	25.8	30.7	28.7	34.5	40.2	37.8
F test	S	S	S	S	S	S
SE m ±	0.53	0.53	0.53	0.47	0.47	0.47
CD(0.05)	1.52	1.52	1.52	1.34	1.34	1.34
M_1				45.4	59.8	54.2
M_2				43.1	56.0	52.3
F test				S	S	S
SE m ±				0.38	0.38	0.38
CD(0.05)				1.09	1.09	1.09

S - Significant

was significantly superior to M_2 at all stages of growth. Variations among I_1,I_2 and I_3 were significant and I_1 (17.70, 41.10 and 59.80 at 35 DAT, 70 DAT and harvest respectively) recorded the maximum number of branches followed by I_2 and I_3. C_1 was significantly superior to C_2 and C_0.

Wick irrigation was superior to all other treatments which reoorded 22.30, 49.70 and 69.00 branches at 35 DAT, 70 DAT and harvest respectively.

M x I interaction was not significant. Among I x C interaction at 70 DAT, I_1C_1 reoorded the highest number of branches (48.30) which was on a par with I_2C_1 (47.70). Both were significantly superior to all other treatments. Same trend was observed at harvest also. At all levels of irrigation, C_1 was significantly superior to C_0 and C_2 and C_2 superior to C_0 at both stages (Table 4.2a). M x C interaction at harvest was significant. M_1C_1 was the superior most treatment combination (59.80). The variation among the treatment combinations was significant and M_2C_0 recorded the lowest value (43.10). Under both methods of irrigation, C_1 revealed its superiority (Table 4.2a).

4.1.3. Leaf Area Index (LAI)

The influence of various treatments on LAI is presented in Table 4.3.

Table 4.3. Effect of irrigation and conservation methods on Leaf Area Index LAI

Treatments	LAI 35 DAT	LAI 70 DAT	LAI Harvest
Methods of irrigation			
M_1	0.85	1.60	2.50
M_2	0.77	1.50	2.30
F test	S	S	S
SE m±	0.01	0.02	0.04
CD (0.05)	0.04	0.07	0.12
Levels of irrigation			
I_1	0.99	1.90	2.70
I_2	0.94	1.70	2.50
I_3	0.49	1.10	2.10
F test	S	S	S
SE m±	0.02	0.03	0.05
CD (0.05)	0.05	0.09	0.15
Methods of conservation			
C_0	0.65	1.30	2.10
C_1	0.96	1.90	2.70
C_2	0.82	1.60	2.40
F test	S	S	S
SE m±	0.02	0.03	0.05
CD (0.05)	0.05	0.09	0.15
Control	0.91	1.30	2.80
Treatment VS Control	S	S	S
SE m±	0.06	0.10	0.22

S - Significant

Table 4.3a. Interaction effect of levels and method of irrigation and conservation methods on LAI

Treatments	70 DAT		Harvest	
	M_1	M_2	M_1	M_2
I_1	2.03	1.80	2.80	2.60
I_2	1.80	1.70	2.60	2.50
I_3	1.10	1.20	2.10	2.00
F test	S	S	S	S
SE m ±	0.04	0.04	0.07	0.07
CD(0.05)	0.13	0.13	0.22	0.22
C_0	1.30	1.30	2.20	2.10
C_1	1.90	1.90	2.80	2.60
C_2	1.70	1.50	2.50	2.30
F test	S	S	S	S
SE m ±	0.04	0.04	0.07	0.07
CD(0.05)	0.13	0.13	0.22	0.22

S - Significant

The data revealed significant influence of methods and levels of irrigation and conservation methods on LAI at all stages. At all stages M_1 (0.85, 1.60 and 2.50 respectively) I_1 (0.99, 1.90 and 2.70 respectively) and C_1 (0.96, 1.90 and 2.70 respectively) recorded the highest LAI.

Wick irrigation recorded the highest LAI compared to all other treatments (2.80) at harvest.

Interactions I x C at all stages and M x I and M x C at 35 DAT were not significant. In M x I interaction at both stages ie., 70 DAT and harvest, M_1I_1 recorded the highest LAI. But at harvest M_1I_1 (2.80) was on a par with M_1I_2 (2.60) and M_2I_1 (2.60) (Table 4.3a).

Among M x C interaction, M_1C_1 (1.90 and 2.80) and M_2C_1 (1.90 and 2.80) recorded significantly higher LAI at both stages while they themselves were at par.

4.1.4. Dry Matter Production (DMP)

The influence of various treatments on DMP presented in Table 4.4 revealed that the methods and levels of irrigation and conservation methods had significant influence on DMP at all stages of growth. M_1, I_1 and C_1 recorded the highest at all stages of growth But at 35 DAT, I_1 (2.70 g plant^{-1}) and I_2 (2.60 g plant^{-1}) were at par.

Table 4.4 Effect of irrigation and conservation methods on dry matter production at 35 DAT, 70 DAT, and Harvest

Treatments	DMP g $plant^{-1}$		
	35 DAT	70 DAT	Harvest
Methods of irrigation			
M_1	2.30	8.50	27.30
M_2	2.00	7.20	25.10
F test	S	S	S
SE m±	0.04	0.25	0.28
CD (0.05)	0.12	0.74	0.81
Levels of irrigation			
I_1	2.70	10.80	36.40
I_2	2.60	7.80	25.80
I_3	1.10	5.00	16.50
F test	S	S	S
SE m±	0.41	0.31	0.35
CD (0.05)	0.14	0.91	0.99
Methods of conservation			
C_0	1.50	5.40	20.90
C_1	2.70	10.00	31.30
C_2	2.30	8.20	26.40
F test	S	S	S
SE m±	0.41	0.31	0.35
CD (0.05)	0.14	0.91	0.99
Control	3.50	12.70	46.20
Treatment VS Control	S	S	S
SE m±	0.16	1.10	1.16

S - Significant

Table 4.4a. Interaction effect of levels of irrigation and conservation methods on DMP

Treatments	g plant^{-1}					
	70 DAT			Harvest		
	C_0	C_1	C_2	C_0	C_1	C_2
I_1	7.11	13.50	11.70	28.4	43.8	36.9
I_2	5.20	10.20	7.90	19.6	31.9	25.9
I_3	3.80	6.20	5.00	14.7	18.2	16.5
F test	S	S	S	S	S	S
SE m $\pm$	0.53	0.53	0.53	0.60	0.60	0.60
CD(0.05)	1.57	1.57	1.57	1.72	1.72	1.72

S - Significant

Wick irrigation was significantly superior to all other treatments at all stages of growth (3.50, 12.70 and 46.20 g $plant^{-1}$)

Interactions M x I and M x C did not produce any significant influence on DMP at any stage of growth. I x C interaction had significant influence, but only at 70 DAT and harvest. I_1 C_1 recorded the highest DMP (13.5 and 43.8 g $plant^{-1}$) followed by I_1C_2 (11.7 and 36.9 g $plant^{-1}$) at both stages respectively. At all levels of irrigation, C_1 was significantly higher (Table 4.4a).

4.1.5. Root studies

The observations on root area and tap root length at 70 DAT and harvest and root dry weight at 70 DAT were recorded.

4.1.5.1. Root area and taproot length

The influence of various treatments on root area and tap root length are presented in Table.4.5.

M_1 recorded tne maximum root area at both stages compared to M_2 while the effect on tap root length was not significant. Regarding the levels of irrigation, the effect due to I_1 and I_2 on root area was on a par and was

Table 4.5. Effect of irrigation and conservation methods on root area and tap root length

Treatments	Root area (cm^2)		Tap root length (cm)	
	70 DAT	Harvest	70 DAT	Harvest
Methods of irrigation				
M_1	72.20	126.70	11.10	19.90
M_2	63.70	108.70	10.90	19.80
F test	S	S	NS	NS
SE m±	0.74	0.94	0.07	0.06
CD (0.05)	2.20	2.70	-	-
Levels of irrigation				
I_1	73.90	127.00	10.97	20.10
I_2	74.40	128.60	11.20	19.60
I_3	55.40	97.50	10.70	19.90
F test	S	S	S	S
SE m±	0.91	1.15	0.09	0.08
CD (0.05)	2.70	3.30	0.27	0.24
Methods of conservation				
C_0	61.30	99.20	10.00	18.30
C_1	73.70	128.80	11.30	20.50
C_2	68.90	125.10	11.70	20.80
F test	S	S	S	S
SE m±	0.91	1.15	0.09	0.08
CD (0.05)	2.70	3.30	0.27	0.24
Control	63.70	131.50	9.00	18.90
Treatment VS Control	NS	S	S	S
SE m±	3.17	4.89	0.31	0.34

S - Significant

NS - Not significant

Table 4.5a. Interaction effect of levels and method of irrigation and conservation methods on root area

Treatments	70 DAT		cm²	Harvest		
	C_0	C_1	C_2	C_0	C_1	C_2
I_1	66.30	77.30	77.90	107.00	140.00	134.10
I_2	64.80	84.90	74.40	111.00	142.40	132.60
I_3	52.70	58.90	54.50	80.10	104.00	109.00
F test	S	S	S	S	S	S
SE m ±	1.58	1.58	1.58	1.99	1.99	1.99
CD(0.05)	4.70	4.70	4.70	5.70	5.70	5.70
M_1	63.20	78.60	14.90	104.10	135.60	140.30
M_2	59.50	68.80	62.90	94.30	122.00	110.00
F test	S	S	S	S	S	S
SE m ±	1.28	1.28	1.28	1.64	1.64	1.64
CD (0.05)	3.80	3.80	3.80	4.70	4.70	4.70

S - Significant

Table 4.5b. Interaction effect of levels and method of irrigation and conservation methods on tap root length

Treatments	70 DAT			cm Harvest			70 DAT		Harvest	
	C_0	C_1	C_2	C_0	C_1	C_2	M_1	M_2	M_1	M_2
I_1	10.30	10.90	11.70	18.80	20.10	21.50	10.60	11.40	19.40	20.80
I_2	10.50	11.20	12.00	18.80	20.20	19.80	11.30	11.20	20.40	18.90
I_3	9.30	11.70	11.20	17.20	21.30	21.00	11.30	10.20	20.10	19.70
F test	S	S	S	S	S	S	S	S	S	S
SE m ±	0.13	0.13	0.13	0.12	0.12	0.12	0.13	0.13	0.12	0.12
CD(0.05)	0.38	0.38	0.38	0.33	0.33	0.33	0.38	0.38	0.33	0.33
M_1	9.01	11.60	12.50	17.10	20.70	22.00				
M_2	11.00	10.90	10.90	19.50	20.40	19.50				
F test	S	S	S	S	S	S				
SE m ±	0.13	0.13	0.13	0.12	0.12	0.12				
CD(0.05)	0.38	0.38	0.38	0.33	0.33	0.33				

S - Significant

significantly superior to I_3 at both stages. I_2 recorded maximum tap root length at 70 DAT while I_1 recorded maximum length at harvest which was on a par with I_3. Regarding conservation methods maximum root area was observed at C_1 at both stages. Maximum root length was observed at C_2 at both stages.

Wick irrigation was supèrior to all treatments with respect to root area at harvest. But the tap root length was significantly inferior to all treatments except control at harvest.

I x C interaction had significant effect on both root area and tap root length in both stages. Maximum root area was observed at I_2C_1 in both, stages. But at harvest, this treatment was on a par with I_1C_1 . Minimum root area was observed in both stages at I_3C_0 (Table 4.5a). Maximum tap root length was observed at I_1C_2 and I_3C_1 levels. Both of the these treatments were on a par and were significantly superior to all other treatments in both stages (Table 4.5b). Regarding M x C interaction at 70 DAT maximum root area was obtained at M_1C_1 and at harvest by M_1C_2 which was on a par with M_1 C_1. M_2 C_0 recorded lowest root area at both stages (Table 4.5a). Maximum tap root length was at M_1C_2 at both stages and lowest tap root length was at M_1C_0 (Table 4.5b). Regarding M x I interaction, maximum tap root length was obtained at M_1I_2 at both stages.

4.1.5.2. Root dry weight

The influence of various treatments on root dry weight at 70 DAT is presented in Table 4.6.

Maximum root dry weight was at M_1 (2.30g) and C_1 (2.74 g). Regarding the irrigation levels, effects due to I_1 (2.50 g) and I_2 (2.40 g) were significantly superior and were on a par with each other.

Wick irrigation did not produce any significant effect on root dry weight.

All interaction effects were significant. Among M x I interaction, under both M_1 and M_2,I_1 and I_2 levels behaved similarly but was significantly superior to I_3. In I x C interaction, maximum root dry weight was at I_1C_1 (3.20 g) which was on a par with I_2 C_1 (3.00 g) and was significantly superior to all other treatment combinations. At all levels of irrigation, C_1 was significantly higher. In M x C interaction, M_1 C_1 recorded maximum and significant root dry weight (2.90 g). Under both methods of irrigation, C_1 was significantly higher (Table 4.6a).

4.1.6. Shoot Root Ratio (S:R)

The influence of various treatments on S:R ratio at 70 DAT and harvest is presented in Table 4.7

Table 4.6. Effect of irrigation and conservation methods on root dry weight

Treatments	Root dry weight (g) 70 DAT
Methods of irrigation	
M_1	2.30
M_2	2.10
F test	S
SE m±	0.044
CD (0.05)	0.13
Levels of irrigation	
I_1	2.50
I_2	2.40
I_3	1.70
F test	S
SE m±	0.054
CD (0.05)	0.16
Methods of conservation	
C_0	1.72
C_1	2.74
C_2	2.11
F test	S
SE m±	0.054
CD (0.05)	0.16
Control	2.25
Treatment VS Control	NS
SE m±	0.18

S - Significant

NS - Not significant

Table 4.6a. Interaction effect of levels and method of irrigation and conservation methods on root dry weight

Treatments	g plant^{-1}				
	C_0	C_1	C_2	M_1	M_2
I_1	1.80	3.20	2.40	2.50	2.50
I_2	2.00	3.00	2.30	2.40	2.50
I_3	1.40	1.90	1.60	1.90	1.50
F test	S	S	S	S	S
SE m $\pm$	0.09	0.09	0.09	0.07	0.07
CD (0.05)	0.27	0.27	0.27	0.22	0.22
M_1	1.82	2.90	2.04		
M_2	1.60	2.60	2.20		
F test	S	S	S		
SE m $\pm$	0.07	0.07	0.07		
CD (0.05)	0.22	0.22	0.22		

S - Significant

Table 4.7. Effect of irrigation and conservation methods on shoot root ratio

Treatments	Shoot root ratio	
	70 DAT	Harvest
Methods of irrigation		
M_1	1.98	2.30
M_2	1.73	2.10
F test	S	S
SE m±	0.03	0.014
CD (0.05)	0.09	0.04
Levels of irrigation		
I_1	2.01	2.30
I_2	1.90	2.10
I_3	1.70	2.20
F test	S	S
SE m±	0.037	0.018
CD (0.05)	0.11	0.05
Methods of conservation		
C_0	1.70	2.03
C_1	1.97	2.32
C_2	1.90	2.20
F test	S	S
SE m±	0.037	0.018
CD (0.05)	0.11	0.05
Control	2.30	2.60
Treatment VS Control	S	S
SE m±	0.13	0.077

S - Significant

Table 4.7a. Interaction effect of levels and method of irrigation and conservation methods on shoot root ratio

	Harvest				
Treatments	C_0	C_1	C_2	M_1	M_2
I_1	2.20	2.40	2.30	2.40	2.20
I_2	2.00	2.30	2.10	2.30	2.00
I_3	1.90	2.30	2.30	2.20	2.10
F test	S	S	S	S	S
SE m ±	0.03	0.03	0.03	0.024	0.024
CD(0.05)	0.09	0.09	0.09	0.07	0.07

M_1	2.10	2.50	2.30
M_2	2.00	2.20	2.10
F test	S	S	S
SE m ±	0.024	0.024	0.024
CD(0.05)	0.07	0.07	0.07

S - Significant

At both stages maximum ratio was observed at M_1, I_1 recorded maximum ratio at both stages but it was on a par with I_2 at 70 DAT. In both stages, C_1 recorded significantly higher S:R ratio but at 70 DAT, the effect was on a par with C_2.

Wick irrigation was significantly superior to all treatments and recorded values of 2.31 and 2.60 at 70 DAT and harvest respectively.

At 70 DAT, none of the interactions were significant. At harvest all interactions were significant (Table 4.7a) Regarding M x I interaction M_1I_1 recorded maximum and significant S:R ratio (2.40) and M_2I_2 the lowest (2.00). In I x C interaction, I_1C_1 recorded maximum ratio (2.40) which was significantly superior to all other treatments. In M x C interaction M_1C_1 recorded a S:R ratio of 2.50 which was significantlv superior to all other treatments.

4.1.7. Net Assimilation Rate (NAR) and Relative Growth Rate (RGR)

The influence of various treatments on NAR and RGR are presented in Table 4.8. NAR and RGR were computed at 35 to 70 DAT and 70 DAT to harvest.

No significant difference in RGR was observed between 35 to 70 DAT with respect to methods of irrigation.

Table 4.8. Effect of irrigation and conservation methods on Net Assimilation Rate and Relative growth rate

Treatments	NAR (mg $cm^{-2} day^{-1}$)		RGR (mg day^{-1})	
	70 DAT	Harvest	70 DAT	Harvest
Methods of irrigation				
M_1	0.30	0.52	39	34
M_2	0.27	0.54	38	35
F test	S	NS	NS	S
SE m±	0.01	0.013	0.77	0.71
CD (0.05)	0.034	-	-	2.1
Levels of irrigation				
I_1	0.33	0.66	39	35
I_2	0.23	0.49	31	35
I_3	0.30	0.43	45	35
F test	S	S	S	NS
SE m±	0.014	0.017	0.98	0.87
CD (0.05)	0.042	0.051	2.9	-
Methods of conservation				
C_0	0.26	0.54	41	39
C_1	0.31	0.52	38	32
C_2	0.29	0.53	36	38
F test	NS	NS	S	S
SE m±	0.014	0.017	0.98	0.87
CD (0.05)	-	-	2.9	2.6
Control	0.48	1.02	36	37
Treatment VS Control	S	S	S	S
SE m±	0.0015	0.0018	0.104	0.003

S - Significant

NS - Not significant

Table 4.8a. Interaction effect of levels and method of irrigation and conservation methods on NAR and RGR

	NAR (mg cm^{-2} day^{-1})					RGR (mg day^{-1})		
Treatments	C_0	C_1	C_2	M_1	M_2	C_0	C_1	C_2
Initial stage								
I_1	0.26	0.36	0.37			39	40	40
I_2	0.19	0.26	0.23			29	33	31
I_3	0.33	0.29	0.28			56	41	38
F test	S	S	S			S	S	S
SE m ±	0.024	0.024	0.024			1.66	1.66	1.66
CD(0.05)	0.073	0.073	0.073			4.90	4.90	4.90
Final stage								
I_1	0.65	0.67	0.66	0.62	0.71	40	34	33
I_2	0.72	0.12	0.49	0.52	0.73	38	33	34
I_3	0.49	3912	4349	0.43	0.43	39	31	34
F test	S	S	S	S	S	S	S	S
SE m ±	0.029	0.029	0.029	0.024	0.024	1.52	1.52	1.52
CD(0.05)	0.088	0.088		0.072	0.072	4.50	4.50	4.50

S - Significant

But at later stage M_2 recorded significantly higher value (35 mg day^{-1}). Effect of methods on NAR was significant only in the initial stage. Significantly higher value was recorded by M_1 (0.3 mg cm^{-2} day^{-1}). Effect of irrigation levels on RGR was significant only in the initial stage. Maximum value was observed at I_3 (45 mg day^{-1}). Effect of irrigation on NAR was significant at both stages. Maximum NAR was observed at I_1 level at both stages. Regarding the effect of conservation methods, C_0 recorded maximum RGR while the effect of NAR was not significant at both stages.

Wick irrigation was significantly superior to all other treatments at both stages with respect to NAR. In the initial stages RGR was inferior in Wick irrigation.

M x I interaction was significant only on NAR at later stage. Maximum was observed at M_2I_2. I x C interaction was significant at all stages on both parameters. Maximum RGR was observed at I_3 C_0 at the initial stage (35 to 70 DAT) and at I_1C_0 at later stage (70 DAT to harvest). Maximum NAR was observed at I_1 level for both C_1 and C_2 at initial stage. At later stage, all the three conservation methods at I_1 level and C_0 at I_2 level behaved similarly and was significantly superior to all others (Table 4.8a). Interaction MXC was not significant.

4.2. Yield and yield attributes

4.2.1. Time of 50 per cent flowering

The data on the influence of various treatments on 50 per cent flowering are presented in Table 4.9.

Methods and levels of irrigation and conservation methods had profound influence on 50 per cent flowering. M_1 (36.60 days) was significantly superior to M_2. Earliness in flowering occured with increase in quantity of water applied. Significant variations were noticed among I_1, I_2 and I_3. I_1 was the superiormost (34.80 days) followed by I_2 (35.60 days) and I_3 (43.00 days). C_1 (35.90 days) was significantly superior to C_2 (37.60 days) and C_0 (39.90 days).

Wick irrigation was superior to all other treatments (30.30 days).

Interactions M x I and I x C were not significant. But the interaction M x C was significant. M_1C_1 (34.40 days) was the superiormost followed by M_1 C_2 (36.40 days). Flowering was delayed most in M_2 C_0 (41.10 days) (Table 4.9a).

Table 4.9. Effect of irrigation and conservation methods on time of 50 per cent flowering, Number of flowers plant^{-1}, setting per cent and fruits plant^{-1}

Treatments	Time of 50 per cent flowering	Number of flowers plant^{-1}	Setting per cent	Number of fruits plant^{-1}
Methods of irrigation				
M_1	36.60	111.90	42.90	47.80
M_2	39.10	106.30	39.90	42.60
F test	S	S	S	S
SE m±	0.20	0.72	0.32	0.36
CD(0.05)	0.57	2.07	0.91	1.03
Levels of irrigation				
I_1	34.80	115.40	46.70	54.00
I_2	35.60	109.60	45.20	48.50
I_3	43.00	102.40	32.50	33.10
F test	S	S	S	S
SE m±	0.24	0.89	0.39	0.44
CD(0.05)	0.69	2.54	1.12	1.27
Methods of conservation				
C_0	39.90	104.90	39.10	41.40
C_1	35.90	113.80	43.90	50.10
C_2	37.60	108.60	41.30	44.10
F test	S	S	S	S
SE m±	0.24	0.89	0.39	0.44
CD(0.05)	0.69	2.54	1.12	1.27
Control	30.30	125	48.80	61.00
Treatment vs Control	S	S	S	S
SE m±	1.02	3.75	0.95	1.24

S - Significant

4.2.2. Number of flowers plant^{-1}

The data showing the influence of various treatments on number of flowers plant^{-1} are presented in Table 4.9.

Methods and levels of irrigation and conservation methods had significant influence on number of flowers plant^{-1}. M_1 (111.90) was significantly superior to M_2 (106.30). Number of flowers increased with increase in quantity of water applied. Variations among I_1, I_2 and I_3 were highly significant. I_1 recorded the highest (115.40) and I_3 the lowest (102.40) number of flowers. C_1 recorded the highest number of flowers (113.80) and C_0 the lowest (104.90).

Wick irrigation resulted in maximum number of flowers (125) and was significantly superior to all other treatments.

The interaction M x I and I x C were not significant. However the interaction M x C had significant effect on number of flowers plant^{-1}. M_1 C_1 (118.80) recorded the highest number of flowers plant^{-1} followed by M_1C_2 (110.70) and M_2 C_1 (108.90) which were on a par with each other. M_2C_0 recorded the lowest number of flowers (Table 4.9b).

Table 4.9a. Interaction effect of levels and method of irrigation and conservation methods on setting per cent and time of 50 per cent flowering

Treatments	Setting per cent			Time of 50 per cent flowering		
	C_0	C_1	C_2	C_0	C_1	C_2
I_1	45.50	49.50	45.00			
I_2	41.50	47.20	47.00			
I_3	30.40	35.00	32.00			
F test	S	S	S			
SE m ±	0.67	0.67	0.67			
CD(0.05)	1.93	1.93	1.93			
M_1	40.10	44.88	43.90	38		
M_2	38.10	43.00	38.70	41		
F test	S	S	S	S	S	S
SE m ±	1.60	1.60	1.60	0.34	0.34	0.34
CD(0.05)	0.56	0.56	0.56	0.98	0.98	0.98

S - Significant

4.2.3. Setting per cent

The influence of various treatments on setting per cent are given in Table 4.9.

Methods and levels of irrigation and conservation methods had significant influence on setting per cent. Setting percentage was significantly higher in M_1 (42.90) than M_2 (39.90). Setting percentage increased with increase in levels of irrigation. Variations among I_1,I_2 and I_3 were significant. I_1 recorded the highest setting per cent (46.70) and I_3 the lowest (32.50). C_1 was the superiormost (43.90) followed by C_2 (41.30). C_0 (39.10) recorded the lowest setting per cent.

Wick irrigation was significantly superior to all other treatments (48.80).

Interaction M x I was not significant. Interaction I x C and M x C had significant influence on setting percentage. I_1C_1 recorded the maximum setting per cent (49.50). At all levels of irrigation C_1 increased setting percent significantly compared to C_0 and C_2. Interaction M_1C_1 recorded the highest (44.80) and M_2C_0 recorded the lowest setting percent (38.10) (Table 4.9a)

Table 4.9b. Interaction effect of levels and method of irrigation and conservation methods on number of flowers and fruits plant^{-1}

Treatments	Flowers plant^{-1}			Fruits plant^{-1}		
	C_0	C_1	C_2	C_0	C_1	C_2
I_1				50.20	60.30	51.50
I_2				44.30	52.70	48.50
I_3				29.70	37.30	32.30
F test				S	S	S
SE m ±				0.77	0.77	0.77
CD(0.05)				2.20	2.20	2.20
M_1	106.40	118.80	110.70	43.10	53.60	46.70
M_2	103.30	108.90	106.60	39.70	46.70	41.60
F test	S	S	S	S	S	S
SE m ±	1.25	1.25	1.25	0.63	0.63	0.63
CD(0.05)	3.58	3.58	3.58	1.80	1.80	1.80

S - Significant

4.2.4. Fruits $plant^{-1}$

The data on number of fruits $plant^{-1}$ are presented in Table 4.9.

Methods and levels of irrigation and conservation methods had significant influence on number of fruits $plant^{-1}$. M_1 (47.80) was significantly superior to M_2 (42.60). I_1, I_2 and I_3 showed significant variations. I_1 recorded the maximum number of fruits $plant^{-1}$ (54.00) and I_3 recorded the lowest (33.10). C_0, C_1 and C_2 differed significantly. C_1 was the superior most (50.10) and C_0 was the most inferior (41.40).

Wick irrigation was significantly superior to all other treatments (61.00).

Interaction MxI was not significant, but IxC and MxC interactions were significant. I_1C_1 recorded the highest number of fruits $plant^{-1}$ (60.30) followed by I_2C_1 (52.70) which was on a par with I_1C_2 (51.50). I_3C_0 recorded the lowest number of fruits $plant^{-1}$ (29.70). At all levels of irrigation C_1 was significantly superior to C_0 and C_2. In MxC interaction, M_1C_1 recorded the highest number of fruits $plant^{-1}$ (53.60) followed by M_1C_2 (46.70) which was on a par with M_2C_1 (46.70). M_2C_0 recorded the lowest number of fruits $plant^{-1}$ (39.70). Under both methods of irrigation C_1 was significantly higher than C_0 and C_2 (Table 4.9b).

4.2.5. Length of fruit

The data on length of fruit are presented in Table 4.10.

The effect of methods and levels of irrigation and conservation methods on length of fruit was highly significant. M_1 (8.20 cm) was superior to M_2 (8.03 cm). With respect to levels of irrigation, I_1 recorded the maximum length of fruit (8.30 cm). Among the conservation methods C_1 recorded the maximum length (8.40 cm) and C_0 the minimum (7.80 cm).

Wick irrigation was significantly superior to all other treatments (8.80 cm).

The interactions M x I, I x C and M x C were not significant.

4.2.6. Girth of fruit

The influence of various treatments on girth of fruit are presented in Table 4.10.

M_1 recorded higher girth of fruit (4.30 cm) than M_2 (4.20 cm). I_1 recorded the maximum girth of fruit (4.50 cm). Among conservation methods, C_2 recorded maximum girth (4.60 cm).

Table 4.10. Effect of irrigation and conservation methods on length, girth and volume of fruit and hundred fruit weight

Treatments	Length of fruit (cm)	Girth of fruit (cm)	Volume of fruit (cm^3)	Hundred fruit weight (g)
Methods of irrigation				
M_1	8.20	4.30	41.90	358.20
M_2	8.03	4.20	40.00	316.10
F test	S	S	S	S
SE m±	0.027	0.021	0.37	2.44
CD(0.05)	0.08	0.06	1.07	6.99
Levels of irrigation				
I_1	8.30	4.50	45.50	372.80
I_2	8.20	4.40	43.40	347.80
I_3	7.70	3.80	33.90	290.80
F test	S	S	S	S
SE m±	0.03	0.027	0.45	3.00
CD(0.05)	0.09	0.08	1.30	8.60
Methods of conservation				
C_0	7.80	3.90	35.90	316.70
C_1	8.40	4.60	46.70	360.30
C_2	8.10	4.20	40.10	334.40
F test	S	S	S	S
SE m±	0.03	0.027	0.45	3.00
CD(0.05)	0.09	0.08	1.32	8.60
Control	8.80	5.10	48.70	397.30
Treatment VS Control	S	S	S	S
SE m±	0.14	0.11	1.95	12.7

S - Significant

Wick irrigation was significantly superior to all other treatments (5.10 cm).

M x I interaction was not significant, but I x C and M x C interactions had significant influence on girth of fruit. I_1C_1 gave the maximum fruit girth (5.00 cm) and I_3C_0 the lowest (3.50 cm). At all levels of irrigation, significantly higher fruit girth was observed at C_1. Among MxC interaction, M_1C_1 recorded the highest value (4.80 cm) and M_2C_0 the lowest value (3.90 cm) for fruit girth. C_1 was significantly higher at both methods of irrigation (Table 4.10a).

4.2.7. Volume of fruits

The data on the influence of various treatments on fruit volume presented on Table 4.10 revealed that methods and levels of irrigation and conservation methods produced significant effect. Fruit volume was significantly higher in M_1 (41.90 cm^3). The variations among I_1, I_2 and I_3 were significant and I_1 recorded the highest fruit volume (45.50 cm^3). Conservation method C_1 recorded the maximum fruit volume (46.70 cm^3).

Table 4.10a. Interaction effect of levels and method of irrigation and conservation method on fruit girth, fruit volume and hundred fruit weight

Treatments	Fruit girth (cm)			Fruit volume (cm^3)			Hundred fruit weight (g)		
	C_0	C_1	C_2	C_0	C_1	C_2	C_0	C_1	C_2
I_1	4.20	5.00	4.50	40.70	51.00	44.80	354.20	403.00	361.20
I_2	4.10	4.80	4.30	36.20	50.20	43.80	316.30	374.30	352.70
I_3	3.50	4.10	3.80	31.00	39.00	31.70	279.70	303.20	289.70
F test	S	S	S	S	S	S	S	S	S
SE m ±	0.04	0.04	0.04	0.08	0.08	0.08	5.17	5.17	5.17
CD(0.05)	0.13	0.13	0.13	2.30	2.30	2.30	14.80	14.80	14.80
M_1	4.00	4.80	4.20						
M_2	3.90	4.50	4.70						
F test	S	S	S						
SE m ±	0.04	0.04	0.04						
CD(0.05)	0.11	0.11	0.11						

S - Significant

Wick irrigation was significantly superior to all other treatments (48.70 cm^3).

M x I and M x C interactions were not significant, but I x C had significant influence on pod volume. The treatment combination I_1 C_1 recorded the highest value (51.00 cm^3) which was on a par with I_2C_1 (50.20 cm^3). C_1 was significantly higher than C_0 and C_2 at all levels of irrigation. (Table 4.10a).

4.2.8. Hundred fruit weight

The data on the influence of methods and levels of irrigation and conservation methods on hundred fruit weight are presented in Table 4.10.

The treatments had significant influence on hundred fruit weight. M_1 (358.20 g) was superior to M_2 (316.10 g). Variations among I_1, I_2 and I_3 were significant and I_1 gave the maximum value (372.80g). C_1 recorded the maximum hundred fruit weight (360.30 g) than C_0 and C_2.

Wick irrigation was superior to all other treatments (397.30 g).

M x C interaction was not significant, but M x I and I x C interactions were significant. M_1I_1 gave the

Table 4.10b. Interaction effect of levels and method of irrigation on hundred fruit weight

Treatments	I_1 (g)	I_2 (g)	I_3 (g)
M_1	383.00	360.90	330.70
M_2	362.60	344.80	251.00
F test	S	S	S
SE m $\pm$	4.22	4.22	4.22
CD(0.05)	12.10	12.10	12.10

S - Significant

maximum hundred fruit weight (383.00 g) followed by M_2I_1 (362.60 g). Under both methods of irrigation I_1 recorded significantly higher hundred fruit weight (Table 4.10b). I_1C_1 recorded the highest hundred fruit weight (403.70 g). Lowest fruit weight was recorded by I_3C_0 (279.70 g). The difference between I_3C_0 and I_3C_2 was not significant. Under all levels of irrigation C_1 was significantly superior (Table 4.10a).

4.2.9. Yield per plant

The data presented in Table 4.11 revealed that yield $plant^{-1}$ is significantly influenced by methods and levels of irrigation and conservation methods. M_1 recorded the highest yield $plant^{-1}$ (196.90 g). I_1 (196.90 g) followed by I_2 (168.90 g) and I_3 (100 g) gave the highest respective yields $plant^{-1}$ with respect to levels of irrigation. Among conservation methods C_1 reoorded the highest yield (181.30 g) and C_0 the lowest (139.20 g).

Wick irrigation was significantly superior to all other treatments (244.10 g).

All interactions had significant influence on yield $plant^{-1}$.In M x I interaction, M_1I_1 recorded the maximum yield (203.40 g) followed by M_2I_1 (190.40 g). I_1 recorded significantly higher yields under both methods of irrigation.

Table 4.11. Effect of irrigation and conservation methods of yield plant^{-1}

Treatments	Yield plant^{-1}(g)
Methods of irrigation	
M_1	196.90
M_2	142.80
F test	S
SE m$\pm$	0.71
CD (0.05)	2.04
Levels of irrigation	
I_1	196.90
I_2	168.00
I_3	100.00
F test	S
SE m$\pm$	0.87
CD (0.05)	2.50
Methods of conservation	
C_0	139.20
C_1	181.30
C_2	144.20
F test	S
SE m$\pm$	0.87
CD (0.05)	2.50
Control	244.10
Treatment VS Control	S
SE m$\pm$	3.7

S - Significant

Table 4.11a. Interaction effect of levels and method of irrigation and conservation methods on yield plant^{-1}

Treatments	g plant^{-1}				
	C_0	C_1	C_2	M_1	M_2
I_1	[illegible]94.50	226.50	169.70	203.40	190.40
I_2	[illegible]35.80	206.80	161.40	176.90	159.00
I_3	[illegible]7.30	110.80	101.50	120.90	78.80
F test	S	S	S	S	S
SE m $\pm$	1.50	1.50	1.50	1.22	1.22
CD(0.05)	4.30	4.30	4.30	3.50	3.50
M_1	147.90	198.40	154.90		
M_2	130.50	164.30	133.40		
F test	S	S	S		
SE m $\pm$	1.22	1.22	1.22		
CD(0.05)	3.50	3.50	3.50		

S - Significant

Among IxC interaction $I_1 C_1$ (226.50 g) followed by I_2C_1 (206.80 g) recorded the highest yield. Variations among the treatment combinations were highly significant. I_3C_0 gave the lowest yield (87.30 g). Yield obtained at C_1 was significantly higher than that at C_0 and C_2 at all levels of irrigation. In interaction MxC, M_1C_1 recorded the highest yield (198.40 g) and M_2C_0 recorded the lowest value (130.50 g). Under both methods of irrigation C_1 recorded significantly higher yield (Table 4.11a).

4.2.10. Harvest index (HI)

The data on the influence of various treatments on HI are presented in Table 4.12.

Methods and levels of irrigation had profound influence on HI. But the influence of conservation methods was not significant. M_1 (0.64) was superior to M_2(0.59). I_1 gave the highest HI (0.77). Variations between I_1,I_2 and I_3 were significant.

Wick irrigation was significantly superior to all other treatments (0.69) except I_1 (0.77).

M x I and I x C interactions were highly significant (Table 4.12a). Among M x I interaction the highest value was obtained at M_1I_1 (0.77) which was on a par with M_2I_1 (0.77). M_2I_3 recorded the lowest HI (0.40). Under

Table 4.12. Effect of irrigation and conservation methods on harvest index

Treatments	Harvest Index
Methods of irrigation	
M_1	0.64
M_2	0.59
F test	S
SE m$\pm$	0.0084
CD(0.05)	0.02
Levels of irrigation	
I_1	0.77
I_2	0.65
I_3	0.43
F test	S
SE m$\pm$	0.01
CD(0.05)	0.03
Methods of conservation	
C_0	0.63
C_1	0.61
C_2	0.61
F test	NS
SE m$\pm$	0.01
CD(0.05)	-
Control	0.69
Treatment VS Control	S
SE m$\pm$	0.04

S - Significant

Table 4.12a. Interaction effect of levels and method of irrigation and conservation methods on harvest index

Treatments	C_0	C_1	C_2	M_1	M_2
I_1	0.80	0.76	0.74	0.77	0.77
I_2	0.68	0.62	0.65	0.67	0.62
I_3	0.40	0.45	0.44	0.47	0.40
F test	S	S	S	S	S
SE m ±	0.02	0.02	0.02	0.015	0.015
CD(0.05)	0.05	0.05	0.05	0.042	0.042

S - Significant

both methods of irrigation I_1 was superior. In IxC interaction I_1C_0 and I_1C_1 were significantly superior to all other treatments while they themselves were on a par, the latter was on a par with I_1C_2. Interaction MxC was not significant.

4.3. Water Use Efficiency (WUE)

The data on the influence of various treatments on WUE are presented in Table 4.13.

WUE was significantly higher for M_1 (12.80 g litre^{-1}) I_2 (12.90 g litre $^{-1}$) and C_1 (13.70g litre^{-1}) with respect to methods of irrigation, levels of irrigation and conservation methods respectively.

WUE of wick irrigation (10.80g litre^{-1})was higher than M_2 (10.50g litre^{-1}).

All interactions had significant influence on WUE. In M x I interaction, M_1I_2 produced the highest WUE (13.60g litre^{-1}) and M_2I_3 the lowest (7.90g litre^{-1}). In IxC interaction, I_2C_1 recorded the maximum (15.90g litre^{-1}) and I_3C_0 the lowest WUE (8.70g litre^{-1}). Among MxC interaction M_1C_1 recorded the maximum WUE (15.20g litre^{-1}) followed by M_2C_1 (12.20g litre^{-1}) which was on a par with M_1C_2 (12.10g itre^{-1}) (Table 4.13a).

Table 4.13. Effect of irrigation and conservation methods on water use efficiency

Treatments	WUE (g $litre^{-1}$)
Methods of irrigation	
M_1	12.80
M_2	10.50
F test	S
SE m±	0.06
CD (0.05)	0.17
Levels of irrigation	
I_1	12.00
I_2	12.90
I_3	10.10
F test	S
SE m±	0.07
CD (0.05)	0.21
Methods of conservation	
C_0	10.30
C_1	13.70
C_2	11.00
F test	S
SE m±	0.07
CD (0.05)	0.21
Control	10.80
Treatment VS Control	S
SE m±	0.31

S - Significant

Table 4.13a. Interaction effect of levels and method of irrigation and conservation methods on WUE

Treatments	g litre^{-1}				
	C_0	C_1	C_2	M_1	M_2
I_1	11.80	13.80	10.40	12.50	11.50
I_2	10.30	15.90	12.40	13.60	12.10
I_3	8.70	11.40	10.20	12.30	7.90
F test	S	S	S	S	S
SE m ±	0.13	0.13	0.13	0.10	0.10
CD (0.05)	0.36	0.36	0.36	0.29	0.29
M_1	11.10	15.20	12.10		
M_2	9.50	12.20	9.90		
F test	S	S	S		
SE m ±	0.10	0.10	0.10		
CD (0.05)	0.29	0.29	0.29		

S - Significant

Table 4.14. Effect of irrigation and conservation methods on chlorophyll content

Treatments	Chlorophyll content (mg g^{-1} of fresh leaf) 70 DAT	Harvest
Methods of irrigation		
M_1	0.48	0.19
M_2	0.46	0.18
F test	S	S
SE m±	0.0027	0.0019
CD (0.05)	0.008	0.006
Levels of irrigation		
I_1	0.52	0.24
I_2	0.50	0.18
I_3	0.42	0.16
F test	S	S
SE m±	0.0030	0.0024
CD (0.05)	0.005	0.007
Methods of conservation		
C_0	0.46	0.18
C_1	0.50	0.20
C_2	0.48	0.18
F test	S	S
SE m±	0.0030	0.0024
CD(0.05)	0.005	0.003
Control	0.50	0.24
Treatment VS Control	S	S
SE m±	0.0016	0.0051

S - Significant

4.4. Chemical analysis

4.4.1. Chlorophyll content

The influence of various treatments on chlorophyll content is presented in Table 4.14.

Maximum and significant chlorophyll contents were observed in M_1, I_1 and C_1 at 70 DAT and harvest.

Wick irrigation was superior to other methods of irrigation and recorded a chlorophyll content of 0.50 mg g^{-1}.

None of the interactions were significant.

4.4.2. Nutrient uptake

The data on nutrient uptake is presented in Table 4.15.

M_1 recorded maximum and significantly higher uptake of all nutrients compared to M_2. Uptake of nitrogen and potassium was maximum at I_1 level while the effect due to I_1 and I_2 on uptake of phosphorus was similar and was significantly superior to I_3. C_1 recorded maximum uptake of all nutrients.

Wick irrigation was significantly superior to all treatments with respect to nitrogen uptake.

Table 4.15. Effect of irrigation and conservation methods on nutrient uptake

Treatments	Nutrient uptake (g $plant^{-1}$)		
	N	P_2O_5	K_2O
Methods of irrigation			
M_1	0.71	0.18	1.32
M_2	0.70	0.17	1.30
F test	S	S	S
SE m±	0.008	0.0012	0.0019
CD (0.05)	0.02	0.003	0.009
Levels of irrigation			
I_1	0.80	0.18	1.35
I_2	0.77	0.18	1.34
I_3	0.50	0.16	1.25
F test	S	S	S
SE m±	0.0098	0.0014	0.0023
CD (0.05)	0.03	0.004	0.007
Methods of conservation			
C_0	0.52	0.17	1.30
C_1	0.86	0.18	1.33
C_2	0.69	0.17	1.31
F test	S	S	S
SE m±	0.0098	0.0014	0.0023
CD(0.05)	0.03	0.004	0.007
Control	0.95	0.18	1.30
Treatment VS Control	S	S	S
SE m±	0.04	0.0061	0.0097

S - Significant

Table 4.15a. Interaction effect of levels and method of irrigation and conservation method on nutrient uptake

Treatments	I_1	I_2	I_3
	Potassium (g $plant^{-1}$)		
M_1	1.36	1.35	1.27
M_2	1.35	1.33	1.23
F test	S	S	S
SE m ±	0.0032	0.0032	0.0032
CD(0.05)	0.0093	0.0093	0.0093
	Nitrogen (g $plant^{-1}$)		
C_0	0.60	0.56	0.41
C_1	0.96	0.94	0.70
C_2	0.79	0.80	0.47
F test	S	S	S
SE m ±	0.017	0.017	0.017
CD(0.05)	0.05	0.05	0.05

S - Significant

Table 4.16. Economics of cultivation

Treatments	Cost of treatments pot^{-1} Rs. Ps	Returns pot^{-1} Rs. Ps	Profit pot^{-1} Rs. Ps
$I_1M_1C_0$	0.12	1.98	1.86
$I_1M_1C_1$	0.32	2.40	2.08
$I_1M_1C_2$	0.62	1.72	1.10
$I_2M_1C_0$	0.12	1.43	1.31
$I_2M_1C_1$	0.32	2.20	1.88
$I_2M_1C_2$	0.62	1.67	1.05
$I_3M_1C_0$	0.12	1.03	0.91
$I_3M_1C_1$	0.32	1.35	1.03
$I_3M_1C_2$	0.62	1.24	0.62
$I_1M_2C_0$	0.00	1.90	1.90
$I_1M_2C_1$	0.10	2.12	2.02
$I_1M_2C_2$	0.52	1.67	1.15
$I_2M_2C_0$	0.00	1.28	1.28
$I_2M_2C_1$	0.10	1.93	1.83
$I_2M_2C_2$	0.52	1.54	1.02
$I_3M_2C_0$	0.00	0.71	0.71
$I_3M_2C_1$	0.10	0.85	0.75
$I_3M_2C_2$	0.52	0788	0.26
Absolute control	0.80	2.44	1.64
M_1	0.35	1.66	1.32
M_2	0.21	1.42	1.21
W	0.81	2.44	1.64
C_0	0.06	1.38	1.32
C_1	0.21	1.80	1.59
C_2	0.57	1.43	0.86

M x I interaction was significant only for the uptake of potassium. Maximum uptake was observed at M_1I_1 (1.36g $plant^{-1}$) and the lowest at M_2I_3 (1.23g $plant^{-1}$). IxC interaction was significant with respect to uptake of nitrogen. Maximum uptake as recorded by I_1C_1 (0.96g $plant^{-1}$) and I_2C_1 (0.94g $plant^{-1}$) but they themselves were on a par (Table 4.15a). M x C interaction was not significant.

4.5 Economics of cultivation

Economics of cultivation for the various treatments are presented in Table 16.

The data revealed that the maximum profit (Rs. 2.08) was obtained for the treatment of drip irrigation at 100 per cent FC with coir pith mulching. Among the methods of irrigation, W (Rs. 1.64) was the most profitable. C_1 (Rs. 1.59) gave the maximum profit oompared to C_0 and C_1.

DISCUSSION

5. DISCUSSION

Result of the investigation "Evaluation of low cost techniques in potted vegetables grown in roof gardens" and to determine the water requirement of vegetables are discussed in this chapter.

5.1. Effect of methods of irrigation on growth and yield of chilli

Three methods of irrigation viz. pot, drip and wick were compared and the effects on chilli is discussed.

Drip irrigation promoted growth characters like height, number of branches and LAI at all growth stages. Height increased by 3.9 per cent, branches by 5.1 per oent and LAI by 8.6 percent at harvest stage compared to pot irrigation.

Root area increased by 13.3 and 16.5 per cent at 70 DAT and at harvest respectively. Root dry weight increased by 9.5 per cent at 70 DAT. Similar increase in root dry weight by drip irrigation was reported by Goldberg and Shmueii (1971) in green pepper. Better root growth resulted in better uptake of nutrients (Russell, 1982). Uptake of nitrogen, phosphorus and potassium was increased by 1.4, 5.8

and 7.5 per cent respectively compared to pot watering. The NAR and chlorophyll content also increased by drip irrigation. The increased availability of nitrogen helped to increase the chlorophyll content. (Tisdale and Nelson, 1985). The better values of NAR might be due to better tapping of solar radiation in drip irrigated plants due to better spreading and higher LAI. Leaves are the actual sites of photosynthesis and LAI is the best index to study the ability of a crop to produce dry matter. This better uptake of nutrients coupled with higher content of chlorophyll and NAR resulted in significant increase in growth characters. Similar increase in leaf growth and root development by drip irrigation had been reported by Shmueli and Goldberg (1971) in chilli. A significant increase in DMP was observed at 35 and 70 DAT by drip irrigation. This was due to the higher plant height, more number of branches and higher LAI resulted by drip irrigation. Similar increase in plant DMP due to the increase in number of leaves per plant and LAI had been reported by Shmueli and Goldberg (1971) in drip irrigated muskmelon.

A positive and significant influence on yield contributing characters like number of flowers plant^{-1}, setting per cent, fruits plant^{-1}, fruit length, fruit girth, fruit volume and fruit weight were also observed by drip irrigation. Fruits plant^{-1} increased by five and 100 fruit weight increased by 42 g plant $^{-1}$ compared to pot watering (Table4.9 and 4.10). Similar increase in yield contributing characters by drip irrigation had been reported by Goldberg and Shmueli (1971) in green peppers, Shmueli and Goldberg (1971) in muskmelon, Sivanappan et al (1976)in bhindi and Wivutvongvana et al. (1990) in sweet pepper. A significant positive correlation had been noticed between growth characters like plant height, branches and LAI and yield contributing characters like fruits plant,$^{-1}$ fruit length, fruit girth, fruit volume and fruit weight with yield. This favourable influence on growth and yield contributing characters resulted in higher yield in drip irrigation. By pot watering yield plant $^{-1}$ was 142.8 g and increased to 196.9 g by drip irrigation. Similar increase in yield by drip irrigation had been reported by Goldberg and Shmueli (1971) in green pepper, Sivanappan et al. (1976) in bhindi and Ramesh (1986) in chilli.

In drip irrigation, since water is applied in droplets directly to the root zone, loss is less and availability is more, and this enable the plants to maintain better turgidity of leaves. This along with greater plant vigour and fast growth rate gave higher yield under drip irrigation. (Sivanappan et al. 1976). In drip irrigation, since water is made available to plant in small quantities, evaporation and leaching losses are reduced (Bressler, 1977). Data presented in Appendix II showed that pots irrigated with drip irrigation analyzed a moisture content of 7.6 per cent more than that of pot irrigation. This showed that soil moisture potential was maintained high in drip irrigated pots.

Growth characters viz. height, branches plant^{-1} and LAI at all stages were superior in wick irrigation compared to drip irrigation and pot watering. This better performance may be due to the continuous availability of water which helped in better uptake of nutrients. The uptake of nitrogen, increased by 25.2 per cent than drip irrigation. There was a significant increase in NAR and chlorophyll content also by wick irrigation.

Higher chlorophyll content may be due to higher uptake of nitrogen due to better availability of water. Increased availability of nutrients might have helped in the better expression of growth characters, which helped in better tapping of solar radiation. All these might have resulted in a significant increase in DMP in wick irrigated plants.

Yield contributing characters viz. flowers plant^{-1}, fruits plant^{-1}, length, girth, volume and weight of fruits were also significantly higher in wick irrigation. This higher fruit weight and size could be attributed to higher rate of photosynthesis and increased translocation of photosynthates to the fruits because of continuous supply of waters. (Kaufmann, 1974). This favourable influence on growth and yield contributing characters resulted in higher yield in wick irrigation.

5.2. Effects of levels of irrigation on growth and yield of chilli

Chilli was subjected to three levels of irrigation (60, 80 and 100 per cent FC) and the effect of these levels is discussed here.

When the soil moisture regime was increased from 60 to 80 and 100 per cent FC, a progressive and significant increase in plant height and branching was observed. This increase in plant height and branching resulted in the production of more number of leaves and significantly increased the LAI from 0.49 to 0.94 and 0.99 at 35 DAT and from 1.1 to 1.7 and 1.9 at 70 DAT and from 2.1 to 2.5 and 2.7 at harvest when the moisture potential was increased from 60 to 80 and 100 per cent FC respectively. Similar results were reported by Tamaki and Naka (1971) in broad beans, Beese <u>et al</u>. (1982) in Chilli, George Thomas (1984) in bittergourd, Wankhade and Morey (1984) in chilli and Jayakrishnakumar (1986) in bhindi.

Water is the most important limiting factor among the various factors contributing to plant growth. It is a universal solvent and major constituent of protoplasm which is often regarded as the "physiological basis of life". Increased growth of plants is related to increased turgidity of cell with increase in soil moisture availability leading to cell enlargement and cell division - the two vital processes in plant growth. On the contrary, low available soil moisture or water stress adversely affected the above processess and retarded growth (Begg and Turner, 1976). Reduction in rate of leaf initiation and cell division might be the causes the production of lesser number of leaves under water stress.

A significant and progressive increase in chlorophyll content was observed with increasing levels of moisture. Root area was also increased with increasing levels of soil moisture and this resulted in better exploitation of nutrients which helped to increase the uptake of nutrients. Russell (1982) had opined that low water potential reduces root growth and restrict nutrient uptake because of the reduced root metabolic activity.

Suryanarayana et al. (1983) had reported an increase in chlorophyll content with reduction in irrigation frequency. Uptake of nitrogen increased from 0.5 to 0.8 and P_2O_5 from 0.16 to 0.18 and K_2O from 1.25 to 1.35g plant^{-1} when the moisture content was increased from 60 to 100 per cent FC. This higher uptake of nutrients is mainly due to the reduction in moisture stress under higher levels of irrigation. Similar results in nutrient uptake was reported by Gamayun (1980) in tomato and George Thomas (1984) in bittergourd. Thus higher values of LAI, better branching and higher content of chlorophyll might have resulted in better tapping of solar radiation which might have resulted in higher NAR at 100 per cent FC compared to the lowest level. DMP was profoundly influenced by irrigation (Table 4.4). The production of dry matter is influenced more by moisture supply. It was considered to be the most sensitive index for water supply (Black, 1973). Efficient utilisation of nutrients in the frequently irrigated treatments (Table 4.14) had increased plant growth as evident from the plant height, leaf area index and thereby DMP. Photosynthesis is the basic process for the build up of organic substances and the amount of DMP depend upon the effectiveness of photosynthesis. Leaves are the actual sites of photosynthesis and LAI is the best measure to study the ability of a crop to produce dry matter. Higher DMP due to frequent irrigation had been reported by Tamaki and Naka (1971) in broad beans, Hafeez and

Cornillion (1976) in brinjal, Desai and Patil (1984) in Muskmelon and George Thomas (1984) in bittergourd.

All these resulted in better expression of yield parameters. Setting percentage increased with increasing levels of irrigation and resulted in more number of fruits plant^{-1} which increased from 33.12 to 49.50 and 54.00 with increasing levels of irrigation. Besides the number, the length, girth, volume and weight of fruits also increased with increasing levels of irrigation. Significant positive correlation was noticed between yield and fruit number (0.95), fruit length (0.87) fruit girth (0.88)and fruit volume (0.88). Similar results had been reported by Doss et al. (1975), Goldberg et al. (1976), Gupta and Rao (1978), Beese et al. (1982) and Kwapata (1990). According to Kaufmann (1974) water deficit induced retardation of floral primordia development, flower production, fruit set and induced flower and fruit abscission leading to decrease in fruit production. Increase in fruit length due to frequent irrigation could be attributed to continuing cell division, progressive initiation of tissues and on the differentiation and enlargement of cell (Fisher, 1973). The results are in conformity with the findings of O'Dell (1983) in Capsicum and George Thomas (1984) in bittergourd. Yield plant^{-1} increased by 68 to 96.9 per cent when the irrigation level was increased from 60 to 80 and 100 per cent FC (Table 4.11).

This better performance of crop under 100 per cent FC will be due to the better availability of water which helped to promote the nutrient uptake and various other metabolic activities. Vegetables being highly sensitive to water, maintaining the water potential at higher level must have helped in increasing the yield significantly. This is in agreement with the findings of Smittle and Threadgill (1982) in cucumber and George Thomas (1984) in bittergourd.

5.3. Effects of conservation methods on growth and yield of chilli

Effects of various moisture conservation methods like mulching with coir pith, application of a hydrophilic amendment, Jalsakhti on the performance of chilli are discussed in comparison with control where no conservation method was adopted.

Compared to control and application of hydrophilic amendment, coir pith mulching was significantly superior. Mulching with coir pith must have reduced the evaporation loss of water (Nathan, 1991). Soil temperature recorded at different growth stages showed a reduction by about 1-2^{o}c (Appendix II and Fig.2) compared to other two methods. Final moisture content in pots mulched with coir pith was about

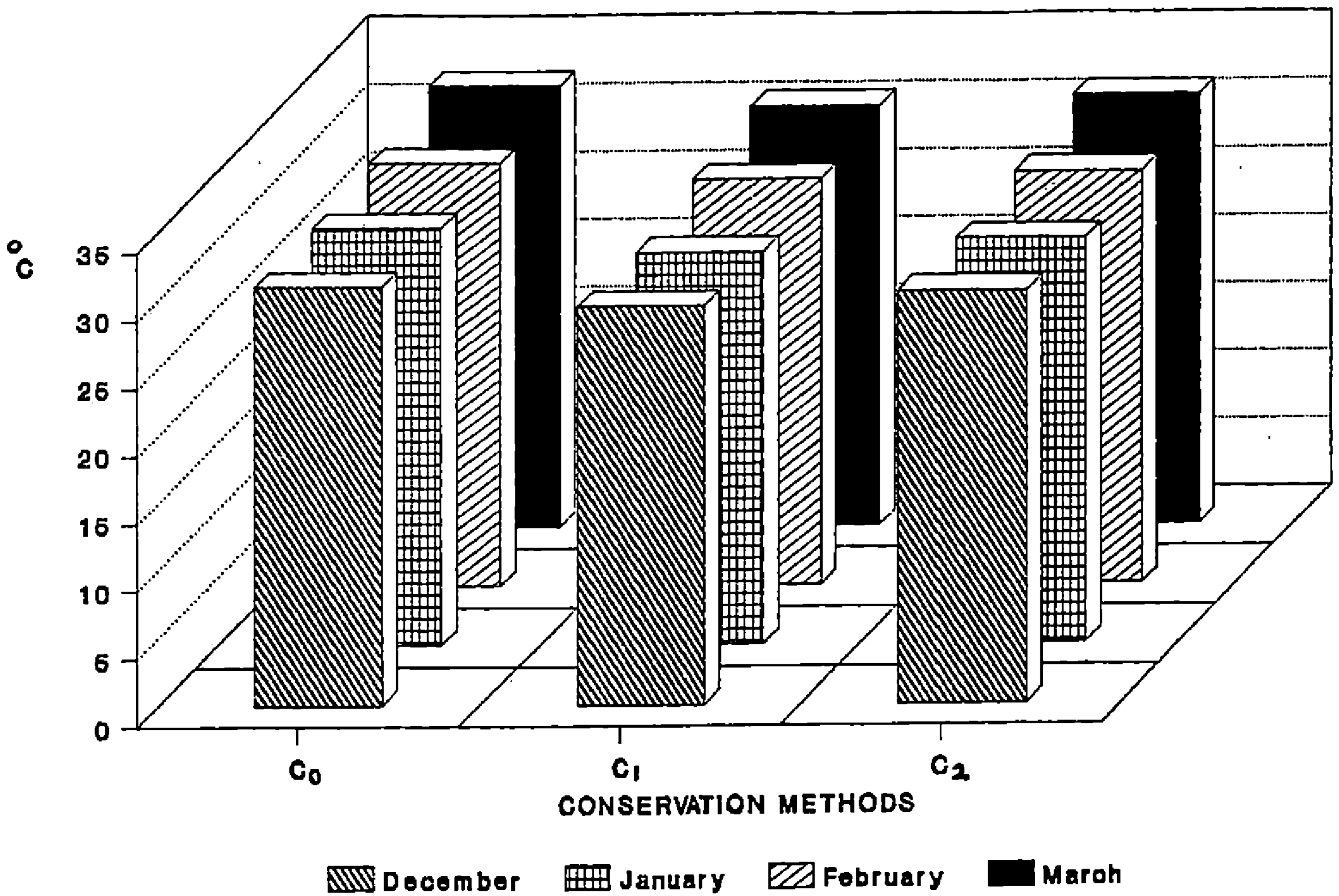

Fig. 2. Soil temperature as influenced by conservation methods

18.9 and 7.8 per cent higher than control and Jalsakhti (Appendix II). This shows that water potential was maintained at higher level in this treatment. According to Bar-Yosef and Sagiv (1982) slight difference in soil matric potential at even a relatively high level of soil moisture can result in marked difference in growth and yield of vegetables

Uptake of nutrients and root spread were also higher in pots mulched with coir pith. High soil moisture content and low soil temperature helped in better growth of root system. (Uthaiah et al 1989). Increase in uptake of nutrients with coir pith mulching was reported by Jayaraj (1992) in rice. This better absorption of water and nutrients resulted in better expression of growth parameters like height, number of branches and LAI which resulted in better DMP. Not only DMP, but also the distribution was favoured by mulching with coir pith . Higher values of NAR was observed at 35-70 DAT. This better NAR may be due to the better development of the solar tapping surface as evidenced by higher LAI and better plant spread. Leaves are the actual sites of photosynthesis. Thus high LAI indicates higher photosynthetic efficiency and thereby higher DMP and distribution. LAI increased by 47.6 and 17.1 per cent by coir pith mulching compared to control and application of Jalsakhti at 35 and 70 DAT respectively. This result is in conformity with the findings of Patil and Bansod (1972) and Olasantan (1985) in tomatoes and Vander Werken and Wilcox (1988) in bell pepper.

Improved growth associated with mulched crops resulted from both the cooling effect of mulch and the improved soil moisture retention by mulch (Uthaiah _et al_. (1989). Mulch also benefits crop production through weed control; improved soil physical and chemical properties and enhanced biological activity (Ekern, 1967; Lal _et al_. 1980; Tumuhairwe and Gumbs 1983). Coir pith analysed a nutrient content of 0.5, 0.09 and 0.84 per cent nitrogen, phosphorus and potassium respectively.

All yield contributing characters were significantly higher in coir pith mulched plots and this resulted in an yield of 181.3 g $plant^{-1}$ compared to 144.2 g $plant^{-1}$ in Jalsakhti and 139.2 g $plant^{-1}$ in control. This significantly higher yield is due to the favourable moisture retention, facilitating better availability and uptake of nutrients. Similar increase in yield contributing characters and finally yield had been reported by Patil and Bansod (1972) and Olasantan (1985) in tomatoes, Negreiros _et al_. (1990) in capsicum and Kwapata (1990) in tomatoes.

Jalsakhti produced significantly superior effect over control. Jalsakhti has the capacity to hold thousand times its weight of water and slowly release it for crop use. This ensures continuous supply of water to crop even at times of shortage. Final moisture content in pots treated with Jalsakhti was about 12 per cent higher than control (Appendix II). This high water potential enabled better root spread and thereby better uptake of nutrients. This better absorption of nutrients and water resulted in better expression of growth parameters like height, branches plant^{-1} and LAI which resulted in better DMP over the control. Similar increase in growth parameters had been reported by Wallace et al (1984) in tomatoes and Woodhouse and Johnson (1991) in lettuce.

All yield contributing characters were higher in pots treated with Jalsakhti compared to control. This higher yield might have resulted from the cumulative favourable effect on various growth and yield contributing characters. Higher yield with supersorbing polymers had been reported by Woodhouse and Johnson (1991) in lettuce. Hydrophilic polymer improved drainage and aeration, root growth, shoot growth and reduced plant water stress (Wallace et al. 1984).

Result of this the study show that coir pith mulching is superior to application of Jalsakhti.

5.4. Water use efficiency as influenced by irrigation and conservation methods

WUE is defined as the ratio of the economic yield to the quantity of water utilised by the crop. WUE is highly determined by different methods and levels of irrigation and moisture conservation. Drip irrigation recorded the maximum WUE compared to pot watering and wick irrigation. Under drip irrigation 13.06 litres of water was used, whereas, the quantity of water consumed in pot and wick irrigation was 13.15 litres and 22.5 litres respectively (Appendix III). This shows that the quantity of water used in drip irrigation is less than that used under pot and wick irrigation. Eventhough yield was more under wick irrigation, WUE was high under drip irrigation. This is due to the reduction in quantity of water used under drip irrigation. Similar results had been reported by Sivanappan (1979) in solanaceous vegetables and Wivutvongvana et al. (1990) in muskmelon on comparing drip and furrow irrigation. This higher WUE reflects reduction in loss under drip irrigation. This reduction in loss is because water is being given only at the root zone and this minimise various types of losses. The reduction in water loss along with better availability had resulted in higher WUE. Kaniszewski and Dysko (1988) in tomatoes had reported that water use was 35 per cent lower and water consumption per kg of fruit was the lowest in drip system and the highest in hand watering.

With respect to levels of irrigation maximum WUE was observed at I_2 level. Quantity of water used under I_2 level was 13.03 litres wh[illegible] 20.5 per cent lesser than I_1 level and 24.2 per cent [illegible] than I_3 level. At I_2 level, eventhough yield was less than I_1 level, WUE was high. This is due to saving of irrigation water. Water above the optimum level may get lost in the form of excessive evaporation and transpiration. WUE is likely to increase with decrease in soil moisture supply until it reaches the minimum critical level because the plants may try to economise water loss in the range from minimum critical to optimum soil moisture level. These findings are in agreement with the reports of Singh and Singh (1978) and Sharma and Parashar (1979). At 100 per cent field capacity, the evaporation loss might have been more compared to the just lower level. Additional yield obtained at 100 per cent field capacity over 80 per cent was not enough to compensate with the extra quantity of water used. At I_3 level, yield was much less and that has resulted in lower WUE.

Among the conservation methods, coir pith resulted in significantly higher WUE. This is due to the cumulative effect of higher yield and lesser quantity of water used in coir pith mulched pots. Coir pith can hold eight times its weight of water. It is an excellent rooting medium and insulating material and also a soil conditioning medium (Menon and Pandalai, 1958). Nagarajan et al. (1987) had reported that moisture content of soil was increased substantially by continuous application of coir pith and the increase varied from 0.5 to 11.6 per cent. Coir pith can increase the surface and subsurface water holding capacity of soil and can reduce weed population. Coir pith conserved moisture by reducing evaporation and by holding more moisture. Increase in WUE due to mulching was due to saving of irrigation water and enhanced fruit yield (Uthaiah et al. 1989; Jayaraj 1992). Higher availability of moisture under mulching affected growth and yield contributing characters favourably which ultimately caused higher yields.

Thus it is seen that drip irrigation gave the highest WUE eventhough the highest yield was obtained by wick irrigation. 80 per cent field capacity gave higher WUE eventhough yield was high at 100 per cent field capacity. The increase in yield obtained at 100 per cent FC is not enough to compensate the additional amount of water used. Coir pith gave higher WUE compared to Jalsakhti and control. This may be due to the low soil temperature and high moisture retentivity resulted from coir pith mulching.

5.5. Growth, yield and nutrient uptake of chilli as influenced by levels and methods of irrigation and moisture conservation methods

The interaction effect of two methods of irrigation with different levels of irrigation revealed that under drip method of irrigation, yield increased by 26.5 and 56 per cent when the level was increased from I_3 to I_2 and I_1. Corresponding percent of increase in pot watering was 31.4 and 80.2 respectively. Under both methods of irrigation, the highest yield was obtained at the highest level. The percentage increase in yield was more in pot watering compared to drip irrigation. This difference in yields obtained under different levels of irrigation in drip irrigation was less compared to pot watering. This shows that the loss of water is less under drip irrigation compared to pot watering, since water is applied in droplets directly to the rootzone of the crop. This results in the maintenance of high soil water potential in the root zone of the crop. Under pot watering, maintenance of the highest level of water potential had resulted in an increase of only 13.5 per cent more yield than that obtained at 80 per cent field capacity in drip irrigation. But at 80 percent FC, yield realised in pot watering was 18 per cent less than that obtained in drip irrigation. The corresponding values at 60 and 100 per cent

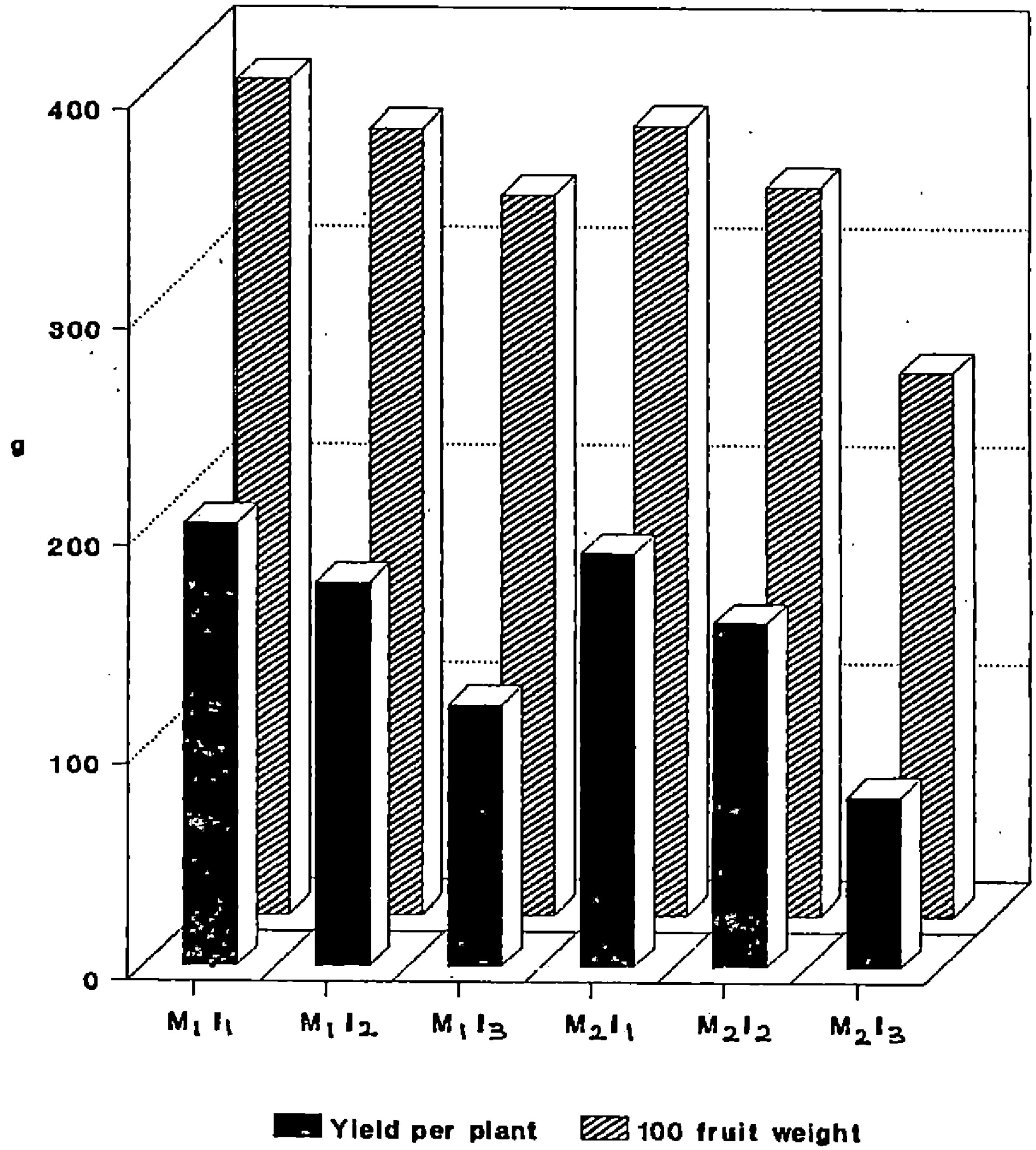

Fig. 3. Interaction effect of levels and methods of irrigation on 100 pod weight and yield $plant^{-1}$

field capacity were 42.1 and 13 respectively. This shows that with increasing levels of water, the differences in yield obtained under drip irrigation decreases. This is due to better availability of water under drip irrigation. Even at 60 per cent FC yield obtained, under drip irrigation is almost double compared to yield realised under pot watering at the same level. At 80 per cent FC yield realised under drip irrigation was only 7.1 per cent less than yield realised at 100 per cent FC under pot watering. The highest hundred fruit weight was obtained for drip irrigation at 100 per cent FC, but it was only 5.7 per cent less than drip irrigation at 80 per cent FC. Significent positive correlation was noticed between hundred fruit weight (0.91) and yield (Fig.3). This shows that about 20 per cent of water can be saved without much reduction in yield by adopting drip irrigation. Kaniszewskii and Dysko (1988) in tomatoes noted that water use in drip systems was about 35 per cent lower than hand watering by hose. The increase in yield obtained at 60 per cent FC under drip irrigation over pot watering may be due to the low degree of stress created by drip irrigation as reported by Lin _et al_. (1983).

At each level of irrigation coir pith recorded significantly higher yield. By mulching with coir pith, maintenance of water potential at 80 per cent realised an yield (206.8g) which was significantly higher than the yield

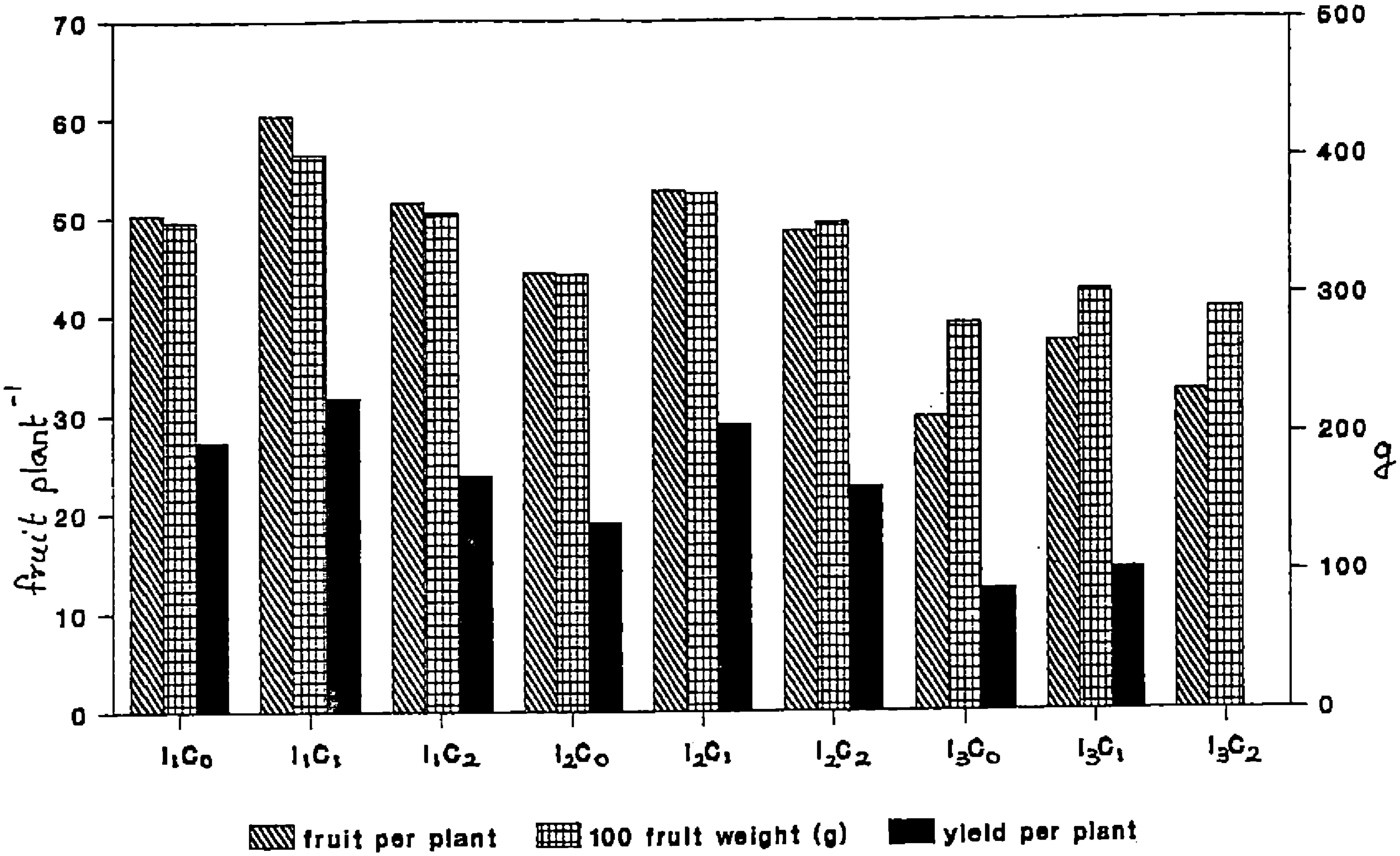

Fig. 4. Interaction effect of levels of rrigation and conservation on 100 fruit weight, fruit plant^{-1} and yield plant^{-1}

that is realised under I_1 C_0 and I_1 C_2. This showed that about 20 percent water can be saved by mulching with coir pith at I_2 level. 100 per cent FC with coir pith mulch significently influenced fruit plant $^{-1}$ and hundredfruit weight. But the percentage increase in fruit plant $^{-1}$ and hundred fruit weight by this treatment combination over 80 per cent FC with coir pith mulching was only 1.2 and 7 respectively. Significent positive correlation was observed between fruits plant^{-1} (0.95) and hundred fruit weight (0.9) with yield (Fig.4). This better effect of coir pith may be due maintenance of better water potential by reducing evaporation loss. Tumuhairwe and Gumbs (1983) had reported that mulching increased the available water by 40 per cent with irrigation and 20 per cent without irrigation and this significantly increased the growth and yield of cabbage. Similar result was reported by Patel and Singh (1979). The increase in yield may be due to the increased fruit weight with mulching.

In both methods of irrigation, coir pith mulched plants recorded significantly higher number of fruits plant^{-1} and yield over control and Jalsakhti. Significant correlation was observed between number of fruits and yield plant $^{-1}$ (Fig.5). The increase in yield in drip irrigated pots was 20.75 per cent over pot watered pots mulched with coir pith. The reduction in yield in drip irrigated control

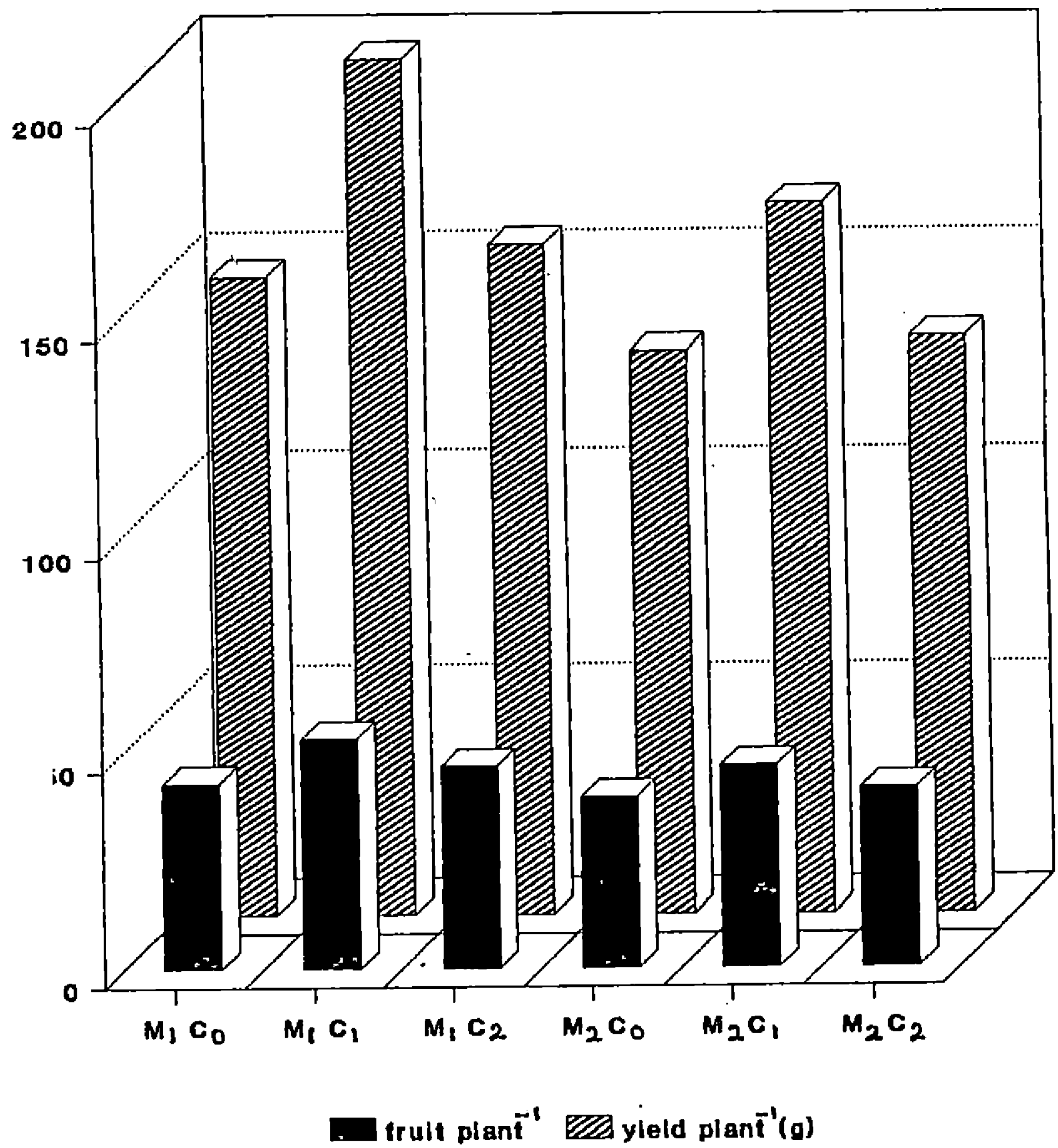

Fig. 5. Interaction effect of methods of irrigation and conservation methods on the fruit and yield plant^{-1}

pots was only 11.1 per cent less than coir pith mulched pots irrigated by pot watering. This is due to the reduction in evaporation loss of water and also maintenance of high soil water potential by drip irrigation. Improved growth associated with mulched crops resulted from favourable environment and improved soil moisture retention by mulching (Vanderwerken and Wilcox, 1988)

Maximum yield was obtained on drip irrigating to FC along with coir pith mulching (Appendix III). However, Wick irrigation out yielded all other treatment combinations.

5.6. WUE as influenced by level and methods of irrigation and conservation methods

Under all levels of irrigation WUE was higher under drip irrigation compared to pot watering. Same trend had been observed with respect to yield also. Higher yield in drip irrigation is due to better availability of moisture, which resulted in better fruit growth and uptake of nutrients. Better uptake of nutrients resulted in better expression of the various growth characters which finally culminated in higher yield of the crop. So higher yield coupled with reduction in quantity of water used had resulted in better WUE under drip irrigation. Visalakshi (1991) had reported of

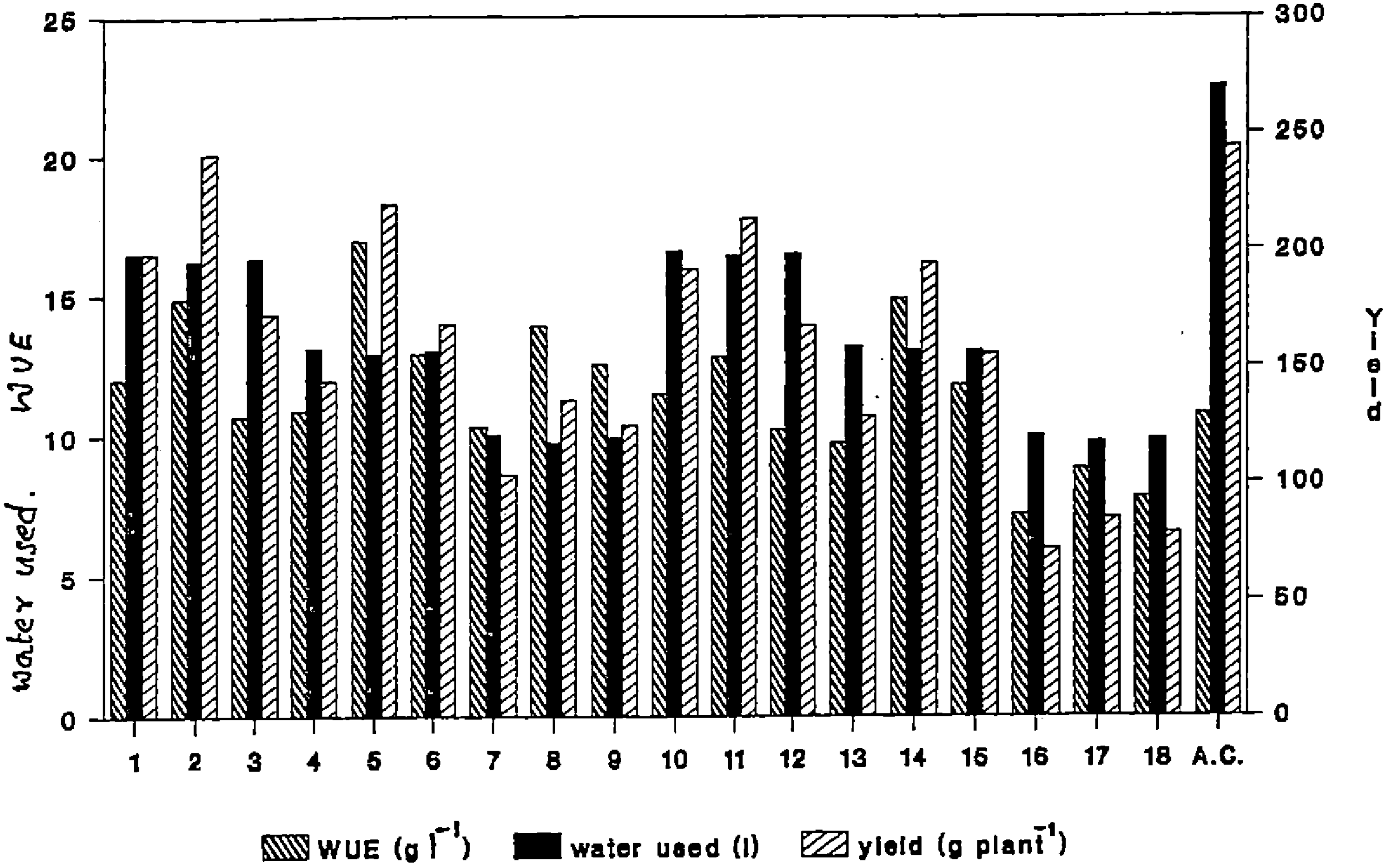

Fig. 6. Interaction effect of levels and methods of irrigation and conservation methods on water used, WUE and yield

higher WUE under drip irrigation compared to basin irrigation in ash gourd.

At all levels and methods of irrigation, significantly higher yield was recorded by coir pith mulching. Water requirement was also less in coir pith mulched pots. This low water requirement coupled with higher yield resulted in higher WUE in coir pith mulched pots. Higher WUE with mulching was reported by Gupta 1975. Maximum WUE was obtained with 80 per cent FC by drip irrigation and coir pith mulching (Fig.6 and Appendix III).

SUMMARY

SUMMARY

A pot culture study was conducted at the College of Agriculture, Vellayani to evaluate the lowcost techniques in potted vegetables and to compare the efficiency of various techniques for economising water use in vegetables. The experiment was conducted with chilli cultivar 'Jwalasakhi' as test crop. The treatments included three levels of irrigation. (I_3=60, I_2=80 and I_1=100 percent field capacity), two methods of irrigation (M_1=indigenous auto irrigation using hospital drip and M_2=pot watering) and three moisture conservation methods (C_0=control without any conservation, C_1=application of coir pith, and C_2=application of Jalsakhti). One absolute control viz. wick irrigation was compared with other treatments potting mixture prepared by mixing sand, soil and cowdung in 1:1:1 proportion by weight was used as the rooting medium. The medium was low in available nitrogen, high in available phosphorus and low in available potassium. The field capacity and permanent wilting point were 18.4 and 7.4 percent respectively. The experiment was laid out in completely randomised design with six replication. The results of the investigation are summarised below.

1. Plant height, branches and LAI and DMP differed significantly with methods and levels of irrigation and

conservation methods at all stages of growth. Values of all these growth characters were maximum with drip irrigation, at 100 percent FC with respect of levels of irrigation and with coir pith mulching among conservation methods.

2. Root area differed significantly with treatments at 70 DAT and harvest. Maximum area was with drip irrigation, 80 percent FC which was on par with 100 percent FC and coir pith mulching. The effect on tap root length was significant only with levels of irrigation and conservation methods. Maximum length was at 70 DAT at 80 percent FC and coir pith mulching. At harvest maximum length was at 100 percent FC.

3. Methods and levels of irrigation and conservation methods had profound influence on root dry weight at 70 DAT. Maximum weight was observed with drip irrigation, 100 percent FC and coir pith mulching respectively.

4. At 70 DAT and harvest shoot root ratio differed significantly with treatments. Maximum ratio was with drip irrigation, 100 percent FC and coir pith mulching respectively.

5. Effect of methods of irrigation on NAR was significant only in the initial stage with higher value recorded

with drip irrigation. But for RGR, significantly higher value was obtained with pot watering in the later stages. Levels of irrigation was significant on NAR in both stages and RGR in the initial stage. Maximum NAR was at 100 percent FC at both stages and RGR at 60 percent FC.

6. Significant influence was observed on 50 percent flowering, flowers plant^{-1}, setting percent and fruits plant^{-1} with treatments. Drip irrigation, 100 percent FC and coir pith mulching respectively were the superiormost in their influence on the above parameters.

7. Treatments had significant effect on fruit length, fruit girth, fruit volume and hundred fruit weight. The maximum values for all the above parameters were obtained for drip irrigation, 100 percent FC level and coirpith mulching respectively.

8. Effect of methods and levels of irrigation and conservation methods on yield plant^{-1} was highly significant. Maximum yield was obtained for drip irrigation, 100 percent FC level and coir pith mulching respectively.

9. HI was significntly influenced by methods and levels of irrigation. Highest HI was for drip irrigation, and irrigation at 100 percent FC respectively.

10. WUE differed significantly with respect to treatments. WUE was high for drip irrigation, irrigating at 80 percent FC and coir pith mulching.

11. Chlorophyll content varied significantly with treatments at 70 DAT and harvest. Chlorophyll content was high at drip irrigation, 100 percent FC and coir pith mulching.

12. Significant influence of treatments on nutrient uptake was observed. Drip irrigation increased nutrient uptake compared to pot watering. With respect to levels of irrigation, nitrogen and potassium uptake were maximum at 100 percent FC but phosphorus uptake was high at 80 percent FC. Coir pith mulching recorded maximum uptake of all nutrients.

13. With respect to methods of irrigation, wick irrigation was superior to drip irrigation in all the above parameters except for LAI at 70 DAT, taproot length, RGR and WUE.

14. Significant correlation was noticed between yield and the various yield attributes.

15. Economics of cultivation revealed maximum profit for drip irrigation to 100 percent FC along with coir pith mulching.

16. Interaction effect due to methods and levels of irrigation were significant on LAI and taproot length at 70 DAT and harvest, root dry weight, shoot root ratio at harvest, NAR in the later stages and hundred fruit weight, HI and potassium uptake. Irrigation at 100 percent FC under drip irrigation was superior with respect to LAI, taproot length shoot root ratio, hundred fruit weight, HI and potassium uptake. Root dry weight was similar by drip irrigation at 100 per cent and 80 per cent FC. Maximum NAR was at 80 per cent FC under pot watering.

17. Interaction effect due to levels of irrigation and conservation methods was significant on plant height at 70 DAT, number of branches, DMP, root area and tap root length at 70 DAT and harvest, root dry weight, shoot root ratio, RGR and NAR at both stages, setting per cent, fruits plant^{-1}, fruit girth, fruit volume and nitrogen uptake.

    Irrigation at 100 per cent FC with coir pith mulching recorded maximum value with respect to height at harvest, number of branches and DMP at 70 DAT and harvest, tap root length, shoot root ratio, NAR at later stage, setting per cent, fruits plant^{-1}, fruit girth fruit volume, hundred fruit weight, HI and nitrogen uptake. With respect to root dry weight and root area, 80 per cent FC with coir pith mulching was the best. Maximum NAR was at 100 per cent FC with coirpith mulching during the initial stage.

18. Interaction effect of methods of irrigation and conservation had profound influence on plant height at 70 DAT, number of branches at harvest, LAI, root area and tap root length at 70 DAT and harvest, root dry weight, shoot root ratio, time of 50 per cent flowering, flowers plant^{-1}, setting per cent, fruits plant^{-1}, fruit girth and hundred fruit weight. Drip irrigation with coir pith mulching proved best with respect to plant height, number of branches, LAI, shoot root ratio, 50 per cent flowering, flowers plant^{-1}, setting per cent, fruits plant^{-1}, fruit girth and hundred fruit weight.

19. All the three interactions were significant for tap root length at 70 DAT and harvest, root dry weight, shoot root ratio, yield plant^{-1} and WUE. Yield plant^{-1} was maximum at 100 per cent FC under drip irrigation, 100 per cent FC with coir pith mulching and at drip irrigation with coir pith mulching.

    WUE was high for 80 per cent FC under drip irrigation, 80 per cent FC with coir pith mulching and drip irrigation with coir pith mulching.

20. Drip irrigation at 100 per cent FC along with coir pith mulching recorded maximum yield $plant^{-1}$. and drip irrigation at 80 per cent FC with mulch gave the highest WUE.

This study shows that WUE is maximum at 80 per cent FC while maximum yield was at 100 per cent FC. Among the methods of irrigation wick outyield drip and pot but WUE is maximum for drip. Coirpith stands first with respect to yield and WUE among moisture conservation materials tried for this study.

Future line of work

1. Feasibility of the indigenous auto irrigator for fertigation should be studied

2. Detailed investigations on the effect of coir pith on various soil properties is warranted

3. Different rate of application of irrigation water should be tried

4. Wick irrigation can be tried at different mositure regimes

5. The investigation should be tried with different vegetable crops

REFERENCES

REFERENCES

Arvind kumar, Ved Prakash and Singh, R.P. (1991). Influence of starch polymer on yield attributes, yield and quality of mustard (Brassica juncea) under rainfed conditions. Indian J. Agron. 36(4): 610-611.

Balaswamy, K., Basker Reddy, B., Anand Reddy, K., Buccha Reddy, B. and Madhava Reddy, V. (1986). Effect of planting patterns, mulches and soil moisture regimes on growth and yield attributes of maize. Madras Agric J. 73(10): 553-557.

Bandhopadhyay, S.K. and Ray, S.B. (1988). Changes in some physical properties of sandy loam soil as influenced by Jalsakhti. Indian J. Agron. 33(4): 447-450.

Bar-Yosef., Claire Sammers. and Sagiv, B. (1980). Growth of trickle irrigated tomato as related to rooting volume and uptake of nitrogen and water. Agron. J. 72(5): 815-822.

Bar-Yosef. and Sagiv, B. (1982). Response of tomatoes to nitrogen and water applied via a trickle irrigation system. Agron. J. 74(4): 637-639.

Beese, F., Horton, R. and Wierenga, P.J. (1982). Growth and yield response of chile pepper to trickle irrigation. Agron. J. 72(5): 556-561.

Begg, J.E. and Turner, N.C. (1976). Crop water deficits. Adv. Agron. 28: 161-207.

Bernstein, L. and Francois, L.R. (1973). Comparison of drip, furrow and sprinkler irrigation. Soil Sci. 115: 73-76.

Bhella, H.S. (1988). Tomato response to trickle irrigation and black polyethylene mulch. J. Amer. Soc. Hort. Sci. 113(4): 543-546.

Black, C.A. (1973). Soil Plant Relationship. 2nd edition. Wiley Eastern Pvt. Ltd., New Delhi. PP. 111.

Blackmann, C.A. (1919). Comparative physiological studies on the growth of field crops. Ann. Bot. 11: 41-76.

Borelli, A. and Zerbi, G. (1977). Effect of different irrigation methods and levels on greenhouse muskmelon. Aota Horticulturae. 58: 129-135.

Bower, C.A., Krasky, B.A. and Iheda, N. (1975). Growth of tomato on a tropical soil under plastic cover as influenced by irrigation practise and soil salinity. J. Amer. Soc. Hort. Sci. 100(5): 519-521.

Bressler, E. (1977). Trickle-drip irrigation principles and applications to soil water management. Adv. Agron. 29: 343-393.

*Bryon, H.H., Stall, W.M., Datton, J.D. and Ford, H.W. (1976). Response of vegetables to drip and overhead irrigations in calcareous soils. Proc. Fla. St. Hort. Sci. 88: 190-196.

Bucks, D.A., Eric, L.J. and French, O.F. (1974). Quality, quantity and frequency of trickle irrigation and furrow irrigation for efficient cabbage production. Agron. J. 66(2): 53-57.

Carters, J. and Johnson, C. (1988). Influence of different types of mulches on egg plant production. Hort. Sci. 23(1): 143-145.

Chartzoulakis, K. and Michelakis, N. (1990). Effect of different irrigation systems on root growth and yield of greenhouse cucumbers. Acta Horticulturae. 278: 237-243.

Desai, J.B. and Patil, V.K. (1984). Effects of sowing dates and irrigation on growth, yield and quality of water melon. J. Maharashtra Agric. Univ. 9(1): 34-37.

Dirks, V.A. and Tan, C.S. (1988). Root distribution of irrigated and non irrigated crop. Acta Horticulturae 228: 229-316.

Donald, C.M. (1962). In search of yield. J. Aust. Inst. Agr. Sci. 28: 171-178.

Doss, B.D., Evan, C.K. and Johnson, W.A. (1975). Rates of nitrogen and irrigation for tomatoes J. Amer. Soc. Hort. Sci. 100(4): 435-437.

Ekern, P.C. (1967). Soil moisture and soil temperature changes with the use of black vapor-barrier mulch and their influence on pineapple (Ananas comosus) growth in Hawaii. Soil. Sci. Soc. Amer. Proc. 31: 270-275.

Elmstorm, G.W., Locascio, S.J. and Myers, J.M. (1982). Water melon response to drip and sprinkler irrigation. Proc. Fla. St. Hort. Soc. 94: 161-163.

*Ferreyra, E.R., Sellesvan, S.G. and Gonzalez, P.M. (1987). Effect of different water levels of pepper. III Plant water relations and N, P and K absorption. Agricultura Tecnica. 47(3): 304-307.

Fischer, R.A. (1973). Plant response to climatic factor. pp. 233-241, UNESCO, Paris.

Flannery, R.L. and Busscher, W.J., (1982). Use of synthetic polymer in potting soils to improve water holding capacity. Commn. Soil Sci. Pl. Anal. 13(2): 103-111.

*Gamayun, I.M. (1980). Development, growth and productivity of midseason tomato in relation to irrigation regimes. Sel skakhzyaistaennaya Biologiyas 15(1): 141-142.

George Thomas. (1984). Water management practices for bittergourd (Momordica charantia. L.) under different fertility levels. M.Sc. (Ag.). Thesis. Kerala Agricultural University.

*Goldberg, D., Gornat, B. and Rimon, D. (1976). Drip irrigation principles, design and agricultural practises. Drip irrig. Sci. Publ. (Kfar, Shumaryaha), Israel. pp. 295.

Goldberg, D and Shmueli, M. (1971). Sprinkler and trickle irrigation of green pepper in an arid zone. Hort. Sci. 6(6): 559-562.

Gupta, A. (1989). Note on response of tomato to irrigation and nitrogen. Indian J. Hort. 46(3): 401-403.

Gupta, A. and Rao, G.G. (1978). Note on the response of spring planted tomato to irrigation and nitrogen. Indian J. Agrl. Sci. 48(3): 183-184.

*Gupta, J.P. and Gupta, G.N. (1987). Response of tomato and okra crops to irrigation and mulch in an arid region of India. Agrochimica. 31(3): 193-202.

Gupta, U.S. (1975). Physiological aspects of dryland farming. Oxford and IBH publishing Co., NewDelhi. pp. 3-145.

*Gutal, G.B., Jadhav, S.S. and Takte, R.L. (1990). Response of chilli crop to drip irrigation. In Proc. Int. Agr. Engg. Conf and exhibition. Thailand. 3-6 Dec.

Hafeez, A.T.A. and Cornillion, P. (1976). Effect of irrigation rhythm on growth, fruit set, yield and quality of egg plant (Solanum melongena) in South France. Plant and Soil. 45(1): 213-225.

Halevy, I., Boaz, H., Zohar, Y., Shani, M. and Dan, M. (1973). In Trickle irrigation, FAO Irrig. Drain. Paper No. 14: 75-117.

Hankin, Lester and David, E. Hill. (1982). Effect of mulches on bacterial population and enzyme activity in soil and vegetable yields. Plant and Soil. 64(2): 193-202.

Hanna, H.Y., Shao, K.P. and Adams, A.J. (1985). Drip irrigation increases yield of fresh market tomatoes. Louisiana agriculture. 28(3): 10-12.

*Hanson, E.G. and Peterson, T.C. (1974). Vegetable production and water use efficiency as influenced by drip, sprinkler, sub surface and furrow irrigation methods. Proc. 2nd. Int. Drip. Irrig. Congr. 97-102.

Hegde, D.M. (1988). Effect of irrigation and nitrogen fertilization on yield, quality, nutrient uptake and water use of onion. (Allium cepa. L.) Singapore J. Primary Industries. 16(2): 111-123.

Hegde, D.M. (1988a). Effect of irrigation regimes on growth, yield and water use of sweet pepper. (Capsicum annum. L.) Indian J. Hort. 45(3-4): 288-294.

Hegde, D.M. (1988b). Effect of irrigation and nitrogen requirement of bell pepper. (Capsicum annum. L.) Indian J. Agrl. Sci. 58(9): 668-672.

Hegde, D.M. and Srinivas, K. (1988). Growth, nutrient accumulation and quality of tomato fruits in relation to irrigation. S. Indian Hort. 38(2): 90-94.

*Isenberg, F.M. and Odland, M.L. (1950). Comparative effect of various organic mulches and clean cultivation on the yields of vegetable crops. Prog. Rep. Pa. Agri. Expt. St. 35: 1-10.

Jackson, M.L. (1973). Soil Chemical Analysis (2nd ed.) Prentice Hall of India (Pvt.) Ltd., NewDelhi. 498 pp.

Jagmail Singh., Bharadwaj, S.N. and Munshi Singh. (1990). Leaf size and Specific leaf weight in relation to its water potential and relative water content in upland cotton. (Gossypium hirsutum). Indian J. Agrl. Sci. 60(3): 215-216.

Jayakrishnakumar, V. (1986). Water management in relationship to split application of nitrogen on bhindi (Abelmoschus esculentus (L.) Moench). M.Sc. (Ag.) Thesis. Kerala Agricultural University.

Jayaraj, S. (1992). Coir pith as organic supplement for crop fields 'The Hindu' 8th April.

Jayasree, P. (1987). Effect of different mulches on physico chemical properties of soil. M.Sc. (Ag.) Thesis. Kerala Agricultural University.

Kafkafi, G. and Bar. Yosef, B. (1980). Trickle irrigation and fertilization of tomatoes in highly calcareous soils. Agron. J. 72(6): 892-893.

Karlen, D.L. and Camp, C.R. (1985). Fresh market tomato response to N and K fertilization and water management practices. Commn. Soil. Sci. Pl. Anal. 16(1): 71-81.

*Kartalov, P. and Dimitrov, Z. (1970). Water regime of pepper grown in hot beds. "V. Kolarov". Plovdiv, 19(2): 89-95.

Karthikakutty Amma. (1977). Plant and soil analysis. pp. 23-25.

Kaufmann, M.R. (1974). Plant responses and control of water balance-water deficit and reproductive growth. In "Water deficits and plant growth" Vol. III (Ed. T.T. Kozlowskii). Academic Press, New York pp 91-124.

Kwapata, H.B. (1990). Response of contrasting tomato cultivars to depth of applied mulch and irrigation frequency under hot, dry, tropical conditions. Tropic. Agric. 68(3): 301-303.

Lal, R.D., De Vleeschanwer and Malafa Nganje. (1980). Changes in properties of newly cleared tropical alfisol as affected by mulching. Soil Sci. Soc. Amer. J. 44: 828-833.

Lin, S.S.M., Hubbel, J.N., Samson., Tson, S.C.S. and Splittstoesser, W.E. (1983). Drip irrigation and tomato yield under tropical conditions. Hort. Sci. 18(4): 460-461.

Loganathan, S. (1990). Effect of certain tillage practices and amendments on physico-chemical properties of problem soils. Madras Agric J. 77(5&6): 204-208.

Menon, K.P.V. and Pandalai, K.M. (1958). Coir dust. The coconut palm. Monograph. pp. 341.

Michael, A.M. (1985). Irrigation Theory and Practise. Vikas Publishing House Pvt. Ltd. pp. 547.

*Nagarajan, T.S., Manickan and Kothandaramam, C.V. (1987). Coir pith as manure for ground nut. Coir. 31(2): 15-18.

Narayana Rao, K. and Kondap, S.M. (1988). Effect of herbicides under different soil moisture regimes on weed control, yield and quality of chilli. (Capsicum annuum. L.). The J. Res. APAU. XVI (2) pp 185.

Nathan K.K. (1991). Mulches for managing the microclimate of crops. Kisan world January. p. 48-50.

*Negreiros, M.Z. De., Pedrosa, J.E. and Noguiera, C.C. (1990). Effect of mulching on Capsicum cv in the Mossoro-RN region. Horticultura Brasiliera. 8(1): 11-13.

O'Dell, C. (1983). Trickle did the trick. American Vegetable Grower. 31(4):56.

Olasantan, F.O. (1985). Effect of intercropping, mulching and stacking on growth and yield of tomatoes. Expl. Agric. 21 pp. 135-144.

Padmakumari, O. and Sivanappan, R.K. (1978). Studies on drip irrigation in brinjal crop. Madras. Agric. J. 65(9): 608-609.

Pai, A.A. and Hukeri, S.B. (1979). (Ed.). Manual on irrigation water management. Ministry of Agriculture and irrigation, Department of Agriculture, Krishi Bhavan, New Delhi. pp. 3-26.

Palled, Y.B., Radder, G.B. and Chandrasekhariah, G.B. (1985). Response of chillies to various moisture regimes, nitrogen levels and spacings. Indian J. Agron. 30(1): 131-132.

Patel, J.C. and Singh. R.M. (1979). Water use and yield of sunflower (Helianthus annuus. L.) as influenced by irrigation, mulch and cyocel application. Madras Agric. J. 66(12): 777-782.

Patil, A.V. and Bansod, A.D. (1972). Effect of different mulching treatments on soil properties, growth and yield of tomato. (Var. SIOUX). Indian J. Hort. 29(2): 418-420.

Piper, C.S. (1966). Soil and Plant Analysis. University of Adelaide, Australia. p. 368.

Prabhakar, M. and Srinivas, K. (1990). Effect of irrigation practises on growth, yield and water of okra (*Abelmoschus esculentus*). Indian J. Agrl. Sci. 62(5): 309-132.

Pulekar, C.S., Patil, B.P. and Rajput, J.C. (1990). Water use, yield and economics of chilli as influenced by irrigation regimes and genotypes. J. Maharashtra Agrl. Univ. 15(2): 247-249.

Raja, V. and Bishnoi, K.C. (1990). ET, WUE. moisture extraction pattern and plant water relations of rape (*Brassica campestris*) genotypes in relation o root development under varying irrigation schedules. Expl. Agric. 26: 227-233.

Ramesh, S. (1986). A study on drip and furrow methods of irrigation in green chilli (*Capsicum annuum*. L.) under different planting patterns and planting density. M.Sc. Thesis. GKVK. Bangalore.

Randall, H.C. and Locascio, S.J. (1988). Root growth and water status of trickle irrigated cucumber and tomato. J. Amer. Soc. Hort. Sci. 113(6): 830-935.

Richards, L.A. (1947). Pressure membrane apparatus construction and use. Agr. Engg. 28: 451-454.

Rivera, L.E. and Goyal, M.R. (1986). Mulch types for soil moisture retention in drip irrigated summer and winter peppers. J. Agric. Uni. Puerto Rico., 70(4): 303-305.

Russel Scott. (1982). Plant root systems. Their function and interaction with the soil. McGraw Hill Book Company Ltd. pp. 97-99.

*Sadykov, I.M., and Mikhael ZH-YU (1982). Irrigation regime in direct sown capsicums. Trudy Kuban S-kh In-t No. 197: 114-118.

Saffadi, A.S. and Battikhi, A.M. (1988). A preliminary study on the effect of soil moisture depletions under black plastic mulch and drip irrigation on root growth and distribution of squash in Central Jordan Valley. Dirasat 15(10): 30-42.

Sanders, D.C., Howell, T.A., Hile, M.H.S., Hodges, L. and Phene, C.J. (1989). Tomato root development affected by travelling trickle irrigation rate. Hort. Sci. 24(6): 930-933.

Selvaraj, K.V. (1976). Studies on the influence of soil on moisture regimes and topping on the yield and quality of cotton. M.Sc. Thesis Agrl. College and Research Inst. Coimbatore.

*Sharma, J.P. and Prasad, R. (1973). Yield of pods, crude protein content and nitrogen uptake by okra. (Abelmoschus esculentus) as affectod by nitrogen and water management. Garten bauwissenchaft 38(2): 163-169.

Sharma, R.P. and Parashar, K.P. (1979). Effect of different water supplies, levels of nitrogen and phosphorus on consumption use of water and moisture extraction pattern by cauliflower (Var. snowball-16). Indian J. Agron. 24(3): 315-321.

Shmueli, M. and Goldberg, D. (1971). Sprinkler, furrow and trickle irrigation of musk melon in an arid zone Hort. Sci. 6: 557-558.

Singh, S.D. and ~~Punjab~~ Singh, P. (1978). Value of drip irrigation compared with conventional irrigation for vegetable production in a hot arid zone. Agron. J. 70:945-947.

Singh, Y.V. (1990). Plastics for optimal use of limited water for crop production. In Proceedings of the 11th International congress on the use of plastics in agriculture. 26th Feb - 2nd Mar: 111-117.

Sivanappan, R.K. (1979). Drip irrigation in vegetable crops. Punjab Hort. J. 29(1&2): 83-85.

Sivanappan, R.K., Aruna Rajagopal and Palaniswamy, D. (1978). Response of chillies to drip irrigation. Madras Agric. J. 65(9): 576-579.

Sivanappan, R.K., Muthukrishnan, C.R., Natarajan, P. and Ramadas, S. (1974). The response of bhindi to the drip system of irrigation. S. Indian Hort. 22: 98-100.

Sivanappan, R.K., Seemanthini Ramadas, and Muthukrishnan, C.R. (1976). The influence of drip system of irrigation on early crop yields in okra (Abelmoschus esculentus). Indian J. Hort. 33(3&4): 254-257.

Smittle, D.A. and Threadgill, E.D. (1982). Response of squash to irrigation, nitrogen fertilization and tillage systems. J. Amer. Soc. Hort. Sci., 107(3): 437-440.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. (6th ed.) Oxford and IBH Publishing co., Calcutta-16. pp. 349-351.

Srivastava, B.K., Singh, N.P. and Singh, M.P. (1981). Effect of mulches on growth, weed density and yield of summer tomato. S. Indian Hort. 29(4): 182-185.

Starnes, W.J. and Hadley, H.H. (1965). Chlorophyll content of various strains of soybeans. Crop. Sci. 5: 9-11.

Subbha Rao, R. (1989). Water management and NK nutrition of cucumber (Cucumis sativus L.) M.Sc. (Ag.) Thesis, Kerala Agricultural University.

Subba Reddy, D. (1986). Effect of straw and soil mulches on moisture retention and crop yields under rainfed agriculture. Res. J. APAU XIV/2: 148-152.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. Current Sci. 25(8): 259-260.

Suh Hyo-Duk. (1990). The use of fertilizers, mulching and irrigation for vegetable production II. The temperate zone-Korea. FFTC Extension Bulletin No. 245.

Suryanarayana, V., Rao, K.T.R. and Rao, D.V.S. (1983). Effect of irrigation frequencies and antitranspriants on Chilli. Veg. Sci. 10(2): 77-83.

Tamaki, K. and Naka, J. (1971). Effect of soil mositure on growth and chemical composition of various parts of broad bean. Tech. Bull. Faculty of Agriculture, Kagawa University, Japan. 22(2): 73-82.

Tekinel, O., Kanber, R., Onder, S., Baytorun, N. and Bastug, R. (1989). The effect of trickle and conventional irrigation methods on some crops, yield and water use efficiency under Cukurowa conditions. In Irrigation - Theory and Practice. Southampton. U.K.

Tisdale, S.L., Nelson, W.L. and Beaton, J.O. (1985). Soil fertility and fertilizers (4th ed.) Mac Millan Publishing Co. Inc. New York. 61 pp.

Trouse, A.C. (1971). Soil conditions as they affect plant establishment, root development and yield. In "Compaction of Agrl. Soils". Amer. Soc. Agrl. Engg. 2950 Niles Road. Michigan.

Tumulhairwe, Joy K., and Gumbs, F.A. (1982). Effect of mulches and irrigation on the production of cabbage (Brassica oleracea) in the dry season. Tropic. Agric. 60: 122-127.

Uthaiah, B.C., Lingaiah, H.B. and Balakrishna Rao, K. (1989). Studies on the effect of mulches on coconut seedling establishment. Indian Coconut J. 20(4): 7-8.

Vanderwerken, J.E. and Wilcox-Lee D. (1988). Influence of plastic mulch and type and frequency of irrigation on growth and yield of bell pepper. Hort. Sci. 23(6,1): 985-988.

Vasanthakumar, G.K. (1984). Efficiency and adoption of drip irrigation in cultivation of tomato. Ph.D Thesis UAS Bangalore.

Visalakshi, R. (1991). Study on drip irrigation in ashgourd. S. Indian. Hort. 72(2): 31-32.

Wallace, G. Pill and Colette C Jacono (1984). Effect of hydrogel incorporation in peatlite on tomato growth and water relations. Commn. Soil Sci. Pl. Anal. 15(7): 799-810.

Wankhade, B.N. and Morey, D.K. (1984). Water use studies on chilli. PKV Res. J. 9(2): 20-25.

White, A.W., Gidden Jr., J.E. and Morris, H.D. (1959). The effect of saw dust on crop growth and physical and biological properties of cecil. Soil Sci. Soc. Amer. Proc. 23: 365-368.

William, R.F. (1946). The physiology of plant growth with special reference to the concept of NAR. Ann. Bot. 10: 41-72.

Wivutvongvana, P., Methi Ekasingh, Paungmanee, J., Klodpeng, T., Nikornpun, M. and Lumyong. P. (1990). The use of fertilizers, mulching and irrigation for vegetable production 1. The tropical zone. Thailand. FFTC. Extension Bulletin No. 245.

Woodhouse, J.L. and Johnson, M.S. (1991). Effect of superabsorbent polymers on survival and growth of crop seedlings. Agrl. Water Management. 20(1): 63-70.

Younis, S.M. (1986). Study on different irrigation methods in Western Nobaria to produce tomato. Alexandria J. Res. 31(3): 11-19.

Zheng, J.S. and Wang, Y.V. (1986). Studies on mineral nutrient absorbing capacity of cucumbers with a plastic film mulch. Acta Horticulturae, 13(1): 49-54.

Zhong, L.F. and Kato, T. (1988). The effects of soil moisture on the growth and yield of solanaccous fruits. Research reports of the Kochi Uni. Agrl. Sci. 37: 51-59.

* Originals not seen

APPENDICES

Appendix I

Weekly data on weathers conditions during the crop period

Period	Standard week	Mean evaporation (mm)	Mean relative humidity (%)
12	49	2.60	76.36
	50	2.86	77.00
	51	2.50	82.14
	52	3.38	78.56
1	1	3.29	73.14
	2	3.86	77.64
	3	2.86	81.29
	4	3.71	76.00
	5	4.29	71.23
2	6	4.00	48.92
	7	4.00	78.14
	8	4.83	79.64
	9	4.71	76.79
3	10	5.00	74.71
	11	5.00	78.28
	12	4.64	74.42

(contd....)

Appendix I (contd....)

Period	Standard week	Mean temperature °C	
		Maximum	Minimum
12	49	30.06	22.00
	50	30.05	22.22
	51	30.91	22.40
	52	30.42	19.27
1	1	30.38	18.62
	2	30.44	21.12
	3	29.85	20.74
	4	31.89	21.69
	5	31.00	19.65
2	6	30.75	20.31
	7	31.44	21.94
	8	31.17	22.87
	9	31.64	22.26
3	10	32.71	21.12
	11	32.64	24.17
	12	32.32	23.72

Appendix II

Soil temperature and soil mositure content of the end of the experiment as influenced by treatments

Treatments	Soil temperature (^oC)				Soil
	Dec	Jan	Feb	Mar	mositure(%)
$I_1M_1C_0$	30.2	29.5	30.6	32.0	16.25
$I_1M_1C_1$	29.5	27.0	28.9	30.2	20.00
$I_1M_1C_2$	30.0	28.5	29.6	31.4	18.75
$I_2M_1C_0$	31.0	30.6	30.9	32.4	13.75
$I_2M_1C_1$	29.5	28.4	28.8	30.8	16.25
$I_2M_1C_2$	30.6	29.2	29.7	31.2	15.00
$I_3M_1C_0$	31.5	30.5	31.4	33.0	8.75
$I_3M_1C_1$	30.2	29.0	30.1	31.5	12.50
$I_3M_1C_2$	30.8	29.6	30.9	32.9	10.00
$I_1M_2C_0$	30.5	30.9	31.1	32.3	15.00
$I_1M_2C_1$	28.5	28.2	29.9	30.9	17.50
$I_1M_2C_2$	29.8	28.9	30.2	31.2	16.25
$I_2M_2C_0$	30.8	31.5	31.4	32.6	12.50
$I_2M_2C_1$	29.2	30.8	30.6	30.8	15.00
$I_2M_2C_2$	30.5	31.2	31.0	31.6	15.00
$I_3M_2C_0$	30.8	31.8	31.7	32.8	8.75
$I_3M_2C_1$	29.0	30.5	30.8	30.9	11.25
$I_3M_2C_2$	29.8	31.2	31.2	31.2	10.00
Absolut control	29.4	27.9	29.0	30.5	17.9

APPENDIX III

Interaction effect of levels and methods of irrigation and conservation methods on water used WVE and yield of chilli.

Treatments	Water used l pot^{-1}	WUE gl^{-1}	Yield g $plant^{-1}$
1 $I_1M_1C_0$	16.50	12.00	197.50
2 $I_1M_1C_1$	16.20	14.87	240.20
3 $I_1M_1C_2$	16.30	10.70	172.40
4 $I_2M_1C_0$	13.10	10.90	143.20
5 $I_2M_1C_1$	12.90	16.96	219.70
6 $I_2M_1C_2$	13.00	12.90	167.80
7 $I_3M_1C_0$	10.00	10.30	103.00
8 $I_3M_1C_1$	9.70	13.90	135.20
9 $I_3M_1C_2$	9.90	12.56	124.50
10 $I_1M_2C_0$	16.60	11.50	191.50
11 $I_1M_2C_1$	16.40	12.80	212.70
12 $I_1M_2C_2$	16.50	10.20	167.00
13 $I_2M_2C_0$	13.20	9.70	128.40
14 $I_2M_2C_1$	13.06	14.87	193.80
15 $I_2M_2C_2$	13.00	11.80	154.70
16 $I_3M_2C_0$	10.00	7.16	71.70
17 $I_3M_2C_1$	9.80	8.83	84.50
18 $I_3M_2C_2$	9.90	7.90	78.40
10 Absolute control	22.50	10.80	244.20

Appendix IV

Correlation of yield and yield attributes

Parameters	Yield
50 per cent flowering	-0.92**
Number of flowers plant^{-1}	0.81**
Number of fruits plant^{-1}	0.95**
Setting per cent	0.89**
Fruit length	0.87**
Fruit girth	0.88**
Pod volume	0.88**
DMP	0.90**
LAI	0.77**
Chlorophyll	0.79**
HI	0.79**
100 fruit weight	0.91**

R value

5 % = 0.26

1 % = 0.39

** Significant correlation

EVALUATION OF LOW COST TECHNIQUES IN POTTED VEGETABLES GROWN IN ROOF GARDENS

By

ROSHNI, G.C., B.Sc. (Ag.)

ABSTRACT OF THESIS
SUMBITTED IN PARTIAL FULFILMENT
THE REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI — TRIVANDRUM
1993

ABSTRACT

A pot culture study was conducted at the College of Agriculture, Vellayani to evaluate the lowcost techniques in potted vegetables and to compare the efficiency of various techniques for economising water use in vegetables. The experiment was conducted with chilli cultivar 'Jwalasakhi' as test crop. The treatments included three levels of irrigation (I_3 - 60, I_2 - 80 and I_1 - 100 per cent field capacity), two methods of irrigation (M_1 - indigenous auto irrigator using hospital drip and M_2 - pot watering) and three moisture conservation methods (C_0 - control without any conservation, C_1 - application of coir pith and C_2 - application of Jalasakhti). One absolute control viz., wick irrigation was compared with other treatments. Potting mixture prepared by mixing sand, soil and cowdung in 1 : 1 : 1 proportion by weight was used as the rooting medium. The medium was low in available nitrogen, high in available phosphorus and low in available potassium. The field capacity and permanent wilting point were 18.4 and 7.4 per cent respectively. The experiment was laid out in completely randomised design with six replications. The results of the investigation are summarised below.

Plant height, branches, LAI at harvest, DMP, S : R ratio and root dry weight at different growth stages differed significantly with methods, levels of irrigation and conservation methods. All these parameters were better under wick irrigation, 100 per cent FC and coir pith mulching. Whereas drip irrigation recorded maximum LAI at initial stages and tap root length. All yield parameters like number of flowers/plant, fruits/plant, fruit girth, fruit volume and hundred fruit weight were better under wick irrigation followed by drip irrigation. Among the moisture regimes 100 per cent FC registered better values for all the yield attributes. Coir pith mulching top seeded with respect to these characters.

Maximum yield was obtained for wick irrigation, 100 per cent FC and coir pith mulching. With respect to WUE, coir pith mulching followed the same pattern as yield. Whereas drip irrigation recorded maximum WUE and 80 per cent FC resulted in higher WUE compared to the other two irrigation regimes.

Uptake of N, P and K were maximum in wick irrigation and coir pith mulching. N and K uptake were maximum at 100 per cent FC, but P uptake was high at 80 per cent FC.

Under all levels of irrigation, maximum yield and WUE were obtained by drip irrigation and coir pith mulching. Coir pith mulching revealed its superiority under both methods of irrigation with respect to yield and WUE.

Maximum yield was obtained at drip irrigation at 100 per cent FC with coir pith mulching while maximum WUE was obtained at drip irrigation at 80 per cent FC with coir pith mulching.

Maximum profit was realised by drip irrigation at 100 per cent FC with coir pith mulching.

With drip irrigation and coir pith mulching 20 per cent water can be saved without much reduction in yield.