CROP WEATHER RELATIONSHIP STUDIES IN BITTER GOURD

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THESIS

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DECLARATION

I hereby declare that the thesis entitled '**Crop weather relationship studies in bitter gourd**' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship, associateship or other similar title of any other university or society

Vellanikkara

P LINCY DAVIS

CERTIFICATE

Certified that the thesis entitled '**Crop weather relationship studies in bitter gourd**' is a record of research work done independently by **Miss P Lucy Davis**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her

Dr P Balakrishna Pillai
Professor of Agrometeorology
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CERTIFICATE

We, the undersigned members of the Advisory Committee of **Miss P Lincy Davis**, a candidate for the degree of **Master of Science in Agriculture with major in Agricultural Meteorology**, agree that the thesis entitled **'Crop weather relationship studies in bitter gourd'** may be submitted by Miss P Lincy Davis in partial fulfilment of the requirement, for the degree

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P Lincy Davis

To my parents

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Introduction

INTRODUCTION

Bitter gourd (*Momordica charantia* L) is one of the most important cucurbitaceous vegetables cultivated in Kerala The importance of this vegetable has long been accepted on account of its high nutritive value, unique medicinal properties and consumer preference

Bi r gourd is rich in Vitamin C (88 mg) Carbohydrate (4 2 g) Protein (1 6 g) Carotene (120 μg) and iron (1 8 mg It is characterized by the bitter principle cucurb tacins The fruits and leaves are used in various indigenous medicines and it finds important place in the iet of diabetic patients The tender fruits are used in various preparations like pickles curries and fries The cultivation of this crop is highly remuner itive and hence is gaining popularity among the vegetable growers

A m ijor problem towards productivity increase is the reaction of crop to the varying agroclimatic situations The yield response is very sensitive to the changing weather parameters that exist in different seasons peculiar to these agroclimatic regions

The growth and yield of bitter gourd and the incidence of pest and diseases vary greatly with the weather conditions that prevail during the growing season A combination of temperature sunshine duration humidity etc determines the growth period crop performance and productivity The effect of meteorological parameters on the crop car be studiec by varying the sowing dates so that an optimum date of sowing can be arrived at

Sowing date is a nonmonitory input and earlier research works have shown that by sowing the crop at correct time the growth and yield of the crop can be enhanced with no extra effort on the part of farmer Besides occurrence of pest and diseases can be controlled to a certain extent

It was reported by many agronomists that bitter ourd yielded higher during the north east monsoon season as compared to other seasons of the year However no information is available with regard to the performance of the crop during different months of South West monsoon and Summer seasons With this in mind twelve sowing dates were screened for one year in the present investigation

In view of these situations the present investigation was undertaken with the following objectives

1 To study the effect weather parameters on growth and yield of bitter gourd
2 To arrive at an optimum time of sowing to realise maximum yield of bitter gourd
3 To study the effect of weather parameters on the incidence of major pests and diseases of bitter gourd
4 To correlate the meteorological parameters to the phenological stages and yield of the crop
5 To prepare crop weather models

Review of Literature

REVIEW OF LITERATURE

2.1 Effect of date of sowing on growth and yield

Surlekov and Ivanov (1969) reported that cucumber sown in April produced plants with the largest number of fruits, the highest mean fruit weight, 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.

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 the highest with the earliest date of sowing.

Schroder and Drews (1982) concluded that in cucumber date of planting generally controlled the earliness of the harvest. The total yields, however, were little affected by the planting date.

Khristc (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) reported that the vine girth of water melon was the lowest when sown on 20th November 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 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 The yield was the lowest in 20th November sowing

Asiegbu (1985) investigated the influence of planting date on growth and productive life of fluted pumpkin sown on May June and August It was found that seedling emergence was the lowest with August sowing Plant growth and yield parameters were better for earlier

Desai and Patil (1985) studied the effect of date of sowing on the expression of sex ratio and yield contributing parameters of water melon (cv Sugar Baby) and reported that male female sex ratio was the lowest in plants sown on the earliest date (3 86) and the highest (8 48) in those sown on the latest date 20th The yield was the highest in plants sown on December 30th and January 20th

Jacob (1986) studied the effect of date of sowing on growth and yield of bitter gourd variety Priya and found that bitter gourd can be raised successfully in summer season by sowing on December 1st Snake gourd sown on November 16th produced the highest yield (Thankamani 1987) Mohammed and Mohammed (1987) obtained the highest total yield for squash plant when sown on March 1st

Bruyn and Sande (1988) in a glass house trial using cucumber (cv Corona) planted on 15th July 24th July 12th August or 25th August reported that earlier planting gave the highest total yield (upto 17 6 kg/m^2) Each week s delay in planting resulted in yield loss of 1 7 kg/m^2

Alvarez (1989) showed that musk melon sown in January February March and April achieved higher feminization rate than plants sown in May June and July Plants sown in September October and November did not produce any pistillate flowers whereas in plants sown in December the feminization rate was intermediate

Wawrzyniak (1988) found that the highest yield of short cucumbers (1514 0 kg/100 m^2) was obtained when the seedlings were planted out during the first half of March

Maeda Martinez (1989) from an experiment on cucumber sown in summer/satumn (August to October) and winter (November to March) found out that both seasons gave equal yield of 10 11 kg/m^2 The length of the growing period increased from 90 days in summer/autumn to 150 days in winter

Moglashan and Fielding (1990) carried out three experiments on musk melon cultivars planted at monthly intervals from 15th November 1986 to 15th January 1987 5th January 1988 to 5th March 1988 and on 12th March 1989 Highest yield was obtained with November planting in the first trial and the January planting in the second trial

Tams (1990) working with cucumber sown on 14 or 21 March found that cumulative yields and average fruit weight were the highest with the younger (later sown) plants on which all stem fruits were retained

Vegter (1990) from an experiment on cucumber with four date of planting and three temperature regime concluded that the higher temperature regime enhanced early flowering and fruiting of older plants but with younger plants the time of flowering and early yields were little affected By the end of harvest however the temperature regime made little difference to yield/m^2 fruit numbers or average fruit weight

Campiothi *et al* (1991) reported that for cucumber cultivars the mean fruit weight and the number of fruits/plant were much lower in the autumn than in the spring season

Palumbo *et al* (1991) investigated the effect of summer squash (*Cucurbita pepo*) planting dates on the seasonal abundance of *Anasa tristis* popula tions and fruit yields Significantly higher adult population densities developed on older larger plants containing higher numbers of leaves than on younger plants with fewer leaves Regardless of planting date *Anasa tristis* was abundant on plants during flowering and fruit set

Benzioni *et al* (1991) observed that in *Cucumber metuliferus* optional germination was between 20°C and 35 C Germination was delayed at 12°C totally inhibited at 8°C and greatly inhibited above 25°C Plants sown in mid March set fruit in mid May and gave a higher yield of export quality fruits than plants sown in mid April which set fruits norma y but produced a large proportion of small (< 200 g) fruits Plants sown in June did not flower until October Plants sown in a green house on three dates in October and November developed very slowly during the cold months and had chlorotic leaves However growth and development resumed in the spring and high yields (46 4 64 0 t/ha) were eventually achieved

Three cultivars of *Cucumis melo* var reticulatus Laguna Easy Rider and Durango were evaluated for time and sum of degree days required for fruit maturity following field plantings in February and March Results indicated that fruit maturity was insensitive to large differences in temperature regardless of cultivar (Dunlop and Maas, 1991)

I yutova and Kamontseva (1992) working with cucumber sown in December and January, found that the early and total yields in terms of number of fruits/plant k plant and g/ha were the highest with December sowing

Walerer (1993) planted musk melons (cv Earlisweet) in the field on 15th May (very early) 24th May (early) and 4th June (recommended date) in 1990 and 1991 It as found that early planting increased fruit yield n row covers were used while late pl nting was best in no cover treatments

Mulkey and Talbot (1993) reported that April sowing produced Zucchini summer squash with highest yield

A wangbog *et al* (1995) from an experiment on pumpkin (*Cucurbita moschata* Duch) found that May was the best planting time for the production of ripe fruits

2 2 Effect of environmental factors

2 2 1 Temperature

Miller and Ries (1958) found that low temperature (60°C) 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 50 F night temperature plants produced more fruits under long day conditions

Toki (1978) concluded that night temperature should be maintained 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 the remaining night This temperature regime increased the cucumber yield by 12 per cent as compared with those of the conventional cultivation for night and day temperatures

Research findings of Vooran and Challa (1978) indicated that in cucumber the date of first harvest 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

Buttrose and Sedgley (1978) found that increase in temperature above 25 C resulted in longer main shoot and prolific lateral growth in watermelon Toki (1978) observed that in cucumber translocation and respiration were greatly affected by the night temperature

Drews *et al* (1980) found that in cucumber low night temperature (16°C) resulted in yield increase but the start of yielding was delayed High temperature (23 C) caused earlier bearing, but because of earlier planting the total yield was decreased This was supported by Vooren (1980) and according to him increasing night temperature from 12 20°C delayed maturity in cucumber At the same time an increase in day temperature from 20 26°C also showed a similar response Heij (1981) reported that both increase in temperature and delay in planting promoted earliness of fruit production i cucumber He reported that stem elongati on rate increased with rise in temperature

Slack and Hand (1981) reported hat the early fruit yield of cucumber rose with increasing night temperatu e upto 23°C but showed no increase at day temperature above 22 C After 20 weeks of picking, the highest cumulative fruit yield was obtained at a night temperature of 20°C and a day temperature of 22°C

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) observed that lower night temperature resulted in higher flower abortion in glass h use cucumber

Lint and Heij (1982) with four plantings of glass house cucum' r 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

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

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

Heissner and Drews (1985) in studies on yield increase in green house cucumber in relation to temperature conditions found that neither planting date nor night temperature (11°C, 14°C 17°C) affected the total yield but both affected earliness

Klapwijk (1987) studied the relationship between glass house temperature and the initiation and growth of leaves and fruits He reported that growth is negligible at 15°C but is greatly accelerated at temperature upto and above 30°C provided moisture is adequate Photosynthesis, however, is maximum at about 20°C

Experiment with the cucumber hybrid (cv TSKGA 77) showed that the temperature requirement in the post transplanting period varied with the growth stage Upto mass flowering day air temperature of 20°C 30°C night air temperature not below 12°C and soil temperature not below 17°C were required During flowering and fruiting in natural light optimal day night and ground temperature combination were 25° 27°C 15° 18°C and 17°C and 25° 27°C 12°C and 25°C respectively (Palkin 1987)

Dunlap (1988) examined the germination rate and final germination percentage of four cultivars of *Cucumis melon* in response to incubation temperature of 20 C 26 C and 32°C and found that germination of cultivar TAM Uvalde was constantly slow at 20 C 26°C and 32 C

Uffelen (1988) in a glass house trial comparing the effect of different temperature regimes on cucumber revealed that raising the aver 24 hour temperature by 1°C advanced harvest by 4 days when the rise was due to a higher night temperature However when the rise was due to an increase in day temperature harvest was advanced by 12 days A relatively high day temperature also increased plant vigour and there were fewer female flowers in the leaf axil thus reducing the number of fruitlets to be thinned

Malinina and Alekseeva (1988) carried out experiments on the germination of melon seeds at fluctuating temperatures of 28/20°C 20/10°C 15/5°C and 35/5°C It was observed that temperatures of 15/5°C proved best for preliminary evaluation of resistance to low temperatures

Uffelen and Van (1989) compared the effects of different day/night temperature regimes of 26/18 5°C 23/20°C and 18/22 5°C on cucumbers cv Venture He found that plant growth (elongation) was markedly affected by temperature differences and at the highest day temperature plants reached the top of the wire (about 2 2 m) in 34 days compared with 56 days at the lowest day temperature Corresponding leaf numbers/plant varied between 16 7 and 25 8 to the top of the wire Leaf and fruit colour was much darker at high day temperatures Fruit numbers/plant were highest with regimes of 23/20° or 21/21° The time of harvest was advanced and shelf life was improved at the highest day temperature, but average fruit weight was the lowest with this regime

Growth of peas radish and spinach was significantly reduced by soil temperature < 10 C It was limited in bean cucumber egg plant sweet pepper and watermelon when soil temperatures were maintained in the 16 7 18 9°C temperature or lower (Wilcox and Pfeiffer 1990)

Ying and Li (1990) conducted experiments on four cucumber cultivars and observed that low night temperatures help to enhance female flower production

Marcelis (1990) from an experiment on cucumber cv Corona observed that fruits grown at an average temperature of 17 6°C were only 0 8 cm longer than those grown at 23 6°C Fruit growth duration was 19 6 days and 11 9 days respectively at lower and higher temperature It was also observed that fruit dry matter content was 3 3 and 2 9 per cent respectively at the lower and higher temperatures

In melon cv Earl s Favorite Winter No 3, root zone warming to 25°C increased total dry matter production, tissue content of N P and K and the proportion of protein N to total N (Takano, 1991)

Shi *et al* (1991) conducted experiments in green house plants at 25 to 35°C The highest net photosynthetic rate was recorded at 30°C when plants were at an early growth stage and at 35°C during the mid-late growth stage Evapotranspiration was highest at 30 to 35°C when stomatal resistance was the lowest Fruits received the largest quantity of assimilates at 30°C whereas at 35°C the largest quantity of assimilates was distributed to vegetative parts

Bulder *et al* (1991) conducted experiments on three cucumber cultivars and observed that growth at low root temperature was inversely related with the sterol/phospholipid ratio

Markovskaya and Sysoeva (1991) reported that temperature influence dry matter distribution between stem (hypocotyl) and root

Kapitsminadi *et al* (1991) conducted experiments on four cucumber (*Cucumis sativus*) and found that the number of days from sowing to seedling emergence decreased with increasing temperature

Milotay *et al* (1991) studied the germinating capacity of seeds of 15 cultivars at constant and fluctuating temperatures ranging from 15 to 25°C At 17°C significant differences were found in the germination percentage and radicle growth Germinating capacity decreased drastically with temperature Uniform germination could be expected above 17°C and therefore early sowing in cold soil should be avoided

Krug and Liebig (1991) conducted a trial to investigate the effect of soil temperature on cucumber cv Pc ninex From the results, the optimum soil temperature recommended for the 1st (1 week after planting), 2nd (until anthesis) and 3rd (until harvesting) growth phases are 24 16 18 and 15 18°C, respectively and the minimum recommended temperatures for the three phases are 16 14 16 and 12 14°C respectively

Ryloki and Alom (1991) conducted studies on Parthenocarpic fruit set and development in cucurbitaceae under protected cultivation in mild winter climate They observed that the percentage fruit set at night temperature of 8 10°C was much higher than that at 18 20°C At the lower temperatures fruits were seedless and deformed whereas at 18 20° they were well shaped and contained approximately 150 seeds/fruit

Schaffer *et al* (1991) suggested that premature leaf chlorosis in winter grown cucumber plants may be caused by starch accumulation in the chloroplast as a result of the inhibition of starch and soluble sugar export from the leaf by low temperatures

Huyskens *et al* (1992) observed that germination of *Momordica charantia* (Karela) was optimum at temperatures between 25° and 35°C and inhibited at 8°C 12°C 40°C and 45°C It was also reported that more female flowers were being produced in Spring Summer under long days and high temperatures than in Autumn Winter under short days and low temperatures

Grimstad and Frimanslund (1993) studied the effect of different day and night temperature regimes on green house cucumber cv Farbiola An increase in Average Day Temperature (ADT) and Difference in day and night temperature (DIF) increased internode length However, increasing the ADT by only raising the day temperature affected the internode elongation more than an equivalent rise in day and night temperatures An increase in negative values of DIF (ie , lower day temperatures) reduced the number of flower buds to a greater extent than an increase in positive values of DIF The optimum temperature for the seedling development phase based on the earliest harvest date and the early yield, was approximately 25°C Raising the ADT from 15°C to 25°C delayed the earliest harvest date by 1 6 days per 1°C and increased the average total yield during the first 8 weeks after transplanting by 0 54 kg m^{-2} $°C^{-1}$

Marcelis (1993) working with cucumber cv Corona observed that fruit development was closely related to the sum of temperatures after anthesis When fruit growth was not constrained by assimilate supply a decrease in the growing period due to increasing temperature was more than compensated for by a marked increase in growth rate, resulting in increased final fruit weight High temperature (27 5°) had a great effect on fruit growth rate at later stages of development

Marcelis (1993) conducted studies with cucumber cv Corona, grown at 18°C or 25°C and wi ' four intensities of fruit removal He found that fruit dry matter percentage decreased as the number of fruits on a plant increased and was higher at 25°C than at 18°C The higher temperature increase fruit fresh weight/plant but had little effect on fruit dry weight/plant

Kusmetsov *et al* (1993) studied changes in the level of chloroplast transcript in pumpkin cotyledons during heat shock and concluded that increasing the temperature to 46 48°C induced a sharp decrease in transcript levels which correlated with plant damage

Cornillon and Obeid (1993) reported that at low root temperatures the influence of substrate phosphorus concentration is marked by low temperature

Kim *et al* (1994) studied the influence of growth temperature on parthenocarpic fruit set in a late parthenocarpy type cucumber He observed that a low growing temperature (15°C) resulted in the highest average rate of parthenocarpic fruit set 78 per cent at all growth stages The rate was below 50 per cent at 20 25 and 30°C

Marcelis (1994) studied the effect of temperature on fruit shape on cucumber cv Corona and revealed that at 25°C the length circumference ratio increased until four days after anthesis and declined thereafter Increasing the temperature hastened fruit development but when the length, circumference ratio was plotted against the temperature sum, the effects of temperature on the ratio were only small

Root dry weight leaf area and leaf concentrations of most nutrient elements were all reduced as the root temperature was raised to 35°C and to 38°C in particular Du (1994) suggested that disturbance of carbohydrate metabolism in the root is a primary factor responsible for the growth inhibition and dysfunctions of cucumber roots grown at supraoptimal root temperature

Du (1994) studied photosynthate translocation and metabolism in cucumber roots held at supraoptimal temperature Translocation of ^{14}C photo synthates to the roots was faster at 38°C than at 25°C However the amounts of ^{14}C accumulated per unit dry weight of root tissue did not increase, because of increased carbon loss by respiration of the roots at 38°C At 38°C more ^{14}C was allocated to soluble carbon than to insoluble carbon while the reverse was the case at 25°C

Choi *et al* (1994) from an experiment on cucumber opined that a temperature of 22°C and 12°C resulted in the highest and lowest concentrations of NO_3, H_2PO_4 K^+ and Ca^{2+} in the xylem sap respectively The photosynthesis and transpiration were significantly lower at 12°C than at 22°C or 32°C

Markovsakiva (1994) observed that the optimum day and night temperature range for cucumber seedlings (cv Alma Atinskii) was from 28 to 32°C

2 2 2 Effect of temperature radiation and light

Tiedjens (1928) succeeded in materially changing the ratio of staminate to pistillate flowers in 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 v ations 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 females and 92 67 males 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

Danielson (1944) conducted experiments with cucumber grown in contracted diurnal photoperiods of 8 and 12 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 day lengths while maximum stem elongation occurred in the 8 hour day length In contrast to this Hall (1949) reported that in cucumber stem length of long day plants was greater than that of short day plants Long day plants consistently accumulated greater fresh and dry weight than short day plants He also found that maximum staminate flower production on the basis of total number of flowers produced occurred in the 8 hour day

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

Nitch *et al* (1952) observed that high temperatures and long days tended to keep the vines in the male phase, whereas 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 per cent 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

Ito and Saito (1957) noted that short days and low night temperature favoured pistillate flower formation and long days and high night temperature favoured staminate flower formation in cucumber Niller and Ries (1958) found that low temperature (60°F) increased 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 fruits under long day conditions

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 Takushima *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

Buttrose and Sedgley (1978) found that in water melon, increasing light intensity and day length promoted lateral growth, whereas main shoots were less affected

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 Increase 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 at low relative humidity encouraged fruit drop About 30 per cent of female flowers (135 flowers per plant) developed into marketable fruits

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

Rietze and Wiebe (1987) reported at for cucumber cold temperature during light periods caused necrosis or death of the youngest leaves whereas cold temperature in the dark caused chlorosis only in the interveinal region of older leaves

In cucumber, efficiency of assimilated CO_2 conversion into dry matter depended on temperature and photoperiod (Kuree *et al* , 1989) Wacquant (1989) studied the effect of various environmental factors on the growth and development of melon and reported that high light levels were necessary for flower production In cultivars Doublons nd Vedrantiais, fruit development was faster and fruits were larger when the minimum night temperature was 19 C than when it was 15°C Temperature above 35°C 45°C decreased the sugar content and increased the pro portion of glassy fruits

Gueymard *et al* (1989) from their studies on tomato and cucumber noted that the profitability of supplementary lighting was determined at 20-30 w/m^2

In cucumber, plant development was closely related to the accumulated temperature measured at 2 m above the ground The most reliable development stage for estimating harvesting date was DC 61 The precision of the forecast could be further improved b including the amount of sunshine The start of harvest occurs after an accumulation of 950 1000°C if sunshine is about 350 h Higher sunshine levels (400 450 h) require a temperature accumulat n of 1000 1050°C (Scheunemann 1990)

Foti (1991) concluded that supplementary lighting reduced the number of days to the opening of the Ist flower by 15, 9 and 9 days, and increased yields by 67 24 and 14 per cent in *C pepo** and cucumber respectively These yield increases were due to increased number of fruits/plant than increased individual fruit weight

Warrington and Norton (1991) conducted experiments on cucumber cv Triumph grown under 8, 12 18 and 24 h day length and 3 photosynthetic photon fluxes (PPF) They noted that flower node count in cucumber were linearly related to daily quantum integral upto the highest values examined

Gustafasson and Weick (1991) reported that Co_2 uptake by tomato and cucumber crops was linearly related to the intensity of solar radiation It was also observed that the rate of evapotranspiration was dependent on both the solar radia tion intensity and the air moisture deficit of the green house atmosphere Measurements of the full scale green house climate resulted in the development of evapotranspiration calculation models

Suzuki *et al* (1991) from a three year trial with cucumber grown out doors with fluctuating light/dark observed that small or slight negative effects were found on total DW of cucumber cv Samukimidori

Sin *et al* (1991) studied the effects of growth temperature (GT) and light intensity (LI) on Oacental melon and revealed that GT and LI were positively correlated with sugar accumulation Besides fruit weight tended to increase more under low GT and high LI

Jeong *et al* (1991) observed that the rate of cucumber tendril elongation and the rate of free coiling or coiling on contact with the support increased with increasing temperature and decreased when light intensity was reduced by 50 per cent Coiling on contact with the support increased as light intensity increased from 25 to 100 per cent of day light and day length increased from 8 to 16 h

Working with cucumber cv Corona, Marcelis (1993) found that total leaf area and leaf weight/plant were greater at 25°C than at 18°C, though the reverse was true for individual leaf area and weight With increasing light levels from 30 to 100 per cent of full light, the number of fruits and leaves/plant as well as the individual leaf area and weight increased while specific leaf area decreased

Marcelis (1993) working with cucumber, observed that the biomass allocation to the fruits increased with increasing irradiance when plants were treated over an extended period (62 days) In the short term (4 days), the allocation to the fruits did not increase with increasing irradiance The positive long term effect of high irradiance on the biomass distribution to the fruits could be ascribed primarily to an increase in the number of fruits growing at the same time on the plant

Marcelis (1994) conducted experiments on cucumber grown at 18 or 25°C or at three levels of irradiance With increasing irradiance, the dry weight of the vegetative part of the shoot increased, but proportion of the total dry matter distributed to this part decreased In fruit bearing plants, an increase in temperature had no effect on the dry matter allocation to the leaves, stems and petioles, but reduced the allocation to the roots

Widders and Kwantes (1995) opined that expansion growth rates of cucumber fruits as measured by changes in fruit diameters, were most rapid under high nocturnal temperatures (24 or 29°C), full sunlight and regular irrigation

2 2 3 Effect of relative humidity and rainfall

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

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 per cent relative humidity

Pelletier (1969) conducted an experiment on cucumber cv Regina and concluded that high humidities led to increased disease incidence although yield was not affected

Staked cucumber cv Sprint 440 (S) were grown in 4 experiments conducted in the spring (22 March to 13 June) summer (6 June to 9 August) and autumn (23 August to 25 October) of 1985 and ing (14 April to 3 July) of 1987 Irrigation was applied when the soil moisture tension at 6 inches depth reached 30 50 centibars The amount of water applied was 32000 16000, 4000 and 24000 gal/acre for the four periods respectively While rainfall from sowing to harvest was 17 20, 21 5 and 18 inches respectively Yields were significantly increased by irrigation (Hanna and Adams, 1989)

Andreas (1990) conducted an experiment with cucumber cv Corona, sown on 9 January and 23 June 1989 with mean temperature of 20 8 and 21 9°C and mean RH of 72 2 and 71 4 per cent obtained yields of 63 and 23 cucumbers/m^2 respectively

Van (1991) conducted some tests in hot house cucumber and observed that the incidence of mildew (*Erysiphe cichoracearum*) as slightly lower in the misted compartments while the infection rate of stem Botrytis (cinerea) was significantly lower

Bakker (1991) described the response of leaf conductance (in Scm ^{1}) as an empirical non linear function of vapour pr ssure deficit at the leaf surface and solar radiation Results indicated that effects of relative humidity on cuticular conductance may contribute to the increased leaf conductance observed at low vapour pressure deficit

Sanden *et al* (1992) from an experiment on cucumber seedlings (cv Corona) grown at air relative humidities of 55 75 or 95 per cent concluded that relative growth rate increased with increasing air humidity This was attributed to increasing net assimilation rate and stomatal conductance as air humidity increased from 55 to 75 per cent and to increasing specific leaf area as humidity increased from 75 to 95 per cent Leaf water potential changed in parallel with changes in the water potential of the root environment

Oda *et al* (1993) observed that the chlorophyll fluorescence of cucumber seedlings decreased to 5 per cent at 25°C immediately after a high humidity and 46°C treatment The reduction in chlorophyll flourescence was attributed to the high leaf temperature and humidity which depressed inspiration

Adams and Hand (1993) studied the effects of humidity on dry matter High humidity decreased leaf dry weight in cucumber Ca concentration (%) in the leaf DW was reduced by high humidity at day or night

Staub and Navazio (1993) conducted experiments on cucumber cv Corolina under four temperature regimes and concluded that the pillowy fruit disorder symptoms were most severe at high temperature and RH and thus both parameters contribute to the development of this disorder

Kitano *et al* (1994) from an experiment on cucumber cv Chajitsu Ochiaiplants suggested that the control of evaporative demand can be used as a reliable way to manipulate plant water use and dry matter production

Kretschmer (1995) studied the influence of temperature and soil water capacity on the emergence of *Cucumis sativus* L seeds Germination temperatures of 15 20 25 or 30°C were combined with soil moisture at 40, 50, 60, 70 or 80 per cent of water capacity corresponding to soil moisture tensions from pF 3 2 to 2 2 He found that high emergence (86 93%) occurred with all moisture contents at 30°C and 40 50 per cent of water capacity at 25°C At 20°C the emergence fell from 79 to 20 per cent with increasing water capacity There was low emergence at 15 C

Developing fruits of musk melon (cv Galia) were subjected to two relative humidity treatments (22 to 89%) The period from anthesis to harvesting was 39 and 44 days in the high and low RH treatments respectively and the fruit soluble solids content was 10 8 and 12 2° brix respectively The lower RH resulted in lower seed numbers per fruit a lower mean fruit growh rate and smaller fruits (Combrink *et al* 1995)

2 3 Crop weather models

Kirtusingh *et al* (1974) reported that in bhindi yield had negative correlation with days to flower They also obtained positive correlation between yield/plant and flower number, number of branches, plant height and fruits/plant both at phenotypic and genotypic levels

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

Ka anasundaram (1976) reported that fruit weight was positively and significantly correlated with diameter size and flesh thickness of the fruits in musk melon

In bitter gourd Srivastava and Srivastava (1976) noted that yield/plant was positively correlated with number of female flowers number of fruits and number of lateral branches

Ramachandran (1978) found that yield in bitter gourd was highly correlated with length of main vine fruit weight fruit length number of fruits/plant number of female flowers/plant and number of primary branches/plant

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

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 day length

Welter *et al* (1989) studied the effect of thrips infestation on total cucumber yield, mean fruit size and total fruit and observed that as the number of the thrip days increased to a maximum of 45 0/cm^2, total fruit weight was reduced by 54 2 per cent at final harvest He obtained a highly significant linear regression between the total number of thrip days per leaf and the various agronomic variables Total yields for the season were reduced by 10 per cent by the highest level of thrips damage Less total leaf dry weight was associated with heavy feeding damage

Yoshida and Eguchi (1989) working with cucumber seedlings cv Chojitsu Ochiai, reported that temperature effects on gas exchange and on water uptake followed parallel sigmoid curves, the responses decreasing at temperatures below 12° and increasing at temperatures above 16°

Yield data in green house trials, in which planting date harvesting date temperature and amount of radiation varied, were used to develop a model for cucumber growth It was found that the influence of temperature was stronger during the early stages of crop growth than during the harvesting period There was a strong linear relationship between radiation and yield potential (Tesi and Nencini, 1989)

The Hannover approach is one way of developing a planning model with its possibilities and constraints Liebig (1989) collected data from several experiments with radishes cucumbers, lettuces and kohlrabi From fitted growth functions mean growth rates were derived, mean data of temperature, radiation and CO_2 were computed for the same period

Liebig (1989) started to examine the effects of temperature and radiation on yield More than 1500 data points were recorded Results of regression analysis indicated temperature to be less important than radiation

Yang *et al* (1990) studied a green house cucumber crop (cv Mustang) and observed that transpiration rate varied with solar radiation and was not uniformly distributed within the canopy Leaf temperature was lower than air temperature on clear summer days owing to high transpiration rates Stomatal resistance w s computed and was exponentially related to solar energy No significant correlations between stomatal resistance and other climatic variables were found

Schacht and Schenk (1990) developed a model on controlling the nutrient supply to cucumbers (*Cucumis sativus*) Nitrogen uptake during fruiting was linearly correlated with solar radiati n in the range investigated 900 to 4000 Wm^{2} day^{2}

Juzu e and Sakiyam (1991) reported that the amount of CO_2 (R) respired from fruits was proportional to the increment of fruit volume which occurred in the same period (V), with the regression equation The proportionality between R and V indicated that respiration c n be used to monitor, non destructively the fruit growth in terms of dry weight

Marcelis (1992) estimated the percentage of dry matter of a fruit by a regression model with temperature sum, temperature and fruit size as input variables Growth of the fruits could be described by a Richards function for upto 25 days after flowering (at 20°C), well after normal harvest (17-22 d) The relative growth rate based on fresh weight and dry weight increased during the first week after flowering at (20°C) and then declined in a concave manner without being constant for any peri l

Rippen and Krug (1994) estimated the yield of cucumber with lp of models The yield was estimated in the recommended temperature range, as long as plants were not weakened The period from planting to start of harvest as a function of irradiance and temperature was also well described

Marcelis (1994) described the sink strength of each individual fruit as function of its temperature sum after anthesis and the actual temperature and that of the vegetative plant parts as a function of act l temperature only The formation rate of nonaborting fruits is essentially a function of the source sink ratio Results from the model agreed well with the measured fluctuating distribution of dry matter between fruits and vegetative parts

Hamamoto *et al* (1995) estimated the hypocotyl length in cucumber cv Namkyoku No 2 seedlings by quadratic regressions It was highly correlated with day temperature and to a lesser extent with difference between day and night temperature and showed low correlations with average day temperature and night temperature

Materials and Methods

MATERIALS AND METHODS

A field experiment was conducted during 1995 96 at the College of Horticulture llamkkara, to study the crop weather relationship in bitter gourd variety MC 84 The details of the Materials u d and the techniques adopted during the course of the study are briefly discussed below

3 1 Materials

3 1 1 Site climate and soil

The experimental field is situated at 10° 32' N latitude and 76° 10 E longitude with an altitude of 22 25 m above MSL The area enjoys a typical tropical humid climate

The details of the meteorological observations during the experimental period are presented in Table 1 and Fig 2

Composite soil samples from 0 60 cm depth taken before commencement of experiment were used for the determination of physiochemical prope ties and the date are given in Appendix I

3 1 2 Season

The experiment was conducted during the period April 1995 to March 1996

3 1 3 Variety

M C 84

3 1 4 Manures and fertilizers

Farm yard manure was applied uniformly to all the pits as basal dose at the rate of 20 tonnes per hectare Nitrogen (at the rate of 70 kg N/ha), Phosphorus (at the rate of 25 kg P_2O_5/ha) and Potassium (at the rate of 25 kg K_2O/ha) were applied to the crop in the form of urea, superphosphate and muriate of potash respectively P and K were applied basally as single dose However N was applied as 2 splits half as basal and the other half at the time vining

3 2 Methods

3 2 1 Layout

The experiment was laid out in Randomised Block Design with three replications The layout of the experimental field is given in Fig 1 The treatments consisted of 12 times of sowing starting from April 15th and ending the March 15th The details of the different treatments and their notations used are given below

Treatments (sowing dates)	Notation
April 15	D_1
May 15	D_2
June 15	D_3
July 15	D_4
August 15	D_5
September 15	D_6
October 15	D_7
November 15	D_8
December 15	D_9

FIG.1. LAYOUT PLAN

R III	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}
R II	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}
R I	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}

TREATMENTS

Date of sowing (1995-1996)

D_1 - April 15th
D_2 - May 15th
D_3 - June15th
D_4 - July 15th
D_5 - August 15th
D_6 - September 15th
D_7 - October 15th
D_8 - November 15th
D_9 - December 15th
D_{10} - January 15th
D_{11} - February 15th
D_{12} - March 15th

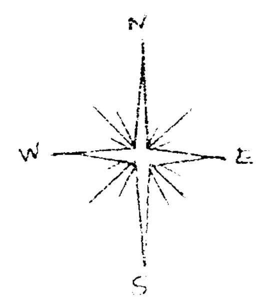
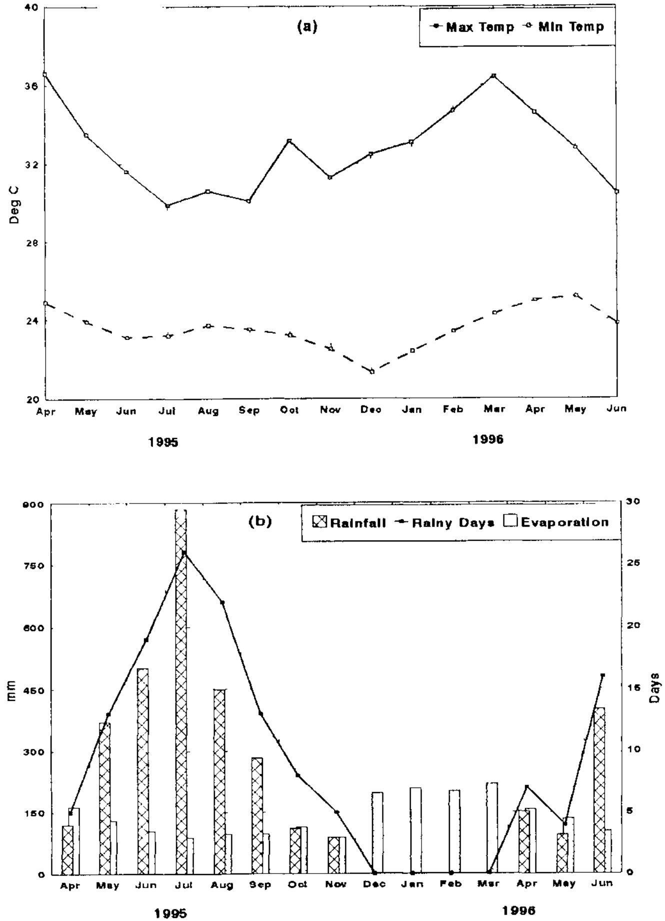


Table 1 Mcan monthly weather parameters for the crop growth period

	Max temp (°C)	Min temp (°C)	RH morning (%)	RH afternoon (%)	Rainfall (mm)	Rainy days	Evaporation (mm)	Sunshine hours	Wind speed (km/hr)
April	[illegible]	24 9	87	55	118 7	5	164 3	9 1	4 7
May	33 [illegible]	23 9	91	65	370 5	13	129 3	6 5	3 5
Junc	31 6	23 1	94	77	500 4	19	103 7	3 7	3 7
July	29 9	23 2	96	81	884 7	26	88 5	2 1	2 1
Aug	30 6	23 7	94	78	448 7	22	96 4	3 7	2 6
Scp	30 1	23 5	94	70	282 5	13	97 7	6 1	4 2
Oct	33 2	23 2	91	65	110 4	8	113 8	8 3	1 3
Nov	31 3	22 5	91	69	88 4	5	89 1	6 5	0 6
Dec	32 5	21 3	71	43	0 0	0	195 9	10 3	3 9
Jan	33 1	22 4	71	35	0 0	0	208 6	9 4	3 3
Feb	34 7	23 4	72	34	0 0	0	200 9	9 9	6 1
March	36 4	24 3	82	37	0 0	0	219 2	9 3	5 5
April	34 0	25 0	87	59	152 0	7	157 1	8 3	1 8
May	32 8	25 2	91	63	95 4	4	135 0	7 7	2 3
Junc	30 5	23 8	94	75	400 3	16	103 4	4 7	2 0

Fig.2 Weather during crop growth period



January 15	D_{10}
February 15	D_{11}
March 15	D_{12}

The plot size was 4 m x 4 m with 4 pits in each plots consisting of 2 plants each The spacing adopted was 2 m x 2 m The experiment was replicated thrice with the total number of experimental plots number 36 For each and every treatment ıc control plot was maintained

3 2 2 Cultural operations

The land was ploughed well foll ed by levelling Then it was divided into 48 plots of size 4 m x 4 m Then 4 numbers of pits were taken in each plot with 30 cm depth and 60 cm diameter with a spacing 2 m x 2 m

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

The seeds were soaked in water overnight and sown on the prescribed dates The seedlings were thinned o three plants per pit, about 15 days after sowing Weeding and irrigation were done as and when required When the plants started running they were trailed on to iron frames having a height of 1 5 m Top dressing of N was done at the time of vining Plant protection measures were taken as and when required using the recommended chemicals

3 2 4 Harvesting

The fruits were harvested as and when they matured by visual judgement

3 2 5 Observations

3 2 5 1 Biometric observations

(a) Length of vine

The length of the vine in cm was recorded on the 30th day, 45th day and 60th day after sowing

(b) Node at which the first female flower appeared

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

(c) Days to maturity

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

(d) Frequency of female flower emergence

The number of female flowers produced per plant on the 45th, 60th, 75th and 90th day after sowing was counted

(e) Number of female flowers

Total number of female flowers produced per plant w[illegible] counted

(f) Number of male flowers

Total number of male flowers produced per plant was counted

(g) Sex ratio

The male to female flower ratio was recorded

(g) Fruit set

The percentage of fruit set was recorded

(i) Number of fruits

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 measurement

(j) Weight of fruit

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

(k) Length of fruit

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

(l) Girth of fruit

Girth was recorded from the top 1/4th bottom 1/4th and the middle of the fruit in cm and averaged for the 10 fruits

(m) Yield

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

(n) Incidence of pest and diseases

Observations on the incidence of major pests and diseases were recorded from the control plot The total number of fruits affected in each and every treatment was counted and the percentage of damage was worked out In order to find out the percentage of infestation on leaves the number of damaged leaves were recorded The method of visual grading was adopted for recording the hopper burn symptoms The percentage of disease intensity was worked out by finding out the ratio between plants affected by mosaic disease to the total number of plants in a treatment The symptoms of downy mildew and leaf spot diseases were graded with appropriate scores and the percentage of disease index was worked out

3 2 6 Weather data

The daily data on the different weather elements recorded from the meteorological observatory of the College of Horticulture, Vellanikkara were used for the study

3 2 7 Statistical analysis

The data obtained from the experiment was analysed statistically as per the methods suggested by Pans and Sukhatme (1978)

Simple correlations were computed between the growth and yield characters with the weekly mean values of maximum temperature, minimum temperature relative humidity and sunshine hours to determine the effect of weather elements on the growth and yield of bitter gourd Regression equations were worked out from these observations Crop weather models are arrived at using the above data

Results

RESULTS

During the course of investigation observation on various biometric characters of bitter gourd variety MC 84 were recorded to study the crop weather relationship The data were subjected to statistical analysis and the results are presented below

4 1 Weather during the crop period

The rainfall maximum and minimum temperature sunshine hours morning and afternoon humidity open pan evaporimeter values rainy days and wind speed are furnished in Table 1

4 2 Biometric observations

4 2 1 Length of vine at 30 DAS

The mean length of vine at 30 45 and 60 DAS are given in Table 2 As evident from the table date of sowing had a significant influence on vine length The crop sown during April recorded the highest vine length of 127 cm at 30 DAS followed by the crops sown during February March January and December The lowest vine length was observed in the case of July sown crop (98 cm) which was followed by the crops sown during September June, October and August

4 2 2 Length of vine at 45 DAS

The highest vine length was observed in the case of April sown crop (274 3 cm) which was followed by the crops sown during February March

Table 2 Effect of date of sowing on length of vine at 30th 45th and 60th days after sowing

Treatments	Vine length (cm)		
	30 DAS	45 DAS	60 DAS
Date of sowing			
April 15	127 0	274 3	481 0
May 15	112 3	257 0	452 7
June 15	102 0	248 3	441 0
July 15	98 0	244 7	435 0
August 15	108 3	253 0	449 0
September 15	100 3	247 0	439 3
October 15	105 0	250 3	446 0
November 15	111 0	254 7	451 0
December 15	116 3	262 0	462 0
January 15	117 0	263 0	464 0
February 15	124 7	270 0	476 3
March 15	120 0	267 3	471 0
SEm +	4 2	5 9	11 4
CD	12 23	17 3	33 5

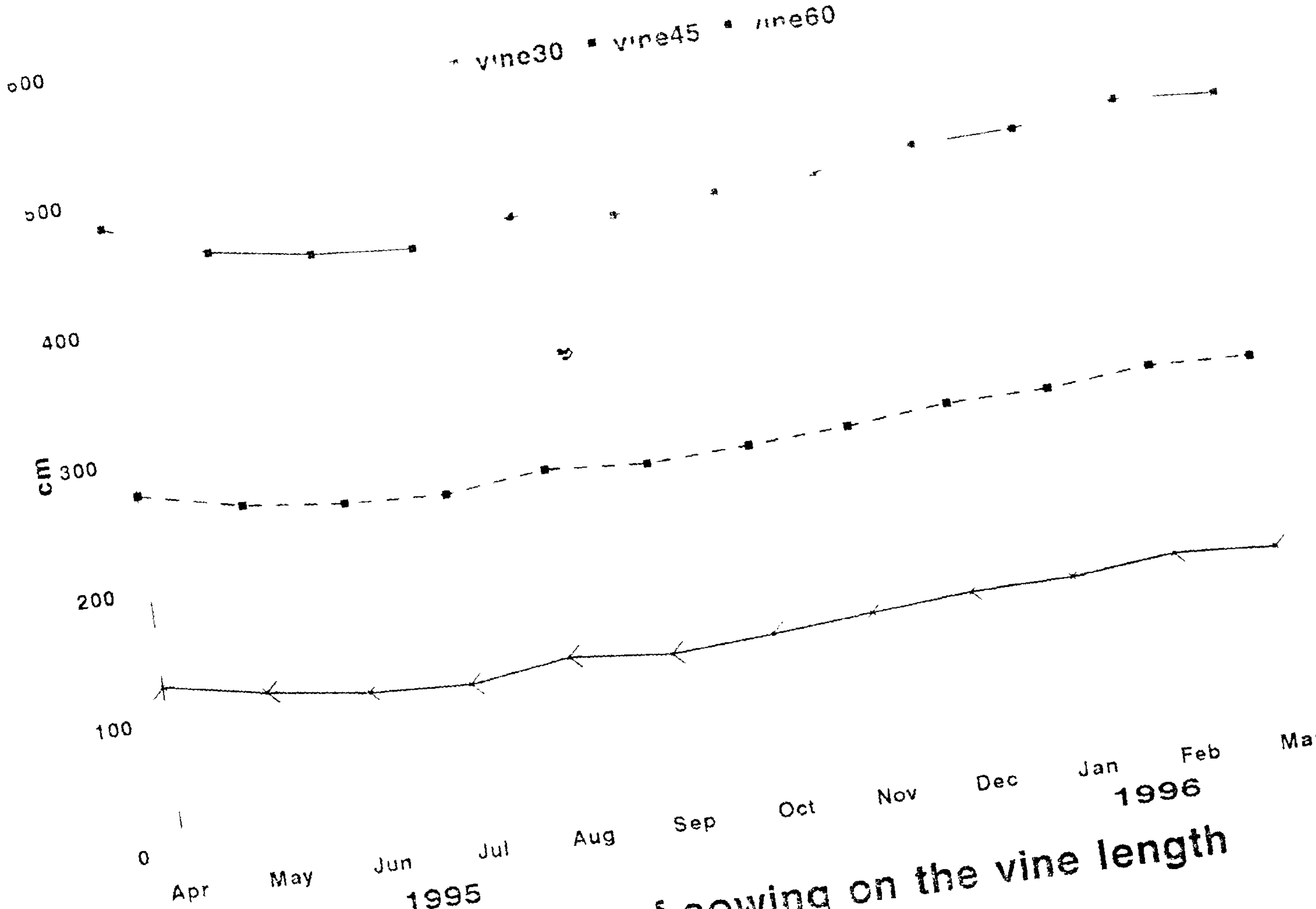


Fig. 3 Effect of date of sowing on the vine length

January December and May respectively The lowest vine length was recorded in July sown crop (244 7 cm)

4 2 3 Length of vine at 60 DAS

The length of vine at 60 DAS also showed a similar trend as that of 30 and 45 DAS The highest vine length was recorded in the case of April sown crop (481 cm) It was followed by the crops sown during February March January December May November and August The lowest vine length was observed in the July sown crop (435 cm) and all other treatments were on par with one another

4 2 4 Node at which the first female flower was produced

The mean values of the node at which the first female flower was produced are presented in Table 3

As evident from the table the node at which the first female flower was produced showed significant variation depending on the different dates sowing The lowest node was recorded in case of February sown crops (14 nodes) It was followed by the crops sown during January December March, November and October The sowing taken during June registered the maximum number of nodes (20 nodes) for the production of the first female flower

4 2 5 Days to picking maturity

The mean number of days taken to attain picking maturity from flowering are given in Table 3

Table 3 Effect of date of sowing on node at which first female flower was produced and the days to picking maturity

Treatments	Node at which first female flower was produced	Days to picking maturity
Date of sowing		
April 15	18	15
May 15	20	17
June 15	20 3	15 7
July 15	19	15 7
August 15	19	13 7
September 15	18 3	15
October 15	16 7	15
November 15	16 7	13 7
December 15	16	14 7
January 15	16	13 3
February 15	14	13 3
March 15	16 3	13 7
SEm ±	1 20	0 58
CD	3 52	1 71

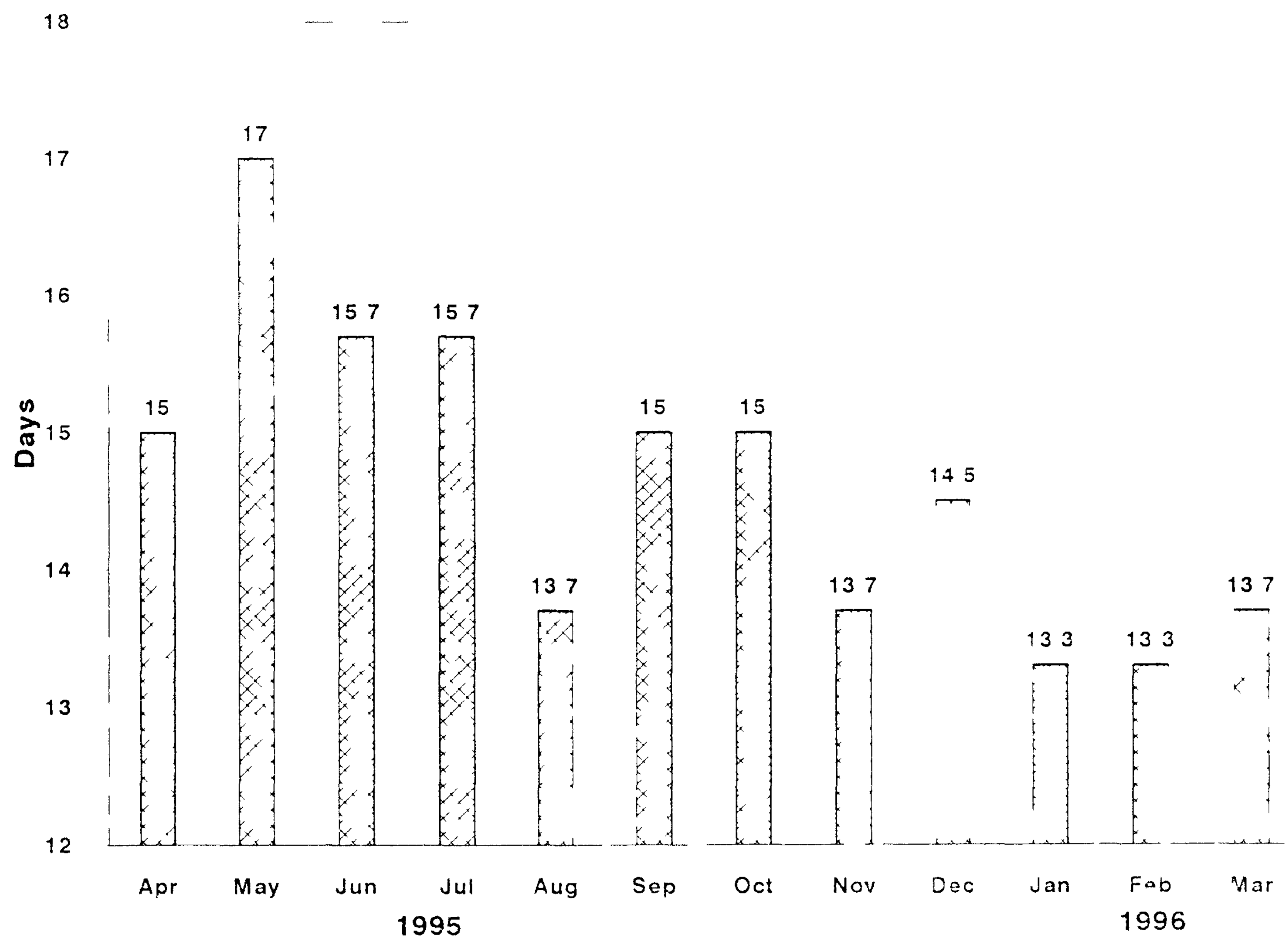


Fig. 4 Effect of date of sowing on days to picking maturity

As clear from the table the date of sowing significantly influenced the picking maturity The lowest number of days for fruit maturity was observed when the crops were sown during January and February (13 days each) followed by November, August, March, December, October, September and April respectively All the other treatments recorded higher values and the highest number of days for fruit maturity was recorded in May sown crop

4 2 6 Frequency of female flower emergence

The mean number of female flowers produced per plant on 45th 60th 75th and 90th days after sowing are given in Table 4

The crops sown during January and February recorded the highest number of female flowers at 60 DAS and 45 DAS respectively The highest number of female flowers at 75 DAS and 90 DAS was observed in October sown crops

4 2 7 Number of female flowers

The data on the number of female flowers per plant are given in Table 5

It is clear from the table that the dates of sowing significantly influenced the number of female flowers Crops sown during October recorded highest number of female flowers (29 numbers) and was on par with the January sown crop The crop sown during May recorded the lowest number of female flowers (20 number) which was on par with the other treatments

4 2 8 Number of male flowers

The data relating to the mean number of male flowers produced per plant is given in Table 5

Table 4 Effect of date of sowing on frequency of female flower emergence

Treatments	Number of female flower/plant			
	45 DAS	60 DAS	75 DAS	90 DAS
Date of sowing				
April 15	1 8	10 3	21 0	21 0
May 15	0 7	8 7	13 8	20 2
June 15	0 7	7 5	16 3	21 0
July 15	1 2	9 7	16 8	20 3
August 15	1 3	10 0	21 2	22 3
September 15	1 0	7 5	16 5	21 0
October 15	1 2	10 2	21 8	29 0
November 15	1 5	11 0	21 7	22 3
December 15	1 3	10 0	20 5	21 8
January 15	1 2	12 2	21 5	26 2
February 15	2 0	11 7	21 7	21 7
March 15	1 7	10 5	20 7	21 3

Table 5 Effect of date of sowing on number of female flowers and male flowers per plant and sex ratio

Treatments	Number of flowers/plant		Sex ratio
	Female	Male	
Date of sowing			
April 15	21 0	567	27 3
May 15	20 2	404	20 0
June 15	21 0	456	22 0
July 15	20 3	507	25 0
Agusut 15	22 3	518	23 4
September 15	21 0	500	24 0
October 15	29 0	644	22 4
November 15	22 3	586	26 3
December 15	21 8	595	27 3
January 15	26 2	558	21 7
February 15	21 7	542	25 2
March 15	21 3	546	26 0
SEm ±	1 4	7 7	1 4
CD	4 1	22 6	4 1

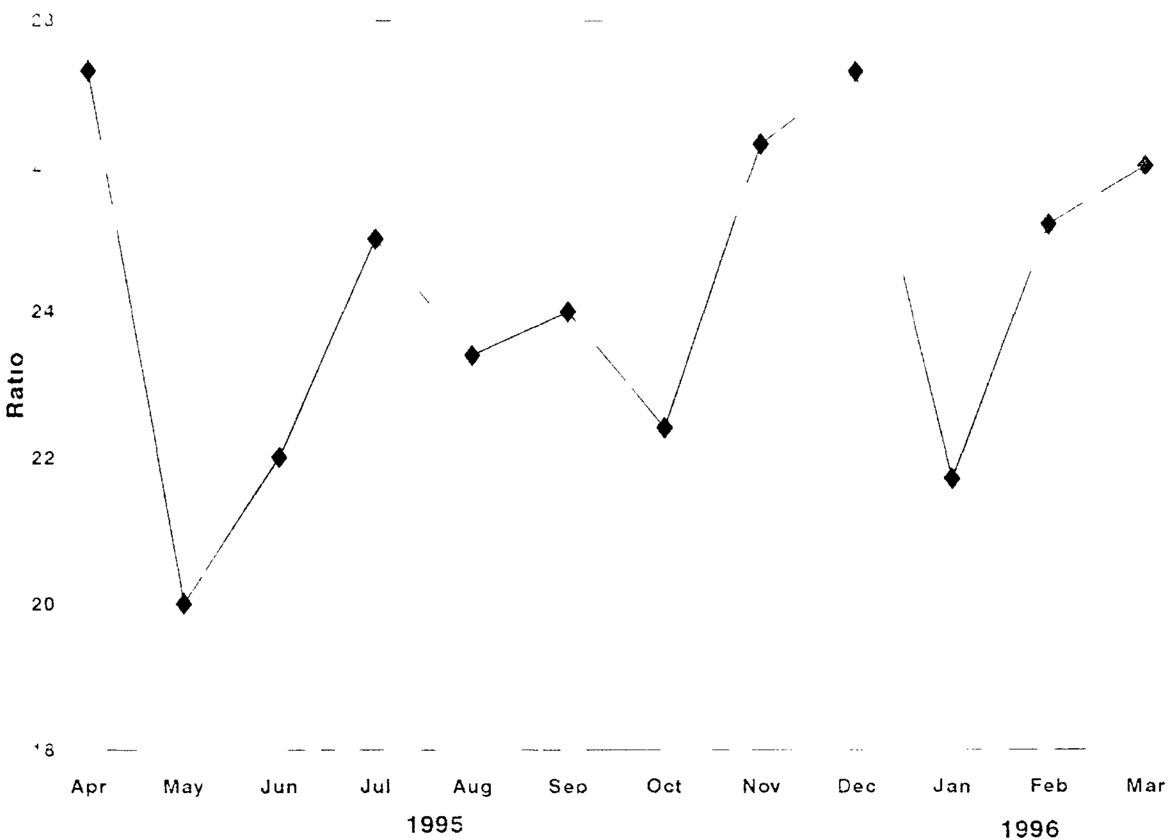


Fig. 5 Effect of date of sowing on sex ratio

As evident from the table, the dates of sowing significantly influenced the male flower production The crops sown during October recorded highest number of male flowers (644 flowers) The crops sown during May, recorded the lowest number of male flowers (404 flowers)

4 2 9 Sex ratio

The mean value of sex ratio for the different treatments are given in Table 5 There was significant difference in the value of sex ratio among different dates of sowing The crops sown during April and December recorded the highest sex ratio (27 3) which was followed by November, March, February July September and August respectively The crop sown during May registered the lowest sex ratio (20) followed by crops sown during January, June and October respectively

4 2 10 Number of fruits

The mean number of fruits for the different treatments are presented in Table 6 The mean number of fruits was significantly influenced by the time of sowing The crops sown during October recorded the highest fruit number (23 fruits) and was followed by January sown crop The lowest fruit number was observed during May and July sown crops (15 fruits) and the other treatments were on par with one another

4 2 11 Fruit set

The mean values of fruit set are given in Table 6 There was significant

Table 6 Effect of date of sowing on number of fruits per plant and percentage of fruit set

Treatments	Number of fruits/plant	Fruit set (%)
Date of sowing		
April 15	15.5	73.8
May 15	14.5	71.9
June 15	15.5	73.8
July 15	14.5	71.3
August 15	17.0	76.1
September 15	15.5	73.8
October 15	23.0	79.3
November 15	17.5	78.3
December 15	16.5	75.5
January 15	20.3	77.6
February 15	15.5	71.6
March 15	15.0	70.3
Sem ±	1.1	0.4
CD	3.2	1.1

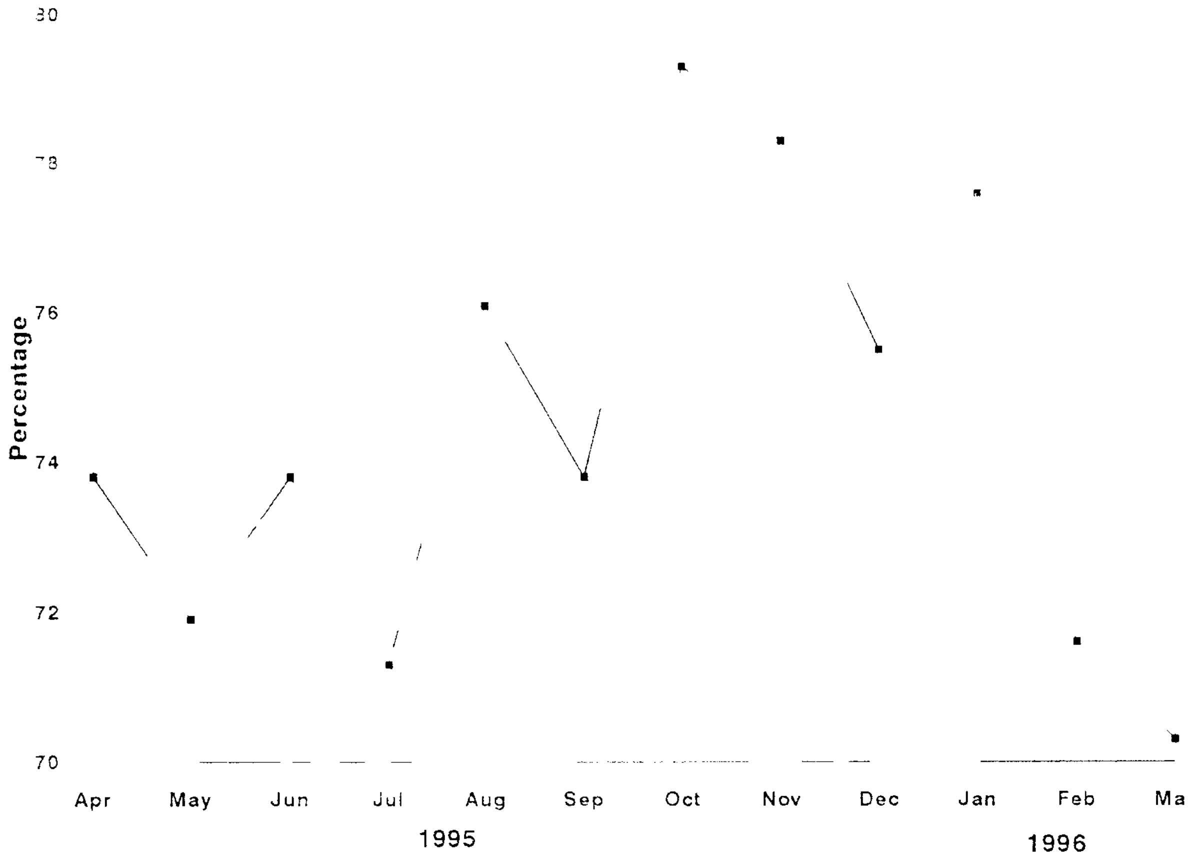


Fig. 6 Effect of date of sowing on fruit set

difference in the fruit set among different dates of sowing The crops sown during October recorded the highest fruit set (79 27 per cent), which was on par with November sown crops The sowing taken during March recorded the lowest fruit set (70 33 per cent), which was on par with October sown crops

4 2 12 Length of fruit

The mean values for fruit length are given in Table 7 The fruit length varied significantly with the dates of sowing The crops sown during October recorded the highest fruit length (24 7 cm) and was on par with the crops sown during December January, August November, April and September respectively All other treatments were significantly inferior to the above treatments

4 2 13 Girth of fruit

The data pertaining to the girth of fruit are presented in Table 7 The effect of dates of sowing on the girth of fruit was not significant However, January sown crops registered highest fruit girth (16 3 cm) followed by December sown crops The lowest girth value (13 3 cm) was recorded in May sown crops

4 2 14 Weight of fruit

The mean values for the weight of fruits are given in Table 7 The mean weight of fruit was highest in October sown crop (88 g) and was followed by the crops sown during January, November December, August April and September The lowest fruit weight was observed in July sown crops

Table 7 Effect of date of sowing on length, girth and weight of fruit

Treatments	Fruit characters		
	Length (cm)	Girth (cm)	Weight (g)
Date of sowing			
April 15	21 0	15 0	81
May 15	16 7	13 3	71
June 15	19 0	14 6	74
July 15	17 3	14 0	71
August 15	22 3	15 7	83
September 15	20 7	15 0	78
October 15	24 7	15 7	88
November 15	21 3	15 7	85
December 15	24 3	16 0	84
January 15	23 0	16 3	85
February 15	18 7	14 7	73
March 15	18 3	14 3	72
SEm ±	1 4	1 1	4 1
CD	4 2	3 3	12 0

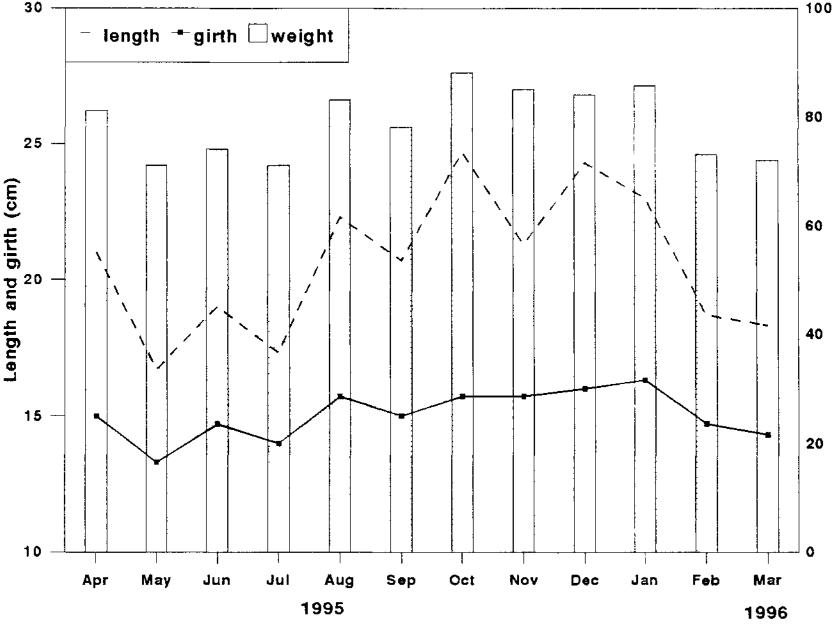


Fig. 7 Effect of date of sowing on fruit characters

Table 8 Effect of date of sowing on yield in kg/plant and t ha^{1}

Treatments	Yield	
	kg/plant	t ha^{1}
Date of sowing		
April	1 25	9 4
May	1 01	7 6
June	1 15	8 6
July	1 03	7 7
August	1 41	10 6
September	1 21	9 1
October	2 03	15 2
November	1 49	11 2
December	1 38	10 3
January	1 60	12 0
February	1 14	8 5
March	1 08	8 1
SEm ±	0 06	0 5
CD	0 09	0 7

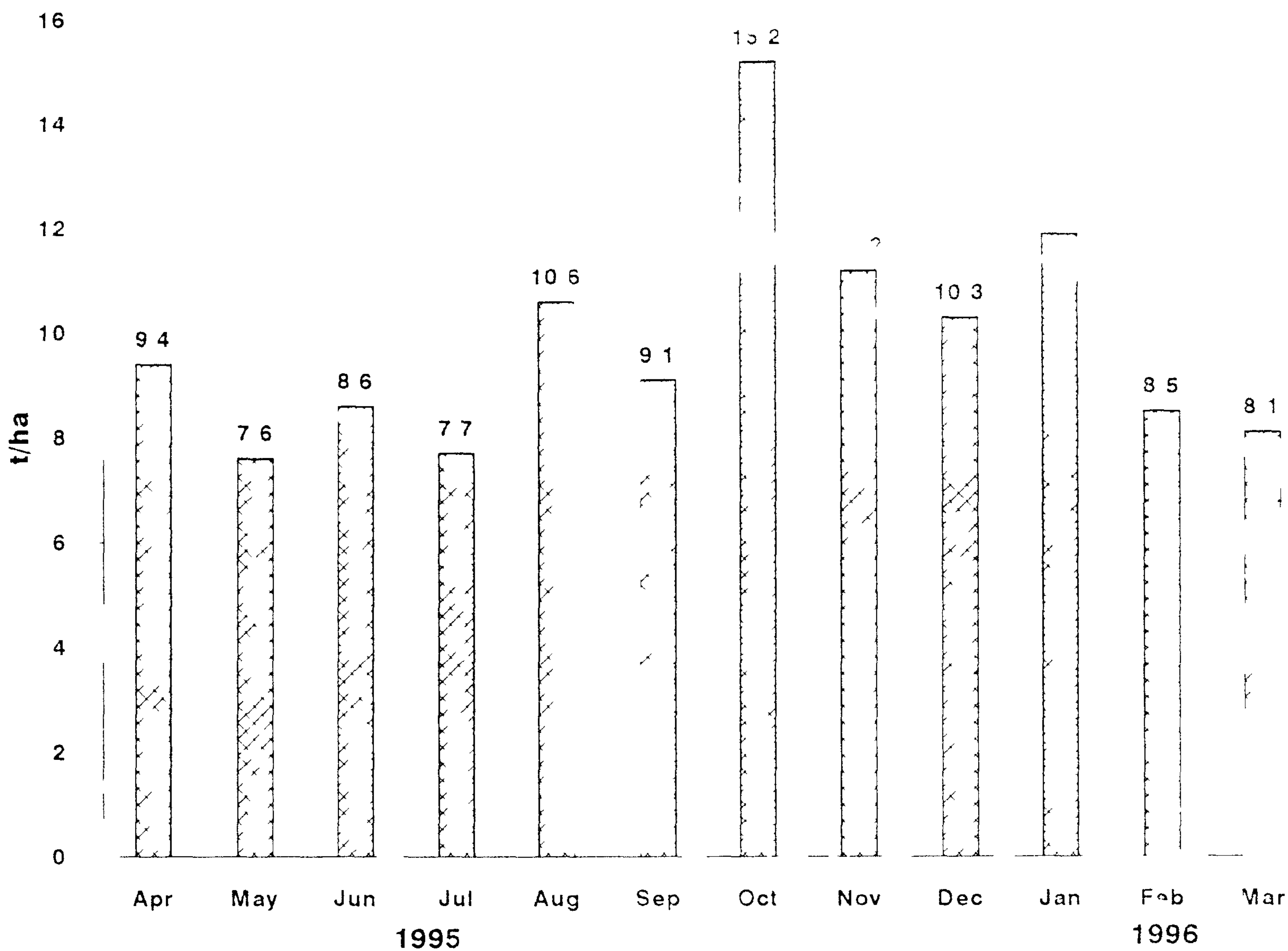


Fig. 8 Effect of date of sowing on yield

4 2 15 Yield

The mean values of the yield in kg per plant and t ha^{1} are given in Table 8 The highest yield was recorded in the October sown crop (15 24 t ha^{1}) which was significantly superior to all the other treatments This was followed by January and November sown crops respectively The lowest yield was produced by May sown crops (7 6 t ha^{1}) Regarding the other treatments, an average yield was recorded

4 2 16 Crop weather relationship

Simple linear correlation between important morphological and yield characters viz total number of female flowers produced & yield (t/ha) and important weather parameters like maximum and minimum temperature, temperature range, sunshine hours, morning relative humidity, afternoon relative humidity, mean relative humidity, rainfall and wind speed was worked out It was found that the temperature range during 45 to 65 days after sowmg and sunshine hours during 45 to 55 days after sowmg were positively correlated with both total yield and total number of female flowers Minimum temperature and rainfall during 45 to 55 days after sowing and humidity (both morning and mean) during 45 to 65 days after sowing were negatively correlated with both total yield and number of female flowers The correlation coefficients for these are given in Table 9 and 10

Because of the multi colinearity of the variables, only four variables were selected ie , minimum temperature, temperature range, sunshine hours and morning humidity while working out the regression equation Multiple regression equation with the above four weather parameters resulted in a reasonably better

Table 9 Correlation coefficients between yield and weather parameters

Weather element	Correlation coefficients Period	 Yield (t/ha)
Maximum temperature	45-65 DAS	0 455
Temperature range	do	0 815**
Humidity (morning)	-do-	0 752**
Humidity (afternoon)	do	0 389
Humidity (mean)	do	0 712**
Minimum temperature	45 55 DAS	-0 775**
Rainfall	do	683*
Sunshine hours	do	0 781**
Wind speed	-do-	0 429

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

Table 10 Correlation coefficients between number of female flowers per plant and weather parameters

Weather parameters	Correlation coefficients	
	Period	Total number of female flowers
Maximum temperature	45-65 DAS	0 519
Temperature range	do	0 778**
Humidity (morning)	do-	0 678*
Humidity (afternoon)	do	-0 258
Humidity (mean)	do-	-0 665*
Minimum temperature	45-55 DAS	0 617*
Rainfall	do-	0 583*
Sunshine hours	do	0 733**
Wind speed	do	0 280

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

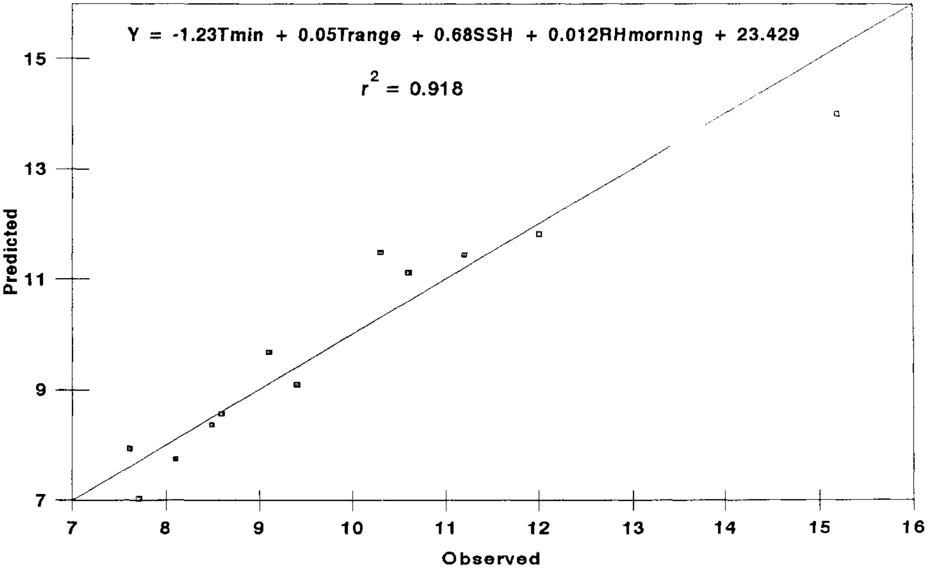


Fig. 9 Observed and predicted yield (t/ha) of bittergourd

Table 11 Actual and estimated yield in t ha [1]

Treatments	Yield	
	Observed	Predicted
Date of sowing		
April 15	9 4	9 1
May 15	7 6	7 9
June 15	8 6	8 6
July 15	7 7	7 0
August 15	10 6	11 1
September 15	9 1	9 7
October 15	15 2	14 0
November 15	11 2	11 5
December 15	10 3	11 5
January 15	12 0	11 8
February 15	8 5	8 4
March 15	8 1	7 8

predictor of fruit yield with higher coefficient of determination The regression equation for total yield was

Y = 1 23 Tmin + 0 05 Trange + 0 68 SSH + 0 012 RHmorning + 23 429

r^2 0 918

where Y = yield in t/ha

The estimated yield using the regression equation and the actual observed values are given in Table 11 and Fig 9

4 2 17 Effect of date of sowing on the incidence of pest

Incidence of the following pests was observed in the control plot

Major pests

1) Fruit fly	*Bactrocera cucurbitae* (Coq)
2) Pumpkin caterpillar	*Eudioptes indica* (Saund)
3) Pod caterpillar	*Helicoverpa armigera* (Hb)
4) Epilachna beetle	*Henosepilachna vigintioctopunctata* (F)
5) Leaf hopper	*Amrasca biguttula biguttula* (Ischida)

The percentage of pest infestation are given in Table 12 The crop sown during April met with the severe incidence of the pest *Bactrocera cucurbitae* (Coq) while in the case of September, October and November sown crops, there was no incidence at all The incidence of *Eudioptes indica* (Saund) was observed in all the treatments and was found to be severe in crops sown during March, April and May Crops sown during August, September and October were infested by *Helicoverpa*

Table 12. Incidence of pests

Treatments	% of infestation of fruits			% of infestation of leaves	
	Bactorcera sp	*Eudiopetes* sp	*Helicoverpa* sp	*Amrasca* sp	*Henosepilachna* sp
Date of sowing					
April 15	24 13	27 00	0 00	0 00	26 00
May 15	20 68	24 13	0 00	0 00	0 00
June 15	16 13	22 58	0 00	0 00	0 00
July 15	10 87	17 39	0 00	0 00	0 00
August 15	8 82	20 58	5 88	0 00	0 00
September 15	0 00	16 13	19 35	0 00	12 00
October 15	0 00	13 80	13 80	13 33	0 00
November 15	0 00	11 43	0 00	18 66	0 00
December 15	6 06	15 15	0 00	38 66	0 00
January 15	9 67	19 35	0 00	58 00	0 00
February 15	16 13	22 58	0 00	49 33	0 00
March 15	20 00	23 33	0 00	31 33	0 00

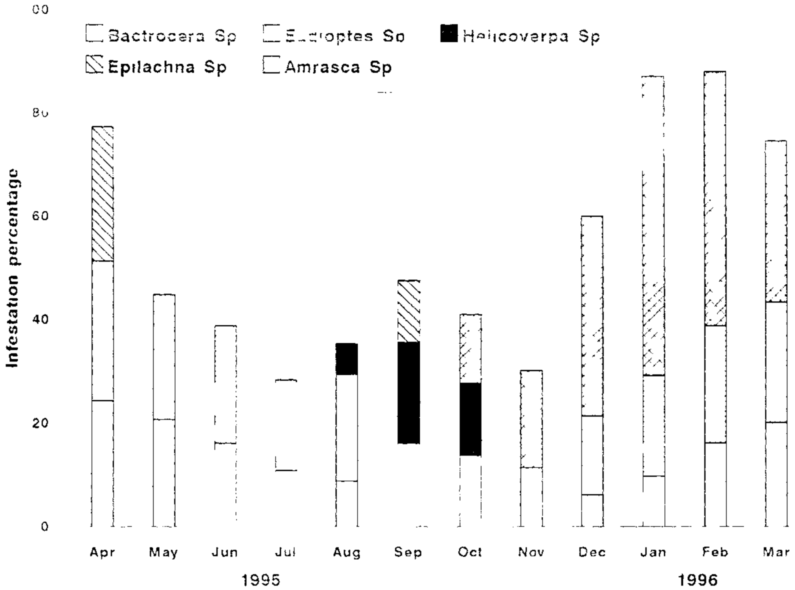


Fig. 10 Effect of date of sowing on incidence of pests

Table 13 Effect of date of sowing on incidence of diseases

Treatments	% of disease index		
	Cucumis mosaic virus I	*Pseudopernospora* sp	*Colletotrichum* sp
Date of sowing			
April 15	7 14	0 00	19 33
May 15	3 57	26 00	26 00
June 15	0 00	48 00	0 00
July 15	0 00	29 33	0 00
August 15	0 00	15 33	0 00
September 15	0 00	0 00	0 00
October 15	7 14	0 00	0 00
November 15	10 70	0 00	0 00
December 15	17 85	0 00	0 00
January 15	25 00	0 00	0 00
February 15	28 57	0 00	0 00
March 15	14 00	0 00	0 00

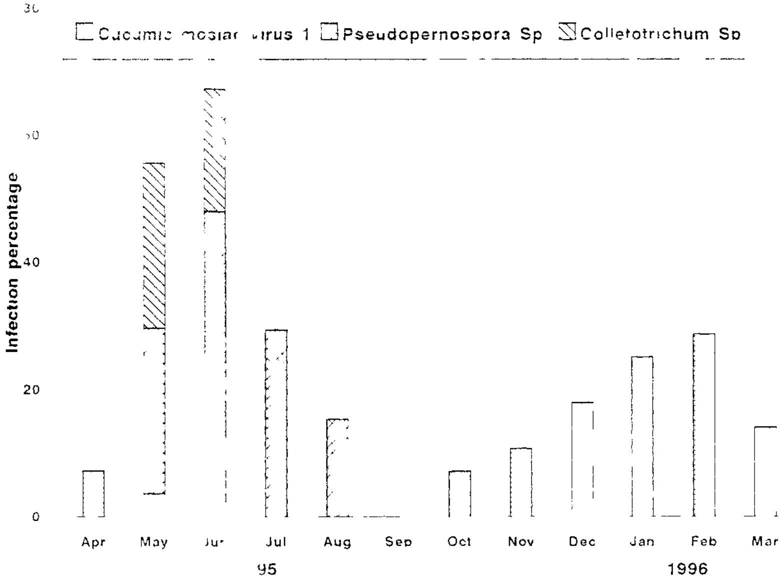


Fig. 11 Effect of date of sowing on incidence of diseases

armigera (Hb) The crops sown during December, January and February showed severe hopper burn symptoms caused by *Amrasca biguttula biguttula* (Ischida) The incidence of the pest *Heinosepilachna vigintioctopunctata* (F) was observed in the crops sown during April and September

4 2 18 Effect of date of sowing on the incidence of disease

Incidence of the following diseases was observed in the control plot

1) Mosaic disease — *Cucumis* virus I

2) Downy mildew — *Pseudopernospora cubensis* (B & C)

3) Anthracnose — *Colletotrichum* sp

The percentage of disease index are given in Table 13 The crops sown in January and February were severely infected with mosaic virus I The occurrence of the disease downy mildew caused by *Pseudopernospora cubensis* (B and C) was observed in the crops sown during May, June, July and August The anthracnose disease caused by *Colletotrichum* sp was observed in May and June sown crops

Plate 1 Experimental field

Plate 2 October sown crop

Plate 1

Plate 2

Plate 3 January sown crop

Plate 4 Fruits - October sown crop

Plate 3

Plate 4

Discussion

DISCUSSION

The present investigation was taken up with a view to determine the effect of various weather elements on the growth and yield of bitter gourd variety MC-84 The results of the experiments detailed m the previous chapter are discussed here under

5 1 Biometric observations

5 1 1 Length of vine

The sowings during April, February, March, January and December recorded significantly higher vine length at 30, 45 and 60 DAS The maximum temperature (32 35°C), minimum temperature (22-25°C), sunshine hours (7-10 hrs) and relative humidity (52 76%) during the vegetative phase favoured the elongation of vine The growth difference due to variation in weather was noted by Hall (1949), Surlckov and Ivanov (1978) and Heij (1981) in cucumbers, Buttrose and Segley (1978), Desai and Patil (1984) m water melon, Jeong *et al* (1991), Huyskens *et al* (1992) and Sanden *et al* (1992)

5 1 2 Node at which the first female flower was produced

The time of sowing exerted significant effect on the node at which the first female flower was produced When the crop was sown during February the first female flower appeared on 14th node While when the crop was sown during June the first female appeared on 20th node The highest mean maximum temperature (36 2°C) during the vegetative phase fastened the appearance of the first female

Table 14 Mean meteorological parameters prevailed during vegetative and reproductive phases of bitter gourd

Months	Maximum temp °C		Minimum temp °C		Temperature range °C		Sunshine (hrs)		Relative (%)		Rainfall (mm)	
	Veg	Rep	Veg	Rep	Veg	Rep	Veg	Rep	Veg	Rep	Veg	Rep
April	34 8	32 5	24 6	23 1	2 3	4 7	7 2	5 3	76	82	116 2	81 7
May	32 6	30 1	23 3	23 3	9 3	6 8	5 6	2 4	82	89	106 8	177 4
June	30 3	30 7	23 0	23 7	7 3	7 0	2 5	3 9	89	86	168 8	128 2
July	30 3	30 5	23 4	23 6	3 4	6 9	3 1	4 2	87	85	154 7	108 1
Aug	30 6	33 0	23 6	23 2	7 0	9 8	4 3	8 5	85	78	109 0	8 1
Sep	32 3	32 6	23 2	22 8	9 1	9 8	7 8	6 7	80	80	28 6	35 0
Oct	32 2	32 4	22 8	21 4	9 4	11 0	7 1	10 3	80	59	30 4	0
Nov	32 0	32 9	21 7	22 4	10 3	10 5	9 5	9 5	67	54	0 1	0
Dec	32 6	34 2	22 1	22 9	10 5	11 3	9 7	9 9	56	51	0	0
Jan	34 1	36 4	22 8	24 4	11 3	12 0	9 6	8 9	52	59	0	0
Feb	36 2	34 7	24 1	25 0	12 1	9 7	9 5	8 0	56	73	0	30 4
March	35 5	33 1	24 9	25 3	10 6	7 8	7 9	8 2	70	77	22 8	21 1

Veg Vegetative phase, Rep Reproductive phase flower The position of female flower on the vine depends on sunshine hours and night temperature (Nitch *et al* , 1952) But Warringten and Norton (1991) reported that flower node count in cucumber were linearly related to sunshine hours

5 1 3 Days to maturity

The May sown crop took more days to picking maturity Vooren and Challa (1978) indicated that in cucumbers, earliness was strongly affected by sowing dates and night temperatures The lower maximum temperature (30 1°C), and lower sunshine hours (2 4 hrs) during the reproductive phase delayed the days to picking maturity Similar observations were made by Drews *et al* (1980), Heig (1981), Slack and Hand (1981) m cucumber

5 1 4 Number of female flowers produced

At both 75 and 90 DAS, the October sown plants produced greater number of female flowers This may be due to more sunshine hours (10 3 hrs) and low minimum temperature (21 4°C) experienced during the flowering period Effect of date of sowing on female flower production was reported by Edmond (1930), Nitch *et al* (1952), Venketram (1963), Matsuo (1968), Kamalanathan and Thamburaj (1970), Cantliffe (1981), Ying and Li (1990)

5 1 5 Number of fruits per plant

Among the various sowings, October sowing produced considerably higher number of fruits This is due to the highest fruitset (80%), favoured by the availability of more sunshine hours (10 3 hrs), low minimum temperature (21 4°C), high morning relative humidity (80%) and lower afternoon relative humidity (59%)

It is interesting to note that the October sown crop has experienced suffieicent amount of rainfall during the vegetative growth stage and a dry period during the flowring stage No other treatment has this combination of weather, which may be the reason for the higher fruit set Difference 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)

5 1 6 Length of fruit

Plants sown in October produced longer fruits than the later sowings The higher sunshine hours (10 3 hrs) and the lower minimum temperature (21 4 °C) experienced during pre-bearing period by the October sowing caused the increase in length This view was supported by the work of Miller and Ries (1958)

5 1 7 Girth of fruit

January sown plants produced fruits with the highest girth (16 3 cm) The increase in girth may be due to the higher maximum temperature (36 4 °C) during the reproductive phase

5 1 8 Weight of fruits

The plants sown in October produced fruits with higher mean weight (88 g) The influence of favourable weather conditions for carbon assimilation is the reason for the higher fruit weight in October This was supported by Gustafasson and Weich (1991), Juzuke and Sakiyam (1991) and Marcelis (1992) The higher sunshine hours (10 3 hrs), the lower minimum temperature (21 4 °C), high morning relative humidity (80%) and lower afternoon humidity (59%) during the reproductive phase increased the fruit weight Similar variation in fruit weight due to difference in planting date was reported by Sin *et al* (1991)

5 1 9 Yield

Plants sown in October produced significantly higher yield (15 2 t ha ^{1}) The lowest value was recorded by the plants sown during May (7 6 t ha ^{1}) This decrease in yield can be attributed to a more or less similar 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 Availability of more sunshine (10 3 hrs) and the effect of cool nights (minimum temperature 21 4°C) during the reproductive phase might be the cause for the highest fruit set, fruit size and fruit weight Effect of sowing dates on the yield was recorded by Kartalov (1970), Kmiecik and Lisiewska (1981) in cucumbers and by Khristov (1983) and Desai and Patil (1984) in melons

5 1 10 Crop weather relationship

Each crop species will have a threshold level of optimum temperature requirement, below and above of which a disturbance is induced in the metabolic processes The trend of temperature was always on higher side particularly during summer season Progressive increase in day temperature must have impaired the different morpho physiological processes and enzymatic behaviour controlled by thermal mechanism In addition, higher temperature would demand the plant to undergo higher photorespiration rates, the result of which might reflect in reduced accumulation of net assimilates (Yang *et al* , 1990) Sometimes, very high temperature as seen during summer season cause dehydration of stigma resulting in abortion of flowers and decreased fruit set efficiency The overall impact of the higher temperature, limits the potential productivity of the crop

In general, the maximum temperature had a positive effect on the crop throughout the crop period This was supported by Marcelis (1994) The effect is more predominent during the flowering stage However, the correlation was statistically not significant Choi *et al* (1994) reported that photosynthesis and transpiration were significantly lower at low temperatures Where as the minimum temperature had a strong negative influence The impact of minimum temperature on bitter gourd was marked during summer season and marginal during the other period The minimum temperature during 45-55 days after sowing had the highest negative correlation with both the yield and total number of female flowers per plant This view was supported by the work of Wilcox and Pfeiffer (1990)

Relative humidity during reproductive phase negatively influenced the yield of the crop It is clear from the data that higher humidity during the reproductive phase decreased the yield of bitter gourd It is interesting to note that though the same trend is seen, afternoon humidity had no significant correlation with both the yield and number of female flowers per plant On the contrary to the above Andreas (1990) reported that yield increased with rise in relative humidity

Sunshine hours during different phenophases had strong impact on the growth and yield of bitter gourd particularly Solar energy is a source of photo energy required for photosynthesis as well as thermo energy required for the morphogenetic process of plants Sunshine hours during the crop period posi tively influenced the performance of crop both directly and in association with other weather parameters Eventhough the variety of bitter gourd taken in the study was considered as photoperiod insensitive, the sunshine hours had considerable impact on the performance of crop by altering the growth and yield components in a favourable way with increased periods of day length The sunshine hours during 45 55 days after sowing were positively correlated with the yield and the number of female flowers per plant This was supported by Tesi and Nencini (1989) and Marcelis (1993)

Heavy rainfall during the flowering period caused pollen shedding and the fruit set percentage was decreased The rainfall during 45-55 days after sowing was negatively correlated with the yield and the number of female flowers per plant

Wind speed had no significant correlation with the yield and number of female flowers per plant

The regression equation for the total yield was

Y = 1 23 Tmin + 0 05 Trange + 0 68 SSH + 0 012 RHmorning + 23 429

where Y = yield in t/ha

Liebig (1989) proved that temperature has less importance than radiation Rippen and Krug (1994) estimated the yield with the help of models The vegetative growth can be estimated by quadratic regressions (Hamamoto *et al* , 1995)

5 1 11 Pests and diseases

All the crops were attacked by pest and diseases during flowering and fruit set (Palumbo *et al* , 1991) Crop sown during September, October and

November were free from the attack of *Bactrocera cucurbitae* (Coq), while *Eudioptes indica* (Saund) occurred throughout the year Mosaic disease incidence was severe in crops sown from December to February and downy mildew disease was severe in crops sown during June September sown crop was free from all diseases Pelletier (1989) reported that high humidities led to increased disease incidence, this was supported by Staub and Navazio (1993) Contrary to the above Van (1991) observed that the disease was lower in the misted compartments

Summary

SUMMARY

An experiment was conducted at the College of Horticulture Vellanikkara to study the crop weather relationship in bitter gourd, variety MC 84 during 1995 96 The biometric observations of the crop characters, flowering and yield attributes were recorded at different stages of development of the crop The incidence of pest and diseases was observed in the control plot 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 influenced by the sowing time Sowing on April 15th produced plants with the highest vine length

2 February sown crops took the least number of nodes for female flower production

3 January and February sown plants took the least number of days to reach picking maturity

4 February sown plants consistently produced the highest number of female flowers at 45 DAS

5 January sown plants produced the highest number of female flowers at 60 DAS

6 October sowing gave significantly higher number of female flowers at 75 and 90 DAS

7 Maximum number of male flowers was recorded from the plants sown during October

8 The crops sown during April and December recorded the highest sex ratio

9 October sowing produced significantly higher number of fruits

10 The crops sown during October recorded the highest fruit set

11 October sowing was significantly superior in increasing the fruit length

12 The highest girth fruit was recorded from October sowing

13 The mean weight of fruit was hig est in October sown crop

14 The sowing taken during October gave significantly higher yield

15 The crop weather relationship studies showed that the temperature range during 45 65 days after sowing and sunshine hours during 40 60 days after sowing were positively correlated with both total yield and number of female flowers per plant While minimum temperature during 45 60 DAS and mean relative humidity during 45 70 DAS were negatively correlated with both total yield and number of female flo vers per plant

16 The crop sown during April met with severe in idence of the pest *Bactrocera cucurbita* (Coq)

17 The incidence of *Eudioptes indica* (Saund) was observed in crops throughout the year

18 Crop sown during December January and February showed severe hopper burn symptoms due to *Amrasca biguttula biguttula* (Ischida)

19 M aic disease was severe in crop sown during January and ebruary

20 The downy mildew disease was severe in the crops sown during June, July August and September

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* Originals not seen

Appendices

APPENDIX 1

Soil characteristics of the experimental site

Fraction	Per cent composition	Procedure adopted
1 Mechanical composition		
Coarse sand	16 18	Robinsons International Pipette method
Fine sand	27 10	
Silt	10 00	
Clay	36 20	
Textural class		I S S S System
2 Physical constants of the soil		
Field capacity (0 3 hars)	19 23	Pressure Plate apparatus
Moisture percentage at 15 bars	10 90	Pressure Plate apparatus
Bulk density ($g\ cm^{-3}$)	1 41	Core method
Particle density ($g\ cm^{-3}$)	2 18	Pycnometer method
3 Chemical properties		
Organic carbon (%)	0 47	Walkley and Black rapid titration method
Available Nitrogen ($kg\ ha^{-1}$)	0 058	Alkaline permanganate method
Available Phosphorus ($kg\ ha^{-1}$)	0 003	Chlorostannous reduced molybdophospherous blue colour method in hydrochloric acid system
Available Potassium ($kg\ ha^{-1}$)	0 008	Flame photometry, Neutral normal ammonium acetate extraction
Soil reaction (pH)	5 4	Soil water suspension of 1 2 5
Electrical conductivity ($mmhos\ cm^{-1}$)	0 35	Soil water extract of 1 2 5

APPENDIX II

Analysis of variance for vine length 30 DAS, 45 DAS, 60 DAS node at which the the first female flower was produced and the days to picking maturity

Source	Degrees of freedom	Mean square				
		Vine length			Node at which first female flower was produced	Days to picking maturity
		30 DAS	45 DAS	60 DAS		
Replication	2	184 75	322 11	1079 36	7 195	0 75
Treatment	11	269 61*	279 66*	679 42*	10 69*	3 16*
Error	22	52 17	103 81	390 88	4 315	1 023

* Significant at 5% level

APPENDIX III

Analysis of variance for the number of female flowers number of male flowers sex ratio, number of fruits and fruitset

Source	Degree of freedom	Mean square				
		Number of female	Number of male	Sex ratio	Number of fruits	Fruitset
Replication	2	23 88	165 08	22 80	13 78	0 056
Treatment	11	20 42*	12410 25*	17 07*	19 63*	26 11*
Error	22	0 265	178 08	5 71	3 48	0 397

* Significant at 5% level

APPENDIX-IV

Analysis of variances for the length, girth and weight of fruits and yield (kg/plant)

Source	Degree of freedom	Mean square			
		Length of fruit	Girth of fruit	Weight of fruit	Yield kg/plant
Replication	2	6 03	4 78	54 53	2 34
Treatment	11	21 14*	2 33	121 36*	14 33*
Error	22	6 18	4 81	49 89	0 639

* Significant at 5% level

CROP WEATHER RELATIONSHIP
STUDIES IN
BITTER GOURD

By
P. LINCY DAVIS

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirements for the degree of

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Department of Agricultural Meteorology
COLLEGE OF HORTICULTURE
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1996

ABSTRACT

CROP WEATHER RELATIONSHIP STUDIES IN BITTER GOURD VARIETY MC 84

An experiment was conducted during 1995 96 at the College of Horticulture Vellanikkara to find out the optimum date of sowing and to study the crop-weather relationship in bitter gourd variety MC 84 The experiment was laid [illegible] randomised [illegible] with [illegible] replications The treatments consisted [illegible] twelve dates of sowing starting from April 15th 1995 and ending in March 15th 1996 For each and every treatment one control plot was maintained

The biometric observations of the crop growth characters, flowering and yield attributes were taken at different stages of development of the crop The observations on the incidence of pests and diseases were recorded from the control plots The observations on weather elements were recorded daily

[illegible] significantly superior to other [illegible] number of female flower production number of fruits fruit set fruit length [illegible] weight and yield

The crop weather relationship studies showed that the temperature range during 45 to 65 DAS and sunshine hours during 40 60 DAS were positively correlated with both total yield and number of female flowers per plant while minimum temperature during 45 60 DAS and mean relative humidity during 45 70 DAS [illegible] related [illegible] both total yield and number of [illegible] flowers per plant

Crop sown during September, October and November were free from the attack of *Bactrocera cucurbitae* (Coq.). While *Eudioptes indica* (Saund.) occurred throughout the year. Mosaic disease incidence was severe in crops sown from December to February, downy mildew disease was severe in crops sown during June. But September sown crop was free from diseases.