CATALOGUING AND IDENTIFICATION OF PROMISING ASHGOURD ECOTYPES IN RELATION TO SEASON AND MATURITY

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that the thesis entitled **'Cataloguing and identification of promising ashgourd ecotypes in relation to season and maturity'** 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 or other similar title, of any other University or Society.

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CERTIFICATE

Certified that the thesis entitled **'Cataloguing and identification of promising ashgourd ecotypes in relation to season and maturity'** is a record of research work done independently by **Ms.P.Mini Menon,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the Advisory Committee of **Ms.P.Mini Menon,** a candidate for the degree of **Master of Science in Horticulture** agree that the thesis entitled **'Cataloguing and identification of promising ashgourd ecotypes in relation to season and maturity'** may be submitted by Ms.P.Mini Menon, in partial fulfilment of the requirement for the degree.

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Mini Menon

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To my beloved parents

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Introduction

INTRODUCTION

Ashgourd [*Benincasa hispida* (Thumb.) Cogn.] occupies a prominent position among the tropical cucurbitaceous vegetables cultivated in Kerala. Its synonyms are hairy melon, winter melon, ash pumpkin, white pumpkin, chinese preserving melon, wax gourd and white gourd. Fruits contain on an average 96.7% moisture, 1.9 g carbohydrate, 0.4 g protein, 0.1 g fat, 0.06 mg thiamine, 0.01 mg riboflavin, 1 mg vitamin C, 36 mg calcium, 0.8 mg iron and 10 cal of energy per 100 g of edible portion (Gopalan *et al.*, 1994).

The fruit of ashgourd is cooked as a vegetable and when ripe it is used for preparing the sweet delicacy-petha. The fruit also finds use as laxative, diuretic and antipyretic and in naturopathy treatment. The ayurvedic nerval tonic 'Kushmandarasayanam' is prepared from the immature fruits of small types of ashgourd. Seeds could be a potent source of vegetable oil and protein. There is great potential for the crop to be used as a nutritious cattle feed.

In spite of its economic importance, very little attempt has so far been made to improve the crop. The present day ashgourd ecotypes are non-descript ones and vary widely in their genetic characters because of the high rate of cross pollination. There is need to catalogue these ecotypes which help in selecting the high yielding ones.

The success of any breeding programme aimed at evolving high yielding varieties with superior quality fruits depends mainly on the extent of available genetic variability. In selecting an elite ecotype one should be reasonably sure that there is a good chance of superiority of selection being inherited by the progenies.

This can be ascertained by partitioning the total variability into heritable and non-heritable components with the aid of appropriate statistical methods. Information on heritability of polygenic characters and relation among yield and yield contributing characters are the pre-requisites for any crop improvement programme.

Performance of the same ecotypes is often at variance with the growing season. The weather conditions that prevail during the growing season exerts a profound influence on the growth and yield of ashgourd and on the incidence of pest and disease. A combination of temperature, sunshine hours, humidity etc. determines the growth, duration and productivity. The effect of meteorological parameters on the crop can be studied by changing 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 at right time, the growth and yield of the crop can be enhanced with no extra effort on the part of farmers. The occurrence of pest and disease also will be minimum.

Farmers generally harvest ashgourd before full maturity for the fresh market. Picking of first set fruits generally removes the inhibition for further set. The presence of developing fruits on a plant usually limits future fruit set, presumably due to the competition for food (Greulach, 1973). Data on the influence of periodicity of harvests and right fruit maturity for maximum yield potential of the crop is not available.

In ashgourd only a meagre work has so far been done on these directions. Therefore the present investigation was undertaken with the following objectives.

1. To catalogue and to find out the extent of variability among ashgourd ecotypes.
2. To estimate heritability, genetic advance and phenotypic and genotypic correlation coefficients.
3. To determine the direct and indirect effects of component characters on yield by utilizing path coefficient analysis.
4. To select a high yielding ecotype from the available collections.
5. To study the effect of weather parameters on yield to arrive at an optimum time of sowing.
6. To study the influence of periodicity of harvests and maturity of fruits on the expression of yield potential of the crop.

Review of Literature

REVIEW OF LITERATURE

The literature on the research topic "Cataloguing and identification of promising ashgourd ecotypes in relation to season and maturity" are reviewed under the following heads.

2.1 Genetic parameters

2.1.1 Variability

A wider variability for sex ratio in watermelon (*Citrullus lanatus* Thunb. Mansf.) and muskmelon (*Cucumis melo* L.) was reported by Whitaker (1930). Thakur and Nandpuri (1974) studied the variability in watermelon and reported significant differences among the varieties for length of vine, branches per plant, sex ratio, fruits per plant, fruit weight, yield per plant, seeds per kilogram of fruit weight and 100 seed weight.

In bittergourd Srivastava and Srivastava (1976) obtained variability for all the characters except male flowers per plant. The highest genotypic coefficient of variation (37.45) was recorded for fruits per plant followed by yield per plant (32.13).

Ramachandran (1978) worked on 25 bittergourd types and found significant differences among the types for primary branches per plant, length of main vine, node at which first female flower appeared, days to opening of the first female flower, female flowers per plant, per cent of female flowers, yield per plant, fruits per plant, fruit weight, length of fruit, girth of fruit, flesh thickness, seeds per fruit and 100 seed weight.

In an experiment conducted to measure the extent of variability in eighteen pumpkin genotypes, Gopalakrishnan (1979) observed considerable variability among yield and its component characters like days to first female flower anthesis, days to first male flower anthesis, length of main vine, male flowers per plant, female flowers per plant, per cent of female flowers, average fruit weight, weight of first mature fruit, fruits per plant and per cent of fruit set. The maximum value of genotypic coefficient of variation was observed for male flowers per plant followed by fruits per plant.

High genotypic coefficients of variation for fresh weight of fruits, yield per plant and fruit length were recorded by Indiresh (1982) in bittergourd.

While studying the yield and related characters in 18 lines of pointed gourd (*Trichosanthes dioica* Roxb.), Singh *et al.* (1986) observed significant differences for all characters including days to flowering, days to fruit set, days to ripening, fruits per plant, fruit length and yield.

When nine agronomic characters were studied in 95 diverse stock of muskmelon (*Cucumis melo* L.), fruits per vine, flesh thickness and yield per vine showed the greatest genotypic coefficient of variation (Vijay, 1987).

Hamid *et al.* (1989) evaluated nine local germplasms of ashgourd [*Benincasa hispida* (Thumb.) Cogn.] and observed a wide range of variability for vine growth, flowering habit, fruit bearing, fruit weight and size.

High genetic variability was observed by Rajendran and Thamburaj (1994) among 30 indigenous and exotic genotypes of watermelon. The genotypes showed variation in 11 biometric traits. Similar studies were conducted by Thakur *et al.* (1994) in bittergourd in which mean square estimates for genotypes were significant for all the characters studied.

Another experiment conducted by Katiyar *et al.* (1996) in bittergourd indicated that all characters showed variation in various genetical parameters. The phenotypic coefficient of variation (pcv) for yield per plant showed the maximum variation followed by length of main vine. Genotypic coefficient of variation was minimum for female flower and maximum for yield per plant.

When twenty one diverse bittergourd genotypes were evaluated for eleven characters, Rajput *et al.* (1996) found a large variation for yield and its components both at the phenotypic and genotypic level.

Germplasm of various cucurbits including pumpkin, watermelon, cucumber, bottlegourd, bittergourd and muskmelon were evaluated at Pantnagar. High variability was shown for days to first male flower (except in muskmelon), days to first female flower, number of nodes at which first male or female flower emerged, vine length (except in muskmelon), number of primary laterals, number of nodes on main vine, number of fruits per plant and fruit length, breadth and weight (Ram *et al.*, 1996).

2.1.2 Heritability and genetic advance

Genetic advance provides the degree of improvement in performance of selected lines over the original population (Lush, 1949).

Thakur and Nandpuri (1974) reported high heritability estimates for length of plant, sex ratio, number of fruits per plant, fruit weight, total soluble solids, number of seeds per kilogram of fruit and 100 seed weight in watermelon. The heritability estimate was 92.92 per cent for 100 seed weight and 84.97 per cent for seeds per kilogram of fruit. Low heritability estimates were reported for number of branches per plant, number of days to fruit harvest and yield per plant of which the minimum was for number of branches per plant (25.95%). Expected genetic advance was high for number of seeds per kilogram of fruit.

According to Srivastava and Srivastava (1976) fruits per plant in bittergourd had the highest estimate of genetic advance (71.73%) and heritability (99.31%). Male flowers per plant recorded the lowest estimate of genetic gain (16.73%) and heritability (49.93%). Fruit weight, yield per plant and length of fruit had high heritability along with high genetic gain.

Fruits per plant in bittergourd recorded the highest heritability of 99.80 per cent and the lowest was recorded by seeds per fruit (43.37%). Genetic advance was found to be highest for yield per plant (81.93%). High heritability along with high expected genetic advance was observed for yield, fruits per plant and female flowers per plant (Ramachandran, 1978).

Brar and Nandpuri (1978) reported that the characters like yield, duration of female flowering and number of female flowers per plant in watermelon which showed low estimates of narrow sense heritability were highly susceptible to environmental fluctuations.

Gopalakrishnan (1979) recorded the highest heritability estimate of 99.14 per cent for male flowers per plant followed by per cent of female flowers and female flowers per plant in pumpkin. The lowest heritability estimate of 76.97 per cent was observed for per cent of fruit set.

Solanki and Seth (1980) opined that the characters with high heritability and high genetic advance implies additive gene effects which can be improved by selection.

In bittergourd, Indiresh (1982) observed high heritability estimates for leaf number per plant, leaf area, vine length, fresh fruit weight, length, girth and volume of fruits. Yield per plant and days for fruit development had low heritability estimates.

When variability and correlation studies were conducted in nineteen lines of pumpkin, high estimates of heritability and genetic advance were obtained for vine length and percentage fruit set (Rana, 1982). Variability and heritability studies in watermelon by Vashistha *et al.* (1983) showed that heritability estimates were high for all characters except yield per plant.

In sponge gourd (*Luffa cylindrica* Roem.), Prasad *et al.* (1984) obtained high heritability and genetic advance for yield, number of fruits and fruit size. Similar observations were recorded by Singh *et al.* (1986) in pointed gourd (*Trichosanthes dioica* Roxb.) in which fruits per plant, fruit length and yield showed high heritability and genetic advance.

Heritability and genetic advance were high for fruits per vine, total soluble solids, flesh thickness and yield per vine in muskmelon (Vijay, 1987).

Rajendran (1989) observed higher estimates of heritability and genetic advance for yield per vine, 100 seed weight, sex ratio, average fruit weight and number of seeds per fruit in watermelon and these traits were recommended for use as selection criteria.

Thakur *et al.* (1994) conducted genetic variability and heritability studies in bittergourd and obtained very high heritability in broad sense for all characters which ranged from 56.41 to 87.79 per cent. High heritability was recorded for total yield, marketable yield and fruit fly infestation.

The heritability estimates obtained by Rajput *et al.* (1996) in bittergourd were high for almost all the yield and related characters. The joint consideration of genetic advance and heritability suggested that all the characters were controlled by additive gene effects except days to first harvest which was under non-additive gene control. Wehner and Cramer (1996) found that fruit yield, earliness and quality have low to moderate heritability but were traits of major importance in cucumber.

In a genetic evaluation and correlation study in cucumber, De-Paiva (1997) concluded that heritability was lowest for fruit number and highest for quality index. High heritability values were also obtained for number of fruits greater than 18 cm in length.

2.1.3 Correlation

In bittergourd (*Momordica charantia* L.), Singh (1953) stated that there was no significant relationship (i) between the number of staminate and pistillate flowers and (ii) between nodal position of first staminate flower and sex ratio.

Thamburaj and Kamalanathan (1973) recorded in pumpkin and ashgourd, significant and positive correlations between incidence of female flowers at lower nodes and the number of female flowers per vine and between flowering at lower nodes and earliness of flowering. The sex ratio was positively correlated with incidence of female flowers at lower nodes and with early appearance of female flowers.

Srivastava and Srivastava (1976) reported that in bittergourd fruit yield per plant was positively associated with female flowers per plant ($r_g = 0.87$), fruits per plant ($r_g = 0.86$) and lateral branches per plant ($r_g = 0.59$). Female flowers and lateral branches per plant were found positively associated with fruits per plant. Days to first female flower opening was negatively correlated with fruits per plant and female flowers per plant but positively with fruit weight. A negative correlation existed between number of fruits per plant and individual fruit weight.

Yield in bittergourd was highly correlated with length of main vine, fruit weight, fruit length, number of fruits per plant, number of female flowers per plant and number of primary branches per plant. Number of seeds per kilogram of flesh showed negative correlation with yield (Sidhu and Brar, 1981).

According to Indiresh (1982) yield in bittergourd was positively and significantly correlated with number of leaves per plant, leaf area, fresh weight of fruit, length, girth and volume of fruits and length of vine.

Rana (1982) found a highly significant positive association with yield per plant for female flowers per plant, fruit number, fruit weight and flesh thickness in pumpkin. Correlations between most yield components were positive and significant.

Correlation studies of five varieties of melons conducted by Salk (1982) revealed that total fruit yield per plant was positively correlated with number of fruits per plant and negatively correlated with fruit weight. Positive correlations were found between flesh thickness, fruit weight and fruit diameter but selection for the last two characters did not necessarily result in greater flesh thickness in fruits of a given diameter.

Earliness in bittergourd and bottlegourd was associated with higher fruit weight and yield, and with larger number and size of fruits in bittergourd. Fruit weight and size were more correlated with yield than with fruit number (Pal and Vani, 1986). Singh *et al.* (1986) observed that in pointed gourd, yield was positively and significantly correlated with fruits per plant (r = 0.95) and length of vine (r = 0.60). Days to flowering, days to fruit set and days to ripeness were negatively correlated with all other related characters, with the exception of a positive correlation between days to flowering and fruit weight.

A study of 30 diverse genotypes of cucumber by Choudhary and Mandal (1987) revealed high positive correlations at the genotypic and phenotypic levels between yield per plant and number of fruits, female flowers per plant, fruit length and fruit weight. These characters along with fruit diameter were the most important characters determining yield.

When 20 cultivars of *Trichosanthes dioica* were grown, Singh *et al.* (1987) observed that yield was significantly correlated with length of fruit (r = 0.59), diameter of fruit (r = 0.51) and weight of seed (r = 0.48). Days to flowering was negatively correlated with seed size (-0.69), length of fruit was significantly correlated with fruit diameter (0.54), fruit weight (0.71) and seed number per fruit (0.50), diameter of fruit with fruit weight (0.55), seed size (0.55) and seed weight (0.54), pulp thickness of fruit with seed size (0.73), weight of fruit with seed number per fruit (0.74) and weight of seed (0.61).

Studies on morphological and agronomical components of pointed gourd by Prasad and Singh (1990) indicated positive correlations of yield with lateness in flowering and number of seeds per fruit with fruit weight.

Amaral *et al.* (1994) reported in pumpkin that the genotypic estimates showed better correlation than the phenotypic and environmental, with all pairs of characters showing positive genotypic correlation (r > 0.75).

When Chen *et al.* (1994) compared seven monoecious cucumber cultivars for four parthenocarpic yield components there were significant positive correlations between number of pistillate flowers, number of parthenocarpic fruits and yield, and between parthenocarpic yield, number of fruits and average single fruit weight. Damarany *et al.* (1995) observed a negative relationship between total yield and relative early yield in summer squash (*Cucurbita pepo* L.).

In cucumber Ma *et al.* (1995) reported that total yield had a significant positive correlation with total fruit number (r = 0.84 or 0.83), fruit growth rate (r = 0.66 or 0.67) and average fruit weight (r = 0.42 or 0.41). Stem diameter and plant height also had an effect on total yield. This was in accordance with the observations by Neikov and Alexandrova (1995) in cucumber where the yield was significantly correlated with fruit number and weight.

The genotypic and phenotypic correlation study of 21 bittergourd genotypes by Paranjape and Rajput (1995) revealed that yield was mainly contributed by number of fruits per vine, average fruit weight, fruit length and number of female flowers. The physiological attributes like vine length, primary branches and average leaf area were mutually associated and had effects on yield.

Saikia *et al.* (1995) conducted correlation studies in eight genotypes of cucumber and observed that yield per plant had strong positive association with main vine length, number of secondary branches, leaf area, fruiting percentage, number of fruits per plant, fruit weight and fruit length both at genotypic and phenotypic levels. De-Paiva (1997) obtained high phenotypic and genotypic correlation coefficients between yield and number of fruits having a length greater than 18 cm.

2.1.4 Path coefficient analysis

Srivastava and Srivastava (1976) reported that female flowers per plant had the maximum direct effect on yield (2.75) followed by fruits per plant (0.90) and lateral branches per plant (0.89) in bittergourd. The indirect effects of other characters towards yield were mainly through lateral branches per plant, fruits per plant and female flowers per plant. Fruits per plant also had high indirect contribution towards yield through weight of fruits.

Ramachandran (1978) observed that fruit weight (0.55), fruits per plant (0.40) and length of main vine (0.30) had high positive direct effects on yield, and primary branches per plant, female flowers per plant and fruit length had negative direct effects on fruit yield. When 25 quantitative characters were examined by Gopalakrishnan *et al.* (1980) in 18 genetically distinct types of pumpkin, main stem length and average fruit weight proved to have the greatest direct effects on yield.

Path coefficient analysis in watermelon by Sidhu and Brar (1981) revealed that the number of nodes to the first female flower and flesh weight had high positive direct effect on fruit yield. Rana (1982) conducted path coefficient analysis in pumpkin and found that the magnitude of direct effects of the characters studied on yield depended on environment.

In parwal, days to flowering, fruit diameter, fruit weight, size of fruit and weight of seed had direct effects on yield while fruit length, pulp thickness and seed number per plant had indirect effects (Singh *et al.*, 1987). Vijay (1987) obtained strong direct effect for fruits per vine and fruit weight on yield in musk melon. This was in agreement with the findings of Saikia *et al.* (1995) in cucumber.

An analysis of data on 10 yield traits in watermelon by Rajendran and Thamburaj (1989) indicated that mean fruit weight had a marked direct effect on fruit yield while number of fruits per stem, harvest index, number of seeds per fruit and leaf index on 60th day contributed indirectly to yield. Solanki and Achal Shah (1989) employed path analysis in cucumber which revealed that internodal length, number of female flowers and days to maturity had a positive highly significant direct effect on fruit yield.

Chen *et al.* (1994) could obtain a direct effect for the number of pistillate flowers on yield in cucumber which was much lower than its indirect effect on number of fruits. Paranjape and Rajput (1995) reported that fruit weight had maximum direct bearing on yield in bittergourd. However, vine length, primary branches, nodes on main axis, leaf area, fruit length, number of fruits per vine and seed content indirectly contributed towards yield.

2.2 Effect of date of sowing on growth and yield

2.2.1 Effect on vegetative stage

Lint and Heij (1982a) conducted an experiment to investigate the effects of lower and varying night temperatures on cucumber. Plants of the cultivar Farbio were planted on 13th or 27th December and 10th or 24th January and grown at 3 minimum night temperatures 12°C, 16°C or 20°C from planting until 1st April. The number of nodes per stem increased as the night temperature fell and internodes were longer with later planting.

In cucumber Schroder and Drews (1982) recommended economic planting dates as January end to mid February.

Desai and Patil (1984) reported that in watermelon the length of vine was significantly reduced in plants sown on 20th January and the number of leaves were highest in vines of 30th December sowing. When cucumbers were grown on 13th or 27th December and 10th or 24th January at 3 night temperatures 12°C, 16°C or 20°C, Heij and Lint (1985) found that leaf development was faster at higher temperature and with later planting.

After sowing watermelon cultivar Arka Manik at fortnightly intervals between 1st December 1982 and 1st February 1983, and between 1st November 1983 and 1st February 1984, Naik (1991) observed that sowing from 1st November to 1st December gave better plant establishment.

2.2.2 Effect on reproductive stage

In bittergourd, year round planting at monthly intervals revealed that September sown plants yielded best and had the highest proportion of pistillate flowers. August was the next most favourable month for sowing (Srinivasan *et al.*, 1976).

Vooran *et al.* (1978) studied the influence of varying night temperatures on cucumber and found that earliness of the crop was strongly affected by planting date and night temperature.

The effect of sowing dates on the expression of sex ratio and yield parameters of watermelon cultivar Sugar Baby was investigated by Desai and Patil (1985). The results indicated that when plants were sown between 20th November and 10th February, the sex ratio was lowest (3.86) in plants sown on 20th November and highest (8.48) in those sown on 20th January. Further, the yields were highest on plants sown on 30th December and 20th January.

Heissner and Drews (1985) in studies on yield increase in greenhouse cucumber in relation to temperature condition found that neither planting date nor night temperature affected the total yield but both affected earliness.

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, where as in plants sown in December the feminization rate was intermediate.

Studies by Huyskens *et al.* (1992) revealed that flowering pattern in bitter gourd was affected by planting season. More female flowers were produced in spring-summer under long days and high temperature than in autumn-winter under short days and low temperature. In another experiment with ridge gourd also Huyskens *et al.* (1993) found that planting season significantly influenced flowering pattern with more female flowers under long day and high temperature conditions.

2.2.3 Effect on yield

Kartalov (1970) conducted tests to establish appropriate dates for sowing and planting hotbed cucumber. He obtained highest yield with the earliest sowing (17th January) and planting date (22nd February).

The effect of sowing dates on growth, development and productivity of watermelon was studied by Belik and Porokhnya (1973). The highest yield was obtained for watermelon sown on 20th to 24th March.

Cucumber sown outdoors on 20th April produced the highest yield of best quality seed in southern Bulgaria (Surlekov and Ivanov, 1974).

Nandpuri and Lal (1978) reported that muskmelon planted during March took significantly fewer days to ripen than those planted during November.

Ivanov (1979) opined that the best time of sowing cucumber was 20th April. Sowing after 30th April resulted in reduced seedling vigour and produced fruits with lower seed weight.

Studies conducted by Verlodt and Harbaoui (1979) revealed that the yield of a late outdoor melon crop depended mainly on the sowing date. Late sowing in August gave very small fruits; the best time being late June.

In an experiment with winter squash cultivar Arizona sown on 12th or 28th August or 13th September and harvested between 20th November and 8th January, Ibarlucea and Bravo (1981) obtained highest yield with later planting.

Kmiecik and Lisiewska (1981) in a trial with cucumber sown in the 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.

Heij and Lint (1982) in an experiment with cucumber planted in the greenhouse 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.

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

Khristov (1983) reported that the highest total yield for melons grown under tunnel was produced 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 the yield.

Yakimenko (1984) in his investigation to find the optimal summer sowing dates for cucumber observed that early sowing on 3rd May gave best yields in all the four varieties used.

In a field experiment conducted with fluted pumpkin (*Telfairia occidentalis* Hook f.) sown in May, June, July and August, Asiegbu (1985) observed that plant growth and yield parameters were better for earlier than for later sowing, due to lower soil temperatures and heavy rainfall during August.

Cucumber cultivars were sown on 5th May with an air temperature ranging from 12.0 to 26.8°C and on 5th December with an air temperature ranging from 18.5 to 30.2° and their performance was compared. The results showed that yields were higher and fruit quality was better for May sowing (Dematte and Simao, 1985).

To guarantee high and stable yields from outdoor gherkins, Krumbein (1985) suggested sowing from mid May to 10th June at one or two week intervals.

Jacob (1986) studied the effect of date of sowing on growth and yield of bittergourd variety Priya and revealed that bittergourd can be raised successfully in summer season by sowing on December 1st. Mohamed and Mohamed (1987) obtained the highest total yield for squash plant sown on March 1st. In an year round planting trial, Thankamani (1987) found that snakegourd sown on November 16th produced highest yield.

Bottle gourd was sown on 17th March, 15th April and 15th June to study the effect of planting dates on yield. The results showed that sowing on 17th March gave the greatest number of fruits (48286 ha^{-1}) and the highest yield (38 t ha^{-1}) and fruit weight (0.83 kg per fruit) whereas sowing on 15th June gave the lowest number of fruits (25517 ha^{-1}), yield (19.7 t ha^{-1}) and fruit weight (0.7 kg per fruit) (Al-Bahash and Wajdyi, 1988).

Bruyn and Sande (1988) in a glasshouse trial using cucumber cultivar Corona planted on 15th July, 29th July, 12th August and 25th August reported that the earlier planting gave the highest total yields. The total yields of another cultivar Lucinde planted on 14th July, 5th and 26th August showed a reduction with latest plantings which was associated with a decline in fruit numbers per square metre and average fruit weight.

Wawrzyniak (1988) found that the highest yield of short cucumber (1514.0 kg per 100 m^2) was obtained when the seedlings were planted during the first half of March.

When two Polish Zucchini cultivars were sown or transplanted between mid-May and mid-June, Gajc and Skapski (1989) obtained the highest yields with the earliest transplanting.

Martinez (1989) from an experiment on cucumber sown in summer (August to October) and winter (November to March) found 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.

Mohammed *et al.* (1989) had sown snake cucumber *Cucumis melo* var. *flexuosus* on 20th March, 4th April, 4th May and 19th May to study the effect of planting date on yield. They observed that delayed planting significantly decreased plant dry weight, average fruit weight and total fruit yield but the number of fruits per plant did not differ markedly.

Among the four distinct cucumber growing seasons, June-August was found to be the best season by Munoz and Abreu (1989).

McGlashan and Fielding (1990) found that when muskmelon cultivars were planted at monthly intervals from 15th November 1986 to 15th January 1987, highest yields were obtained with November planting, and when planted from 5th January to 5th March 1988, January planting gave the highest yields.

According to Bittsanszky *et al.* (1990) sowing of pickling cucumber in mid-April and transplanting in May without covers gave the highest early yields.

In a field experiment, watermelon variety Sugar Baby sown between 1st and 15th November recorded significantly higher yield and better quality fruits compared to delayed sowing of the crop in Konkan region of Maharashtra (Rajput *et al.*, 1990).

Tanis (1990) working with cucumber sown on 14th or 21st 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.

In an experiment, *Cucumis metuliferus* 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 fruit normally but produced a large proportion of small

(< 200 g) fruits. Plant sown in June did not flower until October (Benzioni *et al.*, 1991).

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

The effect of planting date on the production of cucumber under tunnels was investigated by El-Aidy (1991). In the winter season, a planting date of 1st October resulted in higher yields of cultivar Beit Alpha than 15th September, 15th October or 1st November. In early summer season, 2nd February planting resulted in higher yields of the cultivar than 14th February, 5th or 30th March or 18th April.

Watermelon cultivar Arka Manik was sown at fortnightly intervals between 1st December 1982 and 1st February 1983, and between 1st November 1983 and 1st February 1984. Sowing from 1st November to 1st December gave higher yields than later sowing dates (Naik, 1991).

Lyutova and Kamontseva (1992) working with cucumber sown in December and January, found that the early and total yields were the highest with December sowing.

According to Mulkey and Talbot (1993) Zucchini summer squash plants sown in April produced the highest yield.

Waterer (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 was found that early planting increased fruit yield when row covers were used, while late planting was best in no cover treatments.

When tuberous roots of *Momordica dioica* cv. Kathali were planted on 1st February, 1st April and 1st June, Islam *et al.* (1994) and obtained highest yields of 31.5 t ha^{-1} from planting on 1st February.

A field experiment to study the response of field pumpkin to sowing date was conducted by Sant Parkash *et al.* (1994). They found that early sowing (30th March) resulted in significantly higher fruit yield compared with delayed sowings (15th or 30th April).

On evaluating various methods of Zucchini and Scallop (*Cucurbita pepo*) production Gajc-Wolska and Skapski (1994) had the opinion that early sowing or transplanting on 15th May compared to 29th May resulted in 30-40 per cent yield increase in both crops.

An *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.

Resende *et al.* (1996) found that sowing of *Cucurbita maxima* in the dry season (May and August) resulted in significantly higher average yield than those sown in the rainy season (November and February).

2.3 Effect of weather parameters on growth, sex ratio and yield

2.3.1 Temperature, day length and radiation

Tiedjens (1928) succeeded in 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 short light duration the ratio of pistillate to staminate flowers tend to increase.

Edmond (1930) working with cucumber cultivar "Extra Long White Spine" noted that seasonal variation in sex expression of cucumber could be attributed to change 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 24th, 1.67 females and 134 males.

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 responses peculiar to each day length. Stem elongation was retarded in 16 hour day lengths, while maximum stem elongation occurred in the eight hour day length.

Hall (1949) found that the peak of flower formation 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.

In *Cucurbita pepo,* high temperature and long days tend to keep the vine in the male phase whereas low temperature and short days enhanced the early expression of female phase (Nitsch *et al.*, 1952).

Heslop-Harrison (1957) reported that watermelon plants cultivated in a green house at 43.5°C day temperature produced only male flowers, while cucumbers raised under cold conditions formed only female flowers. In water melon, when the plants were transferred from 18° to 20°C to a cooler temperature of 8° to 11°C, female flower production was promoted.

Ito and Saito (1956) had noted that short days and low night temperatures favoured pistillate flower formation and long days and high night temperatures favoured staminate flower formation in cucumber.

While conducting an experiment to study the effect of environment on fruit development of pickling cucumbers Miller and Ries (1958) observed that low temperature increased the length to diameter ratio.

Hussey (1963) opined that the leaf formation was accelerated by both temperature and light intensity. Increasing the light intensity accelerated the formation and growth of leaves and hastened the enlargement of the vegetative apex. On the other hand, increasing the temperature accelerated the formation and growth of leaves, but delayed the enlargement of vegetative apex.

Fakushima *et al.* (1968) showed that cucumber 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. They also observed that lowering the temperature from 20° to 10°C under short day conditions gave pistillate flowers. Kamalanathan (1972) found that low minimum temperature of 18.2° to 18.9°C enhanced the pistillate flower production in ashgourd.

While working with three varieties of watermelon in rainy season, Sharma and Nath (1971) found that the sex ratio was the highest during the period with an average of 28.9°C temperature.

In cucumber, a long day of more than 14 hours and a high light intensity resulted in high maleness in the monoecious plants (Cantliffe, 1974).

Prakash (1974) reported that in bittergourd short day treatment slightly reduced the production of staminate flowers but increased the number of pistillate flowers and lowered the node number at which the first pistillate flower appeared. Long day treatment significantly increased the production of staminate flowers, and raised the node number at which the first pistillate flower appeared and suppressed the development of pistillate flowers. Prakash (1975) also observed that the total number of female flowers in muskmelon and the ratio of female and male flowers were greatly increased by short days. Long day treatment had the reverse effect.

In muskmelon, Nandpuri *et al.* (1976) reported that sex ratio showed a positive correlation with temperature in the greenhouse.

Short days (eight hours) and a day temperature of 27°C increased the number of female flowers in watermelon according to Rudich and Peles (1976). A day length of 16 hours and a day temperature of 32°C inhibited the development of female flowers.

In watermelon, increasing light intensity and day length enhanced lateral growth, where as the main shoot was less effected (Buttrose and Sedgley, 1978).

Mann (1978) observed that the glasshouse cucumbers produced the highest yields under good natural light conditions at 25.2°C day and 18.7°C night temperature and the lowest yields were produced under poorer light conditions at 23.1°C day and 20.6°C night temperature.

In cucumber 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 the remaining night. This temperature regime increased the cucumber yield by 12 per cent as compared with those of the conventional cultivation.

According to Drews (1979) low night air temperature enhanced fruit set in greenhouse cucumbers whereas high air temperatures (> 35°C) at low relative humidity encouraged fruit drop. Drews (1980) also explained that low night temperatures (< 17°C) increased fruit set and total yield in cucumber, while a rise in light intensity and air temperature improved fruit development and shortened the time from pollination to harvest from 25 to 13, or even 8 days.

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.

Cucumber cultivar Farbio was planted by Heij (1981) at weekly and fortnightly intervals between 13th December and 24th January and they were given different day/night temperature. He reported that stem elongation increased with rise in temperature.

Krug and Liebig (1981) tested the response of cucumber to day/night temperature. The plants showed no specific reaction to 28°/10°C day/night temperatures. Higher night temperature led to slower stem growth.

Response of January sown cucumbers to 14° to 23°C night and 16° to 25°C day temperature were investigated by Slack and Hand (1981) and found that earliest fruits were produced at highest day temperature.

Vooren (1981) conducted trials with the cucumber cultivar Corona grown at 12° to 24°C night and 17° to 26°C day temperatures. The best results with regard to earliness (54-61 days from transplanting) and yield (11.8 kg per plant) were generally obtained from plants grown at 16°/26°C night/day temperature. Increasing night temperature from 12 to 20°C delayed maturity. An increase in day temperature from 20 to 26°C also decreased earliness.

On comparing the night temperatures of 12, 16 and 20°C with respect to its effect on flower abortion of glasshouse cucumbers, Lint and Heij (1982b) found that lower the night temperature, higher was the level of abortion.

Cucumber grown with a 25°/17°C day/night temperature regime and a 12 h day length grew faster, flowered, cropped earlier and gave 11 per cent higher average fruit weight than those grown at a constant temperature of 21°C (Uffelen, 1982).

Nelson *et al.* (1983) reported that in buffalo gourd the vine growth appeared to be restricted when maximum air temperature was above 40°C.

When cucumber plants of cultivar Farbio were grown at 15, 21 or 27°C, fewer buds were formed at higher than at lower temperature (Vlugt, 1983).

According to Obshatko and Shabalina (1984) the time when cucumber plants started fruiting was related to early temperature conditions; those raised at relatively low temperatures had lower requirements for both temperature and light than plants raised at relatively higher temperature.

Gosselin and Trudel (1985) opined that low night air temperatures reduced plant growth and leaf development in cucumber.

Studies on sex expression in *Momordica charantia* by Yonemori and Fujieda (1985) revealed that the production of female flowers was increased by low temperature treatment (20°C) and by chilling at night (25°C day, 15°C night), especially under short days.

The growth and development of hybrid squash (*Cucurbita maxima* L.) in the field was investigated by Buwalda and Freeman (1986). They found that dry matter accumulation and hence yield was affected by incident radiation and temperature. Incident radiation and dry matter accumulation were higher during most stages of phenology for the early sown crop than for the late sown crop, resulting in total fruit yields at harvest of 4.6 and 3.0 kg m^{-2}, respectively. The number of female flowers increased to about eight per plant for both crops during crop maturity, but final fruit numbers were only 1.0-1.3 per plant following high rates of flower abortion.

In cucumber, a high night temperature of 17°C was associated with high early yields until the end of May and a low night temperature of 11°C with high total yields until the end of July (Heissner and Drews, 1986).

Takahashi and Saito (1986) studied the photoperiodic responses controlling sex expression of flowers in sponge gourd (*Luffa cylindrica*) and bottle gourd (*Lagenaria siceraria*). He explained that short days increased flower production and the proportion of female flowers in spongegourd. Female sex expression increased acropetally along the stem. The critical day length for female flower induction was 12-16 h. In bottlegourd, flower formation was promoted by short days but sex expression was unaffected. Only a few pistillate flowers appeared on the main stem.

Klapwijk (1987) observed that growth of cucumber is negligible at 15°C, but is greatly accelerated at temperatures up to and above 30°C when moisture is adequate. He also found that photosynthesis is maximal 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 to 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° to 27°C, 15° to 18°C and 17°C and 25 to 27°C, 12°C and 25°C respectively (Palkin, 1987).

Černe (1988) opined that vegetative and generative development of the cucumber plants was positively correlated with daily soil and air temperatures.

The effect of photoperiod on growth and yield of green house cucumber cultivars Corona and Sandra was tested by Turcotte and Gosselin (1988). They concluded that plants exposed to long days showed better rates of growth and higher yields than control, with 20 h > 18 h > 16 h or 14 h > control (eight hour day length). Corona and Sandra plants grown under 20 h photoperiod yielded 1.1 and 2.0 kg per plant respectively, compared with 0.5 and 0.7 kg per plant respectively, in controls.

Uffelen (1988) in a glasshouse trial comparing the effect of different temperature regimes on cucumber revealed that raising the average 24 hour temperature by 1°C advanced harvest by four 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.

In cucumber, efficiency of assimilated CO_2 conversion into dry matter depended on temperature and photoperiod (Kuree *et al.*, 1989).

Munoz and Abreu (1989) found that yield of cucumber in each season was mainly influenced by temperature, especially the mean temperature of the first month of development and the difference between the temperature of the first and third months.

Uffelen (1989) compared the effects of different day/night temperature regimes of 26/18.5°C, 23/20°C and 18/22.5°C on cucumber cv. Venture. He found that plant growth 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 per 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 per plant were highest with regimes of 23/20°C or 21/21°C. 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.

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 and Vedrantais, fruit development was faster and fruits were larger when the minimum night temperature was 19°C than when it was 15°C.

In an experiment with cucumber cv. Corona, sown on 9th January and 23rd June 1989 with mean temperature of 20.8 and 21.9°C and mean RH of 72.2 and 71.4 per cent Andreas (1990) obtained yields of 63 and 23 cucumbers per m^2 respectively.

When cucumber was grown on four dates of planting and three temperature regime Vegter (1990) found 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.

Growth was limited in cucumber 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 enhanced female flower production.

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

Edelstein *et al.* (1991) examined the relationships among germination, emergence and early seedling growth at low (20°/14°C or 17°/12°C) and high (27°/22°C) day/night temperature in cold tolerant and cold sensitive cultivars of muskmelon. Emergence was delayed and dry matter accumulation was decreased by low temperature.

While studying the response of cucumber to climate, Liebig and Krug (1991) found that the influence of temperature was stronger during the early stages of crop growth than during the harvesting period and there was a strong linear relationship between radiation and yield potential.

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

Shi *et al.* (1991) conducted experiments in greenhouse cucumber at 25°C 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.

In melon cv. Earl's Favorite Winter No.3, warming of root zone to 25°C increased total dry matter production (Takano, 1991).

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 one to six days per 1°C and increased the average total yield during the first eight weeks after transplanting by 0.54 kg $m^{-2}C^{-1}$.

Huyskens *et al.* (1993) obtained maximum germination of Ridge gourd (*Luffa acutangula*) at 35°C and at 8°, 12° and 45°C germination was completely inhibited.

The effect of temperature on fruit growth and biomass allocation to the fruits in cucumber was studied by Marcelis (1993). He concluded that with the same number or weight of fruits on a plant, the biomass allocation to the fruits was greater at 25°C than at 18°C. There were less number of fruits on a plant at 25°C than at 18°C. The reduction in individual fruit growth rate with increase in number of fruits per plant was lower at 18°C than at 25°C. The higher temperature increased fruit fresh weight per plant but had little effect on fruit dry weight per plant.

Hagiuda (1994) reported that night temperature of 9°, 13° or 17°C did not affect fruit set, fruit weight or the number of ripe seeds in melons grown in plastic green houses.

Marcelis (1994) studied the effect of temperature on fruit shape in 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.

The optimum day and night temperature range for cucumber seedlings (cv. Alma-Atinskii) was from 28 to 32°C (Markovskaya, 1994).

The effect of temperature and day length on the production of female flowers in watermelons was investigated by Sugiyama *et al.* (1994). He observed that most female flowers were produced at 15°C with eight hour days and the least at 25°C with 16 h days.

2.3.2 Relative humidity and rainfall

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

Sharma and Nath (1971) worked with three varieties each of watermelon, musk melon, snap melon and long melon and the results indicated that the sex ratio in all the three varieties of watermelon was the highest during the rainy season with 75.6 per cent relative humidity.

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

While studying the influence of humidity on the outbreak of cucumber powdery mildew, Abiko and Kishi (1979) suggested that high humidity was most conducive to conidial germination but at later stages of infection low humidity was more favourable to the fungus.

The effect of high or low relative humidity during the day or night, on growth, cropping and fruit quality of cucumber was discussed by Bakker (1987). He stated that growth and total yields were enhanced by high RH especially during the day. The highest yields (up to 29 kg m^{-2}) were obtained in the spring, with high RH in the day and night (about 81 and 89%, respectively).

Pelletier (1989) conducted an experiment on cucumber cv. Regina and concluded that high humidities led to increased disease incidence although yield was not affected.

In an experiment with cucumber cv. Carona sown on 9th January and 23rd June, Andreas (1990) obtained yields of 63 and 23 cucumbers per m^2 respectively with mean RH of 72.2 and 71.4 per cent.

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. Combrink *et al.* (1995) subjected developing fruits of musk melon (cv. Galia) to two relative humidity treatments (22 and 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 number per fruit, a lower mean fruit growth rate and smaller fruits.

2.4 Effect of stage of harvest on growth and yield

Dhillon (1966) reported that the presence of fruits exerted an inhibitory effect on development of plant and production of female flowers.

Greulach (1973) observed that the presence of developing fruits on a plant frequently limited future fruit set, presumably because of the competition for food. Picking of the fruits already set generally removes the inhibition on further fruit setting.

Meyer *et al.* (1973) found that when fruits in tomato were allowed to remain on the plant and enlarge, vegetative development and the formation of flowers gradually slowed down as more and more fruits began to develop.

The studies conducted by Sedgley and Buttrose (1978) in watermelon revealed that the inhibitory effect of the developing fruit on the vine affected the floral development more, than the vegetative growth. The presence of fruits on the vine resulted in fewer flowers per plant and in reduced ovary length and diameter. They also stated that small fruits with few seeds imposed less inhibition on the vine than the larger fruits with more seeds.

According to Gifford and Evans (1981) photosynthetic rate would be reduced to the rate at which sinks could accept assimilate. For photosynthesis to be at maximum potential rates, sink must be able to utilize all the assimilate produced. Under these conditions partitioning would be controlled by sink strength, that is, sink availability and the rate at which available sinks could utilise assimilates.

Slack and Hand (1981) observed that the removal of early fruits increased the size of the vegetative frame work but did not result in higher total yield. Similar observations were made by Lint and Heij (1982b) in cucumber. They found that systematic pruning of flowers or young fruits in advance of spontaneous abortion could be done without having adverse effects on production.

While studying the influence of pruning methods on growth and yield of cucumber Liebig (1984) found that removing fruit diminished their negative effects on vegetative growth.

Bakker and Vooren (1985) planted cucumber in greenhouse and had their flowers and fruits removed from the first 5, 10, 20 or 25 axils. They observed that the more stem fruits were removed the greater was the delay in fruit production but production was higher.

Stephenson *et al.* (1988) stated that the presence of 6 to 15 day old fruits significantly decreased the probability of female flower production while significantly increased the probability of fruit abortion in Zucchini squash (*Cucurbita pepo*). Also the strength of dominance by a developing fruit depended on the number of seeds it contained and that influenced the result of fruit to fruit competition. They concluded that the presence of mid-aged fruit exerted the greatest influence on the probability of maturation while old fruits exerted the least influence. The presence of one young and one mid fruit on the vine apparently increased the probability of fruit maturation.

In an investigation to study the effect of different fruit ripening stage on the size and quality of Zucchini cultivars, the fruits were harvested at three stages namely, when they were 10-15 cm or 25-30 cm long or physiologically ripe with developed seeds. It was observed that the highest yield was obtained from harvesting 25 to 30 cm long fruits, but shorter fruits had higher nutritional value (Gajc and Skapski, 1989).

While studying the effect of fruit load on fruit growth and biomass allocation to the fruits in cucumber, Marcelis (1993) observed that increasing the number of fruits per plant increased the total fruit growth at the expense of the vegetative growth and decreased the fruit growth rate. This lengthened the growing period between anthesis and harvest maturity. Fruit dry matter percentage decreased as the number of fruits on a plant increased.

In a field trial, Estrada *et al.* (1995) subjected a bean cultivar to daily flower removal for either the first or the second half of the flowering period and this resulted in increased number of pods, seeds and seed yield.

The sink capacity after anthesis affected the yield and partitioning of photosynthates in wheat cultivars. A high sink capacity increased leaf photosynthesis and the translocation of photosynthates to the ears (Guo *et al.*, 1995).

When winter squash (*Cucurbita maxima*) cultivars were harvested at different developmental stages, it was found by Nerson (1995) that the fruit yield of cultivars decreased with increasing age at harvest.

The effect of source-sink relationship on yield was studed by Saranga *et al.* (1996) in sunflower. Seeds from the peripheral area of the small and large heads of sunflower were removed at the cessation of flowering. Floret number was significantly lower in small than in large heads, but was not affected by the source-sink manipulations.

Bhatt and Rao (1997) studied the source-sink relationship in okra by removing all flower and flower buds up to the eighth node. Reduction of the reproductive sinks decreased the total dry matter accumulation per plant.

Materials and Methods

MATERIALS AND METHODS

The present investigation was carried out in the vegetable research farm of the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara during August 1995 to March 1997. The experimental area was located at an altitude of 23 M above MSL and between 10°32" and 76°16" E longitude.

The experiment was conducted in two heads.

3.1 Cataloguing and identification of promising ashgourd ecotypes

3.1.1 Experimental materials

The experimental material consisted of 30 ecotypes of ashgourd varying in size and shape (Plate 1) collected from different parts of Kerala. The source and morphological description of the different ecotypes are given in Table 1 and 2.

3.1.2 Experimental methods

The experiment was conducted during August 1995 in randomised block design with three replications. Crop management practices were done as per the Package of Practices Recommendations (KAU, 1993). Seeds were sown in pits at a spacing of 4.5 m x 2 m and two plants were retained per pit. FYM at the rate of 20 t ha^{-1} and NPK at the rate of 70:25:25 kg ha^{-1} was applied. Nitrogen was applied in two splits, half as basal and the other half at the time of vining. The whole of phosphorus and potash were applied basally.

Table 1. Source and morphological descriptions of ashgourd ecotypes
1) Vegetative characters

Accession No.	Sources	Plant growth habit	Stem shape	Tendrils	Leaf size	Leaf colour	Colour of leaf spots or checks	Leaf margin	Leaf lobes	Leaf pubescence (dorsal surface)	Leaf pubescence (ventral surface)
BH 21	Nileswar	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 72	Changaramkulam	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 114	Coimbatore	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 115	Kuttippuram	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 116	Edappilly	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 117	Malappuram	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 118	Pilicode	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 119	Pilicode	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 120	Palakkad	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 137	Chirayinkeezhu	Prostrate	Angular	Present	Small	Dark green	Absent	Dented	Shallow	Low	Low
BH 138	Pattambi	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 139	Kannur	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 140	Vadakara	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 141	Kozhikode	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 142	Perumbavoor	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 143	Kottakkal	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 144	Wynad	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 145	Kannur	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 146	Calicut	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 147	Palakkad	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 148	Thalassery	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 149	Kasargod	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 150	Perumbavoor	Prostrate	Angular	Present	Small	Dark green	Absent	Dented	Shallow	Intermediate	Intermediate
BH 151	Thalayolaparambu	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 152	Thodupuzha	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 153	Pandalam	Prostrate	Angular	Present	Large	Dark green	Absent	Dented	Intermediate	Low	Low
BH 154	Pollachi	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 155	Edapilly	Prostrate	Angular	Present	Small	Dark green	Absent	Dented	Intermediate	Low	Low
BH 156	Thrissur	Prostrate	Angular	Present	Intermediate	Dark green	Absent	Dented	Intermediate	Low	Low
BH 157	Aroor	Prostrate	Angular	Present	Small	Dark green	Absent	Dented	Shallow	Low	Low

Contd.

2) Inflorescence characters

Accession No.	Flower size	Ovary pubescence	Peduncle transectional shape	Peduncle separation from fruit	Stem-end fruit shape	Blossom-end fruit shape
BH 21	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 73	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 114	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 115	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 116	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 117	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 118	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 119	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 120	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 137	Small	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 138	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 139	Large	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 140	Large	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 141	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 142	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 143	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 144	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 145	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 146	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 147	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 148	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 149	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 150	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 151	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 152	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 153	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 154	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 155	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Flattened
BH 156	Intermediate	Short	Smoothly angled	Intermediate	Depressed	Depressed
BH 157	Intermediate	Short	Round	Easy	Flattened	Depressed

Contd.

3) Fruit characters

Accession No.	Fruit shape	Fruit ribs	Predominant fruit skin colour at maturity	Fruit skin texture	Fruit lustre	Fruit size variability	Fruit skin hardness	Flesh colour	Flesh texture
BH 21	Oblate	Absent	Green	Smooth	Intermediate	High	Soft	White	Smooth-firm
BH 73	Oblate	Absent	Green	Smooth	Intermediate	High	Soft	White	Smooth-firm
BH 114	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 115	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 116	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 117	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 118	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 119	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 120	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 137	Elliptical	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 138	Elliptical	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 139	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 140	Oblong blocky	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 141	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 142	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 143	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 144	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 145	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 146	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 147	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 148	Oblate	Absent	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm
BH 149	Oblong blocky	Absent	Green	Smooth	Intermediate	High	Soft	White	Smooth-firm
BH 150	Oblong blocky	Superficial	Green	Smooth	Intermediate	High	Soft	White	Smooth-firm
BH 151	Oblong blocky	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 152	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 153	Oblate	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 154	Oblong blocky	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 155	Oblong blocky	Absent	Green	Smooth	Intermediate	Intermediate	Soft	White	Smooth-firm
BH 156	Globular	Absent	Green	Smooth	Intermediate	High	Soft	White	Smooth-firm
BH 157	Oblate	Present	Green	Smooth	Intermediate	Low	Soft	White	Smooth-firm

Contd.

4) Seed characters

Accession No.	Seed size	Ease of seed and placenta separation from flesh	Ease of seed separation from placenta	Seed surface	Seed surface lustre	Seed coat colour	Seed margin	Seed margin colour
BH 21	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 73	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 114	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 115	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 116	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 117	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 118	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 119	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 120	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 137	Small	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 138	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 139	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 140	Intermediate	Intermediate	Intermediate	Smooth	Dull	White	Thin and uniform	White
BH 141	Intermediate	Intermediate	Intermediate	Creased	Dull	White	Thin and uniform	White
BH 142	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 143	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 144	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 145	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 146	Small	Intermediate	Intermediate	Smooth	Glossy	White	Thin and uniform	White
BH 147	Small	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 148	Small	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 149	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 150	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 151	Small	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 152	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 153	Small	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 154	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 155	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 156	Intermediate	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White
BH 157	Small	Intermediate	Intermediate	Smooth	Intermediate	White	Thin and uniform	White

Table 2. Performance of ashgourd genotypes

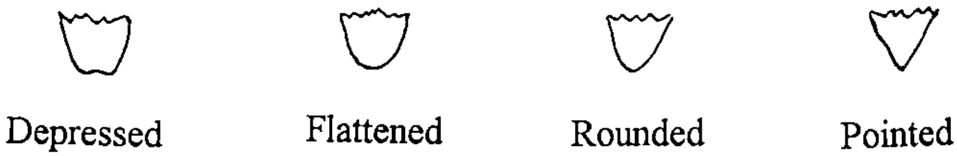
Accession No.	Length of main vine (m)	Nodes on main vine	Primary branches per plant	Inter-nodal length (cm)	Leaves per plant at 30 DAS	Days to first female flower anthesis	Node at which first female flower appeared	Node at which the first fruit is retained	Male flowers per plant	Female flowers per plant	Per cent of female flowers	Average fruit weight (kg)	Fruits per plant	Per cent of fruit set	Circum-ference of fruit (cm)	Length of fruit (cm)	Fruit shape index	Seeds/ fruit	100 seed weight (g)	Fruit yield/ plant (kg)
BH 21	6.50	103.00	6.67	10.67	14.67	62.00	27.67	38.67	105.67	8.67	7.83	3.40	4.33	50.50	61.80	38.87	1.97	1062.00	7.30	14.70
BH 73	3.47	58.67	3.33	6.97	9.33	74.00	21.33	27.00	56.00	5.00	7.43	2.93	2.33	46.67	65.60	38.70	1.87	443.33	4.97	6.87
BH 114	4.17	63.67	1.33	5.93	10.33	66.67	27.00	31.00	64.33	5.00	7.40	2.77	2.67	53.33	70.10	39.10	1.77	541.67	5.00	7.30
BH 115	3.53	61.00	2.33	5.83	8.33	61.33	25.33	36.67	51.67	4.67	8.30	2.13	2.00	41.10	61.00	32.70	1.13	520.67	4.60	4.10
BH 116	4.50	61.67	2.33	5.80	7.67	57.67	39.67	42.67	48.00	3.67	7.23	2.87	1.33	36.10	86.90	31.10	1.73	751.67	5.40	3.77
BH 117	3.90	51.33	3.00	5.80	9.67	70.33	36.67	38.67	62.00	5.67	8.70	2.40	3.00	52.37	62.83	37.10	1.90	655.67	5.13	7.00
BH 118	4.17	64.33	3.33	7.90	14.00	64.33	24.67	30.00	75.67	10.00	11.73	1.73	6.33	63.43	55.20	24.20	1.37	457.33	4.30	10.90
BH 119	2.87	47.67	2.00	6.93	10.33	61.67	22.67	26.67	64.67	5.33	7.57	2.70	2.00	35.97	62.40	38.03	1.93	526.33	5.07	5.07
BH 120	2.90	50.00	2.33	7.13	10.33	68.00	29.67	36.00	60.33	4.67	7.07	2.77	2.33	49.03	61.90	37.60	1.70	650.00	5.03	6.57
BH 137	3.17	47.67	1.00	3.27	5.67	61.67	23.00	30.00	38.67	2.67	6.50	0.27	1.00	38.87	22.00	12.00	1.77	53.67	4.00	0.27
BH 138	3.73	60.67	2.00	5.40	7.00	60.00	28.00	33.00	60.33	5.00	7.57	2.33	2.00	38.70	51.37	29.33	1.77	443.00	3.47	4.83
BH 139	3.43	59.00	2.67	5.27	8.67	63.33	36.67	41.00	55.67	4.67	7.73	3.30	1.67	35.53	57.00	32.00	1.53	293.00	5.00	5.13
BH 140	3.57	57.00	1.33	5.73	8.33	59.67	32.67	37.67	62.67	4.67	6.77	2.80	1.67	33.70	60.00	29.00	1.63	314.00	5.50	4.07
BH 141	5.70	73.33	4.33	8.47	14.33	63.00	31.00	34.33	87.33	3.00	3.20	3.50	1.33	46.67	59.60	31.00	1.43	448.00	4.53	4.30
BH 142	3.33	55.00	2.67	6.27	10.33	61.00	23.67	29.33	53.00	3.00	5.40	3.90	1.00	33.30	61.00	27.70	1.43	327.00	5.00	3.90
BH 143	4.53	61.67	1.33	3.40	7.00	72.67	35.00	38.00	46.33	4.00	7.90	5.70	1.33	32.77	63.00	31.90	1.60	278.00	3.77	7.13
BH 144	5.13	72.00	4.00	9.83	13.00	62.67	36.00	46.67	60.33	5.33	8.07	2.17	2.33	40.70	53.07	30.90	1.80	432.67	3.37	4.70
BH 145	3.43	57.67	2.00	4.93	10.00	58.67	27.33	34.33	46.00	3.00	6.10	4.00	1.33	44.43	62.57	29.2	1.47	249.00	3.50	5.23
BH 146	2.07	49.00	2.00	7.43	10.00	63.00	23.00	26.67	40.33	3.33	6.73	2.40	2.00	61.13	55.40	23.50	1.33	199.00	2.73	4.77
BH 147	4.63	78.00	2.33	4.43	10.00	62.00	27.67	31.00	39.67	3.00	7.13	3.70	1.00	36.10	62.20	26.60	1.37	553.00	5.03	3.70
BH 148	4.67	55.33	5.67	9.53	12.33	58.67	33.00	38.00	72.33	4.67	7.73	1.30	1.67	34.43	46.10	22.20	1.53	244.00	5.00	1.97
BH 149	2.70	46.00	2.00	6.57	9.33	67.00	28.33	31.00	55.33	3.67	8.07	4.50	2.00	57.80	64.30	29.00	1.37	480.00	5.50	9.00
BH 150	3.13	52.00	4.33	7.70	12.00	71.33	30.33	34.33	43.00	2.67	5.50	4.60	1.33	50.00	65.50	28.60	1.37	378.00	5.00	5.90
BH 151	3.07	38.33	3.00	6.43	9.33	64.00	23.67	29.00	43.33	4.67	10.20	4.00	2.00	41.10	61.60	27.00	1.37	615.00	4.00	7.20
BH 152	4.07	65.67	2.67	6.30	8.00	68.67	29.67	36.00	58.00	3.67	6.13	3.60	1.33	38.33	57.50	30.30	1.63	223.00	4.27	4.47
BH 153	6.27	63.33	17.0	14.20	12.67	67.00	32.33	34.67	78.00	6.33	7.60	5.50	2.00	32.40	62.50	31.23	1.60	867.00	5.77	11.00
BH 154	4.50	52.67	1.67	8.47	15.00	81.00	36.00	41.67	65.67	6.00	8.03	2.60	2.33	37.00	54.90	24.60	1.43	637.00	6.03	5.20
BH 155	3.50	56.67	2.00	6.60	11.67	89.00	36.33	40.33	63.00	5.67	8.30	4.30	3.00	52.37	60.10	27.40	1.50	423.00	5.73	12.47
BH 156	3.03	51.00	3.00	6.60	10.33	81.00	27.33	32.33	59.00	2.67	4.33	4.80	1.00	38.87	67.70	27.20	1.20	967.00	5.60	4.80
BH 157	3.20	50.00	5.00	6.47	11.33	90.00	26.67	33.33	61.00	5.67	8.97	0.20	2.67	46.67	24.37	12.33	1.60	563.00	1.60	0.50

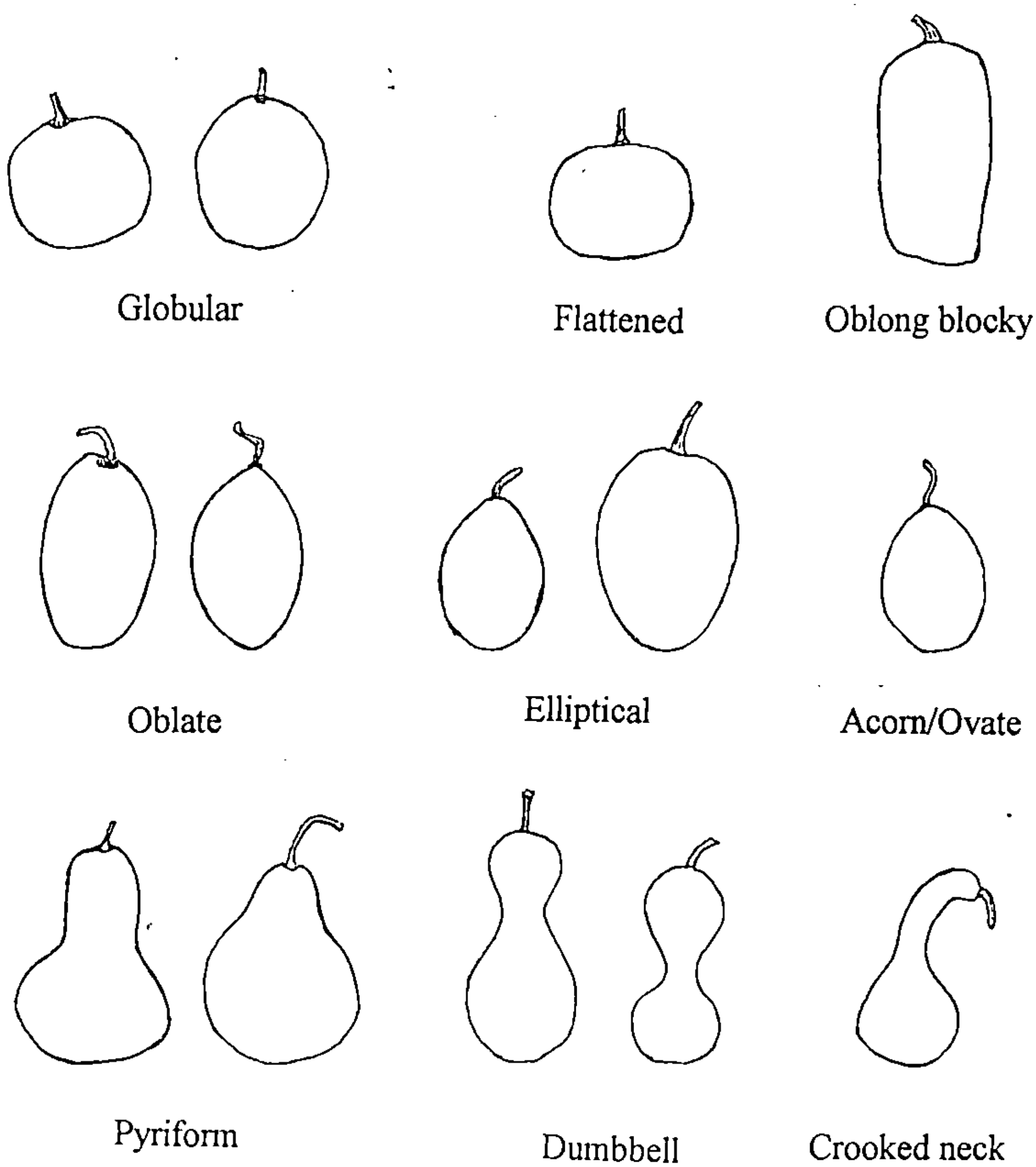
The accessions were catalogued as per the descriptor developed for *Cucurbita* by IBPGR (1983). Necessary modifications were made to suit the crop ashgourd.

Characters	Description		
VEGETATIVE			
Plant growth habit	Bushy	Intermediate	Prostrate
Stem shape	Rounded	Angular	
Tendrils	Absent	Present	
Leaf size	Small	Intermediate	Large
Leaf colour	Light green	Intermediate	Dark green
Colour of leaf spots or checks	Absent Both	Light green Other	Silver
Leaf margin	Smooth	Dented	
Leaf lobes	Absent Deep	Shallow	Intermediate
Leaf pubescence (dorsal surface)	Absent High	Low	Intermediate
Leaf pubscence (ventral surface)	Absent High	Low	Intermediate
INFLORESCENCE			
Flower size	Small	Intermediate	Large
Overy pubescence	Short	Intermediate	Long
FRUIT			
Peduncle transectional shape	Round	Smoothly angled	Sharply angular
Peduncle separation from fruit	Easy	Intermediate	Difficult
Stem-end fruit shape	Depressed Pointed	Flattened	Rounded

Depressed Flattened Rounded Pointed

Blossom-end fruit shape	Depressed	Flattened	Rounded Pointed
Fruit shape	Globular Oblate Pyriform Other	Flattened Elliptical Dumbbell	Oblong blocky Acorn/ovate Crooked neck





Fruit ribs	Absent Deep	Superficial	Intermediate
Predominant fruit skin colour at maturity	White Cream Red Grey	Green Yellow Pink Black	Blue Orange Brown Other
Fruit skin texture	Smooth Shallowly wavy With spines	Grainy Netted Other	Finely wrinkled With warts
Fruit lustre	Matt	Intermediate	Glossy
Fruit size variability	Low	Intermediate	High
Fruit skin hardness	Soft	Intermediate	Hard
Flesh colour	White Orange	Green Salmon	Yellow
Flesh texture	Smooth-firm Fibrous-gelatinous	Grainy-Firm Fibrous-dry	Soft-spongy

<u>SEED</u>

Seed size	Small	Intermediate	Large
Ease of seed and placenta separation from flesh	Difficult	Intermediate	Easy
Ease of seed separation from placenta	Difficult	Intermediate	Easy
Seed surface	Smooth Scaly	Wrinkled Creased	Slightly pitted
Seed surface lustre	Dull	Intermediate	Glossy
Seed coat colour	Absent Yellow Grey	White Orange Black	Tan Brown
Seed margin	Absent Thick and uniform	Thin and uniform Thick and irregular	Thin and irregular
Seed margin colour	Absent Yellow Grey	White Orange Black	Tan Brown

Along with the above morphological characters, the following quantitative characters were also recorded.

Length of main vine

The length of main vine in metre was recorded.

Nodes on main vine

The number of nodes on the main vine was counted.

Primary branches per plant

The number of primary branches per plant was counted.

Internodal length

The length of 6th, 7th, 8th, 9th and 10th internodes was recorded in centimetre and averaged.

Leaves per plant

The number of leaves per plant 30 days after sowing was counted.

Days to first female flower anthesis

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

Node at which first female flower appeared

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

Node at which the first fruit is retained

The node on the stem at which the first fruit was retained was counted from the cotyledonary node and recorded.

Male flowers per plant

The number of male flowers produced per plant was counted.

Female flowers per plant

The number of female flowers produced per plant was counted.

Per cent of female flowers

The percentage of female flowers to the total flowers was calculated.

Average fruit weight

The weight of fruits produced per plant was averaged and recorded in kilogram.

Fruits per plant

The number of fruits produced per plant was counted.

Per cent of fruit set

The number of fruits produced per plant was noted and the percentage calculated.

Circumference of fruit

The circumference was measured from the middle of the fruit and recorded in centimetre.

Length of fruit

Length of the fruit from the stalk end to the tip was recorded in centimetre.

Fruit shape index

Ratio of the fruit length to fruit diameter was recorded.

Seeds per fruit

The number of seeds contained in each mature fruit was counted and recorded.

100 seed weight

Seeds extracted from the mature fruits were washed and dried uniformly, hundred bold seeds were selected and the weight recorded in gram.

Fruit yield per plant

Total weight of the fruits harvested from each plant was worked out and recorded in kilogram.

3.1.3 Statistical analysis

The data obtained on different characters were subjected to statistical analysis.

3.1.3.1 Phenotypic, genotypic and environmental variances

The variance components were estimated using the formula suggested by Burton (1952).

Phenotypic variance $(V_p) = V_g + V_e$

where,

V_g = Genotypic variance

V_e = Environmental variance

$$\text{Genotypic variance } (V_g) = \frac{V_T - V_E}{N}$$

where,

V_T = mean sum of squares due to treatments

V_E = mean sum of squares due to errors

N = number of replications

Environmental variance $(V_e) = V_E$

3.1.3.2 Phenotypic and genotypic coefficients of variation

The phenotypic and genotypic coefficients of variation were calculated by the formula suggested by Burton and Devane (1953).

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{V_p}{\bar{x}} \times 100$$

where, V_p = phenotypic variance

$\bar{x}$ = mean of character under study

$$\text{Genotypic coefficient of variation (GCV)} = \frac{V_g}{\bar{x}} \times 100$$

where, V_g = genotypic variance

$\bar{x}$ = mean of character under study

3.1.3.3 Heritability

Heritability in the broad sense was estimated by the formula suggested by Burton and Devane (1953).

$$\text{Heritability in the broad sense, H} = \frac{V_g}{V_p} \times 100$$

where, V_g = genotypic variance

V_p = phenotypic variance

3.1.3.4 Expected genetic advance

The genetic advance expected for the genotypes at five per cent selection pressure was calculated using the formula suggested by Lush (1949) and Johnson *et al*. (1955a) with value of the constant K as 2.06, as given by Allard (1960).

$$\text{Expected genetic advance, GA} = \frac{V_g}{V_p} \times K$$

where, V_g = genotypic variance

V_p = phenotypic variance

K = selection differential

3.1.3.5 Genetic gain (Genetic advance as percentage of mean)

Genetic advance (GA) calculated by the above method was used for estimation of Genetic gain.

$$\text{Genetic gain, GG} = \frac{GA}{\bar{x}} \times 100$$

where, GA = genetic advance

$\bar{x}$ = mean of character under study

3.1.3.6 Phenotypic, genotypic and environmental correlation coefficients

The phenotypic, genotypic and environmental covariances were worked out in the same way as the variances were calculated. Mean product expectations of the covariance analyses are analogous to the mean square expectations of the analysis of variance. The different covariance estimates were calculated by the method suggested by Fisher (1954).

Phenotypic covariance between two characters 1 and 2

$$(Cov_p\ 1\ 2) = Cov_g\ 1\ 2 + Cov_e\ 1\ 2$$

where, $Cov_g\ 1\ 2$ = genotypic covariance between characters 1 and 2

$Cov_e\ 1\ 2$ = environmental covariance between characters 1 and 2

Genotypic covariance between characters 1 and 2

$$Cov_g\ 1\ 2 = \frac{Mt_{1\,2} - Me_{1\,2}}{N}$$

where, $Mt_{1\,2}$ = mean sum of product due to treatment between characters 1 and 2

$Me_{1\,2}$ = mean sum of product due to error between characters 1 and 2

N = number of replications

The phenotypic, genotypic and environmental correlation coefficient among the various characters were worked out in all possible combinations according to the formula suggested by Johnson *et al.* (1955b).

Phenotypic correlation coefficient between characters 1 and 2,

$$(r_p\ 1\ 2) = \frac{Cov_p\ 1\ 2}{v_p\ 1\ v_p\ 2}$$

where, $Cov_p\ 1\ 2$ = Phenotypic covariance between characters 1 and 2

$v_p\ 1$ = Phenotypic variance of character 1

$v_p\ 2$ = Phenotypic variance of character 2

Genotypic correlation coefficient between characters 1 and 2,

$$(r_g\ 1\ 2) = \frac{Cov_g\ 1\ 2}{v_g\ 1\ v_g\ 2}$$

where, $Cov_g\ 1\ 2$ = Genotypic covariance between characters 1 and 2

$v_g\ 1$ = Genotypic variance of character 1

$v_g\ 2$ = Genotypic variance of character 2

Environmental correlation coefficient between characters 1 and 2,

$$(r_e\ 1\ 2) = \frac{Cov_e\ 1\ 2}{v_e\ 1\ v_e\ 2}$$

where, $Cov_e\ 1\ 2$ = Environmental covariance between characters 1 and 2

$v_e\ 1$ = Environmental variance of character 1

$v_e\ 2$ = Environmental variance of character 2

3.1.3.7 Path coefficient analysis

In path coefficient analysis the correlation among cause and effect are partitioned into direct and indirect effects of causal factors on effect factor. The principles and techniques suggested by Wright (1921) and Li (1955) for cause and effect system were adopted for the analysis using the formula given by Dewey and Lu (1959). The characters were subjected to step down regression and the characters most related to yield were selected for path coefficient analysis.

3.2 Studies on effect of sowing time and periodicity of harvests on yield of ashgourd

This part of the experiment was conducted from December, 1995 to March, 1997.

3.2.1 Experimental materials

A high yielding ecotype of ashgourd (BH 21) was selected from the first experiment using the selection index as suggested by Fisher (1936). This ecotype was raised in the field for 12 successive months to identify the best time of planting.

3.2.2 Experimental methods

Layout

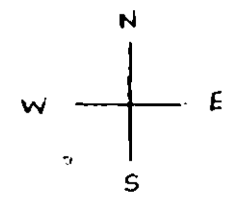
The experiment was laid out in split plot design. The treatments consisted of 12 months of sowing (main plot treatment) and four intervals of harvest (sub plot treatments). The layout plan is given in the Fig.1.

Details of the treatments are given below:

Main plot treatments (sowing dates)	Notations
December 22nd 1995	D_1
January 22nd 1996	D_2
February 22nd 1996	D_3
March 22nd 1996	D_4
April 22nd 1996	D_5
May 22nd 1996	D_6
June 22nd 1996	D_7
July 22nd 1996	D_8
August 22nd 1996	D_9
September 22nd 1996	D_{10}
October 22nd 1996	D_{11}
November 22nd 1996	D_{12}

Fig.1. Layout Plan

R_1				R_2				R_3			
D_3H_3	D_2H_4	D_2H_1	D_2H_2	D_6H_4	D_6H_2	D_6H_3	D_6H_1	$D_{10}H_2$	$D_{10}H_3$	$D_{10}H_4$	$D_{10}H_1$
D_5H_1	D_5H_3	D_5H_2	D_5H_4	D_1H_2	D_1H_3	D_1H_1	D_1H_4	D_6H_4	D_6H_3	D_6H_2	D_6H_1
D_7H_4	D_7H_1	D_7H_3	D_7H_2	D_4H_3	D_4H_4	D_4H_2	D_4H_1	$D_{12}H_1$	$D_{12}H_2$	$D_{12}H_4$	$D_{12}H_3$
D_3H_3	D_3H_2	D_3H_4	D_3H_1	D_9H_1	D_9H_4	D_9H_3	D_9H_2	D_7H_2	D_7H_1	D_7H_3	D_7H_4
$D_{10}H_1$	$D_{10}H_4$	$D_{10}H_3$	$D_{10}H_2$	$D_{11}H_2$	$D_{11}H_3$	$D_{11}H_1$	$D_{11}H_4$	D_4H_2	D_4H_3	D_4H_4	D_4H_1
D_1H_4	D_1H_1	D_1H_3	D_1H_2	D_7H_1	D_7H_4	D_7H_2	D_7H_3	D_2H_2	D_2H_1	D_2H_3	D_2H_4
D_6H_1	D_6H_2	D_6H_4	D_6H_3	D_3H_4	D_3H_2	D_3H_1	D_3H_3	D_5H_1	D_5H_2	D_5H_4	D_5H_3
$D_{11}H_3$	$D_{11}H_4$	$D_{11}H_2$	$D_{11}H_1$	$D_{12}H_4$	$D_{12}H_2$	$D_{12}H_3$	$D_{12}H_1$	D_8H_3	D_8H_1	D_8H_2	D_8H_4
D_4H_2	D_4H_1	D_4H_4	D_4H_3	D_5H_2	D_5H_1	D_5H_3	D_5H_4	$D_{11}H_2$	$D_{11}H_4$	$D_{11}H_1$	$D_{11}H_3$
D_9H_4	D_9H_2	D_9H_3	D_9H_1	D_8H_1	D_8H_2	D_8H_4	D_8H_3	D_1H_4	D_1H_2	D_1H_1	D_1H_3
$D_{12}H_2$	$D_{12}H_1$	$D_{12}H_4$	$D_{12}H_3$	$D_{10}H_1$	$D_{10}H_3$	$D_{10}H_4$	$D_{10}H_2$	D_9H_4	D_9H_3	D_9H_2	D_9H_1
D_8H_3	D_8H_2	D_8H_1	D_8H_4	D_2H_4	D_2H_2	D_2H_1	D_2H_3	D_3H_4	D_3H_1	D_3H_3	D_3H_2



Treatments

Date of sowing	Notations	Date of sowing	Notations	Periodicity of harvests	Notation
December 22nd 1995	D_1	June 22nd 1996	D_7	Harvesting at 14 days maturity	H_1
January 22nd 1996	D_2	July 22nd 1996	D_8	Harvesting at 21 days maturity	H_2
February 22nd 1996	D_3	August 22nd 1996	D_9	Harvesting at 28 days maturity	H_3
March 22nd 1996	D_4	September 22nd 1996	D_{10}	Harvesting at full maturity	H_4
April 22nd 1996	D_5	October 22nd 1996	D_{11}		
May 22nd 1996	D_6	November 22nd 1996	D_{12}		

Subplot treatments
(Harvesting)

Harvesting at 14 days maturity	H_1
Harvesting at 21 days maturity	H_2
Harvesting at 28 days maturity	H_3
Harvesting at full maturity	H_4

The cultural operations were the same as followed in Experiment I. Harvesting of the fruits was done at four intervals (Plate 2). In addition to the biometric observations recorded in the previous experiment, a few more were taken in the present experiment and they were:

Days to first male flower anthesis

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

Flesh thickness

The flesh thickness was measured after cutting the fruit through the centre and recorded in centimetre.

Incidence of pest and disease

The incidence of pest and disease on the plant was recorded.

Rating of pest and disease incidence was done as follows:

Fruit fly

< 30 per cent of fruits affected was rated as - low (L)

30-60 per cent of fruits affected was rated as - medium (M)

> 60 per cent of fruits affected was rated as - heavy (H)

Pumpkin beetle

< 30 per cent of the total number of leaves are affected during first 20 days - low

30-60 per cent of the total number of leaves are affected during first 20 days - medium

> 60 per cent of the total number of leaves are affected during first 20 days - heavy

Mosaic

Even a single plant was not affected - Nil

<30 per cent of plants were affected - low

30-60 per cent of plants were affected - medium

> 60 per cent of plants were affected - heavy

Downy mildew

Plants totally free from disease - absent

Even a single plant was affected - present

Meteorological observation

The weekly mean data of meteorological factors recorded at the meteorological observatory of College of Horticulture, Vellanikkara were used for the study.

3.2.3 Statistical analysis

The data obtained were analysed statistically as per the methods suggested by Panse and Sukhatme (1954).

Simple correlations were computed between the yield and the weekly mean values of maximum temperature, minimum temperature, relative humidity and sunshine hours to determine the effect of weather elements on the yield of ashgourd.

Plate 1. Variability in ashgourd

Plate 2. Ashgourd fruits at different levels of maturity


FULL MATURITY
28 DAYS
21 DAYS
14 DAYS

Results

RESULTS

Investigations were conducted to estimate the variability in ashgourd and to study the effect of time of sowing and periodicity of harvests on yield of ashgourd. The results are presented under the following heads:

4.1 Genetic variability

4.2 Effect of sowing time and periodicity of harvests on yield

4.1 Genetic variability

4.1.1 Variability, heritability and genetic advance

The general analysis of variance showed significant differences for all the 20 characters studied (Appendix I). The population mean, range, genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic gain for the 20 characters are given in Table 3.

4.1.1.1 Length of main vine

There was significant difference among the ecotypes for length of main vine and it ranged from 2.07 m to 6.5 m (Table 3). The overall mean length was 3.9 m. The ecotype with the least main vine length was BH 146 and BH 21 was the longest. The heritability observed was 0.75. The phenotypic and genotypic coefficients of variation were 29.04 and 25.09 respectively. The genetic advance was 1.74 and genetic gain was 44.62 per cent.

Table 3. Range, mean, gcv, pcv, heritability, genetic advance and genetic gain as percentage of mean for 20 characters in ashgourd

Sl.No.	Characters	Range	Mean	GCV	PCV	Heritability	Genetic advance	Genetic gain (%)
1	Length of main vine (m)	2.07-6.50	3.90	25.09	29.04	0.75	1.74	44.62
2	Nodes on main vine	38.33-103.00	58.78	19.33	22.41	0.74	20.18	34.33
3	Primary branches per plant	1.00-17.00	3.29	86.72	91.63	0.90	5.56	169.00
4	Internodal length (cm)	3.27-14.20	6.88	30.92	33.12	0.87	4.09	59.45
5	Leaves per plant	5.67-14.67	10.37	21.47	25.47	0.71	3.87	37.32
6	Days to first female flower anthesis	57.67-90.00	67.04	12.51	13.08	0.91	16.52	24.64
7	Node at which first female flower appeared	21.33-39.67	29.41	12.39	24.07	0.27	3.87	13.16
8	Node at which the first fruit is retained	26.67-46.67	34.67	10.59	20.35	0.27	3.93	11.34
9	Male flowers per plant	38.67-105.67	59.24	22.30	28.66	0.61	21.18	35.75
10	Female flowers per plant	2.67-8.67	4.67	31.80	43.03	0.55	2.26	48.39
11	Per cent of female flowers	3.20-11.73	7.37	15.59	30.42	0.26	1.21	16.42
12	Average fruit weight (kg)	0.20-5.70	3.11	40.58	45.42	0.80	2.32	74.60
13	Fruits per plant	1.00-6.33	2.08	47.70	60.71	0.62	1.60	76.92
14	Per cent of fruit set	32.40-63.43	43.31	15.66	27.11	0.33	8.07	18.63
15	Circumference of fruit (cm)	22.00-70.10	58.65	20.01	20.63	0.94	23.44	39.97
16	Length of fruit (cm)	12.00-39.10	29.35	21.97	23.52	0.87	12.40	42.25
17	Fruit shape index	1.13-1.97	1.57	12.10	16.23	0.56	0.29	18.47
18	Seeds per fruit	53.67-1062.00	486.53	46.57	47.25	0.97	460.07	94.56
19	100 seed weight (g)	1.60-7.30	4.71	22.88	24.09	0.90	2.11	44.80
20	Fruit yield per plant (kg)	0.27-14.70	5.89	51.40	59.74	0.74	5.37	91.17

4.1.1.2 Nodes on main vine

The nodes on the main vine also showed significant difference among the ecotypes (Table 3). This character ranged from 38.33 to 103.00. The maximum node number was recorded in BH 21. GCV was 19.33 and PCV was 22.41. The character had a genetic gain of 34.33 per cent.

4.1.1.3 Primary branches per plant

There was significant variation for the number of primary branches among the ecotypes (Table 3). BH 137 had the minimum number of primary branches (1.0) and BH 21 had the highest number (6.7). The general mean of the character was 3.29. The heritable components of variation showed high values; GCV was 86.72 and PCV was 91.63. Genetic gain was also high (169%).

4.1.1.4 Internodal length

The ecotypes showed significant difference in the internodal length with in a range of 3.27 cm in BH 137 to 14.20 cm in BH 153 (Table 3). GCV value was 30.92 and PCV value was 33.12. The heritability recorded for this character was 0.87 with a genetic gain of 59.45 per cent.

4.1.1.5 Leaves per plant at 30 days after sowing

The number of leaves per plant at 30 days after sowing ranged from 5.67 to 15.00 (Table 3). BH 154 recorded the maximum number of leaves per plant. The heritability observed was 0.71. The genetic advance was 3.87 and genetic gain was 37.32 per cent. The phenotypic and genotypic coefficients of variation were 25.47 and 21.47 respectively.

4.1.1.6 Days to first female flower anthesis

There was significant difference among the ecotypes for days to first female flower anthesis (Table 3). The ecotype BH 116 was the earliest (57.67 days) and BH 157 was the most delayed one (90 days). The overall mean was 67.04 days. Heritability was 0.91. The phenotypic and genotypic coefficients of variation were 13.08 and 12.51 respectively. The genetic advance was 16.52 and genetic gain was 24.64 per cent.

4.1.1.7 Node at which first female flower appeared

This character differed significantly among the ecotypes (Table 3) and ranged from 21.33 to 39.67. The mean of the character was 29.41. BH 73 was the ecotype to produce a female flower at the lowest node (21.33). Heritability recorded was 0.27. GCV showed a low value of 12.39 and PCV had a value of 24.07.

4.1.1.8 Node at which the first fruit is retained

The node at which the first fruit was retained ranged from 26.67 in the ecotypes BH 119 and BH 146 to 46.67 in BH 144 (Table 3). The general mean of the character was 34.67. The character had a heritability value of 0.27 and genetic gain of 11.34 per cent. The GCV and PCV values were 10.59 and 20.35 respectively.

4.1.1.9 Male flowers per plant

The number of male flowers per plant showed significant difference among the ecotypes (Table 3). BH 21 produced the maximum number of male flowers (105.7) while BH 137 produced the minimum (38.7). GCV of this character was 22.30 and PCV was 28.66. The heritability for this character was 0.61 and the genetic gain was 35.75 per cent.

4.1.1.10 Female flowers per plant

This character also had significant variation among the ecotypes (Table 3). BH 21 had the maximum number of female flowers per plant (8.67) and BH 137, BH 150 and BH 156 had the minimum number (2.67). Heritability was low (0.55). GCV and PCV observed were 31.80 and 43.03 respectively. The genetic gain was 48.39 per cent.

4.1.1.11 Per cent of female flowers

The per cent of female flowers produced was minimum for BH 141 (3.2%) and maximum for BH 118 (11.73%). The heritability was 0.26 and genetic gain was 16.42 per cent (Table 3). The GCV value was 15.59 and PCV value was 30.42. The genetic advance showed a very low value of 1.21.

4.1.1.12 Average fruit weight

The average fruit weight of the 30 ecotypes showed significant differences (Table 3). The highest fruit weight was observed for BH 143 (5.7 kg) and the lowest was for BH 157 (0.2 kg). The heritability was 0.80 and the genetic gain was 74.60 per cent. The GCV was 40.58 and PCV was 45.42.

4.1.1.13 Fruits per plant

There was significant difference among the 30 ecotypes for this character (Table 3). The minimum number of fruits (1.0) was observed for BH 137, BH 142, BH 147 and BH 156 and the maximum number of fruits was observed for BH 118 (6.3). The heritability was 0.62. Genetic advance was 1.6 and genetic gain had a value of 76.92 per cent. The general mean of the character was 2.08. The GCV and PCV values observed were 47.7 and 60.71 respectively.

4.1.1.14 Per cent of fruit set

BH 118 had the maximum fruit set (63.43%) and BH 153 had the minimum (32.4%) (Table 3). Heritability (0.33) and genetic gain (18.63%) observed were low. The GCV was 15.66 and PCV was 27.11.

4.1.1.15 Circumference of fruit

There was significant difference among the ecotypes for this character (Table 3). It ranged from 22.0 cm (BH 137) to 70.1 cm (BH 114). The character had a heritability of 0.94 and genetic gain of 39.97 per cent.

4.1.1.16 Length of fruit

The fruit length ranged from 12.00 cm in BH 137 to 39.1 cm in BH 114 (Table 3). The general mean of the character was 29.35 cm. This character had a heritability of 0.87 and genetic gain of 42.25 per cent. The GCV and PCV values were 21.97 and 23.52 respectively.

4.1.1.17 Fruit shape index

The general mean of the character was 1.57. It ranged from 1.13 in BH 115 to 1.97 in BH 21 (Table 3). The heritability value of this character was 0.56.

Genetic advance was low (0.29). The heritable components of variation showed moderately low values. GCV was 12.10 and PCV was 16.23.

4.1.1.18 Seeds per fruit

This character also showed significant differences among the ecotypes. The seeds per fruit ranged from 53.67 in BH 137, to 1062 in BH 21 (Table 3). Heritability and genetic advance showed high values of 0.97 and 460.67 respectively. GCV was 46.57 and PCV was 47.25.

4.1.1.19 100 seed weight

The weight of 100 seeds among the ecotypes ranged from 1.6 g (BH 157) to 7.3 g (BH 21) (Table 3). The character had a heritability value of 0.9 and genetic gain of 44.8 per cent. The GCV and PCV values were 22.88 and 24.09 respectively.

4.1.1.20 Fruit yield per plant

There was significant difference among the 30 ecotypes for this character (Table 3). The lowest yield was recorded by BH 137 (0.27 kg) and the highest by BH 21 (14.7 kg) with mean value of 5.89 kg. The heritability observed was 0.74. Genetic gain gave a high value of 91.17 per cent. The genotypic and phenotypic coefficient of variation was 51.40 and 59.74 respectively.

4.1.2 Correlation studies

The genotypic and phenotypic correlations of various yield components with yield were worked out (Tables 4 and 5). The characters having significant correlation with yield were length of main vine, nodes on main vine, primary

Table 4. Phenotypic correlation coefficients (r_p) among yield and its components in ashgourd

Characters	Nodes on main vine	Primary branches per plant	Inter-nodal length	Leaves/ plant (at 30 days after sowing)	Days to first female flower anthesis	Node at which first female flower appeared	Node at which the first fruit is retained	Male flowers/ plant	Female flowers/ plant	Percent of female flowers	Average fruit weight	Fruits/ plant	Percent of fruit set	Circum-ference of fruit	Length of fruit	Fruit shape index	Seeds/ fruit	100 seed weight	Fruit yield/ plant
Length of main vine	0.692**	0.487**	0.501**	0.415**	-0.148	0.236*	0.281**	0.590**	0.313**	-0.038	0.124	0.196	-0.113	0.118	0.212*	0.214*	0.359**	0.339*	0.300
Nodes on main vine		0.256**	0.292**	0.335**	-0.206	0.213*	0.345**	0.478**	0.281**	-0.043	0.081	0.237*	0.015	0.175	0.266*	0.154	0.282**	0.276*	0.327
Primary branches per plant			0.766**	0.390**	0.024	0.132	0.123	0.402**	0.293**	0.069	0.211*	0.113	-0.156	0.009	0.025	0.028	0.411**	0.187	0.298
Internodal length				0.709**	0.000	0.133	0.192	0.550**	0.384**	0.058	0.096	0.268*	0.040	0.080	0.166	0.046	0.443**	0.287**	0.366
Leaves per plant (at 30 days after sowing)					0.179	0.062	0.155	0.515**	0.365**	0.036	0.027	0.371**	0.195	0.025	0.086	-0.052	0.354**	0.239*	0.311
Days to first female flowers anthesis						0.068	0.041	0.020	0.099	0.078	0.095	0.120	0.136	-0.181	-0.216*	-0.083	0.201	-0.040	0.134
Node at which first female flower appeared							0.814**	0.152	0.057	0.047	0.112	-0.046	-0.150	0.207	0.017	-0.050	0.073	0.153	0.101
Node at which the first fruit is retained								0.185	0.095	0.060	0.009	-0.020	0.226*	0.120	0.036	0.040	0.092	0.101	0.041
Male flowers per plant									0.552**	-0.047	-0.060	0.495**	0.155	0.031	0.256*	0.205	0.434**	0.359**	0.467
Female flowers per plant										0.741**	-0.245*	0.899**	0.232	-0.041	0.146	0.196	0.348**	0.165	0.624
Percent of female flowers											-0.243*	0.631**	0.082	-0.091	-0.053	0.040	0.084	-0.105	0.367
Average fruit weight												-0.286**	-0.177	0.583**	0.403**	-0.160	0.230*	0.365**	0.425
Fruits per plant													0.600**	-0.047	0.119	0.138	0.272**	0.109	0.664
Percent of fruit set														-0.028	0.051	-0.014	0.041	-0.012	0.429
Circumference of fruit															0.687**	-0 066	0.395**	0.494**	0.364
Length of fruit																0.417**	0.362**	0.468**	0.437
Fruit shape index																	0 106	0.142	0.084
Seeds per fruit																		0.499**	0.445
100 seed weight																			0.477

* Significant at 5 per cent level; ** Significant at 1 per cent level

Table 5. Genotypic correlation coefficients (r_g) among yield and its components in ashgourd

Characters	Nodes on main vine	Primary branches per plant	Inter-nodal length	Leaves/ plant (at 30 days after sowing)	Days to first female flower anthesis	Node at which first female flower appeared	Node at which the first fruit is retained	Male flowers/ plant	Female flowers/ plant	Percent of female flowers	Average fruit weight	Fruits/ plant	Percent of fruit set	Circum-ference of fruit	Length of fruit	Fruit shape index	Seeds/ fruit	100 seed weight	Fruit yield/ plant
Length of main vine	0.855**	0.649**	0.611**	0.550**	-0.164	0.622**	0.707**	0.732**	0.474**	0.018	0.181	0.219*	-0.372**	0.136	0.247*	0.321**	0.431**	0.394**	0.376
Nodes on main vine		0.272**	0.324**	0.392**	-0.249*	0.112	0.339**	0.658**	0.419**	-0.151	0.116	0.316**	-0.038	0.173	0.385**	0.343**	0.338**	0.363**	0.413
Primary branches per plant			0.853**	0.465**	0.021	0.087	0.041	0.533**	0.342**	0.004	0.259**	0.140	-0.141	-0.020	0.057	0.099	0.447**	0.207	0.362
Internodal length				0.775**	0.032	0.132	0.185	0.756**	0.537**	0.059	0.146	0.376**	0.109	0.080	0.164	0.102	0.485**	0.345**	0.481
Leaves per plant (at 30 days after sowing)					0.253**	0.202	0.238**	0.799**	0.617**	0.102	0.039	0.585**	0.411**	0.023	0.041	-0.128	0.437**	0.139	0.473
Days to first female flowers anthesis						0.225*	0.136	0.046	0.131	0.119	0.096	0.160	0.260*	-0.199	-0.214*	-0.118	0.225*	-0.050	0 152
Node at which first female flower appeared							1.013**	0.149	0.046	-0.065	0.303**	-0.113	-0.413**	0 328**	0.249*	0 357**	0 182	0 403**	0.087
Node at which the first fruit is retained								0.304**	0.263*	0.061	0 039	0.077	-0.318**	0.124	0.209	0.409**	0.220*	0.372**	0.117
Male flowers per plant									0.759**	0.174	-0.003	0.593**	0.122	0.019	0.353**	0.423**	0.544**	0.524**	0.554*
Female flowers per plant										0.731**	-0.206	0.941**	0.146	-0.085	0.210*	0.398**	0.439**	0.262*	0.616*
Percent of female flowers											-0.357**	0.814**	0.573**	-0.216*	-0.081	0.164	0.136	-0.131	0.348*
Average fruit weight												-0.250*	-0.121	0.686**	0.435**	-0.324	0.266*	0.419**	0.550*
Fruits per plant													0.675**	-0.057	0.139	0.211*	0.314**	0.120	0.600*
Percent of fruit set														0.061	0.062	-0.180	0.037	-0.186	0.456*
Circumference of fruit															0.765**	-0.034	0.419**	0.538**	0.457*
Length of fruit																0.375**	0.390**	0.509**	0.538*
Fruit shape index																	0.148	0.114	0.147
Seeds per fruit																		0.528**	0.493*
100 seed weight																			0.575*

* Significant at 5 per cent level; ** Significant at 1 per cent level

branches per plant, internodal length, leaves per plant, male flowers per plant, female flowers per plant, per cent of female flowers, average fruit weight, fruits per plant, per cent of fruit set, circumference of fruits, length of fruits, seeds per fruit and 100 seed weight. All these characters had positive and significant correlation with yield. The number of fruits per plant had the highest positive and significant phenotypic correlation with yield (r_p = 0.66, r_g = 0.6). The highest significant genotypic correlation of yield was found with female flowers per plant (r_p = 0.62, r_g = 0.616). The correlation values of the character length of main vine, to fruit yield are r_p = 0.3, r_g = 0.376. This was the character having least positive and significant phenotypic correlation value. But the least positive and significant genotypic correlation value was found to be for per cent of female flowers (r_g = 0.348, r_p = 0.367).

4.1.2.1 Inter correlation among different characters

Among the different characters studied, six characters were found to have very significant positive correlations with yield and their associations were estimated. Length of main vine was found to have significant positive association with nodes on main vine (r_g = 0.86), primary branches per plant (r_g = 0.65), internodal length (r_g = 0.61) and leaves per plant (r_g = 0.55). Male flowers per plant was observed to have positive and significant association with yield through length of main vine (r_g = 0.73), nodes on main vine (r_g = 0.66), primary branches per plant (r_g = 0.53), internodal length (r_g = 0.76) and leaves per plant (r_g = 0.8). Similar positive association was found between female flowers per plant and length of main vine (r_g = 0.47), nodes on main vine (r_g = 0.42), primary branches per plant (r_g = 0.34), internodal length (r_g = 0.54) and leaves per plant (r_g = 0.62).

Average fruit weight had correlation with yield through significant positive associations with length of fruit and circumference of fruit (r_g = 0.44,

r_g = 0.69). But the same character had negative association with fruits per plant (r_g = -0.25). Fruits per plant had a significant positive association with male flowers per plant (r_g = 0.59), female flowers per plant (r_g = 0.94) and per cent of fruit set (r_g = 0.68). Seeds per fruit also had positive association with yield through length of fruit (r_g = 0.39) and circumference of fruit (r_g = 0.42).

4.1.3 Path coefficient analysis

The direct and indirect contribution of the component characters on yield can be found out by partitioning the correlations between yield and component characters into direct and indirect effects (Table 6 and Fig. 2). Step down regression was performed and the characters which showed significant correlations with yield were selected for path coefficient analysis. These characters were - nodes on main vine (x_1), internodal length (x_2), leaves per plant (x_3), male flowers per plant (x_4), female flowers per plant (x_5), per cent of female flowers (x_6), average fruit weight (x_7), per cent of fruit set (x_8) and 100 seed weight (x_9).

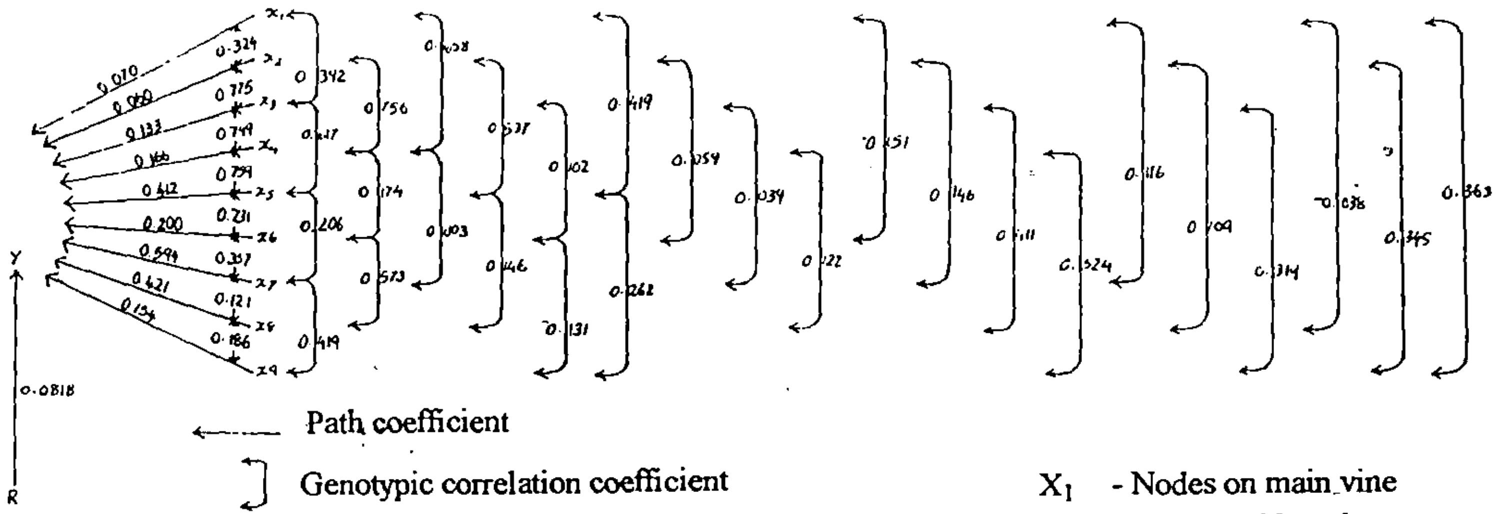
The average fruit weight exhibited the highest positive direct effect on fruit yield per plant (0.594). This was followed by per cent of fruit set (0.421) and the female flowers per plant (0.412). Leaves per plant at 30 days after sowing exhibited a negative direct effect on fruit yield per plant (-0.133). The other characters like nodes on main vine, internodal length, male flowers per plant, per cent of female flowers and 100 seed weight had positive direct effect on fruit yield per plant.

Nodes on main vine had a positive correlation with fruit yield per plant (0.3781) even though its direct effect on yield was low. This character had a low positive and indirect effect on yield through internodal length (0.017), male flowers per plant (0.079), female flowers per plant (0.116), average fruit weight (0.048), per

Table 6. Direct and indirect effects of yield components on fruit yield in ashgourd

Characters	Nodes on main vine	Internodal length	Leaves per plant	Male flowers per plant	Female flowers per plant	Per cent of female flower	Average fruit weight	Per cent of fruit set	100 seed weight	Correlation with yield
Nodes on main vine	0.070	0.017	-0.045	0.079	0.116	-0.009	0.048	0.006	0.043	0.3781
Internodal length	0.021	0.060	-0.094	0.091	0.158	0.012	0.057	0.017	0.044	0.4365
Leaves per plant	0.024	0.042	-0.133	0.085	0.150	0.007	0.016	0.082	0.037	0.4066
Male flowers per plant	0.034	0.033	-0.068	0.166	0.227	-0.009	-0.036	0.065	0.055	0.5103
Female flowers per plant	0.020	0.023	-0.049	0.092	0.412	0.149	-0.146	0.098	0.025	0.6178
Per cent of female flower	-0.003	0.003	-0.005	-0.008	0.305	0.200	-0.144	0.035	-0.016	0.3465
Average fruit weight	0.006	0.006	-0.004	-0.010	-0.101	-0.049	0.594	-0.074	0.056	0.5009
Per cent of fruit set	0.001	0.002	-0.026	0.026	0.096	0.017	-0.105	0.421	-0.002	0.4340
100 seed weight	0.019	0.017	-0.032	0.060	0.068	-0.021	0.217	-0.005	0.154	0.5372

The underlined diagonal values indicate direct effects
Residual - 0.0818



X_1	- Nodes on main vine
X_2	- Internodal length
X_3	- Leaves per plant
X_4	- Male flowers per plant
X_5	- Female flowers per plant
X_6	- Per cent of female flowers
X_7	- Average fruit weight
X_8	- Per cent of fruit set
X_9	- 100 seed weight

Fig.2. Path diagram showing direct and indirect effects of the components of yield

cent of fruit set (0.006) and 100 seed weight (0.043). The indirect effect of nodes on main vine through leaves per plant at 30 days after sowing (-0.045) and per cent of female flowers (-0.009) was negative and low.

The internodal length had a high positive correlation with yield (0.4365). The direct effect of this character on yield was very low and positive (0.060). The indirect effect of internodal length through leaves per plant at 30 days after sowing was low and negative (-0.094). The indirect effects through the other characters were very low but positive. The character - leaves per plant at 30 days after sowing, had a positive correlation with yield (0.4066) eventhough its direct effect on yield was low and negative (-0.133). This character had low and positive indirect effects through all other characters like nodes on main vine, internodal length, male flowers per plant, female flowers per plant, per cent of female flowers, average fruit weight, per cent of fruit set and 100 seed weight.

Male flowers per plant had a high and positive correlation with fruit yield per plant (0.5103). This character had low and negative indirect effects on yield through leaves per plant at 30 days after sowing (-0.068), per cent of female flowers (-0.009) and average fruit weight (-0.036). The indirect effect of male flowers per plant through nodes on main vine (0.034), internodal length (0.033), female flowers per plant (0.227), per cent of fruit set (0.065) and 100 seed weight (0.055) was positive eventhough low.

The character female flowers per plant had the highest correlation with yield (0.6178). This was mainly due to the high positive direct effect it had on yield (0.412). The indirect effect of this character on yield through nodes on main vine (0.090), internodal length (0.023), male flowers per plant (0.092), per cent of female flower (0.149), per cent of fruit set (0.09) and 100 seed weight (0.025) was positive. This character had low and negative indirect effects on yield through leaves per plant at 30 days after sowing (-0.049) and average fruit weight (-0.146).

Per cent of female flowers had a positive correlation with yield (0.3465) and a positive direct effect on yield (0.200). This character had a positive indirect effect on yield through internodal length (0.003), female flowers per plant (0.305) and per cent of fruit set (0.035). But the indirect effects through the other characters were low and negative (-0.003, -0.005, -0.008, -0.144 and -0.016).

The average fruit weight had the highest direct effect on yield (0.594). The correlation with yield was also positive (0.5009). The indirect effect on yield through nodes on main vine (0.006), internodal length (0.006) and 100 seed weight (0.056) were positive even though low. This character had low and negative indirect effects on yield through leaves per plant at 30 days after sowing (-0.004), male flowers per plant (-0.010), female flowers per plant (-0.101), per cent of female flowers (-0.049) and per cent of fruit set (-0.074).

The character per cent of fruit set had a positive correlation with yield (0.4340). This had the second highest direct effect on yield (0.421). The indirect effect of this character on yield through nodes on main vine (0.001), internodal length (0.002), male flowers per plant (0.026), female flowers per plant (0.096) and per cent of female flowers (0.017) was positive. The indirect effect through other characters were negative and low (-0.026, -0.105 and -0.002).

Hundred seed weight had a high positive correlation with yield (0.5372) even though its direct effect on yield was positive and low (0.154). Its indirect effect on yield through nodes on main vine (0.019), internodal length (0.017), male flowers per plant (0.060), female flowers per plant (0.068) and average fruit weight (0.217) was positive. The indirect effect of 100 seed weight through leaves per plant (-0.032), per cent of female flower (-0.021) and per cent of fruit set (-0.005) was negative and low. The residual effect due to unknown factors influencing yield was found to be 0.0818.

From the above experiment a high yielding ecotype viz., BH 21 was selected using the selection index. This ecotype was raised in the field for 12 successive months to identify the best season of planting and to examine the effect of periodicity of harvests on total yield. Ashgourd is a crop which comes to flowering only after 50th day of sowing by which time it put forth more than 60 per cent of its vegetative growth. So the effect of periodicity of harvests was studied with respect to the reproductive and yield characters only. The vegetative characters and the characters taken as index of earliness were not selected for studying the periodicity of harvests on yield.

4.2 Effect of sowing time and periodicity of harvests on yield

4.2.1 Vegetative characters

4.2.1.1 Length of main vine

The mean length of main vine is presented in Table 7. As evident from the table, date of sowing had a significant influence on vine length. The highest vine length (6.11 m) was recorded by the crop sown during November followed by the crops sown during October, September, August and December. The lowest vine length was observed in the case of April sown crop (3.65 m).

4.2.1.2 Nodes on main vine

The number of nodes on main vine is given in Table 7. The number of nodes on main vine showed a significant difference with different dates of sowing. The crops sown during October produced the maximum number of nodes on main

Table 7. Effect of date of sowing and periodicity of harvests on length of main vine and nodes on main vine

Treatments	Length of main vine (m)	Nodes on main vine
Date of sowing		
December 22	5.16 [bcd]	36.42 [e]
January 22	4.81 [de]	38.08 [e]
February 22	4.13 [ef]	37.67 [e]
March 22	5.02 [cd]	50.33 [bc]
April 22	3.65 [f]	39.83 [de]
May 22	3.73 [f]	52.33 [bc]
June 22	4.78 [de]	51.83 [bc]
July 22	4.48 [de]	45.83 [cd]
August 22	5.68 [abc]	57.42 [ab]
September 22	5.72 [ab]	56.42 [ab]
October 22	6.08 [a]	61.08 [a]
November 22	6.11 [a]	48.08 [a]
Periodicity of harvests		
14 days after anthesis	5.01 [a]	49.42 [a]
21 days after anthesis	5.02 [a]	49.14 [a]
28 days after anthesis	4.98 [a]	47.83 [a]
Full maturity	4.77 [a]	45.39 [a]

Treatments having the same alphabet form one homogeneous group

vine (61.1) followed by August sown plants (57.4). The December sown crops produced the minimum number of nodes on main vine (36.4).

4.2.1.3 Primary branches per plant

The mean number of primary branches per plant is given in Table 8. There was a significant difference in the number of primary branches per plant among different dates of sowing. The crop sown during October produced the highest number of primary branches per plant (7.7) followed by September and August sown crops. The lowest number of primary branches per plant was produced by January sown crop (2.3).

4.2.1.4 Internodal length (cm)

The data relating to the mean internodal length is given in Table 8. The crops sown during different months differed significantly with respect to internodal length. The maximum internodal length was seen in June sown crop (11.48 cm) and the minimum for crops sown during January (7.63 cm).

4.2.1.5 Leaves per plant (at 30 days after sowing)

The mean number of leaves per plant at 30 days after sowing is giving in Table 8. The number of leaves produced per plant at 30 days after sowing varied with different sowing dates. The maximum number of leaves per plant at 30 days after sowing was produced by the August sown crop (14 leaves) followed by crops sown during February, March and April. January sown crop produced the minimum number of leaves at 30 days after sowing (7 leaves).

Table 8. Effect of date of sowing and periodicity of harvests on primary branches per plant, internodal length and leaves per plant.

Treatments	Primary branches per plant	Internodal length (cm)	Leaves/plant (at 30 days after sowing)
Date of sowing			
December 22	2.83 [def]	7.70 [e]	7.50 [f]
January 22	2.33 [f]	7.63 [e]	7.17 [f]
February 22	3.58 [cde]	7.93 [de]	13.33 [ab]
March 22	4.17 [c]	8.19 [de]	12.00 [bc]
April 22	2.67 [def]	8.01 [de]	12.00 [bc]
May 22	2.75 [def]	7.71 [e]	9.33 [de]
June 22	3.75 [cd]	11.48 [a]	9.50 [de]
July 22	2.50 [ef]	8.68 [cde]	9.25 [de]
August 22	6.58 [b]	9.93 [bc]	14.08 [a]
September 22	6.83 [ab]	10.03 [b]	10.58 [cd]
October 22	7.75 [a]	9.18 [bcd]	8.17 [ef]
November 22	3.75 [cd]	8.60 [cde]	11.42 [c]
Periodicity of harvests			
14 days after anthesis	4.72 [a]	8.33 [b]	9.61 [b]
21 days after anthesis	4.50 [ab]	8.88 [ab]	10.64 [a]
28 days after anthesis	3.69 [b]	9.04 [a]	10.75 [a]
Full maturity	3.58 [b]	8.78 [ab]	10.44 [ab]

Treatments having the same alphabet form one homogeneous group

4.2.2 Earliness

4.2.2.1 Days to first female flower anthesis

The mean number of days taken for the first female flower to open are given in Table 9. The February sowing took the least number of days for production of female flowers (52.5 days). The maximum number of days for first female flower anthesis was taken by May sowing (71.25 days) which was on par with January sowing (Fig. 3).

4.2.2.2 Days to first male flower anthesis

The data relating to the mean number of days taken for the first male flower anthesis are given in Table 9. The production of first male flower was significantly influenced by date of sowing. The least number of days for the opening of first male flower was taken by March sown crop (51.75 days) followed by February sown crop (52.67 days). May and October sown crops were on par and took maximum number of days for the first male flower to open (65 days).

4.2.2.3 Node at which first female flower appeared

The mean value of the node at which the first female flower was produced are given in Table 10. The influence of date of sowing on the node at which the first female flower was produced was significant. The lowest node number at which the first female flower was produced was in October sown crop (21st node). It was followed by the crops sown during December, September and January. The sowing done during May registered the highest node number (33rd node) for the production of the first female flower.

Table 9. Effect of date of sowing and periodicity of harvests on days to first female flower anthesis and days to first male flower anthesis

Treatments	Days to first female flower anthesis	Days to first male flower anthesis
Date of sowing		
December 22	57.67 def	53.75 efg
January 22	69.67 a	61.33 b
February 22	52.50 f	52.67 fg
March 22	55.00 ef	51.75 g
April 22	59.58 bcde	55.58 de
May 22	71.25 a	65.58 a
June 22	58.33 def	55.17 def
July 22	59.42 cde	55.92 cde
August 22	60.17 bcde	56.75 cd
September 22	66.00 ab	61.33 b
October 22	65.83 abc	64.92 a
November 22	62.42 bcd	58.50 c
Periodicity of harvests		
14 days after anthesis	60.33 a	58.75 a
21 days after anthesis	61.50 a	57.11 a
28 days after anthesis	62.06 a	57.17 a
Full maturity	62.06 a	58.06 a

Treatments having the same alphabet form one homogeneous group

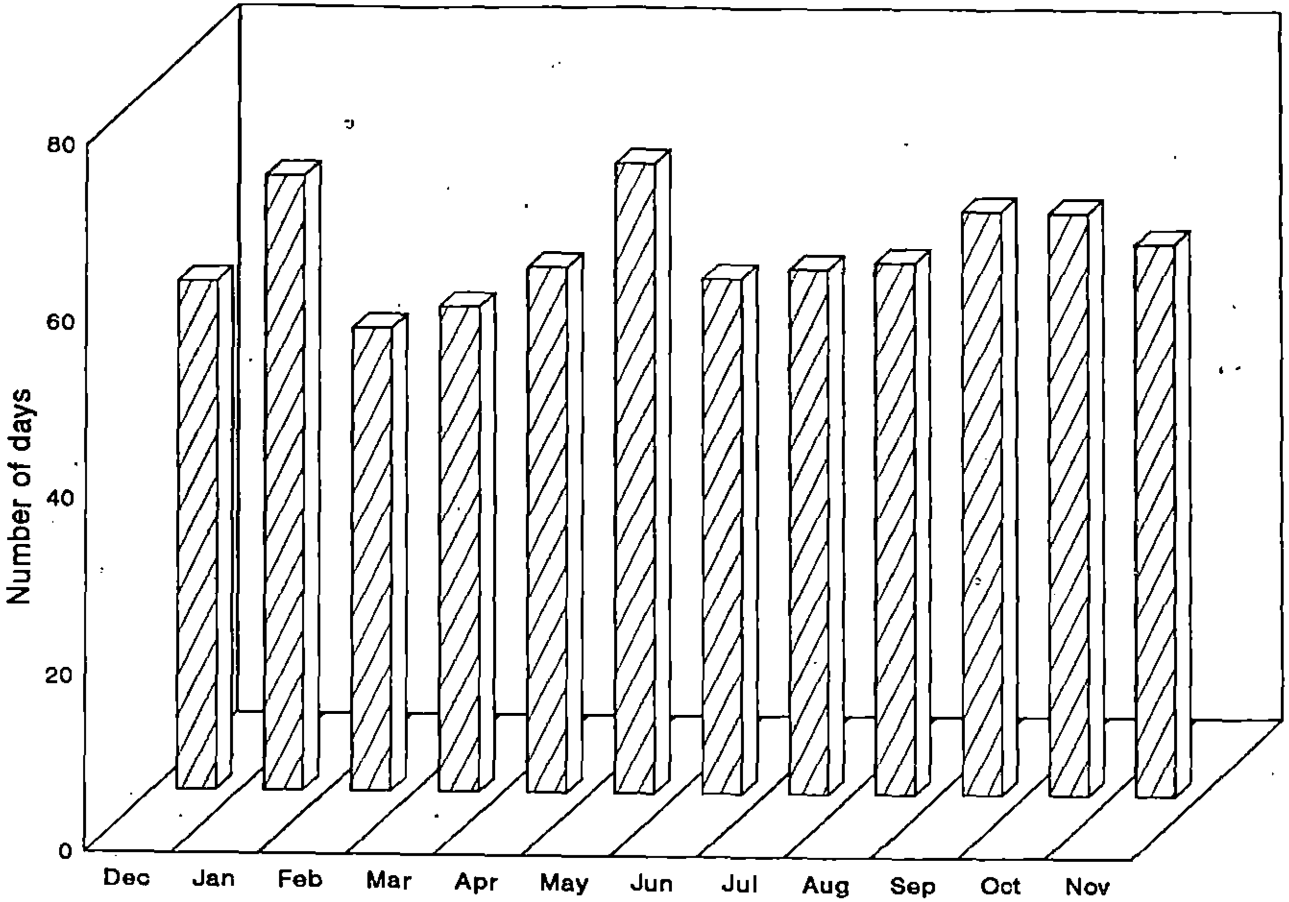


Fig. 3. Effect of dates of sowing on days to first female flower anthesis

Table 10. Effect of date of sowing and periodicity of harvests on node at which first female flower appeared and node at which the first fruit is retained

Treatments	Node at which first female flower appeared	Node at which the first fruit is retained
Date of sowing		
December 22	23.25 [fg]	27.08 [a]
January 22	25.08 [ef]	26.67 [a]
February 22	26.50 [de]	29.58 [a]
March 22	29.92 [bc]	36.00 [a]
April 22	30.17 [abc]	34.83 [a]
May 22	33.25 [a]	33.25 [a]
June 22	28.75 [bcd]	34.83 [a]
July 22	30.75 [ab]	34.42 [a]
August 22	28.83 [bcd]	29.58 [a]
September 22	24.92 [ef]	34.75 [a]
October 22	21.08 [g]	26.17 [a]
November 22	27.42 [cde]	28.33 [a]
Periodicity of harvests		
14 days after anthesis	26.42 [b]	26.53 [a]
21 days after anthesis	26.78 [b]	25.72 [a]
28 days after anthesis	29.47 [a]	26.33 [a]
Full maturity	27.31 [ab]	29.92 [a]

Treatments having the same alphabet form one homogeneous group

4.2.2.4 Node at which the first fruit is retained

Node at which the first fruit is retained is given in Table 10. The node at which the first fruit is retained differed significantly with dates of sowing. The first fruit was retained at the lowest node by the crop sown during October (26th node). It was followed by January, December and November sown crops. March sown crop retained the first fruit at the highest node (36th node).

4.2.3 Flower and fruit characters

4.2.3.1 Male flowers per plant

The data relating to the mean number of male flowers produced per plant are given in Table 11. The crops sown during January recorded highest number of male flowers (99.3 flowers). The crops sown during November recorded the lowest number of male flowers (49.4 flowers).

The crops with a harvesting interval of 14 days produced the maximum number of male flowers (78.3 flowers) and were superior to the crops with the harvesting intervals of 21 days, 28 days and full maturity which were on par with one another.

4.2.3.2 Female flowers per plant

The data on the number of female flowers per plant are given in Table 11. It is clear from the table that there was significant difference in the number of female flowers per plant among different dates of sowing. The highest number of female flowers per plant was observed when the crops were sown during October (23.5 flowers) followed by the crops sown in September (18 flowers), January (14 flowers) and February (10.5 flowers). April sown crop recorded the lowest number

Table 11. Effect of date of sowing and periodicity of harvests on male flowers per plant, female flowers per plant and per cent of female flowers

Treatments	Male flowers per plant	Female flowers per plant	Per cent of female flowers
Date of sowing			
December 22	70.33 [a]	9.99 [cd]	12.44 [b]
January 22	99.33 [a]	14.01 [bc]	12.36 [b]
February 22	75.67 [a]	10.50 [cd]	12.19 [b]
March 22	53.00 [a]	5.49 [d]	9.39 [cd]
April 22	52.25 [a]	4.50 [d]	7.93 [de]
May 22	49.92 [a]	5.01 [d]	9.12 [cd]
June 22	94.00 [a]	9.24 [cd]	9.00 [cd]
July 22	84.58 [a]	7.26 [cd]	7.91 [de]
August 22	67.83 [a]	8.49 [cd]	11.12 [bc]
September 22	65.92 [a]	18.00 [ab]	21.45 [a]
October 22	77.67 [a]	23.49 [a]	23.22 [a]
November 22	49.42 [a]	6.75 [d]	12.02 [b]
Periodicity of harvests			
14 days after anthesis	78.39 [a]	13.08 [a]	14.30 [a]
21 days after anthesis	68.89 [b]	11.01 [a]	13.78 [a]
28 days after anthesis	65.86 [b]	8.25 [b]	11.13 [a]
Full maturity	63.49 [b]	8.58 [b]	11.90 [a]

Treatments having the same alphabet form one homogeneous group

of female flowers per plant (4.5 flowers) followed by May sown crop (5 flowers) (Fig. 4).

Significant difference was noticed in the number of female flowers per plant with respect to the periodicity of harvests (Fig. 5). Plants with a harvest interval of 14 days produced the highest number of female flowers. The October sown plants at harvest interval of 14 days registered the maximum number of female flowers per plant (33 flowers).

4.2.3.3 Per cent of female flowers

The data relating to the per cent of female flowers produced are given in Table 11. The per cent of female flowers differed significantly with dates of sowing. The maximum was produced by the crops sown during October (23.22%) followed by September sown crops (21.45%). The crops sown during July registered the minimum percentage of female flowers (7.91%).

The periodicity of harvests did not influence the per cent of female flowers produced. The interaction between dates of sowing and periodicity of harvests on per cent of female flowers was not significant.

4.2.3.4 Average fruit weight (kg)

The mean values for the fruit weight are given in Table 12. The mean fruit weight was highest in August sown crop (3.2 kg) and was followed by March, June and February sown crops. The lowest fruit weight was observed in April sown crops (0.82 kg) (Fig. 6).

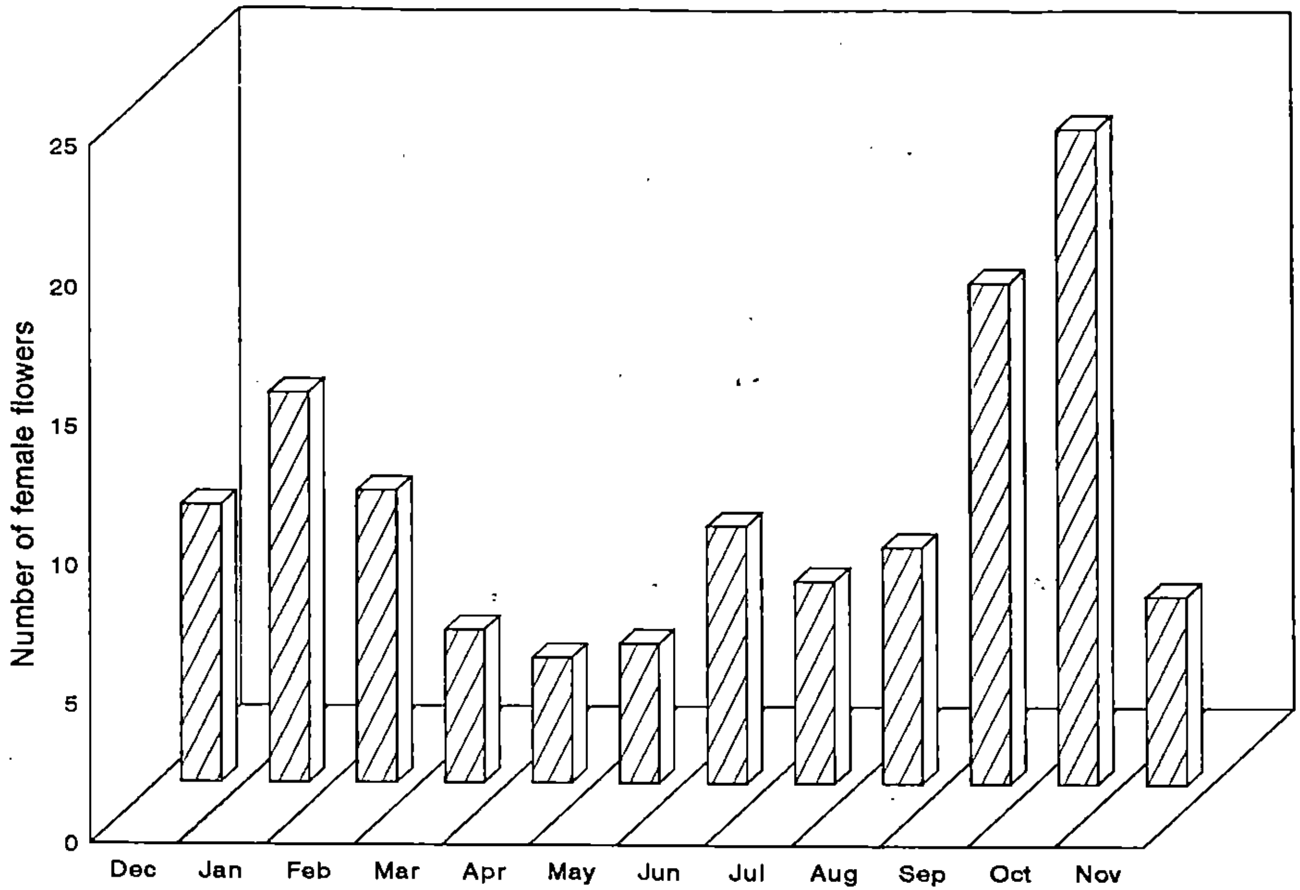


Fig. 4. Effect of date of sowing on female flower per plant

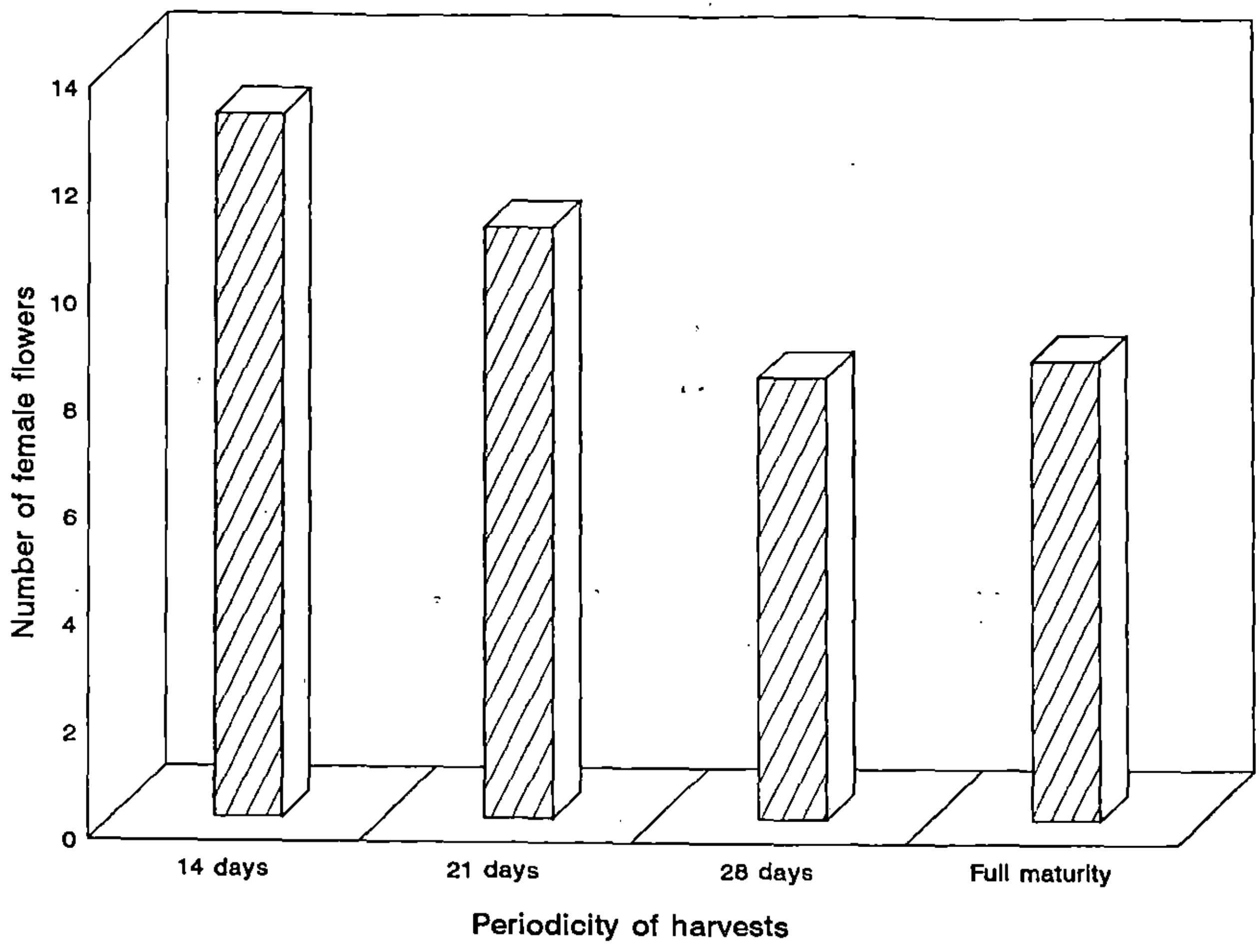


Fig. 5. Influence of periodicity of harvests on female flowers per plant

Table 12. Effect of date of sowing and periodicity of harvests on average fruit weight, fruits per plant and per cent of fruit set

Treatments	Average fruit weight (kg)	Fruits per plant	Per cent of fruit set
Date of sowing			
December 22	2.35 bcde	4.75 bc	52.46 a
January 22	2.41 bcd	5.50 ab	37.18 a
February 22	2.74 abc	4.25 bcd	44.78 a
March 22	2.98 a	3.50 cd	44.91 a
April 22	0.82 g	0.50 e	11.28 b
May 22	0.95 g	0.50 e	5.98 b
June 22	2.91 a	3.00 d	34.18 a
July 22	2.33 cde	3.00 d	53.25 a
August 22	3.23 a	4.50 bcd	54.83 a
September 22	2.47 bc	5.00 bc	27.77 a
October 22	2.23 def	6.50 a	31.93 a
November 22	1.83 ef	3.75 cd	49.91 a
Periodicity of harvests			
14 days after anthesis	1.76 c	4.08 a	35.06 b
21 days after anthesis	2.13 bc	3.75 a	37.81 ab
28 days after anthesis	2.36 b	2.82 b	35.86 b
Full maturity	2.68 a	3.99 a	40.76 a

Treatments having the same alphabet form one homogeneous group

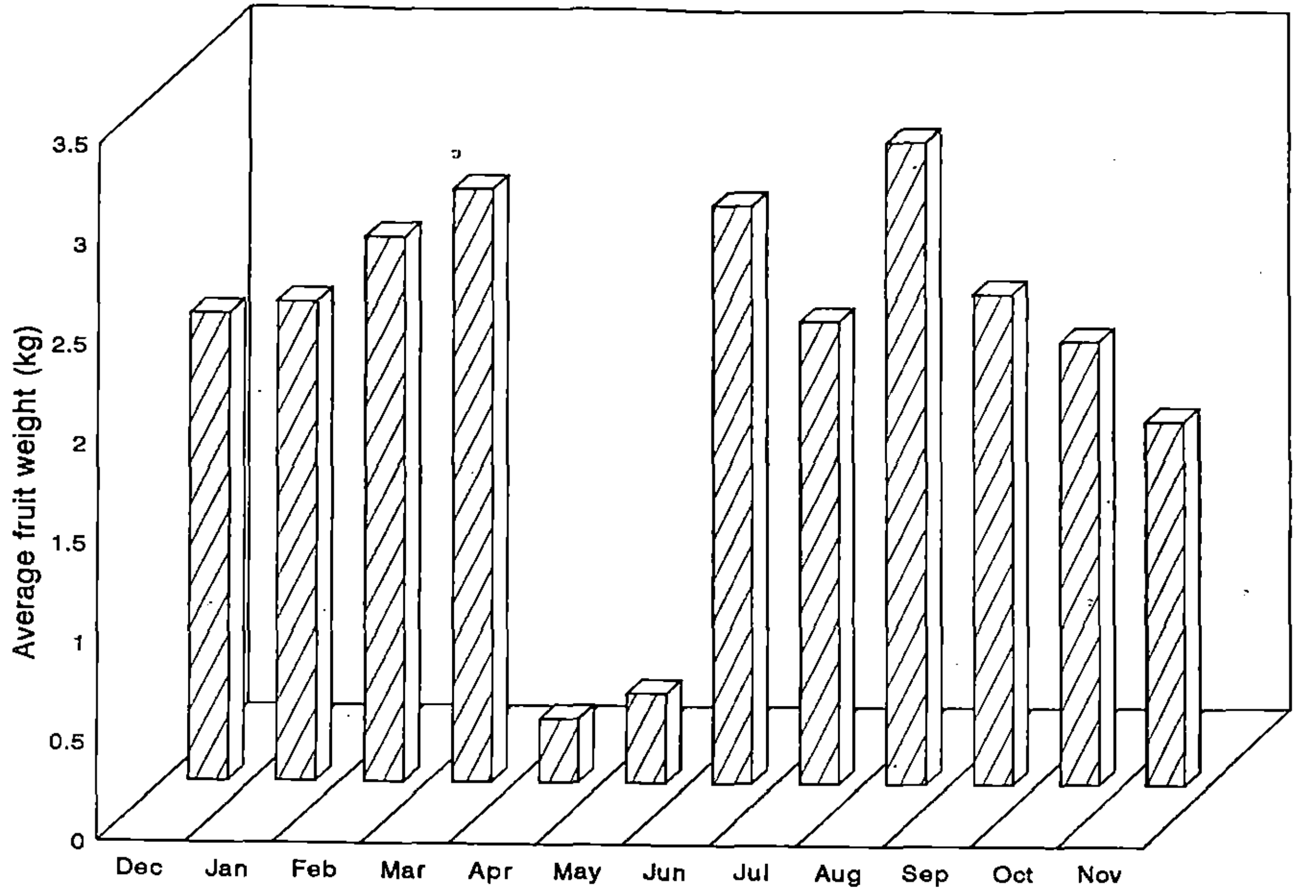


Fig. 6. Effect of date of sowing on average fruit weight

The fruits harvested at full maturity showed the highest fruit weight (2.7 kg) and was superior to all the other treatments. The crops with harvesting interval of 14 days produced fruits with the lowest fruit weight (1.8 kg).

The combined effect of dates of sowing and periodicity of harvests on average fruit weight was not significant.

4.2.3.5 Fruits per plant

The number of fruits per plant for the different treatments are presented in Table 12. The time of sowing significantly influenced the number of fruits per plant. The highest number of fruits were produced by October sown crop (6.5 fruits) which was followed by crops sown during January, September and December. The least number of fruits were produced by April and May sown crops (0.5 fruits) (Fig. 7).

Influence of periodicity of harvests on the number of fruits per plant was not significant. However, the crops with a harvesting interval of 14 days produced more number of fruits per plant (4.08 fruits) (Fig. 8).

4.2.3.6 Per cent of fruit set

The mean per cent of fruit set are given in Table 12. There was significant difference in fruit set among the different dates of sowing. August sown crop recorded the highest fruit set (54.83%) and the lowest (5.98%) was for May sown crop.

The per cent of fruit set was not influenced by the harvesting intervals. The interaction effect was also not significant.

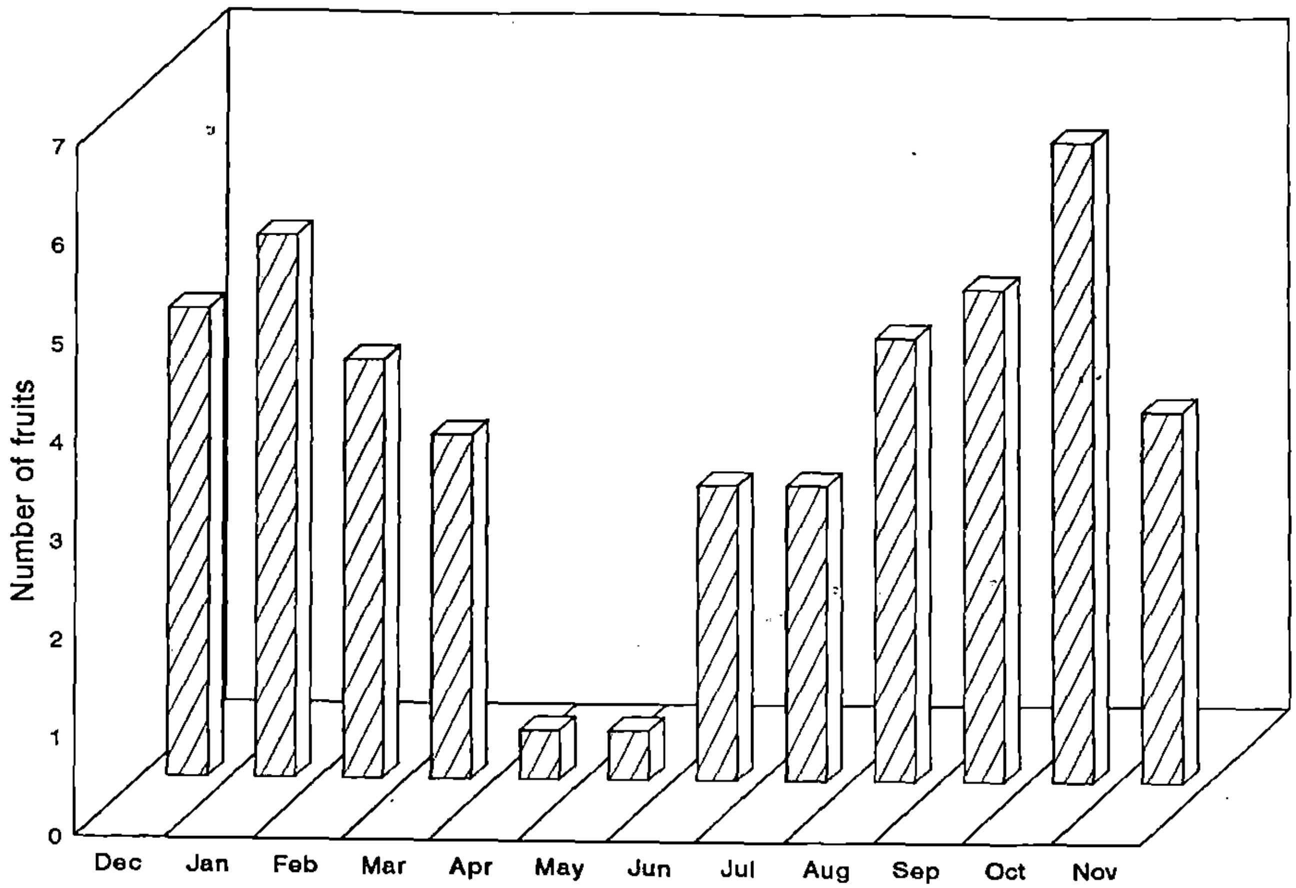


Fig. 7. Effect of date of sowing on fruits per plant

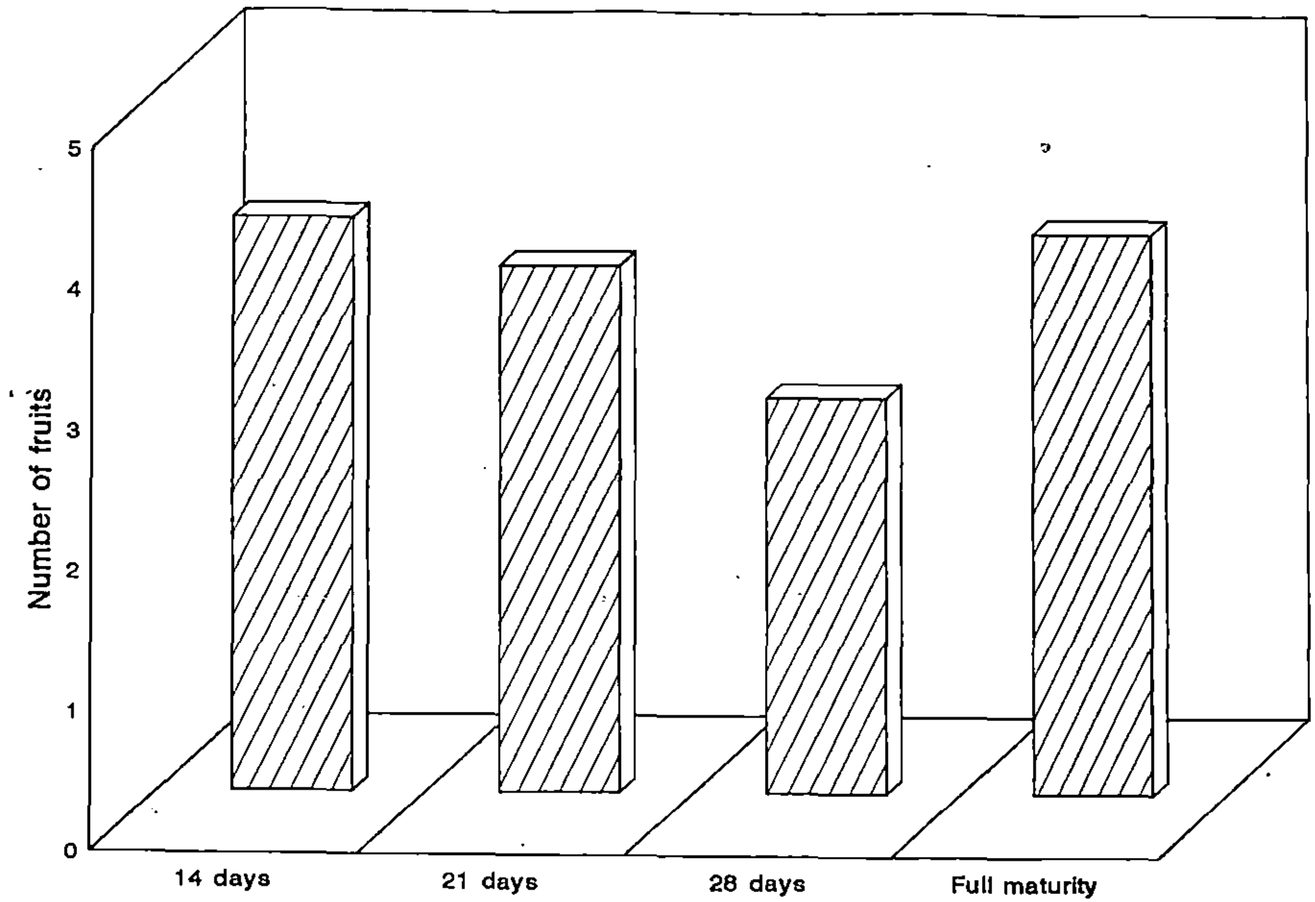


Fig. 8. Influence of periodicity of harvests on fruits per plant

4.2.3.7 Circumference of fruit (cm)

Circumference of fruits differed significantly with dates of sowing (Table 13). Crop sown during August produced fruits with maximum circumference (52.04 cm), followed by crops sown during February, October and March. Fruits with minimum circumference was produced by May sown crop (37.87 cm).

4.2.3.8 Length of fruit (cm)

The mean fruit length is presented in Table 13. There was significant difference in fruit length among the different dates of sowing. Maximum fruit length was recorded by August sown crop (26.58 cm) followed by February sown crop (25.28 cm).

Among the intervals of harvest, the maximum fruit length was registered by fruits harvested at full maturity (23.16 cm). This treatment was superior to other harvesting intervals of 14 days, 21 days and 28 days.

The interaction between the effect of dates of sowing and periodicity of harvests on the length of fruit was not significant.

4.2.3.9 Fruit shape index

The mean fruit shape index is presented in Table 13. Crops sown during June and September showed the highest fruit shape index (1.68). The smallest fruit shape index was for the April sown crop (1.41).

The highest value of fruit shape index was recorded by the fruits harvested at full maturity stage. The interaction effect was not significant.

Table 13. Effect of date of sowing and periodicity of harvests on circumference of fruit, length of fruit, fruit shape index and flesh thickness

Treatments	Circumference of fruit (cm)	Length of fruit (cm)	Fruit shape index	Flesh thickness (cm)
Date of sowing				
December 22	47.60 [ab]	24.12 [ab]	1.60 [a]	3.68 [abc]
January 22	44.91 [ab]	22.99 [ab]	1.50 [a]	3.18 [bc]
February 22	50.74 [ab]	25.28 [a]	1.60 [a]	3.92 [a]
March 22	49.31 [ab]	24.92 [ab]	1.60 [a]	3.71 [abc]
April 22	37.98 [c]	18.22 [c]	1.41 [a]	2.58 [d]
May 22	37.87 [c]	18.43 [c]	1.42 [a]	2.60 [d]
June 22	47.41 [ab]	25.00 [ab]	1.68 [a]	3.46 [abc]
July 22	44.99 [ab]	23.10 [ab]	1.63 [a]	3.02 [c]
August 22	52.04 [a]	26.58 [a]	1.58 [a]	3.88 [ab]
September 22	43.31 [b]	22.94 [ab]	1.68 [a]	3.91 [ab]
October 22	50.69 [ab]	24.61 [ab]	1.53 [a]	3.46 [abc]
November 22	43.17 [b]	20.94 [b]	1.43 [a]	3.28 [abc]
Periodicity of harvests				
14 days after anthesis	37.79 [b]	19.50 [b]	1.36 [a]	2.66 [b]
21 days after anthesis	40.17 [b]	20.14 [b]	1.31 [a]	2.83 [b]
28 days after anthesis	39.72 [b]	20.24 [b]	1.32 [a]	3.23 [a]
Full maturity	45.65 [a]	23.16 [a]	1.46 [a]	3.50 [a]

Treatments having the same alphabet form one homogeneous group

4.2.3.10 Flesh thickness

The data pertaining to the flesh thickness of fruits are given in Table 13. Effect of date of sowing on flesh thickness was significant. Thickness of the flesh was highest for the crop sown during February (3.92 cm). The least value was recorded by April sown crop (2.58 cm).

Among the four intervals of harvest, the fruits harvested at full maturity stage had the maximum flesh thickness (3.5 cm). This treatment was statistically on par with the fruits harvested at 28 days maturity (3.2 cm) and was superior to those harvested at 14 days (2.7 cm) and 21 days maturity (2.8 cm). The interaction effect was not significant.

4.2.3.11 Seeds per fruit

The mean values for the number of seeds per fruit are given in Table 14. The number of seeds per fruit was highest in October sown crop (510 seeds). August sown crop followed this (503 seeds). The crop sown in April produced fruits with lowest number of seeds (40).

Fruits harvested at full maturity had the highest number of fully developed seeds (329). The combined effect of sowing dates and periodicity of harvests was not significant for number of seeds per fruit.

4.2.3.12 100 seed weight

The mean values of hundred seed weight is given in Table 14. The weight of 100 seeds differed significantly with sowing dates. The weight of 100 seeds was

Table 14. Effect of date of sowing and periodicity of harvests on number of seeds per fruit and 100 seed weight

Treatments	Seeds per fruit	100 seed weight (g)
Date of sowing		
December 22	266.20 [e]	5.60 [a]
January 22	291.80 [de]	5.13 [abc]
February 22	434.50 [ab]	6.12 [a]
March 22	434.40 [ab]	5.16 [ab]
April 22	39.58 [g]	1.03 [d]
May 22	47.08 [g]	0.83 [d]
June 22	396.10 [bc]	4.02 [c]
July 22	380.90 [bcd]	4.18 [bc]
August 22	503.30 [a]	5.88 [a]
September 22	171.80 [f]	5.69 [a]
October 22	509.60 [a]	5.39 [a]
November 22	308.80 [cde]	6.10 [a]
Periodicity of harvests		
14 days after anthesis	317.30 [a]	4.44 [b]
21 days after anthesis	296.70 [a]	4.65 [ab]
28 days after anthesis	318.50 [a]	4.31 [b]
Full maturity	328.80 [a]	4.98 [a]

Treatments having the same alphabet form one homogeneous group

highest in crops sown during February (6.1 g) and lowest in May sown crop (0.83 g).

The fruits harvested at full maturity had the highest 100 seed weight.

4.2.3.13 Fruit yield per plant

The data pertaining to the fruit yield per plant is given in Table 15. Among the different sowing dates, the maximum fruit yield per plant was registered by the crop sown during October (15.23 kg) followed by the crop sown during January (14.58 kg), August (14.45 kg) and September (11.7 kg). April sown crop recorded the lowest fruit yield per plant (0.95 kg) (Fig. 9).

Among the four intervals of harvest, the fruits when harvested at full maturity stage recorded the highest fruit yield per plant (12.0 kg).

A significant influence was shown by the combined interaction of dates of sowing and harvest intervals on fruit yield per plant (Fig. 10). The crops sown during January gave the highest yield (16.8 kg) when harvested at 14 days interval followed by August and February sowing. October sowing recorded highest yield (31.1 kg) when harvested at 21 days maturity. This was followed by January and September sowing. When harvested at 28 days maturity, March sowing yielded the highest (12.5 kg) followed by September and December. At full maturity, August sowing recorded the highest yield (23.0 kg) closely followed by December, January and March sowing. The crops sown during October and harvested at 21 days interval showed the maximum fruit yield per plant (31.1 kg).

Table 15. Combined effect of date of sowing and periodicity of harvests on yield of ashgourd

Date of sowing	Yield (kg/plant)				Mean
	14 days	21 days	28 days	Full maturity	
December 22	8.20	6.00	11.60	20.20	11.50
January 22	16.80	14.60	6.90	20.00	14.58
February 22	12.80	9.90	11.10	11.70	11.38
March 22	6.80	9.00	12.50	14.40	10.68
April 22	0	0	0	3.80	0.95
May 22	0	0	1.90	3.50	1.35
June 22	6.53	5.40	10.00	13.00	8.73
July 22	6.43	8.20	8.00	5.30	6.98
August 22	15.20	8.70	10.90	23.00	14.45
September 22	11.30	14.27	11.63	9.60	11.70
October 22	11.00	31.10	7.10	11.70	15.23
November 22	8.40	7.40	5.10	8.00	7.23
Mean	8.62	9.55	8.06	12.00	

CD for comparing main plot treatments - 3.63
CD for comparing sub plot treatments - 2.32

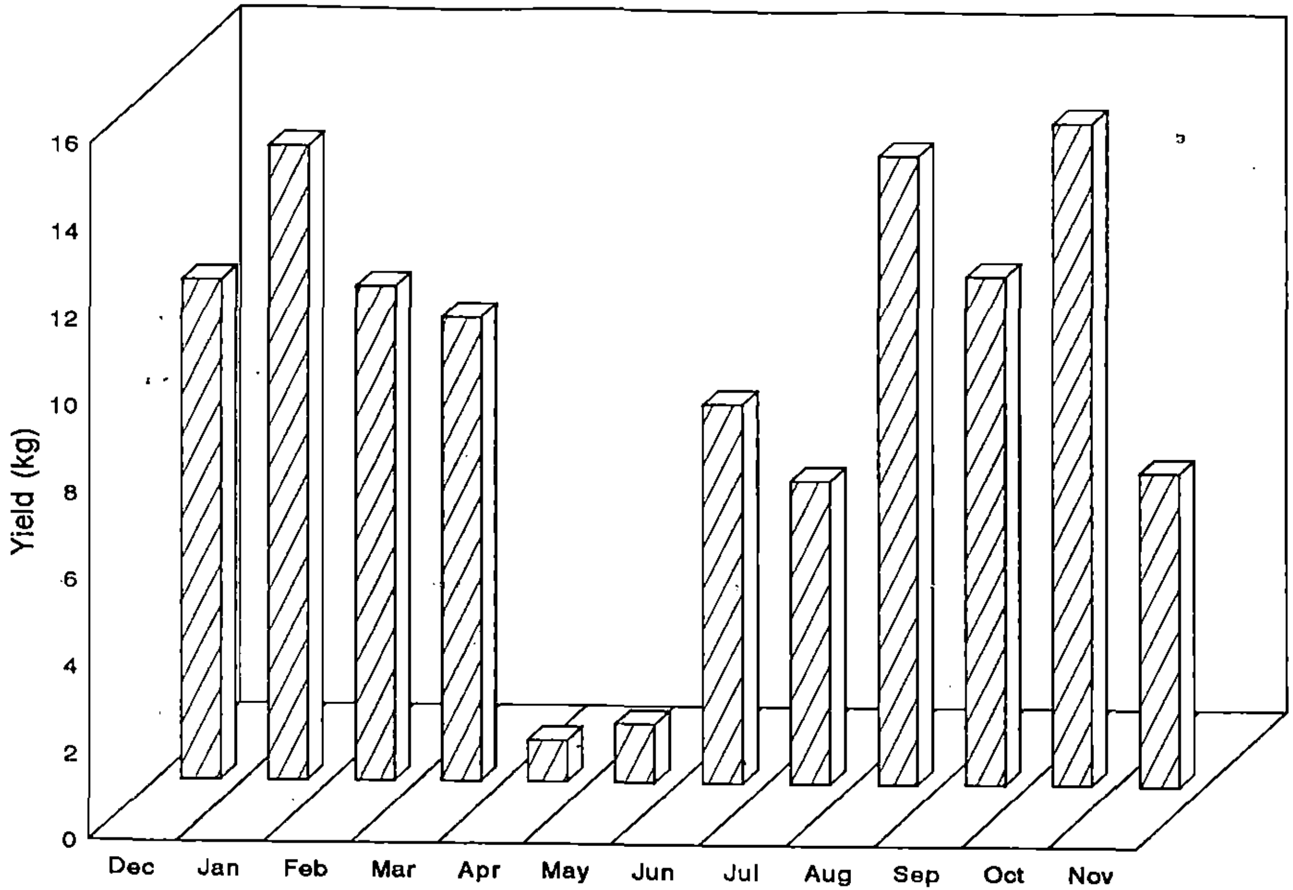


Fig. 9. Effect of date of sowing on fruit yield per plant

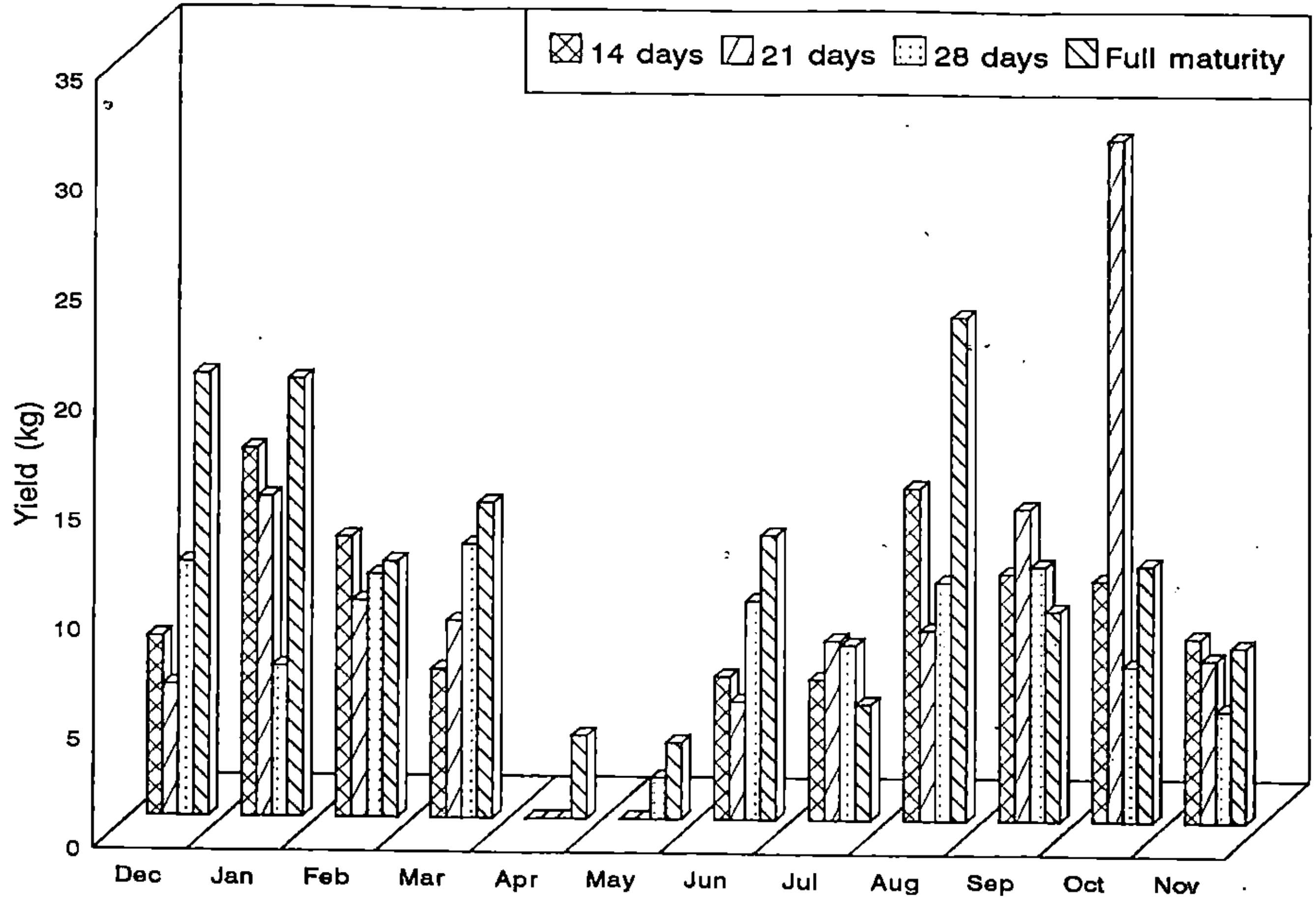


Fig. 10. Influence of dates of sowing and periodicity of harvests on yield of ashgourd

4.2.4 Incidence of pests and diseases

Fruit flies and pumpkin beetles were the major pests and mosaic and downy mildew were the diseases noticed during the cropping seasons.

The rating of pest and disease infestation is given in Table 16. The crop sown during April, May and June were severely affected by fruit flies and the lowest, incidence was noticed in July, August, September and October sown crops. The incidence of pumpkin beetle was found to be severe in February, March, April and May sown crops.

The occurrence of mosaic was severe in crops sown in November, December, January and February. Downy mildew was observed in June and July sown crops.

4.2.5 Crop weather relationship

Simple linear correlation was worked out between yield and important weather parameters like maximum and minimum temperature, morning relative humidity, afternoon relative humidity and sunshine hours. It was found that minimum temperature, maximum temperature during 1st and 2nd week after anthesis and sunshine hours during the 4th week after anthesis were positively correlated with yield. Relative humidity during morning and afternoon hours for the first three weeks after anthesis were negatively correlated with yield. The correlation coefficients for these are given in Table 17.

For obtaining a reasonably better predictor of fruit yield only two variables were selected viz., maximum temperature and afternoon relative humidity,

Table 16. Rating of pest and disease incidence

Dates of sowing	Pests		Diseases	
	Fruit fly	Pumpkin beetle	Mosaic	Downy mildew
December 22	L	L	H	A
January 22	M	M	H	A
February 22	M	H	H	A
March 22	M	H	L	A
April 22	H	H	L	A
May 22	H	H	Nil	A
June 22	H	M	Nil	P
July 22	L	M	Nil	P
August 22	L	M	Nil	A
September 22	L	M	Nil	A
October 22	L	L	L	A
November 22	M	L	H	A

L - Low, M - Medium, H - High, A - Absent, P - Present

Table 17. Correlation coefficients between yield and weather parameters

Weather parameters	Correlation coefficients	
	Period	Yield
Maximum temperature	1-2 WAA	0.660*
Minimum temperature	1-3 WAA	0.320
Sunshine hours	4 WAA	0.441
Humidity (morning)	1-3 WAA	-0.214
Humidity (afternoon)	1-3 WAA	-0.338

WAA - Weeks after anthesis
* Significant at 5% level

while working out the regression equation. The regression equation for total yield was

$$y = 0.558\ T\ max + 0.014\ RH\ afternoon - 15.488$$

where, y = yield in kg

The estimated yield using the regression equation and the actual observed values are given in Table 18.

Table 18. Observed and expected yield

Treatments	Yield (kg)	
	Observed	Predicted
Date of sowing		
December 22	20.20	16.21
January 22	20.00	18.57
February 22	11.70	15.72
March 22	14.40	13.91
April 22	3.80	8.86
May 22	3.50	5.91
June 22	13.00	14.54
July 22	5.30	5.78
August 22	23.00	19.12
September 22	9.60	13.44
October 22	11.70	9.98
November 22	8.00	12.46

Discussion

DISCUSSION

5.1 Genetic variability

Information on variability, heritability, genetic advance and correlation among yield and its components largely determines the success of any crop improvement programme. This is because the success of crop improvement largely depends on the magnitude of variability and extent of heritability exhibited by the desirable characters. The existence of very high variability with respect to vegetative, productive and quality characters in cucurbits had been reported by Nath and Dutta (1970), Thakur and Nandpuri (1974) and Bhathal and Sandhu (1984) in watermelon and Wahab and Gopalakrishnan (1993) in bittergourd.

There was significant difference among the 30 ecotypes for all the 20 characters studied. This reveals ample scope for improving the population. The studies conducted by Hamid *et al.* (1989) also revealed a wide range of variability for most of the characters in ashgourd.

The earliest flowering ecotype was BH 116 (57.67 days) followed by BH 145 (58.67 days) and BH 148 (58.67 days). BH 73 produced the first female flower at the lowest node (21.33). The first fruit was retained at the lowest node by BH 119 (26.67) and BH 146 (26.67) followed by BH 73 (27.00). The highest number of female flowers per plant was observed in BH 118 (10.00) followed by BH 21 (8.67). BH 137, BH 150 and BH 156 recorded the lowest number of female flowers per plant (2.67). The average fruit weight was highest for BH 143 (5.7 kg) and lowest for BH 157 (0.2 kg). The number of fruits per plant was maximum in BH 118 (6.33) followed by BH 21 (4.33). The yield per plant was highest in BH 21 (14.7 kg).

The genotypic coefficient of variation was of high magnitude for primary branches per plant, fruit yield per plant and seeds per fruit and it resulted in high heritability. This indicated that the expression of these characters were least influenced by the environment. In the present study GCV was lowest for node at which first fruit is retained, fruit shape index, node at which first female flower appeared, days to first female flower anthesis, per cent of female flowers and per cent of fruit set indicating the high influence of environment on these characters. The effectiveness of selection depends upon the heritability and genetic advance of the characters studied. In this experiment, high heritability along with high genetic gain was observed for primary branches per plant, fruit yield per plant, seeds per fruit and average fruit weight. High heritability along with high genetic gain for these characters was mainly due to additive genes and so these characters can be improved by selection. Rajendran and Thamburaj (1994) observed high heritability and high genetic advance for 100 seed weight, average fruit weight, yield per vine and number of seeds per fruit in watermelon. Eventhough heritability was high for circumference of fruit, days to first female flower anthesis, internodal length and length of fruit, the genetic gain was low indicating the non additive gene action for the expression of these characters. The present study also indicated that high heritability is not always coupled with high genetic gain.

5.2 Correlation studies

The identification and improvement of better ecotypes becomes more effective with a thorough knowledge of the relationship between yield and its component characters. The yield was significantly and positively correlated with fruits per plant, female flowers per plant, 100 seed weight, seeds per fruit, length of fruit, percent of fruit set, average fruit weight, per cent of female flowers, internodal length, circumference of fruit, nodes on main vine, leaves per plant, length of main vine and primary branches per plant (Tables 4 and 5). This is in agreement with the findings of Srivastava and Srivastava (1976), Ramachandran (1978), Salk (1982), Choudhary and Mandal (1987) and Singh *et al.* (1987) all of whom reported a positive and significant correlation of these characters with yield in various cucurbits. The phenotypic correlations were larger than genotypic correlations for the characters - node at which first female flower appeared, female flowers per plant, per cent of female flowers and fruits per plant indicating that environment had larger effects on these characters. The phenotypic correlation of all the other characters were smaller than genotypic correlation which proved that environment had smaller but similar effects on these characters.

5.3 Path coefficient analysis

The path coefficient analysis showed maximum direct positive effect of fruit weight (0.594) on yield per plant followed by per cent of fruit set (0.421). Therefore it can be inferred that fruit weight is the most important component character for yield. This is in accordance with the findings of Rajendran (1989) in which mean fruit weight had a direct effect on fruit yield of watermelon. Ramachandran (1978) reported that yield of bittergourd was highly correlated with fruit weight. Studies by Choudhary and Mandal (1987) in cucumber also revealed similar findings.

The direct effect of nodes on main vine on yield was positive. Its correlation with yield was also positive probably due to the indirect effects of internodal length, female flowers per plant, average fruit weight, per cent of fruit set and 100 seed weight. The direct effect of internodal length on yield was positive and its correlation with yield was also positive due to the indirect effects of nodes on main vine, male flowers per plant, female flowers per plant, per cent of female flowers, average fruit weight, per cent of fruit set and 100 seed weight. Eventhough the direct effect of leaves per plant at 30 days after sowing was negative, its correlation with yield was positive possibly due to the indirect effect through nodes on main vine, internodal length, female flowers per plant, per cent of female flowers, average fruit weight, per cent of fruit set and 100 seed weight.

The direct effect of female flowers on yield was positive and also its correlation with yield was positive due to the indirect effects through nodes on main vine, internodal length, per cent of female flowers, per cent of fruit set and 100 seed weight. The direct effect of per cent of female flowers on yield was positive and so also its correlation with yield possibly due to female flowers per plant and per cent of fruit set.

The direct effect of fruit weight on yield and its correlation with yield was positive due to the indirect effect through nodes on main vine, internodal length and 100 seed weight. The direct effect of per cent of fruit set on yield and its correlation with yield was positive, probably due to nodes on main vine, internodal length, female flowers per plant and per cent of female flowers. The direct effect of 100 seed weight on yield was positive and its correlation with yield was also positive. The residual effect of 0.0818 indicated that nearly nintytwo per cent of the variation in the fruit yield was due to the nodes on main vine, internodal length, leaves per plant at 30 days after sowing, male flowers per plant, female flowers per plant, per cent of female flowers, average fruit weight, per cent of fruit set and 100 seed weight.

5.4 Effect of sowing time and periodicity of harvests on yield

This part of the investigation was taken up to determine the effect of time of sowing and periodicity of harvests on growth and yield of ashgourd. The results of the experiments are discussed here under.

5.4.1 Vegetative characters

5.4.1.1 Nodes on main vine

Among the various dates of sowing, October sowing produced the maximum number of nodes on main vine followed by August and September sowing. The low mean minimum temperature (22.6-21.1°C) prevalent during that month might be the reason for this (Table 19). This is in accordance with the findings of Lint and Heij (1982a) in cucumber in which number of nodes per vine increased as the night temperature fell.

5.4.1.2 Primary branches per plant

The October sown crop produced the maximum number of primary branches per plant. The low minimum temperature (21.1°C) experienced during the pre-bearing period by the October sown plants might have caused the production of more number of primary branches. Similar was the finding by Desai and Patel (1984) in watermelon in which the number of primary branches increased when the minimum temperature was low.

5.4.1.3 Internodal length

The maximum internodal length was recorded by the crop sown in June. The crop raised in June experienced the lowest sunshine hours (3.4 hrs) and the maximum relative humidity (88%). Vegetative growth was enhanced by either day

Table 19. Mean meteorological parameters prevailed during vegetative and reproductive phases of ashgourd

Months	Maximum temperature °C		Minimum temperature °C		Sunshine (hrs)		Relative humidity (%)		Rainfall (mm)	
	Vegetative phase	Reproductive phase	Vegetative phase	Reproductive phase	Vegetative phase	Reproductive phase	Vegetative phase	Reproductive phase	Vegetative phase	Reproductive phase
December	33.3	36.1	22.5	24.5	9.7	9.2	53	60	0	0.2
January	35.3	33.8	23.6	25.1	9.6	8.2	54	74	0	4.6
February	36.0	33.3	24.5	25.2	9.0	8.0	62	76	0.3	4.4
March	34.2	31.2	25.1	24.1	7.9	5.8	73	82	5.4	10.6
April	32.2	28.6	24.7	23.0	6.6	3.4	79	86	8.3	14.7
May	30.1	29.2	23.7	27.9	4.2	4.0	85	85	14.1	8.8
June	29.1	29.6	23.4	23.7	3.4	4.9	88	84	14.6	9.8
July	29.4	30.1	24.0	23.1	3.5	6.1	88	81	11.3	8.1
August	29.6	30.9	23.6	22.7	4.6	7.0	84	73	11.0	1.9
September	30.4	31.1	23.1	21.5	6.5	7.8	82	56	7.1	1.1
October	30.8	32.5	22.6	21.1	6.9	9.4	72	62	1.7	0.0
November	31.2	34.2	21.6	22.2	7.6	9.5	68	60	1.0	0.0

or night humidity (Bakker *et al.*, 1987). January sown crop possessed shorter internodes and this crop experienced a high maximum temperature (35.3°C), more sunshine hours (9.6 hrs) and low relative humidity (54%). Lint and Heij (1982a) reported that more light resulted in lower internodal length.

5.4.1.4 Leaves per plant

August sown plants possessed maximum number of leaves at 30 days after sowing. This might have resulted from a low maximum temperature (29.6°C) and high relative humidity (84%) prevalent in August during the vegetative phase. Desai and Patil (1984) also obtained maximum number of leaves in watermelon for the vines of November sown crop which experienced the low maximum temperature and high relative humidity.

5.4.2 Earliness

5.4.2.1 Days to first female flower anthesis

The time of sowing exerted significant effect on the days to first female flower anthesis. The crop sown in February had shown a tendency to produce female flowers earlier than all other sowings. The highest mean maximum temperature (36°C), high mean minimum temperature (24.5°C) and sunshine hours (9.0 hrs) during the vegetative phase of February sown crop hastened the appearance of first female flower. A period of high night temperature decreased the number of days for flower production (Vooran *et al.*, 1978). According to Vooran (1981) the highest temperature generally resulted in earliest fruits in cucumber but a high day temperature appeared to be more effective than a high night temperature. The strong effect of planting date on earliness would most probably be caused by the increased radiation received by the plants (Vooran *et al.*, 1978). The role of high temperature for earliness in cucumber was also reported by Slack and Hand (1983).

5.4.2.2 Days to first male flower anthesis

The earliness in male flower production was seen in March sown crop followed by February sown crop. March sown crop experienced a comparatively high mean maximum temperature (34.2°C) and the highest mean minimum temperature (25.1°C) which shows that maximum and minimum temperatures at higher level favours the early production of male flowers similar to female flowers.

5.4.2.3 Node at which first female flower appeared

The crop sown during October produced the first female flower on the lowest node. The crop experienced a low mean minimum temperature of 22.6°C, maximum temperature of 30.8°C and sunshine hours (6.9 hrs) during the vegetative phase. Higher day and lower night temperature combination might cause earliness of cropping, according to Slack and Hand (1981). The position of female flowers on the vine depended on sunshine hours and night temperature (Nitsch *et al.*, 1952). Warrington and Norton (1991) reported that the node number for the first female flower in cucumber was linearly related to sunshine hours.

5.4.2.4 Node at which the first fruit is retained

Among the various sowings, October sowing retained the first fruit at the lowest node. The crop sown during October produced the first female flower on the lowest node retaining the fruit also at the lowest node. Prolonged sunshine hours

(9.4 hrs) and low minimum temperature (21.1°C) during the reproductive phase of this crop might also have favoured the fruit retention at a lower node.

5.4.3 Flower and fruit characters

5.4.3.1 Male flowers per plant

January sown crop recorded the maximum number of male flowers per plant which might be due to high maximum temperature (35.3°C), more sunshine hours (9.6 hrs) and low relative humidity (54%). Tiedjens (1928) reported that abundance of light increased the number of male flowers in cucumber and vice versa. According to Sedgley and Buttrose (1978) an increase in temperature caused an increase in number of flowers per plant upto 35°C in watermelon. Increase in temperature associated with decrease in RH narrowed down the sex ratio in melons (Sharma and Nath, 1971). Increase in number of male flowers with increase in temperature was also observed by Rudich and Peles (1976) in watermelon and Desai and Patil (1985) in watermelon.

5.4.3.2 Female flowers per plant

Plants sown in October produced greater number of female flowers. Low minimum temperature (22.6°C) and more sunshine hours (9.6 hrs) experienced during the flowering period might have increased the number of female flowers. Similar observations were made by Lint and Heij (1982a) and Ying and Li (1990) and they observed that low night temperature helped to enhance female flower production. The higher number of flowers was associated with the higher number of nodes and both with lower night temperature (Lint and Heij, 1982a). Sowing in October produced plants with maximum number of nodes on main vine. Effect of low temperature and day length on female flower production was reported by

Nitsch *et al.* (1952), Matsuo (1968), Kamalanathan and Thamburaj (1970) and Cantliffe (1981).

Plants under the harvest interval of 14 days produced the highest number of female flowers per plant. The presence of fruits on the vine resulted in fewer flowers per plant (Sedgley and Buttrose, 1978). More number of pistillate flowers fall off due to strong sink developed by the developing fruits (Desai and Patil, 1985). This confirmed the earlier findings of Dhillon (1966).

5.4.3.3 Per cent of female flowers

The ratio of female flowers to the total flowers was highest in October sowing. This can be expected as October sowing produced more number of female flowers when compared to male flowers.

5.4.3.4 Length of fruit

Plants sown in August produced longer fruits than the later sowings followed by February sown crop. The lower minimum temperature (22.7°C) experienced by the crop might be the reason for the production of longer fruits. Miller and Ries (1958) and Heij and Lint (1982) also observed that longer fruits were harvested at lower night temperature. They also reported that heavier fruits were longer.

5.4.3.5 Fruit shape index

June sown crop produced fruits with high fruit shape index. Miller and Ries (1958) found that low temperature caused an increase in length to diameter ratio of pickling cucumber fruits. The low maximum temperature (29.6°C) experienced by the crop might be the reason for a high fruit shape index.

5.4.3.6 Average fruit weight

Among various dates of sowing August sowing produced the fruits with maximum weight. The climatic conditions experienced by August sown crop includes a maximum temperature of 30.9°C, low minimum temperature of 22.7°C, sunshine hours of 7.0 hrs and relative humidity of 73 per cent which might have resulted in better growth and higher average fruit weight. Low night temperature delivered slightly heavier fruit (Heij and Lint, 1982). The crop sown in April produced fruits with a minimum average weight because it experienced a climate with a low maximum temperature (28.6°C), less sunshine hours (3.4 hrs), high relative humidity (86%) and high rainfall (14.7 mm) during reproductive phase. Variation in fruit weight due to difference in planting date was reported by Surlekov and Ivanov (1974) in cucumber, and Jacob (1986) in bittergourd.

5.4.3.7 Fruits per plant

October sowing produced considerably higher number of fruits. This might be the effect of high fruit set, favoured by availability of more sunshine hours (9.4 hrs), low minimum temperature (21.1°C) and low relative humidity (62%). Drews (1980) had explained that low night temperature increased fruit set in cucumber. Difference in fruit number due to difference in sowing date have been reported by Surlekov and Ivanov (1974) in cucumber and Desai and Patil (1984) in watermelon. This variation might be due to the effect of night temperature and day length (Miller and Ries, 1958 and Heij and Lint, 1982).

5.4.3.8 Per cent of fruit set

A high fruit set or a low fruit drop was experienced by the August sown crop grown under a low maximum temperature (30.9°C), low minimum temperature (22.7°C) and moderately high relative humidity (73%). Low night air temperatures enhanced fruit set where as high air temperatures at low relative humidity encouraged fruit drop (Drews, 1979).

5.4.3.9 Seeds per fruit

October sown plants produced fruits with maximum seeds. Plants sown in April produced fruits with lowest seeds. These plants were grown under a low light intensity during reproductive phase. Sedgley and Buttrose (1978) obtained small fruits with few seeds in water melon under conditions of short days and low light intensity.

5.4.3.10 100 seed weight

Fruits produced in February sown crops recorded greater 100 seed weight than the other sowings. February planting had produced larger fruits with respect to circumference, length of fruit and flesh thickness.

5.4.3.11 Fruit yield per plant

The plants sown in October produced significantly higher yield (15.23 kg per plant) than the other dates of sowing. Availability of more sunshine hours (9.4 hrs), low minimum temperature (21.1°C) and low relative humidity (62%) during the reproductive phase of October sown plants might be the reason for the production of more female flowers and thus more fruits per plant. The lowest yield was recorded by the plants sown in April (0.95 kg per plant). This decrease can be because of a more or less similar trend in yield attributes like female flowers per plant, average fruit weight, fruits per plant, length of fruit, circumference of fruit and flesh thickness. This is to be expected since fruit yield is the ultimate manifestation of the cumulative effect of these characters. Rajput *et al.* (1990) attributed a similar decline in yield of watermelon to the reduced fruit weight, number of fruits per vine, length of vine and number of branches per vine. Effect of sowing dates on yield was recorded by Kartalov (1970) in cucumber, Kmiecik and Lisiewska (1981) in cucumber, Yakimenko (1984) in cucumber, Asiegbu (1985) in fluted pumpkin, Al-Bahash and Wajdyi (1988) in bottle gourd, McGlashan and Fielding (1990) in muskmelon, Naik (1991) in watermelon, Sant Parkash *et al.* (1994) in pumpkin and An *et al.* (1995) in pumpkin.

The present study has indicated the existence of variability in the reproductive and yield characters of the crop during each month. When the reproductive and yield characters exhibited by each crop were ranked according to their performance, it was seen that the crops sown during August, September and October were better when compared to the crops sown during other months (Table 20). The crops sown during April and May had the poorest performance with respect to the reproductive and yield characters.

Similarly when the yield characters at different periods of harvest (14 days, 21 days, 28 days and full maturity) were compared, it was found that the crops in which the fruits were harvested at full maturity excelled other crops (Table 21).

Table 20. Ranked performance of ashgourd in different dates of sowing

Characters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Male flowers per plant	1	5	9	10	11	2	3	7	8	4	12	6
Female flowers per plant	3	4	10	12	11	6	8	7	2	1	9	5
Per cent of female flowers	4	5	8	11	9	10	12	7	2	1	6	3
Average fruit weight (kg)	6	4	2	12	11	3	8	1	5	9	10	7
Fruits per plant	2	6	8	10	10	9	9	5	3	1	7	4
Per cent of fruit set	7	6	5	11	12	8	2	1	10	9	4	3
Circumference of fruit (cm)	8	2	4	11	12	6	7	1	9	3	10	5
Length of fruit (cm)	8	2	4	12	11	3	7	1	9	5	10	6
Fruit shape index	6	3	3	9	8	1	2	4	1	5	7	3
Flesh thickness (cm)	8	1	4	11	10	6	9	3	2	6	7	5
Seeds per fruit	8	3	4	12	11	5	6	2	10	1	7	9
100 seed weight (g)	8	1	7	11	12	10	9	3	4	6	2	5
Fruit yield per plant (kg)	2	6	7	12	11	8	10	3	4	1	9	5

Table 21. Ranked performance of ashgourd based on the periodicity of harvests

Characters	14 days	21 days	28 days	Full maturity
Male flowers per plant	1	2	3	4
Female flowers per plant	1	2	4	3
Per cent of female flowers	1	2	4	3
Average fruit weight (kg)	4	3	2	1
Fruits per plant	1	3	4	2
Percent of fruit set	4	2	3	1
Circumference of fruit (cm)	4	2	3	1
Length of fruit (cm)	4	3	2	1
Fruit shape index	2	4	3	1
Flesh thickness (cm)	4	3	2	1
Seeds per fruit	3	4	2	1
100 seed weight (g)	3	2	4	1
Fruit yield per plant (kg)	3	2	4	1

The effect of interaction between date of sowing and periodicity of harvests on yield was compared. The crop sown during October and harvested at 21 days interval showed the maximum fruit yield per plant.

5.4.4 Incidence of pest and disease

The crops sown throughout the year were attacked by pests and diseases. Fruit fly infestation was severe in April, May and June sown crop. Severe pumpkin beetle incidence was found in February, March, April and May sown crop. Mosaic was seen in crops sown in November, December, January and February. June and July sown crops exhibited downy mildew disease. Temperature between 20°C and 22°C along with extended rains provides ideal condition for the infection and spread of downy mildew (Bains and Jhooty, 1978). Pelletier (1989) reported that high humidity led to increased disease incidence.

5.4.5 Crop weather relationship

The correlation studies revealed that maximum temperature during first and second weeks after anthesis had a significant positive effect on the yield, contributed by the fruits havested at full maturity. This view was supported by the work of Drews (1980), Vooran (1981) and Marcelis (1993). The minimum temperature had a positive correlation with yield though not statistically significant. Wacquant (1989) reported that with rise in night temperature fruit development was faster and fruits were larger. Lint and Heij (1982b) also stressed the need of a higher night temperature to reduce the level of abortion.

Relative humidity during reproductive phase negatively influenced the fruit yield at full maturity, that is, higher the humidity, lower the yield. Humidity in the afternoon was more negatively correlated with yield than humidity in the morning even though both were not significant statistically. Nandpuri *et al.* (1976) obtained a negative correlation between sex ratio and relative humidity.

Sunshine hours during reproductive phase positively influenced the performance of the crop by altering yield components in a favourable way. Buwalda and Freeman (1986) stated that an increase in incident radiation resulted in higher dry matter accumulation and hence yield. This was supported by Liebig and Krug (1991).

The regression equation for the yield was

$$Y = 0.558\ T\ max + 0.014\ RH\ afternoon - 15.488$$

where Y = yield in kg

The study on cataloguing and identificiation of promising ashgourd ecotypes in relation to season and maturity revealed that considerable variability existed among ecotypes for all characters studied. Out of the 30 ecotypes evaluated BH 21 was selected as the best yielder. This ecotype when grown for 12 successive months it was found that the crops sown during August, September and October were performing comparatively better with respect to the crops raised during other months. The crops in which the fruits were harvested at full maturity excelled other crops in terms of fruit weight. But the maximum number of fruits were obtained when harvested at 14 days interval. The crop weather relationship studies showed that maximum temperature, minimum temperature and sunshine hours had a positive correlation with yield where as relative humidity was negatively correlated.

Summary

SUMMARY

An experiment was conducted in the Department of Olericulture, College of Horticulture, Vellanikkara to catalogue and identify promising ashgourd ecotypes in relation to season and maturity during 1995-96. Variability studies in 30 ecotypes of ashgourd were carried out and these ecotypes were evaluated for twenty characters.

The thirty ecotypes selected for the study expressed their genotypic and phenotypic differences. The genotypic coefficient of variation was maximum (86.72) for primary branches per plant followed by fruit yield per plant (51.40). The highest heritability estimate was observed for seeds per fruit (0.97) followed by circumference of fruit (0.94). The lowest estimate of heritability was observed for per cent of female flowers. Primary branches per plant had the highest genetic gain (169.00). High heritability along with high genetic gain was observed for primary branches per plant, fruit yield per plant, seeds per fruit and average fruit weight.

The number of fruits per plant had the highest positive and significant phenotypic correlation with yield (r_p = 0.66). This indicates that environment had larger effects on number of fruits per plant. The highest genotypic correlation of yield was found with female flowers per plant (r_g = 0.616).

Yield was positively and significantly correlated with length of main vine, nodes on main vine, primary branches per plant, internodal length, leaves per plant at 30 days after sowing, male flowers per plant, female flowers per plant, per cent of female flowers, average fruit weight, fruits per plant, per cent of fruit set, circumference of fruit, length of fruit, seeds per fruit and 100 seed weight.

Average fruit weight exhibited the highest positive direct effect on fruit yield per plant followed by per cent of fruit set, female flowers per plant, nodes on main vine, internodal length, male flowers per plant, per cent of female flowers and 100 seed weight. Leaves per plant at 30 days after sowing exhibited a negative direct effect on fruit yield per plant.

The present study could identify BH 21 as the promising line with the longest main vine (6.5 m), maximum number of nodes (103), maximum number of female flowers (8.67), maximum fruit yield (14.7 kg per plant), maximum number of seeds per fruit (1062) and maximum 100 seed weight (7.3 g).

The effect of sowing time and periodicity of harvests on yield was studied using the ecotype BH 21. This evaluation was done using split plot design with three replications. Months of sowing was taken as main plot treatment and intervals of harvesting as sub plot treatments. The biometric observations, flowering and yield attributes were recorded at different stages of development of the crop. The effect of periodicity of harvests with regard to reproductive and yield characters were studied.

All biometric characters were significantly influenced by the sowing time. January sown crop produced the highest number of male flowers per plant. February sowing took the least number of days for the production of female flowers. March sowing took the lowest number of days for production of male flowers. March sown crop retained the first fruit at the highest node. Female flowers and fruits per plant was lowest in plants sown during April. The average fruit weight was also lowest in April sown crop. May sown crop took the maximum number of days for the production of both male and female flowers and produced the first female flower at the highest node. Maximum internodal length was produced by June sown crop.

The crops sown during July recorded the highest fruit set. August sown crop produced the maximum number of leaves per plant at 30 days after sowing. The average fruit weight and fruit size in terms of length and circumference was highest in August sown crop. Plants with maximum number of nodes and primary branches were produced in October sowing. October sown crop produced the first female flower and retained the first fruit, at the lowest node. Maximum number of female flowers, fruits per plant, yield and number of seeds per fruit was also recorded by the plants sown during October. Sowing in November produced plants with the longest vine. In general the plants raised during August, September and October only could express its yield potential fully.

The plants under the harvest interval of 14 days produced the highest number of female flowers and fruits per plant. Fruits harvested at full maturity had the highest average weight, circumference, fruit shape index, flesh thickness and number of fully developed seeds as expected. Fruits when harvested at full maturity recorded the highest fruit yield per plant.

The crops sown throughout the year were attacked by pests and diseases. Fruit fly infestation was severe in April, May and June sown crop. Severe pumpkin beetle incidence was found in February, March, April and May sown crop. Mosaic was seen in crops sown in November, December, January and February. June and July sown crops exhibited downy mildew disease.

The crop weather relationship studies showed that maximum temperature during first and second weeks after anthesis had a significant positive correlation with yield at full maturity. Minimum temperature and sunshine hours had a positive correlation with yield though not significant. A negative correlation exist between relative humidity during 1st three weeks after anthesis and yield.

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Appendices

Appendix I. General analysis of variance for 20 characters in 30 genotypes of ashgourd

Source of Variation	df	Mean sum of squares																			
		Length of main vine	Nodes on main vine	Primary branches per plant	Inter-nodal length	Leaves per plant	Days to first female flower anthesis	Node at which first female flower appeared	Node at which the first fruit is retained	Male flowers per plant	Female flowers per plant	Per cent of female flowers	Average fruit weight	Fruits per plant	Per cent of fruit set	Circum-ference of fruit	Length of fruit	Fruit shape index	Seeds per fruit	100 seed weight	Fruit yield per plant
Replication	2	1.45	17.92	0.21	0.83	1.2	0.16	8.34	13.23	10.84	6.63	17.98	5.66	2.01	75.31	76.88	0.23	0.04	1360.00	0.13	1.04
Genotype	29	3.19**	431.59**	25.35**	14.23**	16.88**	217.65**	76.68**	76.71**	637.24**	8.44**	7.68**	5.17**	3.56**	229.98**	421.80**	130.76**	0.14*	155518.64**	3.60**	30.74**
Error	58	0.32	44.47	0.95	0.66	2.02	6.62	36.82	36.29	113.71	1.83	3.71	0.40	0.61	91.88	8.76	6.10	0.03	1503.06	0.13	3.22

** Significant at 1 per cent level; *Significant at 5% level

APPENDIX-II

Mean monthly weather parameters during the crop growth period

	Maximum temperature (°C)	Minimum temperature (°C)	RH morning (%)	RH afternoon (%)	Sunshine hours	Rainfall (mm)
December, 1995	32.5	21.3	71	43	10.3	0.0
January, 1996	33.1	22.4	71	35	9.4	0.0
February	34.7	23.4	72	34	9.9	0.0
March	36.4	24.3	82	37	9.3	0.0
April	34.6	25.0	87	59	8.3	152.0
May	32.8	25.2	91	63	7.7	95.4
June	30.5	23.8	94	75	4.7	400.3
July	28.8	23.1	96	83	2.7	588.7
August	29.1	23.6	95	78	3.7	310.0
September	29.2	23.7	94	74	4.3	391.6
October	30.1	22.9	93	70	6.0	219.3
November	31.5	23.6	84	59	7.1	23.1
December	30.5	21.8	80	50	6.8	60.8
January, 1997	32.0	22.9	78	45	9.6	0.0
February	33.9	21.8	82	39	9.3	0.0
March	35.7	24.0	82	37	9.6	0.0

CATALOGUING AND IDENTIFICATION OF PROMISING ASHGOURD ECOTYPES IN RELATION TO SEASON AND MATURITY

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ABSTRACT OF THE THESIS

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ABSTRACT

CATALOGUING AND IDENTIFICATION OF PROMISING ASHGOURD ECOTYPES IN RELATION TO SEASON AND MATURITY.

An experiment was conducted during 1995-96 in the Department of Olericulture, College of Horticulture, Vellanikkara to catalogue and identify promising ashgourd ecotypes in relation to season and maturity.

Thirty ecotypes of ashgourd were studied for their variability. The experiment was laid out in randomised block design with three replications. High heritability along with high genetic gain was observed for the characters primary branches per plant, fruit yield per plant, seeds per fruit and average fruit weight. Yield was positively and significantly correlated with length of main vine, nodes on main vine, primary branches per plant, internodal length, leaves per plant at 30 days after sowing, male flowers per plant, female flowers per plant, per cent of female flowers, average fruit weight, fruits per plant, percent of fruit set, circumference of fruit, length of fruit, seeds per fruit and 100 seed weight. Average fruit weight exhibited the highest positive direct effect on fruit yield per plant.

The ecotype BH 21 possessing highest values for characters like length of main vine, number of nodes, number of female flowers, fruit yield per plant and number of seeds per fruit was selected to study the effect of sowing time and periodicity of harvests on yield. This experiment was laid out in split plot design taking months of sowing as main plot treatments and intervals of harvesting as subplot treatments.

All biometric characters were significantly influenced by the sowing time. The crop sown in October was superior to other crops with regard to number of

nodes, earliest node at which the first female flower was formed and fruit retained, number of female flowers, per cent of female flowers, number of fruits per plant, number of seeds per fruit and fruit yield per plant. In general the crops sown during August, September and October performed better in yield contributing characters when compared to the crops raised during other months of the year.

The plants under the harvest interval of 14 days produced the highest number of female flowers and fruits per plant. Average fruit weight, circumference, fruit shape index, flesh thickness and number of fully developed seeds were highest for fruits harvested at full maturity. Though more number of fruits were obtained from plants under a harvest interval of 14 days the highest yield in terms of total fruit weight was realised from plants harvested at full maturity.

The crop was succumbed to the attack of pests and diseases throughout the year. Fruit fly infestation was severe in April, May and June sown crop. Incidence of pumpkin beetle was severe in February, March, April and May sown crop. Mosaic was severe on crops sown in November, December, January and February. June and July sown crops exhibited downy mildew disease. The better expression of yield contributing characters and lower incidence of pests and diseases for the crops sown during August, September and October indicated that these months are most ideal for raising a crop of ashgourd.

The crop weather relationship revealed that maximum temperature during first and second weeks after anthesis had a significant positive correlation with yield at full maturity. Minimum temperature and sunshine hours also have a positive correlation though not significant. A negative correlation exist between relative humidity and yield.