EFFECT OF DATE OF SOWING AND LEVELS OF IRRIGATION ON THE GROWTH AND YIELD OF BITTER GOURD VARIETY PRIYA

By

SARAH JACOB

THESIS

submitted in partial fulfilment of the
requirements for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1986

D E C L A R A T I O N

I hereby declare that this thesis entitled "Effect of date of sowing and levels of irrigation on the growth and yield of bitter gourd, variety Priya" is a bonafide record of research work done by me during the course of research and this thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similiar title of any other university or society to me.

College of Horticulture,
Vellanikkara.
19 4 86

S Jacob
Sarah Jacob

C E R T I F I C A T E

Certified that this thesis entitled "Effect of date of sowing and levels of irrigation on the growth and yield of bittergourd, variety Priya" is a record of research work done independently by Miss. Sarah Jacob under my guidence and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to her.

19/4/86

Dr. P. Balakrishna Pillai
Professor of
Agrometeorology.

Vellanikkara
19 4 86

C E R T I F I C A T E

We the undersigned members of the advisory committee of Miss. Sarah Jacob, a candidate for the degree of Master of Science in Agriculture with major in Agronomy agree that the thesis entitled "Effect of date of sowing and levels of irrigation on the growth and yield of bittergourd variety Priya" may be submitted by Miss. Sarah Jacob, in partial fulfilment of the requirements for the degree.

19/4/86

Dr. P. Balakrishna Pillai

(Adviser and Chairman)

19.4.86

R. Kulandaivelu

External Examiner

Dr. C. Sreedharan

(Member)

Sri. T.P. George

(Member)

Dr. K.V. Peter

(Member)

ACKNOWLEDGEMENT

I wish to place on record, my deep sense of gratitude to Dr. P. Balakrishna Pillai, Chairman of my Advisory Committee and Professor, Department of Agrometeorology for his inspiring guidence, sustained interest and constructive criticism throughout the period of investigation and preparation of the manuscript.

I also express my gratitude to Dr. C. Sreedharan, Professor and Head, Department of Agronomy, Dr. K.V. Peter, Professor and Head, Department of Olericulture, Prof. T.P. George, Professor and Head, Department of Agricultural Engineering, members of my advisory committee for the timely advice and keen interest they showed in this investigation.

I am extremely thankful to Dr. P. K. Gopalakrishnan, Associate Dean, College of Horticulture for providing the necessary facilities to carry out the study.

The valuable and critical suggestions given by Sri. A.V.R. Kesava Rao, Assistant Professor, Department of Agrometeorology, during the course of this investigation is gratefully acknowledged.

The encouragement and support of the staff and students of the Department of Agronomy and my friends has come a long way in helping me complete this investigation and I shall ever be grateful to them.

My sincere thanks are due to the members of the staff of the Pepper Research Scheme, Vellanikkara, for all the assistance and co-operation rendered to me.

My father, mother and sister have always been a constant source of encouragement and support to me and this helped me in completing this study.

I gratefully acknowledge the award of K A U Junior Fellowship during the period of my study.

My sincere thanks are due to Sri. Sidharthan. P.S. for typing this thesis neatly.

Above all, I thank God for his abiding presence and blessings, without which this work would not have been possible.

Vellanikkara Sarah Jacob

To my parents

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Figure No.

LIST OF PLATES

Introduction

INTRODUCTION

Bittergourd (*Momordica charantia* L) is one of the most important cucurbitaceous vegetables cultivated during summer in Kerala. The importance of this vegetable has long been accepted on account of its high nutritive value, unique medicinal properties and consumer preference. The cultivation of this crop has been found to be highly remunerative under irrigated condition during summer and hence gaining popularity among the vegetable farmers of the state. Therefore technologies useful in increasing the production and net income per unit area need emphasis.

In Kerala where a well defined dry spell occurs from November to May, water is the most important factor limiting vegetable production. Here judicious application of the available water is most important. Increased areas could be brought under cultivation with the same quantity of water by judicious irrigation management.

The water requirement of any crop during summer vary according to the variation in the evaporative demand of the atmosphere. Evapotranspiration rate varies from place to place and from season to season, since climate is a major component that determine its rate. Scheduling of irrigation based on evaporation values is more practicable and measurements are simple as compared to other methods. Information on the irrigation requirement of the crop raised during different seasons of the year is however scanty.

As both crop yield and water requirement are affected by climatic factors the water use efficiency also will vary with the season. It is possible to arrive at the best season which gives the highest water use efficiency and the most economic use of applied water.

The growth and yield of all crops vary greatly with the weather condition that prevail during the growing season. A combination of temperature, sunshine duration, humidity etc however determines the growth period, crop performance and productivity. The effect of these meteorological parameters on the crop can be studied by varying the sowing dates, so that an optimum date of sowing can be arrived at. Sowing date is a non monetary input and by sowing the crop at the correct time, the growth and yield of the crop can be enhanced, with no extra effort on the part of the farmer.

So far no detailed studies have been undertaken to study the effect of date of sowing and levels of irrigation on the growth and yield of bittergourd in Kerala or elsewhere. The present investigation was therefore undertaken on the cultivation of bittergourd during summer of 1984-85 at the Pepper Research Station, Kerala Agricultural University, Vellanikkara with the following objectives.

(1) To study the influence of time of sowing on growth and yield of bittergourd - variety Priya during summer.

(2) To find out the optimum time of sowing bittergourd in summer.

(3) To study the growth and yield response of bittergourd under different irrigation schedule.

(4) To find out the optimum number and intervals of irrigation for bittergourd in sandy clay loam soils of Vellanikkara.

Review of Literature

REVIEW OF LITERATURE

The full potential of any vegetable during summer can be exploited only with judicious water management practices. Vegetable production is also affected by integral effect of environmental factors like radiation,, temperature, humidity and wind. Maximum yield is possible only through providing a suitable combination of these factors in the optimum range. The literature pertaining to the studies on the effect of date of sowing and levels of irrigation on cucurbit vegetables are reviewed here under.

2.1 Effect of irrigation on Growth and Yield

Mc Gillivray (1951) reported that in two out three years, the yield of cantaloups were increased by irrigation, although the size of fruits and total soluble solids were not greatly affected. Frohlich and Henkel (1961) found that the yield of outdoor cucumbers were increased by an average of 16.7 percent by irrigation before flowering when the soil moisture fell to 50 percent of field capacity and after flowering when it fell to 60 - 65 percent of field capacity.

Abolina *et al.* (1963) observed that the melon plants watered regularly produced greater number of female flowers. Flocker *et al.* (1965) showed that yield response to irrigation was mostly by increase in fruit size. Heavier irrigation increased cull fruits associated with increased vine growth and succulence, while high moisture stress increased culls associated with restricted vine growth in cantaloups.

The result of three trial in the irrigation of melons by Molnar (1965) showed that irrigation increased the number of female flowers and advanced their flowering. Fruit set in general was not improved, but fruit drop was reduced.

Dunkel (1966) reported that the highest yield of cucumber was obtained when soil moisture did not drop below 70 percent of field capacity.

Bradley and Rhodeo (1969) concluded that irrigation at 7, 14 and 21 days interval made very little difference to the yield of summer squash harvested frequently. But at the 21 day interval, the yield was markedly reduced. While describing the cultivation of bittergourd, Hali (1969) emphasised the necessity of daily irrigation to the crop during summer in Kerala.

Neil and Zunino (1972) observed that higher irrigation rate with melons produced more and heavier melons with improved flavour and decreased firmness; the dry matter content was unaffected. Varga (1973) observed that in cucumbers, the period between flowering and fruit ripening was critical for fruit development. During this period, it was necessary to supply the crop with 40 mm of water. However, excessive application of water was found deleterious.

Dimitrov (1973) showed that a field capacity of 70 - 80 percent maintained over the entire season was the most economic treatment for melons. But from glass house trials with cucumber, Dimitrov (1974) found that the highest yield was produced at 70 percent field capacity before picking and 90 percent field capacity during the picking period. On a four year average, the yield was 26 percent higher than control, wherein, 70 percent of the field capacity was maintained during the entire growing period.

Hammett <u>et al</u>. (1974) found that a constant supply of moisture was necessary during the growth of cucumbers, especially during flowering and fruiting. Jagoda and Kaniszewski (1975) observed that yield and fruit quality were appreciably improved by irrigation. Krynska (1975) studied the effect of irrigation on cucumber yield and found that irrigation increased yield by 8 - 19 percent.

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

In a three year experiment with melons, Caro and Linsalata (1977) observed that furrow irrigation increased yield and fruit weight. But the highest percentage of sugar content in the fruit occured in unirrigated plots or plots irrigated at the lowest frequency.

Motoki and Kurokawa (1977) applied irrigation to melons at different soil moisture regimes ranging from pF 2.7 to 2.0 and they obtained the optimum plant growth and yield with irrigation at pF 2.5. According to Loomis and Crandall (1977), the best irrigation schedule for pickling cucumbers involved removal by plants between 48 - 64 percent of the available water in the upper 90 cm of the soil profile between irrigations. Abreu et al. (1978) obtained the highest average yield of 13.82 t ha^{-1} when irrigation was applied at 0.7 atmospheres.

Rudich et al.(1978) found that irrigation given during the fruit development stage resulted in average yield increases of 24.5 and 13.5 t ha^{-1}, but did not affect fruit quality.

Doorenbos and Kassan (1979) are of the opinion that within certain water deficit limits, irrigationpractices do not greatly affect the number of fruits per plant, but affect the fruit size, weight, shape and quality in water melon. The water utilization efficiency for harvested yield of fresh fruits containing about 90 percent moisture varies between 5 and 8 kg m^{-3}.

According to Haynes and Herring (1980), the highest yield of marketable squash (45.5 kg per 6 plants) was obtained by irrigation at 700 mbars, while the number of marketable fruits (328 per 6 plants) with irrigation at 300 mbars.

Ware and Mc Collum (1980) showed that the cucumber crops require a continuous supply of moisture during the growing season. The most critical need occurs at the time of fruiting. Moisture stress then can seriously reduce the yield of marketable fruits.

Henriksen (1980) showed that 60 percent more fruits were produced with irrigation than without irrigation. In general irrigation improved quality and reduced the tendency towards spongy fruits, but did not improve fruit uniformity. Twice as many fruits per plant and upto three times greater weight of fruit per plant were obtained by irrigation.

With musk melons, Kashi (1981) obtained maximum yield and enhanced soluble solid content with irrigation intervals of 6 and 8 days. Goto et al. (1981) obtained the highest fruit yield when forced cucumbers were watered when soil suction measured by a tensiometer reached pF 2.3. Yabe et al. (1981) studied the effect of soil moisture at various growth stages and recommended soil pF values of 2.3 - 2.5, 2.3 - 2.7, and 2.5 - 2.7 at the vegetative, fruit swelling and maturing stages respectively for obtaining optimum growth and high yield.

Trials conducted by Indian Council of Agricultural Research (1982) showed that in ashgourd when irrigation was scheduled at 0.7 IW/CPE ratio, the increase in yield over 0.4 IW/CPE ratio was 25.4 percent. This was due to an increase in weight per fruit coupled with more number of fruits per plant upto 0.7 IW/CPE ratio.

Yamashita et al. (1982) reported that in cucumbers, elongation of lateral branches was the best at a soil moisture of pF 2.0. Smittle and Threadgill (1982) obtained the highest marketable fruit yield of 24.2 t ha^{-1} from applying irrigation at 0.3 bar soil water tension. Mannini and Roncuzzi (1983) showed that irrigation at an interval of 3 - 6 days did not affect cucumber yield, but the volume of water applied was important.

Tau et al. (1983) from their two year study on pickling cucumbers found that the highest yield was obtained from multi harvest operations with irrigation at 60 percent available soil moisture level, while maximum yield was obtained with irrigation at 25 percent available soil moisture level in the once over harvest operation.

Pew and Gardner (1983) observed that, with direct sown musk melons, higher yield, longer fruit and earlier maturity were obtained by irrigating when soil moisture tensions at 25 cm depth reached 50 or 75 k pa compared with 25 k pa. Chander and Mangal (1983) from their studies on musk melon found that the best growth and flowering were obtained from plots irrigated at 0.9 pan evaporation coefficient.

Desai and Patel (1984) reported that, with water melons , the 1.2 IW/CPE ratio gave significantly greater number of fruits per ha. While 0.6 IW/CPE ratio gave the lowest number of fruits per ha. Scheduling irrigation at 1.0 and 1.2 IW/CPE ratio gave higher yield and vegetative growth, than other treatments.

Thomas (1984) obtained higher yield and growth of bitter gourd at IW/CPE ratio 1.2 than at other lower levels of irrigation.

Lakshmanan (1985) observed no significant difference in yield between irrigating at 25, 50 and 75 percent depletion of available soil moisture for pumpkin, oriental pickling melon and ashgourd.

2.2 Method of Irrigation

Bujanovskaja (1970) observed that root development in field grown cucumber was better following flood irrigation than following sprinkler irrigation or no irrigation.

Mondal (1974) evolved a new technique for growing plants with spreading canopy using very small amount of water. Earthen ware pitchers, usually used for storing drinking water were buried in the soil up to their neck. Pitchers were filled with irrigation water and the seeds of water melon, musk melon, pumpkin and bottle gourd were sown around each pitcher. After sowing the pitchers were refilled with water every morning to replensih the loss that occurred due to seepage. The water requirement of plants grown by this technique varied from 1.23 - 1.98 cm ha^{-1} which was only a fraction of their normal water requirement under normal irrigation.

Mondal (1978) conducted experiments with pitcher irrigation using water melon, musk melon and bottle gourd. The total yield of each of the three crops were highest with water replenished every 3rd, 4th and alternate days respectively.

Balakumaran (1982) studied the comparative effect of pitcher irrigation and pot watering in cucumber. Porous 9 litre earthen ware pitchers were buried in the soil upto the neck and four plants were planted around each pitcher. The pitchers were topped up with water once every two days and the quantity used was recorded. The control plants were watered conventionally via pots. Although yields were slightly higher on pot watered plots, water economy was appreciably greater under pitcher irrigation.

Reddy and Rao (1983) worked on the response of bittergourd to pitcher and basin system of irrigation. Clay pitchers of 20 lit. capacity with four 1 mm holes at 5 cm from the bottom were buried in the soil upto the brim and filled with water every 4th or 8th day. Basins, 65 cm in diameter similarily treated were also filled with a similiar quantity of water every 4th and 8th day. Distance between pitchers and basins was 2.5 m and four plants were planted around each container. The yield was highest (21.6 kg per 25 m^2) on plots with pitchers filled every 4th day and lowest (15.9 kg per 25 m^2) on plots with basin filled every 8th day.

2.3 Consumptive use and Water Requirement

Neil and Zunino (1972) studied the water requirement of melons and found that the maximum evapotranspiration in irrigated cantaloups was 60 percent of potential evapotranspiration. Between flowering and fruit formation, the water uptake represented 55 percent of potential evapotranspiration, this increased during fruit enlargement reaching 85 percent at harvesting, but by mid harvest it had dropped to 55 percent. 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} upto fruit enlargement, 882 m^3 upto prematurity and 280 m^3 upto harvest.

Cselotel and Varga (1973) worked out the relationship between development and water utilization in cucumbers. They found that during the period upto the begining of flowering, the water uptake was small amounting to 5 lit. per plant. In the 30 day period following the begining of flowering the water uptake amounted to 30 - 31 litre per plant. In the subsequent 30 day period, corresponding to full development of the fruits, the water uptake was 20 litres. Konishi (1974) in his study of the amount and nature of water consumption in musk melon plants, observed that the total water consumption by a fruit bearing plant with a final leaf area of about 1100 cm^2 was 90 - 85 litre. less water was consumed by plants without fruit. As the plants grew, the ratio of total water consumption per plant to pan evaporation increased to a maximum at the netting stage and then declined with aging. Young leaves transpired faster than old leaves. Most transpiration occurred when soil pF was 1.6 - 2.0.

Pavlov (1976) found that the highest yield of cucumber (26.6 kg m^{-2}) was obtained when water was applied at 70 - 100 litre m^{-2} during the plant growing phase followed by 480 - 570 lit m^{-2} during fruiting. Borelli and Zerbi (1977) tried four levels of irrigation, equivalent to total of 216, 297, 378 and 459 mm of water over the growing season for musk melons and observed that yield increments declined with increasing soil moisture level.

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

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

Thomas (1984) reported that the consumptive use increased with increase in the levels of irrigation in the case of bittergourd. According to Lakshman (1985) treatments which received frequent irrigation showed higher values of consumptive use through out the crop growth period in the case of cucurbitaceous vegetables.

2.4 Soil Moisture Depletion Pattern

Loomis and Crandall (1977) indicated that cucumbers extracted 50 percent of the total amount of water consumed from the upper 30 cm of the soil profile, 30 percent from the next 30 cm and 10 percent from the next 30 cm.

Zabara (1978) from his investigations on the effect of irrigation on root distribution in cucumbers has concluded that in irrigated cucumbers, the root distribution at bearing was 64.5 percent, at 0 - 10 cm depth, 28.5 percent at 10 - 20 cm and 6.2 percent 20 - 30 cm. Whereas in unirrigated cucumbers, the figures were 53.7 percent at 0 - 10 cm, 29.0 percent at 10-20 cm and 14.9 percent at 20 - 30 cm.

Doorenbos and Kassan (1979) observed that the root system of water melon can be deep and extensive upto a depth of 1.5 to 2 m. The active root zone where most of the water is extracted under adequate supply is limited to the first 1 to 1.5 m.

Thomas (1984) reported that in bittergourd, the top 15 cm of the soil layer accounted for 42 - 48 percent of the total moisture depleted. The moisture use from 15 to 30 cm layer was as high as that from the next 30 cm soil layer below. The top 30 cm layer contributed about 66.71 percent of total water use. Moisture depletion decreased rapidly with depth. He also observed that in comparison with wet regimes, dry regimes extracted more soil water from the lower soil layers. Similiar observations were made by Lakshmanan (1985).

2.5 Irrigation scheduling based on evaporation

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

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

According to Loomis and Crandall (1977) the ratio of consumptive water use to evaporation pan loss reached a maximum of 1.5 during the early harvest season of cucumber.

Singh and Singh (1978) reported the highest total yield with drip irrigation daily at 68 percent of the evaporation from a class A pan, when compared with other methods, where water was applied when accumulative evapotranspiration total reached 3.2 cm with crops like bottle gourd, round gourd and water melon.

Experiments conducted by the Indian Council of Agricultural Research (1981) have conclusively prooved that among the levels of irrigation, the highest yield was recorded by IW/CPE ratio of 1.0 which was on par with 0.7 IW/CPE ratio in the case of ashgourd. Both these levels were significantly superior to 0.4 IW/CPE ratio.

Chander and Mangal (1983) in the trials with musk melon plants grown at 0.3, 0.6, 0.9 or 1.2 pan evaporation coefficient, observed that the best growth, flowering and cropping were obtained on plots irrigated at 0.9 PEC.

Desai and Patil (1984) found that of the four irrigation ratios (IW/CPE 0.6, 0.8, 1.0 and 1.2), good plant growth, fruit quality and the highest yield were obtained from water melon irrigated at IW/CPE = 1.0.

Thomas (1984) reported that the highest yield was recorded by IW/CPE = 1.2 which was on par with the ratio

IW/CPE = 0.8 but significantly superior to the ratio 0.4 in the case of bittergourd grown in summer rice fallows.

2.6 Effect of date of sowing on the growth and yield

The environmental factors have a remarkable influence on the growth and yield of cucurbitaceous vegetables.

(i) Effect on the early vegetative stage

Danielson (1944) conducted experiments with cucumber grown in contracted diurnal photoperiods of 8, 12 and 16 hours. He found that the quantitative measurements of stem, leaf and root growth, as well as chemical composition showed vegetative responses peculiar to each day length. Stem elongation was retarded in 16 hour daylengths, while maximum stem elongation occured in the 8 hour daylength. In contrast to this Hall (1949) reported that in cucumber, stem of long day plants attained a greater length than stem of short day plants. Long day plants consistently accumulated greater fresh and dry weight than short day plants.

Surlekov and Ivanov (1969) from an experiment on cucumber using cultivars, starozagorski Langi and Donski-175 sown on 20th and 30th April and 10th and 30th May, concluded that the April sowing and planting dates produced plants of the greatest length and the largest number of laterals.

Buttrose and Sedgley (1978) found that in water melon, increasing light intensity and daylength promoted later al growth, whereas main shoots were less affected. Increase in temperature above 25°C resulted in longer main shoots and prolific lateral growth. Toki (1978) observed that in cucumber translocation and respiration were greately affect by night temperature.

Heij (1981) planted cucumber cultivar Farbio at weekly or fortnightly interval between 13th December and 24th January and they were given different day/night temperatures. He reported that stem elongation increased with rise in temperature. Lint and Heij (1982 a) with four plantings of glass house cucumber grown at three night temperatures observed that the number of nodes per stem increased with lower night temperature. The relation is asymptotic towards full suppression of elongation near 11°C. With later planting dates, internodes were longer.

Desai and Patil (1984) reported that the lowest vine girth of water melon was recorded on 20th November sowing while the 20th January sowing produced vine with maximum girth. The length of vine was significantly reduced at 20th January sowing. The number of leaves were highest with vines of 30th December sowing. The water requirement increased as sowing dates proceeded from 20th November to 10th February ie. 350 to 520 mm respectively.

(ii) Effect on earliness

Hall (1949) found that the peak of flower production occured 15 days earlier in cucumber treated with short days and about 50 percent more flowers were formed in short day than in long day plants.

Ivanov (1978) from his field trials with cucumber sown on six different dates in April and May showed that there was a strong negative correlation between effective temperature and duration of all growth stages. There was also a weak negative correlation between duration and daylength. Research findings of Vooran and Challa (1978) indicated that in cucumber, earliness in days from planting till first yield of the crop was strongly affected by planting date and night temperature. Nandpuri and Lal (1978) reported that in a two year trial with eight muskmelon cultivars the March planted crop took significantly fewer days to ripen than the November planted crop.

Drews et al. (1980) found that in cucumber low night temperature of 16°C resulted in a yield increase but the start of yielding was delayed. High temperatures of 23°C caused earlier yieldings, but because of earlier plant aging, the total yield was decreased. This is supported by Vooran (1980) and according to him increasing night temperature from 12 - 20°C did decrease earliness; a further increase till 24°C did not influence earliness. At the same time an increase in day temperature from 20 - 26°C also decreased earliness. Heij (1981) also reported that both increase in temperature and delay in planting promoted earliness of fruit production in cucumber. Slack and Hand (1981) opined that in cucumber, at the highest temperature the earliest fruits were produced, but a high day temperature was more effective than a high night temperature.

Uffelen (1982) observed that cucumber with a 25°/17° day night temperature regime and a 12 hour day length grew faster and flowered and cropped earlier than those grown at a constant temperature of 21°C.

(iii) Effect on flowering

Tiedjens (1928) succeeded in materially changing the ratio of staminate to pistillate flowers in the cucumber by varying the amount of light to which the plants were exposed. Under reduced light intensity and shorter light duration, the ratio of pistillate to staminate flowers tended to increase.

Edmond (1930) working with cucumber 'Extra Long White Spine' noted that seasonal variations in sex expression of cucumber could be attributed to changes in day length. He found that plants grown from June 27th to September 6th had 154.4 male flowers against 7.3 female flowers per plant; from December 15th to April 15th, the count was 0.67 males and 92.67 females and from February 17th to May 25th, 1.67 males and 134 females. Whitaker (1931) concluded that environmental control of sex expression in cultivated cucumber may be possible. Scott (1933) laid out a trial with 3 varieties of bush pumpkins planted throughout the growing season ie. May 9th, June 8th, July 6th; August 3rd and August 31st.

But, the data showed no consistent variation in the average sex ratios of the different plantings.

Danielson (1944) reported that when cucumbers were grown in diurnal photo periods of 8, 12 & 16 hours, maximum staminate flower production on the basis of total number of flowers produced, occured in the 8 hour day.

Nitch et al. (1952) observed that high temperatures and long days tended to keep the vines in the male phase, where as low temperature and short days speeded up the development, so that the female phase was reached after a much smaller number of nodes. The production of female flowers rapidly became 100 percent and the size of the ovaries increased before full bloom until a parthenocarpic fruit was produced, thus representing the ultimate product in the feminisation process. The position of the first female flower on the vine depended on day length and night temperatures.

Singh (1958) from his studies on ridge gourd and smooth gourd showed that maximum number of male flowers appeared during rains.

Venketram (1963) found that lesser light duration was more conducive for the female phase in snake gourd. An interesting observation linked with the sex ratio was made by him with reference to the node at which the first female flower was borne. This node number was observed to be an index of the sex ratios in that, the lower the node number, the higher was the female/male ratio. This trend was observed practically in all the treatments tried.

Matsuo (1968) reported that although low temperature and short day length usually induce female flower differentiation in cucumber, some varieties appeared to be insensitive. This view was supported by Fakushima et al. (1968). They showed that cultivars belonging to the South Chinese variety complex were sensitive to low temperatures and short days, whereas those belonging to the North Chinese and European variety complexes were sensitive to low temperature but insensitive to day length.

Kamalanathan and Thamburaj (1970) studied the influence of weather factors on sex expression in pumpkin and the optimum time of sowing under Coimbatore conditions. They found that the preflowering and flowering phases were governed mainly by day length and temperature. Cloudiness favoured the production of pistillate flowers. July and August were the best months for sowing to produce a low ratio of staminate to pistillate flowers and an early crop with high yield.

Sharma and Nath (1971) worked with three varieties each of water melon, musk melon, snap melon and long melon and their results indicated that in rainy season, in all three varieties of water melon, the sex ratio was highest during the period with an average of 28.78°C temperature and 75.62 percent relative humidity.

Nandpuri et al. (1976) reported that with musk melon, sex ratio was found to be positively correlated with temperature in the green house and negatively with the relative humidity in the field.

Cantliffe (1981) studied the alteration of sex expression in cucumber due to changes in temperature, light intensity and photoperiod. He found that temperature influenced sex expression more than light intensity or photoperiod. Lint and Heij (1982 b) observed that lower night temperature resulted in higher flower abortion in glass house cucumber.

(iv) Effect on fruiting and yield

Miller and Ries (1958) found that low temperature (60°F) caused an increase in the length to diameter ratio of pickling cucumber fruits. Plants grown at 70°F night temperature produced more fruits at the 11 hour day than at the 15 hour day, while at 60°F night temperature, plants produced more fruit under long day conditions.

Surlekov and Ivanov (1969) reported that April sowing and planting dates produced plants with the largest number of fruits, the highest mean fruit weight and the greatest seed number and weight. Kartalov (1970) conducted some tests to establish appropriate dates for sowing and planting cucumber cultivars for hot bed production. He found that the highest yield was obtained with the earliest sowing and planting dates viz. 17th January and 22nd February respectively.

Toki (1978) concluded that night temperature should be controlled at 16°C for 4 hours from 17.00 to 21.00 hours in the evening followed by lower temperature of 10°C to 12°C for remaining night. This temperature regime increased the cucumber yield by 12 percent as compared with those of the conventional cultivation for night and day temperatures.

Drews (1979) observed the fruit set and development in cucumbers (cv. Trix) from February to July and found that small fruits gained 25 - 30 g fresh weight per day. Daily growth in length and width varied between 20 - 30 mm and 2.5 - 3.5 mm respectively. Increases in light intensity and air temperature reduced the period of fruit development from 25 to 13 days. Low night air temperatures enhanced fruitset, whereas high air temperatures (35°C) at low relative humidity encouraged fruit drop. About 30 percent of female flowers (135 flowers per plant) developed into marketable fruits.

Vooran (1980) found a positive effect on yield and production from increasing day temperature, which was probably caused by a better shoot development.

Kmiecik and Lisiewska (1981) from a three year trial with cucumber sown in field in early or late May or early June, observed that the average yield of commercial and processing cucumbers were highest with the earliest date of sowing.

Slack and Hand (1981) reported that the early fruit yield rose with increasing night temperature upto 23°C but showed no increase at day temperature above 22°C.

After 20 weeks of picking, the highest cummulative fruit yield was obtained at a night temperature of 20°C and a day temperature of 22°C.

Uffelen (1982) suggested that plants grown with a 25°/17° day night temperature regime gave 11 percent higher average fruit weight than those grown at a constant temperature of 21°C.

Heij and Lint (1982) working with cucumber seedlings planted in the green house on 13th or 27th December or 10th or 24th January and grown at 21 - 27°C day temperature and 12,16 or 20°C night temperature found that the later planting produced more fruits than early planting. Night temperature had only a slight effect on fruit number per stem, but there was an optimum near 16°C.

Khristov (1983) reported that the highest total yield was produced by melons grown under tunnel by planting on April 10th (25.36 t ha^{-1}) or by direct sowing on 1st April (23.63 t ha^{-1}). Delayed sowing or planting reduced yield.

Desai and Patil (1984) studied the effect of sowing date on the yield of water melon. He found that the highest fruit number per hectare and the highest yield per hectare were obtained when the sowing was done on 30th December and 20th January. It was the lowest in 20th November sowing.

Materials and Methods

MATERIALS AND METHODS

A field experiment designed to study the effect of date of sowing and levels of irrigation on the growth and yield of bittergourd, variety Priya was conducted during summer of 1984-85 at the Pepper Research Station, Kerala Agricultural University, Vellanikkara. The details of the materials used and the techniques adopted during the course of the investigation are briefly described below.

1. Materials

1.1 Site, Climate and Soil

The research station is situated at 10° 32'N Latitude and 76° 10'E Longitude at an altitude of 22.25 m above MSL. This area enjoys a typical humid tropical climate.

The details of the meteorological observations for the period are presented in Table - 1 and Fig - 1 and 2.

Composite soil samples from 0-60 cm depth taken before commencement of experiment were used for the determination of physiochemical properties and the data are given in Table - 2.

Table - 1

Mean weekly weather parameters for the crop growth period

Period No.	Dates	Week No.	Maximum tempera-ture(°C)	Minimum tempera-ture(°C)	Sun-shine hours	Relative humidity (%)	Wind speed (km/hr)	Total Evapo-ration (mm)	Total rain-fall (mm)
XI	Nov.26 - Dec. 2	48	31.2	22.4	8.3	60	9.4	41.4	16.0
XII	Dec. 3 - Dec. 9	49	32.1	19.6	9.9	47	8.2	48.0	0.4
	" 10 - " 16	50	31.7	19.2	9.3	54	9.9	53.7	0
	" 17 - " 23	51	34.3	22.6	9.9	63	8.0	51.4	0
	" 24 - " 31	52	31.9	23.7	5.4	80	7.4	36.4	0
I	Jan. 1 - Jan. 7	1	32.1	21.9	9.8	73	12.4	47.9	14.7
	" 8 - " 14	2	32.5	23.7	9.5	67	17.1	62.7	0
	" 15 - " 21	3	33.1	21.6	10.4	52	14.4	71.2	0
	" 22 - " 28	4	34.7	22.7	10.3	56	11.4	56.8	0
	" 29 - Feb. 4	5	33.5	21.6	6.2	64	4.8	40.5	0

Table - 1 Continued

Period No.	Dates	Week No.	Maximum temperature (°C)	Minimum temperature (°C)	Sunshine hours	Relative humidity (%)	Wind speed (km/hr)	Total Evaporation (mm)	Total rainfall (mm)
II	Feb. 5 - Feb. 11	6	34.7	23.1	9.1	68	5.3	39.4	0
	" 12 - " 18	7	35.4	23.5	10.1	46	6.6	44.1	0
	" 19 - " 25	8	36.1	22.8	10.1	61	5.5	48.5	0
	" 26 - Mär. 4	9	36.8	23.6	9.7	56	8.5	57.0	0
III	Mar. 5 - Mar. 11	10	37.0	24.7	8.6	54	7.7	67.0	0
	" 12 - " 18	11	35.5	25.5	8.5	70	5.4	49.0	0
	" 19 - " 25	12	35.7	25.2	7.4	70	6.7	47.5	0
	" 26 - April I	13	35.8	23.8	[illegible].6	69	5.6	46.4	2.0

Table - 1 Continued

Period No.	Date	Week No.	Maximum tempera-ture(°C)	Minimum tempera-ture(°C)	Sun-shine hours	Relative humidity (%)	Wind speed (km/hr)	Total evapo-ration (mm)	Total rain-fall (mm)
IV	April 12 - April18	14	35.3	25.7	6.6	66	5.4	41.0	16.1
	" 9 - " 15	15	35.4	25.4	9.2	65	5.6	49.8	0
	" 16 - " 22	16	35.3	25.2	8.8	67	6.5	47.7	0
	" 23 - " 29	17	35.9	26.2	9.4	65	6.6	49.8	3.0
	" 30 - May 6	18	35.9	26.5	8.8	66	5.4	49.7	0
V	May 7 - May 13	19	36.4	26.6	9.3	66	5.4	36.4	13.22
	" 14 - " 20	20	34.1	25.1	4.6	72	5.1	32.3	26.4
	" 21 - " 27	21	31.8	24.5	6.5	79	6.5	15.0	86
	" 28 - June 3	22	28.8	23.6	1.5	91	3.6	22.2	169.7
VI	June 4 - June10	23	29.4	23.1	2.3	86	4.5	22.3	110.8

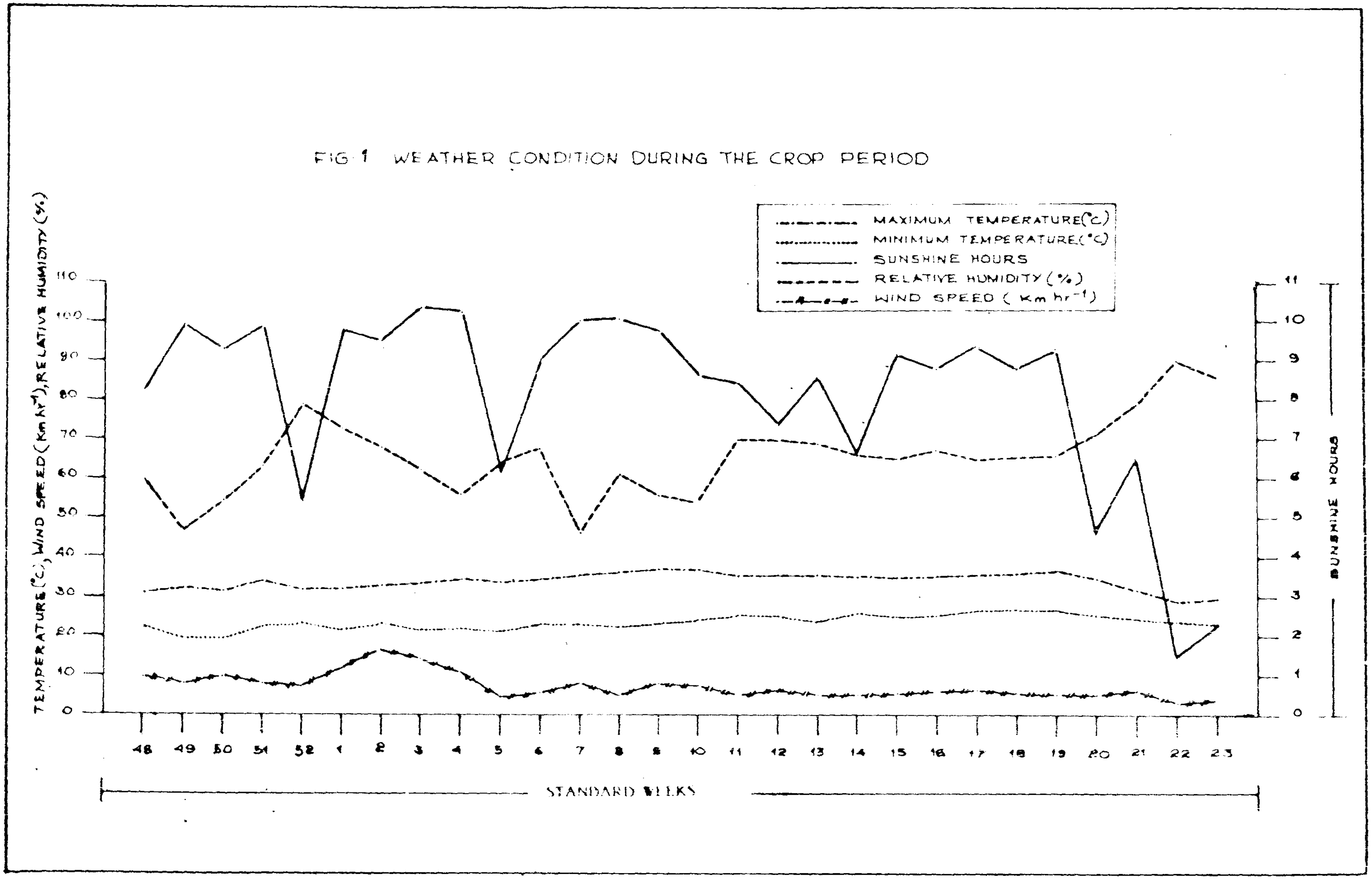


FIG 1 WEATHER CONDITION DURING THE CROP PERIOD
MAXIMUM TEMPERATURE(°C)
MINIMUM TEMPERATURE(°C)
SUNSHINE HOURS
RELATIVE HUMIDITY (%)
WIND SPEED (Km hr⁻¹)
TEMPERATURE (°C), WIND SPEED (Km hr⁻¹), RELATIVE HUMIDITY (%)
SUNSHINE HOURS
STANDARD WEEKS
48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Table - 2

Properties of the soil

1. Mechanical composition

Fraction	Percent composition	Procedure adopted
Coarse Sand	26.18	Robinsons International
Fine sand	27.10	Pipette method
Clay	36.20	(Piper, 1950)
Silt	10.00	
Textural class	Sandy clay loam	ISSS System

2. Physical constants of the soil

Constant	Value	Procedure adopted
Field capacity (0.3 bars)	19.23%	Pressure plate apparatus (Richards, 1947)
Moisture percentage at 15 bars	10.9%	Pressure plate apparatus (Richards, 1947)
Bulk density g cm^{-3}	1.41	Core method (Blake, 1965 a)
Particle density g cm^{-3}	2.18	Pycnometer method (Blake, 1965 b)

Table - 2 Continued

Chemical Properties

Description of properties	Value	Method employed
Organic carbon	0.47%	Walkley and Black rapid titration method (Jackson, 1958)
Available nitrogen	0.058%	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus	0.003%	Chlorostannous reduced molyhdo phosphoric blue colour method in hydrochloric acid system (Jackson, 1958)
Available potassium	0.008%	Flame photometry, neutral normal amonium acetate extraction (Jackson, 1958)
Soil reaction (pH)	5.4	soil water suspension of 1 : 2.5 (Jackson, 1958)
Electrical conductivity (mmhos cm^{-1})	0.35	Soil water extract of 1 : 2.5 (Jackson, 1958)

1.2 Season

The experiment was conducted during the period December, 1984 to June, 1985.

1.3 Variety

Bittergourd variety VK-1 (Priya), selected for this investigation is a high yielding variety of about 110 days duration developed at the Department of Olericulture, College of Horticulture, Vellanikkara. It is grown on commercial scale in Kerala State. It produces long broad fruits with prominant spines and is devoid of smooth ridges.

1.4 Manures and Fertilizers

Farm yard manure at the rate of 20 tonnes per hectare was applied uniformly to all the pits as basal dose. Urea, Super phosphate and Muriate of Potash were used as fertilizers to supply the required quantity of nitrogen (at the rate of 70 kg N per hectare), Phosphorous (at the rate of 25 kg P_2O_5 per hectare) and Potassium (at the rate of 25 kg K_2O per hectare) respectively. N was applied in two splits, half as basal and the other half at the time of vining. The whole of P and K were applied basally.

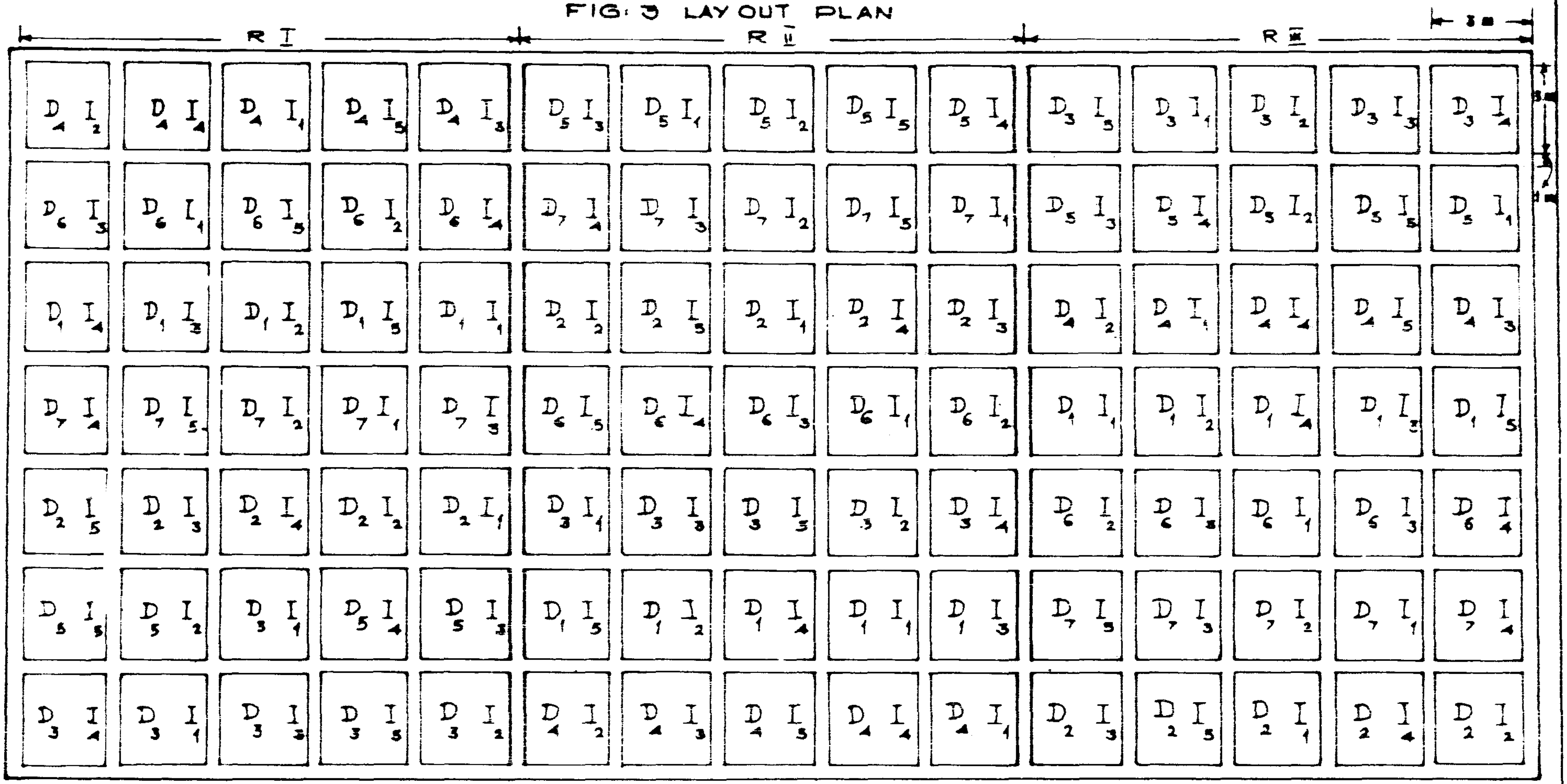
2. Methods

2.1 Layout

The experiment was laid out in split plot design with three replications. The lay out plan is given in Fig - 3. The treatments consisted of 7 date of sowing in the main plot and 5 levels of irrigation in the sub plot. The details of the different treatments and the notations used to represent the treatments are given below.

Main plot Treatments (Sowing dates)		Notations
December I^st	-	D_1
December 16^th	-	D_2
December 31^st	-	D_3
January 15^th	-	D_4
January 30^th	-	D_5
February 14^th	-	D_6
March I^st	-	D_7

FIG: 3 LAY OUT PLAN



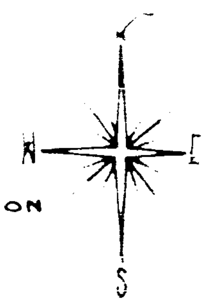
TREATMENTS

DATE OF SOWING:-

D_1 - DECEMBER 1st
D_2 - DECEMBER 16th
D_3 - DECEMBER 31st
D_4 - JANUARY 15th
D_5 - JANUARY 30th
D_6 - FEBRUARY 14th
D_7 - MARCH 1st

IRRIGATION

I_1 - IW/CPE:1
I_2 - IW/CPE:0.75
I_3 - IW/CPE:0.50
I_4 - CONVENTIONAL IRRIGATION
I_5 - PITCHER IRRIGATION



Subplot Treatments

(Irrigation)

Irrigation at IW/CPE ratio of 1	-	I_1
Irrigation at IW/CPE ratio of 0.75	-	I_2
Irrigation at IW/CPE ratio of 0.50	-	I_3
Conventional method of irrigation	-	I_4 *
Pitcher irrigation	-	I_5 **

* The treatment I_4 was standardise after surveying the farmers local practice of irrigation (One pot @ 10 lit/day).

** Earthern ware pitchers of 10 litre capacity filled with water, were buried up to the neck in each basin and the water replensihed when the level of water in the pitcher went down by half.

The plot size was 3 m x 3 m and there were 4 pits in each plot having 2 plants each. The spacing given was 1.5 m x 1.5 m. There were three replications and the total number of plots were 105. The depth of irrigation was 30 mm.

2.2 Cultural Operation

The land was ploughed well and then levelled.

Plots of 3 x 3 m size were taken leaving buffer strips of 1 m width all around the plot. Area inside each plot was scrupulously levelled and four pits of 30 cm depth and 60 cm diameter were taken at a spacing of 1.5 x 1.5 m.

The pits were filled with top soil and the recommended quantity of farm yard manure. The basal dose of fertilizers were applied and mixed well with soil.

The seeds were soaked overnight in water and sown on the prescribed date of sowing. The seedlings were thinned to two plants per pit, two weeks after sowing. When the plants started to run, they were trailed on to the pandals constructed at a height of 1.5 m. Nitrogen was top dressed at the time of vining. The plots were kept weed free throughout the crop growth period. Protective spraying with Rogor was given at fort-nightly intervals.

2.3 Irrigation

A presowing irrigation with one pot of water (10 litres) was given uniformly to all pits. For the first 5 days after sowing, half pot of water was given daily to each pit. Thereafter one pot of water per pit was given daily upto the 20th day after sowing. On the 21st day, the treatments I_1, I_2 and I_3 were irrigated to a depth of 30mm. From then onwards 30 mm irrigation water was applied as and when the respective cumulative pan evaporation values are attained in the various treatments. Accordingly irrigations were scheduled when the evaporation values from the class A pan evaporimeter accumulated to 30 mm, 40 mm, and 60 mm respectively in the case of ratio 1.0, 0.75 and 0.50. Hose pipes of 1½ inch diameter were used to supply water to the plots. The irrigation water was measured by the volume method, whereby the flow is collected in a container of known volume for a measured period of time. The rate of flow is calculated by the formula.

$$\text{Discharge rate, litres sec}^{-1} = \frac{\text{Volume of container, (litres)}}{\text{Time required to fill (seconds)}}$$

(Michael, 1978)

Table - 3

Details of the irrigation treatment

Treatments		Total number of irrigation	Interval of irri-gation (days)	Quantity of water applied (mm)	Pre-treatment irriga-tion (mm)	Effective rainfall (mm)	Total quantity of water used (mm)
Sowing Date	Irrigation						
	I_1	19	3 - 9	570	78	14.70	662.70
	I_2	14	4 - 10	420	78	14.70	512.70
D_1	I_3	9	6 - 14	270	78	11.20	359.20
	I_4	daily	-	395.6	78	4.40	478.00
	I_5	-	-	40	78	14.70	132.70
	I_1	19	3 - 6	570	78	0	648.00
	I_2	15	4 - 7	450	78	0	528.00
D_2	I_3	10	6 - 12	300	78	0	378.00
	I_4	daily	-	400	78	0	478.00
	I_5	-	-	40	78	0	118.00

Table - 3 Continued

Treatments: Sowing Date	Treatments: Irrigation	Total number of irrigation	Interval of irrigation (days)	Quantity of water applied (mm)	Pre-treatment irrigation (mm)	Effective rainfall (mm)	Total quantity of water used (mm)
D_3	I_1	18	3 - 6	540	78	14.30	632.30
	I_2	15	4 - 7	450	78	2.00	530.00
	I_3	10	5 - 10	300	78	14.30	392.30
	I_4	daily	-	391.2	78	8.80	478.00
	I_5	-	-	40	78	14.30	132.30
D_4	I_1	17	3 - 9	510	78	14.30	602.30
	I_2	13	4 - 9	390	78	14.30	482.30
	I_3	9	6 - 11	270	78	2.00	350.00
	I_4	daily	-	391.2	78	8.8	478.00
	I_5	-	-	40	78	17.3	135.30
D_5	I_1	18	2 - 8	540	78	17.30	635.30
	I_2	13	3 - 12	390	78	17.30	485.30
	I_3	9	5 - 13	270	78	17.30	365.30
	I_4	daily	-	386.8	78	13.20	478.00
	I_5	-	-	40	78	30.50	148.50

Table - 3 Continued

Treatments: Sowing Date	Treatments: Irrigation	Total number of irrigation	Interval of irrigation (days)	Quantity of water applied (mm)	Pre-treatment irrigation (mm)	Effective rainfall (mm)	Total quantity of water used (mm)
D_6	I_1	16	2 - 9	480	78	63.15	621.15
	I_2	13	3 - 10	390	78	44.62	512.62
	I_3	8	6 - 18	240	78	49.15	367.15
	I_4	daily	-	316.4	78	83.60	478.00
	I_5	-	-	40	78	115.32	233.32
D_7	I_1	12	4 - 9	360	78	111.00	549.00
	I_2	9	6 - 12	270	78	77.27	425.27
	I_3	6	9 - 14	180	78	70.9	328.90
	I_4	daily	-	259.2	78	140.8	478.00
	I_5	-	-	40	78	154.36	272.36

In the conventional method of irrigation 10 litres of water was applied per pit per day till the end of the experiment.

In the case of pitcher method of irrigation, uniform sized earthen ware pitchers of 10 litre capacity were collected. From these, only those pitchers that seep out approximately 1 litre water per day were selected. One pitcher was buried in each pit up to its neck with only the mouth exposed. For the first 20 days, these plants were irrigated daily. After the 21st day, irrigation water was filled into the pitcher only and replenished when the level of water inside the pitcher went down by half.

The details of the irrigation given are presented in Table - 3.

2.4 Harvesting

The fruits were harvested as and when they matured, the maturity for vegetable purpose being judged by visual observation. The harvesting was completed by110 days after sowing.

2.5 Observations

2.5.1 Biometric Observations

(a) Length of vine

The length of the vine in cm was recorded on the 30th day after sowing.

(b) Node at which the first female flower was produced

The node at which the first female flower appeared was counted from the cotyledon node and recorded.

(c) Days taken for the first female flower to open

The number of days taken by the first female to open from the date of sowing was recorded.

(d) Days to picking maturity

Ten female flowers per plot were tagged at the time of opening and the number of days taken from flowering till harvest was noted and the mean worked out.

(e) Number of female flowers

The number of female flowers produced per plant on the 45th, 60th and 75th day after sowing was counted.

(f) Number of fruit per plant

The number of fruits harvested from each plot was counted and the number of fruits produced per plant was worked out.

After harvest, 10 fruits were randomly selected from each treatment for recording the following measurements.

(g) Weight of fruit

Weight of 10 fruits were recorded in g and the mean weight worked out.

(h) Length of fruit

Length was measured from the stalk end to the tip in cm for the 10 fruits and the average worked out.

(i) Girth of fruit

Girth was recorded from the top ¼th, bottom ¼th and the middle of the fruit in cm. and averaged for the 10 fruits.

(j) Flesh thickness

By using a vernier caliper, the flesh thickness was measured after cutting through the centre of the fruit and recorded in mm.

(k) Number of seeds per fruit

Number of seeds contained in each fruit was counted and the average for 10 fruits worked out.

(l) Hundred seed weight

Seeds extracted from the ripe fruits were washed and dried uniformly. 100 bold seeds were selected from each treatment and the weight recorded in g.

(m) Dry matter content and water content of fruit

Three fruits, randomly selected from each plot were weighed fresh and then dried to a constant weight in a hot air over at 80 $\pm$ 5°C. The weight of dry matter obtained was expressed as percentage of the fresh weight. The difference between the fresh and dry weight was expressed as percentage of dry weight to get the water content of fruit.

(n) Yield

Total weight of fruit harvested from each plot was recorded and the yield in tonnes per hectare and kilogrammes per plant were worked out.

(c) Total dry matter production

Total dry matter production in g per plant was worked out.

2.5.2 Water use efficiency

Water use efficiency was worked out by dividing the total crop yield by the amount of water used and is expressed in kg ha mm^{-1}.

2.5.3 Soil moisture studies

(a) Soil sampling

Soil samples were collected from 0-15, 15-30 and 30 - 60 cm depth using a soil auger, before and 24 hours after each irrigation. Thermo gravimetric method of soil moisture determination was adopted.

(b) Consumptive use

Consumptive use was worked out from the data on soil moisture depletion. The potential evapotranspiration for the 24 hours after each irrigation was extrapolated from class A pan evaporation data and was taken in the calculation of consumptive use. The effective rainfall during the crop growth period was also taken into account for the determination of consumptive use.

(c) Moisture depletion pattern

The average relative soil moisture depletion from each soil layer in the root zone was worked out for each irrigation interval. The potential evapotranspiration values for the 24 hours after each irrigation, extrapolated from the class A pan evaporation data were added to the depletion in the first layer and the total loss from each layer was determined on percentage basis at the end of the period.

2.6 Meteorological observations

The daily values of meteorological elements recorded at the meteorological observatory of the College of Horticulture, Vellanikkara were used.

2.7 Statistical analysis

The data recorded was subjected to statistical analysis by applying the analysis of variance technique for split plot design as suggested by Panse and Sukhatme (1954).

Simple correlations were computed between the two important yield characters (total yield and number of fruits) and the weekly mean values of maximum temperature, minimum temperature relative humidity and sunshine hours, to identify their significant period of influence. From these, regression equations were worked out.

Results

RESULTS

The results of the experiment on the "effect of date of sowing and levels of irrigation on the growth and yield of bittergourd, variety Priya" are furnished in this chapter.

1. Biometric Observations

1.1 Length of vine

The mean values of the length of vine recorded on the 30th day after sowing are presented in Table - 4 and its analysis of variance in Appendix - I.

It is evident from the table that the length of vine was significantly influenced by irrigation. The conventional method of irrigation, I_4 recorded the highest vine length of 100.67 cm, which was on par with the treatment I_1. Vine length decreased with the levels of irrigation and I_3 recorded a value significantly lower than I_4 and I_1, but on par with I_2. The lowest value was recorded by the pitcher irrigated plants. I_5 (68.74 cm) which was significantly inferior to all other treatments.

Table - 4

Length of vine at 30 days after sowing

Treatments	Vine length (cm)
Date of sowing	
D_1 (December 1st)	94.69
D_2 (December 16th)	96.93
D_3 (December 31st)	86.68
D_4 (January 15th)	93.70
D_5 (January 30th)	76.11
D_6 (February 14th)	84.63
D_7 (March 1st)	76.57
SEm $\pm$	3.02
CD	9.14
Irrigation	
I_1 (IW/CPE = 1)	98.01
I_2 (IW/CPE = 0.75)	86.01
I_3 (IW/CPE = 0.50)	81.79
I_4 (Conventional)	100.67
I_5 (Pitcher)	68.74
SEm $\pm$	1.70
CD	4.80

Table - 4 (a)

Combined effect of date of sowing and levels of irrigation on the length of vine at 30 days after sowing (cm)

Treat- ments	I_1	I_2	I_3	I_4	I_5
D_1	107.00	94.87	87.05	109.05	75.49
D_2	105.92	111.25	97.15	105.17	65.17
D_3	99.31	83.82	76.85	102.97	70.43
D_4	101.25	86.50	83.17	115.00	82.58
D_5	83.00	70.78	82.17	78.19	66.42
D_6	100.57	76.87	76.38	106.25	63.07
D_7	89.01	77.99	69.80	88.05	57.98

SEm $\pm$ = 4.49

CD = 12.71

The date of sowing also exerted a significant influence on vine length. The highest value was observed from D_2 (96.93 cm) which was on par with D_1 and D_4. The sowing date D_3 was significantly inferior to D_2, but was on par with D_1 and D_4. The later date of sowing D_5, D_6 and D_7 were on par, but inferior to D_1, D_2 and D_4.

The interaction between date of sowing and levels of irrigation significantly influenced vine length (Table - 4 a). The highest vine length was recorded by the combination $D_4 \times I_4$ (115 cm) and the lowest by the combination $D_7 \times I_5$ (57.98 cm).

1.2 Days taken for the first female flower to open

The mean number of days taken for the first female flower to open are given in Table - 5 and the analysis of variance table in Appendix - I.

As evident from the table, the irrigation levels significantly influenced the number of days taken for female flower production. Higher levels of irrigation hastened the female flower production. The treatment I_1 produced female flowers earlier (41 days) than all other treatment and it was on par with I_2, I_4 and I_3. Significantly more days were taken by I_5 for the opening

Table - 5

Days taken for first female flower to open, node at which the first female flower was produced and the days to picking maturity

Treatments	Days taken for 1st female flower to open	Node at which first female flower was produced	Days to picking maturity
Date of sowing			
D_1	44.53	16.45	15.99
D_2	45.83	15.43	16.56
D_3	41.96	16.77	17.34
D_4	40.71	15.78	15.71
D_5	37.44	14.56	14.90
D_6	40.17	15.83	13.13
D_7	40.30	13.20	13.03
SEm $\pm$	0.69	0.89	0.79
CD	2.14	2.74	2.44
Irrigation			
I_1	40.58	14.06	14.56
I_2	41.20	14.62	15.56
I_3	41.32	16.13	16.23
I_4	41.22	13.97	13.79
I_5	43.51	18.37	16.05
SEm $\pm$	0.40	0.63	0.37
CD	1.12	1.79	1.06

of first female flower.

The dates of sowing D_2 and D_1 were on par and they took 46 and 45 days respectively for female flower production. The dates D_3, D_4, D_7 and D_6 were on par and they took significantly less days for female flower production than D_2 and D_1. However D_5 took significantly the least number of days for production of female flowers.

The interaction effect of date of sowing and levels of irrigation on days taken for the first female flower to open was not significant.

1.3 Node at which the first female flower was produced

The mean value of the node at which the first female flower was produced are given in Table - 5 and its analysis of variance table in Appendix - I.

The irrigation treatment I_4 took the least number of nodes for the female flower production (14 nodes). However it was on par with I_1 and I_2. The treatment I_3 took significantly more number of nodes for female flower production, than I_4 and I_1. The treatment I_5 produced female flowers at a significantly higher node than all other treatments (18 nodes).

The influence of date of sowing on the node at which the first female flower was produced was not significant. The interaction effect of irrigation and date of sowing was also not significant.

1.4 Days to picking maturity

The mean number of days taken to attain picking maturity from flowering are shown in Table - 5 and its analysis of variance in Appendix - I.

The conventionally irrigated plants, I_4 took the least number of days to reach picking maturity, but it was on par with I_1. The treatment I_1 was on par with I_2, but significantly different from I_5 and I_3.

The date of sowing D_3 took the most number of days to reach picking maturity, but it was on par with D_2, D_1 and D_4. The least number of days were taken by D_7 which was on par with D_6 and D_5.

The interaction effect of irrigation and date of sowing on picking maturity was not significant.

1.5 **The number of female flowers produced on 45th, 60th and 75th day after sowing**

The mean number of female flowers produced per plant on the 45th, 60th and 75th day after sowing are presented in Table - 6 and illustrated in Fig - 4 and 5. Its analysis of variance table is given in Appendix -II.

On the 45th day after sowing, the highest number of female flowers were produced by the treatments receiving the highest levels of irrigation ie I_1, I_4 and I_2. The treatments I_3 and I_5 produced significantly less number of female flowers. There was no significant difference among the dates of sowing with respect to female flower production. The highest value was recorded by D_1.

Among the levels of irrigation, a similiar trend was noticed on the 60th day after sowing, with respect to female flower production. The frequently irrigated treatments I_1 and I_4 recorded the highest value. The treatments I_2, I_3 and I_5 were inferior to I_1 and I_4 and were significantly different from each other, with I_5 registering the least value for female flower production.

Table - 6

Number of female flowers produced on 45th, 60th and 75th days after sowing

Treatments	Number of female flowers		
	45th DAS	60th DAS	75th DAS
Date of sowing			
D_1	1.67	2.13	2.67
D_2	1.40	2.13	2.13
D_3	1.47	2.60	1.73
D_4	1.40	1.87	1.93
D_5	1.20	1.67	1.80
D_6	1.47	1.40	1.27
D_7	1.33	1.20	1.00
SEm $\pm$	0.19	0.18	0.22
CD	0.59	0.56	0.68
Irrigation			
I_1	2.00	2.62	2.48
I_2	1.62	2.00	1.86
I_3	0.86	1.43	1.33
I_4	1.95	2.57	2.24
I_5	0.52	0.67	0.76
SEm $\pm$	0.13	0.16	0.15
CD	0.39	0.46	0.42

FIG: 4 EFFECT OF IRRIGATION LEVELS ON THE NUMBER OF FEMALE FLOWERS PRODUCED ON THE 45th, 60th AND 75th DAY AFTER SOWING

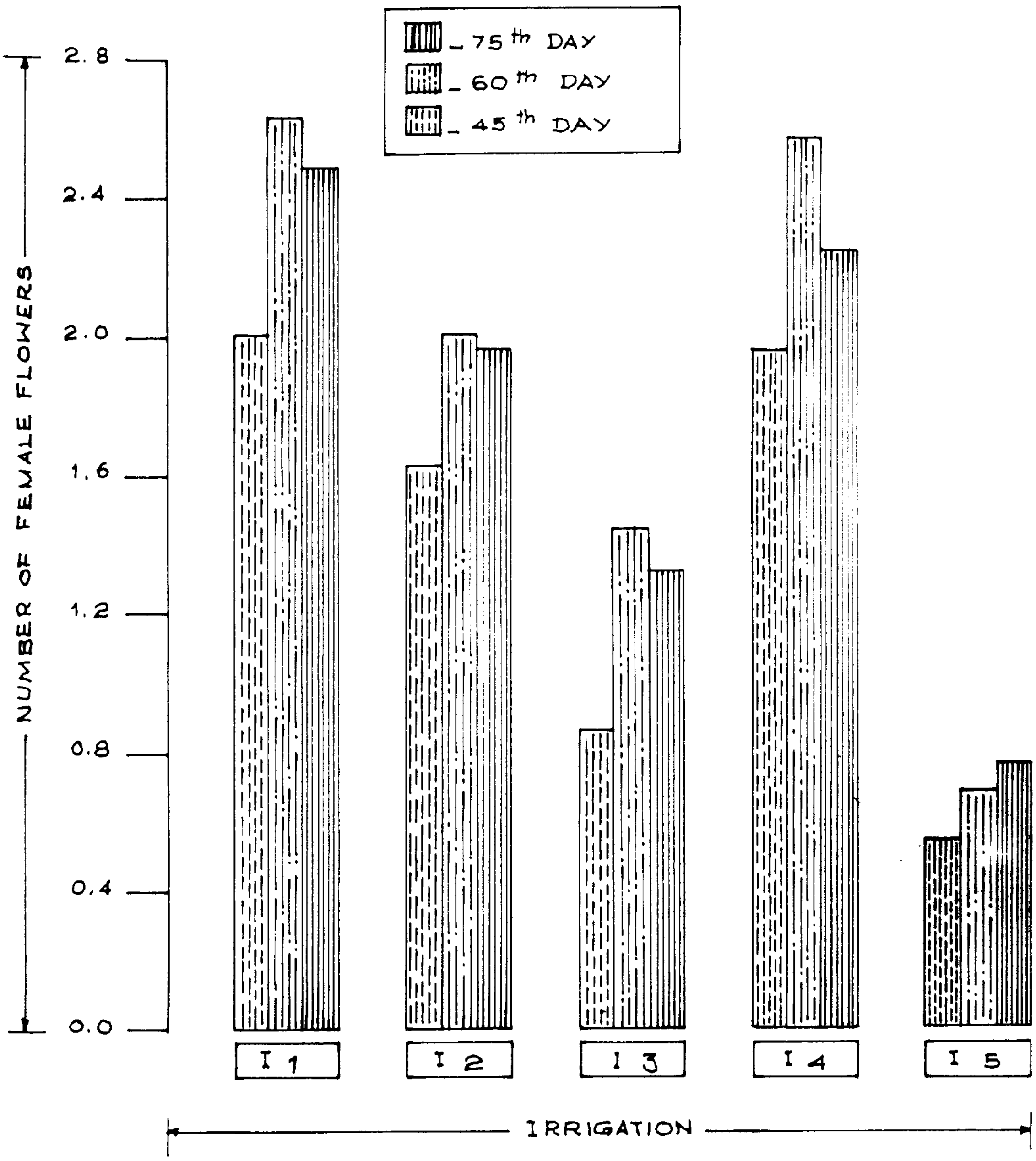
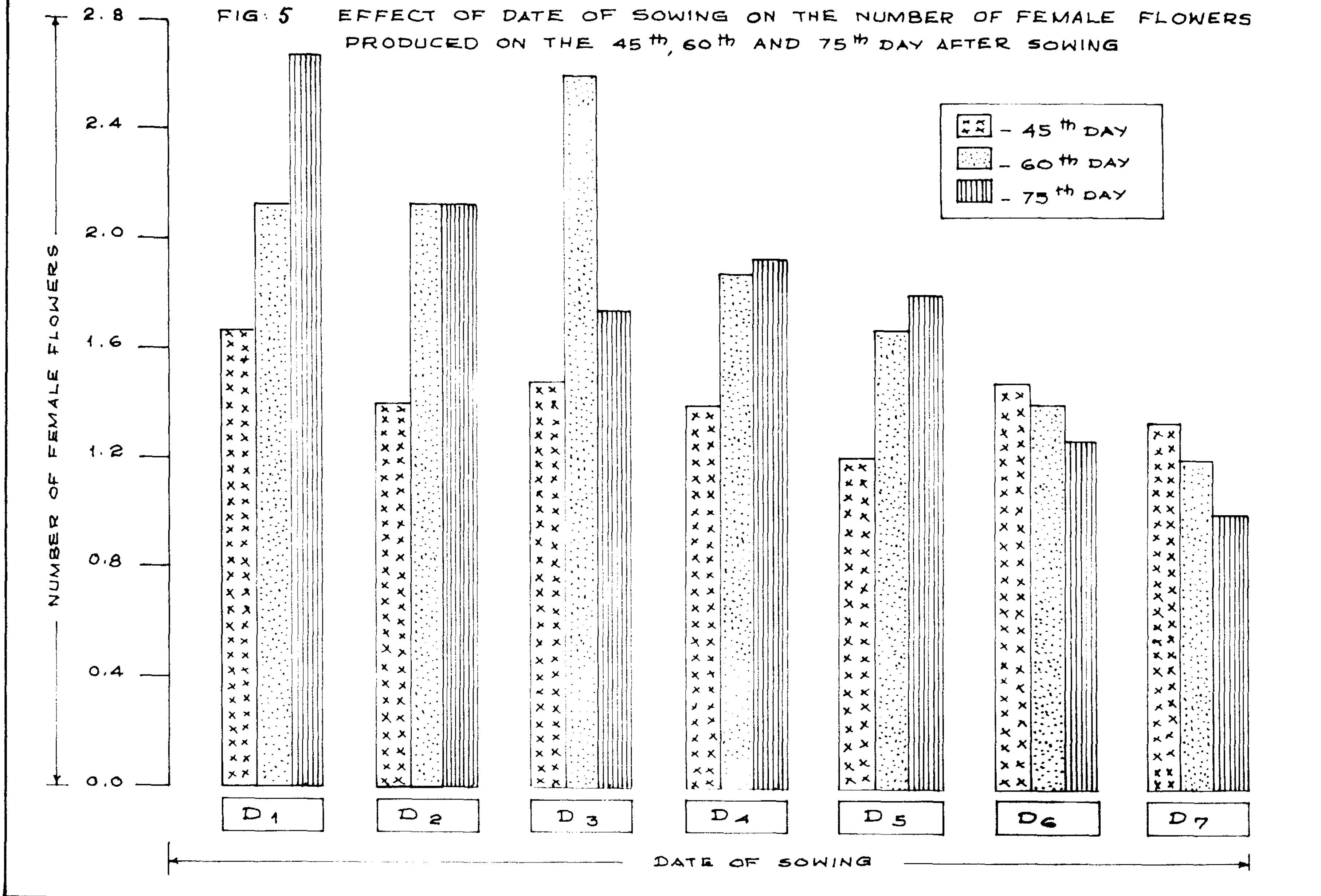


FIG: 5 EFFECT OF DATE OF SOWING ON THE NUMBER OF FEMALE FLOWERS PRODUCED ON THE 45th, 60th AND 75th DAY AFTER SOWING



The date of sowing D_3 produced the highest number of flowers which was on par with D_1 and D_2. The treatments D_4 and D_5, were significantly inferior to D_3 and was on par with the date D_6. The last date of sowing, D_7 recorded the least value and was on par with D_5 and D_6. In almost all the treatments, more number of flowers were produced on the 60th day after sowing than on the 45th day.

On the 75th day after sowing, irrigation treatment I_1 produced the highest number of female flower and was on par with I_4. Though I_2 was significantly inferior to I_1, it was on par with I_4. I_3 and I_5 were significantly different from each other as well as from higher irrigation treatments, with I_5 registering the least value. Among the dates of sowing D_1 recorded the highest number of female flowers and it was on par with D_2, D_4, D_5 and D_3. The treatment D_6 was on par with D_3 and D_5 but was significantly inferior to the former dates of sowing. The last date of sowing D_7 produced the least number of female flowers, but it was on par with D_6.

The interaction effect of dates of sowing and levels of irrigation on the female flower production was not significant on the 45th, 60th and 75th days after sowing.

1.6 Weight of fruit

The mean weight of fruits for the different treatments are given in Table - 7 and the analysis of variance table is presented in Appendix - III.

The mean weight of fruits was highest for the irrigation treatment I_4 (78.01 g) which was on par with I_1 and I_2. The treatment I_3 was significantly inferior to I_4 and I_1. The significantly lowest value for mean weight of fruit was recorded by I_5 (47.85 g).

The effect of date of sowing on fruit weight is illustrated in Fig - 6. The date of sowing D_2 recorded the highest mean weight of fruit (90.99 g) which was on par with D_1, but significantly superior to the later dates of sowing. There was no significant difference between the later sowing dates and the numerically lowest value was recorded by D_6 (52.59 g).

The combined effect of dates of sowing and levels of irrigation on the weight of fruit was significant (Table - 7 a) and the highest value (120.44 g) was recorded by the combination $D_2 \times I_4$ and the lowest (34.1 g) by the combination $D_6 \times I_5$.

Table - 7

Weight of fruit and number of fruits per plant

Treatments	Weight of fruit (g)	Number of fruits per plant
Date of sowing		
D_1	87.89	17.42
D_2	90.99	15.25
D_3	66.26	12.85
D_4	61.49	13.20
D_5	60.51	11.81
D_6	52.59	11.14
D_7	57.99	8.25
SEm $\pm$	4.57	0.81
CD	14.07	2.51
Irrigation		
I_1	75.96	15.41
I_2	72.86	14.67
I_3	66.56	12.73
I_4	78.01	14.27
I_5	47.85	7.14
SEm $\pm$	2.43	0.50
CD	6.87	1.42

Table - 7 (a)

Combined effect of date of sowing and levels of irrigation on the weight of fruit (g)

Treatments	I_1	I_2	I_3	I_4	I_5
D_1	99.50	98.37	84.65	104.91	51.99
D_2	108.21	98.72	74.91	120.44	52.69
D_3	78.07	60.46	55.01	78.18	51.57
D_4	68.22	65.99	63.25	59.96	50.06
D_5	67.53	60.28	66.33	62.23	46.23
D_6	50.61	60.65	60.07	57.53	34.10
D_7	59.58	57.52	61.72	62.80	48.23

SEm $\pm$ = 6.42

CD = 18.18

Table - 7 (b)

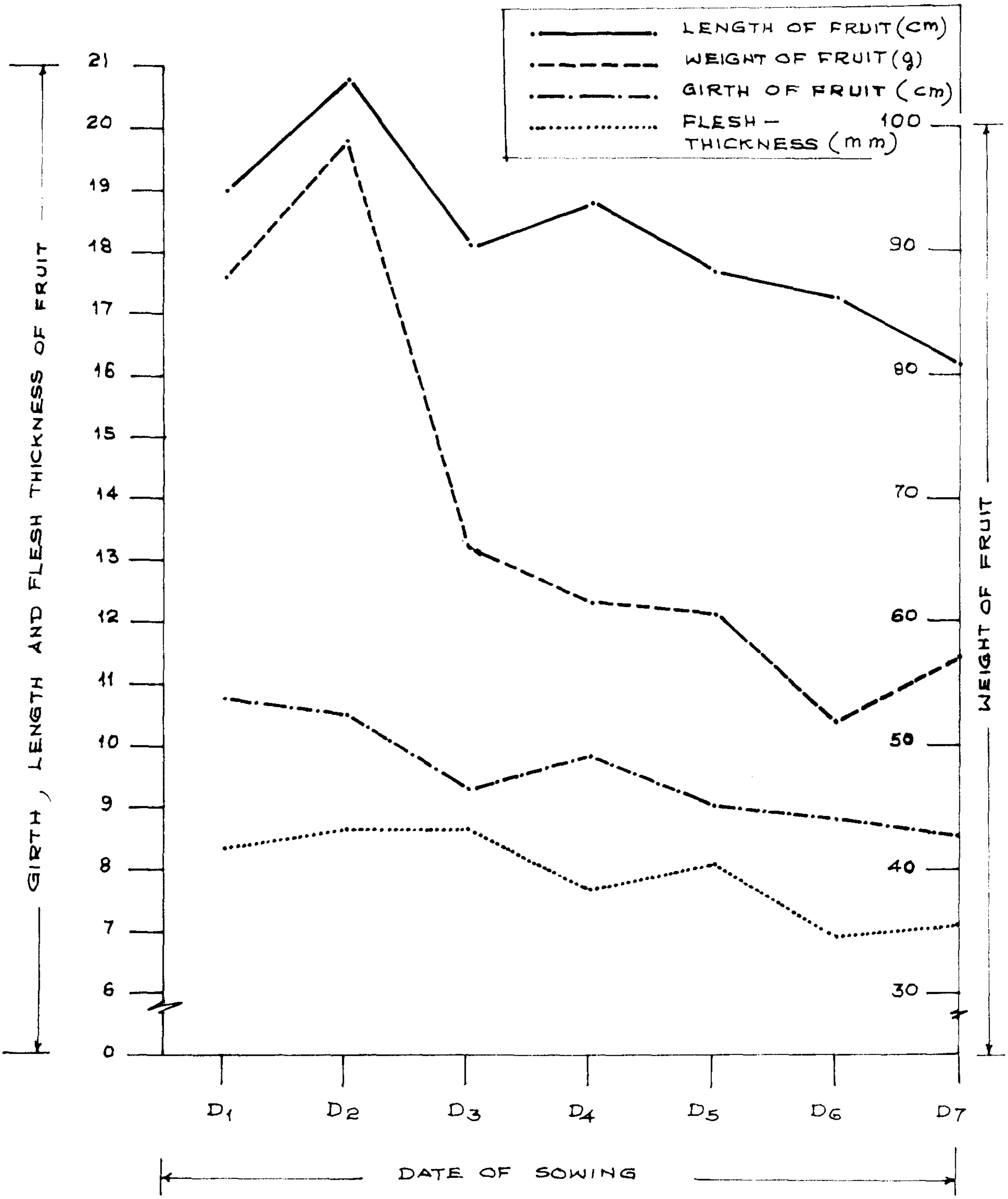
Coimbined effect of date of sowing and levels of irrigation on the number of fruits per plant

Treat-ments	I_1	I_2	I_3	I_4	I_5
D_1	20.50	19.82	17.06	19.30	10.40
D_2	18.90	17.10	15.68	16.25	8.30
D_3	14.50	14.90	13.16	14.60	7.10
D_4	16.50	14.60	13.13	14.19	7.60
D_5	14.30	13.77	11.18	13.21	6.60
D_6	13.90	12.73	10.73	13.22	5.10
D_7	9.30	9.75	8.20	9.10	4.90

SEm $\pm$ = 1.33

CD = 3.77

FIG: 6 EFFECT OF DATE OF SOWING ON THE WEIGHT, LENGTH, GIRTH AND FLESH THICKNESS OF FRUIT



1.7 Number of fruits per plant

The mean values for the number of fruits per plant are presented in Table - 7 and its analysis of variance is given in Appendix - III.

With respect to number of fruits per plant, the irrigation treatment I_1 (15 fruits) was found to be on par with I_2 and I_4 and significantly superior to other treatments. I_3 recorded a significantly lower value than the higher levels of irrigation but was higher than that of I_5. The lowest value (7 fruits) was recorded by I_5, the pitcher irrigated plants.

Among the dates of sowing the highest number of fruits were produced by D_1 (17 fruits) which was on par with D_2. D_3, D_4, D_5 and D_6 were on par and were significantly inferior to D_1. The least number of fruits were produced by D_7 (8 fruits) which was significantly inferior to all other dates.

The interaction effect of date of sowing and levels of irrigation had a significant influence on fruit number (Table - 7 b) and the highest value was produced by the treatment combination, $D_1 \times I_1$ (21 fruits) and the lowest by $I_5 \times D_7$ (5 fruits).

1.8 Length of fruit

Data pertaining to the length of fruit are given in Table - 8 and the analysis of variance table is given in Appendix - III.

The highest length of fruit was recorded from the irrigation treatment I_1 (19.78 cm) which was on par with I_4 and I_2. The treatment I_3 was on par with I_2, but it was significantly inferior to I_1 and I_4. I_5 was found to be significantly inferior to all other treatments (15.17 cm).

Effect of date of sowing on the length of fruit is illustrated in Fig - 6. Among the dates of sowing, D_2 (20.77 cm) recorded the highest length of fruit which was on par with D_1, but significantly higher than the later dates of sowing. The next highest value was recorded by D_4 which was on par with D_3, D_5 and D_6, but significantly superior to D_7.

The combined effect of dates of sowing and levels of irrigation had no significant influence on the length of the fruit.

Table - 8

Length, girth and flesh thickness of fruits

Treatments	Length of fruit (cm)	Girth of fruit (cm)	Flesh thickness (mm)
Date of sowing			
D_1	18.96	10.84	8.43
D_2	20.77	10.51	8.64
D_3	18.01	9.38	8.65
D_4	18.80	9.86	7.66
D_5	17.71	9.04	8.08
D_6	17.26	8.86	6.99
D_7	16.18	8.52	7.07
SEm $\pm$	0.62	0.16	0.19
CD	1.92	0.49	0.59
Irrigation			
I_1	19.78	9.86	8.49
I_2	18.85	9.67	8.29
I_3	17.90	9.53	7.52
I_4	19.52	9.78	8.58
I_5	15.17	8.81	6.78
SEm $\pm$	0.40	0.14	0.16
CD	1.14	0.39	0.45

Table - 8 (a)

Combined effect of date of sowing and levels of irrigation on the flesh thickness of fruits (mm)

Treat-ments	I_1	I_2	I_3	I_4	I_5
D_1	8.70	8.93	7.96	9.11	7.45
D_2	9.32	9.30	7.28	11.01	6.30
D_3	9.64	8.62	8.10	8.80	8.08
D_4	8.35	7.80	7.10	8.03	7.01
D_5	8.37	8.25	8.36	8.28	7.13
D_6	7.88	7.28	6.56	7.10	6.13
D_7	7.18	7.83	7.30	7.74	5.40

SEm $\pm$ = 0.42

CD = 1.19

1.9 Girth of fruit

The mean values for the girth of fruit are given in Table - 8. Its analysis of variance table is furnished in Appendix - III.

The irrigation treatments I_1, I_2, I_4 and I_3 were on par and significantly superior to I_5. The highest value was recorded by I_1 (9.86 cm).

Effect of date of sowing on the girth of fruit is illustrated in Fig - 6. The dates of sowing D_1 (10.84 cm) and D_2 (10.51 cm) produced the highest girth of fruits which were significantly superior to other dates. This was followed by D_4 and D_3 which were on par, but significantly different from other treatments. D_7 recorded the least value which was on par with D_6 but significantly different from D_5. However D_5 and D_6 were found to be on par.

The interaction effect was not significant.

1.10 Flesh Thickness

Mean values for the flesh thickness of fruit are given in Table - 8 and illustrated in Fig - 6 and their analysis of variance table is presented in Appendix - III.

The treatments receiving higher levels of irrigation ie I_4, I_1 and I_2 were on par, but gave significantly higher values than I_3 and I_5. The numerically highest value was for I_4 (8.58 mm). I_3 was found to be significantly superior to I_5.

The highest value for flesh thickness was recorded by D_3 (8.65 mm) which was on with D_2, D_1 and D_5. The date of sowing D_4 was on par with D_5 but was significantly lower than D_3, D_2 and D_1. The lowest values were recorded by D_6 and D_7 which were on par.

The interaction effect was significant (Table - 8 a) and the highest flesh thickness was for the combination, $D_2 \times I_4$ (11.01 mm).

1.11 Number of seeds per fruit

The data relating to the mean number of seeds per fruit are given in Table - 9 and the analysis of variance table is given in Appendix - IV.

The treatments I_4, I_3, I_1 and I_2 were on par with to respect to the number of seeds per fruit and were significantly superior to I_5.

Table - 9

Number of seeds per fruit and 100 seed weight

Treatments	Seeds per fruit	100 seed weight (g)
Date of sowing		
D_1	24.97	18.74
D_2	25.99	18.51
D_3	23.42	18.77
D_4	24.12	19.09
D_5	20.87	20.07
D_6	23.30	19.54
D_7	23.03	21.93
SEm ±	0.79	0.36
CD	2.45	1.11
Irrigation		
I_1	24.18	19.23
I_2	24.05	19.65
I_3	24.61	19.47
I_4	25.26	19.13
I_5	20.27	20.13
SEm ±	0.57	0.31
CD	1.63	0.88

D_2 produced the highest number of seeds per fruit which was on par with D_1 and D_4. The treatments D_3, D_6 and D_7 were significantly different from D_2. The treatment D_5 was significantly inferior to all other treatments.

Interaction effect was not significant.

1.12 100 seed weight

The mean values for the 100 seed weight are given in Table - 9 and its analysis of variance table is furnished in Appendix - IV.

Irrigation treatments did not significantly influence the 100 seed weight. The date of sowing D_7 was significantly superior to other treatments. This was followed by D_5 which was on par with D_6 and D_4. The treatments D_3, D_1 and D_2 were on par but significantly different from D_7 and D_5.

Interaction effect was not significant

1.13 Water content of fruit

The mean values pertaining to the water content of fruit on dry weight basis, are given in Table - 10 and

Table - 10

Water content and dry matter content of fruits

Treatments	Water content of fruits (%) on dry weight basis	Dry matter content of fruits (%)
Date of sowing		
D_1	873.02	10.62
D_2	1086.66	8.62
D_3	772.82	11.51
D_4	721.43	13.79
D_5	760.32	13.33
D_6	664.33	13.80
D_7	719.02	12.43
SEm $\pm$	47.94	0.45
CD	147.80	1.39
Irrigation		
I_1	898.43	11.10
I_2	804.26	11.81
I_3	813.41	12.27
I_4	815.94	11.21
I_5	666.24	13.68
SEm $\pm$	43.29	0.41
CD	122.62	1.15

the analysis of variance table is furnished in Appendix -IV.

The water content of fruits from plots receiving higher irrigation level ie I_1, I_4, I_2 and I_3 were on par and significantly superior to I_5.

Among the dates of sowing D_2 produced fruits with significantly higher water content than other treatments followed by D_1 which was on par with D_3 and D_5 but significantly higher than D_4, D_7 and D_6.

Interaction effect was not significant.

1.14 Dry matter content of fruit

The mean values of the dry matter content of fruit on fresh weight basis are given in Table - 10 and the analysis of variance table for the same is given in Appendix - IV.

Dry matter content of fruit was significantly higher for I_5. This was followed by I_3 which was on par with I_2 and I_4 but significantly higher than I_1.

The date of sowing D_6, D_4, D_5 and D_7 were found to be significantly superior to D_1 and D_2 with respect to the dry matter content of fruit. The significantly lowest value was recorded by D_2.

1.15 Yield

Mean values of the yield in kg per plant and t ha^{-1} are given in Table - 11 and illustrated in Fig - 7 and 8. Its analysis of variance table is presented in Appendix - V.

The highest yield was recorded by I_1 (12.81 t ha^{-1}) which was significantly superior to all other irrigation treatments. This was followed by I_2 (11.50 t ha^{-1}) which was on par with I_4 (11.07 t ha^{-1}). The treatment I_3 recorded a yield (8.76 t ha^{-1}) which was significantly inferior to I_1, I_2 and I_4. The significantly lowest yield was from I_5, the pitcher irrigated treatment (3.08 t ha^{-1}).

Among the dates of sowing, the highest yield was produced by the first date of sowing D_1 (14.57 t ha^{-1}) which was significantly superior to other dates of sowing. This was followed by D_2 which was on par with D_4 and D_3 but superior to the later dates of sowing. The significantly lowest yield was produced by D_7 (5.02 t ha^{-1}).

Table - 11

Yield in kg per plant and t ha^{-1} and total dry matter production

Treatments	Yield		Total dry matter production (g)
	kg/plant	t ha^{-1}	
Date of sowing			
D_1	1.64	14.57	343.93
D_2	1.26	11.20	217.09
D_3	1.08	9.64	228.18
D_4	1.08	9.62	240.57
D_5	0.89	7.91	217.62
D_6	0.90	8.01	223.15
D_7	0.56	5.02	185.15
SEm $\pm$	0.08	0.70	10.29
CD	0.23	2.16	36.19
Irrigation			
I_1	1.44	12.81	302.55
I_2	1.28	11.50	279.71
I_3	0.98	8.76	218.71
I_4	1.25	11.07	274.52
I_5	0.34	3.08	107.14
SEm $\pm$	0.05	0.45	8.69
CD	0.15	1.28	24.64

Table - 11 (a)

Combined effect of date of sowing and levels of irrigation on yield in t ha^{-1}

Treatments	I_1	I_2	I_3	I_4	I_5
D_1	19.40	17.58	14.37	17.10	4.40
D_2	18.74	13.11	10.29	12.00	1.87
D_3	11.48	13.61	9.83	11.51	1.79
D_4	12.71	11.66	8.46	11.46	3.81
D_5	11.09	8.42	7.70	9.49	2.83
D_6	10.72	9.47	6.26	9.60	3.99
D_7	5.54	5.92	4.42	6.33	2.89

SEm ± = 1.19

CD = 3.38

Table - 11 (b)

Combined effect of date of sowing and levels of irrigation on yield in kg per plant

Treatments	I_1	I_2	I_3	I_4	I_5
D_1	2.18	1.98	1.62	1.92	0.49
D_2	2.11	1.48	1.16	1.35	0.21
D_3	1.29	1.53	1.09	1.29	0.20
D_4	1.43	1.31	0.95	1.29	0.43
D_5	1.25	0.95	0.87	1.07	0.32
D_6	1.21	1.07	0.70	1.08	0.45
D_7	0.62	0.67	0.50	0.71	0.33

SEm $\pm$ = 0.14

CD = 0.40

FIG: 7 EFFECT OF IRRIGATION LEVELS ON THE YIELD IN $t\ ha^{-1}$

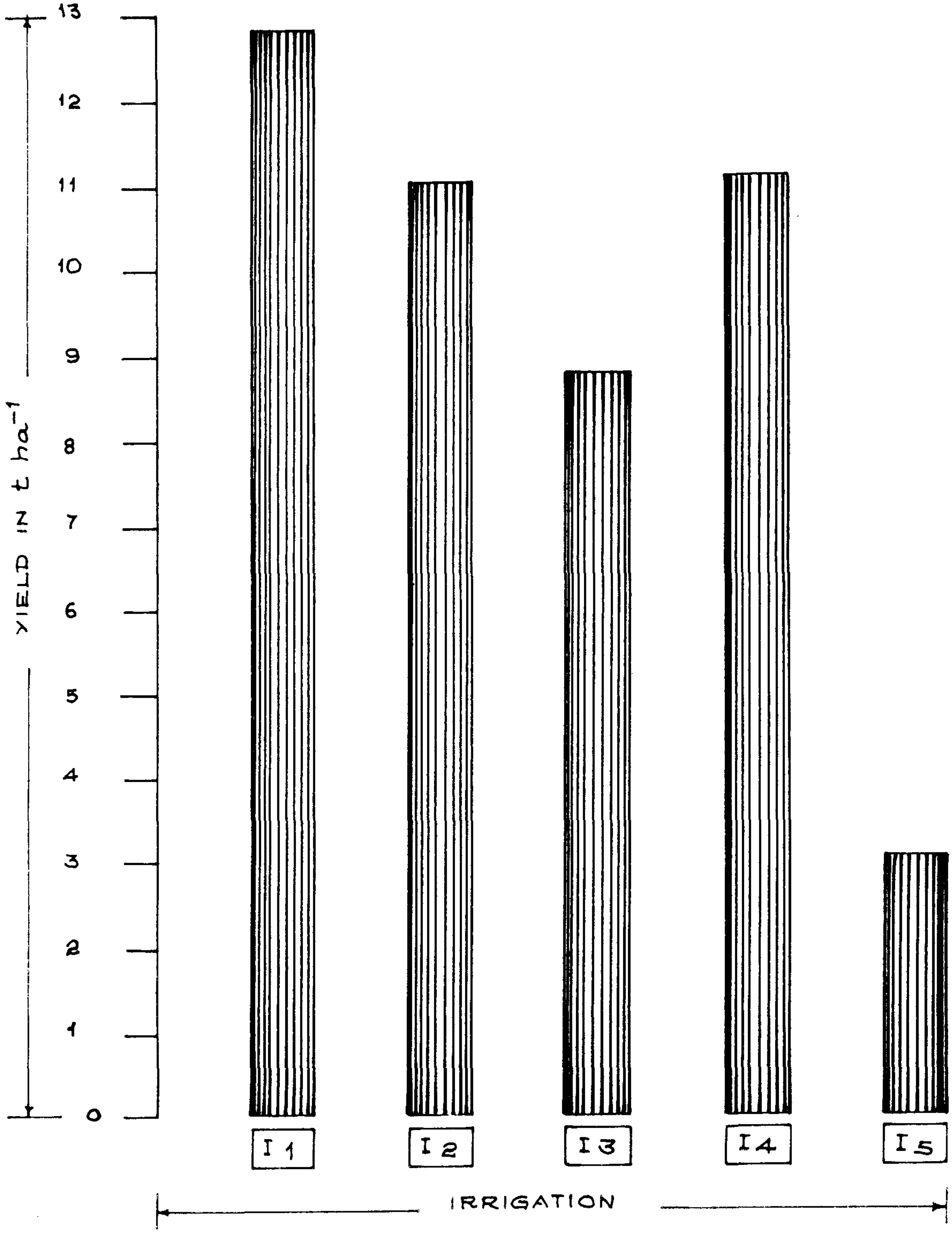
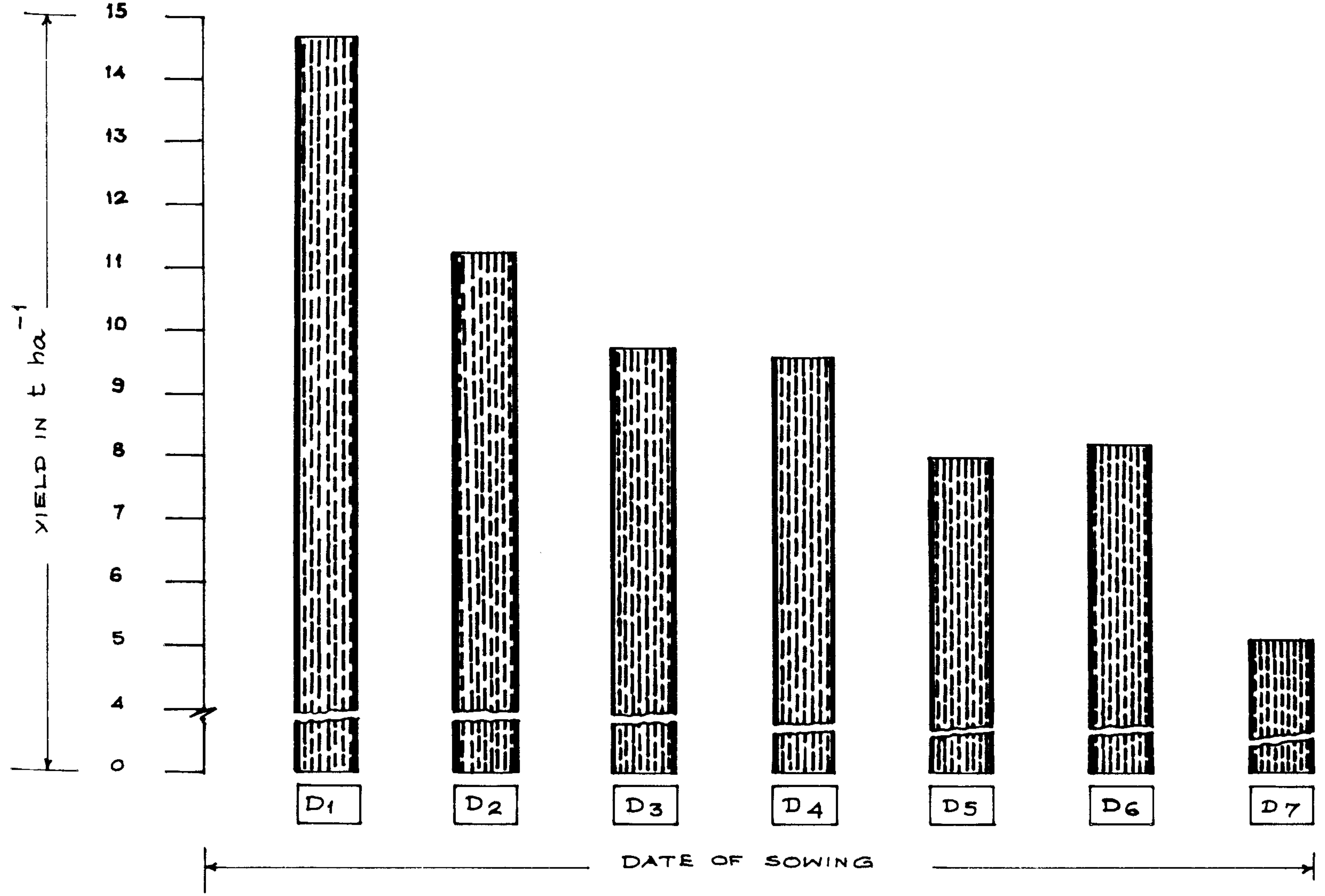


FIG: 8 EFFECT OF DATE OF SOWING ON YIELD IN t ha^{-1}



The combined effect of irrigation and date of sowing influenced the yield significantly (Table - 11 a and b). The highest yield was recorded by the combination D_1 x I_1 (19.40 t ha^{-1}) and the lowest by the combination D_3 x I_5 (1.79 t ha^{-1}).

1.16 Total dry matter production

The total dry matter produced by the plant is given in Table - 11 and the analysis of variance in Appendix - V.

Irrigation treatments significantly influenced the total dry matter production per plant and the highest value was recorded by I_1 (302.55 g) which was on par with I_2 and I_4. The treatment I_3 was significantly lower than the three higher levels of irrigation. The least value was recorded by I_5 (107.14 g) which was significantly inferior to all other treatments.

The earliest date of sowing D_1 (343.93 g) was significantly superior to all other dates of sowing with respect to total dry matter production. The later dates D_2, D_3, D_4, D_5 and D_6 were on par and the significantly lowest value was for D_7 (185.15 g).

The interaction effect of date of sowing and levels irrigation had no significant influence on total dry matter production.

2. Field water use efficiency

Mean table of the field water use efficiency in kg ha mm^{-1} and the corresponding water used for different treatments are given in Table - 12 and the analysis of variance table is provided in the Appendix - V.

The irrigation treatment I_3 registered the highest water use efficiency of 24.13 kg ha mm^{-1} which was on par with I_4 and I_2. I_1 gave significantly lower value than I_3 but was on par with treatment I_5 which recorded the significantly lowest value for water use efficiency (18.39 kg ha mm^{-1}).

The date of sowing D_1 recorded the significantly highest value (33.96 kg ha mm^{-1}) with respect to water use efficiency. D_2 was significantly inferior to D_1, but was on par with D_3 and D_4. The dates D_5 and D_6 were on par with D_3, but significantly superior to D_7 (12.22 kg ha mm^{-1}).

The interaction effect was not significant.

Table - 12

Mean table for the water applied and field water use efficiency

Treatments	Total water applied (mm)	Field water use efficiency kg ha mm^{-1}
Date of sowing		
D_1	429.06	33.96
D_2	430.00	26.05
D_3	432.98	22.26
D_4	409.58	23.49
D_5	422.48	18.72
D_6	442.45	18.10
D_7	410.71	12.22
SEm ±	-	1.57
CD	-	4.81
Irrigation		
I_1	621.54	20.61
I_2	496.60	23.16
I_3	362.98	24.13
I_4	478.00	23.16
I_5	167.50	18.39
SEm ±	-	1.04
CD	-	2.96

3. Soil Moisture Studies

3.1 Consumptive use

The mean values for consumptive use from the 21st day after sowing are given in Table - 13. The calculation of consumptive use from the conventionally irrigated and pitcher irrigated plots were not possible. The consumptive use was worked out by gravimetric method from soil moisture studies for the irrigation treatments I_1, I_2 and I_3 at different dates of sowing. The highest value was recorded by I_1 (408.62 mm) followed by I_2 (328.01 mm) and I_3 (245.10 mm).

Among the dates of sowing the highest consumptive use was observed in D_2 (337.95 mm) followed by D_3, D_1, D_5, D_4, D_6 and D_7.

3.2 Soil moisture depeletion

Mean values of soil moisture depeletion are given in Table - 14 and illustrated in Fig - 9. In all the treatments the upper most layer (0 - 15 cm) recorded the maximum moisture depeletion. It accounted for 47.61 to 53.31 percent of the moisture depeletion. This was followed by the second layer (15 - 30 cm) and then by

Table - 13

Mean consumptive use (mm)

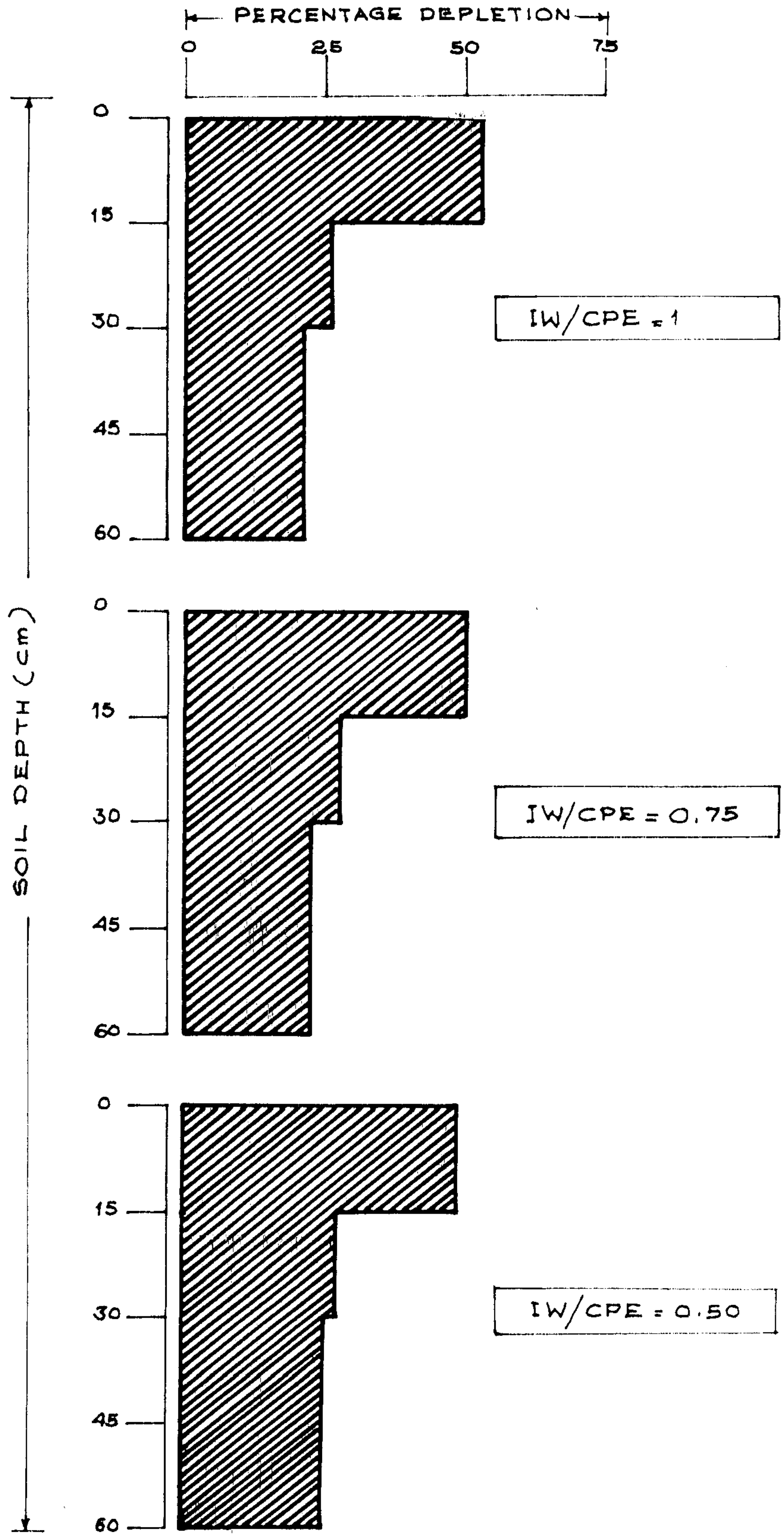
Treatments	I_1	I_2	I_3	Mean
D_1	426.95	332.40	245.76	335.04
D_2	420.86	338.17	254.81	337.95
D_3	423.23	327.06	255.67	335.31
D_4	408.15	332.67	239.16	326.66
D_5	412.50	333.59	240.32	328.80
D_6	394.39	330.38	241.79	322.19
D_7	374.28	301.84	238.19	304.77
Mean	408.62	329.01	245.10	

Table - 14

Relative moisture depletion from different soil layers in %

Treatments	Relative soil moisture depletion		
	0 - 15 cm	15 - 30 cm	30 - 60 cm
I_1	53.31	25.71	20.98
I_2	50.42	26.93	22.65
I_3	47.61	27.10	25.29
D_1	50.57	26.75	22.68
D_2	51.54	26.39	22.07
D_3	50.89	26.49	22.62
D_4	50.70	26.31	22.99
D_5	49.85	27.03	23.12
D_6	49.90	26.40	23.70
D_7	49.90	26.32	23.78

FIG: 9 SOIL MOISTURE DEPLETION PATTERN



the third. Among the three irrigation levels, moisture depeletion was more from the deeper layers in the drier regimes. The later sowing dates extracted moisture from the deeper layer than the earlier sowing dates.

4. Crop Weather Relationship

Simple linear correlations between yield characters and the weekly weather elements for overlapping periods 1 to 14 weeks after sowing were worked out taking two important yield characters (total yield in t ha^{-1} and number of fruits per plant for the irrigation treatment IW/CPE = 1) and the four weather elements (maximum and minimum temperature, relative humidity and sunshine hours). It was found that the maximum temperature during the first 10 weeks, the minimum temperature during 7th to 11th week and relative humidity during 6th to 13th week were negatively correlated with both total yield and number of fruits per plant. While there was positive correlation between sunshine hours during 6th to 13th week and the yield characters. The correlation coefficients for these periods are given in Table - 15.

Table - 15

Correlation coefficients between yield characters and weather elements

Yield character	Weather element	Period (week)	Correlation coefficient
Total yield ($t\ ha^{-1}$)	Minimum temperature	7-11	-0.96**
"	Maximum temperature	1-10	-0.91**
"	Sunshine hours	6-13	0.90**
"	Relative humidity	6-13	-0.88**
Number of fruits per plant	Minimum temperature	7-11	-0.92**
"	Maximum temperature	1-10	-0.86**
"	Sunshine hours	6-13	0.90**
"	Relative humidity	6-13	-0.85**

** Significant at 1 percent level

Because of the multicolinearity of the variables, only two variables were selected ie. maximum temperature and sunshine hours, while working out the regression equations. The regression equation for total yield was $Y = -1.65\ (Tmax) + 3.96\ (s) + 35.81$.
and the regression equation for number of fruits was $Y = -0.98\ (T_{max}) + 3.45\ (s) + 19.68$.

The multiple correlation coefficient for total yield was 0.96 and for the number of fruits was 0.93.

The estimated values for yield and number of fruits using the regression equation and the actual values are given in Table - 16 and Fig - 10 and 11.

Table - 16

Actual yield (t ha^{-1}) and number of fruits per plant with the corresponding values estimated from the regression equation

Date of sowing	Total yield t ha^{-1}		Number of fruits per plant	
	Actual	Estimated	Actual	Estimated
D_1	19.40	19.16	20.50	19.70
D_2	18.74	18.14	18.90	19.39
D_3	11.48	14.24	14.50	16.64
D_4	12.71	11.50	16.50	14.57
D_5	11.09	10.22	14.30	13.59
D_6	10.72	10.28	13.90	13.74
D_7	5.54	6.16	9.30	10.19

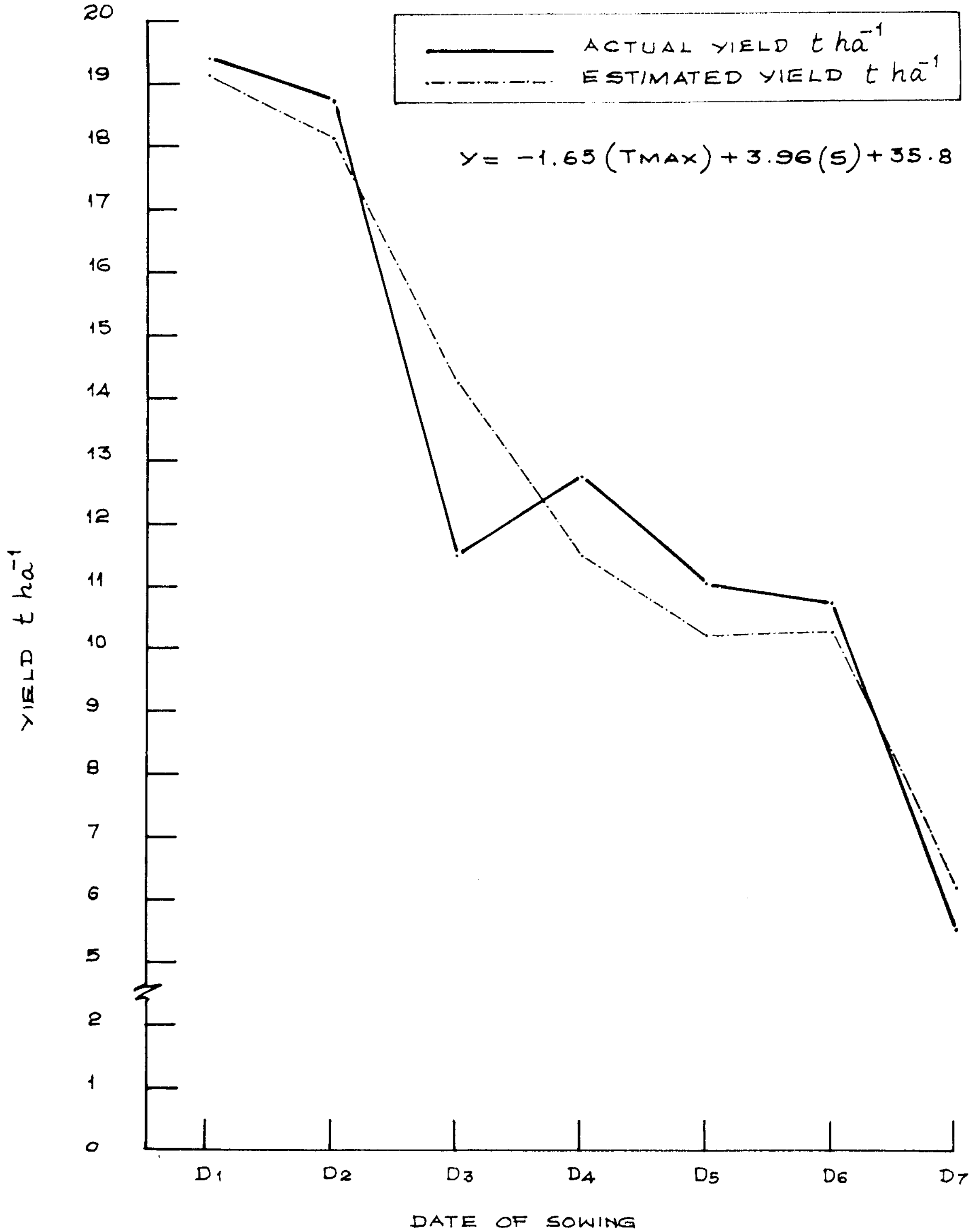


FIG: 10 ACTUAL YIELD IN $t\,ha^{-1}$ AND THE ESTIMATED VALUES FOR DIFFERENT DATE OF SOWING

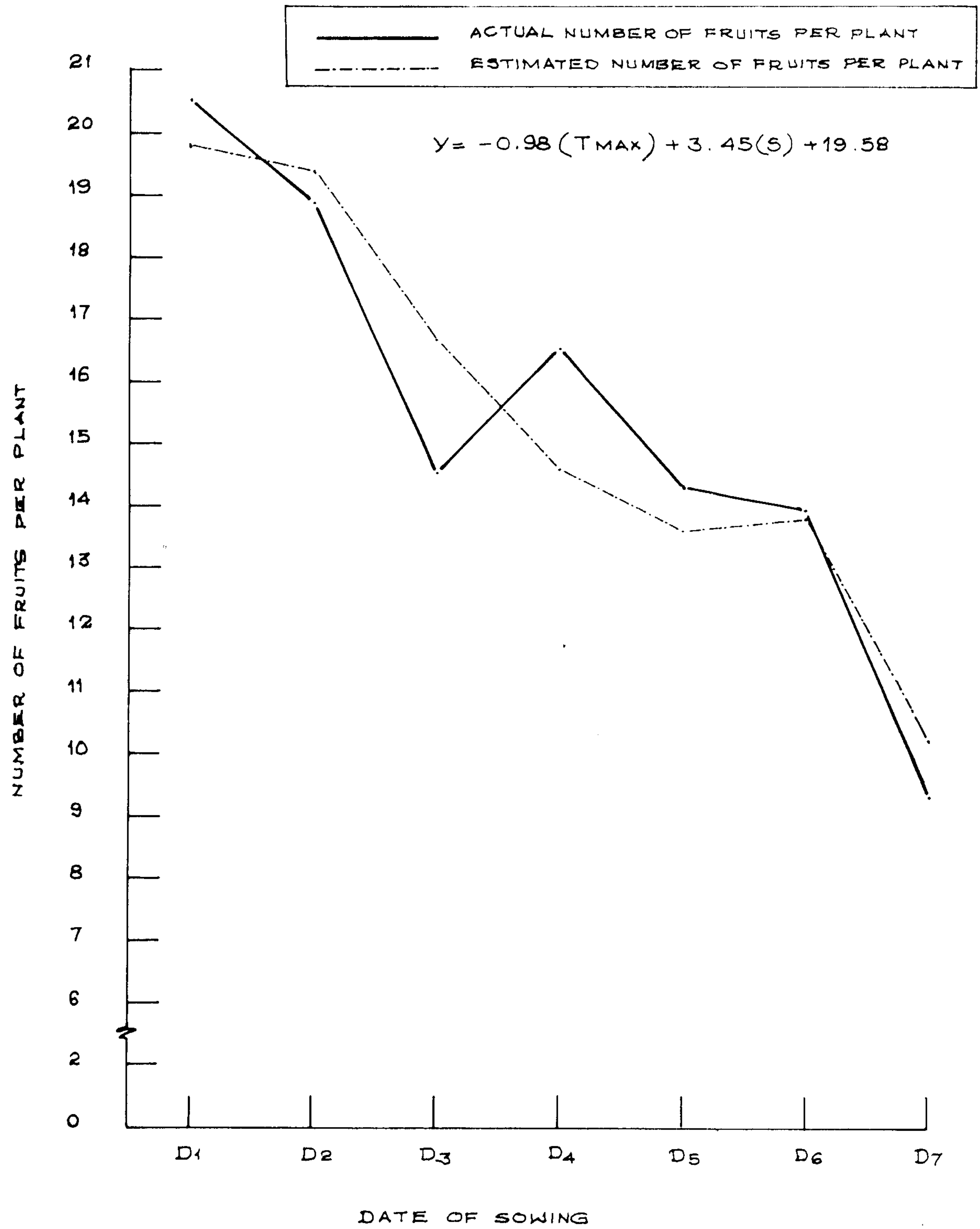


FIG: 11 ACTUAL NUMBER OF FRUITS PER PLANT AND THE ESTIMATED VALUES FOR DIFFERENT DATE OF SOWING

Plate - I Irrigation treatment I_1 (IW/CPE = 1)

Plate II Irrigation treatment I_3 (IW/CPE = 0.5)

Plate I.

Plate II.

Plate III Irrigation treatment I_5 (Pitcher method)

Plate III.

Discussion

DISCUSSION

The present investigation was taken up with a view to determine the effect of date of sowing and levels of irrigation on the growth and yield of bittergourd variety Priya, during summer. The results of the experiment are discussed in the following paragraphs.

1. Biometric Observations

1.1 Length of vine

Irrigation exerted a significant influence on the length of vine recorded on the 30th day after sowing (Table - 4). The highest vine length (100.67 cm) was observed in the conventional irrigation treatment and the lowest in the pitcher irrigated plants, which received the lowest quantity of water. Water deficit is likely to affect two vital processes of growth viz. cell division and cell enlargement, and according to Begg and Turner (1976), cell enlargement is more affected resulting in poor growth. This is in agreement with the findings of Flocker et al. (1965) in cantaloups and Yamashita et al. (1982) in cucumbers.

The earlier date of sowings resulted in a significant increase in vine length over the later sowings. This may be due to the fact that weather conditions were more favourable for the initial vigorous growth during the period of early sown plants. The growth difference due to variation in climate was noted by Hall (1949), Surlekov and Ivanov (1978) and Heij (1981) in cucumbers, Buttrose and Segley (1978) and Desai and Patil (1984) in water melon.

Interaction between date of sowing and irrigation was significant on the length of vine, at 30th day after sowing.

1.2 Days taken for first female flower to open

Plants receiving higher levels of irrigation produced the female flowers earlier (Table - 5). The pitcher irrigated plants which received the least quantity of water took significantly more days for the opening of female flowers. Larson (1975) stated that a slight water stress can reduce the rate of appearance of floral primordia. This was evidenced in the work of Molnar (1965) in melons. Thomas (1984) noted that there was a trend to hasten flowering at higher levels of irrigation in bittergourd.

The plants sown earlier, viz. December 1st and December 16th exhibited a significant delay in the onset of flowering than the later sowings. Temperature and daylength affected the preflowering phase and cloudiness favoured the production of female flower. (Kamalanathan and Thamburaj, 1970). The later sowings experienced high cloud cover, since the sunshine hours recorded during the period ranged from 4.6 to 2.3 hours/day. This may have been the reason for earlier flower production in later sowings. Influence of date of sowing on female flower production has been reported by Edmond (1930) in cucumber, and Sharma and Nath (1971) in Watermelon, musk melon, snap melon and long melon.

1.3 Node at which the first female flower was produced

The node at which the first female flower was borne was observed to be an index of the sex ratio; in that, the lower the node number, the higher was the female/male ratio (Venketram, 1963).

The plants receiving more frequent irrigation produced female flowers at a lower node. The pitcher irrigated plants started flowering at a significantly higher node than the other irrigation treatments. This is to be expected, as the frequently irrigated plants started flowering at an earlier date.

The influence of sowing dates on the node of female flower production was not significant, but there was a decrease in node number with the later sowing dates. Position of female flower on the vine depends on day length and night temperature (Nitch, et al. 1952).

1.4 Days to picking maturity

Treatments receiving higher levels of irrigation reached picking maturity earlier than the pitcher irrigated plants and those receiving irrigation at IW/CPE ratio 0.5. The conventionally irrigated plants took the lowest number of days to reach picking maturity. The fruit development depend primarily on the conditions prevailing during the period of fruit enlargement. During this period considerable amount of water and carbohydrates are transported into the developing fruit (Kaufman, 1972). So the treatments receiving higher levels of irrigation would have better fruit development and might reach maturity faster than the drier regimes. Similar results were reported by Pew and Gardner (1983).

The December planted crop took more days to reach picking maturity than the later planted crop. Vooren and Challa (1978) indicated that in cucumbers, earliness was strongly affected by planting dates and night temperatures. December sown plants experienced lower night temperatures (19-24°C) than the later sowings and this may have resulted in delay in maturity. Simil..ar observations were made by Drews et al. (1980), Heij (1981) and Slack and Hand (1981) in cucumber.

1.5 Number of female flowers produced on 45th, 60th and 75th days after sowing

At all the stages, female flower production was significantly influenced by irrigation. The frequently irrigated plants produced more flowers than the less frequently irrigated ones. This is in agreement with the observations made by Abolina et al. (1963) that the regularly watered plants produced greater number of female flowers. Water stress during inflorescence development reduced the number of primordia and the development of these into fertile florets (Kaufman, 1972 and Begg and Turner, 1976). This view is supported by Molnar (1965) who recorded increased production of female flowers in melons on irrigation.

In all the three stages, the December sown plants produced greater number of female flowers than the plants sown later. The December sown plants were exposed to lower temperatures (19 - 24 °C) than the later sown plants. Effect of low temperatures and day length on female flower production was reported by Edmond (1930) Nitch et al. (1952), Venketram (1963), Matsuo (1968), Kamalanathan and Thamburaj (1970) and Cantliffe (1981) in cucurbit vegetables.

1.6 Number of fruits per plant

Treatments receiving greater quantity of irrigation water induced the production of more fruits per plant (Table - 7). The lowest number of fruits was produced by the pitcher irrigated plants. This is in agreement with the work of Henrickson (1980) in cucumber, Desai and Patil (1984) in water melon and Thomas (1984) in bitter-gourd. The decreased fruit production in water stressed plants may have also resulted from reduced flower production (Kaufman, 1972) and increased fruit drop (Molnar, 1965).

The plants sown in December produced considerably higher number of fruits than the later sown plants. The lowest number of fruits was produced by the March sown plants. This is to be expected as the December sown plants produced more female flowers. Differences in fruit number due to difference in the sowing dates have been reported by Surlekov and Ivanov (1969), Heij and Lint (1982) and Desai and Patil (1984). This variation may have been due to the effect of night temperature and day length. (Miller and Ries, 1958 and Heij and Lint, 1982).

1.7 Weight of fruits

The more frequently irrigated plants favoured the production of fruits with higher weight (75.96g) than those irrigated less frequently. Frequent irrigations might have increased the availability and supply of plant nutrients resulting in better growth and translocation of photosynthates to fruits and fruit weight increased. In fruits and vegetables, the fresh weight often continued to increase even after the increase in dry weight ceased (Begg and Turner, 1976). Since the size and weight of fruit at this stage depended on plant water potential to a greater extent, water deficit had a strong influence on fruit size and fruit weight than the dry weight. This view is endorsed by the work of Niel and Zunino (1972), Caro and Linsalata (1977), Doorenbos and Kasan (1979) in melons and Thomas (1984) in bittergourd.

The plants sown in early December produced fruits with higher mean weight (90.99g) than the later sown plants (57.99g). The influence of favourable climatic conditions for better growth may be the reason for the higher fruit weight in the early sowing. Simil ar variation in fruit weight due to difference in planting date was reported by Ivanov and Surlekov (1969).

1.8 Length of fruit

Fruit length increased with soil wetness and the highest length was recorded by the treatment IW/CPE =1, and the least by the pitcher irrigated treatment. Soil water availability had effect on fruit size by altering the internal plant water status. Effect of water deficit on fruit enlargment probably resulted from decreased turgor pressure in the fruit tissues and during severe stress, from reduced production of photosynthate for growth. Simil ar results were reported by Flocker et al. (1965) and Doorenbos and Kassan (1979) in melons and

Thomas (1984) in bittergourd.

Plants sown in early December produced longer fruits than the later sowings. Low temperature experienced during pre bearing period by the early December sowing may have caused the increase in length. This view was supported by the work of Miller and Ries (1958).

1.9 Girth of fruit

The girth of fruit was also higher for the treatments receiving higher levels of irrigation. The highest girth (9.86 cm) was recorded by IW/CPE = 1 and the lowest by the pitcher irrigated plants. The decrease in girth with diminishing soil wetness may be attributed to the same reason as that of the decrease in fruit length.

Among the dates of sowing the earlier sown plants produced fruits with higher girth (10.84 cm) than the later sown plants (8.52 cm). This may be due to the availability of more favourable climatic condition for vigourous growth of fruits in the early sowings.

1.10 Flesh thickness

The highest flesh thickness was recorded by the treatment receiving higher frequency of irrigation. The highest was recorded by the conventionally irrigated treatments (8.49 mm). This increase in flesh thickness is in correspondence with the overall increase in size of the fruit with higher levels of irrigation.

The December sown plants recorded the highest value for flesh thickness. This result is also in correspondence with the increase in length, girth and weight of fruits shown by the December sown plants.

The interaction effect of irrigation and date of sowing was significant, and the highest flesh thickness (11.01 mm), was recorded by the conventionally irrigated plants sown on December 16th.

1.11 Number of seeds per fruit

Significantly more seeds per fruit was produced by the plants receiving higher levels of irrigation than the pitcher irrigated plants. The highest was recorded by the conventionally irrigated plants. Water shortage at the time of flowering may have resulted in the reduction of number of seeds produced per fruit.

Among the dates of sowing, the earlier sown plants produced more seeds per fruit than the later sown plants. The effect of sowing date on seed production was reported by Surlekov and Ivanov (1969) in cucumber.

The interaction effect of date of sowing and irrigation was not significant.

1.12 100 seed weight

Irrigation did not significantly influence the 100 seed weight. Among the date of sowing, the later sown plants recorded greater 100 seed weight than the earlier ones. The highest was by the plants sown on March 1st (21.93 g). This increase in the 100 seed weight might have been due to of the reduction in the number of seeds per fruit. The interaction effect was not significant.

1.13 Water content of fruits

The plants receiving higher levels of irrigation produced fruits with significantly higher water content than the pitcher irrigated plants. The highest water content was recorded by the I_1 (IW/CPE = 1) and it was

993 percent. Water is the major component of fruits and irrigation results in the hydration of fruits (Kaufman, 1972). The size of the fruit was also higher in frequently irrigated plants, so it is reasonable that the water content of these fruits also show a similar trend.

The sowing date December 16 recorded, the highest water content of fruits (1087 percent). The later sown plants showed a decrease in the fruit water content. The higher succulence of fruit observed in the early sowings when more favourable climatic conditions were obtained might have attributed to higher water content. A similar trend was noted in the size of the fruits also. This explains the increase in water content of fruits in the earlier sowings.

Interaction effect was not significant with respect to water content of fruit.

1.14 Dry matter content of fruits

Dry matter content was the lowest for the treatment I_1 (IW/CPE = 1) and it was only 11.10 percent. The highest was for the pitcher irrigated plants. The significant increase in percent dry matter in response to water stress was reported by Kaufman (1972). This is because of the higher water content of fruits with the moist regimes. Simil ar results have been obtained by Elkner and Radzikowska (1976) in cucumbers and Lakshmanan (1985) in melons, pumpkins and ashgourd and Krynska <u>et</u> <u>al</u>. (1976) in cucumber.

The earlier dates of sowing produced fruits with the lowest dry matter content with the least value recorded by the December 16th sowing (8.62 percent). This is also because of the higher water content of fruits of the earlier sown plants.

1.15 Yield

The yield of fruit t ha^{-1} and kg per plant showed that the plants receiving the highest quantity of water produced the highest yield. This was by I_1 (IW/CPE = 1) and the yield was 12.81 t ha^{-1}. The treatments I_2 (IW/CPE = 0.75) and I_4 (conventional irrigation) were on par and significantly inferior to I_1. The treatment I_3 (IW/CPE = 0.5) recorded a yield significantly lower than I_1, I_2 and I_4. The pitcher irrigated plot recorded the lowest yield. This reduction in yield with decrease in water availability may be due to decreased dry matter production resulting from reduced photosynthesis and translocation. The decreased yield corresponds to a similiar decrease in the yield componen ts like, length, girth, flesh thickness, weight and the number of fruits. The fruit development depends primarily on the conditions prevailing during the period of fruit enlargment, when considerable amount of water and carbohydrates are transported into the developing fruit (Kaufman, 1972). Simil ar observations were made by many workers (Jagoda and Kaniszewski 1975, Krynska 1975, Henriksen, 1980, Hayes and Herring 1980, Kashi 1981, Desai and Patil 1984, Thomas 1984 and Lakshmanan 1985).

The plants sown on December 1st produced significantly higher yield (14.57 t ha^{-1}) than the later sown plants. There was a progressive decrease in yield with the subsequent planting dates. The lowest value was recorded by the plants sown on March 1st (5.02 t ha^{-1}). This decrease in yield with subsequent plantings can be attributed to a more or less simil ar trend in yield attributes like size, weight and number of fruits per plant. This is to be expected, since fruit yield is the ultimate manifestation of the cumulative effect of these characters. Effect of sowing dates on yield was recorded by Kartalov (1970) and Kmiecik and Lisiewska (1981) in cucumbers and by Khristov (1983) and Desai and Patil (1984) in melons.

The interaction effect of date of sowings and irrigation on the yield was significant. The highest yield (19.40 t ha^{-1}) was recorded by the December 1st sown plants irrigated at the ratio of IW/CPE = 1.

1.16 Total dry matter production

The total dry matter production was significantly influenced by irrigation. The irrigation treatments receiving larger quantity of water accumulated more dry matter per plant (343.93 g) than other treatments. Photosynthesis is the basic process for the build up of organic substances by the plant, whereby, sunlight provides the energy required for reducing Co_2 to sugar as the end product of the process. This sugar serves as the building material for all other organic components of the plant. The amount of dry matter production would therefore depend on the effectiveness of photosynthesis of the crop. The less frequently irrigated plants would produce less dry matter, as reduction in water content bring about a similar reduction in the photosynthetic efficiency (Arnon, 1975). A similar trend was noted by Thomas (1984) in bittergourd and by Lakshmanan (1985) in pumpkin, ashgourd and melon.

The plants sown in December 1st which showed vigorous growth and yield accumulated significantly higher dry matter than the other sowings. This could be due the fact that the sunshine duration and temperature conditions were optimum for the plants in this particular treatment than any other treatments. The later sowings recorded a progressive reduction in the dry matter production. This reduction can be attributed to variation in climate as reported by Hall (1949). Photosynthesis of the crop is influenced by the climate experienced by the plant and this in turn influence the dry matter production by the plant.

2. Field water use efficiency

The field water use efficiency increased with decrease in the levels of irrigation. However, pitcher irrigated plants gave the lowest value, since the yield recorded in this case was also correspondingly low. The treatment I_3 gave the highest water use efficiency of 24.13 kg ha mm^{-1}.

Water use efficiency is likely to increase with decrease in soil moisture supply until it reaches the minimum critical level, because plants may try actively to economise water loss in the range from minimum critical to optimum moisture level. However, total production from unit area decreased as the available soil moisture fell below the optimum (Singh and Sinha 1977). Water above the optimum moisture level may be lost in the form of excessive evaporation, excessive transpiration or even as deep percolation. These findings are in agreement with the observatives of Desai and Patil (1984), Thomas (1984), Lakshmanan (1985).

The water use efficiency was higher for the earlier sown plants than the later sown ones with the highest recorded by December 1st planting 33.96 kg ha mm^{-1}. Since the total yield was higher for December sowing, the water use efficiency also showed a corresponding increase. The effect of sowing dates on water use efficiency was reported by Desai and Patil (1984) in melons.

The interaction effect of date of sowing and irrigation on the water use efficiency was not significant.

3. Soil Moisture Studies

3.1 Consumptive use

The consumptive use increased in response to the frequency of irrigation. The highest value was recorded by I_1 (408.62 mm), which was the most frequently irrigated treatment. With the increase in frequency of irrigation, a favourable condition was created for higher evapo-transpiration. Simil ar reports were put forward by Desai and Patil (1984), Thomas (1984) and Lakshmanan (1985).

The highest consumptive use was recorded by D_2 (337.95 mm) followed by D_3, D_1, D_5, D_4, D_6 and D_7. The consumptive use differs with the date of sowing due to the difference in temperature, wind, humidity and other meteorological parameters experienced by the crop. The earlier dates of sowing recorded higher values of consumptive use due to the fact, that the frequency of irrigation was also higher. Simil ar result has been reported by Desai and Patil (1984) in melons.

3.2 Soil moisture depeletion pattern

The maximum soil moisture depletion was from the 0-15 cm soil layer, in all the treatments. This may be because of the higher loss due to evaporation as well as by extraction by the roots of the plant. The moisture depeletion decreased with depth. There was relatively more depeletion from the lower depth in the drier regimes. This may be because of better development of roots to the lower soil layers in the drier regimes. Simil ar observations were made by Loomis and Crandall (1977) in cucumber, Thomas (1984) in bittergourd and Lakshmanan (1985) in pumpkin, ashgourd and melons.

It was also seen that the moisture depeletion was more from the deeper soil layers in the later sowings. This may be due to the effect of the climatic conditions prevailing at that time.

4. Crop weather relationship

From the correlation studies it is seen that maximum temperature during the first 10 weeks were negatively correlated with both total yield and number of fruits per plant. The decrease in yield at higher temperature might be due to earlier plant ageing and decreased translocation of photosynthates. High temperature also tended to keep the vines in the male phase. Fruit drop was also noticed with high temperature. This is in agreement with the observations made by Nitch et al. (1952) and Drews (1974).

The minimum temperature during 7th to 11th week also showed a negative correlation with yield attributes. This is to be expected as the increased night temperature results in a corresponding increase in the respiration rate. Since the photosynthates were used up by respiration, a reduction in yield was observed. This view is supported by Toki (1978).

The relative humidity during 6th to 13th week was negatively correlated with both total yield and number of fruits per plant. Sex ratio was negatively correlated with increase in relative humidity. This is in agreement with the findings of Toki (1978).

The positive correlation between sunshine hours during 6th to 13th week and yield might be due to the increased photosynthetic efficiency in higher sunshine hours. Preflowering and flowering phases are governed mainly by sunshine hours. Simil ar observations were made by Miller and Ries (1958).

Summary

SUMMARY

An experiment was conducted at the Pepper Research Station, Vellanikkara during the summer months of 1984-85 to study the effect of date of sowing and levels of irrigation on the growth and yield of bittergourd variety 'Priya'.

The biometric observations of the crop growth characters, flowering and yield attributes were recorded at different stages of development of the crop. From the moisture studies, water use efficiency, consumptive use and soil moisture depletion pattern were worked out. The observations on weather factors were recorded daily to work out the crop weather relationship.

The main findings are summarised as follows:

1. The length of vine was significantly higher for the conventionally irrigated plants than other irrigation treatments. Sowing on December 16th produced plants with the highest vine length.

2. Irrigation at IW/CPE = 1 produced female flowers earlier than all other irrigation treatments. The later sown plants took significantly less days for female flower production.

3. The conventionally irrigated plants took the least number of nodes for female flower production.

4. The conventionally irrigated plants also took significantly less days to reach picking maturity. March sown plants took the least number of days to reach picking maturity.

5. At all the stages, the plants receiving irrigation at IW/CPE = 1 produced significantly more female flowers. The December sown plants consistantly produced more female flowers than the later sowings.

6. The conventional irrigation and December sowing gave significantly higher fruit weight.

7. Maximum number of fruits were recorded from the irrigation treatment IW/CPE = 1. The December 1st sowing produced significantly higher number of fruits.

8. Highest fruit length was observed in irrigation treatment, IW/CPE = 1. December sowing was significantly superior in increasing the fruit length.

9. The girth of fruit was also higher in IW/CPE = 1, irrigation treatment. The highest girth of fruit was recorded from December sowing.

10. Conventionally irrigated plants gave the highest value for flesh thickness. Sowing in December produced higher flesh thickness.

11. December sown plants produced more seeds per fruit.

12. The last sowing date March 1st gave the highest 100 seed weight.

13. Water content of fruit was higher for the frequently irrigated treatments. December sowing gave fruits with higher water content.

14. Dry matter content of fruit was higher for pitcher irrigated plants. The later date of sowing gave higher values with respect to dry matter content of fruit.

15. The yield was significantly higher for the irrigation treatment IW/CPE = 1. The sowing date D_1 gave significantly higher yield.

16. The total dry matter production was also higher for the irrigation at IW/CPE = 1 and the sowing date December 1st.

17. The plants irrigated at IW/CPE = 0.5, showed the highest water use efficiency. Maximum water use efficiency was recorded from December 1st date of sowing.

18. The consumptive use was seen to increase with the frequency of irrigation.

19. The soil moisture depletion was higher from the top 15 cm of the soil layer. The depletion was more from the deeper layers in drier regimes.

20. The crop weather relationship studies showed that the maximum temperature during the first 10 weeks, the minimum temperature during 7th to 11th week and relative humidity during 6th to 13th week were negatively correlated with both total yield and number of fruits per plant. While there was positive correlation between sunshine hours during 6th to 13th week and the yield characters.

From the study, it can be concluded that irrigation to bittergourd raised in sandy clay loam soils, need be given at IW/CPE ratio of 1. This involves irrigation at intervals of 3-6 days when the cumulative pan evaporation values reached 30 mm. Bittergourd can be raised successfully in summer season by sowing on December 1st.

References

REFERENCES

* Abolina, G.I., Ataullaev, N.A. and Hakimov, A. 1963. The influence of the moisture regime and nutrition on the physiological processes and yields of melons under Uzbekistan conditions. Agrobiologia. No. 3 : 437-441.

* Abreu, T.A.D., Olitta, A.F.L. and Marchetti, D.A.B. 1978. Comparison of two irrigation methods (furrow and drip) on melons in the San Francisco Valley. Pesquisas Agropecuaria Brasileira. 13 (3) : 35-45.

Arnon, I. 1975. Physiological principles of dry land crop production. In. Gupta, U.S.(ed). Physiological Aspects of Dry Land Farming. Oxford and IBH publishing Co., New Delhi, Bombay, Calcutta. pp. 3-145.

Balakumaran, K.N., Mathew, J., Pillai, G.R. and Varghese, K. 1982. Studies on the comparative effect of pitcher irrigation and pot watering in cucumber. Agri. Res. J. Kerala. 20 (2) : 65-67.

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

Blake, G.R. 1965 a. Bulk density. Core method. In. Black, C.A. (ed). Methods of Soil Analysis. Ist Ed. Part I. American Society of Agronomy, Madison, U.S.A. pp. 375-376.

Blake, G.R. 1965 b. Particle density. In. Black, C.A. (ed). Methods of Soil Analysis. Ist Ed. Part I. American Society of Agronomy, Madison, U.S.A. pp. 371-373.

Borelli, A. and Zerbi, G. 1977. Effect of different irrigation methods and levels on green house musk melon. Acta Horticulturae. No. 58 : 129-135.

Bradley, G.A. and Rhodeo, B.B. 1969. Cultural studies on summer squash. Arkans. Fm. Res. 18 (3) : 9.

* Bujanovskaja, J. G. 1970. Some characteristics of cucumber root development under flood irrigation. Nauc. Trudy Omskiji sel-hoz. 81 : 39-44.

Buttrose, M.S. and Sedgley, M. 1978. Some effects of light intensity, day length and temperature on growth of fruiting and non fruiting water melon, Citrullus Lanatus. Ann. Bot. 42 : 599-608.

Cantliffe, D.J. 1981. Alteration of sex expression in cucumber due to changes in temperature, light intensity and photoperiod. J. Am. Soc. Hort. Sci. 106 (2) : 133-136.

* Caro, A.D. and Linsalata, D. 1977. Melon yields as a function of the seasonal volume of irrigation water. La Ricerca Scientifica. No. 99 : 129-138.

Chander, A. and Mangal, J.L. 1983. Studies on nitrogen fertilisation under various soil moisture regimes, on growth, flowering and fruiting behaviour of musk melon. Punjab hort. J. 23 (1) : 105-110.

* Cselotel, L. and Varga, G. 1973. Relationship between development and water utilization in cucumbers. Agrartudo-manyi Egyetem Kozlemencei. pp. 137-149.

Danielson, L.L. 1944. Effect of day length on growth and reproduction of the cucumber. Pl. physiol. 19 (4) : 638-648.

Dastane, N.G., Singh, M., Hukkeri, S.B. and Vamadevan, V.K. 1970. Review of work done on water management of crops in India. Nav bharat, Poona-4. pp. 106.

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

* Dimitrov, Z. 1973. Seasonal irrigation pattern of water melons. Gradinarstov. 15 (11) : 31-34.

* Dimitrov, Z. 1974. Green house cucumber irrigation. B" lgarski Plodove Zelenchutsi Konservi. No.1 : 120-122.

Doorenbos, J. and Kassan, A.H. 1979. Yield Response to Water. F A O Irrigation and Drainage Paper -33 pp. 161-163.

Doorenbos, J. and Pruitt, W.O. 1977. Guidelines for Predicting Crop Water Requirements. F A O Irrigation and Drainage Paper - 24 pp. 30-33.

* Drews, M. 1979. Investigations into fruit development of green house cucumbers. Archiv fur Garten bau. 27 (4) : 153-164.

* Drews, M., Heissner, A. and Augustin, P. 1980. The yield pattern of early green house cucumbers in relation to temperature and radiation intensity. Archiv fur Garten bau. 28 (1) : 17-30.

* Dunkel, K.H. 1966. The effect of varying water supply on yield of tomato and cucumber under glass house. Acta. Hort. Int. Soc. hort. Sci. No. 41 : 42-49.

Edmond, J.B. 1930. Seasonal variation in sex expression of certain cucumber varieties. Proc. Am. Soc. Hort. Sci. 27 : 329-332.

* Elkner, K. and Radzikowska, D. 1976. Influence of irrigation, mineral nutrition and variety on the pickling quality of cucumber Zesyty Problemous Postepow Nauk Rolniczych. No. 181 : 55-70.

Flocker, W.J., Lingle, J.C., Davis, R.M. and Miller, R.J. 1965. Influence of irrigation and nitrogen fertilization on yield, quality and size of cantaloups. Proc. Am. Soc. Hort. Sci. 86 : 424-432.

*Frolich, H. and Henkel, A. 1961. The use of supplementary irrigation for outdoor cucumbers. Arch. Gartenb. No. 9 : 538-551.

Fukushima, E., Matsuo, E. and Fujieda, K. 1968. Studies on the growth behaviour of cucumber Cucumis sativus L.I. The types of sex expressions and its sensitivity to various day lengths and temperature conditions. J. Fac. Agric. Kyushu. 14 : 346-366.

* Goto, Y., Lchikawa, H., Araki, Y., and Shibata, A. 1981. Studies on the variation of soil water suction at the begining of irrigation and the irrigation requirement of some vegetables under green house condition. I. An experiment with cucumber under forcing conditions. Bull. Veg Ornemental Crop Res. Stn. No. 9 : 133-141.

Hali, R. 1969. Bittergourd - A Kerala favourite. Indian Fmg. 12 (5) : 30-31.

Hall, W.C. 1949. Effect of photoperiod and nitrogen supply on growth and reproduction in the gherkin. Pl. Physiol. 24 (4) : 753-769.

* Hammett, H.L., Albritton, R.C., Brock, W.A., Crockett, S.P. and Wagoner, B.E. 1974. Production of cucumbers for pickles. Miss. Agri. For. Sta. Bul. 801.

Haynes, R. and Herring, S. 1980. Effect of trickle irrigation on yield and quality of summer squash. Arkans. Fm. Res. 29 (5) : 6.

Heij. G. 1981. Glass house cucumber, stem elongation and earliness of fruit production as influenced by temperature and planting date. Acta Horticulturae. No. 118 : 105-21.

Heij , G. and Lint, P.J.A.L. 1982. Night temperature and fruiting of glass house cucumber (cucumis sativus L.) Neth. J. agric. Sci. 30 (2) : 137-148.

* Henriksen, K. 1980. Irrigation of ridge cucumbers. Tidsskrift for planteaval. 84 (6) : 679-490.

Indian Council of Agricultural Research. 1981. Ann. Rpt. 1980-81. Co-ordinated project for research on water management (ICAR). Chalakudy Centre.

Indian Council of Agricultural Research..1982. Ann. Rpt. 1981-82. Co-ordinated project for research on water management (ICAR), Chalakudy Centre.

* Ivanov, L. 1978. Effect of temperature and daylength on the growing period of cucumbers. Gradinarska i Lozarska Nauka. 15 (7) : 129-136.

Jackson, M.L. 1958. Soil Chemical Analysis. Prentice Hall. Inc. Engle wood cliffs. N.J. U.S.A. reprint (1973) by Prentice - Hall of India (Pvt.) Ltd., New Delhi. pp. 498.

* Jagoda, J. and Kaniszewski, S. 1975. The effectiveness of irrigation and mineral fertilization during cultivation of two cucumber cultivars. Biutetyn Warzywniczy. 18 : 47-61.

Kamalanathan, S. and Thamburaj, S. 1970. Sex expression in pumpkin (Cucurbita moschata) in relation to certain climatic parameters. Madras Agric. J. 57 (11) : 555-558.

*Kartalov, P. 1970. Possibilities of enchancing the capacity of hot bed cucumbers. Gardinarstvo. 12 (3) : 35-37.

* Kashi, A. 1981. Effect of interval and method of irrigation on some quantitative and qualitative characteristic of semsuri cantaloupe of varamin (Cucumis melo var. reticulatus). Iranian J. agric. Sci. 12 (1) : 1-12.

Kaufman, M.R. 1972. Plant responses and control of water balance - water deficit and reproductive growth. In. Kozlowski, T.T. (ed). Water Deficits and Plant Growth Vol. III Academic Press, New York. 91-124.

* Khristov, B. 1983. Suitable methods for melon forcing. Gradinarska i Lozarska Nauka. 20 (6) : 80-83.

* Kmiecik, W. and Lisiewska, Z. 1981. Effect of sowing time on cropping dates and yield quality and quantity in 4 processed cucumber cultivars. Zeszyty Naukowe Adademii Rolniczej im. Hugona Kollataja w Krakowie Ogrodnictwo. 8 : 177-193.

* Konishi, K. 1974. The amount and nature of water consumption in musk melon plants. Sci. Rpt. Fac. Agric. Okayama Univ. No. 43 : 27-37.

* Krynska, W. 1975. The effects of irrigation and mineral fertilization on cucumber yield. Biuletyn Warzywinczy. 18 : 63-78.

* Krynska, W., Kawecki, Z., and Piotrowski, L. 1976. The effect of fertilization, irrigation and cultivar on the quality of fresh, sour and pickled cucumber. Zeszyty Naukowe Adademii Rolniczo - Technicznei W Olsztynie Rolnictow. No. 15 : 109-123.

Lakshmanan, R. 1985. Scheduling of irrigation for cucurbitaceous vegetables. M.Sc. thesis. Kerala Agricultural University, Vellanikkara.

Larson, K.L. 1975. Drought injury and resistance of crop plants. In. Gupta, U.S.(ed). Physiological Aspects of Dryland Farming. Oxford and IBH publishing Co., New Delhi, Bombay, Calcutta. pp. 147-165.

Lint, P.J.A.L. and Heij, G. 1982 a. Night temperature and number of nodes and flowering of the main stem of glass house cucumber, (Cucumis sativus L.). Neth. J. Agric. Sci. 30 : 149-159.

Lint, P.J.A.L. and Heij, G. 1982 b. Night temperature and flower abortion of glass house cucumber. Neth. J. agric. Sci. 30 : 331-339.

Loomis, E.L. and Crandall, P.C. 1977. Water consumption of cucumbers during vegetative and reproductive stages of growth. J. Am. Soc. Hort. Sci. 102 (2) : 124-127.

* Mannini, P. and Roncuzzi, M. 1983. The yield response of cucumbers to different intervals, volumes and systems of irrigation in the unheated glass house. Colture Protette. 12 (4) : 29-36.

Matsuo, E. 1968. Studies on photo periodic sex differentiation in cucumber, Cucumis sativus L. I. Effect of temperature and photoperiod on sex differentiation. J. Fac Agrc. Kyushu. 14 : 483-506.

Mc Gillivray, J.H. 1951. Effect of irrigation on the production of cantaloups. Proc. Am. Soc. Hort. Sci. 57 : 266-272.

Michael, A.M. 1978. Irrigation. Theory and Practice. Vikas Publishing House Pvt. Ltd., New Delhi. pp. 448-563.

Miller, C.H. and Ries, S.K. 1958. The effect of environment on fruit development of pickling cucumbers. Proc. Am. Soc. Hort. Sci. 71 : 475-479.

* Molnar, B. 1965. Irrigation of melons. Novenytermeles. 14 : 203-214.

Mondal, R.C. 1974. Farming with a pitcher : A technique of water conservation. World Crops 30 (3) : 124-125.

* Motoki, M. and Kurokawa, H. 1977. The effect of irrigating at different moisture levels on melons growing on coarse volcanic ash soils on komagadake. Bull. Hokkaido agric. Exp. Stn. No. 37 : 50-67.

Nadkarni, K.M. 1954. Indian Materia Medica Revised and enlarged by A.K. Nadkarni. Popular Book Depot, Bombay, pp. 296-297.

Nandpuri, K.S. and Lal , T. 1978. Varietal response to date of planting in muskmelon. Veg. Sci. 5 (1) : 8-14.

Nandpuri, K.S., Lal, T., and Singh, S. 1976. Vegetative and reproductive behaviour of muskmelon as studied under diverse conditions *Indian J. Hort.* **33** (3) : 246-51.

* Neil, P. and Zunino, J.B. 1972. Water requirement of melon and methods of irrigation. *Pepinieristes Horticulturs.* No. 123 : 43-54.

Nitch, J.P., Kurtz, E.B., Liverman, J.L. and Went, F.W. 1952. The development of sex expression in cucurbit flowers. *Am. J. Bot.* **39** : 32-43.

* Pavlov, F.I. 1976. Irrigation regime for cucumbers under heated plastic green houses. *Poklady Mosk. S-Ki. Acad. K.A. Timiryzva.* No. 216 : 128-132.

Panse, V.G. and Sukhatme, P.V. 1954. *Statistical Methods for Agricultural Workers.* Indian Council of Agricultural Research, New Delhi. pp. 187-202.

Pew, W.D. and Gardner, B.R. 1983. Effect of irrigation practices on vine growth, yield and quality of musk melon. *J. Am. Soc. Hort. Sci.* **108** (1) : 134-137.

Piper, C.S. 1950. *Soil and Plant Analysis.* University of Adelaide. Australia, pp. 368.

Prihar, S.S., Sandhu, S. and Singh N.T. 1975. *Proc. second world congress on water resources* **1** : 343.

Reddy, S.E. and Rao, S.N. 1983. Response of bittergourd (*Momordica charantia* L.) to pitcher and basin system of irrigation. *S. Indian Hort.* 31 (2) : 117-120.

Richards, L.A. 1947. Pressure membrane apparatus. Construction and use. *Agri. Engg.* 28 : 451-454.

Rudich, J., Elassar, G. and Shefi, Y. 1978. Optimal growth stages for the application of drip irrigation to musk melon and water melon. *J. Hort. Sci.* 53 (1) : 11-15.

Scott, G.W. 1933. Sex ratios and fruit production studies in bush pumpkins. *Proc. Am. Soc. Hort. Sci.* 30 : 520-525.

Sharma, R.P. and Parashar, K.P. 1979. Effect of different water supplies, levels of N and P on consumptive use of water, water use efficiency and moisture extraction pattern by cauliflower var. Snow ball-16. *Indian J. Agron.* 24 (3) : 315-321.

Sharma, R.R. and Nath, P. 1971. A comparative study on sex expression and sex ratio in common melons. *Madras agric. J.* 58 (7) : 578-586.

Singh, N.P. and Sinha, S.K. 1977. *Water Requirement and Irrigation Management of Crops in India.* Water Technology Centre. I.A.R.I., New Delhi. pp. 286-335.

Singh, S.D. and Singh, P. 1978. Value of drip irrigation compared with conventional irrigation for vegetable production in a hot arid climate. Agron. J. 70 (6) : 945-947.

Singh, S.N. 1958. Studies in sex expression and sex ratio in luffa species. Indian J. Hort. 15 (2) : 66-71.

Slack, G. and Hand, D.W. 1981. Control of air temperature for cucumber production. Acta Horticulturae. No. 118 : 175-186.

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

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

* Surlekov, P. and Ivanov, L. 1969. Influence of sowing date on cucumber seed yields. Gradinarstvo. 11 (12) : 14-18.

Tau, C.S., Fulton, J.M. and Nuttal, V.W. 1983. The influence of soil moisture stress and plant populations on the yield of pickling cucumber Scientia Horticulturae. 21 (3) : 217-224.

Thomas, C.G. 1984. Water management practices for bittergourd (*Momordica charantia*. L.) under different fertility levels. M.Sc. (Ag) thesis. Kerala Agricultural University, Vellanikkara.

Tiedjens, V.A. 1928. Sex ratios in cucumber flowers as affected by different conditions of soil and light. *J. agric. Res.* **36** : 721-746.

Toki, T. 1978. Effect of varying night temperature on the growth and yields in cucumber. *Acta Horticulturae*. No. 87 : 249-255.

*Uffelen, J.A.M.V. 1982. Temperatures with cucumbers. *Groenten en Fruit*. **37** (28) : 57-57.

* Varga, D. 1973. The problem of cucumber irrigation in Hungary. *Zanradnictivi*. pp. 199-211.

Venketram, T.M. 1963. Studies in sex expression in the snake gourd with special reference to the influence of photoperiod and growth substances. M.Sc. thesis, University of Madras, Madras.

Vorren, J.V.D. 1980. Effect of day and night temperature on earliness and fruit production in cucumber. *Acta Horticulturae*. No. 118 : 187-189.

Vooren, J.V.D. and Challa, H. 1978. Influence of varying night temperatures on a cucumbers crop. *Acta Horticulturae*. No. 87 : 249-255.

Ware, G.W. and Mc Collum, J.P. 1980. Producing Vegetable Crops 3rd edition. The Inter State Printers and Publishers, Inc. Illinois. pp. 321.

Whitaker, T.W. 1931. Sex ratio and sex expression in the cultivated cucurbits. Am. J. Bot. 18 (5) : 359-366.

* Yabe, K., Sakurai, Y. and Osuga, M. 1981. Studies on the soil moisture management of musk melons growing on non-isolated soil beds. 1. Effect of soil moisture at various growth, stages on growth, yield and fruit quality. Res. Bull. Aichi-Ken agric. Res. Centre. 13 : 157-164.

* Yamashita, F., Takei, A., Yamada, K. and Ito, K. 1982. Studies on the long term cultivation of cucumber (cucumis sativus L.). Effect of rootstock, sowing date, soil moisture and amount of fertiliser. Res. Bull. Aichi-Ken agric. Res. Centre. 14 : 129-127.

* Zabara, Y.M. 1976. The effect of irrigation on root distribution in cucumbers grown on derno-podzolic soil. Nauch Trudy Belorus Nil Kartofelvedi I Plodoovoschchevod No. 2 : 147-150.

* Originals not seen.

Appendices

APPENDIX - I

Analysis of variances for vine length, days taken for first female flower to open, node at which the first female flower was produced and the days to picking maturity

Source	Degrees of freedom	Mean squares			
		Vine length	Days taken for first female flower to open	Node at which first female flower was produced	Days to picking maturity
Replication	2	567.94 *	8.83	4.73	2.04
D	6	1089.60 **	121.24 **	22.14	41.01 *
Error (1)	12	137.00	7.23	11.87	9.43
I	4	3516.00 **	26.55 **	72.38 **	22.64 **
D x I	24	156.96 **	3.39	11.70	4.02
Error (2)	56	60.36	3.27	8.37	2.91

* Significant at 5 percent level

** Significant at 1 percent level

APPENDIX - II

Analysis of variances for the number of female flowers produced on the 45th, 60th and 75 th days after sowing

Source	Degrees of freedom	Mean squares		
		45th DAS	60th DAS	75th DAS
Replication	2	0.75	1.91 *	1.21
D	6	0.48	3.45 **	3.11 *
Error (1)	12	0.55	0.49	0.72
I	4	9.32 **	14.24 **	10.11 **
D x I	24	0.62	0.35	0.25
Error (2)	56	0.39	0.55	0.47

* Significant at 5 percent level

** Significant at 1 percent level

APPENDIX - III

Analysis of variances for the number of fruits per plant and weight, length girth and flesh thickness of fruits

Source	Degrees of freedom	Mean squares				
		Number of fruits per plant	Weight of fruit	Length of fruit	Girth of fruit	Flesh thickness of fruit
Replication	2	34.45	180.27	2.97	0.28	0.33
D	6	129.72 **	3406.63 **	31.95 **	11.04 **	7.39 **
Error (1)	12	9.96	312.51	5.79	0.39	0.55
I	4	233.47 **	3122.58 **	72.86 **	3.76 **	12.32 **
D x I	24	2.18 **	295.48	4.76	0.62	1.15 **
Error (2)	56	5.31	123.46	3.41	0.40	0.53

** Significant at 1 percent level

APPENDIX - IV

Analysis of variances for the number of seeds per fruit, 100 seed weight, water content of fruit and dry matter content of fruit

Source	Degrees of freedom	Mean squares			
		Number of seeds per fruit	100 seed weight	Water content of fruit	Dry matter content of fruit
Replication	2	4.84	5.83	7604.00	8.28
D	6	39.26 *	21.26 **	302386.70 **	54.88 **
Error (1)	12	9.47	1.95	34474.00	3.05
I	4	80.74 **	3.29	147166.00 **	22.89 **
D x I	24	6.51	3.08	35195.00	4.42
Error (2)	56	6.95	2.01	39350.57	3.47

* Significant at 5 percent level

** Significant at 1 percent level

APPENDIX - V

Analysis of variances for yield in t ha^{-1} and kg per plant, total dry matter production and field water use efficiency

Source	Degrees of freedom	Mean squares			
		Yield in t ha^{-1}	Yield in kg/plant	Total dry matter production	Field water use efficiency
Replication	2	27.22	0.34	6920.72	97.36
D	6	133.57 **	1.70 **	37936.25 **	723.96 **
Error (1)	12	7.37	0.09	2068.88	37.13
I	4	308.55 **	3.92 **	129812.68 **	74.44 *
D x I	24	11.80 **	0.15 **	3093.79 *	28.28
Error (2)	56	4.27	0.06	1587.05	22.92

* Significant at 5 percent level

** Significant at 1 percent level

EFFECT OF DATE OF SOWING AND LEVELS OF IRRIGATION ON THE GROWTH AND YIELD OF BITTER GOURD VARIETY PRIYA

By

SARAH JACOB

ABSTRACT OF A THESIS

submitted in partial fulfilment of the
requirements for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1986

ABSTRACT

Effect of date of sowing and levels of irrigation on the growth and yield of bittergourd variety Priya.

An experiment was conducted at the Pepper Research Station, Vellanikkara during the summer months of 1984-85 to study the effect of date of sowing and levels of irrigation on the growth and yield of bittergourd, variety Priya. The experiment was laid out in split plot design with three replications. The treatments consisted of seven dates of sowing (December 1^{st}, December 16^{th}, December 31^{st}, January 15^{th}, January 30^{th}, February 14^{th} and March 1^{st}), in the main plot and five levels of irrigation (IW/CPE = 1, IW/CPE = 0.75, IW/CPE = 0.50, conventional irrigation and pitcher irrigation) in the sub plot.

The biometric observations of the crop growth characters, flowering and yield attributes were taken at different stages of development of the crop. Soil moisture studies were undertaken before and 24 hours after each irrigation. The observations on weather elements were recorded daily.

Irrigation at IW/CPE ratio 1 was significantly superior to others with regard to date and number of female flower production, number of fruits, fruit length and girth, yield, total dry matter production. The conventionally irrigated plants showed maximum vine length, flesh thickness and fruit weight. The December sown plants were superior to others with regard to most of the crop characters.

The crop weather relationship studies showed that the maximum temperature during the first 10 weeks, the minimum temperature during 7th to 11th week and relative humidity during 6th to 13th week were negatively correlated with both total yield and number of fruits per plant. While there was positive correlation between sunshine hours during 6th to 13th week and the yield characters.

It was found that irrigation and sowing date had a significant effect on overall growth and yield of the crop. The highest yield of the crop was recorded in plots irrigated at IW/CPE = 1 and sown on December 1^{st}. The best performance was attributed to the optimum weather condition during the crop period and the effective utilization of water.

From the soil moisture studies it is evident that the consumptive use increased with the frequency of irrigation. The top 15 cm of the soil layer accounted for the highest soil moisture depletion. The depletion was more from the deeper layers in drier regimes. The water use efficiency was highest for the plants irrigated at IW/CPE = 0.5, sown on December 1st.

Results of the present investigation indicate that bittergourd can be raised successfully during the summer months if irrigated at IW/CPE ratio 1 and sown on December 1st.