CROP GEOMETRY STUDIES UNDER DIFFERENT METHODS OF IRRIGATION IN ORIENTAL PICKLING MELON VAR. SAUBHAGYA

By

JAMUNA DEVI, M.

THESIS

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Faculty of Agriculture
Kerala Agricultural University

Department of Olericulture

COLLEGE OF HORTICULTURE
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DECLARATION

I hereby declare that the thesis entitled **"Crop geometry studies under different methods of irrigation in oriental pickling melon var. Saubhagya"** is a bonafide record of research work done by me during the course of research work 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.

M. Jamunadevi

JAMUNA DEVI, M.

Vellanikkara

Date:

CERTIFICATE

Certified that the thesis entitled "**Crop geometry studies under different methods of irrigation in oriental pickling melon var. Saubhagya**" is a record of research work done independently by **Miss. Jamuna Devi, M.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

Vellanikkara
Date : 2.12.03

Dr. T.R.Gopalakrishnan
(Major Advisor, Advisory Committee)
Associate Professor and Head
Department of Olericulture
College Of Horticulture
Vellanikkara.

CERTIFICATE

We, the undersigned members of the advisory committee of **Miss. Jamuna Devi, M.** a candidate for the degree of **Master of Science in Horticulture,** with major field in olericulture, agree that the thesis entitled **"Crop geometry studies under different methods of irrigation in oriental pickling melon var. Saubhagya"** may be submitted by **Miss. Jamuna Devi, M.** in partial fulfillment of the requirement for the degree.

Dr. T. R.Gopalakrishnan
Associate Professor and Head
Department of Olericulture
College of Horticulture
Vellanikkara.

Dr. P.G. Sadhan Kumar
Associate Professor (Hort)
Department of Olericulture
College of Horticulture
Vellanikkara.

Dr. P. A. Joseph
Associate Professor (Agron)
Agricultural Research Station
Mannuthy

Sri. S. Krishnan
Associate Professor (Ag. Stat)
Department of Agricultural Statistics
College of Horticulture
Vellanikkara

3/12/03

EXTERNAL EXAMINER

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

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M. Jamunadevi

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Affectionately Dedicated

To my beloved Mother

Introduction

I. INTRODUCTION

Our country has achieved self sufficiency and stability in food production. Still majority of people are facing the problems of malnutrition and under nutrition. This created an urgent need for providing health security to our population by supplying nutrition through balanced diet (Sidhu, 1998). Vegetables, being rich source of vitamins, minerals and fibre, form the most important component of a balanced diet. Varied agroclimatic conditions in India make it possible to grow a wide variety of vegetable crops all the year round in one or another part of the country.

India is the second largest producer of vegetables in the world, next only to China, with an estimated production of 96.54 million tonnes from an area of 6.89 million hectares with an average yield of 14.01 t ha^{-1} (GOI, 2003). In Kerala, vegetable production is estimated at 5.92 lakh tonnes annually from an area of 73,958 ha (FIB, 2003). The per capita consumption is only 140 g, which is far below the minimum dietary requirement of 280 g/day/person. The demand of vegetables has been increasing fast in the state with rise in standard of living and health awareness. It therefore calls for a major production campaign to meet the targeted production of the 14.35 lakh tonnes annually. As far as the state is concerned, the extent of cultivable land is limited and hence vegetable production can be enhanced only through intensive cropping practices.

Oriental pickling melon (*Cucumis melo* var. *conomon*) popularly known as *Kani vellari* is grown for its golden yellow coloured mature fruits. In Kerala it is mainly cultivated in the rice fallows during summer months. The main constraint of the crop production during summer in the rice fallow is scarcity of water for irrigation. In order to bring more area under vegetable cultivation in the summer fallows, efficient irrigation systems as well as scheduling of irrigation are to be standardised. Drip irrigation is one of the latest innovative methods in which water is most effectively delivered to the plants. Alemeyhu (2001) found that drip irrigation with 125 Ep is cost saving and viable irrigation method for oriental pickling variety Mudicode. The recommended pit to pit spacing of 2.0 x 1.5 m in oriental pickling melon is standardised based on the trials conducted in large fruited and vigorously growing variety Mudicode. The cultivation practices including spacing, fertilizer requirement, method and frequency of irrigation may vary with the variety depending on its growth pattern, duration, productivity etc. and each variety has to be grown under optimum conditions for achieving maximum productivity. This necessicitates the need for standardizing the method of irrigation, optimum spacing and other packages for short duration, early bearing and small fruited variety Saubhagya.

Under this context, an investigation on the "Crop geometry studies under different methods of irrigation in oriental pickling melon var. Saubhagya" was conducted with the following objectives:

1. To study the effect of drip irrigation on growth and yield of oriental pickling melon variety Saubhagya.
2. To standardise the spacing in oriental pickling melon variety Saubhagya for maximising the marketable yield.
3. To study the interaction effects of irrigation methods and spacings and
4. To work out optimum benefit cost ratio for oriental pickling melon variety Saubhagya under different irrigation methods and spacings.

Review of Literature

II. REVIEW OF LITERATURE

Oriental pickling melon locally known as "Vellari" is a popular vegetable of Kerala. Mature and ripe fruits are characterised with unique golden yellow coloured rind. The important varieties grown in the state are Saubhagya, Mudicode and Arunima. Local cultivars are also grown in different parts of the state.

Saubhagya is a less spreading and short duration variety, which bear fruits at lower nodes. The fruits are small to medium sized with good market value. It is an early maturing variety suitable for close planting. Mudicode and Arunima are vigorously growing varieties. with large golden yellow coloured fruits (Gopalakrishnan and Indira, 2002). Productivity of a variety depends on its genetic make up and is influenced by many factors including cultural practices. Optimum spacing and timely irrigation are necessary for achieving maximum growth and yield in vegetable crops. Information on crop geometry studies for maximum returns and benefit cost ratio in oriental pickling melon are rather limited in the country.

The available information on crop geometry and irrigation methods on growth and development of cucurbitaceous vegetables in India and abroad are reviewed under following headings.

2.1. Effect of season and climatic factors on growth and yield

2.2. Effect of irrigation on growth, flowering and productivity

2.3. Effect of methods of irrigation in cucurbits

2.4. Water requirement and scheduling of irrigation in cucurbits

2.5. Effect of spacing and population density on growth, flowering and productivity

2.6. Effect of crop geometry and irrigation on growth and productivity of cucurbits

2.1. EFFECT OF SEASON AND CLIMATIC FACTORS ON GROWTH AND YIELD

Ivanov (1978) observed negative correlation between growth characters and temperature when cucumber was sown at six different dates in April and May. Toka (1978) reported that temperature regime of 16^{0}C in the evening followed by lower temperature of 10^0 to 12^{0}C in night increased yield by 12 per cent compared with the conventional cultivation under normal night and day temperature. Further studies by Slack and Hand (1981) revealed that increasing night temperature up to 23^{0}C increased early fruit yield in cucumber, though increase in day temperature above 22^{0}C had no influence on yield.

Hessiner and Drews (1985) in an experiment on green house cucumber observed that neither planting date nor night temperature affects total yield. Studies by Palkin (1987) revealed that air temperature of 20-30^{0}C, night temperature not below 12^{0}C and soil temperature not below 17^{0}C up to flowering and optimal day, night and ground temperature combination of 25-27^{0}C, 17^{0}C, 12-25^{0}C during flowering and fruiting lead to increase in yield in cucumber.

Ufflen (1988) in an experiment with cucumber hybrid cv.TSKGA-77 observed that increase in night temperature advanced harvest by 4 days , however rise in day temperature advanced harvest by 12 days with increase in plant vigour and decrease in female flower production.

Wacquant (1989) observed that fruit development in cucumber was faster and fruits were larger at19^{0}C night temperature. Temperature above 35-45^{0}C decreased the sugar content and increased the proportion of glossy fruits. Further study by Markovskaya (1994) revealed that day and night temperature ranging from 28 - 32^{0}C at juvenile stage and 19-27^{0}C at flowering stage were optimum for cucumber growth.

In an experiment to find the effect of difference in day and night temperatures on growth of cucumber, Abouhadid *et al.* (1993) observed that night temperature higher than day temperature reduced the plant height mainly due to decrease in internodal length. Medany (1995) in an experiment to find out fruit growth rate of cucumber in relation to night set temperature observed that 18^0C had highest fruit growth rate compared to 10^0C night set point.

In an experiment to find the effect of temperature and light on growth of cucumber, Chen-quingjun *et al.* (1996) observed that under low light, number of leaves and leaf area $plant^{-1}$ were reduced with an increase in internodal length. Yield was mainly affected by sunshine hours, amount of solar radiation and air temperature. Robert *et al.* (2000) reported that leaf number, flower number and fruit growth rates were linearly increased with increasing air temperature and ideal temperature for growth of cucumber was 82^0F. Temperature above 90^0F and below 60^0F caused slow growth.

In water melon, more female flowers per plant were produced in spring than in autumn (Padda and Kumar, 1971). However the proportion of female flower was greater in autumn in the cultivars Midget, Verona and Sugarbaby.

Kamalnathan and Thamburaj (1972) studied the influence of weather factors on sex expression of pumpkin and reported that pre-flowering and flowering phase were altered by change in day length and temperature. Cloudiness favoured the production of pistillate flowers.

2.2. EFFECT OF IRRIGATION ON GROWTH, FLOWERING AND PRODUCTIVITY

Availability of water is one of the major factors influencing plant growth. Hence, adequate water supply throughout the growing season is one of the important requirements for the success of cultivation. For better growth of vegetable crops, soil moisture at about 15 cm depth should not be allowed to drop below 70 per cent of total available moisture (Michael, 1978).

In an experiment conducted at the Agricultural Research Station, Mannuthy, Radha (1985) could not observe significant difference in yield by irrigating at 25, 50 and 75 per cent depletion of available soil moisture in oriental pickling melon. However the number of fruits/plant increased with increase in level of irrigation when trials were conducted at Agricultural Research Station, Chalakudy in the same soil type. Similar studies by Alemeyhu (2001) revealed that vine growth, leaf area and yield increased with increase in level of irrigation in oriental pickling melon variety Mudicode.

Studies by Abolina *et al.* (1963) showed that cantaloupe plants watered regularly produced greater number of female flowers. Flocker *et al.* (1965) and Rhodeo (1969) reported that frequent and heavy irrigation increased the vine growth, succulence and yield in cantaloupes. Yield increase in melon was mainly due to increase in fruit size.

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

Leaf area in cucumber was greatly reduced under water stress (Cummins and Kretchman, 1974). Kretchman (1982) noticed a reduction in the rate of vine growth and number of nodes when plants were subjected to stress for a period of one week. Growth was completely inhibited after two weeks stress.

Studies by Mannini and Roncuzzi (1983) and Hessiner *et al.* (1987) in Green house cucumber showed that irrigation at an interval of 3-6 days did not affect the yield. Linear phases of leaf growth were unaffected by soil moisture tension in the upper layer. From 70 days after planting leaf area decreased with high moisture tension and yield was highest in the 1.0 x Potential evapo transpiration (PET) and significantly lower in 0.6 x PET. Similar studies by Nerson *et al.* (1994) in green house cucumber revealed that increasing water supply from a dry regime to weekly irrigation regime significantly increased the mean fruit weight.

In an experiment to find the effect of irrigation on yield and quality of cucumber, Wangxinyuan *et al.* (1999) found an increase in yield with increasing rate of irrigation, but quality slightly decreased. Water use efficiency (yield/irrigation quantity) decreased with increasing rates of irrigation. Further studies by Kangsangjae *et al.* (2001) revealed that plant height, number of leaves and leaf area at 35 days after sowing were influenced by temperature of irrigation water. Increase in growth rate was found with irrigation water temperature of 25 $\pm 2^0$C. Zhangxianfa and Yuxianchang (2002) reported that the soil water had a greater effect on growth and development of cucumber. The excess or shortage of soil water resulted in reduction of leaf growth, number of tendril and yield in cucumber.

Singh and Singh (1978) reported that yield increase in water melon by irrigation was associated with increase in fruit weight. Bhella (1988) recorded maximum stem growth and total yield when water melon was grown with trickle irrigation and polythene mulch. When the soil matrix potential at 15 cm depth reached - 25 kPa frequent irrigation resulted in maximum dry matter accumulation, leaf area index, leaf area duration leading to higher fruit yield in water melon (Hegde, 1987). Total number of female flowers increased progressively with higher levels of irrigation when water melon was grown in summer rice fallows (Siby, 1993).

According to Katayal (1980) for getting maximum yield during dry weather, weekly irrigation should be given in pumpkin and cucumber. Chernovel (1980) observed that the night-irrigated plants gave highest yield followed by evening, morning and mid-day irrigation. Further, irrigation studies on fruited pumpkin by Asoegwa (1991) showed that irrigating every three days is the best for leaf yield and fruit yield.

In an attempt to analyse the effect of irrigation in bitter gourd Thomas (1984) observed that frequent irrigation at low depletion of available soil moisture was congenial for growth and development.

2.3. EFFECT OF METHODS OF IRRIGATION

Out of several contributing characters for the adoption of drip irrigation foremost is the economical use of water and it's potential to maintain low soil moisture tension in the root zone (Sivanappan and Padmakumari, 1978) and its ability to maximize crop response and yield. Watering through drip irrigation eliminate wide fluctuations of soil moisture resulting in better growth and yield.

The comparative effect of pitcher irrigation and pot watering in cucumber was studied by Balakumaran *et al.* (1982). They reported that yields were slightly higher in pot watered plants, but water economy was appreciably great under pitcher irrigation. Chartzoulakis and Michelakis (1996) reported that water use efficiency for cucumber was highest with drip compared to furrow, microtube drip, porous clay tube and porous plastic tube. In a study on effect of irrigation method on green house cucumber, Komamura *et al.* (1990) found that perforate pipe system maintained adequate soil moisture than drip irrigation.

Monynihan and Harman (1992) compared drip and furrow irrigation systems for small-scale farms and found that water requirement for cucumber was 3-4 times more with less yield and more labour under furrow system than drip irrigation. Aziz *et al.* (1998) during a study on the effect of soil conditioning and irrigation on chemical properties of sandy soils of Inshas, Egypt concluded that drip irrigation was the best method for water management, higher yield, water conservation and water use efficiency in cucumber production. From a trial at Rahuri on yield response of cucumber to micro irrigation, Limbulkar (1998) reported higher yield with 50% water saving in drip irrigation than surface irrigation.

From a comparative study of drip and sprinkler irrigation for pickling cucumber in Germany, Kunzelmann and Paschold (1999) observed that drip irrigation accelerate seedling development leading to earlier yield and prolonged harvesting periods. Yield under drip was 547 t ha^{-1} with 50 per cent water saving compared to sprinkler with a yield of 400 t ha^{-1}.

Farshi (2001) reported an increased WUE of 5.2 kg m^{-3} from drip irrigated cucumber compared to 1.2 kg m^{-3} in surface irrigation. Guler and Ibrikci (2002) reported higher yield (7.8 t ha^{-1}) from drip irrigated plants compared to furrow irrigated plants (7.2 t ha^{-1}).

Foster (1989) evaluated moisture regime and plant growth of vegetables under drip irrigation and conventional furrow irrigation. The results showed greater water savings and higher yields under drip. Drip irrigation gave highest water use efficiency in round gourd (5.10 q ha^{-1} cm) and water melon (10.3 q ha^{-1} cm) than furrow irrigation system (3.70 q ha^{-1} cm) and (8.40 q ha^{-1} cm). The yield increase by irrigation was associated with increase in fruit weight.

Reddy and Rao (1983) worked on the response of bitter gourd to pitcher and basin systems of irrigation. Yield was highest in pitcher filled every 4^{th} day and lowest in basin filled every fifth day.

Srinivas (1986) while working on water requirement of water melon reported that among two different drip irrigation treatments one emitter per two plants recorded slightly higher yields (34 t ha^{-1}) than one emitter per plant (33.15 t ha^{-1}). In a comparison of bubbler and drip methods in bitter gourd (KAU, 1999) an irrigation schedule at 100 per cent evaporation in bubbler gave increased yield of 28.33 kg ha^{-1} with water use of 320 mm compared to drip. Similar studies in okra revealed that bubbler works with the pressure less than that of sprinkler with uniform distribution and increase water use efficiency

However, certain disadvantages, both agricultural and technical have restricted the field level application of drip irrigation. Agricultural problems under drip irrigation were that the localized water application causes development of limited root mass. Technical limitations include clogging of emitters by physical impediments, chemical precipitates, growth of biological organisms, emitter non uniformity, damage by rodents, high initial cost, need for management skill and faulty designs.

2.4. WATER REQUIREMENT AND SCHEDULING OF IRRIGATION

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

Neil and Zuhino (1972) reported that maximum evapotranspiration was 60 per cent of potential evapotranspiration in irrigated cantaloupes and between flowering and fruit formation it was 55 per cent of potential evapotranspiration. The water uptake at successive growth stages of the melon crop was 560 m^3 ha^{-1} between germination and fruit set, 1008 m^3 ha^{-1} up to fruit enlargement, 882 m^3 ha^{-1} up to maturity and 280 m^3 ha^{-1} up to harvest.

Veerputhiran (1996) observed an increase in yield attributing characters in oriental pickling melon with the increase in frequency of irrigation and it was maximum at IW/CPE ratio of 1.2. The peak consumptive use was reached between 36-50 days after sowing for the irrigation intervals of IW/CPE ratio 1.2, 0.8 and 0.4. In a study on the effect of irrigation on fruit weight and total yield, in oriental pickling melon Leekyeongbho *et al.* (1999) observed that plants irrigated up to 20 days after flowering (88.8 mm) produced the highest yield (11.4 t $h^{-1}a$) of good quality fruits. Similar studies in oriental pickling melon revealed that growth, yield and net income increased with increase in level of daily drip irrigation from 50 to 125 per cent E_P and reached maximum at 125 per cent E_P Alemeyhu (2001).

Dunkeil (1966) recorded optimal yield when 600-750 mm of water was applied in cucumber. In an experiment to study the relationship between crop development and water utilization in cucumber Selotel and Varga (1973) observed that water uptake of 5 litres per plant up to flowering, 30 litres per plant at the beginning of flowering and 10-20 litres per plant at the time fruit development increased the yield. Similar studies by Parlor (1976) revealed highest yield (26.6 kg m^{-2}) when 70-100lm^{-2} of water was applied during plant growing phase and 480-570 l m^{-2} during fruiting phase. He also observed that consumptive use increased during flowering and early fruiting and then levelled off during late harvest.

Riley (1990) reported a marked reduction in total yield in gherkin cucumbers when water was not available during early flowering and fruiting stage. Moisture stress given at flowering, vegetative and fruit formation stage leads to reduction in vegetative growth, flower drop, reduction in fruitset and ultimately reduction in yield. Hence three stages viz. vegetative, flowering and fruit formation are highly responsive to moisture.

In irrigation cum fertilizer trial at Thailand, Yingjawal and Markmoon (1993) found that increasing the irrigation rate from 100 to 150 or 200 per cent potential evapotranspiration increased the total yield of cucumber by 12 and 13 per cent, respectively. Further, studies at the Indian Institute of Horticultural Research, Bangalore revealed that irrigation scheduled to replenish 120 per cent of pan evaporation recorded 25 per cent more early harvestable yield (Prabhakar and Naik, 1993).

Similar studies by Robert *et al.* (2000) in cucumber revealed that lowering irrigation sustained the production and increased water use efficiency without significantly decreasing the yield. However irrigation less than 7000 mm ha^{-1} reduced the yield without increasing water use efficiency.

While analysing the effect of irrigation with four irrigation ratios (IW/CPE 0.6, 0.8, 1.0 and 1.2), Singh and Singh (1978) found good plant growth, fruit quality and highest yields of water melon by irrigating at IW/CPE ratio of 1.0. Further studies in water melon by Srinivas *et al.* (1984) with four levels of evaporation (25, 50, 75 and 100%) replenishments under drip and furrow irrigation indicated that replenishments of 25 per cent evaporation losses under drip and 50-70 per cent evaporation losses under furrow irrigation were optimum for higher yield. Yadav *et al.* (1979) reported higher water use efficiency with irrigation at 83 mm cumulative pan evaporation in water melon. Selvaraj and Ramamoorthy (1990) reported that yield and consumptive use of water was higher at IW/CPE ratio1.0, but the water use efficiency was higher at 0.4 IW/CPE and 0.6 IW/CPE ratios. Similar studies by Patil (1988) revealed that significant increase in the yield of watermelon due to irrigation scheduling at 10 mm cumulative pan evaporation.

According to Whitaker and Davis (1962) irrigation water required for water melons and cucumber was 150 ha mm each and that for pumpkins and summer squashes was 180 ha mm each.

Thomas (1984) found that the consumptive use increased with increase in level of irrigation in bitter gourd.

2.5. EFFECT OF SPACING AND POPULATION DENSITY ON GROWTH, FLOWERING AND PRODUCTIVITY

According to Lazin and Simonds (1982) melons when spaced at 1, 2 and 3 feet within rows, decrease in spacing increased the number of fruits per plant but decreased mean fruit size and weight. Similar study by Prabhakar *et al.* (1985) revealed that in muskmelon highest yield of 45 q ha^{-1} was recorded when plants were spaced at 60 x 60 cm compared to other spacings.

Singh (1990) observed induction of early female flowers and total yield at a closer spacing of 90 x 22.5 cm. A wider spacing 90 x 45 cm produced more vine length, branches and leaves per plant in melons. From a spacing trial in muskmelon variety Superstar, Elizabeth and Dennis (1998) reported yield and number of fruits per ha generally increased by increasing plant population from 3074 to 10,076 plants, but number of fruits per plant and fruit weight decreased linearly with decrease in row spacing. Further studies by Nerson *et al.* (1994) revealed an increase in vegetative growth with increase in population from 13,500 to 31,250 plants per hectare in muskmelon.

Pickling cucumber were planted at 1, 2 and 3 plants per hill with a spacing of 20, 40 or 60 cm and row width of 1 m. The greatest number of fruits of acceptable size per hectare was obtained with 40 cm between hills and 3 plants per hill (Garcia *et al.*, 1973). Mangal and Yadav (1979) recorded maximum yield in cucumber grown at spacing of 100 x 60 cm compared to 100 x 90 cm. Similar studies in cucumber revealed that fruit number and yield per m^2 increased with increase in closer spacing (Enthoven, 1980).

Cucumber when planted at different densities, the low density had greater values for growth parameters such as vine length and number of flowers. But leaf area alone was increased at high density planting (Bach and Hruska, 1981). In an experiment to study the effect of spacing on growth and yield, Burgmans (1981) opined an increase in total yield with increase in plant density (1,26,000 plants ha^{-1}). Studies by Khayer (1982) revealed that among the different spacings 1.5, 2.0, 2.5 and 3.0 plants m^{-2}, increase in plant densities increased fruit number and weight per plot. In an experiment with hybrids and open pollinated varieties of cucumber Lower *et al.* (1983) found more staminate flowers and less pistillate flowers with an increase in plant density.

In an attempt to study the effect of plant density on performance of cucumber Staub *et al.* (1992) observed that increased plant density increase the number and weight of fruits per hectare but decreased the fruit weight. Wann (1993) observed among three different spacings 15 x 4, 22 x 3 and 33 x 2 inches, plants spaced at 15 x 4 inches produce higher yield compared to other treatments. Further studies by Hanna and Adams (1993) revealed high plant population achieved by decreasing with in row spacing from 12 to 6 inches increased total yield than plant spaced at 18 inches. In a work with cucumber cv. Japanese Choigounghah *et al.* (1995) found maximum yield of 3,80,020 kg ha^{-1} a planting densities of 45,000 plants per hectare.

In an experiment with the slicing cucumber (Renji, 1998) reported that highest yield from the highest density of 13,333 plants per hectare. Kanthaswamy *et al.* (2000) observed maximum yield of cucumber (125.82 t/ha) at 60 x 60 cm spacing with pruning of all primary branches after two nodes.

Hafidh (2001) observed significant increase in staminate flowers and decrease in pistillate flowers and fruit yield when plant spacing decreased from 30 to 20 cm and 20 to 10 cm. Further studies to determine the effect of plant spacing on yield and quality of pickling cucumber Paroussi and Saglam (2002) observed that among different within row spacing (20, 30 and 40 cm) highest yield was recorded in 20 cm compared to 30 and 40 cm.

Choudri and More (2002) reported among three spacings (1.8 x 0.3m, 1.80 m x 0.45 m, 1.80 m x 0.60 m) highest number of fruits and yield per vine, yield per ha were recorded in 1.80 m x 0.40 m in cucumber. In an experiment to find out the effect of plant density on fruit growth when cucumber was grown at a spacing of 1.8 and 2.3 plants/m^2, Nishimura and Lopezgalvezij (2002) found that increased density decreased the total above ground biomass, the number of fruits but enhanced the biomass allocation to the vegetative shoots.

Echevarria and Castro (2002) observed among four plant densities (2, 1.67, 1.43 and 1.25 plants m^{-2}), production per plant increased with decrease in spacing (6.6, 19.2, 19.7 and 20.7 kg $plant^{-1}$). Earliness and quality were not influenced by plant density.

After evaluating the effect of plant density on growth and yield of watermelon var. Sugarbaby, Bindukala, (2000) found maximum fruits per plot and marketable yield per plant at highest density of 10,000 plants ha^{-1}.

In an attempt to study the effect of density on growth, development and yield on winter squash Botwright *et al.* (1998) found maximum marketable yield of 18 t/ha at 1.1 plants/m^2. In an experiment to find the effect of four plant spacings (3.0 x 0.60 m, 4.0 x 0.60 m, 3.0 x 0. 75 m and 4.0 x 0.75 m) on growth, yield and quality of pumpkin Singh and Naik (1990) observed significance increase in fruit yield per plant with increase in intra row spacing from 60 cm to 75 cm. The closer spacing of 3 m x 60 cm recorded maximum yield of 108.12 q ha^{-1} and induced early female flowers.

Yadav *et al.* (1979), on the effect of spacing on different varieties of pointed gourd, revealed that among two spacings 1.5 x 1.5 m and 3 x 1.5 m, maximum yield of 110.32 q ha^{-1} was recorded at a spacing of 1.5 x 1.5 m.

Parekh (1990) observed maximum main vine length and number of primary branches/plant and TSS at wider spacing of 1.5 x 1.0 m in bitter gourd. Arora and Mallik (1990), in a work on ridge gourd variety Pusa Nasdar, observed that when seeds were sown at 12, 9 and 6 plants bed^{-1}, the spacing of nine plants per bed gave the long plant with highest secondary branches and resulted in early appearance of pistilate flowers. According to Pandit *et al.* (1997) total number of fruits per plant and fruit length increased with decrease in plant spacing in pointed gourd cv. Damodarpandit.

2.6. EFFECT OF CROP GEOMETRY AND IRRIGATION ON YIELD

In an experiment to find the potential of drip method vs furrow method of irrigation in ridge gourd at Rahuri paired row planting pattern (60 - 140 x 80 cm) with irrigation schedule (alternate day application) of 0.6, 0.7 and 0.8 fraction of PE at 0-30, 31-50 and 51 day after transplanting recorded 18 per cent increase in yield compared to furrow method with irrigation scheduling at 50, 75, 100 and 125 mm CPE. It was seen that the irrigated crop area under drip was doubled compared to furrow method (AICRP, 1985).

Similar studies in bitter gourd revealed that paired planting pattern (60 - 140 x 80 cm) with irrigation schedule at 0.6 fraction of PE, 0.7 fraction of PE and 0.8 fraction under drip method recorded 13-15 per cent higher yield with maximum number of fruits plant^{-1} compared to irrigation schedule at 20, 40, 60 and 80 mm CPE under furrow irrigation (AICRP, 1986).

In an experiment on Little gourd it was observed that irrigation schedule at 80 per cent PE with the spacing of 2.0 x 1.0 m recorded 4.5 to 13 per cent higher yield with 20-40 per cent water saving compared to irrigation schedule at 100 per cent PE in furrow method (AICRP 1986).

Materials and Methods

III. MATERIALS AND METHODS

Investigation on "Crop geometry studies under different methods of irrigation in oriental pickling melon variety Saubhagya (*Cucumis melo* var. *conomon*)" was carried out at the college of Horticulture, Vellanikkara Thrissur, Kerala. Two field experiments were conducted consecutively during December 2002 to April 2003 at the Agricultural Research Station, Kerala Agricultural University, Mannuthy, and Thrissur. The details of materials used and techniques adopted during the course of investigation are presented below.

3.1. LOCATION

The experimental site is situated at 12^0 32' N latitude and 74^0 20' E longitude at an altitude of 22.5 m above mean sea level. The area enjoys a typical warm humid tropical climate.

3.2. CROPPING HISTORY

The experimental site is a double crop paddy wet land in which a dry sown crop (April - September) and a transplanted wet crop (September - December) was regularly cultivated. The land is left fallow during summer season. Soil type of the experimental field is sandy clay loam. The soil characteristics of the experimental field are given in Table 1.

3.3. CROP AND VARIETY

Oriental pickling melon variety Saubhagya developed at the Department of Olericulture, College of Horticulture, Vellanikkara was utilized for the study. Its fruits are small to medium in size with uniform oblong shape. The developing fruits are green with light green lines and turn attractive golden yellow on ripening. Specific advantage of the variety is its short duration (60-65days), less vegetative growth and small to medium sized attractive fruits.

3.4. SEASON

Experiment was conducted consecutively for two seasons. First crop was from 2nd December 2002 to 10thFebruary 2003 and second crop was from

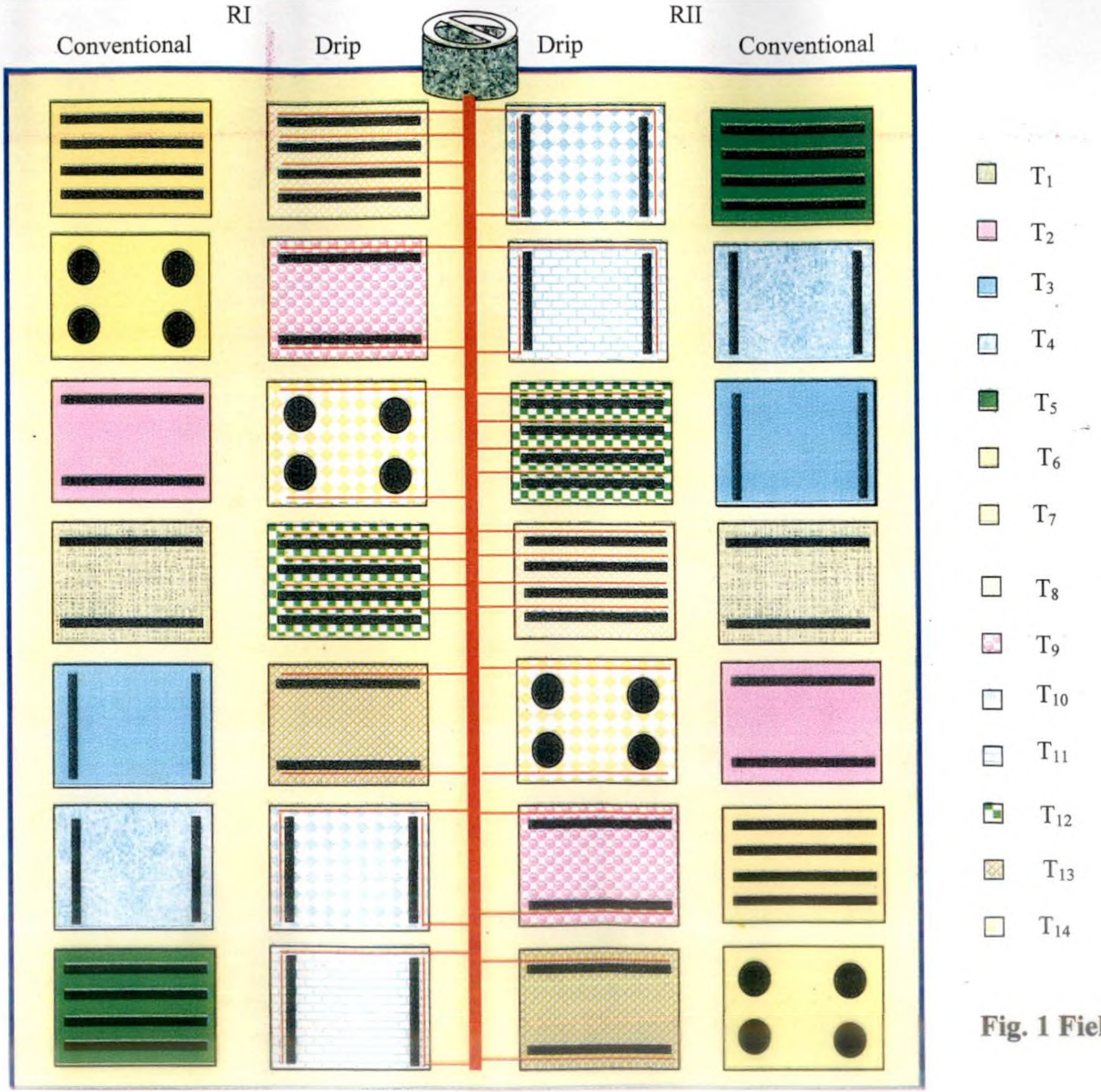

Fig. 1 Field layout

Table 1. Soil characteristics of the experimental field

Particulars	Value
1. Mechanical composition	
1.1. Course sand (%)	27.1
1.2. Fine sand (%)	23.9
1.3. Salt (%)	22.8
1.4. Clay (%)	26.2
1.5. Textural class	Sandy clay loam
2. Physical constants of the soil	
2.1. Field capacity (0.3 Bars)	21.82
2.2. Permanent wilting point (15 bars)	9.34
2.3. Bulk density (g cm^{-3})	
2.3.1. 0-30 cm	1.34
2.3.2. 0-60 cm	1.36
2.4. Particle density (g cm^{-3})	2.16
3. Chemical properties	
3.1. *Organic carbon (%)*	0.43
3.2. Available nitrogen (kg ha^{-1})	233.4
3.3. Available phosphorus (kg ha^{-1})	15
3.4. Available potassium (kg ha^{-1})	55
3.5. Soil reaction (pH)	5.4
3.6. Electrical conductivity (dS m^{-1})	1.25

12th February 2003 to 20th April 2003. Meteorological data during the cropping period are presented in Appendix I. The experiment was laid out in a split plot design with methods of irrigation in the main plots and spacing in sub plots. The lay out of the experimental field is displayed in Fig.1.and the details are given below:

3.5. METHODS

3.5.1. Main plot (Methods of irrigation)

Number of main plots = 2

I_1 - drip irrigation @ 125 E_P

I_2 - conventional method @ 45 l/pit in alternate days at flowering, fruiting and fruit development phases and at half rate during the initial vegetative phase

3.5.2. Sub plot (spacing)

Number of sub plots = 7

Spacing	No of plants per plot (12 m^2)	Population density (plants ha^{-1})
Sowing in channels		
S_1 2.0 x 0.30 m	20	16666
S_2 2.0 x 0.45 m	14	11111
S_3 1.5 x 0.30 m	26	22222
S_4 1.5 x 0.45 m	18	14814
S_5 1.0 x 0.30 m	40	33333
S_6 1.0 x 0.45 m	28	22222
Sowing in pits (3 plants per pit)		
S_7 2.0 x 1.5 m	12	9999

S_1-S_6 were in channels of size 3 m length 30 cm width 20 cm depth

S_7 was in pits of 60 cm diameter retaining 3 plants pit^{-1}

3.5.3. Treatments

The treatments consisted of combination of two methods of irrigation and seven spacing. The details are given below.

Number of treatments: 14

Number of replications: 2

Sl.No	Treatments	Treatment particulars
1	T_1	I_1S_1
2	T_2	I_1S_2
3	T_3	I_1S_3
4	T_4	I_1S_4
5	T_5	I_1S_5
6	T_6	I_1S_6
7	T_7	I_1S_7
8	T_8	I_2S_1
9	T_9	I_2S_2
10	T_{10}	I_2S_3
11	T_{11}	I_2S_4
12	T_{12}	I_2S_5
13	T_{13}	I_2S_6
14	T_{14}	I_2S_7

3.6. CULTURAL PRACTISES

3.6.1. Land preparation

The land was ploughed using tractor drawn disc plough, clods broken, stubbles were removed and the experimental plot was laid out in the main plots and subplots as per treatments.

3.6.2. Manure and fertiliser application

Farmyard manure at the rate of 4 kg $plant^{-1}$ was applied uniformly in all the channels and pits as basal dose. After thorough mixing with top soil, plots were irrigated. Fertilizers were applied as per package of practices recommendations of (Kerala Agricultural University, 1996) N, P_2O_5 and K_2O were applied. @ 70:25:25 kg ha^{-1} in the form of Urea, Rajphos and Muriate of potash on per plant basis (8 g N, 12.5 g P_2O_5 and 4.2 g K_2O).

Half of nitrogen and entire dose of phosphorus and potassium were applied as basal dose just before sowing. The remaining 50 per cent nitrogen was applied in two equal split doses, at the time of veining (15 DAS) and at the time of flowering and fruiting (35 DAS).

3.6.3. Sowing

Two seeds were sown uniformly at a point. Thinning was done on 17th day after sowing by retaining only one plant.

3.6.4. Irrigation

A pre-sowing irrigation was given uniformly to all the channels and pits. After sowing, light irrigation with a rose can was given @ 10 l $channel^{-1}$ and 5 l pit^{-1} for 10 days. Differential irrigation according to the treatments started from 15th day after sowing when the plants were well established. In conventional method, irrigation was given in alternate days @ 7.5 l $plant^{-1}$ at vegetative phase and 15 l $plant^{-1}$ from flowering stage onwards. Drip irrigation was given every day based on the evaporation values of the previous day and the rate fixed was 125 per cent of potential evapotranspiration, (Ep).

One storage tank of 500 l capacity was kept on a platform of 1 m height above the ground. The tank was connected to main line made of rigid PVC pipe having 2 inch diameter. To the main line laterals made of LDPE having 12 mm internal diameter were connected at appropriate intervals. Drippers were connected to each lateral through 4 mm LDPE dripper lateral at positions opposite to the plants and the number of drippers per plot varied with plant density. The required amount of water was provided through single dripper $plant^{-1}$ at the rate of 2 l h^{-1}.

The tank was constantly kept filled with water by connecting to the

Table 2. Total Quantity of water used for two different irrigation methods

Treatment	Conventional		Drip (I Crop)		Drip (II Crop)	
	mm	liters	mm	liters	mm	Liters
S1	575.5	6900	253.0	3040	293.3	3520
S2	402.5	4830	177.3	2128	205.3	2464
S3	690.0	8280	304.0	3648	352.0	4224
S4	517.5	6210	228.0	2736	264.0	3168
S5	1150.0	13800	516.6	6080	586.6	7040
S6	805.0	9660	354.6	4526	410.6	4128
S7	345.0	4140	152.6	1824	176.6	2112
Total	4485.5	53820	1974	23982	2206	27456

pumping line. Wire mesh filter was provided to prevent the impurities from entering into the pipe system. From each line of lateral separate control valve was provided at the beginning. In conventional irrigation, plants were watered with pots on alternate days according to treatments.

3.6.5. After care

Hand weeding and earthing up was done once, on 22^{nd} day after sowing.

3.6.6. Plant protection

Two per cent neem oil and garlic extract was sprayed 10 and 20 days after sowing as a prophylactic measure against the attack of red pumpkin beetle and serpentine leaf minor. Stray incidence of Pythium wilt was controlled by drenching Dithane M 45 @ 0.4 %. At fruit development stage, attack of fruit files were brought under control by spraying Malathion @ 0.02%.

3.6.7. Harvesting

Fruits were harvested when they were fully matured (when they got attractive golden yellow stripes from stalk end to pedicel end).

3.7. BIOMETRICAL OBSERVATIONS

For understanding the effect of treatments on growth and development of the crop, growth and yield parameters were recorded. Growth and yield attributes were recorded from randomly selected five plants $plot^{-1}$ and the average was worked out.

3.7.1. Length of vines (cm)

The length of vines were observed and measured from the base to the tip at 30 DAS and at final harvest, (55 DAS in December sown crop 58 DAS in February sown crop).

3.7.2. Number of branches per plant

The numbers of branches were recorded (at 30 DAS and at the time of final harvest).

3.7.3. Leaf area (cm^2)

Leaf area was measured (by graph paper method).

3.7.4. Days to male and female flower anthesis

3.7.5. Days to first harvest

3.7.6. Days to last harvest

3.7.7. Node at which first flower is formed

3.7.8. Node at which first fruit is retained

The total fruits harvested from each observational plant were considered for recording the following fruit characters.

3.7.9. Length of fruit (cm)

3.7.10. Girth of fruit (cm)

3.7.11. Average fruit weight (g)

3.7.12. Number of fruits $plant^{-1}$

3.7.13. Weight of fruits $plant^{-1}$ (g)

3.7.14. Total Yield Per Plot (kg/m^2)

Total weights of fruits harvested from each plot were recorded.

3.7.15. Productivity ($t\ ha^{-1}$)

Productivity in tonnes per hectare was worked out.

3.7.16. Flesh thickness (cm)

The fruits harvested from the observational plants were cut longitudinally and the flesh thickness from placental end to the distal end was measured.

3.8. FIELD WATER USE EFFICIENCY (FWUE)

FWUE was found out by dividing yield / plot (kg) with the quantity of water of applied (mm).

3.9. INCIDENCE OF PEST AND DISEASES

Stray incidence of pest and diseases noticed during the cropping period were recorded as and when appeared and was brought under control by appropriate control measures.

3.10. STASTICAL ANALYSIS

Analysis of variance was done separately for all the characters at different stages as per the statistical design of split plot and significance was tested by F- test and the treatments were compared using Duncan's Multiple Range Test (DMRT).

3.11. ECONOMICS OF PRODUCTION

The economics of production was worked out based on the input costs, labour charges and the price at which the local sellers accepted the fruits at the time of harvest. Input costs were taken as the actual cost of the materials at the time of conduct of the experiment. Labour charges considered were the prevailing labour wages of the university at the rate of Rs 150 for men and Rs 140 for women. Cost of drip irrigation system used for the experiment was taken as one fifth of the total cost of materials as it is assumed that a unit of drip irrigation can be used atleast for five consecutive crops (Appendix II).

Results

IV. RESULTS

Studies on crop geometry with two methods of irrigation viz., drip irrigation and conventional method of pot watering in oriental pickling melon variety Saubhagya was conducted during 2002 – 2003. The experiment was conducted for two consecutive seasons. The first crop was raised from December 2002 to February 2003 and second crop from February to April 2003 (plate 1, plate 2, plate 3 and plate 4). The results obtained from the study are presented under the following three heads:

4.1. Vegetative characters

4.2. Earliness and duration

4.3. Fruit characters

4.4. Yield characters

4.1. VEGETATIVE CHARACTERS

4.1.1. Length of vine at 30 DAS

The different methods of irrigation did not have significant effect on the length of vine at 30 DAS during both the seasons (Appendix II and III).

Length of vine at 30 DAS was also not affected by different spacing during first crop. During the second crop, different spacing had significant effect on the length of vine. Among different spacing, closer spacing S_5 (1.0 x 0.30 m) recorded significantly the highest vine length (126.9 cm) on par with S_6 (122.5 cm). The vine length was minimum in the control plot, S_7 (102.3 cm) for the second crop (Table 3 and Table 4).

Various treatment combinations of methods of irrigation and spacing did not affect length of vine at 30 DAS for the first crop. Variations due to interaction were significant during second season only (Appendix II). In I_1 maximum interaction was

Plate 1. General view of the experimental field at vegetative phase

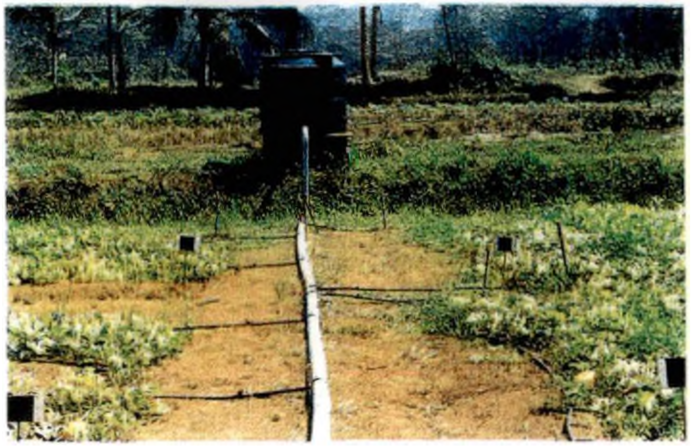

Plate 2. General view of the experimental field at fruiting stage

Plate 3. general view of the experimental field at fruiting stage

Plate 4. Fruits harvested and heaped from the experimental field

observed with S_6 followed by S_5 both of which were on par. In I_2, the interaction effect was highest with I_2S_5 but was on par with I_2S_6 which was ranked second. In short, both methods of irrigation had maximum interaction with S_5 and S_6 spacing. Vine length at 30 DAS was high during second crop season (113.7 cm) compared to first crop season (84.09 cm).

4.1.2. Length of vine at final harvest

The final harvest of the crop was done on 55 days after sowing in December sown crop and 58 days after sowing in February sown crop. During both the seasons the effect of irrigation methods on length of vine at the time of final harvest was not significant (Appendix II and III).

Though not significant during first crop season, the different spacing caused significant variation on length of vine during second crop season. Among different spacing, closer spacing S_5 (1.0 x 0.30 m) recorded the maximum vine length (173.8 cm) followed by S_6 (169.9 cm). The effects of these spacing were on par and significantly superior to all other spacing. The minimum vine length (138.1 cm) was recorded in pit method ie, S_7 (2.0 x 1.5 m) at the time of final harvest.

Effects of treatments combining irrigation systems and spacing on vine length at the time of final harvest was not significant and were also equal in both the seasons.

4.1.3. Number of branches per plant at 30 DAS

The results indicated that different methods of irrigation did not affect the number of branches at 30 DAS.

Though not significant during first crop season, different spacing caused significant effect on number of branches during second crop. S_3 (1.5 x 0.30 m), S_4 (1.5 x 0.45 m) and S_6 (1.0 x 0.45 m) recorded maximum number of branches (3.0). S_3, S_4, S_5 and S_6 were significantly superior to S_1, S_2 and S_7. Number of branches at the flowering and initial fruiting stage was minimum (2.0) in S_7 (2.0 x 1.5 m).

Table 3. Effect of irrigation and spacing on vegetative characters during the first crop

Main plot / Sub plot	Length of vine (cm)		Number of branches		Leaf area (cm^2)	
	at 30DAS	at final harvest	at 30DAS	at final harvest	at 30DAS	at final harvest
A.Irrigation						
I_1	85.84	146.00	2.5	3.5	72.35	74.24
I_2	82.35	164.54	2.4	3.5	73.50	77.78
B.Spacing						
S_1	88.7	135.9	2.3	3.8^{ab}	74.5^{b}	75.0^{b}
S_2	78.1	139.2	2.2	3.2^{c}	63.8^{c}	70.0^{b}
S_3	90.9	161.1	2.6	3.4^{bc}	79.8^{ab}	71.0^{b}
S_4	68.4	160.2	3.0	4.0^{a}	66.9^{c}	74.8^{b}
S_5	96.7	174.7	2.9	3.7^{ab}	85.7^{a}	86.4^{a}
S_6	89.5	169.1	2.1	3.1^{c}	78.8^{ab}	82.6^{a}
S_7	76.5	146.6	2.0	3.4^{bc}	61.3^{c}	72.2^{b}
Mean	84.09	155.27	2.4	3.5	59.97	76.01

Table 4. Effect of irrigation and spacing on vegetative characters during the second crop

Main plot / Sub plot	Length of vine (cm)		Number of branches		Leaf area (cm^2)	
	at 30DAS	at final harvest	at 30DAS	at final harvest	at 30DAS	at final harvest
A.Irrigation						
I_1	114.57	145.72	2.5	3.28	57.85	77.18
I_2	112.95	162.20	2.5	3.21	62.08	83.86
B. Spacing						
S_1	107.7^{cd}	148.9^{de}	2.0^{b}	2.8^{b}	63.3^{bc}	78.5^{bc}
S_2	106.1^{d}	143.1^{ef}	2.0^{b}	2.3^{b}	49.5^{d}	74.9^{c}
S_3	116.4^{b}	160.6^{bc}	3.0^{a}	4.0a	64.1^{b}	82.4^{b}
S_4	114.7^{bc}	154.1^{cd}	3.0^{a}	4.0^{a}	58.4^{bc}	78.9^{bc}
S_5	126.9^{a}	173.8^{a}	2.8^{a}	3.5^{a}	54.5^{c}	91.4^{a}
S_6	122.5^{ab}	169.9^{ab}	3.0^{a}	3.5^{a}	76.5^{a}	84.9^{b}
S_7	102.3^{d}	138.1^{f}	2.0^{b}	2.8^{b}	50.5^{d}	72.9^{c}
Mean	113.77	155.46	2.5	3.3	72.92	80.52

Table 5. Performance of Saubhagya during the first crop - Vegetative characters

Treatments	Length of vine (cm)		Number of branches		Leaf area (cm^2)	
	at 30DAS	at final harvest	At 30DAS	at final harvest	at 30DAS	at final harvest
T_1 - I_1S_1	98.60	112.5	3.0	3.4	71.1	71.8
T_2 - I_1S_2	79.60	116.4	2.0	3.1	59.8	69.2
T_3 - I_1S_3	94.80	156.3	2.7	3.5	82.3	68.5
T_4 - I_1S_4	51.90	157.2	2.7	4.1	68.3	74.5
T_5 - I_1S_5	102.0	165.2	2.8	3.7	84.1	83.5
T_6 - I_1S_6	101.0	175.4	2.0	3.0	80.4	81.1
T_7 - I_1S_7	73.00	139.0	2.0	3.8	60.6	71.0
T_8 - I_2S_1	78.85	159.0	1.5	4.1	77.9	78.1
T_9 - I_2S_2	76.65	162.0	2.3	3.3	67.7	70.8
T_{10} - I_2S_3	86.90	165.9	2.5	3.3	77.3	73.5
T_{11} - I_2S_4	84.80	163.3	3.2	3.8	65.4	75.1
T_{12} - I_2S_5	91.35	184.3	3.0	3.7	87.3	89.2
T_{13} - I_2S_6	77.90	162.7	2.2	3.2	77.2	84.2
T_{14} - I_2S_7	80.00	154.2	2.0	3.0	61.9	73.4
Mean	84.09	155.27	2.4	3.5	59.97	76.01

Table 6. Performance of Saubhagya during the second crop- Vegetative characters

Treatments	Length of vine (cm)		Number of branches		Leaf area (cm^2)	
	at 30DAS	at final harvest	At 30DAS	at final harvest	at 30DAS	at final harvest
T_1 - I_1S_1	102.5^{e}	139.6	2.0	2.5	66.0	77.0
T_2 - I_1S_2	100.7^{e}	128.8	2.0	2.5	45.5	71.0
T_3 - I_1S_3	121.9^{abc}	153.1	3.0	4.0	58.7	80.1
T_4 - I_1S_4	116.9^{ab}	142.8	3.0	4.0	56.8	74.8
T_5 - I_1S_5	128.4^{a}	161.9	2.5	3.5	58.5	86.2
T_6 - I_1S_6	129.1^{a}	159.4	3.0	3.5	73.5	80.2
T_7 - I_1S_7	102.5^{e}	134.7	2.0	3.0	46.0	70.3
T_8 - I_2S_1	112.8^{cde}	158.2	2.0	3.0	60.6	79.9
T_9 - I_2S_2	111.4^{de}	157.4	2.0	2.0	53.5	78.7
T_{10} – I_2S_3	110.8^{de}	168.1	3.0	4.0	69.5	83.6
T_{11} - I_2S_4	112.5^{de}	153.4	3.0	4.0	60.0	82.9
T_{12} - I_2S_5	125.4^{abc}	185.6	3.0	3.5	56.5	90.6
T_{13} - I_2S_6	115.9^{bcd}	180.3	3.0	3.5	79.5	89.7
T_{14} - I_2S_7	102.0^{e}	141.5	2.0	2.5	55.0	75.4
Mean	113.77	155.46	2.5	3.3	72.92	80.52

Variations due to interaction of irrigation methods and spacing on number of branches at 30 DAS were not significant during both the seasons (Appendix II and III). Number of branches at 30 DAS was also almost equal during both the cropping seasons.

4.1.4. Number of branches at final harvest

Number of branches at final harvest was not affected by different methods of irrigation in both the crops.

The effect of spacing on number of branches was significant during both the seasons. Among different spacing during the first crop, maximum number of branches (4.0) was observed in S_4 (1.5 x 0.45 m) and minimum in S_6 (3.1). The effect of S_4 was on par with S_5 and S_1. During second crop season also S_4 (4.0) recorded maximum number of branches, which was on par with S_5 and S_6 and minimum in S_7 (2.8) (Table 3 and Table 4).

Various treatment combinations did not significantly affect the number of branches at the time of final harvest in both the crops (Appendix II and III). It was almost equal in both the crops.

4.1.5. Leaf area at 30 DAS

The influence of methods of irrigation on leaf area at 30 DAS was not significant during both the crops (Appendix II and III). Different spacing had significant effect in both the crops. Among different spacing, closer spacing S_5 (1.0 x 0.30 m) recorded the maximum leaf area (85.7 cm^2) and was on par with S_6 and S_3 and S_7 recorded minimum leaf area (61.3 cm^2) in first crop. During second crop, S_6 (76.5 cm^2) was significantly superior to all other spacing. Leaf area was comparatively more during the first crop.

The interaction effect of main plot with sub plot was not significant on leaf area during both the seasons at 30 DAS.

4.1.6. Leaf area at final harvest

The influence of methods of irrigation on leaf area at the time of final harvest was not significant in both the experiments (Appendix II and III).

Spacing had significant influence on leaf area at the time of final harvest in both the crops. During the both seasons maximum leaf area was observed in S_5, which was on par with S_6 during first season, and both S_5 and S_6 were significantly superior to all other spacing. During the second season S_5 was significantly superior to all other spacing.

Interaction effect of main plot with sub plot was not significant in both the crops. Leaf area at the time of final harvest was more during second crop.

4.2. FLOWERING AND EARLINESS

4.2.1. Days to first male flower anthesis

The effects of different methods of irrigation, spacing and their interaction on days taken to first male flower anthesis were not significant in both the cropping seasons (Appendix II and III).

The treatment combinations of the main plot with sub plot on male flower anthesis were not significant during both the seasons. Days for opening of male flower in the remaining treatments was almost identical and ranged from 26.0 to 28.5 days during first crop and 22.3 to 24.0 during the second crop.

The male flower opening was earlier by four days in second crop compared to first crop.

4.2.2. Days to female flower anthesis

The influence of irrigation methods on days to first female flower anthesis was not significant in both the crops.

Among the different spacing, days taken to first female flower anthesis was significantly earlier in S_4 (27.4) which was on par with S_5 and S_6 during the first crop. In the second crop, spacing had no significant effect and it ranged from 31.2 to 32.8 days (Table 7 and Table 8).

Days to first female flower anthesis was not significantly altered by various treatment combinations in both the crops and in general, female flower opening was earlier by three days in first crop.

4.2.3. Node at which the first female flower formed

Node at which the first female flower formed was not significantly altered by the irrigation systems (Appendix II and III).

The different spacing caused significant variation on the number of nodes for the first female flower formation during second crop season only. Female flowers were formed at the lowest node in S_5 (3.3) and farthest node in S_3 (6.3).

Treatment combinations had no significant effect on the node of female flower formation in both the crops. It is worth to note that during the first crop season female flower formation started at the lowest node (3.7) compared to the node number of (4.5) in the second crop.

4.2.4. Number of female flowers

The two methods of irrigation did not make significant variation on the number of female flowers per plant during both the crops (Appendix II and III).

The effect of spacing on the number of female flowers was significant in the first crop only. Among different spacing, S_4 recorded maximum number of female flowers (8.95). Minimum female flowers were formed in S_7 (7.6).

Effect of treatment combinations on number of female flowers per plant was also significant in the first crop season. Maximum female flowers were observed in I_1S_4 (9.0) followed by I_2S_4 (8.9). I_1S_4 was significantly superior to I_2S_4 in drip

Table 7. Effect of spacing and irrigation on flowering and earliness during first crop

Main plot/subplot	Days to first male flower anthesis	Days to first female flower anthesis	Node at which first female flower formed	No. of female flowers	Fruit set percentage	Node at which first fruit retained	Days to first harvest	Days to last harvest
A.Irrigation								
I_1	26.51	28.60	3.9	7.73	55.1	5.0	44.35	55.85
I_2	27.64	28.37	3.5	8.44	43.9	4.9	45.57	53.78
B. Spacing								
S_1	26.8	28.6^{ab}	3.8	7.95^{d}	44.10^{e}	5.0	46.3^{ab}	53.5^{bc}
S_2	27.0	29.3^{a}	3.7	7.55^{g}	46.91^{d}	5.3	45.3^{b}	54.0^{bc}
S_3	26.9	29.2^{a}	4.1	8.10^{c}	43.90^{e}	5.4	47.0^{a}	55.5^{b}
S_4	27.2	27.4^{c}	4.1	8.95^{a}	61.45^{a}	5.3	45.0^{b}	55.0^{b}
S_5	27.8	28.0^{bc}	3.5	7.65^{e}	55.50^{b}	4.6	42.0^{c}	52.5^{c}
S_6	27.6	27.9^{bc}	3.5	8.80^{b}	54.65^{c}	4.6	42.8^{c}	54.8^{b}
S_7	26.3	29.2^{a}	3.5	7.60^{f}	40.30^{f}	4.8	46.5^{ab}	58.5^{a}
Mean	27.07	28.49	3.7	8.08	50.0	5.0	44.9	54.8

Table 8. Effect of spacing and irrigation on flowering and earliness during the second crop

Main plot/subplot	Days to first male flower anthesis	Days to first female flower anthesis	Node at which first female flower formed	No. of female flowers	Fruit set percentage	Node at which first fruit retained	Days to first harvest	Days to last harvest
A.Irrigation								
I_1	22.74	31.78	4.9	7.80	45.22	5.1	47.9	55.9
I_2	23.80	32.0	4.2	7.77	50.80	5.0	48.0	56.8
B. Spacing								
S_1	22.8	31.9	4.7^{abc}	7.65	45.68	5.2	48.5	56.7
S_2	23.5	31.9	4.5^{bc}	7.10	45.13	5.1	48.1	55.6
S_3	23.4	31.7	6.3^{a}	7.30	61.46	5.0	47.8	56.6
S_4	23.9	31.2	4.0^{bc}	8.30	54.24	4.6	48.5	57.1
S_5	23.3	32.1	3.3^{c}	8.70	48.97	5.1	46.9	57.0
S_6	23.4	31.5	4.0^{bc}	7.25	53.24	5.1	49.2	56.2
S_7	23.8	32.8	5.3^{ab}	8.30	27.36	5.3	47.3	55.8
Mean	23.27	31.88	4.5	7.78	48.0	5.06	48.02	56.42

Table 9. Performance of Saubhagya during the first crop - Flowering and earliness

Treatments	Days to first male flower anthesis	Days to first female flower anthesis	Node at which first female flower formed	No. of female flowers	Fruit set per centage	Node at which first fruit retained	Days to first harvest	Days to last harvest
T_1 - I_1S_1	26.0	29.4	3.8	7.6^{g}	46.04^{h}	4.8	45.5	55.0
T_2 - I_1S_2	26.5	29.4	3.9	7.1^{i}	56.32^{e}	5.4	45.0	54.5
T_3 - I_1S_3	26.0	28.9	4.3	7.5^{h}	53.32^{f}	4.6	47.0	57.5
T_4 - I_1S_4	26.5	27.5	4.9	9.0^{a}	61.10^{c}	5.2	43.5	56.5
T_5 - I_1S_5	27.4	28.3	3.3	7.7^{f}	58.43^{d}	4.7	41.5	54.0
T_6 - I_1S_6	26.7	27.5	3.5	8.7^{c}	64.36^{a}	4.7	41.5	54.5
T_7 - I_1S_7	26.5	29.3	3.6	6.5^{e}	46.14^{h}	6.1	46.5	59.0
T_8 - I_2S_1	27.5	27.9	3.7	8.3^{d}	42.16^{j}	5.1	47.0	52.0
T_9 - I_2S_2	27.5	29.1	3.4	8.0^{e}	37.49^{k}	5.2	45.5	53.5
T_{10} - I_2S_3	27.5	29.4	3.8	8.7^{c}	34.47^{l}	6.2	42.5	53.5
T_{11} - I_2S_4	27.8	27.3	3.4	8.9^{b}	61.45^{b}	5.4	47.0	53.5
T_{12} - I_2S_5	28.0	27.7	3.6	7.6^{g}	52.62^{j}	4.5	47.0	51.0
T_{13} - I_2S_6	28.5	28.3	3.4	8.9^{b}	54.65^{i}	4.6	42.5	55.0
T_{14} - I_2S_7	26.0	29.0	3.5	8.7^{c}	40.30^{l}	3.6	46.5	58.0
Mean	27.07	28.49	3.7	8.08	50.0	5.0	44.9	54.8

Table 10. Performance of Saubhagya during the second crop - Flowering and earliness

Treatments	Days to first male flower anthesis	Days to first female flower anthesis	Node at which first female flower formed	No. of female flowers	Fruit set percentage	Node at which first fruit retained	Days to first harvest	Days to last harvest
T_1 - I_1S_1	22.3	31.7	5.0	7.1	42.46	4.5	49.0	58.7
T_2 - I_1S_2	23.6	31.8	4.5	8.4	29.92	5.1	47.8	55.7
T_3 - I_1S_3	22.6	31.6	6.5	7.3	56.06	5.3	47.6	55.3
T_4 - I_1S_4	22.5	31.2	4.5	7.9	50.64	5.0	48.7	54.8
T_5 - I_1S_5	22.7	32.6	3.5	9.0	49.90	4.6	46.4	57.4
T_6 - I_1S_6	23.0	30.5	5.0	7.2	61.68	5.7	48.8	55.6
T_7 - I_1S_7	23.5	33.1	5.5	7.7	25.91	5.5	47.5	54.6
T_8 - I_2S_1	23.3	32.3	4.5	8.2	48.89	5.9	47.9	54.6
T_9 - I_2S_2	23.3	31.9	4.5	5.8	60.34	5.2	48.4	55.7
T_{10} - I_2S_3	24.1	31.8	6.0	7.3	66.86	4.8	47.9	57.8
T_{11} - I_2S_4	24.3	31.2	3.5	8.7	57.84	4.1	48.4	59.3
T_{12} - I_2S_5	23.9	31.7	3.0	8.4	48.05	5.6	47.5	56.7
T_{13} - I_2S_6	23.8	32.6	3.0	7.3	44.80	4.5	49.5	56.9
T_{14} - I_2S_7	24.0	32.5	5.0	8.7	28.80	5.1	47.0	57.0
Mean	23.27	31.88	4.5	7.78	48.0	5.06	48.02	56.42

irrigation the interaction was significantly highest with S_4. In conventional irrigation also S_4 and S_6 recorded the highest interaction and was significantly the highest compared to the other interactions (Appendix II and III). Number of female flowers was more in the first crop season compared to the second season.

4.2.5. Fruit set percentage

The influence of methods of irrigation on fruit set percentage was not significant in both the crops.

The effect of spacing on fruit set percentage was significant during the first crop. S_4 recorded significantly the highest fruit set (61.45 %) followed by S_5 (55.5 %). During the second crop, spacing had no significant effect on fruit set percentage. Nevertheless S_3 and S_4 recorded higher values.

Treatment combinations had significant effect on fruit set during the first crop season only. In drip irrigation I_1S_6 recorded the maximum fruit set percentage (64.36 %) and was significantly superior to all other combinations. In conventional irrigation, I_2S_4 recorded the highest interaction (61.45 %). However I_2S_4 was inferior to I_1S_6. Compared to second crop, fruit set was relatively more during the first crop.

4.2.6. *Node at which the first fruit is retained*

The effect of different methods of irrigation on the first fruit-retaining node was not significant in both the crops.

Various spacing and treatment combinations also did not significantly affect the fruit-retaining node and it had a narrow range of 3.6 in I_2S_7 to 6.2 in 1_2S_3 during the first crop and 4.1 in I_2S_4 to 5.9 in I_2S_1 during second crop. This character was also not affected in two seasons.

4.2.7. Days to first harvest

Table 11. Effect of irrigation and spacing on fruit characters of Saubhagya in the first crop

Main plot / Sub plot	Length (cm)	Breadth (cm)	Average Fruit weight (g)	Flesh thickness (cm)
A.Irrigation				
I_1	22.22	26.02	549.48	3.071
I_2	22.44	27.30	579.83	3.107
B.Spacing				
S_1	21.9	25.1[b]	526.5[b]	2.95
S_2	21.0	26.8[ab]	505.9[b]	3.20
S_3	21.6	29.3[a]	506.1[b]	2.90
S_4	23.8	28.7[ab]	538.2[b]	3.25
S_5	23.3	26.1[a]	630.7[a]	3.12
S_6	25.0	26.2[ab]	720.0[a]	3.30
S_7	22.1	24.4[b]	535.0[b]	2.87
Mean	22.47	26.64	564.65	3.08

Table 12. Effect of irrigation and spacing on fruit characters of Saubhagya in the second crop

Main plot / Sub plot	Length (cm)	Breadth (cm)	Average fruit weight (g)	Flesh thickness (cm)
A.Irrigation				
I_1	19.41	27.39	693.6	3.071
I_2	19.94	27.94	718.7	3.107
B.Spacing				
S_1	19.56	27.68	662.6[bc]	2.87
S_2	18.96	26.71	604.5[c]	3.30
S_3	20.68	29.80	699.8[bc]	2.95
S_4	19.93	28.40	734.0[ab]	3.20
S_5	20.93	27.30	734.0[ab]	2.90
S_6	19.31	27.69	838.0[a]	3.25
S_7	18.94	25.90	669.0[b]	3.12
Mean	19.67	27.60	706.13	3.08

Table 13. Performance of Saubhagya during the first crop - Fruit characters

Treatments	Length (cm)	Breadth (cm)	Average fruit weight (g)	Flesh thickness (cm)
T_1 - I_1S_1	21.3	23.3	506.5	3.0
T_2 - I_1S_2	20.7	27.1	480.0	3.4
T_3 - I_1S_3	21.9	28.2	504.9	2.9
T_4 - I_1S_4	24.2	28.7	525.8	3.1
T_5 - I_1S_5	22.7	24.6	620.1	3.3
T_6 - I_1S_6	27.4	26.1	691.0	2.4
T_7 - I_1S_7	22.5	24.2	518.0	2.9
T_8 - I_2S_1	22.6	26.8	546.6	2.9
T_9 - I_2S_2	21.5	26.6	531.8	3.1
T_{10} - I_2S_3	21.2	30.3	507.2	2.9
T_{11}- I_2S_4	23.4	28.8	550.7	3.4
T_{12}- I_2S_5	23.9	27.6	641.3	2.9
T_{13}- I_2S_6	22.6	26.3	729.0	3.1
T_{14}- I_2S_7	21.9	24.5	552.0	3.4
Mean	22.33	26.64	546.65	3.08

Table 14. Performance of Saubhagya during the second crop - Fruit characters

Treatments	Length (cm)	Breadth (cm)	Average fruit weight (g)	Flesh thickness (cm)
T_1 - I_1S_1	18.9	27.3	656.8	2.9
T_2 - I_1S_2	18.2	25.8	584.5	2.4
T_3 - I_1S_3	19.7	29.1	722.3	3.0
T_4 - I_1S_4	20.6	27.9	773.3	3.4
T_5 - I_1S_5	20.5	26.4	644.3	2.9
T_6 - I_1S_6	18.4	28.6	829.0	3.1
T_7 - I_1S_7	19.4	27.1	644.7	3.3
T_8 - I_2S_1	20.2	28.0	668.5	3.4
T_9 - I_2S_2	19.8	27.6	624.6	3.1
T_{10} - I_2S_3	20.4	30.5	677.3	2.9
T_{11}- I_2S_4	19.3	28.9	694.7	3.1
T_{12}- I_2S_5	21.4	28.3	824.5	2.9
T_{13}- I_2S_6	20.3	27.3	847.7	3.4
T_{14}- I_2S_7	18.4	24.8	693.5	2.9
Mean	19.67	27.60	706.13	3.08

The effect of different methods of irrigation on days to first harvest was not significant during both the crops (Appendix II and III).

Among different spacing the first harvest was significantly earlier in S_5 (42.0) followed by S_6 (42.8). Their effects were on par and significantly superior to other spacing during first crop season. In the second crop, effect of spacing was not significant (Table 7 and Table 8).

The interaction effect on days to first harvest was not significant in both the crops (Table 9 and Table 10). The first harvest was four days earlier in first crop season compared to the second crop.

4.2.8. Days to last harvest

The influence of irrigation methods on days to last harvest was not significant in both the crops (Table 5 and Table 6).

Different spacing had significant effect on days to last harvest in first crop season only. The day taken for last harvest was maximum in S_7 (58.5) and minimum in S_5 (52.5 days) (Table 7 and Table 8).

Days to last harvest was not influenced by interaction effects in both the crops and in general it was earlier during first crop season (54.6 days) and was delayed by two days during the second crop.

4.3. FRUIT CHARACTERS

4.3.1. Length of fruit

The effect of different methods of irrigation and spacing on length of fruit was not significant in both the crops (Appendix II and III).

Fruit length was also not affected by interaction of main plot with sub plot in both the crops (Table 13 and Table 14). In general, length of fruit was more during the first crop (22.3 cm) compared to the second crop (19.6 cm).

4.3.2. Girth of fruit

The influence of irrigation methods on the girth of fruit was not significant in both the crops.

The effect of spacing on the girth of fruit was significant during the first crop season only (Appendix I). S_3 recorded the maximum girth (29.3 cm), which was on par with S_4, S_2, S_5 and S_6. The lowest value was recorded in S_7 (24.4 cm) during the first crop.

Various treatment combinations formed by different methods of irrigation and different spacing also did not influence girth of fruit (Table 13 and Table 14). Girth of fruit was more during the second crop (27.60 cm) compared to the first crop (26.64 cm).

4.3.3. Average fruit weight

Variation due to irrigation systems was not significant during both the crops (Appendix II and III).

The effect of spacing on the average fruit weight was significant in both the crops. During the first crop, closer spacing S_6 (1.0 x 0.45 m) recorded the maximum fruit weight (720.0 g), which was significantly superior to all other spacing. Average fruit weight in all the remaining spacing was on par and it ranged from 505.0 g to 630.0 g. During the second crop also maximum fruit weight (838.0 g) was observed in S_6 but was on par with S_4 and S_5 (734.0 g).

Interaction effects of main plot with sub plot were not significant on fruit weight in both the crops. Average fruit weight was more (706.13 g) during the second crop compared to the first crop (529.84 g).

4.3.4. Flesh thickness

Table 15. Effect of irrigation and spacing on yield characters during the first crop

Main plot/sub plot	No. of fruits plant^{-1}	Yield plant^{-1} (kg)	Total yield plot $^{-1}$ (kg)	Productivity (t ha^{-1})
A.Irrigation				
I_1	4.2	1.76	22.98	19.15
I_2	3.7	1.79	23.60	19.65
B. Spacing				
S_1	3.5^c	1.295^{bc}	16.64^{de}	13.86^{de}
S_2	3.5^c	1.240^c	16.77^{de}	13.97^{de}
S_3	3.5^c	1.815^b	20.04^d	16.70^d
S_4	5.5^a	2.400^a	24.70^c	20.58^c
S_5	4.5^b	2.575^a	40.73^a	33.93^a
S_6	4.2^d	1.835^b	30.46^b	25.38^b
S_7	3.0^c	1.295^{bc}	13.70^e	11.41^e
Mean	3.7	1.77	23.29	19.409

Table16. Effect of irrigation and spacing on yield characters during the second crop

Main plot/ sub plot	No. of fruits plant^{-1}	Yield plant^{-1} (kg)	Total yield plot^{-1} (kg)	Productivity (t ha^{-1})
A.Irrigation				
I_1	3.42	1.821	20.53	17.11
I_2	3.78	1.824	20.78	17.31
B. Spacing				
S_1	3.5^{bc}	1.525^{cd}	17.0^{de}	14.23^{de}
S_2	3.0^{cd}	1.325^{cd}	14.0^{ef}	11.67^{ef}
S_3	4.25^{ab}	2.150^{ab}	23.8^{bc}	19.85^{bc}
S_4	3.5^{bc}	1.85^{bc}	20.8^{cd}	17.37^{cd}
S_5	4.25^{ab}	2.11^{ab}	27.5^{ab}	22.93^{ab}
S_6	4.5^a	2.67^a	30.1^a	25.12^a
S_7	2.25^d	1.12^d	11.1^f	9.2^f
Mean	3.7	1.82	20.65	17.21

Table 17. Performance of Saubhagya during the first crop -Yield characters

Treatments	No. of fruits plant^{-1}	Yield plant^{-1} (kg)	Total yield plot^{-1} (kg)	Productivity (t ha^{-1})
T_1 - I_1S_1	3.5	1.18	15.57	12.97
T_2 - I_1S_2	4.0	1.11	11.5	9.59
T_3 - I_1S_3	4.0	1.80	21.6	17.98
T_4 - I_1S_4	5.5	2.25	23.4	19.52
T_5 - I_1S_5	5.0	2.70	39.5	32.95
T_6 - I_1S_6	4.5	1.82	33.7	28.05
T_7 - I_1S_7	3.0	1.49	15.6	13.00
T_8 - I_2S_1	3.5	1.41	17.7	14.76
T_9 - I_2S_2	3.0	1.37	22.1	18.35
T_{10} – I_2S_3	3.0	1.83	18.5	15.42
T_{11} - I_2S_4	5.5	2.55	25.9	21.64
T_{12} - I_2S_5	4.0	2.45	41.9	34.91
T_{13} - I_2S_6	4.0	1.85	27.3	22.70
T_{14} - I_2S_7	3.0	1.10	11.8	9.8
Mean	3.7	1.779	23.29	19.40

Table 18. Performance of Saubhagya during the second crop - Yield characters

Treatments	No. of fruits plant^{-1}	Yield plant^{-1} (kg)	Total yield plot^{-1} (kg)	Productivity (t ha^{-1})
T_1 - I_1S_1	3.0	1.15	14.1	11.71
T_2 - I_1S_2	2.5	1.65	13.2	11.01
T_3 - I_1S_3	4.0	2.35	25.4	21.16
T_4 - I_1S_4	4.0	1.95	23.5	19.62
T_5 - I_1S_5	4.5	2.25	28.4	23.66
T_6 - I_1S_6	4.0	2.70	27.3	22.75
T_7 - I_1S_7	2.0	1.00	11.8	9.80
T_8 - I_2S_1	4.0	1.90	20.1	16.75
T_9 - I_2S_2	3.5	1.30	14.2	12.34
T_{10} – I_2S_3	4.5	1.95	22.5	18.54
T_{11} - I_2S_4	3.0	1.75	18.2	15.12
T_{12} - I_2S_5	4.0	1.97	26.6	22.20
T_{13} - I_2S_6	5.0	2.65	33.0	27.50
T_{14} - I_2S_7	2.0	1.25	10.5	8.70
Mean	3.7	1.823	20.65	17.21

The influence of irrigation methods, spacing and their interaction on flesh thickness was not significant in both the crops. Seasons also did not affect flesh thickness and it was (3.08 cm) during both the seasons.

4.4. YIELD CHARACTERS

4.4.1. Number of fruits per plant

The influence of irrigation methods on number of fruits per plant was not significant in both the seasons (Appendix II and III).

The effect of spacing was significant during both the seasons. In the first crop, number of fruits was maximum in S_4 (5.5) followed by S_5 (4.5) and minimum in S_7 (3.0). S_4 was significantly superior to all other spacing. During the second crop, S_6 recorded maximum number of fruits (4.5) and was on par with S_3 and S_5.

Interaction effects of main plot with sub plot treatments were not significant on number of fruits per plant during both the seasons (3.7).

4.4.2. Yield per plant

The effect of irrigation methods on yield per plant was not significant during both the seasons, while spacing had significant effect. Among the different spacing S_5 (1.0 x 0.30 m) recorded the maximum yield per plant (2.58 kg) which was on par with S_4 (2.40 kg). Both S_5 and S_4 were significantly superior to all other spacing in the first season crop. The recommended spacing of S_7 (2.0 x 1.5 m) had minimum yield of (1.3 kg). In the second season crop, S_6 (2.67 kg) recorded the highest per plant yield and was on par with S_3 and S_5. Here also minimum yield was recorded in S_7 (1.12 kg) (Table 17 and Table 18).

The interaction effect of main plot with sub plot on per plant yield was not significant during both the seasons (Appendix II and III). Average per plant yield was more during second season crop (1.82 kg) than the first season crop (1.77 kg).

4.4.3. Total yield per plot (kg/12 m^2)

The effect of irrigation methods was not significant on total yield per plot in both season crops.

Highly significant variation was observed among the different spacing on total yield per plot in both seasons. During the first season, closer spacing S_5 (1.0 x 0.30 m) recorded the maximum yield (40.73 kg) followed by S_6 (30.46 kg). S_5 was significantly superior to all other spacing. Minimum yield (13.7 kg) was recorded in S_7 (2.0 x 1.5 m). In the second crop, maximum yield (30.15 kg) was obtained in S_6 (1.0 x 0.45 m) followed by S_5 (27.5 kg) and lowest in S_7 (11.1 kg). S_6 was on par with S_5 and both were significantly superior to all other spacing.

Effect of various treatment combinations formed by different methods of irrigation and spacing were not significant during both the crops (Appendix II and III). I_2S_5 recorded maximum yield (41.9 kg) followed by I_1S_5 (39.5 kg) during the first crop. During the second crop it was I_2S_6 followed by I_1S_5 (33.0 kg and 28.4 kg, respectively).

More yield was obtained during the first crop (23.29 kg) compared to the second season crop (20.65 kg).

4.4.4. Productivity (t ha^{-1})

Two methods of irrigation did not make significant variation on productivity of fruits (Appendix II and III).

The effect of spacing was significant in both the crops. During the first season, closer spacing S_5 (1.0 x 0.30 m) recorded maximum productivity (33.9 t ha^{-1}) followed by S_6 (28.38 t ha^{-1}). S_6 was significantly far superior to all other spacing. Lowest productivity was recorded in S_7 (11.41 t ha^{-1}). In the second crop, S_6 (1.0 x 0.45 m) recorded maximum productivity (25.12 t ha^{-1}) and was on par with S_5 (22.93 t ha^{-1}). S_7 (2.0 x 1.5 m) recorded minimum productivity (9.2 t ha^{-1}).

Table 19. Economics of production of Saubhagya under drip irrigation

Treatments	Cost of irrigation (Rs)	Cost of input (Rs)	Cultivation cost (Rs)	Total cost (Rs)	Total return (Rs)	Net profit (Rs)
T_1 - I_1S_1	32213.60	10379.0	19060.0	61652.6	49448.0	-12204.6
T_2 - I_1S_2	24350.80	9273.7	19060.0	52684.5	41164.0	-11520.5
T_3 - I_1S_3	40077.8	11421.9	19060.0	70559.7	78290.0	7730.3
T_4 - I_1S_4	29588.1	10107.8	19060.0	58755.0	78206.0	19451.3
T_5 - I_1S_5	59786.0	13755.4	19060.0	92601.4	113232.0	20630.6
T_6 - I_1S_6	41387.0	11561.9	19060.0	72008.9	101598.0	29589.1
T_7 - I_1S_7	22664.3	9077.2	19060.0	50801.5	45664.0	-5137.5

Table 20. Economics of production of Saubhagya under conventional irrigation

Treatments	Cost of irrigation (Rs))	Cost of input (Rs)	Cultivation cost (Rs)	Total cost (Rs)	Total return (Rs)	Net profit (Rs)
T_8 - I_2S_1	23925.0	10379.0	19060.0	53364.0	62996.0	9632.0
T_9 - I_2S_2	23925.0	9237.70	19060.0	52258.0	60364.0	8106.0
T_{10} - I_2S_3	32190.0	11421.9	19060.0	62671.9	68338.0	5666.1
T_{11} - I_2S_4	32190.0	10107.8	19060.0	61357.8	72612.0	11254.2
T_{12} - I_2S_5	48285.0	13755.4	19060.0	81100.4	114152.0	33051.6
T_{13} - I_2S_6	48285.0	11561.9	19060.0	78906.9	100398.0	21491.1
T_{14} - I_2S_7	21750.0	9077.2	19060.0	49887.2	37766.0	-12121.2

Table 21. Details of water used, saved, yield advantage and extension of irrigated area (average of two seasons)

Spacing	Quantity of water used (mm)		Water saving by drip (%)	Productivity under different spacings (t ha⁻¹)		Yield advantage of drip over conventional method (%)	Increase in irrigable area (ha)
	Drip	Conventional		Drip	Conventional		
S_1	273.2	575.5	110.7	14.8	18.9	-21.4	1.1
S_2	191.3	402.5	110.4	12.3	18.1	-32.6	1.1
S_3	328.0	690.0	110.4	23.5	20.5	13.1	1.1
S_4	246.0	517.5	110.4	23.4	22.1	6.4	1.1
S_5	551.6	1150.0	108.05	33.9	34.3	-0.7	1.09
S_6	382.6	805.0	110.4	30.5	30.1	10.5	1.1
S_7	146.6	345.0	135.3	13.4	11.2	19.2	1.35

Table 22. Effect of irrigation and spacing on FWUE

Treatments	FWUE		Increase of FWUE in drips over conventional method (%)
	Drip	Conventional	
S_1	45.2	27.3	65.6
S_2	53.8	38.0	41.6
S_3	59.7	24.6	142.6
S_4	79.6	35.4	124.9
S_5	51.3	24.8	106.9
S_6	66.4	31.2	112.8
S_7	77.8	26.7	191.4

Effect of various treatment combinations during both season crops formed by different methods of irrigation and spacing was not significant in both the seasons. Productivity was more during the first crop (19.41 t ha^{-1}) compared to the second crop (17.21 t ha^{-1})

4.5. SAVING OF IRRIGATION WATER

There was 108.1 to 135.3 per cent saving of irrigation water at different spacing due to drip irrigation over conventional irrigation. In S_3, S_4, S_6 and S_7 there was yield advantage due to drip irrigation over conventional method. However there was the yield reduction in S_1, S_2 and S_5 under drip method over conventional method. It is worth to note that the increase in irrigable area in hectare ranged from 1.09 to 1.35 under drip irrigation over conventional method (Table 21).

4.6. FIELD WATER USE EFFICIENCY (FWUE)

Field water use efficiency, which is fruit yield (kg) / total water applied (mm) varied very much between spacing, both under drip and conventional method of irrigations. FWUE was highest with 1.5 x 0.45 m spacing under drip and with 2.0 x 0.45 m spacing under conventional method of irrigation. Between irrigation methods also FWUE was almost higher by 41.6 to 191.4 percentage under drip compared to conventional methods at the various spacing tried (Table 22).

4.7. INCIDENCE OF PESTS AND DISEASES

There was a stray incidence of American serpentine leaf miner (*Liriomyza trifoli* Burgees) and fruit fly (*Bactrocera cucurbitae* Coquillet) during the first crop. The incidence was noticed uniformly in all the treatments and was not specific to any treatment. This was brought under control by the prophylactic and frequent spray of neemoil garlic emulsion.

During the second crop stray incidence of fruit rot was noticed. Spraying of mancozeb (0.2 %) was conducted for preventing further spread and control of disease.

4.8. ECONOMICS OF PRODUCTION

The cost of cultivation was Rs. 19,060.00 per ha excluding cost of drip irrigation system and labour cost of irrigation. The quantity and cost of seed, FYM, fertilizers, plant protection chemicals, drip irrigation systems and labour cost varied depending upon the population density. The details are given in Appendix IV.

The cost of inputs was maximum (Rs. 13,755.00) in S_5 and minimum (Rs. 9,077.20) in S_7. The cost of drip irrigation system was also high in S_5 (Rs. 2,98,930.00) and minimum in S_7 (Rs. 1,13,321.50). Based on the assumption that the drip system can be utilized at least for five seasons, one fifth of the cost was considered for calculating the cost of irrigation for one season.

Under conventional method of irrigation, labour cost for irrigating channels or pits was maximum at S_5 and S_6 (Rs. 48,288.00). Considering all the above factors together cost of production was maximum for the treatment I_1S_5 (Rs 92,601.40) followeed by I_2S_5 (Rs 81,100.40). The minimum cost of production (Rs 49,887.20) was incurred under I_2S_7. Out of 14 treatments net profit was maximum for I_2S_5 (Rs. 33,051.00) followed by I_1S_6 (Rs. 29,589.10) and I_2S_6 (Rs. 21,491.00). I_1S_1, I_1S_2, I_1S_7 and I_2S_7 had negative values and were at loss. Maximum loss of (Rs. 2,204.60) was noticed in the treatment I_1S_1.

Discussion

V. DISCUSSION

Cucurbits are the most important group of vegetables in the tropics. The family cucurbitaceae include nine genera and 750 species of "vine crops" with spreading growth habit. The genus *Cucumis* to which oriental pickling melon belongs, consists of 30 species. However two species namely *Cucumis melo* and *Cucumis sativus* are of global interest. Oriental pickling melon (*C.melo* var.*conomon*) is a unique vegetable of Kerala and is mainly cultivated during the summer months. Its characteristic golden yellow coloured mature fruits are produced in abundance during the auspicious occasion of "Vishu" festival. The tender fruits can also be used for salad purpose. The fruits are good source of carbohydrate (10.3%), vit.A (4200 IU), ascorbic acid (19.45g) and minerals (19.45g) (Yalwakar, 1980). It is mainly grown as an irrigated crop in the summer rice fallows in Kerala and is a preferred vegetable of farmers in the state because of its high yield with in a short span of three months, easiness in production and low production cost.

The Kerala Agricultural University has developed three open pollinated varieties namely Mudicode, Arunima and Saubhagya. In addition, farmers in different parts of the state also grow a number of local cultivars. Mudicode and Arunima are large fruited varieties with good vegetative growth. Saubhagya is a small-fruited and short duration variety with less vegetative growth. Seed rate, spacing, irrigation, fertilizer requirement etc. of a variety depends on its duration, growth habit, fruiting pattern and yielding ability and may also vary from region to region depending on soil and climatic factors. Hence, adoption of variety specific package with optimum spacing, fertilizer, irrigation etc. are essential for achieving high productivity even in a high yielding variety.

The recommended pit to pit spacing of 2.0 x 1.5 m in oriental pickling melon is standardised based on the trials conducted in large fruited and vigorously growing variety Mudicode. Saubhagya being a short duration variety with less vegetative growth is not seen performing well under this wider spacing. This necessitated the present investigation to test further closer spacing in order to harvest maximum fruits from unit area.

Being a typical tropical vegetable, oriental pickling melon is mainly grown during summer months in Kerala. Water is a scarce component during peak summer months. Usually channel irrigation or basin irrigation or pot watering is followed under large-scale cultivation of oriental pickling melon. For effective utilization of water, drip irrigation has been widely tried in many crops. Alemeyhu (2001) found that drip irrigation with 125 Ep is a cost saving and viable irrigation method in oriental pickling melon variety Mudicode. However a variety differing in growth and duration may also differ in it's response to drip irrigation. Hence, as a preliminary investigation, the study was undertaken with the objective to standardize optimum spacing and to know the feasibility of drip irrigation in Saubhagya and the results are discussed below.

5.1 EFFECT OF CLIMATIC FACTORS ON GROWTH AND PRODUCTIVITY

Phenotypic expression of a plant is the result of sum total of its genetic constitution, environment and genotype environment interaction. The performance of any variety can be improved by subjecting it to favourable environmental conditions. Cucurbitaceous vegetables are essentially warm season crops grown mainly in tropical and subtropical regions. Generally a long period of warm climate, preferably dry weather with abundant sunshine is desired for majority of cucurbits. Excess humidity is reported to promote diseases such as mildews, anthracnose and virus diseases and pests such as fruit fly, mite etc. The oriental pickling melon requires tropical climate with fairly high temperature during fruit development. Cool nights and warm days hasten the maturity.

The oriental pickling melon variety Saubhagya grown under two methods of irrigation and seven spacing during December to February and February to April exhibited variation for a number of vegetative characters, earliness, fruit characters and yield attributes. A comparison of the data of the two growing seasons revealed valuable indications. In the present study the initial growth characters like vine length and leaf area were maximum (113.77 cm and 72.92 cm^2) during February sown crop compared to December sown crop (84.09 cm and 59.97 cm^2). The same trend of increased vegetative growth was continued up to end of the crop also. During the months of February, March and April the length of day recorded (11.5 h, 12.10 h and 12.22 h) respectively were more than that of December and January (11.3 h and 11.45 h respectively). The temperature during February sown cropping period (23.2 to 34.7°C) was also more than that of December sown cropping period (20.92 to 32°C). The climatic factors like long day length and high temperature prevailed during February to April may be responsible for increased vegetative growth in February sown crop. Kamalnathan and Thamburaj (1972) reported the effect of day length and temperature in increasing vegetative growth and delaying flowering phase in *Cucurbita moschata.*

Sex ratio in cucurbits is highly sensitive to environmental factors. In the present study also male flower production was earlier in February sown crop (23.2 days) than in December sown crop (27.2 days). It could be attributed due to long days and high temperature, which favour male tendency by modifying the endogenous gibberlic acid levels. Relatively high levels of gibberlic acid favour the formation of staminate flowers. Atsmon et al. (1969) and Hayashi et al. (1971) already reported similar results. Unlike male flowers, female flower production was earlier by four days in December sown crop (28.4 days). The short day length and optimum temperature of 24-30°C during the cropping period may be responsible for earlier female flower production in December sown crop. Studies by Cantiffe and Phatak (1981) in cucumber, Venkatraman (1967) in snakegourd and Kamalnathan and Thamburaj (1972) in Pumpkin revealed that short day length, low temperature (29.4°C – 29.9°C) and high humidity favoured femaleness.

Days to first harvest which is an important criteria from the farmers point of view was earlier by three days in December sown crop (44.9 days). Early female flower formation and less vegetative growth could have enhanced early maturity. A decrease in gibberlic acid and increase in auxin will increase the levels of ethylene which have positive role for early harvest. The studies by Rudich *et al.* (1973), Shannon and Guardial (1969) revealed that short days produce more auxin and in turn increase ethylene production. Thus, there exists interrelationship between gibberlin, auxin and ethylene in earliness characters.

Flower opening, pollen dehiscence and fruit set in cucurbits are highly influenced by environmental factors. The yield characters like number of female flowers, number of fruits plant^{-1} and total yield plot^{-1} and fruit set were relatively high (8.08, 3.7, 23.29 kg and 50.0 %, respectively) in December sown crop compared (7.7, 3.7, 20.65 kg and 48.0 %, respectively) to February sown crop. The fruit set will be maximum when temperature during the growth period ranges from 24 to 30°C. The optimum temperature and short day length would have enhanced the female flower primordia forming substance like auxin and provide conducive situation for anther dehiscence and fruit set in December sown crop.

The fruit characters like length and girth were not altered by growing seasons but average fruit weight, an important factor contributing to yield, was maximum 706.13 g during February sown crop compared to 564.65g during December sown crop. The increase in fruit weight is found directly related to the vegetative growth. More the vegetative growth, more will be the photosynthates produced and allocation to the fruits. Widders and Price (1989) found that increase in foliar production did not alter the photosynthetic efficiency of leaves but influenced carbon partitioning among alternative sinks within plants.

5.2. EFFECT OF IRRIGATION ON GROWTH AND PRODUCTIVITY

The physiological processes, which determine the ultimate yield and quality of produce, are highly dependent on the availability of soil moisture. Cucurbits, generally cultivated during spring-summer months needs frequent irrigation for maintaining soil moisture, which is a vital factor governing germination of seeds and growth of plants. Application of water in cucurbits should be restricted to the base of plants or root zone and water should not wet the vines or vegetative parts especially at flowering, fruit set and fruit development stages. Frequent wetting of stems, leaves and developing fruits will promote diseases and rotting of fruits.

Oriental pickling melon is usually grown by pot watering or channel irrigation during summer months in Kerala. Small wells dug in the rice fallows usually serve as source for pot watering or channel irrigation. Since plants have to be irrigated in alternate days a number of labourers are to be utilized for irrigating the crop and it ultimately leads to increased cost of production. This has great relevance in the light of high wage rate prevailing in the state.

Alemeyhu (2001) observed that drip method of irrigation at 125 E_P was much superior to conventional method of irrigation in oriental pickling melon variety Mudicode. The yield obtained from drip irrigated plots at 125 E_P was 34.8 t ha^{-1}, which was 24.5 per cent more than conventional method (27.3 t ha^{-1}). Additionally there was 13 per cent water saving and this alone accounted for 47.6 per cent additional income. The above study points to the need for testing the feasibility of drip irrigation in oriental pickling melon variety Saubhagya which differs from Mudicode in duration of the crop, fruit size and growth pattern.

During the present study vegetative characters like length of vine, number of branches and leaf area were not significantly influenced by two methods of irrigation namely drip irrigation at 125 E_P and conventional method @ 15 l $plant^{-1}$. Initial vine length was marginally more in the drip irrigation (Fig. 2). However at the time of final harvest vine length under conventional method

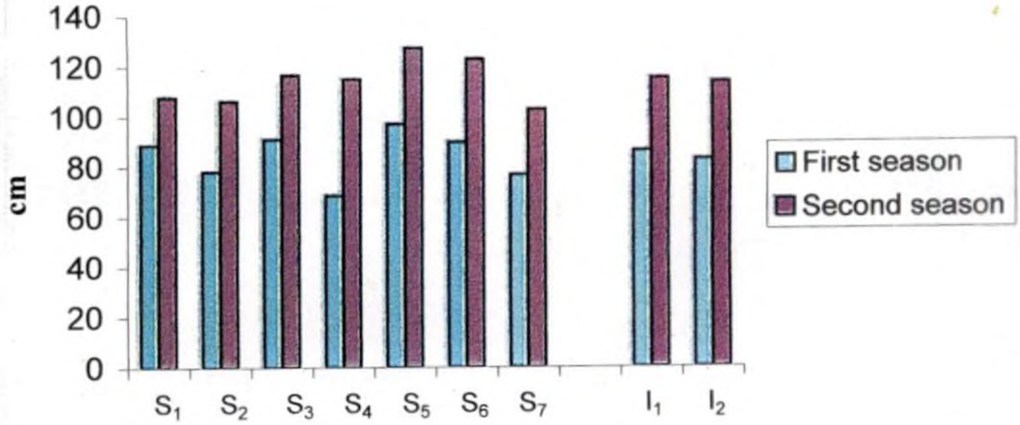

Fig. 2 Effect of spacing and irrigation on length of vine at 30 DAS (cm)

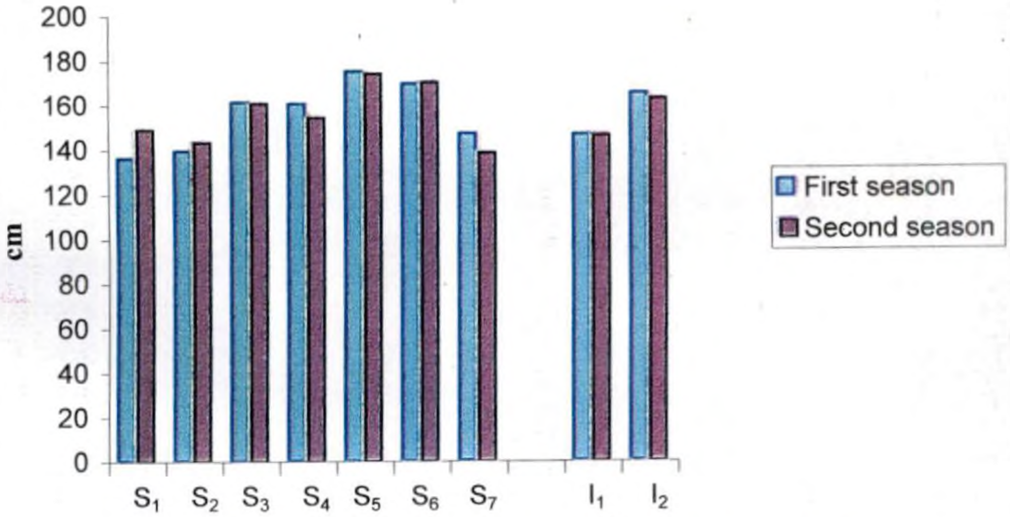

Fig.3 Effect of spacing and irrigation on length of vine at final harvest (cm)

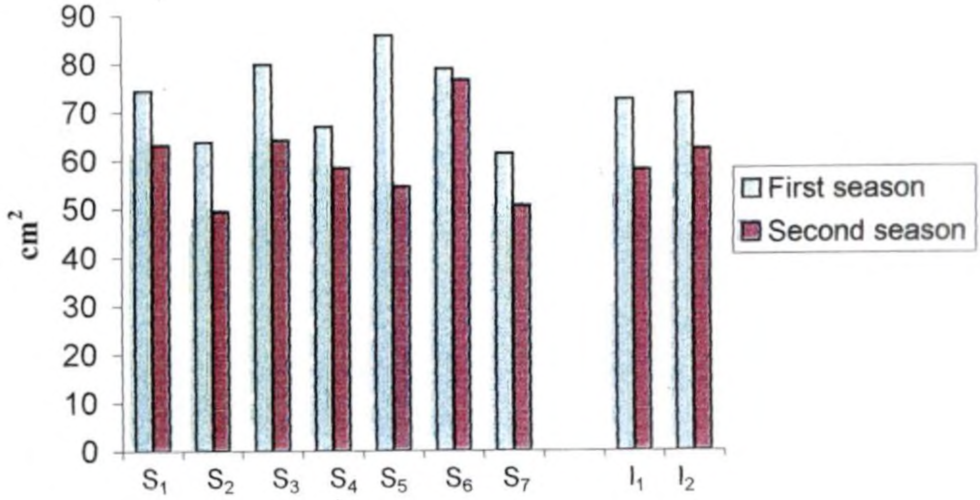

Fig.4 Effect of spacings and irrigation on leaf area at 30 DAS (cm^2)

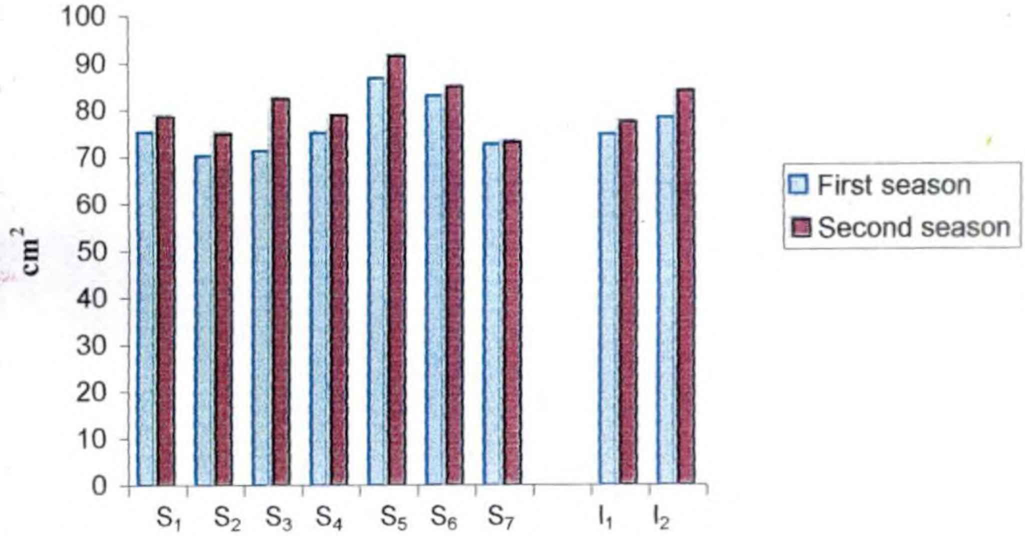

Fig.5 Effect of spacings and irrigation on leaf area at final harvest (cm^2)

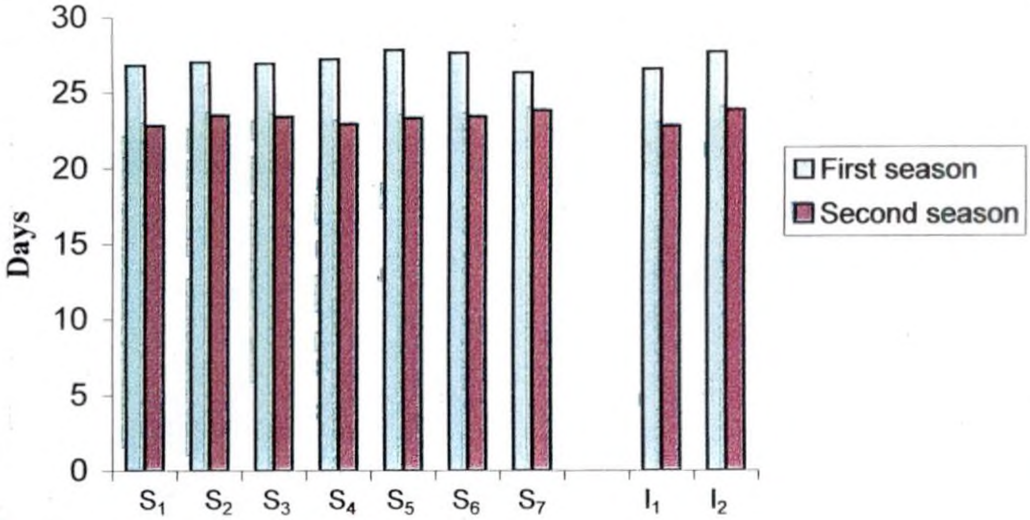

Fig.6 Effect of spacing and irrigation on days to first male flower anthesis

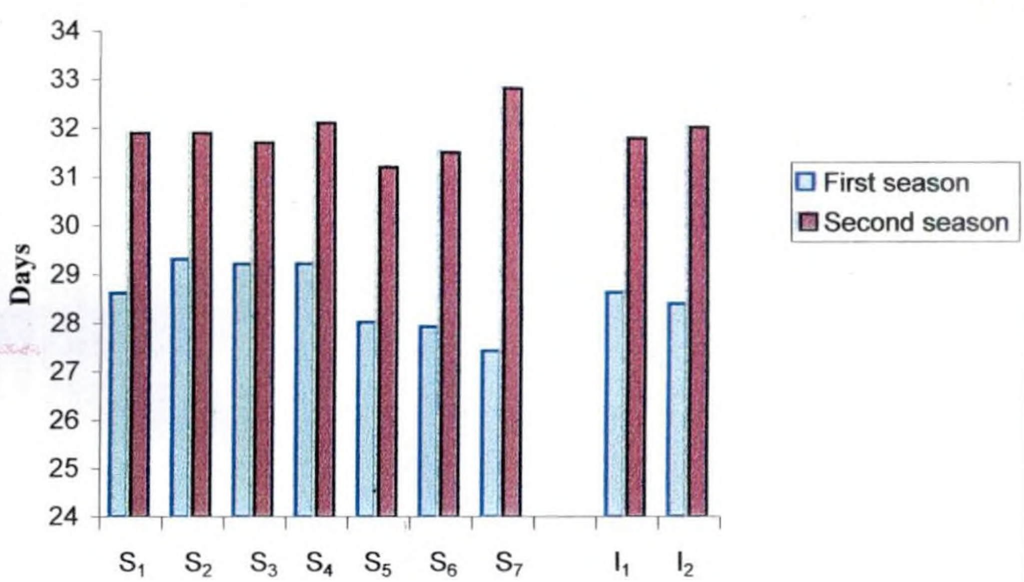

Fig.7 Effect of spacing and irrigation on days to first female flower anthesis

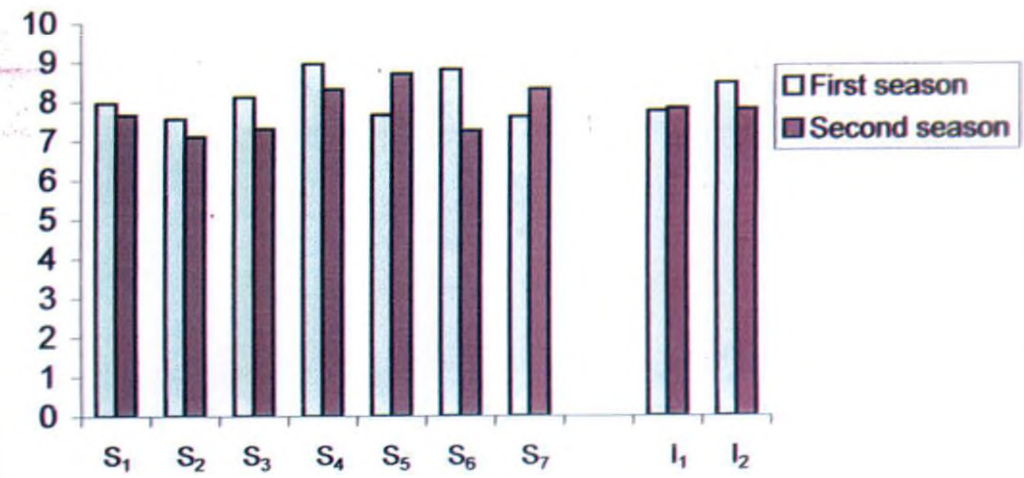

Fig.8 Effect of spacing and irrigation on number of female flower per plant

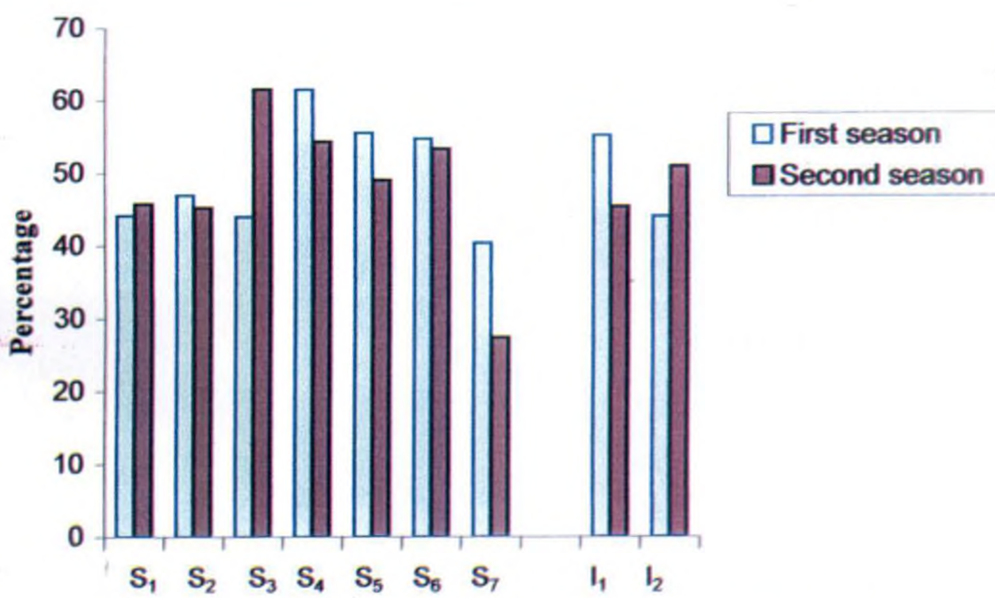

Fig.9 Effect of spacing and irrigation on fruit set percentage (%)

exceeded over drip method in the first and second crops by 12.7 per cent and 11.3 per cent respectively (Fig. 3). Leaf area at the time of final harvest in the conventional method was on par with that in the drip irrigation method. This clearly indicates the scope of saving 50 per cent water under drip method for growing oriental pickling melon (Fig. 4 and 5).

Earliness indicated by the appearance of male and female flowers and node at which the fruits were formed was also not significantly influenced by method of irrigation. However a slight advantage for earliness was observed in plants grown under drip irrigation (Fig. 6,7 and 8). In conventional method due to higher level of irrigation the soil moisture status was favourable for maintaining vegetative growth, delaying the flower production and days to last harvest (Fig. 9). Similar study by Larson (1975) revealed that high level of irrigation increased vegetative phase and delayed reproductive phase. The slow and precise application of water to the root zone led to better moisture replenishment and aeration, which led to earlier harvest. Veeraputhiran (1996) reported similar results of early maturity under drip.

Even though not significant, conventional method receiving 45 l of water per pit in alternate days had the lowest fruit setting percentage during the first crop season (Fig.9). Similar results of poor fruit set in basin irrigation due to imbalance of water and air was reported by Alemeyhu (2001) in oriental pickling melon. Generally, after flood irrigation the soil is becoming saturated with water up to 48 hours. During this period practically there is less root activity in the absence of air in the soil. A proper balance of water and air is not available as net irrigation is scheduled on alternate days. Therefore the physical conditions in the soil like wetness, aeration etc. may not have favoured high fruit set in conventional method.

Alemeyhu (2001) obtained maximum yield in oriental pickling melon variety Mudicode by growing under drip irrigation at 125 E_P. However, during the present study the yield characters like number of female flowers, fruit set percentage, fruits per plant and total yield were not significantly influenced by irrigation methods. This may be due to less vegetative growth and short duration nature of the variety Saubhagya compared to the standard variety Mudicode.

5.3. EFFECT OF SPACING ON GROWTH AND PRODUTIVITY

The cultivation practices of a crop mainly depend on the slope of land, soil texture, rainfall pattern etc. of the area where it is cultivated. Seeds of cucurbits are generally sown in shallow basins in plain lands of summer rice fallows (Plate 5). It is also sown in shallow trenches (Plate 6). Whether the seeds are sown in channels or basins, the crop geometry, which decides the number of plants per unit area, vary with growth habit of the variety.

In the present study Saubhagya was sown in shallow channels spaced at 1 m, 1.5 m, and 2 m. In each channel seeds were sown at a distance of 30 cm and 45 cm. Six spacings formulated with the above were compared with the traditional basin method where seeds are sown in basins at a spacing of 2.0 x 1.5 m (3 seeds/pit). Depending on row to row and plant to plant distance, the number of plants per plot and the population density varied and are furnished below:

Sl.No.	Spacing	No. of plants/plot ($12\ m^2$)	Population density No/ha.
1	2.0 x 0.30 m	20	16666
2	2.0 x 0.45 m	14	11,111
3	1.5 x 0.30 m	26	22,222
4	1.5 x 0.45 m	18	14,814
5	1.0 x 0.30 m	40	33,333
6	1.0 x 0.45 m	28	22,222
7	2.0 x 1.5m	12	9,999

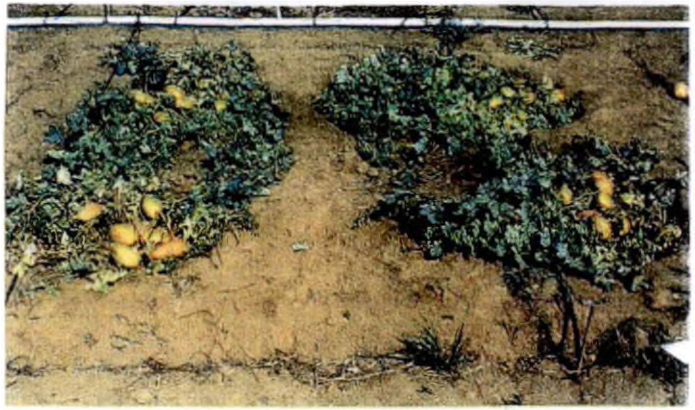

Plate 5. S_7 Sowing of seeds in pits at 2.0 × 1.5 m

Plate 6. I_2S_2 Sowing of seeds in channels 2.0 × 0.45 m

Plate 7. I_2S_5 Sowing of seeds in channels 1.0 × 0.30 m

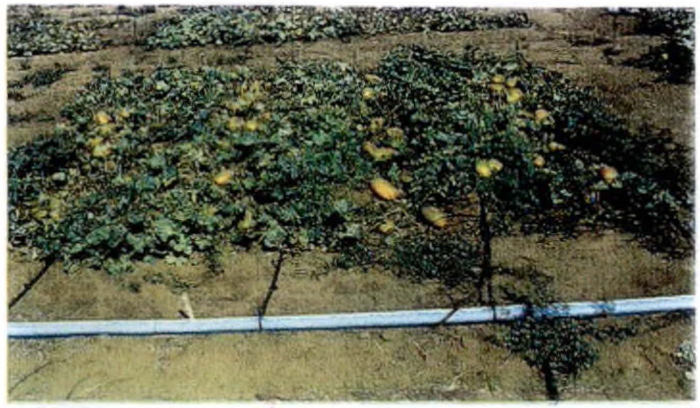

Plate 8. I_1S_6 Sowing of seeds in channels 1.0 × 0.45 m

Less vegetative growth and early yield characterize the variety Saubhagya. However, the plants should attain sufficient vegetative growth for maximum productivity and fruit size. In the present study vegetative growth was assessed by recording length of vine, number of branches and leaf area at flowering and initial fruiting stage (30 DAS) and at final harvest stage. The effect of various spacings on vegetative growth was more pronounced and significant during the second crop. The initial spread of plants were maximum at a closer spacing of 1.0 x 0.30 m (S_5) during both the crops as indicated by maximum vine length recorded at 30 DAS (96.7 cm and 126.9 cm during December and February sown crops, respectively). The same trend continued at the time of final harvest also and vine length in S_5 was 174.7 cm during the first crop and 123.8 cm during the second crop. The length of vine in conventional pit method at a wider spacing of 2.0 x 1.5 m was only (102.3 cm and 132.1 cm) during first crop and second crop respectively. Increase in vine length at closer spacing due to competition and mutual shading from lateral plants has been observed in cucumber by Bach and Hruska (1981).

Compared to other oriental pickling melon varieties Mudicode and Arunima, branching in Saubhagya is very early and from the second node onwards axillary buds emerge. On an average, at flowering and initial fruiting stage, three lateral branches were produced at a spacing of 1.5 x 0.45 m (S_4) during December sown crop and at 1.5 x 0.30 m (S_3), 1.5 x 0.45 m (S_4) and 1.0 x 0.45 m (S_6) during February sown crop. At the final harvest also maximum branches were recorded at moderate spacings of 1.5 x 0.45 m, 1.5 x 0.30 m and 1.0 x 0.45 m compared to the low values at still closer spacings. Availability of sufficient sunlight and area for lateral growth might have contributed for more number of branches in moderately spaced treatments. Hafidh (2001) in cucumber and Renji (1998) in pickling cucumber reported similar results of increased number of branches at moderate population. Suppression of axillary buds in the closely planted crops have indirectly resulted in more vine length in the closer spacing of 1.0 x 0.30 m during the present investigation. The exposed interspaces and resultant radiations on the growing plants may have adverse effect on the growth and development of plants. This is in agreement with the findings of Flocker *et al.* (1965) in Cantaloupe, Yamashitata and Yamada (1982) in cucumber and Nerson *et al.* (1994) in muskmelon.

Majority of cucurbits including oriental pickling melon follows a sequential flowering pattern. The first 4-6 flowering nodes produce staminate flowers and later pistillate flowers appear in secondary branches and laterals. Flowering and sex ratio are highly influenced by environmental factors like temperature and day length, endogenous level of hormones etc. In the present study, days for emergence of male flower was not significantly influenced by various spacings. Male flowers were produced as early as 22.8 days at a wider spacing of 2.0 x 0.3 m in February sown crop and as late as 27.8 days under closest spacing of 1.0 x 0.30 m in December sown crop. Earliness in male flower anthesis under widely spaced treatments may be attributed to the increased soil temperature due to radiation from the exposed interspaces. The increase in temperature affects the levels of GA synthesis, which favour male tendency (Atsmon *et al.*, 1969). From the point of earliness, days to first female flower production, the node number of first female flower and days to first harvest are important. In general, female flower production in oriental pickling melon var. Saubhagya was mainly confined to the laterals and sub laterals. Production of female flowers on main vine was very rare. Female flower production was earlier in the moderate spacing of 1.5 x 0.45 m (27.4 and 31.2 during first and second crop respectively). More number of branches and favourable conditions like optimum light and temperature and favourable microclimate could have contributed for earlier female production. Earliness in female flower anthesis under moderate spacing were already reported by Lower *et al.* (1983) in cucumber and Arora and Mallik (1990) in ridge gourd variety Pusa Nasdar.

Various spacing significantly altered the node number for the emergence of first female flower during February sown crop. Female flowers were formed in the lowest node (3.3) in plants spaced at a closer spacing of 1.0 x 0.30 m and in the farthest node (6.3) in S_3 (1.5 x 0.30 m). A result of the similar study by Renji (1998) in cucumber is in line with present findings.

The production of female flowers was found affected by various spacings. During the present investigation, number of female flowers were maximum (8.95) at a moderate spacing of 1.5 x 0.45 m followed by 8.80 under 1.0 x 0.45 m. Parekh (1990) earlier reported similar results in bitter gourd and Arora and Mallik (1990) in ridge gourd.

The fruit set depends on the position at which flowers are formed, endogenous auxin level and climatic condition at the time of fruiting. In the present study the fruit set was affected by various spacings and maximum fruit set (61.45 %) during December sown crop was observed at a moderate spacing 1.5 x 0.45 m and (61.46 %) under a spacing of 1.0 x 0.30 m during February sown crop. From the farmer's point of view, oriental pickling melon fruits for vegetable purpose are usually harvested at fully mature stage when they develop golden yellow coloured rind. An alternate sequence of flowering pattern of male and female flower was observed until fruit set in Saubhagya. Once the fruits are allowed to mature on the plant, such fruits determine the production of pistillate flowers further down in the vine. Even if female flower production and fruit set are taking place they may not develop fully or shed in immature condition. The vine strikes the physiological balance at the threshold limit of maximum fruits that it can carry to maturity. Seshadri (1979) earlier reported similar results. In the present study node at which first fruits were retained was not affected by various spacings and ranged from 4.8 to 5.4.

Early harvesting is considered as an advantage since the vegetables reaching early in the market fetches premium price. Depending on the nutrition and climatic factors 17 – 20 days are required from flowering to edible harvestable maturity in Saubhagya. The closer spacing, 1.0 x 0.30 m was earliest to harvest the first fruit during both the crops. Though plants at spacing 1.5 x 0.45 m were earlier for female flower opening, they were not earliest in respect to days

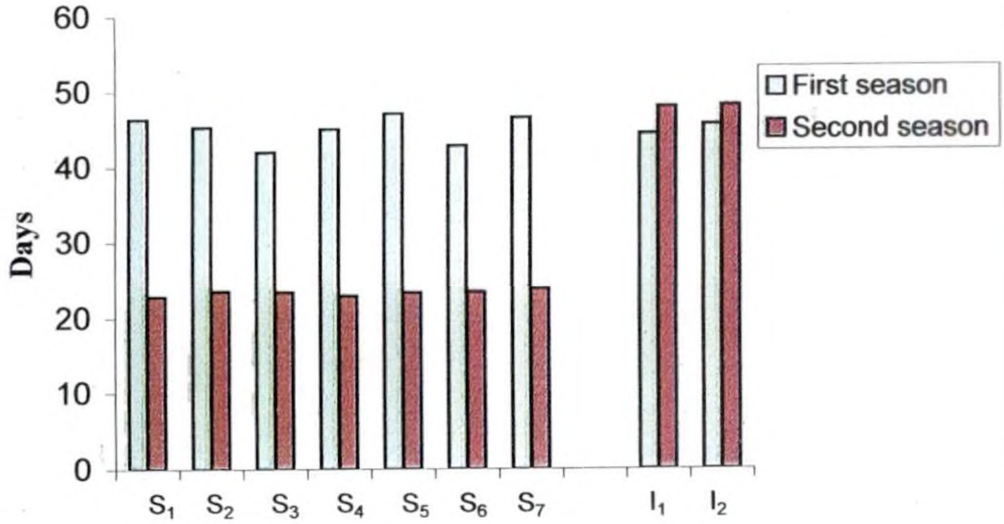

Fig.10 Effect of spacing and irrigation on days to first harvest

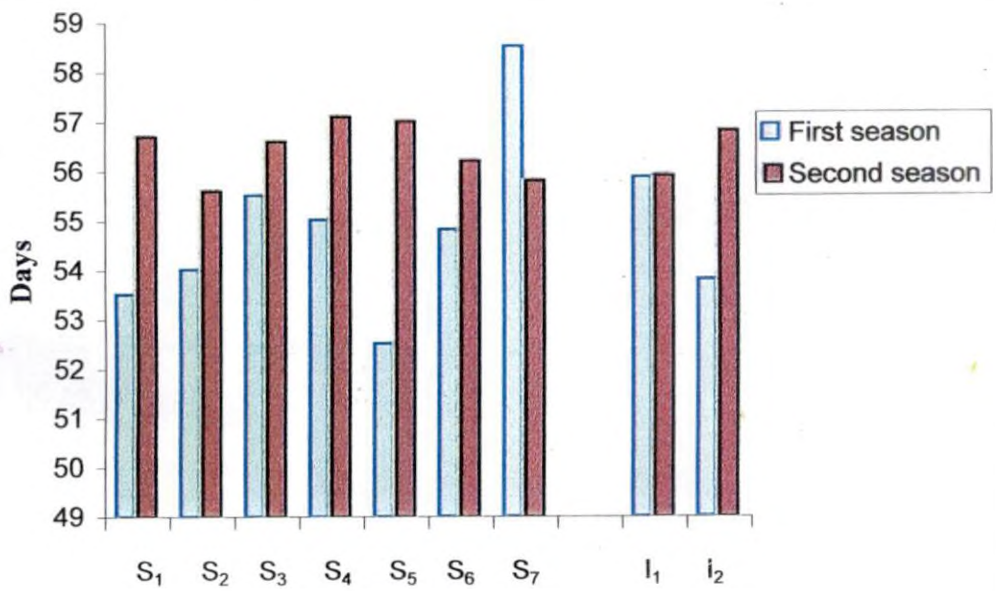

Fig. 11 Effect of spacing and irrigation on days to last harvest

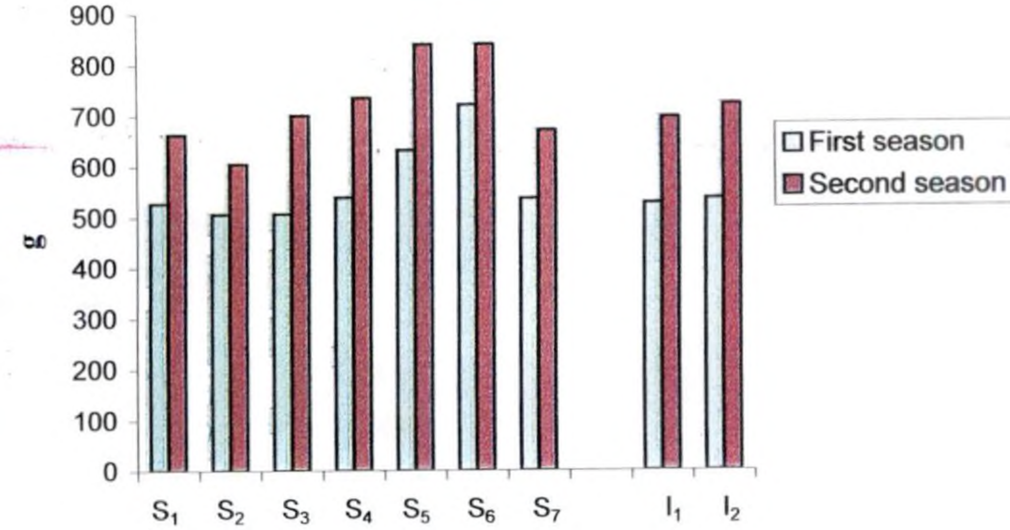

Fig.12 Effect of irrigation and spacing on average fruit weight (g)

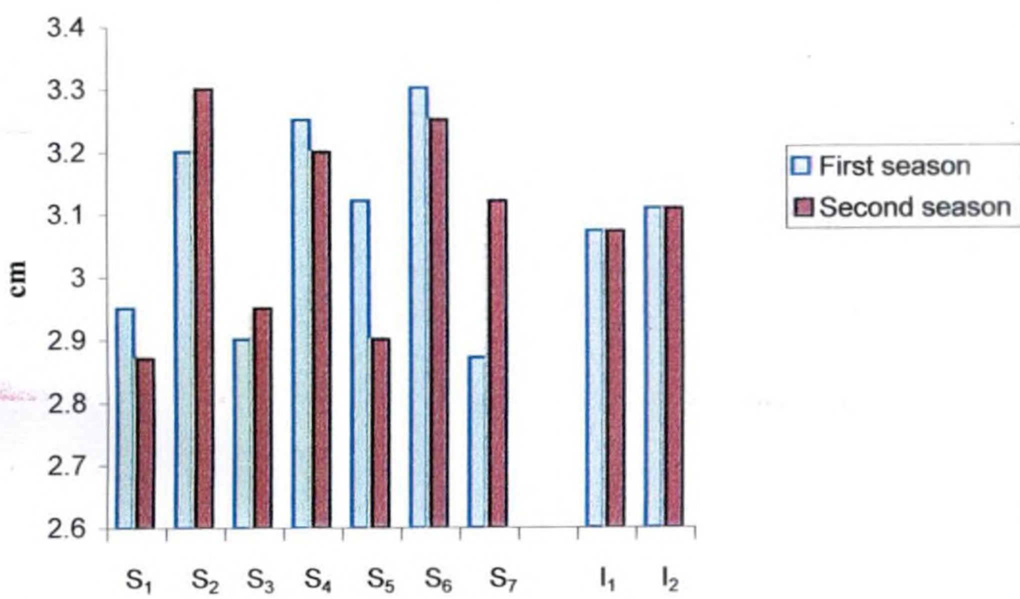

Fig.13 Effect of irrigation and spacing on flesh thickness (cm)

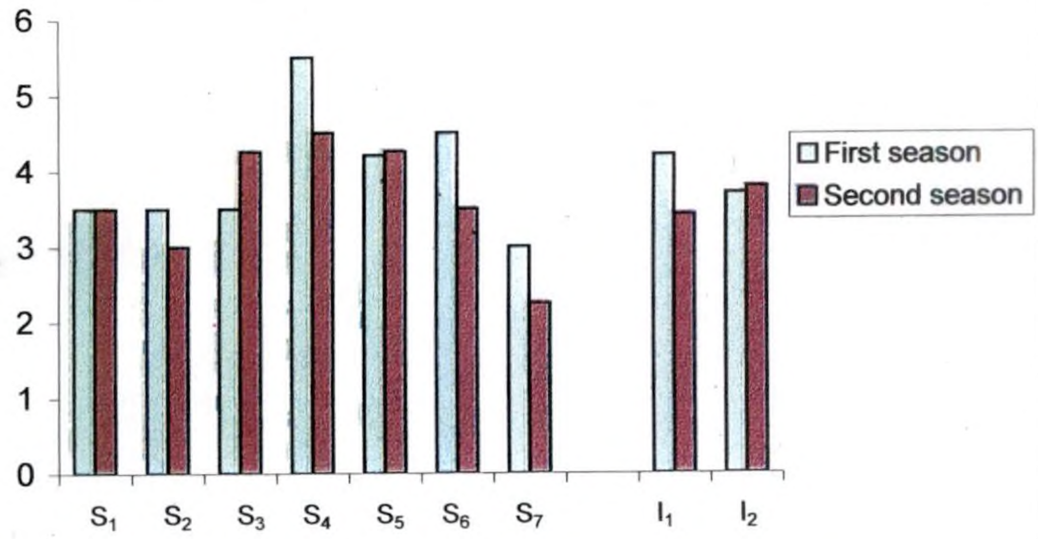

Fig.14 Effect of spacing and irrigation on number of fruits per plant

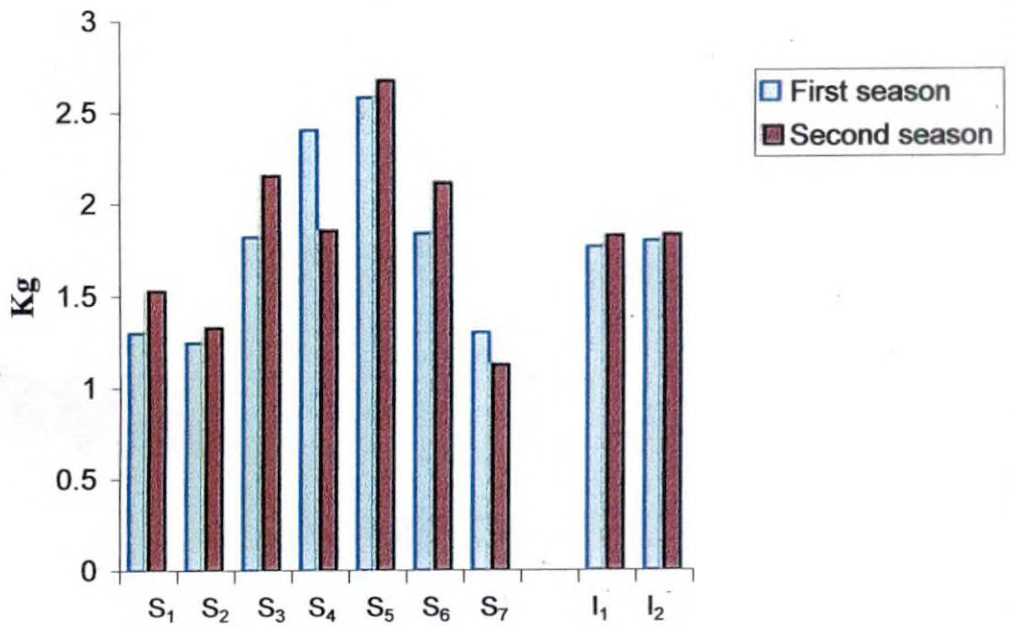

Fig.15 Effect of spacing and irrigation on total yield per plant (kg)

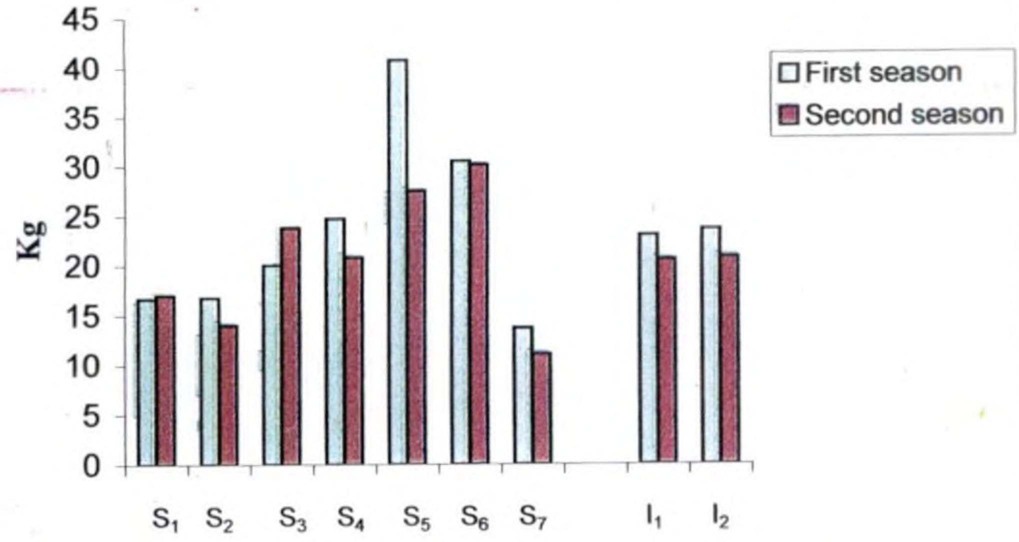

Fig.16 Effect of spacing and irrigation on yield per plot (kg)

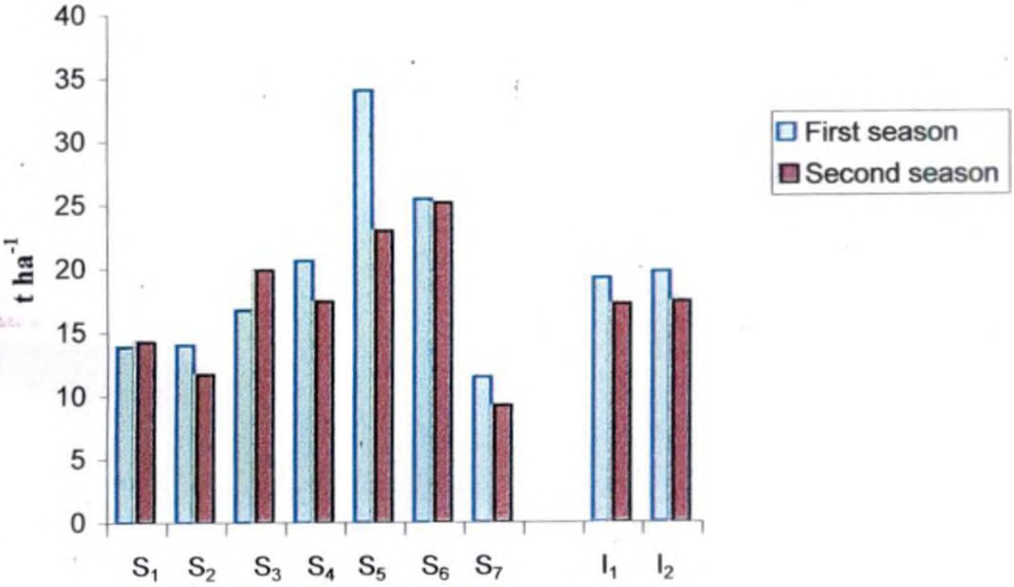

Fig.17 Effect of spacing and irrigation on productivity ($t\ ha^{-1}$)

to first harvest. This indicates that earliness in flowering need not always result in early harvest. Similar observations were made by Pandey *et al.* (1996) in tomato. The first rounds of harvest in all the spacings were completed by 47th day in December and 49.2 day in February sown crop. Earliness and duration of harvest are mainly varietal characters and are modified by cultural practices. The last harvest was completed by 52.5 days in S_5 (1.0 x 0.30 m) and was extended up to 58.5 days in S7 (2.5 x 1.5 m). The harvesting period in the variety was just 18 days during which two harvests were possible. The specific advantage of variety Saubhagya is its short duration and concentrated fruiting. If the fruits are harvested at tender stage the number of harvests can be increased.

Market value of fruits mainly depends on uniformity in size, colour, freshness and freedom from blemishes etc. In oriental pickling melon medium sized and golden yellow coloured fruits with in a range of 500 – 750 g fetches premium price in the market. The size of fruits in terms of girth and weight were affected by different spacing during present investigation. Length of fruit was not significantly changed by different spacing. However it was maximum in S_6 (25 cm) followed S_4 (23.8 cm) and S_5 (23.3 cm) during December sown crop. Girth of fruit in a variety has a prominent role in deciding the weight of fruit and it was maximum (29.3 cm) under a spacing of 1.5 x 0.30 m and was on par with 1.5 x 0.45 m (28.7 cm). This was closely followed by spacing of 1.0 x 0.30 m (26.1 cm) and 1.0 x 0.45 m (26.2 cm). Minimum girth was noticed under widely spaced control plot, S_7 (24.2 cm).

Average fruit weight was found maximum at a closer spacing of 1.0 x 0.45 m (720 g) on par with 1.0 x 0.3 m (630.79) during the first crop (Fig. 12). During the second crop also maximum fruit weight was observed in 1.0 x 0.45 m spacing (838 g) on par with 1.0 x 0.30 m (734 g). The increase in fruit weight in best treatments over the traditional pit method was to the tune of 34-58 per cent during first crop and 25 – 26 per cent during the second crop.

Optimum vegetative growth and better microclimate resulting from minimum evaporation loss in closer to moderate spacing may have contributed for the transfer and accumulation of sink which ultimately result in large sized fruits. This was evidenced by maximum flesh thickness of 3.3 cm at a spacing of 1.0 x 0.45 cm during the first crop and 3.25 cm during the second crop (Fig. 13). Widders and Price (1989) reported increase in the carbon portioning of fruits due to increase in vegetative growth.

The yielding ability of a variety is the outcome of a number of contributing characters like number of female flowers, number of fruits plant^{-1}, fruit size etc. Apart from genetic constitution, the management practices also play a key role on productivity. Population density and system of cultivation are deciding factors for achieving high productivity. In the present investigation yield per plant, yield per plot were significantly influenced by various spacings (Fig. 14 and 15). Yield per plant in terms of weight and number of fruits were maximum at a closer spacing of 1.0 x 0.30 m (2.57 kg and 4.5 during the first crop) which was on par with 1.5 x 0.45 m (2.4 kg and 5.5, respectively). During second crop, the spacing S_5 (1.0 x 0.45 m) produced maximum yield per plant both in terms of weight and number (2.65 kg and 4.5, respectively). Similar results of increased fruit number and yield per plot under closer spacing was reported by Enthoven (1980) in cucumber.

The closest spacing of 1.0 x 0.30 m accommodating 33,333 plants in a hectare yielded maximum fruits (33.93 t ha^{-1}) during the first crop (Fig. 17). This was 66.0 % over the recommended spacing of 2.0 x 1.5 m. The highest productivity at this spacing was resulted from maximum yield per plant (4.5 kg) and by accommodating maximum number of plants without affecting the vegetative growth adversely. Karatev and Salinkova (1983), Hafidh (2001) and Paroussi and Saglam (2002) earlier reported similar findings. S_5 (1.0 x 0.30 m) was closely followed by next closer spacing 1.0 x 0.45 m and 1.5 x 0.45 m in productivity (25.38 t ha^{-1} and 20.58 t ha^{-1}, respectively). Both the above spacings accommodated 22,222 plants in a hectare. During the February sown crop, production was maximum in S_6 (25.12 t ha^{-1}), which also accounted for maximum number of fruits per plant (4.5) and yield per plant (2.67 kg). The superior performance of plants at a spacing 1.0 x 0.45 over 1.0 x 0.30 during second crop may be due to enhanced vegetative growth during second crop. This might have contributed to the superior performance of plants at 1.0 X 0.45 m over1.0 x 0.30m

Based on the average of two seasons yield data it is clear that closer spacing of 1.0 x 0.30 m (S_5) gave the highest yield of 28.40 t ha^{-1} followed by 23.5 t ha^{-1} by 1.0 X 0.45 m. Other spacings recorded the per hectare yield as S_1, 2.0 x 0.30 m (14.0 t ha^{-1}), S_2, 2.0 x 0.45 m (12.8 t ha^{-1}), S_3, 1.5 x 0.30 m (18.3 t ha^{-1}), S_4, 1.5 x 0.45 m (18.9 t ha^{-1}) and S_7, 2.0 x 1.5 m (10.3 t ha^{-1}). Hence Saubhagya variety of oriental pickling melon is highly adopted for the high density planting of 33,333 plants per hectare for exploiting it's yield potential.

5.4. INTERACTION EFFECTS

An adequate water supply and optimum spacing are essential not only for stable and high yield but also for marketable quality, which command premium prices for vegetables. Critical analysis of interaction effects of main plots (methods of irrigation) and sub plot effects (spacings) reveals much valuable information and are discussed below.

In the present study none of the vegetative characters except the initial vine length were significantly influenced by treatment combinations at 30 DAS for February sown crop. At initial flowering phase I_1S_6 (129.1 cm) and I_1S_5 (128.4 cm) recorded maximum vine length in February sown crop. However at final harvest stage length of vine and leaf area was maximum in I_2S_5 for both the crops. The increase in vegetative growth under I_2S_5 may be due to maximum availability of water and suppression of lateral growth under high population density. Linear response of growth due to increase in application of water reported by Hegde (1987) and Singh and Singh (1978) in cucumber support the present findings.

Vegetative growth was generally less in widely spaced plants grown under drip irrigation. The widely spaced treatments I_1S_1, I_1S_2 and I_1S_7 recorded 63.8 per cent, 58.0 per cent and 19.3 per cent less vine growth and 24.2 per cent, 28.9 per cent and 25.6 per cent less leaf area than the superior treatment I_2S_5 (184.3 cm and 89.2 cm^2). Same trend was noticed during second crop also. This may be due to large ground area, which enhanced the evaporation rate and minimized the water availability to the plants. Limited water supply and availability in this treatment might have restricted cell division and cell enlargement which resulted in less vegetative growth. This is in agreement with the findings of Flocker *et al.* (1965) in cantaloupes and Yamashita and Yamada (1982) in cucumber.

The interaction of irrigation methods and spacing were not significant on earliness of flowering and fruiting, duration of the crop and yield attributes. However I_1S_1 was earlier (26.0 and 22.3 days during first and second crop) for male flower production and late for female flower production in both the crops. The less vegetative growth put forth earlier male flowers and delayed and reduced female flower primordia in I_1S_1.

Plants at moderate spacing of I_1S_4 and I_2S_4 were earlier (27.5 and 27.3 days respectively) for female flower production. Above spacing also had maximum number of female flowers (9.0 and 8.9 respectively) number of fruits per plant (5.0, 5.5) and fruit set (61.10 and 61.45 %) during first crop and same trend was observed during second crop also. It was followed by I_1S_6 and I_2S_6.

The increase in "with in row" spacing from 30 to 45 cm and decrease in "row to row" spacing from 2.0 m to 1.5 or 1m have created a favourable microclimate and increased availability of soil moisture and sunlight to individual plants under a moderate population density. This is in agreement with the findings of Molnar (1965) in melon and Thomas (1984) in bitter gourd.

Treatment combinations did not significantly influence the productivity. However it was maximum at I_2S_5 (34.91 t ha^{-1}), which was 71.7 per cent increase over the control I_2S_7 (Plate 7). It was followed by I_1S_5 (32.95 t ha^{-1}), which was 70.25 per cent over pit method, I_2S_7. Maximum productivity was obtained at closer spacing (1.0 x 0.30 m) under conventional and drip method compared to other treatment combination. Maximum productivity of plants at highest population density under conventional method was due to the production of large sized fruits as indicated by more fruit weight (729.08 g). The highest productivity in I_1S_5 during December sown crop was due to maximum per plant yield and number of fruits (2.7 kg and 5.0 respectively). In February sown crop I_1S_6 produced maximum yield (27.5 kg per plot) which also accounted for maximum per plant yield and number of fruits.

At the closest spacing of S_5 (1.0 x 0.30 m) the per hectare yields of drip and conventional method were almost identical (Table 21). But drip method had the advantage of using 598.4 mm less water, which can be used for irrigating an additional area of 1.09 ha by drip. At S_6 (1.0 x 0.45 m) also per hectare yields of drip and conventional method were almost identical. Here also drip method used 422.4 mm less water, which can be used for irrigating an additional area of 1.10 ha by drip. In S_3, S_4 and S_7 drip had convincing yield advantage over conventional method to the tune of 13.1, 6.9 and 19.2 per cent, respectively and water saving by 362, 271.5 and 185.5 mm, respectively. In S_1 and S_2 conventional method had yield advantage over drip method, but water was saved to the tune of 302.3 and 211.2 mm, respectively.

5.5. ECONOMICS OF PRODUCTION

High cost of production due to high wage rate is one of the major factors limiting the cultivation of vegetables in Kerala. This has particular significance due to labour intensive nature of vegetable cultivation. Unless some labour saving and cost effective methods or devices are developed, it is impossible to compete with neighboring states in vegetable production and marketing, During the present study, I_2S_5 and I_1S_6 shared maximum benefit cost ratio of 1.40. In I_2S_5 plants were spaced at closer spacing of 1.0 x 0.30 m (33,333 plants ha^{-1}) under conventional method of irrigation. In I_1S_6 the plants was spaced at 1.0 x 0.45 m accommodating 22,222 plants ha^{-1} under drip irrigation. For an investment of every one rupee we are getting an additional income of 40 paise under both treatments. However the amount of water used under conventional method was

53 per cent more than that of drip. Eventhough I_1S_6 had third position in productivity it ranked first for benefit cost ratio. This is mainly due to moderate population density, which reduces cost of drip materials than that of I_1S_5 which ranked second in productivity. Maximum loss was observed under widely spaced treatments like I_1S_1, I_1S_2 and I_2S_7. For an investment of one rupee there was a loss of Rs. 0.24, Rs. 0.27 and Rs. 0.24, respectively. This is mainly due to high cost of production under these treatments.

Marginal and small farmers mainly carry out oriental pickling melon cultivation in Kerala. Under conventional method of irrigation a spacing of 1.0 x 0.3 m can be followed when family labour is utilized for cultivation of oriental pickling melon. A spacing of 1 x 0.45 m with drip irrigation can be followed under a situation where there is water scarcity and the farmers are capital rich.

5.6. FUTURE LINE OF WORK

The present investigation revealed the necessity of variety specific and location specific package of practices for achieving maximum productivity in each vegetable crop. Since the growth and development of crops vary from season to season, appropriate modifications in the packages are also to be made for better expression of economic characters.

The short duration (54-60 days) nature of oriental pickling melon variety Saubhagya offers scope for cultivation of three crops successively starting from November – May in the same soil utilizing the drip irrigation system. As water requirement of the variety varies with stages of crop growth, differential irrigation frequencies are to be standardized separately for vegetative, flowering and fruiting stages. The possibilities of adopting drip irrigation and plastic mulches are also to be exploited for commercial cultivation of this variety. The drip irrigation system is also to be refined so as to make it more cost of effective and farmer friendly for the easy intercultural operations and to avoid frequent clogging of drippers.

Summary

VI. SUMMARY

A field experiment was conducted for two consecutive seasons in the summer rice fallows of the Agricultural Research Station, Mannuthy, and Thrissur during December 2002- April 2003 to study the effect of "Crop geometry under different methods of irrigation in oriental pickling melon (*Cucumis melo* var. *conomon*) variety Saubhagya".

The experiment was laid out in a split plot design with methods of irrigation in the main plot and spacings in subplot. The treatments consisted of combination of two methods of irrigation (drip irrigation @125 Ep and conventional method @ 45 l pit $^{-1}$) and seven spacings (2.0 x 0.30 m, 2.0 x 0.45 m, 1.5 x 0.30 m, 1.5 x 0.45 m, 1.0 x 0.30 m, 1.0 x 0.45 m and 2.0 x 1.5m) with two replications.

The study was necessitated due to the short duration and less spreading nature of the variety "Saubhagya" compared to the existing variety "Mudicode" based on which the present recommendations were made for oriental pickling melon by the Kerala agricultural university.

1. The variety Saubhagya sown during February exhibited maximum vegetative growth and produced male flowers earlier (23.2 days) than December sown crop (27.07 days).

2. The yield characters like number of female flowers, number of fruitsplant^{-1} total yield plot^{-1} and fruit set were relatively high (8.08, 3.7 and 23.29 kg, 50 %, respectively) in December sown crop compared to February sown crop (7.7, 3.7, 20.65 kg and 48.0 %, respectively).

3. The fruit characters like length and girth were not altered by growing seasons, but the average fruit weight, an important factor contributing

to yield, was maximum (706.13 g) during February sown crop compared to December sown crop (564.65).

4. The vegetative characters like length of vine, number of branches and leaf area were not significantly influenced by two methods of irrigation viz., drip irrigation at 125 E_P and conventional method @ 45 l pit^{-1}.

5. The earliness and yield characters like number of female flowers, fruit set percentage, fruits per plant and total yield were also not significantly influenced by irrigation methods. However, in the drip irrigation there was saving of 108.5 to 135.3 per cent of water during one cropping period, which can be used for bringing1.09 to 1.35 hectares of additional land for cultivation of the variety.

6. The effects of various spacings on vegetative growth were more pronounced and significant during February sown crop. The initial spread of plants were maximum at a closer spacing of 1.0 x 0.30 m (S_5) during both the crops as indicated by maximum vine length recorded at 30 DAS (96.7 cm and 126.9 cm during December and February sown crop, respectively). The same trend continued at the time of final harvest.

7. At the final harvest maximum branches were recorded at moderate spacings of 1.5 x 0.45 m, 1.5 x 0.30 m and 1.0 x 0.45 m compared to the low values at still closer spacings.

8. Female flower production was earlier in the moderate spacing of 1.5 x 0.45 m (27.4 and 31.2 days during first and second crop, respectively). Female flowers were formed in the lowest node (3.3) in plants spaced at a closer spacing of 1.0 x 0.30 m and farthest node (6.3) at moderate spacing of 1.5 x 0.30 m. The number of female flowers were also

maximum (8.95) at a moderate spacing of 1.5 x 0.45 m followed by 8.80 under 1.0 x 0.45 m spacing.

9. The plants in closer spacing 1.0 x 0.30 m were earliest to harvest the first fruit in both seasons. The first round of harvest in all the spacings were completed by 47th day in December sown crop and 49th day in February sown crop. The last harvest was completed by 52.5 days in S_5 (1.0 x 0.30 m) and was extended up to 58.5 days in S_7 (2.0 x 1.5 m).

10. The Girth of fruit was maximum (29.3 cm) under a spacing of 1.5 x 0.30 m and was on par with 1.5 x 0.45 m (28.7 cm). This was closely followed by spacing 1.0 x 0.30 m (26.1 cm) and 1.0 x 0.45 (26.2 cm).

11. Average fruit weight was found maximum at a closer spacing of 1.0 x 0.45 m (720 g) and was on par with 1.0 x 0.30 m (630.79g) in December sown crop. In February sown crop also maximum fruit weight was observed in 1.0 x 0.45 m spacing (838 g) and was on par with 1.0 x 0.30 m (734 g).

12. Yield plant^{-1} in terms of weight and number of fruits were maximum at a closer spacing of 1.0 x 0.30 m (2.57 kg and 4.5, respectively) during December sown crop, which was on par with 1.5 x 0.45 m (2.4 kg and 5.5, respectively). In February sown crop the spacing S_6 (1.0 x 0.45 m) produced maximum yield plant^{-1} both in terms of weight and number (2.65 kg and 4.5, respectively). The closest spacing of 1.0 x 0.30 m accommodating 33,333 plants ha^{-1} yielded maximum fruits (33.93 t ha^{-1}) in December sown crop, which was 66 per cent more than the recommended spacing of 2.0 x 1.5 m. S_5 (1.0 x 0.30 m) was closely followed by next closer spacings 1.0 x 0.45 m and 1.5 x 0.45 m in productivity (25.38 t ha^{-1} and 20.58 t ha^{-1}, respectively). Both the above spacings accommodated 22,222 plants in a hectare. In February

sown crop production was maximum at 1.0 x 0.45 m (25.12 t ha^{-1}), which also accounted for maximum number of fruits $plant^{-1}$ and yield $plant^{-1}$.

13. None of the characters, except length of vine at 30 DAS and fruit set percentage were influenced by the interaction effects of main plot (method of irrigation) and subplots (spacings). However Productivity was maximum at 1.0 X 0.30 m under conventional method of irrigation (34.91 t ha^{-1}), which was 71.7 per cent higher over the recommended spacing 2.0 x 1.5 m under conventional method of irrigation for oriental pickling melon.

14. FWUE was highest with 1.5 x 0.45 m spacing under drip and with 2.0 x 0.45 m spacing under conventional method of irrigation. Between irrigation methods also FWUE was almost higher by 41.6 to 191.4 per cent under drip compared to conventional method at various spacings.

15. Maximum benefit cost ratio (1.40) was shared by I_2S_5 and I_1S_6. In I_2S_5 plants were spaced at a closer spacing of 1.0 x 0.30 m (accommodating 33,333 plants ha^{-1}) under conventional method of irrigation. This treatment can be followed where family labour is utilized for cultivation of oriental pickling melon variety Saubhagya. The treatment with spacing of 1.0 x 0.45 m under drip irrigation can be suggested under a situation where there is water scarcity and farmers are capital rich.

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*Original not seen

Appendices

APPENDIX-1

Weather factors during two Cropping Periods (December 2002 to April 2003)

Standard Week	Temperature (^0C)	Soil Temperature (^0C)	Humidity (%)	Wind (Km/hr)	Sunshine (Hrs)	Rain (mm)	Evaporation (mm)
Dec. 10 to16	32.1-24.3	34.0	50	11.8	10.8	-	8.8
Dec. 17to23	32.2-20.9	32.5	39	8.3	8.3	-	6.5
Dec. 24to30	32.5-10.5	34.2	37	4.1	9.3	-	5.3
Dec. 1 to Jan.7	32.9-22.2	33.9	38	9.0	8.6	-	7.0
Jan. 8 to 14	32.4-23.9	33.7	37	10.0	8.9	-	8.3
Jan. 15to 21	32.9-23.7	34.0	37	10.0	9.8	-	7.9
Jan. 22 to 28	34.6-22.0	34.6	26	6.9	9.9	-	6.9
Jan. 28 to Feb.4	33.9-22.6	34.0	39	5.4	8.7	-	5.5
Feb. 5 to 11	34.8-23.7	36.3	44	7.0	9.8	-	6.4
Feb. 12 to 18	35.7-24.2	37.6	42	4.9	9.8	-	5.4
Feb. 19 to 25	35.1-23.7	37.1	47	3.1	9.2	-	5.3
Feb. 26 to Mar. 24	33.8-23.3	34.5	53	3.2	8.7	-	4.7
Mar. 5 to 11	35.2-24.7	38.2	32	4.0	8.8	-	5.7
Mar. 12 to 18	34.8-24.3	37.0	42	4.0	8.2	3.4	5.2
Mar. 19 to 25	34.2-23.4	36.6	47	4.2	8.7	10.4	5.5
Mar. 26 to Apr. 1	34.1-24.9	39.4	59	2.7	8.1	7.0	4.7
Apr. 2 to 8	34.2-24.6	38.0	56	2.9	6.7	6.2	3.9
Apr. 8 to 15	34.4-25.0	38.7	57	2.8	5.7	5.8	5.4

APPENDIX II

Analysis of Variance for economic characters of Saubhagya during the first crop

Mean squares

Source	Degreees of freedom	Length of Vine 30 DAS	Length of Vine 60 DAS	Number of Branches 30 DAS	Number of Branches 60 DAS	Leaf area 30 DAS	Leaf area 60 DAS
1.Replication	1	202.503	137.82	0.036	0.039	40.80	37.078
2.Factor A	1	85.400	2406.47	0.036	0.007	125.16	87.937
3.Error	1	283.529	29.46	0.630	0.020	0.37	0.624
4.Factor B	6	396.820	890.93	0.616	0.066*	339.50	152.30**
5.A B	6	359.036	458.44	0.446	0.247	35.97**	4.78
6.Error	12	278.637	347.56	0.260	0.88	15.55	14.35

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

Mean squares

Source	Degreees of freedom	Days to Male flower	Days to Female flower	No.of Female flowers	Node to Female flower	Fruit set %	Node at which first fruit retained	Days to first harvest	Days to last harvest
1.Replication	1	2.401	0.001	0.280	0.756	11.097	0.001	12.893	8.036
2. Factor A	1	8.916	0.366	3.571	0.858	864.48	0.122	10.321	30.036
3. Error	1	3.716	0.280	0.000	0.116	0.035	0.007	0.893	0.321
4. Factor B	6	1.103	2.199**	1.326**	0.308	1429.4**	0.412	14.619**	14.560**
5. AB	6	0.659	0.538	0.0678	0.334	408.59	1.491	1.405	2.536
6. Error	12	1.229	0.339	0.000	0.173	0.445	0.496	0.893	1.762

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

Mean squares

Source	Degreees of freedom	Length	Girth	Avg. wt.	Flesh thickness
1.Replication	1	0.480	3.716	283.337	0.060
2.Factor A	1	0.337	10.56	489.47	0.009
3.Error	1	0.174	0.823	447.76	0.009
4.Factor B	6	3.692	12.92*	10308.35**	0.117
5.AB	6	0.793	2.59	3427.79	0.273
6. Error	12	1.985	3.81	2970.28	0.097

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

Mean squares

Source	Degreees of freedom	No.of fruits/ plant	Yield/ Plant	Yield/ plot	Productivity
1.Replication	1	0.321	0.284	0.010	0.007
2.Factor A	1	1.750	0.134	100.662	69.904
3.Error	1	0.036	0.003	1.069	0.742
4.Factor B	6	2.869**	1.188**	364.370**	253.034**
5.AB	6	0.250	0.049	15.279	10.610
6. Error	12	0.179	0.115	7.351	5.105

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

APPENDIX III

Analysis of Variance for economic characters of Saubhagya during second crop

Mean squares

Source	Degreees of freedom	Length of Vine 30 DAS	Length of Vine 60 DAS	Number of Branches 30 DAS	Number of Branches 60 DAS	Leaf area 30 DAS	Leaf area 60 DAS
1. Replication	1	84.182	61.806	0.036	1.750	6.703	34.98
2. Factor A	1	17.840	2653.95	0.036	0.036	9.527	312.22
3. Error	1	10.875	123.48	0.036	0.036	29.82	7.71
4. Factor B	6	323.24**	710.77**	1.036**	1.833**	335.21**	159.44**
5. A B	6	87.73**	49.02	0.036	0.119	25.49	9.31
6. Error	12	28.536	37.59	0.036	0.143	21.09	17.48

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

Mean squares

Source	Degreees of freedom	Days to Male flower	Days to Female flower	No.of Female flowers	Node to Female flower	Fruit set %	Node at which first fruit retained	Days to first harvest	Days to last harvest
1.Replication	1	5.58	0.343	5.851	0.571	1.851	764.015	9.029	8.03
2.Factor A	1	7.92	0.343	0.009	0.571	0.051*	217.502	0.103	5.14
3.Error	1	0.06	1.418	0.000	0.143	3.430	0.596	2.829	6.60
4.Factor B	6	0.42	1.022	1.537**	3.810**	0.227	458.941**	2.356	1.214
5.AB	6	0.91**	0.952	1.646	0.405	0.916	202.47	0.59	7.674
6. Error	12	0.18	0.680	1.672	0.940	1.103	225.89	2.42	3.153

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

Mean squares

Source	Degreees of freedom	Length	Girth	Average wt.	Flesh thickness
1.Replication	1	0.045	1.550	2380.56	0.060
2.Factor A	1	1.967	2.122	4432.68	0.009
3.Error	1	0.588	0.502	1298.80	0.009
4.Factor B	6	2.002	5.986	21785.23**	0.117
5.AB	6	1.56	2.456	6787.13	0.273
6. Error	12	1.09	3.490	3597.32	0.097

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

Mean squares

Source	Degreees of freedom	No. of fruits/ plant	Yield/ plant	Yield/ plot	Productivity
1.Replication	1	0.321	0.033	2.057	1.429
2.Factor A	1	0.893	0.000	0.430	0.299
3.Error	1	0.036	0.357	1.715	1.191
4.Factor B	6	2.521**	1.160**	196.44**	136.421**
5.AB	6	0.643	0.151	19.146	13.296
6. Error	12	0.345	0.130	9.499	6.597

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

Appendix IV

Pequired inputs

Sl No	Unit	S1	S2	S3	S4	S5	S6	S7
1.	Seed (kg)	1.2	0.2	1.5	1.2	2.5	1.7	0.75
2.	FYM (t)	20	20	20	20	20	20	20
3.	Urea(15.19 g pit^{-1})	253.1	168.7	337.5	225.0	506.3	337.5	151.9
4.	Rock phosphate 12.5 g pit^{-1}	208.3	138.8	277.7	185.1	416.6	277.7	125.0
5.	MOP 4.2 g pit^{-1}	69.9	46.6	93.3	62.2	139.9	93.3	42.0
6.	Neem oil+garlic	25+5	25+5	25+5	25+5	25+5	25+5	25+5
7.	Dithane M 45(60 g/650 kg)	1.53	1.02	2.05	1.36	3.0	2.05	0.928

Cost of inputs

Sl No	Particulars	Unit cost	S1	S2	S3	S4	S5	S6	S7
1.	Seed	700	840	560	1050	840	1750	1190	525
2.	FYM	6260	6260	6260	6260	6260	6260	6260	6260
3.	Urea	4.80	1214	809	1620	1080	2430	1620	729
4.	Rockphosphate	2.40	499	333	666.4	444	999.8	666.4	300
5.	MOP	4.40	307.5	205.6	410.5	273.6	615.6	410.5	184.8
6.	Neemoil+ garlic	800	800	800	800	800	800	800	800
7.	Dithane	300	459	306	615	410.2	900	615	278.4
Total			10379	9273.7	11421.9	10107.8	13755.4	11561.9	9077.2

Cost of cultivation

Sl. No	Particulars	No. of labours	Unit cost	Cost
1.	Ploughing by tractor	8hr +1 man	-	1000.00
2.	Taking pits and channels	40 men	150.00	6000.00
3.	Application of FYM and filling	8 women	140.00	1120.00
4.	Incorporation of FYM	20 men	150.00	3000.00
5.	Sowing	3 women	140.00	420.00
6.	Fertilizer application	10 women	140.00	1400.00
7.	Thinning and gap filling	8 women	140.00	1120.00
8.	Spraying of plant protection chemicals	10 men	150.00	1500.00
9.	Harvesting and transport	25 women	140.00	3500.00
10.	Spreading of trailing materials	5 men + 2 women	150.00 + 140.00	1030.00
			Total	19060.00

Labour cost for conventional method of irrigation

Sl No	Unit	S_1	S_2	S_3	S_4	S_5	S_6	S_7
1.	No. of channels /pit	1666	1666	2221	2221	3333	3333	3333
2.	Labour requirement for irrigation @ 300 channels per day	5.5	5.5	7.4	7.4	11.1	11.1	5
3.	Irrigation for 29 days	159.5	159.5	214.6	214.6	321.6	321.9	145
4.	Labour charge	23925	23925	32190	32190	48285	48285	21750

Requirements for drip irrigation

Requirements	S_1	S_2	S_3	S_4	S_5	S_6	S_7
Water tank (1000 l)	5	5	5	5	5	5	5
2" PVC pipe (m)	100	100	100	100	100	100	100
12 mm Lateral	1680	1680	1680	1680	3350	3350	1680
4 mm extension tube	16666	11111	22222	14814	33333	22222	10000
Drippers	16666	11111	22222	14814	33333	22222	10000
Pin connector	16666	11111	22222	14814	33333	22222	10000
Belt wash	180	180	180	180	180	180	180
PVC end cap	2	2	2	2	2	2	2
16 mm tap	1680	1680	1680	1680	3350	3350	1680
2" MTA	5	5	5	5	5	5	5
2" FTA	5	5	5	5	5	5	5
2"Bend	5	5	5	5	5	5	5

Irrigation cost under drip method

Requirements	Unit cost	S_1	S_2	S_3	S_4	S_5	S_6	S_7
Water tank (1000 l)	2025	10125	10125	10125	10125	10125	10125	10125
2" PVC pipe (m)	36	3600	3600	3600	3600	3600	3600	3600
12 mm Lateral	2.82	6720	6720	6720	6720	13266	13266	6720
4 mm extension tube	2.80	46998	31333	62666	41765	93999	62666	28000
Drippers	3.00	49998	33333	66666	44442	99999	66666	30000
Pin connector	1.20	19999	13333	26666	17776	39999	26666	12000
Belt wash	10.0	1800	1800	1800	1800	1800	1800	1800
PVC end cap	8.00	112	112	112	112	112	112	112
16 mm tap	8.00	13440	13440	13440	13440	26800	26800	13440
2" MTA 2" +FTA + 2' Bend	64.00	322	322	322	322	322	322	322
Electricity charge	0.75	954	636	1272	838.5	1908	1272	202.5
Labour charge	140.00	7000	7000	7000	7000	7000	7000	7000
Total		161068	121754	200389	147940.5	298930	206935	113321.5

CROP GEOMETRY STUDIES UNDER DIFFERENT METHODS OF IRRIGATION IN ORIENTAL PICKLING MELON VAR. SAUBHAGYA

By

JAMUNA DEVI, M.

ABSTRACT OF THE THESIS

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Department of Olericulture

COLLEGE OF HORTICULTURE

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ABSTRACT

The present investigation on "Crop geometry studies under different methods of irrigation in oriental pickling melon variety Saubhagya (*Cucumis melo* var. *conomon*)" was conducted at the Department of Olericulture, College of Horticulture, Kerala agricultural university, Vellanikara, Thrissur during 2002 – 2003. The field experiment was conducted for two consecutive seasons in the summer rice fallows of the Agricultural Research Station, Mannuthy, Thrissur during December, 2002- April, 2003. The experiment was laid out in a split plot design with two methods of irrigation (drip irrigation @125 Ep and conventional method @ 45 l pit $^{-1}$) in the main plot and seven spacings (2.0 x 0.3 m, 2.0 x 0.45 m, 1.5 x 0.3 m, 1.5 x 0.45 m, 1.0 x 0.3 m, 1.0 x 0.45 m and 2.0 x1.5 m) in subplot.

The short duration and less vigorously growing variety Saubhagya sown during the month of December had less vegetative growth, earliness and high productivity (19.40 t ha^{-1}) than February sown crop (17.21 t ha^{-1}). None of the vegetative, flower, fruit and yield characters were significantly influenced by the two methods of irrigation. However, in the drip irrigation there was saving of 108.5 to 135.2 per cent of water per cropping period, which can be used for irrigating 1.09 to 1.35 ha of additional land for cultivation of the variety.

The effects of various spacings on vegetative growth and productivity were significant in both the crops. The crop in closer spacing (1.0 x 0.30 m) was earliest to harvest the first fruit. Average fruit weight was found maximum at a closer spacing of 1.0 x 0.45 m, which was on par with 1.0 x 0.30 m. The closest spacing of 1.0 x 0.30 m accommodating 33,333 plants ha^{-1} yielded maximum fruits (33.93 t ha^{-1} for December sown crop). This was 66 per cent more than that of the yield from the recommended spacing of 2.0 x 1.5 m. The next best spacing were 1.0 x 0.45 m and 1.5 x 0.45 m with productivity of 25.38 t ha^{-1} and 20.58 t ha^{-1}, respectively. In February sown crop, production was maximum at 1.0 x 0.45 m (25.12 t ha^{-1}), which also accounted for maximum number of fruits plant^{-1} and

yield plant^{-1}. Interaction effects were not significant for majority of economic characters.

Maximum benefit cost ratio (1.40) was shared by I_2S_5 and I_1S_6. In I_2S_5 plants were spaced at a closer spacing of 1.0 x 0.30 m (accommodating 33,333 plants ha^{-1}) under conventional method of irrigation. This treatment can be followed where family labour is utilized for cultivation of the variety Saubhagya. The treatment with spacing of 1.0 x 0.45 m under drip irrigation can also be suggested for the variety where there is water scarcity and the farmers are capital rich.