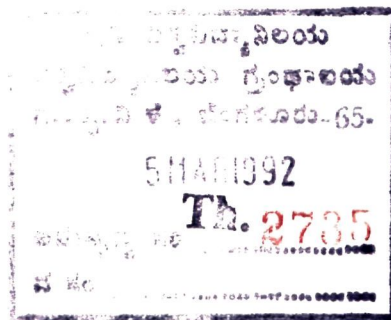


GENETICAL STUDIES IN CUCUMBER
(*Cucumis sativus* L.)

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DIVISION OF HORTICULTURE
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GENETICAL STUDIES IN CUCUMBER
(*Cucumis sativus* L.)

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in partial fulfilment of the requirements
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Dedicated to my Parents

Sri. P. Narasiah

and

Smt. N. Gajalakshamma

Division of Horticulture
University of Agricultural Sciences
Bangalore

C E R T I F I C A T E

This is to certify that the thesis entitled
"GENETICAL STUDIES IN CUCUMBER (Cucumis sativus L.)"
submitted in partial fulfilment of the requirements for
the degree of **DOCTOR OF PHILOSOPHY in HORTICULTURE** to the
University of Agricultural Sciences, Bangalore, is a
record of research work carried out by
Mr.N.Sathyanaarayana, under my guidance and supervision
and that no part of the thesis has been submitted for the
award of any other degree, diploma, associateship,
fellowship or other similar titles.

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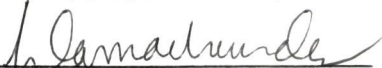
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INTRODUCTION

I. INTRODUCTION

Cucumbers are grown for their tender fruit which are consumed raw, cooked, pickled or processed in other forms. In India, it is mostly consumed raw or cooked. In spite of the extensive cultivation and consumption, cucumbers have not been taken up for systematic research work in order to understand the genetic architecture and endeavour in an improvement programme. Many important features of cultivated crops are not associated with discrete Mendelian traits, but are of a continuous or quantitative nature. Yielding ability is a prime example of such a trait and is of obvious importance. Yield and the many factors that affect it are subject to considerable environmental influence. Biometricians have evolved several methodologies to handle such a complex system. Diallel analysis is one such method, which helps to evaluate inbred line performance in F_1 combination, using combining ability and heterosis.

The very basic problem in cucumbers is concerning the low marketable yield. The reduced marketability of the fruit is due to the deshaping of the fruit. The causes for such deshaped fruit have not been clearly documented. Any stress factor during the crop growth

could result in deshaped fruit. Apart from stress factors, genetical background could also be a factor determining the deshapening of the fruit. An attempt has been made to delineate this aspect in the present study. Another problem left untouched in cucumbers is the seed maturity rate of the fruit. Cucumbers with mature seeds lose marketability, also the yield potentiality gets reduced. Fruit with fast maturing seeds act as strong sinks thereby hindering the growth of other fruit on the vine resulting in reduced yields. Thus, it calls for looking in for slow seed maturing types.

The major limitations to increasing yield is related to lack of genetic variability. Although early yield was improved by the introduction of gynoeceious lines (Peterson, 1960), total multiple-harvest yield was not improved (Wehner and Miller, 1985). The lack of progress for increased fruiting in cucumber might be partially due to the meagre breeding effort in cucumber relative to other crop or to a lack of variability for yield (Wehner et al., 1989). Transfer of quantitatively inherited characters into commercially adapted cultivars from exotic germplasm can be an effective way to obtain greater genetic variation and response to selection (Bliss, 1981; Eberhart et al., 1967). Also, heterosis is

known to be a result of geographic diversity or genetic distance. Thus, the present study involved varieties both indigenous and exotic, which served the twin objective of enriching the gene pool and a resultant heterosis of the desired kind.

The present study was taken up in two stages (a) variability and association studies, and (b) diallel analysis to achieve the following objectives:

1. To study the genetic variability, heritability, genetic gain, correlations and co-heritability for the quantitative characters.
2. To study the general and specific combining ability and elucidate the genetic architecture.
3. To estimate the heterosis and select the best parents/hybrids.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

2.1. HISTORY AND ORIGIN

Cucumber (Cucumis sativus L.) is thought to be indigenous to India. Cultivation of cucumber in India dates back to 3000 years (De Candolle, 1882). The genus Cucumis comprises about 30 species distributed over two distinct geographic areas (i) south-east of Himalayas is an important region of the Asiatic group with chromosome number of $x=7$ to which cucumber belongs, (ii) African group consisting of species with basic chromosome number $x=12$.

Cucumber (Cucumis sativus L.) is found to freely hybridise with Cucumis sativus var. hardwickii R. (a small bitter cucumber with sparse and stiff spines, found in the foot hills of Himalayas) with no reduction of fertility in the F_2 generation suggesting Cucumis hardwickii to be a feril form or more likely a progenitor of Cucumis sativus (Deakin et al., 1971; Horst, 1977).

2.2. TAXONOMY, CYTOGENETICS AND BOTANY

Cucumber (Cucumis sativus L.) belongs to the family Cucurbitaceae. The cucumber is distinct from other Cucumis species as it has seven pairs of

chromosomes ($2n=2x=14$), a true diploid, whereas, most other Cucumis species have 12 pairs of chromosomes, or multiples of 12 (Whitaker and Davis, 1962; Deakin et al., 1971; Robinson et al., 1976). This suggests that most other uncultivated Cucumis species are genetically more similar to the muskmelon ($2n=24$), than to the cucumber. Cucumis anguria var. anguria ($2n=2x=24$), the West Indian gherkin is another related Cucumis species in which the fruits are edible and can be used for pickles (Whitaker and Davis, 1962). It is not cross compatible with cucumber (Deakin et al., 1971).

2.3. GENERAL MORPHOLOGY

Cucumber is commonly a monoecious annual (one can encounter with androecious, gynoecious, hermaphrodite and andromonoecious sex types also), trailing or climbing vine (Bailey, 1969). Cucumbers have hirsute or scabrous stems, triangular-ovate leaves with shallow and acute sinuses, flower 1 or 2 inches in diameter. Staminate flowers are borne either singly or in clusters, but pistillate flowers are often solitary in the leaf axes and have shorter and stout pedicels than staminate flowers. Cucumber fruits are spiny when young and develop in a nearly globular to oblong or cylindrical shape as

they mature, turning to a creamy light yellow or deep orange at seed maturity (Lower and Edwards, 1986).

2.4. UNMARKETABLE FRUIT

Fruit yield in cucumbers has been recorded as marketable yield and total yield. The number of deshaped fruit or its percentage of the total yield is usually not recorded. Total fruit yield in cucumbers is of less importance than the marketable fruit yield. In this context, study pertaining to the proportion of the unmarketable fruit yield is of due importance. Kanahama and Saito (1988) observed the curvature of the cucumber fruits to be due to competition among the carpels, in the uptake of carbohydrates under limited photosynthesis. Each carpel is presumed to be different in sink capacity according to its congenial developmental order and stages. Differential carbohydrate translocation due to localisation of vascular bundle connections between leaves and fruit is improbable.

Deshaped fruit could result from any type of biotic or abiotic stresses. But, under the stress free conditions one can look into the genetic nature of this trait.

2.5. POST HARVEST BEHAVIOUR OF THE FRUIT

Cucumbers are harvested at the physiologically unripe stage. They are botanically fleshy berries with a relatively strong peel. The colour of edible cucumbers is mostly green, while pickling cucumbers may vary from light green to bluish green. The peel itself may be smooth, slightly ribbed or warty. In the physiologically ripe stage, the fruit colour changes to white, yellow or brown (Weichmann, 1987).

Cucumber fruit have a water content of 97 per cent. They are harvested depending on the size preferred by the market. The lowest safe temperature for cucumber cultivation is 12° to 15°C and relative humidity of 90-95 per cent.

Fruit harvested in a physiologically unripe stage will ripen and subsequently senescence starts. Cucumber is a non-climacteric fruit, where continuous decrease in the respiration is seen during the post harvest period. It has a respiration rate of $5-10 \text{ ml CO}_2/\text{kg/hr}$ at 5°C .

Maximum permissible loss (%) of water on fresh weight basis at which the fruit becomes unmarketable in cucumbers is 5 per cent. Post harvest water loss from

cucumber fruit at 15°C and relative humidity 45-65 per cent is 0.4/day/mbar wvpd (Weichmann, 1987).

Prolonged holding of the cucumber fruit decreases the quality of the fruit (Cook et al., 1957). The quality reduction is typically characterised by tissue softening and off flavour development (Esselen and Anderson, 1956).

Smaller fruit produce 2-3 times of ethylene than that of the larger fruit during the first 48 hours of storage. This high rate of ethylene evolution corresponds to high rate of respiration and advances the senescence processes in the first 48 hours. The effect of ethylene on chlorophyll degradation of processing cucumbers as observed by Poenicke et al. (1977) was similar to that previously noted for fresh market cucumbers by Apeland in 1961.

2.6. GENETIC VARIABILITY, HERITABILITY AND GENETIC GAIN

Cucumber improvement programmes have been in practice for more than half a century, but much of the improvement can be attributed to improved cultural practices and incorporation of better levels of disease resistance. The lack of progress in cucumber might be partially due to the little breeding effort in cucumber

relative to other crop species or to a lack of genetic variability. Heritability for yield has been measured in several cucumber populations and is in the range of 0.17 to 0.25 (Smith et al., 1978; Strefeler and Wehner, 1986). The results indicate that genetic variability for yield exists and is sufficient to permit progress.

Information on the mode of inheritance of quantitative characters should be available before proceeding with the formulation of appropriate breeding strategies. Selection within a population is futile where there are no genetic variances for the desired characters. In the development of pure lines, progress from selection depends primarily on the additive action of genes. Dominance, on the other hand, could be efficiently utilised in the production of hybrids.

Cucumber genotypes showed significant differences with regard to vegetative characters, reproductive characters, yield and yield components (Patil and Patil, 1985a, 1985b). A considerable amount of variability among the cucumber genotypes was observed for marketable and early fruit number per plot, percentage of culls, fruit shape, fruit colour, seed cell size and the overall performance (Strefler and Wehner, 1986).

Solanki and Seth (1980) observed a phenotypic coefficient of variation from 10.43 for number of fruit per plant to 71.80 for plant height. Genotypic coefficient of variation was also observed to be lowest for number of fruit per plant (5.99) and highest for plant height (69.03), whereas, the environmental coefficient of variation ranged from 6.89 for days to maturity to 71.20 for fruit yield per plant.

Cucumber variety Pusa Sanyog recorded higher vine length (2.4m) than the other cultivars, cv. White Wonder remained dwarf with lesser number of branches, lesser nodes on main shoot and least internodal length, attributable to its inherent nature (Sandhu et al., 1972; Patil and Patil, 1985a).

Cucumber genotypes varied with regard to fruit number in a range of 2.7 fruit per plant to 46.75 fruit per plant. Fruit yield varied from 238 g/vine to 2755 g/vine. Weight of first fruit harvested varied from 14.45 g to 62.50 g. Genotypes recording the highest number of fruit failed to record higher early yield and higher total yield. Least number of fruit production was attributed to fewer female flower produced and fruit set (Patil and Patil, 1985b).

Choudhary et al. (1985) recorded maximum range of variation for vine length from 1.76 m to 3.16 m, fruit diameter from 4.96 to 5.60 cm. Joshi et al. (1980) observed variability for vine length, number of branches and fruit diameter of cucumber fruit .

The heritability is a measure of efficiency of selection system in separating genotypes. Heritable variation can be determined with greater accuracy, when heritability is studied along with genetic advance (Swarup and Chaugale, 1962). Genetic advance as per cent of mean depends upon selection differential, genetic coefficient of variation and heritability ratio. Thus, characters with higher genetic coefficient of variation and moderate heritability will have high genetic gain, whereas, character with low genetic coefficient of variation and high heritability estimates may have low genetic gain. Hence, high heritability with high genetic gain is associated with additive gene effects (Panse, 1957). On the contrary, non-additive gene effects (dominance or epistasis) is associated with characters exhibiting high heritability and low genetic advance.

Heritabilities for total, marketable and early fruit yield ranged from 0.18-0.25, 0.12-0.22 and 0.03-0.20 for the elite, medium base and wide base populations

respectively (Strefeler and Wehner, 1986). El Shawaf and Baker (1981a), observed heritability estimates to vary from 0-32 per cent for fruit number per plant and fruit weight per plant. Fruit number per plant was found most heritable. Narrow sense heritability for fruit number and fruit weight per plant were 53-60 per cent and 32-65 per cent respectively.

Owens (1983) observed moderately high broad sense heritability for fruit length and fruit weight. Heritability was moderately high (0.8) for fruit length and intermediate (0.6) for fruit weight (Owens et al., 1985a). In another study, heritability for dollar value of the fruit was found to be 0.19 and for number of fruits 0.17.

Number of secondary branches per vine, yield per vine, number of primary branches per vine, length of vine and number of fruit per vine had high genetic advance along with high heritability. Genotypic variance for these characters is probably due to high additive gene effect (Choudhary et al., 1985; Panse, 1957).

High heritability and low genetic advance for number of days for the appearance of first female flower, number of flowers per vine and fruit length was observed,

indicating non-additive gene effects (Johnson et al., 1955b; Choudhary et al., 1985).

Smith et al. (1978) found that heritabilities for fruit quality traits were higher than those for yield traits in the population studied. Additive variance was observed to be important in phenotypic variation. Narrow sense heritability estimates for a number of yield and maturity characters was 40-50 per cent, but for single fruit weight they were considerably lower (Wang and Wang, 1980). Narrow sense heritability estimates have been intermediate (55%) for fruit length and in the low intermediate range (2-44%) for fruit weight.

Plant height, leaf number per plant, number of male/female flowers per plant, internodal distance, days to maturity and fruit yield expressed high heritability and high genetic advance, whereas, fruit yield, average fruit weight, duration of flowering, number of primary branches per plant, number of fruits harvested per plant and number of secondary branches expressed high heritability and low genetic advance. Thus, it is governed by non-additive genes (Solanki and Seth, 1980).

Yield was positively correlated with fruit length, fruit per vine, fruit girth and flesh thickness.

Days to female and male flowering, per cent deshaped fruit and per cent unmarketable yield exhibited negative correlation with yield (Abusaleha and Dutta, 1988).

Higher heritability and high genetic gain for vine length, branches per vine, nodal position of first pistillate flower, fruit per vine and fruit length were observed indicating the presence of additive gene effect for these characters (Abusaleha and Dutta, 1990).

2.7. CORRELATION OF CHARACTERS

Usually more than one trait is measured on progenies evaluated either for a specific trait in cyclical selection programmes or in applied breeding programmes that require a combination of traits to satisfy growers. Although yield is usually the primary trait of interest, yield contributing traits are all corollary traits that a breeder must consider for eventual usefulness of genotypes evaluated. It is only natural, therefore that attention is given to associations among traits during selection and testing of genotypes.

Correlation, measured by a correlation coefficient is important in plant breeding because it measures the degree of association, genetic or non-genetic between two or more characters. If genetic

association exists, selection for one trait will cause changes in other traits, called the correlated response. The cause of correlation can be genetic and/or environmental. Genetic causes may be attributed to pleiotropism and/or linkage disequilibrium. When genes are not closely linked, linkage disequilibrium is not an important cause of correlation between characters in random mated populations. In such cases the existence of genetic correlations is mostly attributable to pleiotropism (Hallauer and Miranda, 1982).

Phenotypic correlations in cucumbers has been reported by Hutchins (1940), Miller and Quisenberry (1976) and Smith et al. (1978). Relatively high genotypic correlations suggest genetic linkage and/or pleiotropy (Robinson and Comstock, 1955).

Yield per vine expressed high positive correlation with number of female flowers per vine, number of fruit per vine, fruit length and weight both at genotypic and phenotypic levels. Path coefficient analysis revealed number of female flowers per vine, number of fruit per vine, fruit length, fruit diameter and fruit weight to be important yield contributing characters (Choudhary and Mandal, 1987).

Fruit yield per vine was positively correlated both at phenotypic and genotypic levels with node at which first female flower appeared, number of days to first female flower appearance, number of female flowers per vine, sex ratio, number of fruit per vine, average fruit weight and number of primary branches per vine. Path coefficient analysis showed number of fruit per vine and average fruit weight to be most important variables (Nagaprosuna and Rama Rao, 1989).

Haribabu (1985) observed fruit yield to be positively correlated with fruit weight (0.62), number of fruit (0.18) and vine length (0.19). Thus, only mean fruit weight contributed more towards yield and not vine length or fruit number. Rastogi and Deep (1990) also found that fruit yield recorded positive and highly significant association at genotypic, phenotypic and environmental levels with fruit weight and number of fruit per plant.

Prudek and Wolf (1985) observed high and significant correlations (0.87-0.95) between the values of yield components in the parent and in F_1 progeny. Jambhale et al. (1988) found total fruit weight to be positively correlated with parameters of vegetative development.

Wehner and Miller (1984) found that the best correlation with yield in the multiple harvest test was

obtained when all the fruits from the plots were counted rather than those of marketable size. On the contrary, total fruit yield had a large positive correlation with marketable (0.72-1.25) and early (0.61-1.12) fruit yield (Strefeler and Wehner, 1986).

Number of nodes to first female flowering is a fair measure of both sex tendency and maturity. The lower the node number the higher the female tendency and earlier the variety (Shifriss and Galun, 1956).

Genotypic and phenotypic correlations for nodal position of first pistillate flower with flowering time and parthenocarpic yield were high (El Shawaf and Baker, 1981b). This would help in selecting early and high yielding types. Strefeler and Wehner (1986) observed highly significant genotypic and phenotypic correlations for the traits total, marketable and early yield, percentage cull fruit, shape and colour of fruit, seed cell size and over all performance.

Early fruit yield in Pusa Sanyog a cucumber hybrid, was associated with lower sex ratio (Patil and Patil, 1985a).

Number of female flowers per vine, fruit length, fruit diameter and weight were positively associated with

yield. Number of days for first female flower emergence was negatively associated with number of fruit per vine and yield per vine (Choudhary et al., 1985). Rastogi and Deep (1990) observed that number of primary branches per plant had significant effect on total fruit yield and influenced other yield contributing characters like number of female flowers per plant, fruit weight and number of fruit per plant.

Choudhary et al. (1985) observed a positive correlation of length and diameter of the fruit with that of the fruit weight. Selection for increased fruit number per plant does not affect the firmness and fruit length to diameter ratio (Neinhuis and Lower, 1988). Kupper and Staub (1988) observed moderate to large negative correlation between fruit number and fruit size.

Moderate to large positive correlations were observed between fruit number and lateral branch number (Hutchins, 1940; Horst and Lower, 1978; Kupper and Staub, 1988). Haribabu (1985) found vine length to be correlated with number of branches per vine (0.66) and number of nodes per vine (0.59). In the same study, number of branches per plant was correlated to number of nodes per plant (0.69) and number of fruit per plant (0.58).

Number of nodes per plant was correlated with number of fruit per plant (0.70) and per cent fruit set (0.49). Number of fruit per plant was negatively correlated with mean fruit weight (-0.80). In cucumbers, mean fruit weight, per cent fruit set, number of nodes per plant and sex ratio are found to be considered as primary yield determining components for exercising selection.

Fredrick and Staub (1989) observed a high correlation between lateral branch number and three harvests yield, but not the first harvest yield, suggesting with the production of more laterals in the later stages of growth, the vine supports more fruit per plant.

Fruit length and fruit diameter, and fruit diameter and seed cavity diameter were found to be correlated (Imam et al., 1977). Rawat et al. (1984) have reported dry matter content of the fruit to be negatively correlated with yield.

Smith et al. (1978) measured a genetic correlation of 1.01 and phenotypic correlation of 0.78 between the fruit number and fruit value, whereas, Smith and Lower (1978) observed a correlation of 0.64 and 0.85. Jambhale et al. (1988) found fruit weight to be positively and significantly correlated with seed dry wt

weight. Thus, relatively smaller fruit gave higher seed ratios. Skin toughness was found to be closely related to the degree of cutinisation of the outer epidermis.

2.8. COHERITABILITY OF CHARACTERS

Coinheritance of pairs of characters indicating the genetic progress resulting from the joint selection for these characters is termed as coheritability. It is a genetic parameter overcoming the lacuna of environmental variance (in simple genetic correlations) which is a component of phenotypic variance to which selection is applied (Nei, 1960),. Coheritability is the proportion of genotypic covariance to phenotypic covariance (Singh and Choudhary, 1977).

Coinheritance of seed yield and pods per plant, seed yield and branches per plant, seed yield and 100 seed weight was observed to be high in Phaseolus aureus. This suggests pods per plant, bunches per plant and 100 seed weight to be traits vital in selection programme for high seed yield (Singh and Malhotra, 1970). Number of pods per plant, seeds per pod and primary branches per plant had high coheritability and genotypic correlation suggesting selection for any of these characters to result in simultaneous selection of other coinherited characters

(Malhotra et al., 1972). Singh (1978) observed high coheritability among green pod yield, pod length and pod width in Dolichos lablab var. typicus.

2.9. DIALLEL ANALYSIS

Diallel cross is the technique often employed to gain information on hybrid vigour, combining ability and the nature of gene action in the quickest possible time, from the first generation itself. It is extensively in practice, since it aids in the early detection of parents and hybrids. Finally it helps to estimate the magnitude and relative importance of the various genetic parameters, to help choose the most efficient method of selection.

The diallel mating design can be very useful if properly analysed and interpreted. Although extensive theoretical research and discussion have been presented, the main problem seems to arise from interpretations and inferences that can be made about estimates obtained from the analysis of the diallel crosses. It is important, however, that the assumptions and limitations of the diallel mating design are realised when one interprets the data (Hallauer and Miranda, 1982).

A crop and an associated methodology to deal with it is essential. Thus, cucumber being the crop and diallel analysis the methodology, one needs to know about the genetic variability, heritability pattern, genetic gain, coheritability, genotypic and phenotypic correlations, combining ability, genetic interaction and heterosis patterns. With this in view the literature pertinent to the field of study is presented below.

2.9.1. Combining ability and genetic architecture

Information on the relative importance of general (GCA) and specific combining ability (SCA) is of value in breeding programmes for species which are amenable to the development of F_1 hybrid cultivars. Such basic information on combining ability in cucumber would aid the breeder in developing improved hybrid cultivars (Tasdighi and Baker, 1981).

Combining ability of inbred lines is the ultimate factor determining future usefulness of the lines for hybrids (Hallauer and Miranda, 1982). Combining ability initially was a general concept considered collectively for classifying an inbred line relative to its cross performance. Sprague and Tatum (1942) refined the concept of combining ability and the two expressions of GCA

and SCA have had a significant impact on inbred line evaluation and population improvement. They defined GCA as the average performance of a line in hybrid combination and SCA as those instances in which certain hybrid combinations are better or poorer than would be expected on the average performance of the parent inbred lines included. They also emphasised that estimates of GCA and SCA are relative to and dependent on the particular set of inbred lines included in the hybrids under test, an important principle that is often forgotten.

Earliness was found to be controlled by additive gene action (Smith et al., 1978; Prudek and Wolf, 1985; Prudek, 1986; Hormuzdi and More, 1989) as well as non-additive gene action (Dolgikh and Sidonova, 1983). The ratio of GCA to SCA variance showed days to harvest (El Shawaf and Baker, 1981a) and days to flowering (Kupper and Staub, 1988; Hormuzdi and More, 1989) to be controlled by additive genes. SCA variances was found significant for days to flowering (El Shawaf and Baker, 1981a; Fredrick and Staub, 1989). Additive gene action was found to operate for node of first female flower emergence (Hormuzdi and More, 1989; Smith et al., 1978).

Vine length, internodal length, number of nodes per vine (Fredrick and Staub, 1989) and number of

branches (Smith et al., 1978; Solanki and Seth, 1981; Lower et al., 1982; Kupper and Staub, 1988; Fredrick and Staub, 1989) were found to be controlled by additive gene action evidenced by high GCA variances over SCA variances. On the contrary, Delaney and Lower (1987) found high SCA variances for number of branches per vine.

Flowering time was reported to be controlled by 1 or 2 genes (Miller and Quisenberry, 1976; Shifriss and George, 1965). El Shawaf and Baker (1981b) pointed out complete dominance for the gene(s) controlling this trait in light of the high degree of dominance for flowering time observed.

Imam et al. (1977) found fruit characters to be controlled by 1 to 5 pairs of genes. Internodal length on the contrary was reported to be controlled by more than one gene, while internodal number was found to be determined by atleast one major factor in addition to the gene of determinate growth habit. Few inter nodes were partially dominant over many (Gonen and Wricke, 1978).

Owens et al. (1985a) found no major genes controlling fruit length or weight but got an estimate of the minimum number of genes controlling it.

Additive gene action evidenced by significant GCA variances was observed for number of female flowers

(Smith et al., 1978; Solanki and Seth, 1981; Tasdighi and Baker, 1981; Fredrick and Staub, 1989) and number of fruit (Smith et al., 1978; Lower et al., 1982; Dolgikh and Sidonova, 1983; Prudek and Wolf, 1985; Kupper and Staub, 1988; Neinhuis and Lower, 1988; Fredrick and Staub, 1989). While Significant SCA variance was observed for number of flowers and number of fruit by Ghaderi and Lower (1979a, 1979b).

Average fruit weight (Smith et al., 1978; Ghaderi and Lower, 1981; Solanki and Seth, 1981; Prudek and Wolf, 1985; Prudek, 1986; Hormuzdi and More, 1989), fruit weight per vine (Smith et al., 1978; Prudek and Wolf, 1985; Prudek, 1986), fruit length to diameter ratio (Smith et al., 1978; Lower et al., 1982; Kupper and Staub, 1988), fruit length (Owens et al., 1985b; Hormuzdi and More, 1989; Fredrick and Staub, 1989 and fruit diameter (Lower et al., 1982; Hormuzdi and More, 1989) were controlled by additive gene action. On the contrary, combining ability estimates confirmed, non-additive gene action for average fruit weight (Ghaderi and Lower, 1979a, 1979b, 1981), fruit weight per vine (Ghaderi and Lower, 1979a; Prudek, 1986) and fruit length (Owens et al., 1985b) in similar studies.

Marketable yield (Tasdighi and Baker, 1981) and total yield per vine (Smith et al., 1978; Wang and Wang,

1980; Tasdighi and Baker, 1981; El Shawaf and Baker, 1981a; Lower et al., 1982; Neinhuis, 1982; Dolgikh and Sidonova, 1983) had high GCA variances indicating the role of additive gene action, while significant SCA variances for total yield (Ghaderi and Lower, 1979a, 1979b; Wang and Wang, 1980) indicated the role of non-additive gene action and its exploitation in heterosis breeding. Ghaderi and Lower (1981) observed fruit number to contribute to the commercial value of the crop.

Low dominance x environment interaction provided evidence for the stability of hybrids under different environments. Additive x environment interaction of various degrees suggests effective selection for yield to be carried out under more than one environment (Ghaderi and Lower, 1979a). G x E interaction variances were observed for number of fruit, length to diameter ratio and fruit firmness (Smith et al., 1978).

2.9.2. Heterosis

Hybrid vigour and heterosis are nearly synonymous. The word heterosis was coined by Shull (1914) to provide a term to describe the phenomenon but it did not include a description of the genetic mechanism involved in its expression (Hallauer and Miranda, 1982). Whaley (1944) elaborated the term heterosis as the developmental

stimulation resulting from the fusion of different gametes. The manifest effect termed the hybrid vigour.

Shull (1908) presented the first theory of heterosis, designated as the physiologic stimulation or heterozygosity hypothesis. East and Hayes (1912) and Shull (1912) supported this theory. In 1936, East reviewed the evidence for heterosis and concluded that dominant favourable growth factors were inadequate to explain heterosis. He proposed that multiple alleles at a locus are differentiated with respect to their physiological functions. As Sprague (1953) indicated, the ideas proposed are included within the limits of the physiologic stimulation hypothesis, but the proposed model was similar to the concept of overdominance suggested by Hull (1945).

The second hypothesis of heterosis, dominant favourable growth factors, was first presented by Bruce (1910). He said, heterosis would occur if the parents differed in the gene frequency and dominance was present. Jones (1917, 1945, 1958) opined that heterosis is manifested by the accumulation of dominant favourable factors at different loci.

Moll and Stuber (1974) listed three possible causes of heterosis; partial to complete dominance,

overdominance and epistasis. Knight (1971) has reported that in addition to the possible genetic causes, apparent heterozygote advantage might be a result of genotype and environment interactions.

Heterosis in seeded cucumbers was reported as early as 1916 by Hayes and Jones. Heterosis was reported for various other characters in cucumbers by Hutchins (1938), Barnes (1966) and Robinson and Whitaker (1974).

Singh et al. (1971) observed a range of increase in early and total yield varying from 70.31 to 153.68 and 45.74 to 78.76 per cent over the well adapted cultivar Japanese Long Green. Increased yield is reported to be due to increased vigour for the number of fruit in the hybrids. Om et al. (1978) found significant positive heterosis for early fruit yield per plant, total fruit yield per plant and total number of fruits per plant. Both additive and non-additive effects were important. Additive effect was more important for early yield per plant.

Hybrids with total yields exceeding 43.90 to 46.80 per cent marketable yields by 61.40 to 61.80 per cent and early yield by 49.10 per cent that of parents were recovered (Timofeen, 1979). Heterosis for yield was

a reflection in increased number of fruits per plant, but mean fruit weight did not exceed the parental values (Pyzhenkov and Koraseva, 1979).

Airapetyan (1981) observed 77.80 per cent of the F_1 hybrids showing heterosis for number of fruit per plant relative to the better parent. Heterosis for number of fruit per plant was observed based on regression of offspring on parents (Horton et al., 1980). Significant ratios were observed for heterosis and heterobeltiosis for number of fruit and weight of fruit per plant in parthenocarpic cucumbers (El Shawaf and Baker, 1981b).

Pyzhenkov and Koraseva (1982) evaluated several hybrids, of which 14 showed heterosis for early yield and 7 showed heterosis for total yield. Lu and Hon (1981) observed hybrid vigour for early maturity and high yields among the 24 F_1 s assessed.

Prudek and Wolf (1985) found mean fruit weight to show no heterosis. Heterosis for both number and weight of fruit per plant was high in some F_1 populations and depended on over dominance (Prudek, 1986).

Om et al. (1978) found significant negative heterosis for ratio of female to male flower and

number of female flowers. There was also positive heterosis observed for number of node at which the first female flower appeared and this character gave high heritability estimates.

Heterosis above the high-parent was observed for fruit weight per plant and main stem length, dominance was the major contributing factor to variation of these traits. F_1 deviation from mid-parent was observed for number of lateral branches (Lower et al., 1982).

Heterosis over better parent was observed for primary branch number per plant (25.26%), secondary branch number per plant (43.60%), number of female flowers (50.95%) average fruit weight (33.33%), fruit number per plant (42.12%) and fruit yield (83.81%). Inbreeding depression in F_2 was less than the heterosis in F_1 indicating the importance of additive x additive gene action in heterosis (Solanki et al., 1982a). Number of branches per plant, number of female flowers, number of fruit, average fruit weight and fruit yield per plant expressed pronounced heterosis over the better parent. Days to maturity had maximum negative heterosis, while plant height had no heterosis (Solanki et al., 1982b; 1982c; Solanki et al., 1987a, 1987b).

Delaney and Lower (1987) observed considerable heterosis over the better parent for average internodal length and main stem length. Number of nodes, number of primary lateral branches, average internodal length, main stem length and number of fruit per plant at maturity showed heterosis over the mid parental values.

Heterosis ranged from 15.34 per cent for fruit diameter to 59.22 per cent for fruit shape index (Imam et al., 1977). The coefficient of heterosis for fruit length was 0.77 for cv. Luma, 0.58 for cv. TP and 0.75 for cv. M29 of cucumber (Lebedeva, 1984).

Hormuzdi and More (1990) observed heterosis for early yield in summer and lack of heterosis of total yield was attributed to inability of the F_1 hybrids to sustain production over late period of harvesting. Cucumber improvement is thus considered to be approached through (a) increase in early component of total yield and (b) help sustain production throughout the harvesting period. Thus, it calls for early flowering and long vine types.

MATERIAL AND METHODS

FNAC as a tool in clinical investigation

FNAC was initially conceived as a means to confirm a clinical suspicion of local recurrence or metastasis of known cancer without subjecting the patient to further surgical intervention. Many clinicians feel that this remains the most important contribution of the technique from a practical point of view. Following the success in this area, the interest focused on preliminary preoperative diagnosis of all kinds of neoplastic processes, benign or malignant, in any organ or tissue of the body and on definitive, specific diagnosis in inoperable cases as a guide to rational treatment. The expansion of FNAC in primary diagnosis of tumours in the last 30 years or so has been enormous and generally successful.

The clinical value of FNAC is not limited to neoplastic conditions. It is also valuable in the diagnosis of inflammatory, infectious and degenerative conditions, in which samples can be used for microbiological and biochemical analysis in addition to cytological preparations. This is of particular importance in patients with acquired immunodeficiency syndrome (AIDS) and in other immunocompromised patients.²⁴ FNAC has proven useful in the diagnosis and monitoring of graft rejection in transplantation surgery,^{25,26} an area that is beyond the scope of this book.

Intraoperative cytology is another application using similar techniques and diagnostic criteria as in FNAC. It is a valuable alternative or complement to frozen section examination with a comparable level of accuracy.²⁷⁻³¹

Advantages and limitations

In the practice of FNAC there are clear advantages to patients, doctors, and taxpayers. The technique is relatively painless, produces a speedy result, and is inexpensive.³² Its accuracy in many situations, when applied by experienced and well-trained practitioners, can approach that of histopathology in providing an unequivocal diagnosis. We should stress, however, that aspiration cytology is not a substitute for conventional surgical histopathology.

When regarded as an essential component of the preoperative investigation of pathological conditions with clinical, radiological, and laboratory findings, definitive specific diagnosis is not possible; but a categorisation of the condition can be provided in a

subcutis, and soft tissues and organs such as the thyroid, breast, salivary glands, and superficial lymph nodes. Modern imaging techniques, mainly ultrasonography (US) and computed tomography (CT), applied to organs and lesions in sites not easily accessible to surgical biopsy offer vast opportunities for percutaneous, transthoracic and transperitoneal fine needle biopsy of deeper structures.³³ Samples may be obtained from the lung and mediastinum, the abdominal, retroperitoneal and pelvic organs and tissues, deep sites in the head and neck, the skeleton and the soft tissues as the first step in laboratory investigation, which can quickly satisfy the avidity of clinicians for rapid diagnoses. Costly days in hospital can be saved, since a tissue diagnosis can be obtained within minutes rather than days. More recently, techniques have been developed to perform US-directed FNB through an endoscope, mainly of lesions in the pancreas or adjacent tissues.³⁴⁻³⁶

Fine needle biopsy (FNB) is less demanding technologically than surgical biopsy. In this respect it is eminently suitable for practice in countries with scant resources which are unable to fund teams of surgeons, anaesthetists, nurses, etc. The low risk of complications is an additional advantage which allows FNB to be performed as an office procedure, in outpatient departments and in radiology theatres. It is also highly suitable in debilitated patients, is readily repeatable and useful for multiple lesions. Instances of serious complications have been reported in relation to different sites and organs, such as major haemorrhage, septicaemia, bile peritonitis, acute pancreatitis, pneumothorax, etc.³⁷ However, such complications are extremely rare in view of the vast numbers of uncomplicated FNBs performed in major centres where close monitoring of patients is the rule. The possibility of cancer cells being disseminated along the needle track³⁸ initially caused a great deal of concern precipitated by early reports of tumour implants at the site of incisional biopsy or of core needle biopsy. The literature was reviewed for reported cases of tumour implantation in the needle track by Roussel et al.³⁹ in 1989 and by Powers⁴⁰ in 1996. Both reviews found that the risk of needle track seeding is extremely low when truly fine needles of 22 gauge or less are used. The question is further discussed in relation to specific organs and sites in several of the following chapters. Multiple passes, larger needles and absence of normal parenchyma covering the lesion appear to increase the risk (see below). The rare severe complications do not diminish the clinical value and wide applications of FNAC, but awareness of their existence should be a reminder always to review the indication for any invasive procedure.

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reported⁴¹ but in our experience rarely cause real diagnostic difficulties. However, the biopsy technique should always be careful and gentle in order to minimise tissue damage.

Although FNAC can be applied to practically every organ and tissue of the body, certain limitations do exist. Experience is still insufficient and diagnostic cytological criteria need to be better defined in some less common conditions. Given the relative absence of tissue architectural patterns in smears, and given the small amount of tissue material obtainable with a fine needle, specific diagnostic conclusions can not always be reached even when samples are adequate and the full armamentarium of ancillary techniques is drawn upon. Nevertheless, some useful information indicating further lines of investigation may still be obtained. In some particularly difficult areas of diagnosis, such as soft tissue tumours,⁴² paediatric tumours,⁴³ etc., patients are best referred to major centres with specialised oncological expertise. Such centralisation is desirable to allow experience to accumulate faster and provide a basis for better definition of diagnostic criteria. Continuous frequent exposure to a particular category of tumours has been clearly shown to be a major factor deciding diagnostic accuracy. On the other hand, because such cases will be seen initially in general medical practices and surgical clinics, all cytopathologists must be able to at least categorise the condition and suggest the appropriate referral. This requires a wide knowledge of the range of possible conditions in any given site.

The numerous case reports of all kinds of rare and exotic tumours and other pathological processes diagnosed by FNAC published in the cytology journals create the impression that nothing is impossible for this technique. However, by studying the literature we can also appreciate the wide range of diagnostic pitfalls, which is a strong warning against overconfidence in cytodagnosis.⁴⁴ A level of diagnostic accuracy high enough to constitute a sufficient basis for major therapeutic decisions can only be reached through the analysis of large series of cases. In 1985, Hajdu and Melamed issued a warning against overconfidence in FNAC diagnosis, which led to a considerable debate in later issues of *Acta Cytologica*.⁴⁵ These thoughts were further developed and discussed at a symposium in 1989 on the value and limitations of aspiration cytology in the diagnosis of primary tumours moderated by Hajdu and attended by a number of international experts.⁴⁶ We believe that a continuing debate of this type and an ongoing evaluation and interchange of the increasing experience are extremely important. All parties involved must fully understand the limitations of the technique.

reason is the increasing pressure on pathologists, including those without sufficient training and experience in diagnostic cytology, to make definitive and specific preoperative diagnoses on needle biopsy material in all kinds of disease processes in all sites. The demand for a definitive diagnosis is particularly strong in the investigation of disease processes in deep sites, in which needle biopsy guided by radiological imaging is the only alternative to explorative laparotomy or thoracotomy. In addition, oncologists increasingly expect various prognostic parameters to be included in the preoperative assessment of tumours, for which FNB may not provide sufficient material. Another important reason is the high dependency on, and the shortage of, pathologists with sufficient training and experience to successfully practice FNAC. Supervision of sampling and specimen handling by a competent pathologist is crucial to achieving a high diagnostic accuracy,⁴⁸ and this may prove logistically unattainable. Core needle biopsy specimens, on the other hand, are handled in theatres and received in laboratories in the same way as any other surgical biopsy.

Although core biopsy needles used today are usually of a lesser calibre than those of the pre-FNAC era, the procedure is more traumatic and carries a slightly greater risk of complications than FNB using needles of 22 gauge or less. The main concern is the possibility of tumour seeding in the needle track. Furthermore, core needle biopsy may not necessarily improve diagnostic accuracy.⁴⁹ There is emerging evidence that diagnostic accuracy may not be as high as expected for core needle biopsy of tumours of the breast and prostate.^{50,51} Cost effectiveness is an important consideration, particularly in practices that involve large numbers of patients, for example in breast cancer screening. We therefore feel that it is not a question of choosing one method to the exclusion of the other, but that the two techniques should be seen as complementary, each with its own specific indications.^{52,53} In our opinion FNB should be the first line approach to the investigation of suspected malignant disease since it is able to resolve the problem in about 2/3 of cases. Core needle biopsy should be used selectively when the information provided by cytology is, or is likely to be, insufficient, incomplete or indecisive. In order to make optimal use of the simple, fast and inexpensive method of FNB, every effort should be made to improve the sampling and preparation to define diagnostic criteria and to identify possible causes of diagnostic error of FNB.

III. MATERIAL AND METHODS

3.1. Material

The investigations reported in the present study were carried out at Indian Institute of Horticultural Research, Hesaraghatta, Bangalore during 1988-1990. The study consisted of variability and associated studies (in one season) and diallel analysis (in two seasons). The parental lines chosen for the investigation were drawn from the germplasm collection maintained at the Division of Vegetable Crops, IIHR, Hesaraghatta, Bangalore.

Variability and associated studies included 22 entries. The brief description of these entries is furnished in Table 1. The diallel analysis included 9 parental entries, IHR 82-1-1, IHR 79-3-1, IHR 68-1-1, IHR 61-1-1, IHR 56-1-1, IHR 45-6-1, IHR 33-1-1, IHR 23-2-2 and IHR 5-1-2. The brief description of the parental entries is furnished in Table 2. The parental entries have been referred to as 1, 2, 3, 4, 5, 6, 7, 8 and 9 respectively throughout the text.

3.2. Methods

3.2.1. Selfing technique: The flower buds likely to open the following day were bagged using butter paper bags.

Table 1. Parental lines of variability and associated studies:a descriptive

NAME	SOURCE	CHARACTERISTICS
IHR 5.1.2 (Mysore local)	Mysore, Karnataka	monoecious, fruit cylindrical, uniform green, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.
IHR 13.2.1 (NBPGR Selection)	N.B.P.G.R., New Delhi	monoecious, fruit cylindrical, mottled green, surface smooth, black spined, non bitter, flesh crisp, white, medium to big seed cavity.
IHR 23.2.2 (NBPGR Selection)	N.B.P.G.R., New Delhi	monoecious, fruit cylindrical, uniform green, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.
IHR 34.3.1 (Poona local)	Poona, Maharashtra	monoecious, fruit cylindrical, mottled green, surface smooth, black spined, bitter, flesh crisp, white, small seed cavity.
IHR 27.2.2 (Pilska)	Bulgaria	monoecious, fruit cylindrical, mottled green, surface smooth, black spined, non bitter, flesh crisp, white, medium to big seed cavity.
IHR 67.2.3 (Poinsette)	U.S.A.	monoecious, fruit cylindrical, dark green, surface smooth, white spined, bitter, flesh crisp, white, medium seed cavity.
IHR 31.1.1 (Pobeda)	Bulgaria	monoecious, fruit cylindrical, uniform green, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.
IHR 32.1.2 (Poona local)	Poona, Maharashtra	monoecious, fruit cylindrical, uniform green, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.
IHR 33.1.1 (Poona local)	Poona, Maharashtra	monoecious, fruit cylindrical, uniform green, surface smooth to warty, black spined, flesh crisp, white, medium seed cavity.
IHR 45.6.1 (Rajasthan local)	Tonk, Rajasthan	monoecious, fruit cylindrical, uniform green, surface warty, black spined, non bitter, flesh crisp, white, medium seed cavity.
IHR 48.3.1 (Spartan Salad)	Ithaca, New York	monoecious, fruit cylindrical, dark green, surface smooth, white spined, non bitter, flesh crisp, white, medium seed cavity.
IHR 50.1.1 (Pickle Hybrid)	Ithaca, New York	monoecious, fruit cylindrical, dark green, surface smooth, white spined, non bitter, flesh crisp, white, medium seed cavity.
IHR 51.1.1 (PMR 551)	Ithaca, New York	monoecious, fruit cylindrical, mottled green, surface warty, black spined, non bitter, flesh crisp, white, medium to big seed cavity.
IHR 56.1.1 (Market More 80.3)	Ithaca, New York	monoecious, fruit cylindrical, dark green, surface warty, white spined, non bitter, flesh crisp, white, medium seed cavity.
IHR 60.1.1 (Poinsette-76)	Ithaca, New York	monoecious, fruit cylindrical, dark green, surface smooth, white spined, bitter, flesh crisp, white, medium seed cavity.
IHR 61.1.1 (Poinsette 83.10)	Ithaca, New York	monoecious, fruit cylindrical, dark green, surface smooth to warty, white spined, bitter, flesh crisp, white, medium seed cavity.
IHR 90.2.1 (Faizabad local)	Faizabad, Uttar Pradesh	monoecious, fruit cylindrical, uniform green, surface smooth, black spined, non bitter, flesh crisp, white, medium to big seed cavity.
IHR 68.2.3 (Market More 76)	U.S.A.	monoecious, fruit cylindrical, dark green, surface smooth, white spined, bitter, flesh crisp, white, medium seed cavity.
IHR 74.1.2 (Bangalore local)	Bangalore, Karnataka	monoecious, fruit cylindrical, uniform white, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.
IHR 79.3.2 (Faizabad local)	Faizabad, Uttar Pradesh	monoecious, fruit cylindrical, mottled green, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.
IHR 81.1.1 (Lucknow local)	Lucknow, Uttar Pradesh	monoecious, fruit cylindrical, mottled green, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.
IHR 82.1.1 (Faizabad local)	Faizabad, Uttar Pradesh	monoecious, fruit cylindrical, mottled green, surface smooth, black spined, bitter, flesh crisp, white, medium seed cavity.

Table 2. Parental lines of diallel analysis: a descriptive

NO.	NAME	SOURCE	CHARACTERISTICS	
1.	IHR 82.1.1 (Faizabad local)	Faizabad, Uttar Pradesh	monoecious, fruit cylindrical, L:D ratio 3.1, surface mottled green, surface smooth, black spined, moderately tough skin, bitter, flesh crisp, white, medium to big seed cavity.	
2.	IHR 79.3.1 (Faizabad local)	Faizabad, Uttar Pradesh	monoecious, fruit cylindrical, L:D ratio 2.8, surface mottled green, smooth, black spined, moderately tough skin, bitter, flesh crisp, white, medium to big seed cavity	
3.	IHR 68.2.3 (Market More 76)	U.S.A.	monoecious, fruit cylindrical, L:D ratio 3.1, surface dark green, smooth to warty, white spined, tough skin, bitter, flesh crisp, white, medium seed cavity.	
4.	IHR 61.1.1 (Poinsette 83.10)	Ithaca, New York	monoecious, fruit cylindrical, L:D ratio 3.5, surface dark green, smooth to warty, white spined, tough skin, bitter, flesh crisp, white, medium seed cavity.	
5.	IHR 56.1.1 (Market More 80.3)	Ithaca, New York	monoecious, fruit cylindrical, L:D ratio 3.3, surface dark green, smooth, white spined, tough skin, non bitter, flesh crisp, white, medium seed cavity.	
6.	IHR 45.6.1 (Rajasthan local)	Tonk, Rajasthan	monoecious, fruit cylindrical, L:D ratio 2.7, surface uniform green, warty, black spined, moderately tough skin, non bitter, flesh crisp, white, medium to big seed cavity.	
7.	IHR 33.1.1 (Poona local)	Poona, Maharashtra	monoecious, fruit cylindrical, L:D ratio 2.2, surface uniform green, smooth, black spined, moderately tough skin, bitter, flesh crisp, white, medium seed cavity.	
8.	IHR 23.2.2 (NBPGR Selection)	N.B.P.G.R., New Delhi	monoecious, fruit cylindrical, L:D ratio 3.0, surface uniform green, smooth, black spined, moderately tough skin, bitter, flesh crisp, white, medium seed cavity.	
9.	IHR 5.1.2 (Mysore local)	Mysore, Karnataka	monoecious, fruit cylindrical, L:D ratio 2.3, surface uniform green, smooth, black spined, moderately tough skin, bitter, flesh crisp, white, medium seed cavity.	

On the succeeding day, between 6 AM and 8 AM pollen from the bagged male flower were dusted on to the stigma of the bagged female flower of the same plant. The female flower pollinated was then labelled and bagged.

3.2.2. Crossing technique: The flower buds likely to flower the following day were bagged. On the succeeding day, between 6 AM and 8 AM the pollen from the male flower of the male parent were dusted on to the stigma of the female flower of the desired female parent. The pollinated flower was then labelled and bagged.

The 9 parents (P) were involved in a diallel cross constituting $(P^2 - P)/2$ combinations excluding the reciprocal crosses. The seeds obtained were split to two equal lots and raised in two different seasons.

3.2.3. Field plot technique

3.2.3.1. Variability and associated studies: The 22 parental entries were raised, in a randomised block design replicated thrice, during November, 1988. A 4.5 m long single row was used for each parental entry. Row to row spacing was 2.5 m. Each row consisted of 10 plants spaced 50 cm apart. Recommended cultural practices were followed. NPK was applied in the ratio of 50:70:30 kg/ha

at the time of sowing. A top dressing of 50 kg N/ha was given after 30 days of sowing. Observations were recorded on 5 randomly selected plants.

3.2.3.2. Diallel analysis: The F_1 s consisting the direct crosses (36) along with the parents (9) constituting 45 treatments were raised, in a randomised block design replicated thrice, during April, 1989 (first season) and January, 1990 (second season). A 4.5 m long single row was used for each treatment, consisting of 10 plants spaced 50 cm apart. Row to row spacing was 2.5 m. Recommended cultural practices were followed. NPK was applied in the ratio of 50:70:30 kg/ha at the time of sowing. A top dressing of 50 kg N/ha was given after 30 days of sowing. Observations were recorded on 5 randomly selected plants.

3.3. Observation recorded

3.3.1. Node at which first female flower appears: The node number from the cotyledonous leaves at which the first female flower appeared was recorded.

3.3.2. Days to first flowering: Number of days taken from the day of sowing to the onset of the first female flower on the vine was recorded.

3.3.3. Days to first harvest: Number of days taken from the day of sowing to first harvest was recorded. Fruit were harvested when the spines on the fruit were loosely attached state (falling out on a gentle touch).

3.3.4. Number of marketable fruit per vine: The number of marketable fruit per vine over all the harvests were counted and recorded.

3.3.5. Number of unmarketable fruit per vine: The number of unmarketable (deshaped) fruit per vine were counted over all the harvests and recorded.

3.3.6. Total number of fruit per vine: The number of fruit per vine over all the harvests was counted and recorded.

3.3.7. Marketable fruit yield per vine (kg): The weight of the marketable fruit per vine was recorded.

3.3.8. Unmarketable fruit yield per vine (kg): The weight of the unmarketable fruit (deshaped fruit) per vine was recorded.

3.3.9. Total fruit yield per vine (kg): The weight of all the fruits per vine was recorded.

3.3.10. Average fruit weight (g): The ratio of total weight of fruit per vine to the total number of fruit per vine gave the average fruit weight.

3.3.11. Per cent deshaped fruit: The ratio of the unmarketable fruit to the total number of fruit per vine expressed as percentage gave the per cent deshaped fruit per vine.

3.3.12. Vine length (m): The length of the vine from the ground level to the tip was measured after the final harvest.

3.3.13. Number of nodes per vine: The number of nodes per vine on the main stem was counted.

3.3.14. Internodal length (cm): The ratio of total vine length to the number of nodes per vine gave the internodal length.

3.3.15. Number of branches per vine: The total number of branches present on each vine was counted after the final harvest.

3.3.16. Specific leaf area (cm^2/g): The fourth or fifth leaf corresponding to fully mature leaf on the vine (assuring the absence of a fruit at the node) was collected after the second harvest. The leaf area was determined by use of a leaf area meter. Later, the leaf was dried at $65^{\circ}\text{C}+2^{\circ}\text{C}$, and the dry weight recorded. The ratio of the leaf area to its dry weight gave the specific leaf area.

3.3.17. Specific leaf weight (g/cm^2): The ratio of the leaf dry weight to the leaf area gave the specific leaf weight.

3.3.18. Fruit size (cm^2): The product of the length of the fruit and its breadth gave the fruit size.

3.3.19. Fruit shape: The ratio of the length of the fruit to its breadth gave the fruit shape.

3.3.20. Cavity size (cm^2): The product of the length of the cavity to its breadth gave the cavity size.

3.3.21. Cavity shape: The ratio of the length of the cavity to its breadth gave the cavity shape.

3.3.22. Rind toughness (kg/cm^2): The freshly harvested fruit were pierced by a penetrometer. The force required to pierce the skin gave the rind toughness.

3.3.23. Flesh thickness (cm): The flesh thickness without the skin was measured and recorded.

3.3.24. Seed maturity at harvest (11 DAF): The fruit tagged were collected 11 days after fruit set (DAF), cut open and observed for the stage of maturity of the seed. The maturity was given scores from 0 to 5, 0 denoting immature seeds and 5 denoting fully mature seeds. The other values indicating intermediate stages of seed maturity.

3.3.25. Seed maturity at harvest (16 DAF): The fruit tagged were cut open and observed for seed maturity 16 days after fruit set, using the scale as mentioned above.

3.3.26. Fruit fresh weight loss at storage (5 DAS) (g): The fruit collected from the first two harvests were stored under laboratory conditions (Appendix IV). The initial weight and weight after 5 days of storage were recorded. The difference in weight determined the fresh weight loss.

3.3.27. Fruit fresh weight loss (10 DAS) (g): The difference between the initial fruit weight and weight 10 days after storage gave the fresh weight loss of the fruit.

3.4. Statistical analysis

The statistical analysis of the data recorded on individual characters was carried out by use of a computer at the Indian Institute of Horticultural Research, Bangalore and University of Agricultural Sciences, GKVK, Bangalore.

3.4.1. Variability and association studies

3.4.1.1. Analysis of variance and covariance: Analysis of variance and covariance for randomised block design was done as follows (Goulden, 1959).

Analysis of variance with expected mean squares

Source	df	SS	MS	E(MS)
Replications	(r-1)	Sr	Mr(x)	-
Treatments	(t-1)	St	Mt(x)	$\sigma_{e(x)}^2 + r\sigma_{g(x)}^2$
Error	(r-1)(t-1)	Se	Me(x)	$\sigma_{e(x)}^2$

Analysis of covariance with expected mean products

Source	df	SP	MP	E(MP)
Replications	(r-1)	SPr	MPr(xy)	-
Treatments	(t-1)	SPt	MPt(xy)	$\sigma_{e(xy)} + r\sigma_{g(xy)}$
Error	(r-1)(t-1)	SPe	MPe(xy)	$\sigma_{e(xy)}$

Where, r = number of replications,

t = number of treatments,

$\sigma_{e(x)}^2$ = error variance, =Me(x),

$\sigma_{g(x)}^2$ = genotypic variance,

$\sigma_{e(xy)}$ = error covariance, =MPe(xy)

$\sigma_{g(xy)}$ = genotypic covariance.

3.4.1.2. Genotypic variance

$$\sigma_{g(x)}^2 = \frac{Mt(x) - Me(x)}{r}$$

3.4.1.3. Phenotypic variance

$$\sigma_{p(x)}^2 = \sigma_{g(x)}^2 + \sigma_{e(x)}^2$$

3.4.1.4. Genotypic covariance

$$\sigma_{g(xy)} = \frac{MPt(xy) - MPe(xy)}{r}$$

3.4.1.5. Phenotypic covariance

$$\sigma_{p(xy)} = \sigma_{g(xy)} + \sigma_{e(xy)}$$

3.4.1.6. Phenotypic and genotypic coefficients of variability: The coefficients of phenotypic (PCV) and genotypic (GCV) variability were calculated as follows (Singh and Chaudhary, 1977).

$$GCV = \frac{\sigma_{g(x)}}{\bar{x}} \times 100$$

$$PCV = \frac{\sigma_{p(x)}}{\bar{x}} \times 100$$

Where, $\sigma_{g(x)}$ = Genotypic standard deviation.

$\sigma_{p(x)}$ = Phenotypic standard variation.

$\bar{x}$ = Population mean.

3.4.1.7. Heritability (in broad sense): Heritability in broad sense (H or h^2) was calculated as a ratio of genetic variance to total variance (Singh and Chaudhary, 1977) and expressed as percentage.

$$H (\%) = \frac{\sigma_{g(x)}^2}{\sigma_{p(x)}^2} \times 100$$

3.4.1.8. Genetic advance: Genetic advance (GA) was calculated using the following formula given by Johnson et al. (1955a).

$$\frac{\sigma_g^2(x)}{\sigma_p^2(x)} \times K$$

where, K = Selection differential (2.06 at 5% intensity)

3.4.1.9. Genetic advance(% of mean) or genetic gain(GG):

$$GG = \frac{GA}{\bar{x}} \times 100$$

3.4.1.10. Critical difference (CD): In order to compare the means of various entries CD was calculated as follows (Singh and Chaudhary, 1977).

$$CD = \left| \frac{2Me}{r} \right|^{\frac{1}{2}} \times 't'$$

where, Me = Error mean square.

t = Table value of t for error df.

3.4.1.11. Coefficient of variation (CV): It was calculated as follows (Singh and Chaudhary, 1977).

$$CV (\%) = \frac{\sigma_e(x)}{\bar{x}} \times 100$$

where, $\sigma_e(x)$ = Error standard deviation.

3.4.1.12. Coefficients of correlation: Genotypic coefficient of correlation (r_g), phenotypic coefficient of correlation (r_p) and environmental coefficient of

correlation (r_e) were calculated using the following formulae (Al-Jibouri et al., 1958).

$$r_{g(xy)} = \frac{\sigma_{g(xy)}}{\sigma_{g(x)} \cdot \sigma_{g(y)}}$$

$$r_{p(xy)} = \frac{\sigma_{p(xy)}}{\sigma_{p(x)} \cdot \sigma_{p(y)}}$$

$$r_{e(xy)} = \frac{\sigma_{e(xy)}}{\sigma_{e(x)} \cdot \sigma_{e(y)}}$$

The significance was tested against 'r' value given by Fisher and Yates (1963).

3.4.1.13. Coheritability: Coheritability was calculated with the help of covariances as follows (Singh and Chaudhary, 1977).

$$\text{Coheritability (\%)} = \frac{\sigma_{g(xy)}}{\sigma_{p(xy)}} \times 100$$

3.4.2. Diallel analysis

3.4.2.1. Analysis of variance: Statistical analysis of the experimental data was made to test the significance of genotypic differences and the analysis of variance table was constructed as follows (Cochran and Cox, 1959).

Source	df	SS	MS	F Ratio
Replications	(r-1)	Sr	Mr	Mr/Me
Treatments	(t-1)	St	Mt	Mt/Me
Error	(r-1)(t-1)	Se	Me	

where, r = number of replications.

t = number of treatments.

3.4.2.2. Combining ability analysis: General and specific combining ability effects were estimated using the procedure given in method 2 and model 1 (i.e., parents and one set of F_1 s) of Griffing (1956b).

The mathematical model assumed for the combining ability analysis was:

$$x_{ij} = \mu + g_i + g_j + S_{ij} + \frac{1}{bc} \sum_k \sum_l e_{ijkl}$$

($i, j = 1 \dots n$)

($k = 1 \dots b$)

($l = 1 \dots c$)

where, x_{ij} = Mean of ixj genotype over k and l .

μ = Population mean or general effect.

g_i = General combining ability (gca) effect of i^{th} parent.

g_j = gca effect of j^{th} parent.

s_{ij} = Specific combining ability (sca) effect for the cross involving i^{th} and j^{th} parent

such that $S_{ij} = S_{ji}$.

b = Number of replications.

c = Number of lines in each treatment.

n = Number of parental lines.

e_{ijkl} = Environmental effect or error effect associated with $ijkl^{th}$ individual.

$$\frac{1}{bc} = \sum \sum e_{ijkl} = \text{Mean error effect.}$$

The total variability in the population was partitioned into components like variance due to gca, sca and error. Using replicate means, the various sums of squares were obtained as given below with the appropriate notations.

Parents	P_1	P_2	$P_3 \dots P_{10}$	$x_{i.}$	$x_{.i} - x_{ii}$	$x_{.i} + x_{ii}$
P_1	x_{11}	x_{12}	$x_{13} \dots x_{110}$	$x_{1.}$		
P_2		x_{22}	$x_{23} \dots x_{210}$	$x_{2.}$		
P_3			$x_{33} \dots x_{310}$	$x_{3.}$		
$\vdots$						
$\vdots$						
$\vdots$						
P_{10}			$\dots x_{1010}$	$x_{10.}$		
				$x_{..}$		

$$\text{SS due to gca} = S_g = \frac{1}{n+2} \left[\sum (x_{i.} + x_{.i})^2 - \frac{4}{N} x_{..}^2 \right]$$

$$\begin{aligned} \text{SS due to sca} = S_s = & \sum \sum x_{ij}^2 - \frac{1}{n+2} \sum (x_{i.} + x_{.i})^2 \\ & + \frac{2}{(n+1)(n+2)} x_{..}^2. \end{aligned}$$

where, $x_{i.}$ = Total of the array of i^{th} parent in a diallel table.

$x_{..}$ = Grand total of n parents and $\frac{n(n-1)}{2}$

F_1 progenies.

x_{ij} = Mean value of i^{th} parent.

x_{ij} = Mean value of ij^{th} cross.

The model of analysis of variance table for combining ability is given below.

Source	df	SS	MS	F Ratio
gca	$n-1$	S_g	M_g	$M_g/M'e$
sca	$\frac{n(n-1)}{2}$	S_s	M_s	$M_s/M'e$
Error	m	S_e	$M'e$	

where, $M'e = M_e/b$.

M_e = Error mean square from RBD analysis.

b = Number of replications.

m = Error df in straight analysis of variance (RBD).

n = Number of parents.

From the above table the components of variation were estimated as follows.

$$\sigma_g^2 = \frac{1}{n+2} (M_g - M_s)$$

$$\sigma_s^2 = M_s - M'e$$

$$\sigma_e^2 = M'e$$

where, σ_g^2 , σ_s^2 , and σ_e^2 are the estimates.

These components were translated into genetic components using following equations.

$$\sigma_g^2 = \frac{1}{2}\sigma_A^2$$

$$\sigma_s^2 = \sigma_D^2$$

where, σ_A^2 = Additive variance.

σ_D^2 = Dominance variance.

The general combining ability effects (g_i) and specific combining ability effects (s_{ij}) were estimated as follows.

$$g_i = \frac{1}{(n+2)} \left[\sum (X_{i.} + X_{ii}) - \frac{2}{n} X_{..} \right]$$

$$s_{ij} = X_{ij} - \frac{1}{n+2} (X_{i.} + X_{ii} + X_{.j} + X_{jj}) + \frac{2}{(n+1)(n+2)} X_{..}$$

where, $X_{.j}$ = Total of the array of j^{th} parent in a diallel table.

X_{jj} = Mean value of j^{th} parent.

The notations used for others have the same meaning as explained earlier.

Standard errors (SE) were estimated as follows.

SE of gca effect

$$SE (g_i) = \left[(n-1) \sigma_e^2 / n(n+2) \right]^{\frac{1}{2}}$$

SE of difference between two estimates of gca effect

$$SE (g_i - g_j) = \left[2 \sigma_e^2 / (n+2) \right]^{\frac{1}{2}}$$

SE of sca effect

$$SE (s_{ij}) = \left[n(n-1) \sigma_e^2 / (n+1)(n+2) \right]^{\frac{1}{2}}$$

SE for testing differences between estimates of sca effects in the same array

$$SE (s_{ij} - s_{ik}) = \left[2(n+1) \sigma_e^2 / (n+2) \right]^{\frac{1}{2}}$$

SE for testing differences between estimates of sca effects in different arrays

$$SE (s_{ij} - s_{kl}) = \left[2n \sigma_e^2 / (n+2) \right]^{\frac{1}{2}}$$

The critical difference (CD) was calculated by multiplying SE with 't' value at error df.

3.4.2.3. Analysis of the diallel table for genetic components of variance

After construction of diallel table for each character, the genetic components were computed by the methods of Jinks and Hayman (1953), Hayman (1954a, b) and Jinks (1954) and explained through a worked example by Aksel and Johnson (1963).

3.4.2.4. Assumptions underlying diallel analysis: The diallel analysis was carried out under the following assumptions.

- i) Diploid segregation.
- ii) Homozygosity of parents.
- iii) Absence of genetic differences between reciprocal crosses.
- iv) Independent action of non-allelic genes.
- v) Independent distribution of genes among parents.
- vi) Absence of multiple allelism.

3.4.2.5. Calculation of various statistics of the diallel table: The following statistics were calculated from the diallel table. Each row was considered as an array.

V_{0L_0} = Variance of the parents (V_p)

V_r = Variance of the r^{th} array (V_{frs})

W_r = Covariance between the parents and their offspring in the r^{th} array ($Cov P_{frs}$)

V_{1L_1} = Mean variance of the arrays

W_{0L_01} = Mean covariance of the arrays

V_{0L_1} = Variance of the array means (V_{fr})

ML_1 = Mean of the n^2 progeny

ML_0 = Mean of n parents.

The above statistics comprised a combination of various genetic and environmental components and were as follows.

$$V_{0L_0} = D+E$$

$$V_r = \frac{1}{4}D - \frac{1}{4}F_r + \frac{1}{4}H [E + \frac{1}{2}(n-1) E]/n$$

$$\begin{aligned}
W_r &= \frac{1}{2}D - \frac{1}{4}F_r + E/n \\
W_0L_{01} &= \frac{1}{2}D - \frac{1}{4}F + E/n \\
V_1L_1 &= \frac{1}{4}D - \frac{1}{4}F + \frac{1}{4}H_1 + [E - \frac{1}{2}(n-2)E]/n \\
V_0L_1 &= \frac{1}{4}D - \frac{1}{4}F + \frac{1}{4}H_1 - \frac{1}{4}H_2 + [E + \frac{1}{2}(n-2)E]/n^2 \\
(ML_1 - ML_0)^2 &= \frac{1}{4}h^2 + (n-1)(n-2)E + E/n^3
\end{aligned}$$

3.4.2.6. Estimation of components of variation: With the expectations given above, the six genetic components were estimated by the following formula.

$$\begin{aligned}
\hat{D} &= V_0L_0 - E \\
\hat{F} &= 2V_0L_0 - 4W_0L_{01} - 2(n-2)E/n \\
\hat{H}_1 &= V_0L_0 - 4W_0L_{01} + 4V_1L_1 - 3(n-2)E/n \\
\hat{H}_2 &= 4V_1L_1 - 4V_0L_1 - 2E \\
\hat{h}^2 &= 4(ML_1 - ML_0)^2 - 4(n-1)E/n^2 \\
\hat{F}_r &= 2(V_0L_0 - W_0L_{01} + V_1L_1 - W_r - V_r) - 2(n-2)E/n
\end{aligned}$$

where, $\hat{D}$ = is the variance due to additive effects of genes.

$\hat{H}_1$ = is the variance due to dominance effects of genes.

$\hat{H}_2$ = is the proportion of dominance variance due to positive (u) and negative (v) effects of genes $H_2 = H_1[1 - (u-v)^2]$.

$\hat{h}^2$ = is the net dominance variance expressed as the algebraic sum over all loci in heterozygous phase in all crosses.

$\hat{F}_r$ = is the proportion of positive and negative effects of genes in the r^{th} parent.

$\hat{E}$ = is the error variance obtained from the analysis of variance of the experimental design, RBD in the present case.

$\bar{F}$ = is the mean of F_r values.

3.4.2.7. Testing the significance of the components: The variance of $(W_r - V_r)/2$ was used as S^2 and standard errors of the various genetic parameters were calculated using the terms of the main diagonal of the covariance matrix of genetic components given by Hayman (1954b) in Table 1 on page 798. The formulae used were as follows.

$$S_D = \sqrt{S^2(n^5 + n^4)/n^5}$$

$$S_F = \sqrt{S^2(4n^5 + 20n^4 - 16n^3 + 16n^2)/n^5}$$

$$SH_1 = \sqrt{S^2(n^5 + 41n^4 - 12n^3 + 4n^2)/n^5}$$

$$SH^2 = \sqrt{S^2(16n^4 + 16n^2 - 32n + 16)/n^5}$$

$$SH_2 = \sqrt{S^2(36n^4)/n^5}$$

$$SF_r = \sqrt{4S^2(3n^3 + 3n^2 - 4n + 4)/n^3}$$

$$SE = \sqrt{(S^2(n^4/n^5))}$$

$$S(D-H_1) = \sqrt{4S^2(9n^2 - 2n + 1)/n^3}$$

With the help of these standard errors, the significance of the components of genetic variance was tested.

3.4.2.8. Testing of hypotheses: The failure or otherwise of hypotheses could be tested by the homogeneity of $(W_r - V_r)$ values over the arrays. In other words $(W_r - V_r)$ should be constant over the arrays. It could also be tested by the 't' test. In the present study, 't' test was used which was applied as follows.

$$t^2 = \frac{n-2}{4} \times \frac{(\text{Var } V_r - \text{Var } W_r)^2}{\text{Var } V_r \times \text{Var } W_r - \text{Cov}^2 (V_r, W_r)}$$

with $n-2$ degrees of freedom.

The significance of t^2 indicated the failure of conformity with the hypotheses.

3.4.2.9. Proportions of genetic components: The different types of proportions and differences of genetic components that were worked out and the indication that they give about the genetics of the characters, are given below.

$(H_1/D)^{\frac{1}{2}}$ = Overall dominance in the diallel cross.

$H_1 - H_2$ = Showed the positive and negative alleles at all loci controlling the characters were in equal proportions in the parents.

$H_2/4H_1$ = Proportion of genes with positive and negative effects.

$\frac{(4DH_1)^{\frac{1}{2}} + F}{(4DH_1)^{\frac{1}{2}} - F} = \frac{KD}{KR}$ = A measure of proportion of dominant and recessive genes in the parents.

$\frac{h^2}{H_2} = K$ = An estimate of the number of genes governing the characters and showing dominance.

$\frac{(\frac{1}{2})D + (\frac{1}{2})H_1 - (\frac{1}{2})H_2 - (\frac{1}{2})F}{(\frac{1}{2})D + (\frac{1}{2})H_1 - (\frac{1}{2})H_2 - (\frac{1}{2})F + E} = h^2_{(ns)}$ = heritability in narrow sense.

$$r = \frac{[\sum Yr(Wr+Vr)] - \left[\frac{(\sum Yr)(\sum (Wr+Vr))}{n} \right]}{\left[\sum Yr^2 - \frac{(\sum Yr)^2}{n} \right] \left[\sum (Wr+Vr)^2 - \frac{(\sum (Wr+Vr))^2}{n} \right]}$$

- the coefficient of correlation between the parental order of dominance ($Wr+Vr$) and parental measurement (Yr).

- to test the significance of r , 't' test was used: $t = r \left[\frac{n-2}{1-r^2} \right]^{\frac{1}{2}}$ with $n-2$ df.

3.4.2.10. Heterosis: Heterosis per cent over mid parental value (MP) and better parent (BP) were estimated (Rai, 1979).

i) Heterosis over mid parental value or relative heterosis

$$MP = \frac{\bar{F}_1 - \bar{MP}}{\bar{MP}} \times 100$$

ii) Heterosis over better parent or heterobeltiosis

$$BP = \frac{\bar{F}_1 - \overline{BP}}{\overline{BP}} \times 100$$

where, $\bar{F}_1$ = Mean value of F_1 hybrid.

$$\overline{MP} = \frac{P_1 + P_2}{2} = \text{Mid parental value.}$$

$\overline{BP}$ = Mean value of better parent.

The following quantities were tested for significance.

i) $H_1 = \bar{F}_1 - \overline{MP}$, for which $CD_1 = SE_m \times (1.5)^{\frac{1}{2}} \times t$.

ii) $H_2 = \bar{F}_1 - \overline{BP}$, for which $CD_2 = SE_m \times (2)^{\frac{1}{2}} \times t$.

where, $SE_m = \left[\frac{Me}{r} \right]^{\frac{1}{2}}$

t = Table value of t at 5% or 1% level of significance for error df.

Me = Error mean squares from RBD analysis.

r = Number of replications.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The experimental findings pertaining to the investigation of the present study are presented below:

4.1. VARIABILITY AND ASSOCIATED STUDIES

4.1.1. Analysis of variance

Analysis of variance to test the genotypic differences among the 22 cucumber genotypes was carried out for all the yield and yield components and the fruit characteristics. The mean values for all those characters are presented in Appendix I. The differences among the 22 genotypes were significant for all the characters except number of branches per vine and flesh thickness. The analysis of variance for all the characters is presented in Table 3.

4.1.2. Variability studies

Various genetic constants were calculated by using the components of variance from the expected mean squares. The general mean, range, coefficient of variation (CV %), estimate of variances, phenotypic (PCV) and genotypic coefficient of variance (GCV), heritability in broad sense (H%), genetic advance, genetic advance (GA)

Table 3. Analysis of variance for 27 characters in 22 genotypes of cucumber

Characters	df	Block 2	Treatment 21	Error 42
1. Node of first female flower emergence		0.02	0.75**	0.25
2. Days to first flowering		2.56	19.32**	1.10
3. Days to first harvest		12.31	18.85**	4.84
4. Vine length (m)		0.03	0.08**	0.03
5. Number of nodes/vine		2.86	13.92**	3.23
6. Internodal length (cm)		1.77	1.60**	0.55
7. Number of branches/vine		1.20	0.43 ^{NS}	0.28
8. Specific leaf weight (g/cm ²)		2.19	0.82**	0.28
9. Specific leaf area (cm ² /g)		2308.50	1129.27**	364.54
10. Fruit size (cm ²)		79.63	608.61**	112.59
11. Fruit shape		0.07	0.44**	0.14
12. Cavity size (cm ²)		78.18	165.43**	46.13
13. Cavity shape		0.32	1.00**	0.23
14. Rind toughness (kg/cm ²)		0.03	3.13**	0.48
15. Flesh thickness (cm)		0.03	0.03 ^{NS}	0.03
16. Seed maturity at harvest (11 DAF)		0.18	0.63**	0.20
17. Seed maturity at harvest (16 DAF)		0.86	0.85**	0.20
18. Fruit fresh weight loss at storage (5 DAS)(g)		32.06	264.10**	28.84
19. Fruit fresh weight loss at storage (10 DAS)(g)		47.47	133.87**	32.85
20. Average fruit weight (g)		457.38	2845.75**	776.63
21. Per cent deshaped fruit		36.57	1010.02**	35.67
22. Number of marketable fruit/vine		0.14	1.95**	0.13
23. Number of unmarketable fruit/vine		0.25	1.05**	0.15
24. Total number of fruit/vine		0.46	1.31**	0.34
25. Marketable fruit yield/vine (kg)		0.0001	0.13**	0.01
26. Unmarketable fruit yield/vine (kg)		0.01	0.04**	0.01
27. Total fruit yield/vine (kg)		0.01	0.10**	0.01

**Significant at P=0.01 per cent

NS=Non-significant

as per cent of mean or genetic gain (GG) are presented in Table 4.

From Table 4 it is clear that almost all the characters had a wide range. Per cent deshaped fruit had the maximum variability (19.0-70.0%), followed by total number of fruit per vine (2.5-4.2), fruit yield (0.5-1.2 kg), number of marketable fruit per vine (0.8-3.3), number of unmarketable fruit per vine (0.8-2.6), fruit size (51.4-95.7 sq.cm) and vine length (0.8-1.5 m). This was coupled with a high coefficient of variability for all characters with an exception of days to first flowering, days to first harvest and rind toughness. The range and CV (%) values thus indicated high variability amenable for pressure on selection for these characters.

PCV and GCV estimates clearly indicate that PCV values were high for all the characters observed than the GCV values indicating a strong environmental influence. Marketable fruit yield per vine had the highest GCV (47.71) followed by per cent deshaped fruit (40.60), number of marketable fruit per vine (40.26), number of unmarketable fruit per vine (36.93) and unmarketable fruit yield per vine (34.67). Days to first harvest (3.74), flesh thickness (4.57), days to first flowering

Table 4. Phenotypic variability, estimates of variance, coefficients of variation, heritability in broad sense (H%), genetic advance (GA) and GA as per cent of mean or genetic gain (GG) for 27 characters in cucumber

Character	General mean ± SE	Range	CV (%)	Variances		Coefficient of variation		H (%)	GA	GG
				Phenotypic	Genotypic	Pheno typic	Geno typic			
Node of first female flower emergence	3.5 ± 0.3	2.7 - 4.3	14.3	0.42	0.17	18.34	11.54	39.6	0.53	15.1
Days to first flowering	41.9 ± 0.6	40.0 - 46.3	2.5	7.17	6.07	6.40	5.88	84.7	4.67	11.1
Days to first harvest	57.8 ± 1.38	56.0 - 59.3	3.8	9.51	4.67	5.33	3.74	49.1	3.12	5.4
Vine length (m)	1.2 ± 0.1	0.8 - 1.5	14.7	0.04	0.02	18.26	10.90	35.61	0.16	13.3
No. of Nodes/vine	14.2 ± 1.0	9.7 - 18.7	12.6	6.79	3.56	18.32	13.27	52.5	2.82	19.9
Internodal length (cm)	8.3 ± 0.4	7.3 - 9.7	8.9	0.90	0.35	11.41	7.12	38.9	0.76	9.2
No. of branches/vine	2.2 ± 0.3	1.6 - 2.7	23.8	0.33	0.05	25.87	10.22	15.6	0.18	8.2
Specific leaf weight (g/cm ²)	5.1 ± 10.3	4.4 - 6.0	10.4	0.46	0.18	13.23	8.20	38.5	0.54	10.6
Specific leaf area (cm ² /g)	197.2 ± 11.0	175.9 - 231.1	9.7	619.45	254.89	12.62	8.09	41.1	21.10	10.7
Fruit size (cm ²)	74.9 ± 6.1	51.4 - 95.7	14.2	277.90	165.33	22.27	17.18	59.5	20.43	27.03
Fruit shape	3.0 ± 0.2	2.2 - 3.6	12.3	0.24	0.10	16.24	10.60	42.6	0.43	14.3
Cavity size (cm ²)	38.3 ± 3.9	22.5 - 52.7	17.7	85.90	39.77	24.14	16.43	46.3	8.84	23.1
Cavity shape	3.7 ± 0.3	2.7 - 4.3	13.0	0.49	0.26	18.96	13.71	52.3	0.76	20.5
Rind toughness (kg/cm ²)	10.1 ± 0.4	9.1 - 11.3	6.9	1.36	0.88	11.54	9.28	64.7	1.56	15.4
Flesh thickness (cm)	1.0 ± 0.1	0.8 - 1.2	16.0	0.03	0.002	16.63	4.57	7.5	0.03	3.0
Seed maturity at harvest (11 DAF)	1.4 ± 0.3	1.0 - 2.0	31.6	0.34	0.15	41.55	27.03	42.3	0.51	36.4
Seed maturity at harvest (16 DAF) *	3.1 ± 0.3	2.7 - 4.0	14.2	0.41	0.22	20.50	14.83	52.4	0.69	22.3
Fruit fresh weight loss at storage (g)	26.8 ± 3.1	12.0 - 48.3	20.2	107.26	78.42	33.90	33.27	73.1	15.60	58.2
Fruit fresh weight loss at storage **	16.9 ± 3.3	8.3 - 36.7	33.8	66.52	33.67	48.06	34.20	50.6	8.50	50.3
Average fruit weight (g)	211.2 ± 16.1	158.7 - 268.0	13.2	1466.34	689.71	18.13	12.43	47.0	37.10	17.6
Percent deshaped fruit	44.4 ± 3.3	19.0 - 70.0	13.5	360.45	324.78	42.77	40.60	90.1	35.24	79.4
No. of marketable fruit per vine	1.9 ± 0.2	0.8 - 3.3	18.6	0.74	0.61	44.36	40.26	82.4	1.46	76.8
No. of unmarketable fruit per vine	1.5 ± 0.2	0.8 - 2.6	26.4	0.45	0.30	45.41	36.93	66.2	0.92	61.3
Total No. of fruit per vine	3.4 ± 0.3	2.5 - 4.2	17.1	0.67	0.32	23.90	16.69	48.8	0.82	24.1
Marketable fruit yield per vine (kg)	0.4 ± 0.04	0.2 - 1.0	19.8	0.05	0.04	51.65	47.71	85.3	0.38	95.0
Unmarketable fruit yield per vine (kg)	0.3 ± 0.04	0.1 - 0.5	24.0	0.02	0.01	42.14	34.67	67.7	0.18	60.0
Total fruit yield per vine (kg)	0.7 ± 0.1	0.5 - 1.2	16.5	0.04	0.02	27.05	21.40	62.6	0.26	37.1

* 5 days after storage (DAS)

** 10 DAS

(5.88), internodal length (7.12) and rind toughness (9.28) had low GCV values.

Broad sense heritability was found to be high for characters per cent deshaped fruit (90.10), fruit yield per vine (85.3), days to first flowering (84.7), number of marketable fruit per vine (82.4), fruit fresh weight loss at storage (73.1), unmarketable fruit yield per vine (67.7) and number of unmarketable fruit per vine (66.2). While it was low for flesh thickness (7.6) and number of branches per vine (15.6).

Genetic gain, genetic advance as per cent of mean was found to be high for characters marketable fruit yield per vine (95.0), followed by per cent deshaped fruit (79.4), number of marketable fruit per vine (76.8), number of unmarketable fruit per vine (61.3) and unmarketable fruit yield per vine (60.0). For rest of the characters the genetic gain values were low.

Marketable fruit yield, unmarketable fruit yield, per cent deshaped fruit, number of marketable fruit, number of unmarketable fruit per vine and fruit fresh weight loss at storage (5 DAS) had high heritability and genetic gain.

Total fruit yield per vine, seed maturity at harvest (11 DAF) and fruit size had moderate genetic gain

and high heritability value. Days to first flowering, days to first harvest and rind toughness had low genetic gain and high heritability value. Vine length, fruit shape, cavity size, cavity shape and average fruit weight had low genetic gain and moderately high heritability. Flesh thickness had very low heritability and genetic gain.

4.1.3. Correlation of characters

Correlations at phenotypic, genotypic and environmental levels were computed for all the 27 characters. The results are presented in Table 5, 6 and 7 respectively.

Total number of fruit per vine had positive and significant correlation genotypically with rind toughness, number of marketable fruit per vine while phenotypically with number of marketable fruit per vine only. It also had strong positive environmental correlation with number of fruit per vine (both marketable and unmarketable) individually.

Total number of fruit per vine had a significant negative correlation with days to first harvest, internodal length, specific leaf weight, cavity size,

Table 5. Phenotypic correlation coefficients among 27 characters in cucumber

Sl. No.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1.	-0.07	-0.23	-0.21	-0.24	0.02	-0.11	-0.08	0.01	-0.02	0.05	-0.08	-0.02	-0.09	0.10	-0.05	-0.03	-0.10	-0.10	-0.09	0.13	-0.03	0.19	0.12	-0.16	0.09	-0.12
2.		0.33	0.43	0.33	0.13	-0.07	-0.06	0.14	-0.01	-0.01	-0.00	0.05	-0.15	-0.31	-0.01	-0.00	0.04	0.15	0.42*	-0.13	-0.05	-0.21	-0.22	-0.04	-0.16	-0.06
3.			0.09	0.04	0.09	-0.05	0.03	-0.01	0.16	0.03	0.15	0.10	-0.37	-0.33	-0.09	-0.09	0.31	0.22	0.42	-0.08	-0.11	-0.22	-0.29	-0.09	-0.17	-0.21
4.				0.81*	0.29	0.13	-0.12	0.03	0.02	0.10	-0.01	-0.13	0.00	-0.14	0.00	-0.09	-0.01	0.15	0.49	-0.26	0.26	-0.20	0.11	0.41	-0.02	0.44*
5.					-0.33	0.15	-0.33	-0.03	-0.11	-0.01	-0.16	-0.02	-0.11	-0.19	0.16	0.03	-0.22	-0.03	0.26	-0.54	0.56	-0.34	0.30	0.61	-0.26	0.51
6.						0.00	0.43*	-0.05	-0.10	-0.18	0.18	-0.12	-0.17	-0.01	-0.27	-0.39	0.45*	0.35	0.35	0.47*	-0.48*	0.27	-0.29	-0.34	0.41	-0.11
7.							0.04	-0.16	0.02	0.03	0.03	0.01	0.05	-0.13	-0.13	-0.03	-0.06	0.05	-0.07	0.06	0.03	0.09	0.12	0.01	0.14	
8.								0.00	-0.06	-0.04	0.06	-0.06	-0.19	0.07	0.09	-0.07	0.29	0.11	0.07	0.25	-0.33	0.15	-0.23	-0.17	0.15	-0.08
9.									0.01	0.24	0.03	0.27	-0.07	0.08	-0.02	0.06	0.19	0.11	0.00	-0.04	-0.04	-0.15	0.16	-0.03	-0.23	-0.19
10.										0.24	0.78*	0.47*	0.13	0.13	0.05	-0.34	-0.01	-0.03	0.20	-0.12	0.01	-0.21	-0.17	0.00	-0.22	-0.14
11.											0.24	0.72*	0.24	0.20	-0.10	-0.04	-0.10	-0.09	-0.01	-0.26	0.11	-0.19	-0.04	0.00	-0.33	-0.22
12.												0.37	0.10	0.11	-0.06	-0.36	0.07	0.04	0.20	0.06	0.21	-0.11	-0.31	-0.22	-0.01	-0.31
13.													0.22	0.15	-0.11	-0.10	0.08	0.02	0.09	-0.30	0.07	-0.30	-0.17	0.40	-0.39	-0.20
14.														0.12	0.21	-0.03	-0.18	-0.21	-0.16	-0.11	0.19	0.13	0.30	0.10	0.01	0.11
15.															0.11	-0.01	-0.22	-0.12	-0.12	0.00	-0.04	-0.10	-0.12	-0.06	-0.10	-0.12
16.																0.23	-0.42*	-0.34	-0.20	-0.13	0.21	0.03	0.18	0.18	-0.17	0.07
17.																	-0.27	-0.23	-0.18	-0.17	0.17	-0.14	0.06	0.15	-0.11	-0.09
18.																		0.59*	0.26	0.35	-0.45*	0.17	-0.33	-0.34	0.27	-0.19
19.																			0.44*	0.42*	-0.40	0.32	-0.16	-0.23	0.49	0.03
20.																				-0.14	-0.01	-0.27	-0.29	0.16	-0.01	0.17
21.																				-0.86*	0.79*	-0.25	-0.84*	0.81*	-0.40	
22.																					-0.45*	0.68*	0.88*	-0.53*	0.82*	
23.																										
24.																										
25.																										
26.																										
27.																										

1. Node of first female flower emergence
2. Days to first flowering
3. Days to first harvest
4. Vine length
5. Number of nodes/vine
6. Internodal length
7. Number of branches/vine
8. Specific leaf weight
9. Specific leaf area
10. Fruit size
11. Fruit shape
12. Cavity size
13. Cavity shape
14. Rind toughness
15. Flesh thickness
16. Seed maturity at harvest (11 DAF)
17. Seed maturity at harvest (16 DAF)
18. Fruit fresh weight loss at storage (5 DAS)
19. Fruit fresh weight loss at storage (10 DAS)
20. Average fruit weight
21. Per cent deformed fruits
22. No. of mark. fruit/vine
23. No. of unmark. fruit/vine
24. Total no. of fruit/vine
25. Mark. fruit yield/vine
26. Unmark. fruit yield/vine
27. Total fruit yield/vine

*, ** Significant at $P = 0.05$ and 0.01 respectively

Table 6. Genotypic correlation coefficients among 27 characters in cucumber

Sl. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1.																										
2.	-0.21																									
3.	-0.39	0.54**																								
4.	-0.25	0.73**	0.21																							
5.	-0.37	0.46*	-0.05	0.85**																						
6.	-0.05	0.29	0.44	0.06	-0.48*																					
7.	-0.48	-0.24	-0.00	0.11	0.27	-0.27																				
8.	-0.03	-0.06	-0.07	-0.06	-0.45*	0.78**	0.28*																			
9.	-0.08	0.11	-0.05	0.18	0.02	0.26	-0.68**	-0.05																		
10.	-0.12	0.01	0.19	-0.13	-0.25	0.20	0.09	-0.32*	0.02																	
11.	-0.08	-0.01	-0.08	-0.23	-0.06	-0.28	-0.39	-0.14	0.11	0.47*																
12.	-0.08	-0.09	0.09	-0.27	-0.40	0.29	-0.20	-0.18	-0.12	0.95**	0.40*															
13.	-0.23	-0.04	0.56	-0.06	0.14	-0.17	-0.21	-0.34	0.17	0.63**	0.95**	0.62*														
14.	-0.02	-0.25	-0.75**	0.05	0.18	-0.31	-0.22	-0.33	0.01	0.25	0.34	0.31	0.37													
15.	0.45	-1.04	-0.81	-0.32	-0.23	0.03	1.27**	0.54	0.06	0.82	0.83	0.84	0.46	0.55**												
16.	-0.09	-0.04	-0.33	0.15	0.25	-0.29	0.24	-0.23	0.11	0.33	-0.04	0.25	-0.05	0.13	1.23*											
17.	0.14	-0.14	-0.11	0.39	0.60**	-0.57**	0.52**	-0.48*	-0.02	-0.61**	-0.07	-0.60**	-0.21	-0.10	0.36	0.16										
18.	-0.06	0.10	0.47*	0.04	-0.29	0.84**	-0.03	0.41	0.14	-0.07	-0.22	-0.07	0.03	-0.21	-0.88*	-0.67**	-0.37									
19.	-0.23	0.18	0.37	0.12	-0.22	-0.73**	0.66**	0.54**	0.03	-0.20	-0.20	-0.15	-0.08	-0.27	-0.82*	-0.52*	-0.21	0.94**								
20.	-0.46*	0.59**	0.70*	0.76**	0.41	0.43*	0.51*	0.11	-0.16	0.26	0.08	0.31	-0.30	-0.40*	-0.60	-0.52*	-0.22	0.54**	0.57**							
21.	0.33	-0.13	-0.12	-0.45*	-0.80**	0.74**	-0.09	0.51*	0.07	-0.14	-0.24	0.13	-0.37	-0.11	0.10	-0.26	-0.23	0.44*	0.54**	-0.14						
22.	-0.22	-0.07	-0.09	0.39	0.74**	-0.85**	0.13	-0.57*	-0.14	0.06	0.14	-0.27	0.15	0.26	0.03	0.34	0.30	-0.56*	-0.61**	-0.09	-0.94**					
23.	0.38	-0.27	-0.39	-0.49	-0.69*	0.46*	0.03	0.35	-0.15	-0.25	-0.10	-0.05	-0.43*	0.24	0.20	-0.24	-0.18	0.23	0.44*	-0.35	0.88**	-0.68**				
24.	0.07	-0.35	-0.49*	0.00	0.35	-0.72**	0.22	-0.44	-0.34	-0.15	0.10	-0.42*	-0.20	0.58**	0.24	0.24	0.23	-0.54**	-0.41	-0.45	0.71**	0.63				
25.	-0.34	0.04	-0.08	0.55*	0.82*	-0.63**	0.38	-0.31	-0.08	0.00	-0.02	-0.36	-0.08	0.12	0.04	0.32	0.21	0.42	-0.43*	0.13	-0.90**	0.93**	-0.72**	0.59**		
26.	0.31	-0.17	-0.22	-0.19	-0.50*	0.59**	0.35	0.43	-0.14	-0.27	-0.27	-0.10	-0.46*	0.06	0.07	-0.37	-0.12	0.37	0.54**	-0.00	0.87**	-0.73*	0.94*	-0.10	-0.65**	
27.	-0.20	-0.06	-0.26	0.60*	0.74**	-0.42*	0.78**	-0.13	-0.22	-0.20	-0.19	-0.54**	-0.19	0.20	-0.13	0.13	0.20	-0.28	-0.18	0.19	-0.57**	0.71*	-0.30	0.68*	0.85**	-0.16

*, ** significant at P = 0.05 and P = 0.01 respectively

Table 7. Environmental correlation coefficients among 27 characters in cucumber

Sl. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1.																										
2. 0.18																										
3. -0.14 -0.07																										
4. 0.24 -0.01 0.11																										
5. -0.13 0.09 0.09 0.73 ^{***}																										
6. 0.01 -0.13 -0.18 0.37 -0.20																										
7. 0.01 0.04 -0.07 0.20 0.11 0.10																										
8. -0.14 -0.09 0.11 -0.18 -0.23 0.22 -0.03																										
9. 0.12 0.07 -0.04 0.24 0.36 -0.24 0.04																										
10. 0.08 -0.04 0.13 0.08 0.07 0.01 0.02																										
11. 0.03 0.03 0.12 -0.004 0.04 -0.11 0.19																										
12. -0.08 -0.20 0.20 0.23 0.07 0.11 0.13																										
13. 0.16 0.08 0.16 -0.32 -0.18 -0.09 0.12																										
14. -0.16 0.14 0.09 0.11 0.02 -0.03 -0.06																										
15. 0.03 -0.12 -0.25 -0.12 -0.21 -0.02 -0.87																										
16. -0.03 0.04 0.10 -0.11 0.08 -0.25 -0.28																										
17. -0.17 0.35 -0.07 -0.21 0.03 -0.25 -0.28																										
18. -0.18 -0.18 0.08 -0.08 -0.11 0.01 0.14																										
19. -0.003 0.11 0.08 0.18 0.17 0.05 -0.21																										
20. 0.19 0.17 0.17 0.26 0.12 0.25 -0.30																										
21. -0.27 -0.15 0.02 0.09 0.03 0.12 -0.13																										
22. 0.28 0.06 -0.18 0.09 0.25 -0.01 0.04																										
23. -0.02 -0.03 0.01 0.11 0.16 0.08 0.03																										
24. 0.16 0.02 -0.10 0.13 0.26 0.05 0.04																										
25. 0.11 0.05 -0.13 0.19 0.23 0.09 -0.07																										
26. -0.16 -0.12 -0.11 0.16 0.08 0.24 -0.20																										
27. -0.04 -0.09 -0.15 0.81 0.20 0.19 -0.19																										

*, ** significant at $P = 0.05$ and $P = 0.01$ respectively.

1. Node of first female flower emergence
 2. Days to first flowering
 3. Days to first harvest
 4. Vine length
 5. Number of nodes/vine
 6. Internodal length
 7. Number of branches/vine
 8. Specific leaf weight
 9. Specific leaf area
 10. Fruit size
 11. Fruit shape
 12. Cavity shape
 13. Cavity shape
 14. Rind toughness
 15. Flesh thickness
 16. Seed maturity at harvest (11 DAF)
 17. Seed maturity at harvest (16 DAF)
 18. Fruit fresh weight loss at storage (5 DAS)
 19. Fruit fresh weight loss at storage (10 DAS)
 20. Average fruit weight
 21. Per cent deshedded fruits
 22. No. of mark. fruit/vine
 23. No. of unmark. fruit/vine
 24. Total no. of fruit/vine
 25. Mark. fruit yield/vine
 26. Unmark. fruit yield/vine
 27. Total fruit yield/vine

fruit fresh weight loss at storage (5 DAS), per cent deshaped fruits and average fruit weight at genotypic level.

Total fruit yield per vine was positively correlated at genotypic level significantly with vine length, number of nodes per vine, number of branches per vine, number of marketable fruit per vine, total number of fruit per vine and marketable fruit yield per vine whereas, it was negatively correlated with internodal length, cavity size and per cent deshaped fruit.

Number of marketable fruit per vine was positively correlated with total number of fruit per vine, marketable fruit yield per vine and total fruit yield per vine phenotypically and number of nodes per vine genotypically, whereas, negatively correlated with internodal length, specific leaf weight, fruit fresh weight loss at storage average fruit weight and per cent deshaped fruit at genotypic level and with number of unmarketable fruit per vine and unmarketable fruit yield per vine phenotypically. Environmental correlation was significantly positive with total number of fruit per vine, marketable and unmarketable fruit yield per vine.

Marketable fruit yield per vine was positively correlated at genotypic level with vine length, number of

node per vine, number of marketable fruit per vine and total number of fruit per vine and in negative direction with internodal length, fruit fresh weight loss at storage, per cent deshaped fruit and unmarketable fruit per vine. At phenotypic level, significant positive correlation was observed with total fruit yield per vine, but negative correlation with unmarketable fruit yield per vine.

Per cent deshaped fruit was positively correlated genotypically with internodal length, specific leaf weight, fruit fresh weight loss at storage and unmarketable fruit yield per vine and phenotypically with internodal length, fruit fresh weight loss at storage, number of unmarketable fruit per vine and unmarketable fruit yield per vine. It had negative correlation with vine length, number of nodes per vine, number of marketable and unmarketable fruit per vine, total number of fruit per vine and marketable yield per vine genotypically and with number of nodes per vine, number of marketable fruit and marketable fruit yield per vine phenotypically. It had negative environmental correlation with fruit shape.

Average fruit weight had positive correlations with days to first flowering, vine length, fresh fruit weight loss at storage both at phenotypic and genotypic

levels. At genotypic level, it was positively correlated with days to first harvest, internodal length and number of branches per vine.

Vine length had positive genotypic and phenotypic correlation with number of nodes per vine, average fruit weight and total fruit yield. It had positive correlation with marketable fruit yield per vine and negative correlation with flesh thickness, per cent deshaped fruit and number of unmarketable fruit per vine at genotypic level.

Number of branches per vine was negatively correlated with specific leaf area while positively with flesh thickness, seed maturity at harvest (16 DAF), fresh fruit weight loss at storage, average fruit weight and total fruit yield per vine at genotypic level.

Node at which first female flower emerged had negative and significant genotypic correlation with number of branches per vine, flesh thickness and average fruit weight.

Days to first harvest was positively correlated with days to first flowering, internodal length, cavity shape index, fruit fresh weight loss at storage and

average fruit weight, while negatively with rind toughness, flesh thickness and total fruit yield per vine at genotypic level.

Fruit size had positive genotypic, phenotypic and environmental correlation with cavity size, positive genotypic correlation with fruit shape and flesh thickness and positive phenotypic correlation with cavity shape. It was negatively correlated genotypically with seed maturity at harvest and cavity shape.

Cavity size had significantly negative genotypic correlation with total number of fruit per vine, total fruit yield per vine and seed maturity at harvest (16 DAF). It had positive correlation with fruit size at genotypic, phenotypic and environmental level and positive genotypic correlation with cavity shape and flesh thickness.

Seed maturity at harvest (11 DAF) was negatively correlated both at genotypic and phenotypic level with fruit fresh weight loss at storage positively correlated with flesh thickness and negatively correlated with average fruit weight at genotypic level.

Environmental correlations were found almost non-significant excepting for very few characters. Thus

the role of environment at the expression is found to be very meagre.

4.1.4. Coheritability of characters

Coheritability among the 27 characters were computed and the results are presented in Table 8.

Total number of fruit per vine had high coheritability and positive genotypic correlation with rind toughness, number of marketable fruit per plant, marketable fruit yield per vine and total fruit yield per vine, while negative genotypic correlation and coheritability with internodal length, specific leaf weight, fruit fresh weight loss at storage (5 DAS), average fruit weight and per cent deshaped fruit.

Total fruit yield per vine had high coheritability and positive genotypic correlation with number of nodes per vine, number of branches per vine, number of marketable fruit per vine, total number of fruit per vine and marketable fruit yield per vine, while it had negative genotypic correlation and high coheritability with internodal length, cavity size and per cent deshaped fruit.

Number of marketable fruit per vine had high coheritability value and positive genotypic correlation

Table 8. Coheritability (%) estimates among 27 characters in cucumber

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1.	182.7	66.9	46.9	70.6	89.7	104.2	-134.1	-60.7	33.2	62.6	43.8	65.9	32.2	78.0	70.4	-34.7	30.4	98.5	216.8	130.9	306.4	104.7	254.0	120.6	183.6	65.3	
2.	108.2	101.5	92.9	130.8	92.9	121.9	121.9	-478.2	-100.8	-260.8	54.1	124.2	124.2	85.4	234.9	11341.4	193.8	79.7	88.3	85.7	120.3	97.2	102.2	-82.2	-82.4	66.5	
3.	100.2	100.2	100.2	100.2	100.2	100.2	100.2	64.2	-109.8	28.9	24.8	113.1	113.1	46.1	161.7	62.0	90.6	82.8	79.0	108.8	51.5	102.1	82.2	94.4	74.8	69.3	
4.	49.4	49.4	49.4	49.4	49.4	49.4	49.4	20.0	-271.1	285.4	97.0	1174.9	-30.2	975.7	41.4	-1543.9	197.0	174.1	34.9	68.4	107.1	77.3	127.7	1.34	81.3	479.2	69.8
5.	61.8	61.8	61.8	61.8	61.8	61.8	61.8	273.7	129.9	429.6	228.4	-484.1	90.6	24.9	78.4	95.8	82.0	389.8	77.8	101.1	87.1	119.1	57.6	90.3	112.4	83.4	88
6.	-1490.1	69.1	64.0	64.7	64.7	64.7	64.7	94.1	62.7	65.4	62.4	89.1	-72.0	44.4	65.6	94.3	94.3	92.7	59.4	93.9	99.3	85.8	109.8	108.2	74.0	182.5	82.5
7.	134.7	111.0	165.9	-301.9	-154.7	-309.1	134.6	102.3	-46.8	-310.0	-15.1	204.5	-304.9	46.8	77.7	40.0	67.6	119.8	1283.2	178.3	46.8	77.7	40.0	67.6	119.8	1283.2	178.3
8.	2410.3	273.7	131.7	-116.2	232.3	84.9	127.0	-101.2	301.3	74.6	222.3	67.8	119.1	94.8	120.3	84.1	103.4	143.5	74.1	119.1	94.8	120.3	84.1	103.4	143.5	74.1	
9.	109.9	19.1	143.0	30.0	-11.0	12.7	-26.0	-14.3	39.6	13.6	-4118.1	13.6	-4118.1	-94.1	231.7	50.1	91.7	169.4	31.5	56.9	-94.1	231.7	50.1	91.7	169.4	31.5	56.9
10.	98.2	69.1	76.1	120.8	136.0	136.0	330.6	101.4	390.7	329.8	68.4	98.1	-234.5	99.0	78.1	26.9	-105.4	-337.2	44.9	46.1	80.9	680.6	72.0	47.7	-4481.8	70.0	86.4
11.	71.9	62.2	83.4	71.1	75.8	14.9	82.8	120.4	98.1	-182.0	73.6	136.4	78.8	27.2	62.8	101.0	61.5	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4	94.4
12.	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7	143.7
13.	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6	97.6
14.	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0	102.0
15.	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2	194.2
16.	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5	70.5
17.	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5
18.	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0
19.	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7
20.	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5	84.5
21.	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1	111.1
22.	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2
23.	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1
24.	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4	81.4
25.	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3	108.3
26.	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5	77.5
27.	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0	-66.0

1. Node of first female flower emergence
2. Days to first flowering
3. Days to first harvest
4. Vine length
5. Number of nodes/vine
6. Internodal length
7. Number of branches/vine
8. Specific leaf weight
9. Specific leaf area
10. Fruit size
11. Fruit shape
12. Cavity size
13. Cavity shape
14. Rim toughness
15. Flesh thickness
16. Seed maturity at harvest (10 DAS)
17. Seed maturity at harvest (15 DAS)
18. Fruit fresh weight loss at storage (5 DAS)
19. Fruit fresh weight loss at storage (10 DAS)
20. Average fruit weight
21. Per cent deshaped fruits
22. No. of mark. fruit/vine
23. No. of unmark. fruit/vine
24. Total no. of fruit/vine
25. Mark. fruit yield/vine
26. Unmark. fruit yield/vine
27. Total fruit yield/vine

* Indicates where genotypic correlation coefficient was significant and negative
** Indicates where genotypic correlation coefficient was significant and positive

with number of nodes per vine, total number of fruit per vine and marketable fruit yield per vine, whereas, it had negative genotypic correlation with specific leaf weight, fruit fresh weight loss at storage and per cent deshaped fruits. However, node at which first female flower emerged had the highest coheritability value.

Per cent deshaped fruit had high coheritability and positive genotypic correlation with internodal length, specific leaf weight, fruit fresh weight loss at storage (10 DAS) and unmarketable fruit yield per vine, while, vine length, number of nodes per vine, fruit fresh weight loss at storage (5 DAS) and total number of fruit per vine had negative genotypic correlation.

Vine length had high coheritability and positive genotypic correlation with number of nodes per vine and average fruit weight, while negative genotypic correlation with per cent deshaped fruit and number of unmarketable fruit per vine, vine length and cavity size had high positive coheritability, while vine length and seed maturity at harvest (11 DAF) had the highest negative coheritability.

Days to first harvest had high coheritability and positive genotypic correlation with internodal length,

cavity shape and average fruit weight, whereas, negative genotypic correlation with rind toughness, flesh thickness and number of unmarketable fruit per vine.

Node at which first female flower emerged had high coheritability and negative genotypic correlation with number of branches per vine and average fruit weight while positively with flesh thickness.

Seed maturity at harvest had high coheritability and positive genotypic correlation with number of nodes per vine, number of branches per vine and flesh thickness, while negatively with fruit size, cavity size, fruit fresh weight loss at storage and average fruit weight.

Fruit size had high coheritability and positive genotypic correlation with fruit shape, cavity size, cavity shape and flesh thickness, while negatively with seed maturity at harvest.

4.2. DIALLEL ANALYSIS

4.2.1. Analysis of variance (ANOVA)

The analysis of variance for the randomised block design was carried out for the observations recorded on all the yield and yield components in both the seasons.

The results of this analysis of variance for both the seasons are presented in Table 9 and the mean values are presented in Appendices II and III. The differences among the 45 treatments (including 36 hybrids and 9 parents) were highly significant for most of the characters. In the first season, characters like number of branches per vine, specific leaf weight, specific leaf area, and marketable yield per vine were found to be non-significant. In the second season, characters like internodal length, number of branches per vine and fruit shape were non-significant.

4.2.2. ANOVA for combining ability

Anova for combining ability was carried out for all the yield and yield components, and the fruit characteristics in both the seasons. The results of this analysis of variance are presented in Table 10.

The variance was partitioned into GCA variance and SCA variance. The ratio of GCA variance to SCA variance was worked out and results pertaining to these are presented in Table 11.

In the first season, GCA was significant for all the characters except for number of branches per vine,

Table 9. Analysis of variance for 27 characters in 9x9 diallel crosses of cucumber for two seasons (S1 and S2)

Characters	df	Block 2		Treatment 44		Error 88	
		S1	S2	S1	S2	S1	S2
1. Node of first female flower emergence		0.62	0.14	0.49**	0.68**	0.20	0.39
2. Days to first flowering		7.83**	48.15**	11.87**	6.74**	0.84	4.46
3. Days to first harvest		2.23*	26.59**	10.20**	9.35**	0.69	2.76
4. Vine length (m)		0.01	0.65**	0.10**	0.10**	0.04	0.05
5. Number of nodes/vine		28.81**	47.75**	15.77**	20.66**	5.20	8.35
6. Internodal length (cm)		6.15**	2.67*	1.83**	0.86	0.72	0.81
7. Number of branches/vine		0.36	3.92**	0.22	0.29	0.25	0.24
8. Specific leaf weight (g/cm ²)		1.38	5.69**	0.72	1.65**	0.60	0.32
9. Specific leaf area (cm ² /g)		1916.00	6386.50**	1084.18	3835.51**	818.39	555.68
10. Fruit size (cm ²)		239.63	2905.94**	1117.92**	526.64**	286.60	343.86
11. Fruit shape		0.10	0.20	0.30**	0.13	0.10	0.11
12. Cavity size (cm ²)		28.23	595.80**	163.60**	192.20**	84.74	98.46
13. Cavity shape		0.20	0.90	0.92**	0.48**	0.26	0.30
14. Rind toughness (kg/cm ²)		1.82**	0.13	1.60**	2.11**	0.40	0.23
15. Flesh thickness (cm)		0.04	0.02	0.11**	0.05**	0.03	0.03
16. Seed maturity at harvest (11 DAF)		0.01	0.45	0.88**	1.13**	0.23	0.27
17. Seed maturity at harvest (16 DAF)		0.81*	0.02	1.97**	2.11**	0.18	0.25
18. Fruit fresh weight loss at storage (5 DAS)(g)		259.82**	70.07	433.08**	279.79**	46.01	27.98
19. Fruit fresh weight loss at storage (10 DAS)(g)		320.75**	160.00	659.68**	759.77**	57.41	56.92
20. Average fruit weight (g)		24693.50**	95173.00**	13431.60**	6342.23**	4493.10	4377.75
21. Per cent deshaped fruit		64.16	44.67	549.79**	253.25**	38.18	34.46
22. Number of marketable fruit/vine		0.06	0.21	1.29**	0.44**	0.18	0.11
23. Number of unmarketable fruit/vine		0.96	0.11	0.86**	0.45**	0.09	0.08
24. Total number of fruit/vine		0.11	0.14	1.90**	1.01**	0.29	0.21
25. Marketable fruit yield/vine (kg)		0.02	0.05**	0.10	0.04**	0.13	0.01
26. Unmarketable fruit yield/vine (kg)		0.01	0.01	0.05**	0.04**	0.004	0.01
27. Total fruit yield/vine (kg)		0.03	0.09	0.14**	0.10**	0.02	0.03

S1=First season

S2=Second season

*Significant at P=0.05 per cent

**Significant at P=0.01 per cent

Table 10. Analysis of variance for combining ability for 27 characters in 9x9 diallel crosses of cucumber for two seasons (S1 and S2)

Characters	df	gca		sca		Error	
		S1	S2	S1	S2	S1	S2
1. Node of first female flower emergence		0.40**	0.31*	0.11**	0.21**	0.07	0.13
2. Days to first flowering		1.12*	2.19	4.58**	2.26**	0.28	1.45
3. Days to first harvest		1.58**	4.02**	3.81**	2.92**	0.23	0.92
4. Vine length (m)		0.05**	0.04	0.03**	0.03**	0.01	0.02
5. Number of nodes/vine		12.08**	12.69**	3.74**	5.59**	1.73	2.73
6. Internodal length (cm)		1.14**	0.25	0.49**	0.29	0.24	0.27
7. Number of branches/vine		0.09	0.05	0.07	0.11*	0.08	0.08
8. Specific leaf weight (g/cm ²)		0.11	0.33**	0.27*	0.60**	0.20	0.11
9. Specific leaf area (cm ² /g)		256.73	743.36**	384.64*	1397.40**	272.80	185.23
10. Fruit size (cm ²)		368.61**	330.01**	373.56**	141.22	95.53	114.62
11. Fruit shape		0.22**	0.07	0.07**	0.04	0.03	0.04
12. Cavity size (cm ²)		47.53	161.60**	56.08**	42.39	28.25	32.83
13. Cavity shape		0.56**	0.33**	0.25**	0.12	0.09	0.10
14. Rind toughness (kg/cm ²)		1.39**	1.48**	0.34**	0.56**	0.13	0.08
15. Flesh thickness (cm)		0.06**	0.03**	0.03**	0.01	0.01	0.10
16. Seed maturity at harvest (11 DAF)		0.23**	0.45**	0.31**	0.36**	0.08	0.09
17. Seed maturity at harvest (16 DAF)		1.27**	2.24**	0.52**	0.36**	0.06	0.08
18. Fruit fresh weight loss at storage (5 DAS)(g)		181.58**	86.60**	136.09**	94.74**	15.47	9.33
19. Fruit fresh weight loss at storage (10 DAS)(g)		235.91**	279.95**	216.33**	247.32**	19.14	28.97
20. Average fruit weight (g)		9924.64**	7661.72**	3266.63**	881.28	1497.71	1459.25
21. Per cent deshaped fruit		333.20**	185.62	149.95**	61.92**	12.73	11.49
22. Number of marketable fruit/vine		0.57**	0.17**	0.40**	0.14**	0.06	0.04
23. Number of unmarketable fruit/vine		0.65**	0.28**	0.21**	0.12**	0.03	0.03
24. Total number of fruit/vine		0.88**	0.38**	0.58**	0.33**	0.10	0.07
25. Marketable fruit yield/vine (kg)		0.02**	0.02**	0.03**	0.01**	0.004	0.004
26. Unmarketable fruit yield/vine (kg)		0.03**	0.22**	0.01**	0.01**	0.001	0.003
27. Total fruit yield/vine (kg)		0.03**	0.05**	0.05**	0.03**	0.01	0.01

*Significant at P=0.05 per cent

**Significant at P=0.01 per cent

S1=First season

S2=Second season

Table 11. Components of variation for 27 characters in 9x9 diallel crosses of cucumber

Characters	σ_g^2		σ_S^2		σ_g^2 / σ_S^2		σ_A^2		σ_D^2	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Node of first female flower emergence	0.03	0.01	0.04	0.08	0.75	0.13	0.06	0.02	0.04	0.08
Days to first flowering	-0.31	-0.01	4.30	0.81	-0.07	-0.01	-0.62	-0.02	4.30	0.81
Days to first harvest	-0.20	0.10	3.58	2.00	-0.06	0.05	-0.40	0.20	3.58	2.00
Vine length	0.002	0.001	0.02	0.01	0.10	0.10	0.004	0.002	0.02	0.01
No. of Nodes/vine	0.76	0.65	2.01	2.86	0.38	0.23	1.52	1.30	2.01	2.86
Internodal length	0.06	-0.004	0.25	0.02	0.24	-0.20	0.12	-0.008	0.25	0.02
No. of branches/vine	0.002	-0.005	-0.01	0.03	-0.20	-0.17	0.004	-0.010	-0.01	0.03
Specific leaf weight	-0.015	-0.025	0.07	0.49	0.21	0.05	0.03	0.05	0.07	0.49
Specific leaf area	-11.63	-59.46	111.84	1212.17	0.10	-0.05	23.26	-118.92	-111.84	1212.17
Fruit size	-0.45	17.16	278.01	26.60	-0.002	0.65	-0.90	34.32	278.01	26.60
Fruit shape	0.01	0.003	0.04	0.00	0.25	0.00	0.02	0.006	0.04	0.00
Cavity size	-0.78	10.84	27.83	9.57	0.03	1.13	1.56	21.68	27.83	9.57
Cavity shape	0.03	0.02	0.16	0.02	0.19	1.00	0.06	0.04	0.16	0.02
Rind toughness	0.09	0.08	0.21	0.48	0.43	0.17	0.18	0.16	0.21	0.48
Flesh thickness	0.003	0.002	0.02	-0.09	0.15	-0.02	0.009	0.004	0.02	-0.09
Seed maturity at harvest	-0.007	0.008	0.23	5.27	0.03	0.03	0.01	0.02	0.23	0.27
Seed maturity at harvest	0.07	0.17	0.46	0.28	0.15	0.61	0.14	0.34	0.46	0.28
Fruit fresh weight loss at storage	4.14	-0.74	120.62	85.41	0.03	-0.01	8.28	-1.48	120.62	85.41
Fruit fresh weight loss at storage	1.78	2.97	197.19	228.35	0.01	0.01	3.56	5.94	197.69	228.77
Average fruit weight	605.27	616.40	1768.92	-577.97	0.34	-1.07	1210.54	1232.80	1768.92	-577.97
Percent deshaped fruit	16.66	11.25	137.22	50.43	0.12	0.22	33.32	22.50	137.22	50.43
No. of marketable fruit per vine	0.02	0.003	0.34	0.10	0.06	0.03	0.04	0.006	0.34	0.10
No. of unmarketable fruit per vine	0.04	0.02	0.18	0.09	0.22	0.22	0.08	0.04	0.18	0.09
Total No. of fruit per vine	0.03	0.005	0.48	0.26	0.06	0.02	0.06	0.010	0.48	0.26
Marketable fruit yield per vine	0.001	0.001	0.03	0.01	0.03	0.10	0.002	0.002	0.03	0.01
Unmarketable fruit yield per vine	0.002	0.001	0.01	0.01	0.20	0.10	0.004	0.002	0.01	0.01
Total fruit yield per vine	-0.002	0.002	0.04	0.02	-0.05	0.10	-0.004	0.004	0.04	0.02

specific leaf weight, specific leaf area and cavity size. SCA was significant for all the characters except for number of branches per vine.

In the second season GCA was significant for all the characters except for, days to flowering, internodal length, number of branches per vine, fruit shape and per cent deshaped fruit. SCA was significant for all characters except for internodal length, fruit size, fruit shape, cavity size, cavity shape, flesh thickness and average fruit weight.

The ratio of the GCA variance to the SCA variance in the first season did not exceed the value of one for any of the characters, thus, indicating the role of the non-additive gene effects. In the second season characters cavity size, cavity shape and average fruit weight had the GCA:SCA variance ratio was either one or slightly more than one indicating the role of both additive and non-additive gene effects.

4.2.3. General combining ability

The estimates of general (gca) and specific combining ability effects (sca) of the 9 parental lines for all the characters observed are presented in Table 12. The first season (S1) and second season (S2)

Table 12. Estimates of general combining ability affects (g_i) of 9 parents for 27 characters in cucumber

Parents	Node of first female flower emergence		Days to first flowering		Days to first harvest		Vine length (m)		No. of nodes/vine		Internodal length (cm)		No. of branches/vine		Rind toughness (kg/cm^2)		Flesh thickness (cm)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
1	-0.13	-0.18	-0.12	0.25	0.16	0.93**	0.05	0.03	-1.86**	-0.28	0.68**	0.18	0.17*	0.08	0.02	-0.16*	0.003	0.08**
2	0.14*	0.09	0.29*	-0.33	0.07	-0.92**	0.04	0.09**	0.38	0.79	0.16*	0.02	-0.01	-0.13	-0.25	-0.31**	-0.08**	-0.01
3	-0.04	0.003	-0.05	0.58	0.07	0.14	-0.05	-0.10*	0.11	-1.87**	-0.35*	0.03	-0.04	-0.04	-0.02	-0.03	0.08**	0.07*
4	-0.40**	-0.27**	0.01	0.03	-0.08	0.05	-0.05	-0.06*	-0.71	-1.21**	0.01	0.20	0.11	0.02	0.70**	0.53**	0.01	0.04
5	0.14*	-0.09	-0.71**	-0.39	-0.96**	-0.34	0.01	0.002	0.62	-0.31	-0.23	0.12	0.05	-0.04	0.54**	0.70**	0.11**	-0.01
6	0.14*	0.31**	0.47**	0.40	0.22	0.36	0.11**	-0.03	0.65	0.08	0.23	-0.23	-0.04	0.02	-0.07	-0.07	-0.04	-0.06*
7	0.17*	0.09	-0.08	0.46	0.04	0.60*	0.10	0.04	1.80**	1.28**	-0.20	-0.06	-0.04	0.05	-0.15	-0.24**	0.03	-0.06*
8	0.08	0.03	0.29*	-0.30	0.28*	-0.07	-0.07*	-0.05	-0.29	1.34**	-0.30*	-0.18	-0.04	-0.01	-0.35*	-0.21**	-0.12**	0.02
9	-0.10	0.003	-0.20	-0.69*	0.22	-0.76**	-0.04	-0.02	-0.71	0.18	0.02	-0.08	-0.13	0.08	-0.42**	-0.22**	0.03	-0.06*
SE (g_i)	0.07	0.10	0.15	0.34	0.13	0.27	0.03	0.04	0.37	0.47	0.14	0.15	0.08	0.08	0.16	0.08	0.03	0.03
CD(g_i) at 5%	0.14	0.20	0.29	0.67	0.25	0.53	0.06	0.08	0.73	0.92	0.27	0.29	0.16	0.16	0.31	0.16	0.06	0.06
CD(g_i) at 1%	0.18	0.26	0.39	0.88	0.33	0.70	0.08	0.10	0.95	1.21	0.36	0.39	0.21	0.21	0.41	0.21	0.08	0.08
SE(g_i-g_j)	0.11	0.15	0.33	0.51	0.20	0.40	0.05	0.05	0.56	0.70	0.21	0.22	0.12	0.12	0.23	0.12	0.04	0.04
CD(g_i-g_j) 5%	0.22	0.29	0.45	1.00	0.39	0.78	0.10	0.10	1.10	1.37	0.41	0.43	0.24	0.24	0.45	0.24	0.08	0.08
CD(g_i-g_j) 1%	0.28	0.39	0.59	1.31	0.52	1.03	0.13	0.13	1.44	1.80	0.54	0.57	0.31	0.31	0.59	0.31	0.10	0.10

data are presented together. A contrasting behaviour in comparison of S1 and S2 would mean a change from negative to positive gca/sca or vice versa over the seasons.

4.2.3.1. Node of first female flower emergence: The estimates of gca were significant and positive in parent 6, whereas, it was significant and negative in parent 4 during both the seasons. In parents 2, 5 and 7, the gca was significantly positive in one season only.

4.2.3.2. Days to first flowering: Significant positive gca was observed in parents 2, 6 and 8, and negative in parents 5 and 9. On comparing S1 and S2, parents 1, 2, 3, 7 and 8 behaved in a contrasting manner.

4.2.3.3. Days to first harvest: Parent 8 had the highest significant positive gca in the first season, while parent 5 had a significantly high negative gca. In the second season, parent 1 had significantly high positive gca, whereas, parents 2 and 9 had high negative gca. Comparing S1 and S2, parents 2, 4, 8 and 9 differed in their behaviour over seasons.

4.2.3.4. Vine length: Positive and significant gca was observed in parents 6, 7 and 2 in one season only. Similarly, significant negative gca was observed in

parents 3, 8 and 4 in one season, and in the other season (S1 or S2) though the gca remained negative, it was not significant. The direction of gca in parents 7, 1 and 2 was positive in two seasons under study.

4.2.3.5. Number of nodes per vine: The highest positive and significant gca was observed in parent 7 during both the seasons. The gca was significant and negative in parents 1, 3 and 8 during one season and during second season, the gca was non-significant.

4.2.3.6. Internodal length: In the first season parents 1 and 2 had the highest positive gca, whereas parents 3 and 8 had significant negative gca. Parents 3, 5, 6 and 9 behaved in a contrasting way over the seasons.

4.2.3.7. Number of branches per vine: Significant positive gca was observed in parent 1 during one season only. The behaviour of the parents was uniform in S1 and S2, with 9, 7 and 5 showing a contrasting behaviour.

4.2.3.8. Rind toughness: Significantly positive gca was observed in parents 4 and 5 during both the seasons, whereas, significantly negative gca was observed in both the seasons in parents 7, 8 and 9. In addition to this, significantly negative gca was observed in parents 1, 2 and 7 during second season.

4.2.3.9. Flesh thickness: Parent 5 had significantly the highest positive gca and parent 8 had significantly the highest negative gca followed by parent 2 in the first season. In the second season it was parent 1 and parents 6, 7 and 9 with higher positive and negative values respectively. Contrasting performance of parents 5, 7, 8 and 9 was observed during S1 and S2.

4.2.3.10. Cavity size: In the first season, parent 6 had the highest positive but non-significant gca followed by 3 and 4, whereas parents 1, 8 and 7 had highest non-significant negative gca. In the second season, parent 6 had significantly high positive gca followed by parents 1 and 2. Significantly high negative sca effect was observed in parent 7, followed by parents 3 and 5. Comparing S1 and S2, parents 1, 3, 4 and 9 differed in their behaviour.

4.2.3.11. Cavity shape: First season data revealed parent 5 to have the highest positive and significant gca, while parent 7 had highest negative and significant gca. It was true with parent 4 and 7 in the second season. Comparing S1 and S2, the behaviour of the parents was nearly uniform except for parents 1, 2, 3 and 6.

4.2.3.12. Fruit size: In the first season, parents 3 and 6 had high positive and significant gca, whereas, parents

Table 12 (Contd.)

Parents	Cavity size (cm ²)	Cavity shape	Fruit size (cm ²)	Fruit shape	Fruit fresh weight loss at storage (5 DAS) (g)	Fruit fresh weight loss at storage (10 DAS) (g)	Seed maturity at harvest (11 DAF)	Seed maturity at harvest (16 DAF)	Specific leaf area (cm ² /g)									
1	-2.26	2.69	0.17*	-0.05	3.98	0.09	0.05	-1.32	0.98	0.41	4.79**	0.08	-0.09	0.42	0.69**	1.45	-12.85**	
2	0.51	2.65	-0.23**	0.09	1.77	5.37	-0.14**	0.01	6.29**	4.04**	4.11	7.43**	0.05	-0.18*	0.27	0.54**	-0.79	-13.70**
3	1.84	-2.32	0.17*	-0.05	6.71*	0.08	0.12*	-0.05	-3.20	-3.47**	-6.13*	-4.30**	-0.07	-0.13	-0.34	-0.16	1.54	1.68
4	1.34	-1.57	0.07	0.33**	2.26	3.85	0.16**	0.09	-5.32**	-4.26**	-2.56	-6.54**	0.20*	0.41**	0.52	-0.41**	12.18*	-3.15
5	-0.53	-2.28	0.36**	0.15	2.65	-4.51	0.15**	0.09	-1.44	-2.05*	-1.89	-5.66**	-8.13	0.09	-0.13	0.28	0.87	9.75*
6	2.51	6.48**	0.01	-0.01	6.02*	4.82	0.02	0.04	2.41	2.59**	5.53*	3.28**	0.17	-0.03	-0.16	-0.04	-9.52	3.76
7	-1.74	-4.71**	-0.36**	-0.27**	-6.28*	-11.01**	0.19**	-0.18**	-0.29	0.13	1.23	-0.30	-0.15	-0.27**	-0.28	0.12	-3.89	6.79
8	-2.01	-0.36	-0.04	-0.05	-6.80*	1.22	-0.03	-0.003	2.07	2.13*	4.62	3.86**	-0.15	0.12	-0.52	-0.37*	2.72	-1.43
9	0.34	-0.59	-0.15	-0.14	1.79	-3.82	-0.17*	-0.04	2.80	-0.08	-5.32*	-2.54*	-0.01	0.18*	1.25**	-0.66**	-4.55	9.14*
SE(g _i)	1.59	1.73	0.08	0.09	2.76	3.01	0.05	0.05	1.71	0.86	2.49	1.22	0.09	0.09	0.38	0.08	4.97	4.27
CD(g _i) at 5%	3.12	3.39	0.16	0.18	5.41	5.90	0.10	0.10	3.35	1.69	4.88	2.40	0.18	0.18	0.74	0.16	9.74	8.37
CD(g _i) at 1%	4.10	4.46	0.21	0.23	7.11	7.15	0.18	0.13	4.40	2.22	6.41	3.14	0.23	0.23	0.98	0.41	12.00	11.00
SE(g _i -g _j)	2.38	2.60	0.12	0.13	4.14	4.51	0.08	0.08	2.57	1.29	3.74	1.84	0.13	0.13	0.57	0.12	7.46	6.41
CD(g _i -g _j) 5%	4.67	5.10	0.24	0.26	8.11	8.84	0.16	0.16	5.04	2.53	7.33	3.61	0.25	0.25	1.12	0.24	14.62	12.56
CD(g _i -g _j) 1%	6.13	6.70	0.31	0.33	10.66	11.62	0.21	0.21	6.62	3.32	9.63	4.74	0.33	0.33	1.47	0.31	19.22	16.51

1, 8 and 7 had high negative gca. In second season, parents 2, 6, 1 and 4 had high positive gca, while parents 5, 7 and 9 had high negative gca. Significant negative gca was observed in parent 7 during both the seasons. In comparing S1 and S2, parents 1, 5, 8 and 9 behaved in a contrasting manner.

4.2.3.13. Fruit shape: In the first season, parents 7, 4, 5 and 3 had high significant positive gca, while 9 and 2 had significantly high negative gca. In the second season, parents 4 and 5 had high positive but non-significant gca, whereas, parent 7 had significantly high negative gca. On comparing S1 and S2, parents 7, 2 and 3 behaved differently.

4.2.3.14. Fruit fresh weight loss at storage (5 DAS): Parent 2 had the highest positive and significant gca and parent 4 had the highest negative and significant gca in the first season, whereas, it was true with parents 2, 6 and 8 and parents 4 and 3 in the second season. Comparing S1 and S2, the behaviour of the parents was almost uniform except for parents 1, 7 and 9.

4.2.3.15. Fruit fresh weight loss at storage (10 DAS): In the first season, parent 6 had positive and significant gca, whereas, parent 3 and 9 had highest negative and

significant gca. In the second season, parents 2 and 1 and parents 4 and 5 had the highest positive and negative significant gca respectively. S1 and S2 data showed parents to perform uniformly but for parent 7.

4.2.3.16. Seed maturity at harvest (11 DAF): Parent 4 had significantly highest positive gca in both the seasons, whereas, parent 7 had the highest negative gca. Comparing S1 and S2, parents 8, 9, 1, 2 and 5 differed in their behaviour.

4.2.3.17. Seed maturity at harvest (16 DAF): Parent 9 had the highest positive and significant gca in the first season and negative and significant gca in the second season. Parents 1 and 2 had the highest positive and significant gca in the second season. In addition, parents 4 and 8 had negative and significant gca in the second season. Comparing S1 and S2, parents 5, 7 and 9 differed in their behaviour.

4.2.3.18. Specific leaf area: The gca was positive and significant in parent 4 during S1 and in parent 5 during S2. Significant negative gca was observed in parents 1 and 2 during S2.

4.2.3.19. Specific leaf weight: In the first season, parents 3 and 1 had high negative gca, while parent 6 had

Table 12 (Contd.)

Parents	Specific leaf weight (g/cm ²)	Average fruit weight (g)	Per cent dehydrated fruit	No. of fruit/vine		Fruit yield/vine											
				Marketable	Unmarketable	Marketable	Unmarketable	Total									
1	-7.61 28.62**	13.49	30.11*	3.23	0.61	-0.14	0.01	0.07	0.08	-0.04	0.12	4.70@	0.06**	0.04	0.06**	0.11**	0.02
2	1.78 24.98**	16.19	38.19**	1.08	0.40	-0.02	-0.02	-0.02	-0.01	0.004	-0.04	-0.04	0.04*	-0.02	0.04*	0.08**	-0.07**
3	-13.97 -4.11	0.56	-16.84	4.50*	6.03**	0.06	0.05	0.28**	0.30**	0.27*	0.24**	92.60@	-0.04*	0.08**	0.06**	0.05	0.07**
4	-3.37 6.50	-41.38**	5.43	0.20	-5.60**	0.19	0.15**	0.10	-0.18**	0.33**	-0.04	1.68@	0.01	-0.01	-0.07**	-0.06*	-0.01
5	-0.94 -24.71**	-29.05*	-20.02	8.84**	4.94**	-0.23*	-0.10*	0.39**	0.14**	0.20	0.05	-0.07*	-0.03	0.07**	0.02	-0.02	9.10@
6	22.69 -9.56	47.22**	11.01	-1.77	1.73	-0.15	-0.14**	-0.22**	-0.07	-0.34**	-0.22**	0.04	-0.04*	-0.02	-0.003	-0.06*	27.30@
7	-4.58 -5.93	0.59	-39.27**	-7.59**	-4.91**	0.38**	0.26**	-0.26**	-0.03	0.13	0.24**	0.06*	0.03	-0.07**	-0.04*	-7.40@	75.80@
8	3.91 -2.59	24.83	14.88	-8.13**	-3.66**	-0.09	-0.07	-0.31**	-0.22**	-0.18	-0.31**	0.04	0.01	-0.06**	-0.04*	-0.04	-0.07**
9	2.09 -13.20	-32.44*	-23.50*	-0.35	0.46	-0.18	-0.02	-0.05	-0.004	-0.37**	-0.03	-0.04	-0.04*	-0.01	-0.03	-0.06*	0.06**
SE(g _i)	12.56 9.18	12.70	10.73	1.95	1.11	0.10	0.05	0.07	0.05	0.13	0.07	0.03	0.03	0.02	0.02	0.03	0.02
CD(g _i) at 5%	24.62 17.99	24.89	21.03	3.82	2.18	0.20	0.10	0.14	0.10	0.25	0.14	0.06	0.04	0.04	0.04	0.06	0.04
CD(g _i) at 1%	32.35 23.65	32.72	27.64	5.02	2.86	0.26	0.13	0.18	0.13	0.33	0.18	0.08	0.05	0.05	0.05	0.08	0.05
SE(g _i -g _j)	40.40 13.77	19.06	16.09	2.93	1.66	0.15	0.17	0.11	0.07	0.19	0.11	0.04	0.03	0.03	0.02	0.04	0.03
CD(g _i -g _j) 5%	79.18 26.99	37.36	31.54	5.74	3.25	0.29	0.33	0.22	0.14	0.37	0.22	0.08	0.06	0.06	0.04	0.08	0.06
CD(g _i -g _j) 1%	104.10 35.47	49.10	41.45	7.55	4.28	0.38	0.44	0.28	0.18	0.49	0.28	0.10	0.08	0.08	0.05	0.10	0.08

*Significant at P=0.05 per cent

**Significant at P=0.01 per cent

@Value $\times 10^{-4}$

high positive gca. In the second season parents 5 and 9 had high negative gca while parents 1 and 2 had high positive gca. Behaviour of the parents over S1 and S2 differed in parents 1, 3, 4, 5, 8 and 9.

4.2.3.20. Average fruit weight: Positive and significant gca was observed in the first season in parent 6, while parents 4, 9 and 5 had significant and negative gca. In the second season it was parents 2 and 1 and parents 7 and 9 respectively. Parents 3, 4 and 7 behaved in a contrasting way over the seasons.

4.2.3.21. Per cent deshaped fruit: Parents 7 and 8 showed significant and negative gca in the first season, whereas, in the second season it was parent 4 followed by 7 and 8. The other parents showed positive gca in both the seasons. Comparing S1 and S2 parent 4 and 6 behaved in a contrasting way.

4.2.3.22. Number of marketable fruit per vine: Parent 7 had high positive and significant gca, while parent 5 had negative and significant gca in the first season. In the second season parents 5 and 6 had negative and significant while parents 7 and 4 had positive and significant gca. The behaviour of the parents in both S1 and S2 were found to be uniform.

4.2.3.23. Number of unmarketable fruit per vine: In the first season, parents 8, 7 and 6 had negative and significant gca and parents 5 and 3 had positive and significant gca. In the second season, parent 4 had negative and significant gca and parents 3 and 5 had positive and significant gca. Behaviour of these parents was uniform in both seasons.

4.2.3.24. Total number of fruit per vine: Parents 4 and 3 had positive and significant gca, while parents 9 and 6 had negative and significant gca in the first season. In the second season it was parents 7 and 3, and parents 8 and 6 with high positive and negative significant gca respectively. Comparing S1 and S2, the behaviour was almost uniform, but for parents 1 and 4.

4.2.3.25. Marketable fruit yield per vine: In the first season, parent 7 had positive and significant gca. Whereas, in second season, parents 1 and 2 had positive and significant gca. Comparing S1 and S2, parents 5 and 9 had negative gca in both the seasons, whereas, it differed in parents 2 and 3.

4.2.3.26. Unmarketable fruit yield per vine: In the first season, parents 3 and 5 had positive and significant gca while parents 7 and 8 had negative and significant gca.

In the second season, the same trend followed. Comparing S1 and S2, the behaviour of the parents over seasons was uniform.

4.2.3.27. Total fruit yield per vine: Positive and significant gca was observed in the first season in parents 1 and 2, while parents 4, 6 and 9 had negative and significant gca. In the second season, parents 2 and 9 behaved differently by having significant negative and positive gca, respectively.

4.2.4. Specific combining ability

The estimates of specific combining ability pertaining to 27 characters studied in 36 hybrid combinations, each in two seasons are presented in Table 13.

4.2.4.1. Node of first female flower emergence: In the first season, 20 crosses had a negative sca, out of which 12 were statistically significant. Of these, 6x9 had the highest negative sca followed by 4x9. The cross 3x8 exhibited the highest sca, followed by cross 5x8. In the second season, 18 crosses had negative sca of which 4 were statistically significant. The cross 6x9 exhibited highest negative sca followed by 4x8. Positive sca was observed in 18 crosses out of which the highest sca was in cross 3x8, followed by 1x2.

Table 13. Estimates of specific combining ability effects (Sij) of 36 cucumber crosses for 27 characters

Crosses	Node of first female flower emergence		Days to first flowering		Days to first harvest		Vine length (cm)		No. of nodes/ vine		Internodal length		No. of branches/ vine		Rind toughness	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
1 x 2	0.41*	0.59*	-1.52*	0.19	-0.88*	2.11**	0.16	0.27**	-0.67	4.50**	0.96*	-0.34	0.50	0.18	-0.39	0.18
1 x 3	0.26*	0.35	-0.52	-0.72	-0.55	0.72	-0.12	0.19	0.51	2.49	-1.06*	0.26	-0.14	0.09	-0.95	-0.93**
1 x 4	-0.04	-0.38	-1.58**	3.49*	-0.73	3.47**	0.01	0.001	2.76*	-0.39	-1.26*	0.35	0.04	0.02	-0.77	-0.49*
1 x 5	-0.25*	-0.56	-2.85**	0.58	-3.19*	1.87	-0.04	-0.08	-2.58*	0.86	0.78*	-0.14	0.10	-0.25	0.36	0.003
1 x 6	0.08	0.38	-0.39	-0.87	-0.70	-0.50	-0.17	-0.05	0.06	-2.58	-1.11*	1.09**	0.19	0.25	0.09	0.10
1 x 7	-0.28*	-0.41	-0.16	-1.93*	-0.52	-1.41	-0.20	0.07	-1.42	1.35	-0.64	0.21	-0.47*	-0.34	-0.43	-0.53
1 x 8	-0.19	-0.02	0.48	-0.51	-0.10	-1.41	0.04	-0.04	1.67	0.02	-0.71	-0.27	-0.47*	-0.28	0.11	-0.72**
1 x 9	-0.01	-0.32	0.96*	0.55	0.63	-2.04**	-0.03	0.03	-0.91	0.12	0.10	0.03	0.28	-0.37	0.24	0.32
2 x 3	-0.35*	-0.59*	-0.82	0.19	-0.46	-0.10	0.06	0.05	3.03	0.96	-0.90*	-0.35	0.04	0.30	-1.31**	-0.62**
2 x 4	-0.32*	0.01	-0.22	-0.60	-0.31	-0.35	-0.01	0.14	1.18	1.67	-0.60	0.07	-0.11	-0.10	0.83	0.16
2 x 5	-0.19	-0.50	-0.16	-0.51	0.24	-1.28*	0.07	0.23*	0.18	3.53**	0.11*	-0.34	0.28	-0.04	-0.04	-0.05
2 x 6	0.47*	0.44	-1.01*	-1.38	-0.95*	-1.78**	0.01	0.01	1.15	0.48	-0.45	-0.39	0.04	0.24	-0.23	0.12
2 x 7	-0.22*	-0.02	-0.79	1.31	-0.76	-0.22	-0.08	0.10	0.33	-2.59	-0.28	0.90*	0.04	0.21	0.98	0.75**
2 x 8	-0.13	-0.62*	-0.82	-1.27	-1.01*	-1.22	-0.12	-0.01	0.75	0.89	-0.92*	-0.31	0.04	-0.40	-0.18	0.72**
2 x 9	0.05	0.07	-1.67**	-0.87	-0.95*	-2.19**	-0.15	-0.29**	-2.15*	0.15	0.70	-0.81	-0.20	0.18	0.71	-0.26
3 x 4	0.53*	0.77**	-0.55	1.49	-1.98*	0.59	-0.05	-0.13	-0.88	-1.47	0.07	0.20	-0.08	0.15	0.30	-1.96**
3 x 5	-0.35*	-0.41	0.18	-0.75	-0.43	-0.35	-0.13	-0.37**	-0.88	-2.71*	-0.32	-0.65	-0.35	-0.46*	-0.13	0.70*
3 x 6	-0.01	0.19	-0.67	-0.54	0.05	-1.04	-0.001	-0.09	-0.24	-0.33	0.13	-0.40	-0.07	-0.19	-0.06	-0.80**
3 x 7	-0.38*	0.07	-0.46	-0.60	-0.76	-1.28	-0.03	0.23	-1.39	-1.07	0.39	0.49	-0.26	0.12	0.85	0.81**
3 x 8	0.72**	0.80**	-0.82	1.82	0.99*	0.72	-0.05	-0.15	-0.97	-0.76	0.09	-0.49	0.07	-0.16	0.42	1.61**
3 x 9	-0.10	-0.17	-1.34**	-0.12	-1.28**	0.41	0.01	-0.02	0.55	-1.87*	0.30	0.81	-0.17	-0.25	1.72**	-0.68**
4 x 5	0.02	0.19	-0.88*	0.13	-0.28	-0.08	0.13	-0.32**	2.27*	-3.93**	-0.24	0.17	0.17	-0.19	-1.02*	-0.15
4 x 6	-0.32*	-0.20	-2.40**	-1.99*	-2.13**	-2.28**	-0.04	0.12	-1.42	2.48	0.53	-0.47	-0.41	-0.25	-0.32	0.25
4 x 7	0.32*	-0.32	-0.52	-1.72*	0.05	-1.52*	0.17	0.05	1.09*	-0.35	0.40	0.02	-0.08	-0.28	-0.27	-0.18
4 x 8	-0.25*	-0.59*	-0.88*	-3.96**	-0.85*	-3.14**	-0.13	0.11	-2.15*	1.72	0.26	-0.36	0.25	0.78*	0.53	0.48*
4 x 9	-0.41*	-0.23	-0.40	1.76	-0.13	-0.16	0.14	0.14	1.93	2.32	0.01	-0.50	0.35	0.36	0.76	0.60*
5 x 6	-0.19	-0.05	0.99*	1.10	0.75*	0.11	0.27*	-0.003	1.90	0.91	0.64	-0.39	-0.02	0.48*	0.24	0.57*
5 x 7	0.11	0.50	-1.12*	-0.30	-1.40*	0.20	0.04	0.04	1.42	-0.53	-0.13	0.17	0.32	0.45*	-0.28	0.48*
5 x 8	0.53*	0.56	-2.16*	-1.21	-2.31*	-1.46	0.25*	0.15	3.18*	-1.12	0.10	0.52	-0.35	0.18	-0.90*	-1.05**
5 x 9	0.05	-0.41	-1.01*	-1.48	-0.58	-2.10**	-0.08	0.28**	1.27	2.91*	-0.82*	0.35	-0.26	-0.58**	0.16	-0.44
6 x 7	0.11	0.10	-1.95*	0.25	-1.92*	-0.50	0.28*	0.08	2.06*	4.89**	0.41	-1.34**	-0.26	0.05	-0.07	0.18
6 x 8	0.20	0.16	-2.34**	1.01	-1.82**	-0.16	0.02	0.04	-1.85	-1.54	0.85*	0.68	0.07	-0.22	-0.03	-0.59*
6 x 9	-0.62**	-0.81**	-0.52	1.10	-1.10*	0.87	0.09	0.22*	-0.09	1.06	0.49	0.57	0.16	0.02	1.03	0.49*
7 x 8	0.17	0.04	-0.46	0.61	0.02	0.59	-0.15	-0.08	-1.33	-1.31	-0.19	0.001	0.07	0.08	-0.09	0.38
7 x 9	0.02	0.07	-0.98*	2.01*	-0.58	1.62*	0.29**	0.05	1.42	1.32	0.82*	-0.14	-0.17	0.33	0.11	-0.57*
8 x 9	-0.22*	0.13	-1.34**	1.43*	-1.82**	1.62*	0.37**	0.15	3.85**	0.36	0.36	0.25	0.16	0.39	-0.02	0.26
SE (s _{ij})	0.21	0.29	0.44	0.98	0.38	0.77	0.09	0.10	1.05	1.34	0.39	0.42	0.23	0.22	0.45	0.24
CD at 5%	0.21*	0.57	0.86	1.92	0.74	1.51	0.17	0.20	2.10	2.62	0.76	0.82	0.45	0.43	0.88	0.47
CD at 1%	0.34	0.75	1.13	2.52	0.98	1.98	0.23	0.26	2.71	3.45	1.01	1.08	0.59	0.57	1.16	0.62
SE (s _{ij} -s _{ik})	0.35	0.48	0.73	1.63	0.64	1.28	0.15	0.17	1.76	2.23	0.65	0.70	0.38	0.37	0.74	0.39
CD at 5%	0.69	0.94	1.43	3.19	1.25	2.51	0.29	0.33	3.45	4.37	1.27	1.37	0.74	0.73	1.45	0.76
CD at 1%	0.90	1.24	1.88	4.20	1.65	3.30	0.39	0.44	4.53	5.74	1.67	1.80	0.98	0.95	1.91	1.01
SE (s _{ij} -s _{kl})	0.33	0.46	0.69	1.54	0.61	1.21	0.14	0.16	1.67	2.11	0.62	0.66	0.36	0.36	0.70	0.37
CD at 5%	0.65	0.90	1.35	3.02	1.20	2.37	0.27	0.31	3.27	4.14	1.22	1.29	0.71	0.71	1.37	0.73
CD at 1%	0.85	1.19	1.78	3.97	1.57	3.12	0.36	0.41	4.30	5.44	1.60	1.70	0.93	0.93	1.80	0.95

*, ** Significant at P = 0.05 and P = 0.01 respectively.

In comparison of S1 and S2, crosses 3x6, 5x9 and 8x9 differed in their performance. Persistent significantly negative estimates during both the seasons were observed in crosses 2x3, 4x8 and 6x9, whereas the persistent and significantly positive estimates were recorded in crosses 3x4 and 3x8.

4.2.4.2. Days to first flowering: Of the 36 crosses, statistically significant and positive sca was observed in 2 crosses in the first season and second season, while significant and negative sca was observed in 13 crosses in the first season and 3 crosses in the second season. Of these cross 5x6 had the highest positive estimates in the first season and crosses 1x5 and 4x6 in the second season. Whereas, crosses 1x4 and 4x8 had highest negative estimates in the first and second season respectively.

Comparing S1 and S2, cross 1x4 behaved in a contrasting manner, while crosses 4x6 and 4x8 had consistent negative estimates over seasons.

4.2.4.3. Days to first harvest: The data revealed 2 crosses to have significant positive estimates in the first season, while in 5 crosses in the second season. Significant negative estimates were observed in 15

crosses in the first season and 8 crosses in the second season. Of these, crosses 3x8 and 1x5 had the highest positive sca in the first and second season respectively. Crosses 1x4 and 4x8 had the highest negative estimates in S1 and S2 respectively.

Comparing S1 and S2 crosses 1x5 and 8x9 had a contrasting behaviour and crosses 2x6, 2x9, 4x6, 4x8 and 5x9 had persistent behaviour with significant negative sca in both the seasons.

4.2.4.4. Vine length: Out of 36 crosses, statistically significant positive sca was observed in 6 crosses and significant negative estimates in only one cross during S1. It was true in 4 crosses and 3 crosses in S2. Crosses 8x9 and 5x9 had the highest positive estimates in S1 and S2 respectively, whereas crosses 1x6 and 3x5 had highest negative estimates in S1 and S2 respectively. Comparing S1 and S2, none of the crosses showed significant contrasting or persistent behaviour.

4.2.4.5. Number of nodes per vine: S1 data revealed, 4 crosses to have significant positive sca, whereas 3 crosses had significant negative sca. Of these, cross 8x9 and cross 1x5 had the highest positive and negative estimates respectively. S2 data revealed, 4 crosses to

be significantly positive and 2 crosses to be significantly negative, of which cross 6x7 and cross 4x5 had the highest positive and negative estimates respectively. Comparing S1 and S2, cross 4x5 had a contrasting behaviour, whereas none of the crosses had a significant persistent behaviour over seasons.

4.2.4.6. Internodal length: In the first season 3 crosses were significantly positive and 6 crosses were significantly negative. Of these crosses 1x2 and 1x4 had the highest positive and negative estimates respectively. In the second season, 2 crosses were significantly positive and only one significantly negative. Of these, cross 1x6 and cross 6x7 had the highest positive and negative estimates. Comparing S1 and S2, cross 1x6 exhibited a contrasting behaviour over seasons, whereas none of the crosses had significant persistent behaviour.

4.2.4.7. Number of branches per vine: Out of 36 crosses, the negative estimates of sca were significant in only two crosses (1x7 and 1x8) during S1, however, none of the estimates were significant and positive in value during the said season. During S2, significant and positive estimates were observed in 3 crosses and negative estimates in only 2 crosses (3x5 and 5x9). Comparing S1 and

S2, none of the crosses had significant contrasting or persistent behaviour over seasons.

4.2.4.8. Rind toughness: Two crosses in S1 (2x7 and 3x7) and 8 crosses in S2 had significant positive estimates, whereas, 4 crosses in S1 and 10 crosses in S2 had significant negative estimates. Cross 3x7 and cross 3x4 had the highest positive and negative estimates respectively in S2, whereas, cross 2x3 had the highest negative estimate in S1.

Comparing S1 and S2, cross 3x9 had a contrasting behaviour whereas crosses 1x3, 2x3 and 5x8 and crosses 2x7 and 6x9 had significantly persistent negative and positive estimates over seasons respectively.

4.2.4.9. Flesh thickness: Of the 36 crosses, 4 crosses each in S1 had significant positive and negative sca. Of these, cross 5x8 and cross 5x7 had the highest positive and negative sca. In S2, two crosses (1x2 and 1x4) had significant positive sca, whereas only one cross (7x8) had significant negative sca. comparing S1 and S2, cross 1x2 behaved in a contrasting way, whereas none of the crosses had a persistent behaviour.

4.2.4.10. Cavity size: In S1, 6 crosses had significant positive sca, with cross 4x6 recording the highest value.

Table 13 (Contd.)

Crosses	Flesh thickness		Cavity size		Cavity shape		Fruit size		Fruit shape		Fruit at storage FWL (5 DAS)		Fruit at storage FWL (10 DAS)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
1 x 2	-0.25**	0.26**	-7.30	7.52	0.01	0.45	-9.11	13.91	-0.07	-0.10	5.12	-4.44	4.33	-7.72
1 x 3	0.26**	-0.01	-1.97	-2.94	-0.13	0.23	-7.38	-6.17	0.07	-0.04	3.93	12.41	8.57	24.01
1 x 4	0.05	0.16*	-3.76	9.54	-0.09	0.51	-0.20	26.22	-0.07	0.19	2.72	9.86	-4.33	7.59
1 x 5	0.13	-0.07	-3.26	-4.65	0.65**	0.19	-2.62	-3.58	0.21	0.09	-7.62	-9.68	0.33	-9.29
1 x 6	-0.002	-0.05	-6.60	-4.17	0.34	-0.85**	1.67	-15.78	-0.16	-0.36*	0.66	2.01	2.58	6.43
1 x 7	-0.06	-0.05	10.52*	-1.72	0.41	-0.26	-21.69	4.29	0.82	0.02	-1.31	-3.87	-10.79	-19.65
1 x 8	-0.24**	-0.13	-4.78	-4.37	0.25	0.02	-10.18	-11.14	0.12	0.21	-7.34	-8.20	-5.52	-18.81
1 x 9	-0.06	0.06	-2.13	-9.50	0.09	0.25	18.70	-16.80	-0.27	0.15	-8.07	-1.99	8.58	-11.75
2 x 3	0.03	0.14	-0.03	-0.23	0.71**	0.59*	10.77	0.24	0.28	-0.10	-15.34	-14.99	-13.79	-27.96
2 x 4	0.12	-0.09	1.11	-10.45*	0.48*	-0.19	3.95	-19.73*	0.27	-0.17	-0.22	-7.20	-0.70	-10.05
2 x 5	0.08	-0.12	0.64	-11.21	-0.73**	-0.18	-2.04	-13.97	-0.05	-0.17	11.90	16.92	10.64	17.41
2 x 6	0.22	0.10	11.76	1.41	-0.25	-0.35	17.62*	7.04	-0.02	0.11	-4.28	-4.38	2.21	22.13
2 x 7	0.08	-0.07	0.99	2.55	0.62**	0.14	14.59	0.53	0.16	0.02	21.08	21.41	14.85	26.38
2 x 8	-0.06	-0.14	-0.15	-2.16	0.12	0.15	3.94	-10.13	0.16	0.05	26.72	22.74	21.79	22.22
2 x 9	0.01	-0.06	-8.89*	-3.89	0.34	0.02	-10.81	-5.69	0.13	0.02	5.33	11.62	18.06	18.28
3 x 4	-0.13	0.06	-2.56	10.98*	-0.19	-0.42	-9.22	10.29	-0.03	-0.28	3.27	7.98	14.88	20.35
3 x 5	-0.11	-0.13	-4.03	-8.44	-0.02	-0.57	-4.78	-15.58	-0.11	-0.18	-4.61	-7.23	5.88	1.47
3 x 6	0.13	-0.07	9.59*	7.37	0.34	-0.36	32.67**	6.46	-0.02	0.30	-6.46	-10.20	2.45	-13.14
3 x 7	0.09	0.06	3.91	-1.88	0.31	-0.05	29.36**	-0.61	0.09	-0.02	0.90	-1.08	-1.58	7.10
3 x 8	0.05	0.15	-3.55	-4.73	0.32	0.06	-9.66	-1.99	-0.01	0.08	3.87	-6.41	-6.30	-12.05
3 x 9	-0.07	-0.14	0.10	-2.19	0.19	-0.47	3.58	-9.00	-0.03	-0.15	2.15	5.80	-9.70	12.88
4 x 5	0.04	-0.09	12.14*	-1.06	0.46*	-0.19	26.51**	-2.58	0.31	0.02	3.51	3.89	0.64	9.71
4 x 6	0.36**	-0.10	13.10**	-6.14	0.61	-0.13	37.14**	-11.11	-0.01	0.03	-4.34	-4.41	-7.79	-4.56
4 x 7	0.02	-0.04	0.36	3.27	-0.19	-0.21	-13.23	-1.42	-0.25	0.01	7.02	2.04	0.85	4.68
4 x 8	0.21**	-0.08	10.43**	7.66	0.55*	0.24	29.06**	3.89	-0.02	0.37*	-8.34	-3.96	-0.88	0.19
4 x 9	-0.18*	-0.07	-6.05	1.39	0.33	0.005	-11.14	-2.81	0.39**	0.18	-7.07	-1.74	2.73	-1.75
5 x 6	-0.06	0.04	5.63	1.60	0.52*	0.65**	-2.42	10.74	0.46**	0.40**	-4.72	4.38	3.21	-3.78
5 x 7	-0.27**	-0.07	-5.31	-1.52	-0.08	0.28	-1.11	10.14	-0.17	0.18	1.48	2.50	7.52	9.80
5 x 8	0.39**	0.06	0.65	-1.40	-0.34	-0.14	11.57	-9.42	-0.17	-0.06	-3.88	7.16	2.78	5.98
5 x 9	0.07	0.07	0.87	0.13	-0.46*	0.26	4.31	11.36	-0.06	-0.12	2.39	-0.62	14.39	2.38
6 x 7	-0.05	-0.01	4.12	-7.41	-0.53*	0.14	-3.15	-4.92	0.26	0.01	5.70	2.86	2.09	-4.81
6 x 8	-0.03	0.08	-2.55	-12.22*	0.05	0.02	-4.41	-10.15	0.06	-0.21	6.60	-2.47	0.70	-11.96
6 x 9	0.12	0.03	6.43	13.54**	0.33	0.41	18.77*	26.56**	0.11	0.12	-5.79	-1.93	-1.70	-5.56
7 x 8	-0.07	-0.16*	-1.96	-1.34	-0.18	-0.34	3.03	-5.42	-0.13	0.002	-13.04	-0.02	5.33	21.95
7 x 9	-0.15	0.09	4.49	-1.97	0.36	-0.22	6.57	-0.41	0.15	-0.16	-11.43	-7.81	1.61	1.68
8 x 9	-0.10	0.02	10.62*	2.14	-0.03	-0.22	7.09	-9.39	0.12	-0.37*	-3.13	1.86	3.55	-1.81
SE (a_{ij})	0.08	0.08	4.51	4.92	0.23	0.25	7.86	8.56	0.15	0.15	-	2.44	7.10	3.48
CD at 5%	0.16	0.16	8.84	9.64	0.45	0.49	15.41	16.78	0.29	0.29	-	4.78	13.92	6.82
CD at 1%	0.21	0.21	11.62	12.67	0.59	0.64	20.25	22.05	0.39	0.39	-	6.29	18.29	8.96
SE ($a_{ij}^{*0.12}$)	0.14	0.14	7.52	8.21	0.39	0.42	13.09	14.27	0.25	0.25	8.12	4.07	11.83	5.81
CD at 5%	0.27	0.27	14.74	16.09	0.76	0.82	25.66	27.97	0.49	0.49	15.92	7.98	23.19	11.39
CD at 1%	0.36	0.36	19.37	21.15	1.01	1.08	33.72	36.76	0.64	0.64	20.92	10.48	30.47	14.97
SE ($a_{ij}^{*0.11}$)	0.13	0.13	7.14	7.79	0.37	0.40	12.42	13.54	0.24	0.24	7.70	3.86	11.22	5.51
CD at 5%	0.26	0.26	13.99	15.27	0.73	0.78	24.34	26.54	0.47	0.47	15.09	7.57	21.99	10.80
CD at 1%	0.34	0.34	18.39	20.07	0.95	1.03	31.99	34.88	0.62	0.62	19.84	9.94	28.90	14.19

*, ** Significant at $P = 0.05$ and $P = 0.01$ respectively.

Whereas, only one cross (2x9) had significant negative sca. In S2, two crosses (6x9 and 3x4) had significant positive sca, whereas, two crosses (6x8 and 2x4) had significant negative sca. Comparing S1 and S2, none of the crosses had significant contrasting or persistent performance.

4.2.4.11. Cavity shape: First season data revealed 7 crosses to have significant positive sca. Of these, 1x5 recorded the highest value, whereas, 3 crosses (2x5, 5x9 and 6x7) had significant negative sca. Second season data revealed, only two crosses (2x3 and 5x6) to have significant positive sca, whereas, only one cross (1x6) had significant negative sca. Comparing S1 and S2, none of the crosses had contrasting behaviour, however, cross 5x6 had a persistently significant positive sca in both the seasons.

4.2.4.12. Fruit size: S1 data showed 8 crosses of the total 36 crosses to have significant positive sca. Of these, cross 4x6 recorded the highest estimate, whereas, S2 data revealed cross 6x9 and cross 2x4 to have significant positive and negative estimates respectively, the other values remaining non-significant. Comparing S1 and S2, cross 6x9 had a persistent behaviour exhibiting significant positive sca in both the seasons.

4.2.4.13. Fruit shape: Crosses 4x9 and 5x6 recorded significant positive estimates in the first season. It was true with crosses 4x8 and 5x6 in the second season, whereas, crosses 1x6 and 8x9 had significant negative sca in the second season. Comparing S1 and S2, cross 5x6 had a persistent behaviour over seasons recording significant positive estimates.

4.2.4.14. Fruit fresh weight loss at storage (5 DAS): In the first season, all the crosses recorded non-significant estimates. However, in the second season, 9 crosses had significant positive sca, of which cross 2x8 recorded the highest sca. 8 crosses recorded significant negative values with cross 2x3 recording the highest value.

4.2.4.15. Fruit fresh weight loss at storage (10 DAS): In the first season, 5 crosses had significant positive estimates and in the second season, 11 crosses had significant positive estimates, whereas 10 crosses had significant negative estimates. Cross 2x8 and cross 1x7 had the highest positive and negative estimate in both the seasons. In addition to cross 2x7, crosses 2x8, 2x9 and 3x4 had a persistent behaviour over seasons recording significant positive estimates.

4.2.4.16. Seed maturity at harvest (11 DAF): S1 data revealed 3 crosses (1x3, 1x7 and 2x3) to have significant

Table 13 (Contd.)

	Seed maturity at harvest				Specific leaf area		Specific leaf weight ($\times 10^{-4}$)		Average fruit weight		Percent deformed fruit	
	(11 DAS)		(16 DAS)		S1	S2	S1	S2	S1	S2	S1	S2
1 x 2	0.02	-0.55	0.19	-0.12	6.61	32.08	-1.92	-7.48**	-6.91	13.94	2.48	10.70**
1 x 3	0.98**	0.08	0.46	0.08	20.27	-9.58	-1.68	1.76	34.06	41.63	-7.61	0.39
1 x 4	-0.13	0.03	0.48	0.67**	-11.36	-32.44**	-4.41	10.04**	-29.67	2.04	-3.31	-6.97*
1 x 5	0.21	0.18	0.75	0.64**	7.61	16.86	4.35	-3.51	-36.00	-15.74	-1.61	0.82
1 x 6	0.24	1.14	1.12	0.95**	8.67	4.25	-3.60	-2.36	58.73	-11.21	5.33	-3.64
1 x 7	0.55*	0.21	0.40	0.30	11.36	-49.48**	-2.62	12.61**	18.36	-53.63	12.81*	7.77*
1 x 8	0.22	0.59*	-0.35	-0.71**	-2.24	27.04*	-2.80	-6.05*	90.12*	-9.95	7.36	3.09
1 x 9	-0.42	-0.41	-1.79	-0.59**	-18.30	-6.47	4.05	0.06	45.73	7.72	-6.76	13.03**
2 x 3	0.84**	0.33	1.28	0.73**	-28.48	-20.13*	7.75**	7.79**	-42.30	-3.48	-7.46	-1.06
2 x 4	-0.10	-0.05	0.80	0.48*	-2.79	-20.27	-0.01	-4.26	36.30	24.73	-11.89	-13.76**
2 x 5	-0.26	-0.23	0.24	0.45*	-20.48	-3.46	2.75	0.05	71.64*	-43.49	-9.79	-7.64*
2 x 6	-0.23	-0.27	0.43	-0.39	15.58	-67.34**	1.05	0.33**	50.70	73.67*	-1.52	-4.09
2 x 7	0.08	0.47*	-0.45	-0.05	22.94	49.39**	0.89*	-0.11	27.00	10.78	-0.70	6.55*
2 x 8	0.09	1.02	0.70	0.11	2.67	-11.55	-0.07	2.98	53.42	-22.47	-0.49	0.64
2 x 9	0.12	0.10	-2.14*	0.06	15.51	-59.96**	-4.22	0.17	-51.30	6.18	0.39	-7.82*
3 x 4	-0.48	-0.42	0.74	0.35	13.00	-75.58*	-4.77	5.31*	16.31	23.01	-2.92	6.94*
3 x 5	0.19	0.73	-0.72	-0.68**	-3.82	-28.91*	-2.35	6.10*	39.61	-31.59	1.45	2.07
3 x 6	0.05	0.02	0.04	-0.36	-0.42	34.74**	0.62	-6.75**	-42.33	-6.50	2.72	-1.06
3 x 7	0.21	-0.41	0.16	-0.35	0.73	-3.29	5.68	-1.12	22.30	18.74	10.07	9.91**
3 x 8	-0.46	-0.70**	0.06	-0.20	13.00	10.90	-3.50	-2.45	-16.61	0.49	11.42*	2.67
3 x 9	-0.26	-0.30	-2.04	-0.08	-30.73**	16.52	0.35	-4.05	30.67	-53.51	2.63	-3.79
4 x 5	0.08	-0.65**	-0.48	-0.92**	-10.12	25.09*	-1.41	-5.63*	35.21	-17.28	-11.92*	6.36*
4 x 6	0.12	0.00**	-0.20	-0.44	0.94	-36.02**	-0.10*	0.05**	16.94	27.03	-10.98*	7.09*
4 x 7	-0.07	0.05	-0.32	-0.42	40.64**	7.28	-10.38**	-3.18	-25.76	-24.10	1.18	2.55
4 x 8	0.27	0.59*	-0.25	-0.11	-17.64	-18.43	3.44	3.82	-52.33	27.34	-4.28	4.30
4 x 9	0.13	-0.00	-1.35	-0.15	3.30	24.10**	-5.30	-6.70**	14.94	30.34	6.27	10.52**
5 x 6	0.45	-0.05	-0.01	-0.47*	1.58	15.92	4.65	2.84	-54.06	21.97	9.72	-2.30
5 x 7	0.27	0.53*	0.95	0.55*	-5.06	20.38	-1.28	-5.05	23.91	32.81	-8.46	-1.33
5 x 8	0.27	1.08	-0.31	0.36	5.00	41.20**	-1.13	-7.05**	-28.67	9.83	-6.58	-5.24
5 x 9	-0.37	0.58*	-1.42	-0.35	19.61	-35.44**	-3.62	6.67*	27.94	-27.90	6.96	0.30
6 x 7	-0.04	0.48*	-0.69	-0.64**	-17.67	114.60**	8.17*	-0.16	104.64**	-18.23	-12.85*	-2.45
6 x 8	0.63	-0.30	-0.11	-0.48*	-7.94	-3.30	1.35	43.02**	-6.94	-24.45	-5.98	0.30
6 x 9	-0.17	-0.30	-1.22	-0.20	-3.33	-35.70**	1.35	6.02**	-1.00	31.76	-12.43*	5.85
7 x 8	-0.38	-0.73**	-0.32	-0.97**	3.42	-21.50	1.56	7.40	-45.97	-10.65	8.51	6.61**
7 x 9	-0.52*	-0.73**	-1.93	-0.52*	-11.64	37.30**	5.00	-8.54**	-36.36	9.01	-2.61	-3.18
8 x 9	0.15	-0.85**	-1.52	-0.97**	-6.50	-24.36*	-4.44	4.79	50.73	30.04	1.27	-11.09**
SE (s_{ij})	0.25	0.24	1.08	0.23	14.15	12.16	3.57	2.61	36.16	30.53	5.56	3.15
CD at 5%	0.49	0.47	2.12	0.45	27.73	23.93	7.00	5.12	70.07	59.04	10.90	6.17
CD at 1%	0.64	0.62	2.70	0.59	36.45	31.32	9.20	6.72	93.15	79.65	14.32	8.11
SE (s_{ij})	0.41	0.41	1.01	0.39	23.50	20.26	5.96	4.35	60.26	50.88	9.27	5.25
CD at 5%	0.80	0.80	3.55	0.76	46.22	39.71	11.68	8.53	119.11	99.73	18.17	10.29
CD at 1%	1.06	1.10	4.66	1.01	60.74	52.19	15.35	11.67	155.23	131.07	23.88	13.52
SE (s_{ij})	0.39	0.39	1.71	0.37	22.37	19.22	5.65	4.13	57.17	48.27	8.79	4.98
CD at 5%	0.76	0.76	3.35	0.73	43.05	37.67	11.07	8.10	112.05	94.61	17.23	9.76
CD at 1%	1.01	1.01	4.41	0.95	57.63	49.51	14.55	10.64	124.34	124.94	22.64	12.83

*,** significant at $P = 0.05$ and $p = 0.01$ respectively

positive sca, whereas, only one cross (7x9) had significant negative sca. S2 data revealed 6 crosses each to have significant positive and negative estimates. Of these, cross 1x6 and cross 8x9 recorded the highest positive and negative value respectively. Comparing S1 and S2, cross 7x9 had a persistent behaviour over seasons recording significant negative estimates.

4.2.4.17. Seed maturity at harvest (16 DAF): Out of the 36 crosses, only one cross (2x9) recorded significant (negative) estimate in the first season, whereas, in the second season, 7 crosses recorded significant positive sca and 9 crosses recorded significant negative sca. Of these, cross 2x3 and cross 8x9 recorded the highest positive and negative estimates respectively. Comparing S1 and S2, none of the crosses had a significant contrasting on persistent behaviour over seasons.

4.2.4.18. Specific leaf area: In the first season, only one cross (4x7) recorded significant positive sca, whereas cross 3x9 recorded significant negative sca. In the second season, 7 crosses had significant positive sca and 12 crosses had significant negative sca. Of these, cross 6x7 and cross 2x6 had the highest positive and negative estimates.

4.2.4.19. Specific leaf weight: S1 data revealed only one cross (6x7) to have significant positive sca, whereas 3 crosses had significant negative sca. S2 data revealed 10 crosses to have significant positive sca and 7 crosses to have significant negative sca. Of these, cross 6x8 recorded the highest positive value. Comparing S1 and S2, cross 4x6 exhibited a contrasting behaviour.

4.2.4.20. Average fruit weight: S1 and S2 data revealed the absence of significant negative estimates, whereas, 3 crosses (1x5, 1x8 and 6x7) in S1 and only one cross (2x6) in S2 had significant positive sca. Comparing S1 and S2, in general most of the crosses higher values in S1 than S2. However, there was no significant contrasting or persistent behaviour.

4.2.4.21. Per cent deshaped fruit: In the first season 2 crosses (1x7 and 3x8) had significant positive sca, whereas, 5 crosses had significant negative sca, of these cross 6x7 had the highest value. In the second season, 7 crosses each had significant positive and negative estimates. Of these, cross 1x2 and cross 2x4 recorded the highest positive and negative estimates respectively.

Comparing S1 and S2, cross 4x5 had contrasting behaviour, whereas, crosses 2x4, 4x6 and cross 1x7 had

persistent negative and positive estimates respectively over seasons.

4.2.4.22. Number of marketable fruit per vine: Seven crosses of the total 36 crosses had significant positive sca in the first season and 3 crosses had significant negative sca. Of these, cross 7x9 and cross 1x7 had the highest positive and negative estimates respectively. S2 data revealed 8 crosses to have significant positive sca and 5 crosses to have significant negative sca, of which cross 1x4 and cross 4x9 had the highest positive and negative estimates respectively.

Comparative evaluation of S1 and S2 data revealed cross 7x8 to have a contrasting behaviour, whereas, cross 3x7 (significant negative) and crosses 1x3, 1x4, 2x4, 5x8 and 7x9 (significant positive) had persistent behaviour over seasons.

4.2.4.23. Number of unmarketable fruit per vine: S1 data revealed 2 crosses (7x8 and 5x8) to have significant positive sca, whereas 3 crosses (2x5, 5x8 and 8x9) had significant negative sca. It was true with 8 crosses and 5 crosses in the second season with cross 1x2 and cross 1x9 recording the highest positive and negative estimates respectively. Comparing S1 and S2 data, cross 5x8 had a

Table 13 (Contd.)

	Number of fruit per vine					Fruit yield per vine						
	Marketable S1	S2	Unmarketable S1	S2	Total S1	S2	Marketable S1	S2	Unmarketable S1	S2	Total S1	S2
1 x 2	0.15	0.28	0.19	0.99**	0.30	1.23**	0.04	0.02	0.06	0.27**	0.29**	0.04
1 x 3	0.60	0.30*	0.05	0.26*	0.73*	0.52*	0.13	0.12*	-0.02	0.14**	0.22**	0.08
1 x 4	0.57*	0.76**	0.23	0.0001	0.77*	0.73**	0.17*	0.10	0.04	-0.05	0.04	0.43**
1 x 5	0.42	0.26	0.35	0.44**	0.74*	0.81**	0.07	-0.01	0.07	0.05	0.04	-0.03
1 x 6	-0.12	0.20	0.22	-0.11	0.07	0.05	-0.02	0.13**	0.13**	0.03	0.16*	0.25**
1 x 7	-0.80**	-0.23	0.13	0.42**	-0.66	0.46*	-0.14	0.04	0.08	0.04	0.07	0.01
1 x 8	-0.53	-0.27	-0.15	-0.16	-0.78*	-0.47*	-0.01	0.02	0.07	0.01	0.03	0.07
1 x 9	0.07	0.01	-0.33	-0.58**	-0.10	-0.61**	0.07	0.05	-0.10*	-0.11**	-0.07	0.04
2 x 3	0.39	0.10	0.07	0.21	0.32	0.32	0.03	0.10*	-0.09	0.06	0.12	0.03
2 x 4	0.66*	0.63**	-0.22	-0.25	0.39	0.39	0.05	0.22**	-0.08	0.08*	0.14*	0.05
2 x 5	-0.26	0.09	-0.71*	-0.28*	-1.01**	-0.20	0.02	0.03	-0.12*	-0.06	-0.03	0.01
2 x 6	-0.07	-0.14	-0.06	-0.26*	-0.17	-0.39	-0.05	-0.05	-0.03	-0.09*	-0.13	-0.14*
2 x 7	-0.67*	-0.10	-0.29	-0.27*	-0.97**	0.15	-0.01	-0.11*	-0.01	-0.01	-0.11	0.06
2 x 8	0.39	0.36**	0.26	0.32*	0.57	0.69**	0.13	0.21**	0.05	0.14**	0.33**	0.13*
2 x 9	0.22	0.44**	0.08	-0.09	0.46	0.35	0.01	0.13**	0.01	-0.03	0.12	0.09
3 x 4	0.01	-0.18	-0.07	0.25	0.02	0.08	0.04	-0.02	0.001	0.09	0.02	-0.01
3 x 5	-0.18	-0.19	0.11	-0.08	0.06	-0.27	-0.02	-0.16**	0.05	-0.11**	-0.30	0.16**
3 x 6	0.02	-0.19	0.19	-0.14	-0.07	-0.33	-0.05	0.02	-0.005	-0.004	-0.01	0.04
3 x 7	-0.62*	-0.34*	0.16	0.23	-0.34	-0.13	-0.07	-0.05	0.09	0.12**	0.02	0.10
3 x 8	0.37	0.15	0.11	0.26*	0.84	0.42*	0.07	0.05	0.25**	0.08*	0.10	0.36**
3 x 9	-0.13	0.16	0.25	-0.13	0.09	0.04	0.07	-0.03	-0.004	-0.10**	-0.17	0.25**
4 x 5	0.36	-0.29*	-0.33	0.10	-0.001	-0.20	0.13	-0.11*	-0.06	0.02	-0.10	0.22**
4 x 6	0.39	0.21	-0.33	-0.12	0.04	0.10	0.16*	0.01	-0.05	-0.06	-0.05	0.08
4 x 7	-0.22	0.06	0.02	0.11	-0.20	0.15	-0.18*	0.02	-0.02	0.05	0.06	0.02
4 x 8	0.15	-0.05	-0.05	0.17	0.05	-0.12	-0.02	-0.04	-0.03	0.03	-0.002	-0.16**
4 x 9	-0.15	-0.44**	0.0001	0.15	0.002	-0.28	-0.03	-0.02	0.02	0.06	0.12	0.03
5 x 6	-0.17	0.37*	0.50	0.16	0.34	0.52	-0.14	0.11*	0.07	0.08*	0.19**	0.01
5 x 7	-0.14	0.08	-0.60**	0.02	-0.73*	0.06	0.06	0.08	-0.10*	0.07	0.15*	-0.22**
5 x 8	0.06**	0.40**	0.57**	-0.33**	0.91*	0.07	0.20*	0.17**	0.02	0.07	0.11	0.30**
5 x 9	0.03	-0.32*	-0.28	-0.08	0.37	-0.23	0.004	-0.18**	0.08	-0.07	-0.23**	-0.17**
6 x 7	0.32	-0.04	-0.30	0.14	0.005	-0.20	0.27**	-0.07	-0.05	-0.09*	-0.16*	-0.17**
6 x 8	-0.48	-0.12	-0.34	-0.04	-0.55	-0.16	0.06	-0.08	-0.07	-0.06	-0.13	0.03
6 x 9	0.65*	0.06	-0.28	0.37**	0.51	-0.44*	0.27**	-0.06	-0.04	-0.02	-0.06	0.20**
7 x 8	0.71*	-0.38*	0.87**	-0.05	1.61**	-0.45**	0.04	-0.16**	0.09	-0.04	-0.20**	0.08
7 x 9	0.91**	0.73**	0.14	0.23	0.90*	0.94**	0.04	0.18**	-0.03	0.07	0.23**	0.15**
8 x 9	-0.36	0.09	-0.39*	-0.44**	-0.58	-0.35	-0.02	-0.01	-0.06	-0.11**	-0.11	-0.16**
SE(eij)	0.29	0.15	0.20	0.13	0.36	0.21	0.08	0.05	0.05	0.04	0.07	0.06
CD(eij) at 5%	0.57	0.29	0.39	0.26	0.71	0.41	0.16	0.10	0.10	0.08	0.14	0.12
CD(eij) at 1%	0.75	0.39	0.51	0.33	0.93	0.54	0.21	0.13	0.13	0.10	0.18	0.16
SE(eij)	0.48	0.25	0.34	0.21	0.50	0.35	0.14	0.08	0.08	0.07	0.12	0.10
CD(eij) at 5%	0.94	0.49	0.67	0.41	0.98	0.69	0.27	0.16	0.16	0.14	0.24	0.20
CD(eij) at 1%	1.24	0.64	0.88	0.50	1.29	0.90	0.36	0.21	0.21	0.18	0.31	0.26
SE(eij)	0.46	0.24	0.32	0.20	0.57	0.33	0.13	0.08	0.08	0.07	0.12	0.10
CD(eij) at 5%	0.90	0.47	0.63	0.39	1.12	0.65	0.26	0.16	0.16	0.14	0.24	0.20
CD(eij) at 1%	1.19	0.61	0.82	0.51	1.47	0.85	0.34	0.21	0.21	0.18	0.31	0.26

*,** significant at P = 0.05 and P = 0.01 respectively

contrasting behaviour over seasons, whereas crosses 8x9 and 2x5 had persistent behaviour with significant negative estimates.

4.2.4.24. Total number of fruit per vine: Out of the 36 crosses, 6 crosses had significant positive sca and 4 crosses had significant negative sca and 4 crosses had significant negative sca in the first season. Of these cross 7x8 and cross 2x5 recorded the highest positive and negative estimates. In the second season, 8 crosses had significant positive sca and 4 crosses had significant negative sca. Among these crosses, 1x2 had highest positive estimate and cross 1x9 had the highest negative estimate.

Comparing the results over two seasons, it was found that cross 7x8 had a contrasting behaviour and cross 1x8 (significant negative) and crosses 1x3, 1x4, 1x5 and 7x9 (significant positive) had a persistent behaviour over seasons.

4.2.4.25. Marketable yield per vine: S1 data revealed 5 crosses to have significant positive estimates. Of these cross 6x7 recorded the highest value. S2 data revealed 9 crosses to have significant positive estimates and 5 crosses to have significant negative estimates. Of these

cross 2x4 had the highest positive value and cross 5x9 had the highest negative value. Comparing S1 and S2 data, cross 5x8 had a persistent behaviour over seasons.

4.2.4.26. Unmarketable yield per vine: In the first season, 2 crosses (3x8 and 1x6) had significant positive sca, and 3 crosses (2x5, 5x7 and 1x9) had significant negative sca. In the second season, 6 crosses had significant positive sca and 7 crosses had significant negative sca. Of these, cross 1x2 and cross 2x9 had the highest positive and negative estimates. Comparing S1 and S2, crosses 1x9 (significant negative) and 3x8 (significant positive) had persistent behaviour over seasons.

4.2.4.27. Total yield per vine: Of the total 36 crosses, 8 crosses had significant positive sca and 4 crosses had significant negative sca in the first season. Of these, cross 2x8 followed by 1x2 had high positive estimates, whereas crosses 5x9 and 7x8 recorded high negative estimates. In the second season, 12 crosses had significant positive sca and 3 crosses significant negative estimates. Of these, crosses 1x4 and 3x8 had high positive estimates, whereas cross 5x7 had high negative estimate. Comparing S1 and S2 crosses 3x9, 5x7, 5x9 and 6x7 had a contrasting behaviour, whereas crosses 1x6, 2x8 and 7x9 (significant positive) behaved persistently.

4.2.5. Genetic analysis

The genetic components of variation like D , H_1 , H_2 , F , E and h^2 , the proportions and differences between the various components were estimated following the procedures of Jinks and Hayman (1953), Jinks (1954) and Hayman (1954b) for all the yield and yield components and the fruit characteristics. The results of this genetic analysis for two seasons are presented in Table 14.

4.2.5.1. Node of first female flower emergence: Comparative view of the data of both seasons revealed the pre-dominant role of dominant genes. While H_1 , H_2 and D were significant in the first season, only H_2 was significant in the second season. The mean degree of dominance $(H_1/D)^{1/2}$ exceeded the value of one in both the seasons revealing a higher degree of dominance. The proportion of positive and negative alleles were unequally distributed. KD/KR ratio suggested, the parents to carry more of dominant genes than recessive genes. h^2/H_2 ratio suggested the role of atleast one group of dominant genes to control the trait expression. Low heritability values in both the seasons gave a clear indication of non-additive gene action. Environment was found to have a significant role.

Table 14 (Contd.)

Characters	(H ₁ /D)		H ₂ /4H ₁		K _D /K _P		H ₁ -H ₂		h ² /H ₂		h ² (ns)		r		t ²	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Node of first female flower emergence	1.92	3.52	0.20	0.20	1.10	1.50	0.07	0.13	0.04	0.09	0.40	0.28	4.37	14.42	0.02	0.30
Days to first flowering	3.70	2.92	0.24	0.22	1.34	1.58	0.37	0.72	5.28	0.05	0.83	-0.70	6.69	6.03	3.44	2.54
Days to first harvest	4.72	4.00	0.24	0.20	1.04	1.36	0.24	1.83	5.01	1.02	0.72	-0.08	3.97	4.59	3.24	3.48
Vine length	2.28	5.29	0.16	0.20	2.28	0.90	0.04	0.02	0.57	0.88	-0.64	0.24	14.84	2.02	0.79	1.20
No. of nodes/vine	1.75	2.33	0.22	0.17	1.05	1.67	1.18	5.57	0.96	0.44	-0.14	-0.58	16.56	11.80	0.37	0.68
Internodal length	1.25	3.18	0.16	0.24	3.22	0.63	0.66	0.03	0.003	0.17	0.74	0.21	48.21	3.09	0.63	0.98
No. of branches/vine	19.59	5.89	0.22	0.23	0.05	2.11	0.01	0.02	0.25	0.38	-0.17	-0.54	0.05	1.36	0.04	0.51
Specific leaf weight	4.44	2.87	0.16	0.19	10.63	2.41	0.27	0.57	0.89	0.01	0.86	0.61	3.00	12.10	0.14	0.01
Specific leaf area	3.06	2.66	0.19	0.19	1.15	2.53	258.55	1480.49	0.53	0.01	-0.56	-0.59	5.01	15.06	0.90	0.95
Fruit size	7.10	1.58	0.18	0.24	3.78	1.26	397.21	10.75	1.51	0.14	-0.76	0.52	1.74	14.34	1.49	0.29
Fruit shape	1.31	2.87	0.25	0.23	1.28	0.28	0.01	0.0	2.25	1.00	-0.63	-0.18	26.37	3.45	1.27	2.60
Cavity size	2.97	1.19	0.13	0.22	5.28	1.46	104.08	9.81	0.87	0.18	-0.73	0.50	9.75	25.92	0.96	0.06
Cavity shape	1.80	2.55	0.24	0.26	1.08	0.41	0.03	0.01	3.64	0.15	-0.24	-0.27	16.72	4.95	3.53	1.56
Rind toughness	1.13	1.47	0.21	0.19	1.95	2.15	0.17	0.56	0.06	0.01	0.28	0.27	46.56	42.53	0.08	0.16
Flesh thickness	1.52	2.74	0.17	0.22	2.94	0.52	0.04	0.00	9.00	1.50	-0.16	0.61	38.71	4.05	0.09	0.10
Seed maturity at harvest (11DAF)	2.31	1.91	0.20	0.19	0.02	2.27	0.22	0.33	0.58	0.19	-0.22	0.01	16.40	24.47	0.04	0.11
Seed maturity at harvest (16 DAF)	2.47	1.94	0.14	0.17	2.59	0.91	1.17	0.50	0.64	0.45	0.62	0.81	18.27	17.26	2.92	4.00
Fruit fresh weight loss at storage (5 DAS)	2.34	2.54	0.18	1.89	2.27	2.25	175.99	101.09	0.01	0.22	-0.14	-0.42	19.15	16.50	1.11	2.39
Fruit fresh weight loss at storage (10DAS)	1.87	1.85	0.20	1.87	2.18	2.44	161.66	272.83	1.00	0.40	-0.22	0.17	28.87	32.02	1.67	1.34
Average fruit weight	2.20	0.35	0.25	0.49	0.50	0.54	52.77	100.58	2.77	1.72	0.16	-0.17	8.86	9.60	4.00	4.00
Per cent deshaped fruit	1.40	1.18	0.15	0.18	3.10	2.35	270.2	77.50	0.75	0.02	0.71	-0.003	59.74	47.48	0.07	0.02
No. of marketable fruit/vine	1.75	1.81	0.19	0.20	2.19	2.13	0.34	0.09	1.34	1.23	-0.15	-0.28	30.90	25.27	0.31	0.95
No. of unmarketable fruit/vine	1.86	2.46	0.19	0.18	1.52	1.60	0.19	0.13	0.06	0.74	0.16	-0.45	24.03	13.87	2.13	3.00
Total No. of fruit/vine	2.78	2.98	0.22	0.19	1.18	1.95	0.21	0.33	1.35	1.74	-0.64	-0.77	10.16	10.65	0.01	0.10
Marketable fruit yield/vine	2.54	4.83	0.21	0.18	1.95	2.16	0.02	0.02	2.67	0.50	-0.40	-0.14	14.63	3.68	3.49	2.78
Unmarketable fruit yield/vine	2.33	2.69	0.18	0.17	1.72	1.80	0.02	0.01	0.75	0.33	0.26	-0.12	17.43	11.31	2.51	4.00
Total fruit yield/vine	5.61	6.10	0.22	0.16	1.44	3.40	0.01	0.05	3.21	0.22	-0.83	-0.38	2.85	2.49	4.00	3.46

4.2.5.2. Days to first flowering: In the first season H_1 and H_2 values were highly significant, whereas, in the second season none of the genetic components of variation were significant. However, the role of dominant genes was very clear in expression of the trait in both the seasons. $(H_1/D)^{1/2}$ values indicated over dominance in both the seasons. The distribution of positive and negative alleles was found to be unequal. KD/KR ratio exceeded the values of one indicating the parents to carry more of dominant genes than recessive genes. h^2/H_2 values suggested at least 6 groups of dominant genes to control the trait expression in the first season, while one group of dominant genes in the second season. Heritability value was low, indicating the role of non-additive gene action. The role of environment was found non-significant in the first season and significant in the second season.

4.2.5.3. Days to first harvest: H_1 and H_2 values were highly significant in both the seasons indicating the predominant role of dominant genes. The mean degree of dominance indicated a clear over dominance. The distribution of positive and negative alleles were found to be unequal. h^2/H_2 values in the first season (5.01) indicated at least six groups of dominant genes to control the

trait expression, whereas, in the second season at least two groups of dominant genes were found to control the trait expression. KD/KR ratio showed the parents to carry more of dominant genes than the recessive genes. Heritability values revealed the involvement of non-additive gene action. The role of environment was found significant only in the second season.

4.2.5.4. Vine length: In the first season H_1 was found to be significant, while in the second season D, H_1 , H_2 and h^2 to be significant. The mean degree of dominance expressed over dominance in both the seasons. The distribution of positive and negative alleles was found to be unequal in both the seasons. The ratio KD/KR exceeded the value of one in the first season thus more of dominant genes than recessive genes was found to control the trait. Whereas, in the second season, it was less than one suggesting more recessive genes to control the trait rather than the dominant genes. h^2/H_2 values suggested at least one group of dominant genes to control the trait in both the seasons. Environment played a significant role in the second season. Heritability value was low indicating the operation of non-additive genes.

4.2.5.5. Number of nodes per vine: In the first season, D, H_1 and H_2 were significant, whereas, in the second

season H_1 , H_2 and h^2 were found to be significant, indicating the role of both additive and non-additive gene action in the inheritance of the character. In the second season dominance was found in heterozygous phase. Mean degree of dominance revealed over dominance in both the seasons. The distribution of positive and negative alleles was found to be unequal in both the seasons. The ratio KD/KR exceeded the value of one revealing the dominant genes to be more in controlling the trait than the recessive genes. h^2/H_2 value suggested at least one group of dominant genes to control the trait expression. The heritability values were 16.56 and 11.80 in the first and second season respectively. Environment played highly significant role in both the seasons.

4.2.5.6. Internodal length: Values D , H_1 and H_2 were significant in the first season suggesting the role of both additive and non-additive gene action. Whereas, in the second season they were not significant. Mean degree of dominance showed over dominance in both the seasons. The positive and negative alleles were found to be unequally distributed in both the seasons. The ratio KD/KR showed more of dominant genes than recessive genes to control the trait in the first season and vice versa in the second season. h^2/H_2 value suggested at least one

group of dominant genes to control the character. In the first season heritability was 48.21 while it was 3.04 in the second season. Environment played a highly significant role in trait expression.

4.2.5.7. Number of branches per vine: The genetic components were not significant in both seasons, however, H_2 was significant in the second season. Mean degree of dominance expressed clear over dominance in both the seasons. The distribution of positive and negative alleles was found to be unequal in both the seasons. The ratio KD/KR showed more of recessive genes than the dominant genes in trait expression in the first season, while it was vice versa in the second season. h^2/H_2 showed atleast one group of genes to control the trait. The heritability values revealed non-additive genes to have a predominant role. Environment played a predominant role in the second season.

4.2.5.8. Specific leaf weight: The genetic component H_1 was found significant in the first season whereas, H_2 was highly significant in the second season indicating the predominant role of non-additive genes. The mean degree of dominance revealed the operation of over dominance. The distribution of positive and negative alleles were found to be unequal in both the seasons. The ratio

KD/KR exceeded the value of one in both the seasons thus suggesting more of dominant genes than recessive genes to control the trait expression. This was confirmed by the positive F value. h^2/H_2 value indicated atleast one group of dominant genes in operation. Heritability value showed non-additive genes to play a predominant role in both the season. Environment played a significant role in the first season.

4.2.5.9. Specific leaf area: Of the genetic components only H_2 was found significant in the second season. Mean degree of dominance suggested the operation of over dominance. The distribution of positive and negative alleles was confirmed to be unequal in both the seasons. The ratio KD/KR showed more of dominant genes than the recessive genes to control the trait expression. h^2/H_2 values showed atleast one group of dominant genes to control the trait. Heritability was 5.01 and 15.06 in the first and second season respectively. Environment played a predominant role in the first season.

5.2.5.10. Fruit size: The genetic components H_1 and H_2 were significant in the first season, while D, H_1 and H_2 were significant in the second season indicating the role played by both additive and non-additive genes.

Mean degree of dominance expressed over dominance for this trait. The distribution of positive and negative alleles were found to be unequal. The ratio KD/KR indicated the involvement of more of dominant genes than the recessive genes in the parents, confirmed by positive F values. Low heritability values indicate the involvement of non-additive genes. Environment played a significant role in the second season.

4.2.5.11. Fruit shape: In the first season D , H_1 and H_2 were significant showing the role of both additive and non-additive gene action. In the second season D , H_2 and h^2 were significant indicating the role of both additive and non-additive gene action and the presence of dominance at the heterozygous phase. Mean degree of dominance suggested over dominance and the distribution of positive and negative alleles were unequal in both the seasons. H_1-H_2 value being zero in the second season showed the distributions to be equal. The ratio KD/KR exceeded the value one suggesting the parents to have more of dominant genes than recessive genes. h^2/H_2 showed atleast 3 groups of dominant genes to control the character in the first season, while in the second season, just one group of dominant genes appeared to control the trait. Heritability was 26.37 and 3.45 in

the first and second season respectively. Environment played a significant role in both the seasons.

4.2.5.12. Cavity size: The genetic components H_1 and H_2 were significant in the first season suggesting non-additive gene action, whereas, in the second season D , H_1 and H_2 were significant indicating the role of both additive and non-additive genes. The mean degree of dominance measure showed over dominance in both the seasons. The distribution of positive and negative alleles in the parents was found to be unequal. Ratio KD/KR revealed the presence of more of dominant genes than recessive genes. This was confirmed by positive F values in both the seasons. h^2/H_2 values indicated at one group of dominant genes controlling the trait. Heritability values were 9.75 and 25.92 in the first and second season respectively. Environment played a highly significant role in the expression of the trait.

4.2.5.13. Cavity shape: D , H_1 and H_2 components were significant in the first season, whereas, components H_1 and H_2 in the second season. The mean degree of dominance revealed an over dominant gene action. The distribution of positive and negative alleles were found to be unequal. The ratio KD/KR exceeded the value of one in the first season indicating the parents to have more

of dominant genes than the recessive genes but vice versa in the second season. h^2/H_2 ratio showed atleast 4 groups of dominant genes to operate in the first season while atleast one group of dominant genes to operate in the trait expression during the second season. Heritability values were 16.72 and 4.95 respectively. Environment played a highly significant value in both the seasons.

4.2.5.14. Rind toughness: The genetic components D, H_1 and H_2 were found to be significant in both the seasons indicating the role of additive and non-additive gene action. Mean degree of dominance exceeded the value of one in both the seasons revealing the operation of over dominance. The distribution of positive and negative alleles were found to be unequal. KD/KR ratio showed the parents to have more of dominant genes than recessive genes. h^2/H_2 value revealed atleast one group of dominant genes to control the trait expression. Heritability values in both the seasons revealed the role of additive and non-additive genes. The role of environment was significant in the first season.

4.2.5.15. Flesh thickness: In the first season, D, H_1 and H_2 were highly significant, whereas, in the second season

they were non-significant. Mean degree of dominance revealed the operation of over dominance. The distribution of positive and negative alleles were found to be unequal in the first season, while their proportion appeared to be unequal at all the loci in the parents in the second season. KD/KR ratio (2.84) showed more dominant genes than recessive genes in the parents in the first season while in the second season (0.52), it was vice versa. h^2/H_2 values showed 9 groups of dominant genes controlling this character. Heritability values were 38.71 and 4.05 in the first and second season respectively. Environment appeared to have significant role in the expression of the trait in both the seasons.

4.2.5.16. Seed maturity at harvest (11 DAF): In both the seasons H_1 and H_2 were found significant indicating the role of non-additive gene action controlling the trait. The mean degree of dominance revealed the operation of over dominance. The distribution of positive and negative alleles was found to be unequal. KD/KR ratio of 0.02 in the first season revealed more of recessive genes to be present in the parents, while in the second season (2.27), more of dominant genes were found to be present in the parents than the recessive genes. h^2/H_2 ratio showed at least one group of dominant genes to control

this trait. Heritability values were 16.40 and 24.47 for first and second season respectively. Environment had a significant role in the first season.

4.2.5.17. Seed maturity at harvest (16 DAF): The genetic components H_1 and H_2 were significant in the first season. In the second season D , H_1 , H_2 and h^2 were significant. Mean degree of dominance suggested the operation of over dominance in both the seasons. The distribution of positive and negative alleles were found to be unequal. The ratio KD/KR exceeded the value of one in the first season indicating the operation of more of dominant genes in the parent than recessive genes. In the second season, KD/KR ratio was less than one indicating the presence of more of recessive genes in the parents. h^2/H_2 values of both the seasons revealed at least one group of dominant genes to operate. The heritability value was low (18.27 and 17.26) indicating the role of non-additive genes. Environment played a significant role in the second season.

4.2.5.18. Fruit fresh weight loss at storage (5 DAS): In both the seasons, H_1 and H_2 were found to be significant indicating the involvement of non-additive genes in the expression of the fruit. Mean degree of dominance suggested the operation of over dominance. The distribution

of positive and negative alleles were found to be unequal. The ratio KD/KR exceeded the value of one indicating the presence of more dominant genes in the parents rather than the recessive genes. This was confirmed by positive F values. h^2/H_2 values in the first season (0.01) suggested at least one group of dominant genes present for the trait expression, while in the second season (0.22) indicated at least one group of dominant genes to be involved. Heritability values indicated, the involvement of only non-additive gene action. Environment had no significant role in expression of the trait.

4.2.5.19. Fruit fresh weight loss at storage (10 DAS): In the first season, H_1 and H_2 components were found to be significant indicating the role of non-additive genes. In the second season, D , H_1 , H_2 and h^2 were found to be significant indicating the role of both additive and non-additive genes in controlling the trait, in addition dominance was found at the heterozygous loci. Mean degree of dominance expressed the operation of over dominance. The distribution of positive and negative alleles were found to be unequal in both the seasons. The ratio KD/KR expressed the presence of more of dominant genes in the parents than recessive genes. h^2/H_2 value revealed at least one group of dominant genes

to be involved in the trait expression. Heritability value in both the season indicated the involvement of only non-additive genes. Environment did not appear to have a significant role.

4.2.5.20. Average fruit weight: The genetic components H_1 and H_2 were significantly high in the first season while D was significant in the second season. Mean degree of dominance showed over dominance in the first season whereas, in the second season it showed partial dominance. The distribution of positive and negative alleles among the parents was found to be unequal in both the seasons. The ratio of KD/KR revealed more dominant genes to control the trait expression than the recessive genes. h^2/H_2 values revealed atleast 3 groups of dominant genes to control the trait in the first season, in S2, atleast 2 groups of dominant genes controlled the trait expression. The heritability was low (8.86 and 9.60) indicating the role of non-additive genes. Environment had significant effect in both the seasons.

4.2.5.21. Per cent deshaped fruit: D , H_1 and H_2 values were significant in both the seasons suggesting the role of both additive and non-additive gene action. The mean degree of dominance revealed over dominance in both the seasons. The distribution of positive and negative

alleles was found to be unequal in both the seasons. The ratio KD/KR exceeded the value of one suggesting more dominant genes rather than the recessive genes to control the trait. This was confirmed by significant positive F value. h^2/H_2 revealed at least 2 groups of dominant genes to play a role. Heritability values of 59.74 and 47.48 in the first and second season respectively revealed the role of both additive and non-additive genes. Environment did not appear to have a significant role.

4.2.5.22. Number of marketable fruit per vine: Comparative evaluation of genetic components of variation over seasons showed the role of both additive and non-additive gene action in expression of the trait. The ratio $(H_1/D)^{1/2}$ exceeded the value of one indicating the role of non-additive genes. The distribution of positive and negative alleles was found to be unequal. The ratio KD/KR exceeding the value of one, coupled with positive F value indicated the parents to carry more of dominant genes than recessive genes. h^2/H_2 values revealed at least two groups of dominant genes to control the trait expression. Heritability values indicated a predominance of non-additive gene action. Environment had a significant role in both the seasons on the trait expression.

4.2.5.23. Number of unmarketable fruit per vine: In the first season significant D , H_1 and H_2 values indicated

the role of both additive & non-additive genes, whereas, in the second season, significant h^2 value suggested the expression of dominance at heterozygous loci. Mean degree of dominance revealed over dominance. The distribution of positive and negative alleles were found to be unequal. The ratio KD/KR exceeded value of one indicating the parents to carry more of dominant genes than recessive genes. h^2/H_2 values revealed at least one group of dominant genes to control the trait. Heritability value was low indicating the predominance of non-additive gene action. Environment had a significant role on the trait expression in the second season.

4.2.5.24. Total number of fruit per vine: A look at the data of both the seasons revealed the H_1 and H_2 values to be highly significant in both the seasons, whereas, h^2 was significant in the second season. Mean degree of dominance revealed over dominance in both the seasons. The value of $H_2/4H_1$ and H_1-H_2 showed unequal distribution of positive and negative alleles in the parents. Ratio KD/KR exceeded the value of one and the F value were positive indicating more of dominant genes than recessive genes to control the trait. h^2/H_2 values indicated at least two groups of dominant genes to control the trait. Heritability was 10.16 and 10.65 indicating a

predominant role of non-additive genes in controlling the trait expression. Environment had no significant role to play.

4.2.5.25. Marketable fruit yield per vine: The variance components H_1 and H_2 values were significant in both the seasons, while h^2 in the second season only. Mean degree of dominance revealed over dominance in both the seasons. The distribution of positive and negative alleles were found to be unequal. Ratio KD/KR exceeding the value of one showed the parents to carry more of dominant genes than recessive genes. h^2/H_2 showed at least 3 groups of dominant genes in the expression of the trait in the first season, whereas at least one group of dominant genes controlled the trait expression in the second season. Low heritability showed predominant role of non-additive genes. Environment played a significant role only in the first season.

4.2.5.26. Unmarketable fruit yield per vine: In both the seasons, H_1 and H_2 values were found to be significant indicating the role of non-additive genes. Mean degree of dominance indicated over dominance. The distribution of the positive and negative alleles were found to be unequal. Ratio KD/KR revealed more of dominant genes than the recessive genes to control the trait, confirmed

by the positive value of F. It also appeared that in both seasons at least one group of dominant genes was operating. Heritability value was low indicating the role non-additive genes. The environment played a significant role during first season.

4.2.5.27. Total fruit yield per vine: In both the seasons, H_1 and H_2 were found to be significant suggesting non-additive genes to play a predominant role. Mean degree of dominance showed over dominance. The distribution of the positive and negative alleles were found to be unequal among the parents. The ratio KD/KR exceeded the value of one showing dominant genes to exceed the recessive genes in the expression of the trait. This was confirmed by positive F value. Low heritability values indicated the role of non-additive genes. However, the environment played a significant role in the expression of the trait.

4.2.6. Heterosis

Heterosis (per cent) over the mid-parental value (heterosis) and the better parent (heterobeltiosis) was computed for all the yield and yield components. The data pertaining to the two seasons are presented separately for each character. First season and second

season are referred to as S1 and S2 respectively. Likewise, heterosis (per cent) over mid-parent and better parent has been designated as d1 and d2 respectively throughout the text. The results are presented in Table 15.

4.2.6.1. Node at which first female flower emerged: In the first season, the d1 values ranged from -27.3 to 33.3 per cent and d2 values ranged from -36.4 to 33.3 per cent. The significant negative and positive values for d1 were observed in two hybrids each, of which, cross 6x9 had the highest negative heterosis, whereas cross 3x8 had the highest positive heterosis. 4 hybrids recorded significant negative d2 values, whereas, cross 3x8 recorded significant positive d2 value. Highest negative d2 value was observed in cross 4x9, whereas, highest positive value was observed in cross 3x8.

In the second season, the d1 values ranged from -30.4 to 41.2 per cent and d2 values from -33.3 to 33.3 per cent. One hybrid each had significant positive d1 and d2 values, whereas 2 d1 values and 7 d2 values were significantly negative. Cross 6x9 recorded the highest negative d1 value, whereas crosses 1x9, 4x9, 5x9 and 7x9 recorded the highest (-33.3%) negative d2 values.

Table 15. Heterosis (%) over mid parent (MP) and better parent (BP) in cucumber for two seasons (S1 & S2)

		Node of first female flower emergence				Days to first flowering				Days to first harvest			
		S1		S2		S1		S2		S1		S2	
		MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1x2	10.0	0.0	0.0	10.0	0.0	-12.7**	-14.3**	-0.9	-1.7	-7.4**	-8.0**	2.8	2.5
1x3	11.1	11.1	17.6	11.1	17.6	-8.8**	-9.3**	-0.9	-1.7	-6.4**	-7.3**	2.5	2.5
1x4	-5.9	-11.1	-22.2	-22.2	-22.2	-13.2**	-14.4**	8.5*	7.6	-7.7**	-8.0**	6.2**	4.9*
1x5	-10.0	-18.2	-26.3	-30.0	-30.0	-16.8**	-17.6**	0.4	0.0	-13.2**	-14.7**	3.4	3.1
1x6	0.0	-9.1	10.0	0.0	0.0	-10.3**	-13.0**	-2.5	-4.2	-8.3**	-9.2**	-2.1	-4.8*
1x7	-10.0	-18.2	-15.8	-20.0	-20.0	-8.8**	-9.2**	-4.7	-5.9	-7.0**	-7.3**	-2.5	-4.2
1x8	0.0	0.0	0.0	0.0	0.0	-8.1**	-10.5**	-2.1	-2.6	-6.6**	-7.2**	-3.4	-4.9*
1x9	-10.0	-18.2	-23.8	-33.3	-33.3	-5.6**	-5.6**	5.0	0.0	-4.7**	-4.7**	-3.5	-4.4
2x3	-10.0	-18.2	-15.8	-27.3*	-27.3*	-10.5**	-12.5**	-0.8	-0.8	-5.8**	-6.1**	-2.8	-3.1
2x4	-15.0	-27.3**	-10.0	-18.2	-18.2	-10.3**	-10.7**	-4.2	-4.2	-6.4**	-6.7**	-4.6*	-5.5*
2x5	-9.1	-9.1	-23.8	-27.3*	-27.3*	-10.1**	-12.5**	-4.7	-5.1	-5.8**	-6.8**	-6.3**	-6.3*
2x6	9.1	9.1	9.1	9.1	9.1	-12.8**	-13.9**	-5.9	-6.7	-8.3**	-9.8**	-8.5**	-10.7**
2x7	-9.1	-9.1	-4.8	-9.1	-9.1	-11.3**	-12.5**	1.3	0.8	-7.1**	-7.4**	-4.0	-5.5
2x8	0.0	-9.1	-20.0	-27.3*	-27.3*	-12.4**	-13.2**	-6.4	-6.8	-8.0**	-9.2**	-6.8**	-7.9**
2x9	9.1	-9.1	-13.0	-16.7	-16.7	-13.6**	-15.2**	-1.3	-6.8	-7.4**	-8.0**	-7.6**	-8.7*
3x4	17.7	11.1	17.6	11.1	11.1	-10.1**	-11.7**	3.4	3.4	-9.5**	-10.1**	-0.6	-1.8
3x5	-10.0	-18.2	-11.1	-20.0	-20.0	-7.9**	-8.4**	-3.0	-3.4	-6.8**	-7.5**	-2.2	-2.5
3x6	0.0	-9.1	15.8	0.0	0.0	-10.8**	-13.9**	-1.7	-2.5	-6.0**	-7.8**	-4.6*	-7.1**
3x7	-10.0	-18.2	11.1	0.0	0.0	-9.3**	-10.1**	-1.3	-1.7	-6.8**	-7.4**	-3.7	-5.5*
3x8	33.3**	33.3**	41.2**	33.3*	33.3*	-11.3**	-14.0**	3.8	3.4	-3.7**	-5.3**	-0.9	-2.4
3x9	-10.0	-18.2	-10.0	-25.0*	-25.0*	-11.6**	-12.0**	3.1	-2.5	-7.7**	-8.7**	-0.3	-1.3
4x5	-5.3	-18.2	-5.3	-10.0	-10.0	-12.4**	-14.4**	-2.1	-2.5	-7.5**	-8.7**	-2.8	-3.7
4x6	-15.8	-27.3**	-10.0	-18.2	-18.2	-16.8**	-18.3**	-6.7	-7.5	-11.3**	-12.4**	-8.2**	-9.5**
4x7	-5.3	-9.1	-15.8	-20.0	-20.0	-10.9**	-11.7**	-5.5	-5.9	-6.0**	-6.0**	-5.5**	-6.1*
4x8	-5.9	-11.1	-22.2	-22.2	-22.2	-12.9**	-14.0**	-12.3	-12.7	-8.3**	-9.2**	-9.5**	-9.8**
4x9	-26.3**	-36.4**	23.8	-33.3**	-33.3**	-10.5**	-11.7**	6.7	0.8	-6.4**	-6.7**	-2.8	-4.9
5x6	-9.1	-9.1	-4.8	-9.1	-9.1	-7.7**	-11.3	0.4	-0.8	-6.0**	-8.5**	-3.7	-6.0*
5x7	0.0	0.0	10.0	10.0	10.0	-12.6**	-13.8**	-2.5	-3.4	-19.5**	-10.7**	-2.2	-3.6
5x8	20.0*	9.1	15.8	22.2	22.2	-16.4**	-19.3**	-6.0	-6.0	-11.8**	-13.8**	-6.2**	-7.3**
5x9	-9.1	-9.1	-27.3*	-33.3**	-33.3**	-12.1**	-12.9**	-2.7	-7.7	-7.8**	-9.3**	-6.3**	-7.5**
6x7	0.0	0.0	4.8	0.0	0.0	-15.2**	-17.4	-0.4	-0.8	-10.6**	-11.8**	-4.5*	-5.4*
6x8	10.0	0.0	10.0	0.0	0.0	-19.7**	-20.0**	0.4	-0.8	-10.8**	-11.1**	-4.8*	-6.0*
6x9	-27.3**	-27.3**	-30.4**	-33.3**	-33.3**	-11.2**	-13.9**	4.9	-1.7	-8.9**	-9.8**	-1.9	-5.4*
7x8	10.0	0.0	5.3	0.0	0.0	-11.2**	-13.2**	0.0	-0.8	-6.3**	-7.2**	-2.1	-2.4
7x9	-9.1	-9.1	-9.1	0.0	0.0	-11.5**	-11.9**	8.0*	1.7	-7.0**	-7.3**	0.9	-1.8
8x9	-10.0	-18.2	-4.8	-16.7	-16.7	-13.5**	-15.8**	5.4	0.0	-9.9**	-10.5**	0.0	-2.4

*Significant at P=0.05; **Significant at P=0.01.

Hybrid 6x9 appeared to be consistent over seasons bearing flower at the lowest node, whereas, cross 3x8 exhibited consistency in bearing the flowers at later nodes.

4.2.6.2. Days to first flowering: First season data revealed all the hybrids to exhibit significant earliness. The d1 values ranging from -19.7 to -5.6 per cent and d2 values ranging from -20.0 to -5.6 per cent. Cross 6x8 recorded the highest negative heterosis (d1 and d2). In the second season, only 2 hybrids recorded significant d1 values exhibiting late flowering. The d1 values ranged from -12.3 to 8.5 per cent and d2 values ranged from -12.7 to 7.6 per cent. Cross 1x4 was significantly later in flowering.

Comparision of S1 and S2 data revealed hybrids to have tendency to early flowering in S1, whereas, later in S2.

4.2.6.3. Days to first harvest: All the hybrids in S1 exhibited significant earliness for days to first harvest. The d1 values ranged from -19.5 to -4.7 per cent and d2 values ranged from -14.7 to -4.2 per cent. Cross 5x7 and cross 1x5 recorded the highest negative d1 and d2 values respectively. During the second season d1 values

ranged from -9.5 to 6.2 per cent and d2 values from -10.7 to 4.9 per cent. 14 hybrids had significant d1 values, whereas, 19 hybrids had significant d2 values. Cross 4x8 and cross 2x6 recorded the highest negative d1 and d2 values respectively. Over seasons, the hybrids exhibited earliness in S1 than in S2.

4.2.6.4. Vine length: Of the 36 hybrids, nearly 50 per cent, of them recorded significant increase in vine length in the first season, of which, cross 8x9 had the highest d1 and d2 values. The d1 values ranged from -17.5 to 47.9 per cent and d2 values ranged from 38.5 to -18.4 per cent. In the second season, it ranged from -34.2 to -29.4 per cent and 29.5 to -27.2 per cent respectively. 9 hybrids recorded increased vine length, of which cross 6x9 had the highest d1 and d2 values.

4.2.6.5. Number of nodes per vine: In the first season, d1 values ranged from 33.9 to -5.8 per cent and d2 values ranged from 31.5 to -17.6 per cent. 11 hybrids recorded significant increase in the number of nodes, of which cross 8x9 had the highest d1 value and cross 5x8 had the highest d2 value. In the second season, d1 values ranged from 49.9 to -23.3 and d2 values ranged from 48.4 to -29.4. 3 hybrids had significant increase in number of

Table 15 (Contd.)

	Vine length				Number of nodes/vine				Internodal length				Number of branches/vine			
	S1		S2		S1		S2		S1		S2		S1		S2	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1x2	4.1	4.1	33.0**	29.5	0.9	-5.3	49.9**	48.4**	-1.7	-9.7	-5.1	-10.6	28.6	12.5	6.7	-11.1
1x3	-17.5	-18.4	14.9	12.1	0.9	-9.5	14.4	9.5	-22.9**	-33.6**	6.3	4.0	-12.5	-12.5	-5.9	-11.1
1x4	-1.1	-10.2	9.0	7.2	23.2*	22.0*	8.0	6.1	-23.4**	-32.1**	6.1	0.7	0.0	0.0	0.0	-11.1
1x5	0.0	-10.2	0.3	-5.0	-5.8	-9.3	-8.0	-8.9	0.9	-15.1*	1.0	-2.7	0.0	0.0	-17.6	-22.2
1x6	-9.5	-12.2	9.3	6.3	1.8	-8.1	-0.5	-1.6	-16.2*	-28.6**	15.1	14.3	6.7	0.0	12.5	0.0
1x7	-12.5	-14.3	21.7*	19.5	-5.1	-17.6*	15.5	2.7	-13.5*	-28.3**	7.3	7.1	-25.0	-25.0	-12.5	-22.2
1x8	9.0	-10.2	6.4	1.5	13.5	9.3	3.8	-10.8	-16.6*	-29.9**	0.4	-0.4	-20.0	-25.0	-12.5	-22.2
1x9	3.6	-12.2	19.8	11.8	1.0	0.0	17.5	17.3	-2.5	-19.2**	5.9	4.6	0.0	-12.5	-17.6	-22.2
2x3	-1.0	-2.0	6.4	6.2	18.3*	12.7	12.8	6.9	-18.1**	-23.7**	-9.0	-12.5	0.0	-12.5	14.3	0.0
2x4	3.4	-6.1	20.0	14.9	18.9*	10.5	28.9**	27.9	-14.1*	-17.3*	-5.0	-5.9	0.0	-12.5	7.7	0.0
2x5	13.6	2.0	21.7*	18.3	15.3	12.3	30.9	19.1	-3.1	-12.0	-9.2	-11.4	14.3	0.0	0.0	-12.5
2x6	7.4	4.0	14.4	8.4	12.6	8.1	25.8	23.2	-5.7	-13.2	-11.0	-15.8*	7.7	0.0	23.1	14.3
2x7	4.2	2.0	24.4*	18.9	8.8	0.0	1.1	-11.0	-6.1	-16.2*	6.8	0.4	0.0	-12.5	23.1	14.3
2x8	-4.5	-14.3	9.7	7.4	13.5	16.7	14.7	-2.3	-16.8*	-24.4**	-8.2	-14.3*	7.7	0.0	-7.7	-14.3
2x9	1.2	-14.3	-2.1	-10.8	0.0	-7.0	25.5	24.0	5.3	-6.0	-12.6	-18.7	0.0	0.0	14.3	0.0
3x4	-4.5	-12.5	-12.4	-15.9	0.0	-11.1	-12.8	-17.9	-5.5	-8.5	0.4	-2.6	-12.5	-12.5	6.7	0.0
3x5	-5.7	-14.6	-29.4**	-27.2*	2.6	-4.8	-28.3*	-26.5*	-7.8	-10.4	-9.0	-10.4	-25.0	-25.0	-25.0	-25.0
3x6	2.1	0.0	-6.0	-10.8	-0.8	-1.6	-1.1	-4.3	2.6	-1.3	-7.3	-8.7	-6.7	-12.5	-6.7	-12.5
3x7	-1.1	-2.1	20.3	15.2	-5.3	-8.8	-9.6	-16.3	3.9	-0.9	6.5	4.0	-25.0	-25.0	6.7	0.0
3x8	-5.7	-14.6	-11.6	-13.7	-2.6	-9.5	-11.7	-21.2	-3.4	-6.1	-6.3	-9.1	-6.7	-12.5	-6.7	-12.5
3x9	7.3	-8.3	3.5	-5.5	1.8	-9.5	-8.6	-12.3	5.7	0.9	11.3	7.5	-14.3	-25.0	-12.5	-12.5
4x5	24.1*	22.5*	-20.4*	-25.7*	30.1**	24.1**	-21.9	-29.4*	-5.4	-10.9	-0.4	-1.9	-12.5	-12.5	-6.7	-12.5
4x6	9.3	2.25	16.5	15.1	0.9	-9.7	26.7*	23.2	8.9	4.1	-9.0	-13.1	-20.0	-25.0	0.0	0.0
4x7	21.8*	12.8	15.1	14.9	14.5	-1.5	3.0	-9.8	5.1	-2.8	-0.4	-5.6	-12.5	-12.5	0.0	0.0
4x8	-1.3	-2.5	11.7	4.8	-0.9	-5.6	9.3	-7.5	0.2	-5.7	-5.7	-11.2	6.7	0.0	42.9**	42.0*
4x9	29.7**	20.0*	23.4*	17.0	26.5**	26.5*	27.5	25.0	2.9	-4.9	-5.8	-11.6	14.3	0.0	20.0	12.5
5x6	36.5**	26.1**	4.2	-3.9	20.7*	12.9	9.9	2.1	14.3	12.5	-7.5	-10.4	-6.7	-12.5	20.0	12.5
5x7	18.6*	8.5	10.6	2.9	18.0*	5.9	-2.9	-6.3	1.4	-0.5	2.0	-1.9	0.0	0.0	20.0	12.5
5x8	33.3**	33.3**	10.8	10.0	31.5**	31.5**	-9.5	-16.0	4.6	4.6	5.4	0.8	-20.0	-25.0	6.7	0.0
5x9	17.8*	10.3	28.5**	14.1	24.3**	18.5	22.6	12.8	-5.2	-6.9	5.1	0.0	-14.3	-25.0	-25.0	-25.0
6x7	31.2**	29.8**	21.4	20.2	13.8	8.8	35.1**	21.3	13.6	9.8	-17.8*	-18.4*	-20.0	-14.3	-14.3	14.3
6x8	12.9	4.3	10.9	2.9	-3.4	-9.7	-3.2	-16.1	16.1*	14.3	6.4	4.9	0.0	0.0	0.0	0.0
6x9	27.5**	10.9	34.2**	28.7*	8.1	-3.2	24.1	23.0	17.8*	13.8	6.9	4.9	7.7	0.0	6.7	0.0
7x8	0.0	-8.5	6.3	-0.4	0.0	-10.3	-6.2	-9.8	-0.5	-2.3	1.0	0.4	-6.7	-12.5	14.3	14.3
7x9	40.7*	21.3*	25.2*	19.0	16.2*	0.0	17.6	4.8	20.6*	20.6*	1.1	0.0	-14.3	-25.0	20.0	12.5
8x9	47.9**	38.5**	23.2*	10.1	33.9**	27.8**	7.7	-7.3	10.3	8.3	5.1	4.6	7.7	0.0	20.0	12.5

*Significant at P=0.05; **Significant at P=0.01.

nodes per vine, of which, cross 1x2 had the highest d1 and d2 values.

4.2.6.6. Internodal length: In S1, d1 values ranged from 20.6 to -23.4 per cent and d2 values from 20.6 to -33.6 per cent. 3 hybrids recorded significant increase and 11 hybrids recorded significant decrease in internodal length. Cross 7x9 had the highest positive d1 and d2 values, whereas cross 1x3 and cross 1x2 had the highest negative d1 and d2 values respectively. In S2, d1 values ranged from 15.1 to -17.8 per cent and d2 values from 14.3 to -18.4 per cent. Of the 36 hybrids, 3 hybrids recorded significant heterosis (negative). Cross 6x7 had the highest negative d1 and d2 values. Comparing S1 and S2, parent 1 tended towards negative heterosis in S1, whereas, towards positive heterosis in S2.

4.2.6.7. Number of branches per vine: S1 data showed d1 values to range from 28.6 to -25.0 per cent and d2 values from 12.5 to -25.0 per cent, whereas, S2 data revealed a range of 47.9 to -25.0 per cent and 42.9 to -25.0 per cent for d1 and d2 values respectively. Over seasons, only one hybrid (4x8) exhibited significant increased branching, the remaining hybrids had either increase or decrease in branching but remained non-significant.

4.2.6.8. Specific leaf area: First season data revealed, d1 values to range from -15.9 to 46.6 per cent and d2 values from -16.6 to 40.5 per cent. Whereas, in the second season it ranged from -38.4 to 79.5 per cent and -44.4 to 50.5 per cent respectively. 4 hybrids in S1 and 5 hybrids in S2 exhibited a significant increase in the specific leaf area. Whereas, 9 hybrids in S2 and none of them in S1 exhibited a significant decrease in the leaf area. Cross 4x7 in S1 and cross 6x7 in S2 recorded the highest positive d1 and d2 values, and cross 6x8 in S1 and cross 2x9 in S2 had the highest positive d1 and d2 values.

4.2.6.9. Specific leaf weight: d1 values ranged from -34.3 to 19.6 per cent in S1 and from -42.3 to 30.0 per cent in S2. Whereas, d2 values ranged from -32.8 to 21.2 per cent in S1 and -50.0 to 27.6 per cent in S2. None of the hybrids recorded significant increase in the specific leaf area in S1. Whereas, 6 hybrids in S2 had a significant increase in the specific leaf area. 4 hybrids in S1 and 7 hybrids in S2 recorded significant negative heterosis. Cross 2x3 in S2 and crosses 4x7 (S1) and 6x7 (S2) recorded the highest positive and negative d1 and d2 values.

Table 15(Contd.)

	Specific leaf area						Specific leaf weight						Rind toughness						Flesh thickness					
	S1			S2			S1			S2			S1			S2			S1			S2		
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1x2	12.2	10.4	4.9	-0.6	-11.5	-12.8	-5.3	-10.6	-7.6	-14.1**	-0.9	-9.4	-21.1*	-31.7**	27.5	22.2								
1x3	7.6	2.0	-10.2	-17.1	-8.9	-4.8	10.0	2.0	-15.1**	-17.2**	-17.8**	-18.5**	20.0*	17.1*	4.1	2.7								
1x4	25.0	19.3	-20.8	-25.3	-24.3*	-15.7	28.2*	20.5	-11.5**	-13.9**	-11.9**	-15.7**	9.9	-4.9	10.5	5.0								
1x5	-3.1	-7.8	8.2	2.0	5.2	-1.3	-7.4	-12.6	-4.3	-8.2	-4.5	-7.4**	11.1	9.8	-8.1	-10.0								
1x6	9.1	6.9	-0.7	-16.5	-8.3	-9.4	-1.1	-7.3	-3.4	-7.9	-3.3	-7.8**	9.1	-12.2	0.0	-8.3								
1x7	15.1	14.6	-8.6	-19.2	-13.1	13.7	12.4	-3.3	-6.0	-13.5	-7.4	-15.3**	-14.9	-9.8	-5.7	-8.3								
1x8	8.3	5.3	10.8	7.3	-9.0	-11.3	-10.0	-13.2	-3.6	-10.4*	-9.8	-16.9**	-21.7*	-34.1**	-10.8	-13.2								
1x9	-0.4	-1.1	-12.9	-24.8**	0.3	-0.6	12.3	-3.3	-2.2	-9.8*	-2.6	-7.2*	-13.9	-17.8*	9.1	0.0								
2x3	-2.4	-8.9	-23.2**	-25.3**	0.6	-4.9	30.0*	27.6	-10.2*	-14.5**	-11.9**	-20.0**	13.0	0.0	14.3	8.1								
2x4	14.5	11.1	-2.1	-2.6	-16.4	-8.5	3.4	3.0	1.4	-8.1	4.1	-8.6**	30.0**	30.0**	-12.3	-20.0								
2x5	-2.4	-8.6	-6.8	-7.3	2.3	-3.0	7.5	7.5	0.2	-10.4*	2.1	-9.1**	17.1	2.5	-15.5	-21.1								
2x6	-2.2	-5.7	-21.7**	-22.2*	0.9	-1.8	28.6*	27.6	0.9	-1.7	4.9	0.3	49.1**	36.7**	11.1	6.1								
2x7	30.6*	29.0	37.4**	15.8	-24.3*	-23.6	-26.8	-36.1**	10.0*	10.0	15.1**	15.1**	2.6	-15.2*	-10.4	-11.8								
2x8	3.9	-0.7	-13.0	-14.9	-3.5	-7.3	14.6	12.1	1.8	1.8	14.0**	13.0**	3.4	0.0	-15.5	-21.1								
2x9	16.2	14.9	-38.7**	-44.4**	-14.7	-15.2	62.1**	47.0**	0.9	0.0	-0.9	-5.2	-4.0	-20.0	-4.8	-9.1								
3x4	19.8	8.6	-18.0*	-19.8*	-23.2	-32.8**	20.6	18.8	-9.0*	-13.6**	-24.4**	-27.1**	4.3	-7.7	1.3	-2.5								
3x5	2.6	2.2	-13.8	-15.8	-5.1	-5.4	14.8	12.7	0.8	-5.6	2.3	0.0	1.3	0.0	-14.7	-15.8								
3x6	-2.8	-6.0	10.8	8.4	3.0	0.0	-10.3	-11.4	-7.4	-9.7*	-11.5**	-16.3**	34.4**	10.3	-4.5	-13.5								
3x7	-7.4	-12.6	6.1	-12.6	5.5	0.6	-12.6	-25.0**	7.8	2.6	6.8	-3.1	3.5	-4.3	1.4	-2.7								
3x8	6.5	3.8	1.1	-3.7	-7.7	-9.3	-1.9	-5.7	9.2*	3.9	14.3**	4.6	13.4	-2.6	9.3	7.9								
3x9	2.9	-3.0	-4.6	-11.2	-3.9	-8.6	4.2	-3.9	4.3	-1.6	-11.9**	-16.6**	-7.1	0.0	-10.4	-18.9								
4x5	8.6	-1.1	10.2	10.2	-15.2	-25.6**	-10.9	-11.2	-10.0**	-11.3**	-4.1	-5.4*	20.0*	5.0	17.9	-20.0								
4x6	22.5*	14.6	-19.8*	-19.9*	-24.6	-32.3	26.0*	25.6*	-3.8	-10.7	0.0	-8.6**	70.9**	56.7**	-14.3	-25.0								
4x7	46.6**	40.5**	20.0*	0.7	-34.3	-40.0**	-15.7	-26.7**	-1.8	-11.0	-1.8	-13.7**	2.6	-15.2*	-13.5	-20.0								
4x8	1.4	-5.8	-11.8	-14.2	-6.9	-17.4	12.8*	10.0	2.4	-7.2	4.2	-7.7**	37.9**	33.3**	-15.4	-21.2								
4x9	26.2*	21.1	0.1	-8.8	-24.9*	-31.3**	-1.7	-10.5	3.2	-7.2	1.9	-6.9*	-12.0	-26.7**	-11.4	-22.5								
5x6	-10.1	-16.6	-5.3	-5.4	13.2	10.3	4.5	3.7	3.1	-5.6	6.3	-1.5	16.9	-5.0	-2.9	-13.2								
5x7	5.3	-0.2	33.6**	12.2	-5.8	-9.9	-25.5*	-12.7	0.8	-9.9	8.1*	-3.8	-20.9**	-26.1**	-16.7	-21.1								
5x8	-0.7	-2.7	21.0**	17.8	-0.7	-2.0	-18.2	-20.0*	-15.9**	-24.8	-7.5*	-17.1**	44.1**	22.5**	-5.3	-5.3								
5x9	7.7	1.9	-19.9**	-27.1**	-9.4	-13.6	23.5	11.9	-5.1	-15.8**	-4.8	-11.8**	3.5	-2.2	0.0	-10.5								
6x7	-3.5	-5.9	79.5**	50.5**	2.5	0.6	-42.3**	-50.0**	-0.9	-3.4	6.3	1.7	1.4	-21.7**	-6.3	-11.8								
6x8	-15.9	-16.6	-2.1	-4.4	19.6	21.2	2.2	-0.7	-2.6	-5.1	-2.5	-5.9	20.8	14.3	2.9	-7.9								
6x9	-2.5	-5.1	-22.6**	-29.4**	2.2	0.0	28.6*	17.4	12.3**	8.5	5.2	5.2	17.1	-8.9	3.3	3.3								
7x8	2.5	-0.8	9.2	-6.2	-0.6	-3.7	-6.9	-17.2*	1.4	1.4	11.0**	10.0*	-10.8	-28.3**	-22.2	-26.3								
7x9	-3.2	-3.4	26.0**	-1.8	2.2	1.9	-23.9*	-38.9**	0.9	0.0	-3.4	-7.6	-23.1**	-23.9**	3.1	-2.9								
8x9	13.3	9.4	-18.0*	-27.1**	-11.2	-14.2	21.3	7.9	0.9	0.0	5.0	1.4	-12.3	-28.9**	-2.9	-13.2								

*Significant at P=0.05; **Significant at P=0.01.

4.2.6.10. Rind toughness: S1 data revealed a range of -15.9 to 12.3 per cent for d1 values and -24.8 to 8.5 per cent for d2 values. 3 hybrids recorded significant increase in rind toughness, whereas, 11 hybrids recorded significant decrease in rind toughness. Of these, cross 6x9 had the highest positive d1 and d2 values. In S2, d1 values ranged from -17.8 to 15.1 and d2 values from -18.5 to 15.1. 5 hybrids recorded significant positive heterosis, whereas, 20 hybrids recorded significant negative heterosis. Cross 2x7 recorded the highest positive d1 and d2 values.

4.2.6.12. Flesh thickness: In the first season, d1 values ranged from -23.1 to 70.9 and d2 values from -31.7 to 56.7. Whereas, in the second season it ranged from -22.2 to 27.5 per cent and -26.3 to 22.2 per cent respectively. 7 hybrids had a significant positive heterosis and 11 hybrids had significant negative heterosis in S1, whereas, none of the hybrids in S2 had significant heterosis. In S1, cross 4x6 followed by 2x6 had the highest positive d1 and d2 values. Comparing S1 and S2, the hybrids behaved in contrasting manner.

4.2.6.12. Cavity size: With a range of -21.5 to 70.1 per cent for d1 values and -23.5 to 58.8 per cent for d2 values in S1, 25 per cent of the 36 hybrids recorded a

Table 15 (Contd..)

	Cavity size						Cavity shape						Fruit size						Fruit shape					
	S1			S2			S1			S2			S1			S2			S1			S2		
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1x2	-21.5	-23.5*	1.2	-1.0	26.9*	9.6	21.1	17.3	-9.4	-13.7	3.7	-1.1	11.6	0.9	-5.0	-7.5								
1x3	-10.9	-12.5	-10.2	-19.8	16.7	16.7	8.3	2.6	-3.6	-7.4	-10.7	-12.3	9.7	5.2	-3.4	-4.4								
1x4	-4.5	-16.3	19.4	0.2	21.9*	14.9	13.6	-1.4	7.3	-4.8	21.3	18.2	8.2	5.3	10.9	10.2								
1x5	-11.3	-18.6	-8.4	-22.4	28.6**	17.4	-8.3	4.2	-2.9	-6.8	8.2	-14.0	15.7*	11.5	5.6	4.4								
1x6	-2.1	-19.1	-12.0	-15.4	29.1**	24.6*	-18.3	-20.9	21.0	0.5	-13.8	-16.4	6.4	3.4	-8.1	-10.2								
1x7	-0.1	-14.3	-11.6	-21.6	27.9**	16.7	-7.2	-8.5	-26.6*	-33.1**	2.5	-12.8	46.5**	29.2**	2.4	-4.5								
1x8	-13.9	-23.5*	-17.1	-19.0	21.6*	21.1*	3.2	-1.8	-12.0	-22.8	-18.1	-20.5	10.6	10.0	9.2	7.9								
1x9	-9.9	-15.2	-20.2	-27.2*	21.5*	14.0	11.5	10.5	20.8	12.7	-15.1	-24.6	1.2	-6.7	3.4	2.2								
2x3	-0.2	-1.1	-8.1	-19.5	48.2**	28.1**	18.2	15.7	30.2**	29.1*	-8.8	-14.5	7.7	-6.2	-9.3	-10.8								
2x4	13.4	1.8	-18.4	-33.2**	47.8**	34.7**	-3.2	-13.6	29.0*	19.7	-21.4	-26.9*	22.9	8.5	-5.6	-8.6								
2x5	3.7	-2.3	-22.1	-35.3**	15.8	-7.2	1.8	-1.7	12.9	12.0	-20.6	-28.9*	9.5	-4.2	-7.1	-8.6								
2x6	44.9**	22.5	-6.0	-7.6	18.5	5.7**	-3.6	-3.6	59.3**	37.8**	1.9	-5.7	14.1	6.0	4.0	-1.1								
2x7	9.6	-3.9	-6.8	-18.9	43.5**	35.1	4.6	2.7	27.7*	21.8	-5.5	-22.7	25.7**	22.2*	-1.8	-10.8								
2x8	3.0	-6.3	-15.7	-19.4	24.5*	7.9	7.1	5.3	20.2	10.2	-20.1	-21.5	14.8	3.3	-0.6	-4.3								
2x9	-14.5	-17.5	-13.1	-22.3	36.6**	25.0*	5.1	2.7	6.1	3.8	-8.5	-22.0	19.7*	17.3	-4.9	-6.5								
3x4	7.7	-4.0	29.5*	20.6	19.1	12.3	-13.7	-21.4*	18.7	9.2	6.1	5.2	5.8	4.1	-9.6	-11.1								
3x5	-3.4	-9.8	-12.9	-18.2	12.7	2.9	-14.2	-15.3	14.2	14.1	-21.0	-24.8	1.6	1.0	-7.8	-7.8								
3x6	41.8**	18.9	8.7	-6.2	9.1**	24.6*	9.3	7.0	81.5**	55.9**	4.1	2.7	7.2	0.0	10.3	6.7								
3x7	16.9	1.8	-9.5	-10.2	25.0*	14.0	-6.8	-10.4	47.8**	39.9**	-4.2	-17.4	13.9	-3.1	-3.6	-11.1								
3x8	-1.9	-11.5	-16.3	-23.7	23.3*	22.8*	-1.3	-1.7	9.3	-0.5	-12.3	-16.3	2.7	-1.0	0.0	-2.2								
3x9	3.3	-1.1	-5.3	-7.5	24.3*	16.7	-14.5	-18.3	25.5	21.8	-9.6	-18.4	5.8	-6.2	-11.1	-11.1								
4x5	42.2**	35.1**	12.0	11.1	28.0**	10.9	-4.7	-12.1	54.0**	41.8**	-4.7	-8.5	17.9**	16.7*	5.1	3.3								
4x6	70.1**	58.8**	-6.6	-24.1*	42.0**	38.7**	-4.0	-14.3	112.0**	96.5**	-7.3	-7.8	11.2	5.3	7.6	5.7								
4x7	24.5	21.3	9.5	2.7	14.9*	10.9	-10.6	-21.4*	6.0	2.9	-0.2	-13.3	4.9	-9.6	4.3	-2.3								
4x8	40.9**	38.9**	13.6	-2.8	34.4**	27.4*	2.4	-7.1*	57.1**	55.3**	-3.5	-8.7	5.4	3.2	16.8*	16.1								
4x9	3.1	-4.4	10.3	0.4	33.7**	32.7**	-2.0	-14.3	14.8	8.7	1.0	-8.1	24.2**	11.7	6.2	4.4								
5x6	39.8**	24.5	4.8	-14.2	25.4**	10.9	21.1*	16.9	35.1**	16.0	9.1	5.2	24.4**	16.7*	18.4*	14.4								
5x7	1.7	-5.7	-2.8	-8.0	6.9	-10.1	6.3	0.8	10.6	4.8	8.0	-2.7	6.1	-9.4	8.4	0.0								
5x8	9.6	5.6	-5.2	-18.3	0.4	-8.7	-1.7	-3.4	28.7*	17.2	-18.6	-25.9	-1.1	-4.2	0.0	-2.2								
5x9	7.9	10.7	5.5	-3.2	0.0	-13.8	9.4	3.4	25.3*	21.7	11.7	5.6	6.4	-5.2	-5.6	-5.6								
6x7	45.6**	39.4	-18.6	-30.2**	0.0	-5.7	1.9	0.0	31.6*	18.7	-2.2	-14.7	26.3**	14.3	3.8	-1.2								
6x8	38.8*	27.9	-26.5*	-30.9**	16.0	12.4	0.9	-0.9	35.6*	27.1	-14.0	-19.0	9.2	5.6	-3.5	-4.7								
6x9	39.4**	21.4	19.0	4.9	28.2**	24.5*	13.5	10.9	64.8**	45.2**	31.4**	20.1	15.7	9.5	4.6	1.1								
7x8	10.0	5.7	-13.9	-22.1	5.3	-3.5	-13.6	-16.7	15.8	11.1	-13.0	-27.9*	5.1	-7.8	1.2	-4.7								
7x9	21.1	9.7	-8.7	-11.5	25.8*	22.0	-10.0	-10.4	21.7	18.6	3.7	-1.4	21.7*	16.0	-8.4	-15.6								
8x9	28.4	20.8	-3.5	-10.0	12.7	6.2	-6.8	-10.5	26.7*	18.6	3.5	-10.4	10.3	1.1	-14.8	-16.7								

*Significant at P=0.05; **Significant at P=0.01.

significant increase in cavity size whereas, only two crosses had a significant reduction in the cavity size. Of these crosses, 4x6 and 1x2 recorded the highest positive and negative (d1 and d2) values respectively. In S2, d1 and d2 values ranged from -26.5 to 29.5 per cent and -35.3 to 20.6 per cent respectively, with one hybrid each exhibiting significant positive (3x4) and negative (6x8) d1 value, and 6 hybrids with significantly negative d2 values. Cross 2x5 had the highest negative d2 value.

Comparing S1 and S2, in both S1 and S2, crosses with parent 1 as one of the parent resulted in negative heterosis, whereas, crosses with parent 2 as one of the parents resulted in positive heterosis in S1 and negative heterosis in S2.

4.2.6.13. Cavity shape: Range of d1 values was between 0.0 to 48.2 and -18.3 to 21.1 in S1 and S2 respectively, whereas d2 values ranged from -13.8 to 38.7 and -21.4 to 17.3 in S1 and S2 respectively. Significant enhancement in cavity shape index was observed in 24 hybrids in S1 and only in one hybrid in S2, whereas, 2 hybrids in S2 recorded significant reduction in the cavity shape index and none of them had significant negative heterosis in S1. Cross 2x3 in S1 and cross 3x4 and 4x7 in S2 recorded

the highest positive and negative heterosis respectively. Comparing S1 and S2, heterosis was more negative or less positive in S2 than in S1.

4.2.6.14. Fruit size: In S1, heterosis was in the range of -26.6 to 112.0 per cent, whereas heterobeltiosis ranged from -22.8 to 96.5. In S2, it corresponded to values -21.4 to 31.4 per cent and -28.9 to 20.1 per cent respectively. 13 hybrids in S1 recorded a significant increase in fruit size, whereas only one cross (6x9) in S2 recorded a significant increase in fruit size. 2 hybrids in S1 and 3 hybrids in S2 recorded a significant decrease in heterosis. Cross 4x6 followed by 3x6 and 6x9 recorded high positive d1 and d2 values in S1.

Comparing S1 and S2 data, it is clear that the extent of positive heterosis was higher in S1 than in S2. In general, crosses involving parents 6 and 9 in different combinations had high positive heterosis.

4.2.6.15. Fruit shape: d1 values ranged from -1.1 to 46.5 per cent and -14.8 to 18.4 per cent in S1 and S2 respectively, whereas, d2 values ranged from -9.6 to 21.2 per cent and -16.7 to 16.1 per cent in S1 and S2 respectively. 9 hybrids in S1 and 2 hybrids in S2 recorded significant positive heterosis, whereas, none of

them recorded significant negative heterosis. Cross 1x7 and cross 5x6 recorded the highest positive heterosis in S1 and S2, respectively. Heterosis in S2 was of a lower degree or sometimes even negative compared to S1.

4.2.6.16. Seed maturity at harvest (11 DAF): First season data revealed d1 values to ranged from -45.5 to 227.3 per cent and d2 values from -53.8 to 200.0 per cent. 15 hybrids had significant positive heterosis while 6 hybrids had significant negative heterosis. Cross 5x6 and cross 7x9 had the highest positive and negative (d1 and d2) values respectively. In the second season d1 values ranged from -56.5 to 220.0 per cent and d2 values from -68.8 to 200.0 per cent. 9 hybrids each recorded significant positive and negative heterosis. Of which, cross 1x6 and cross 7x9 recorded the highest positive and negative values respectively.

4.2.6.17. Seed maturity at harvest (16 DAF): S1 data revealed d1 values to ranged from -50.0 to 42.9 per cent and d2 values from -56.3 to 31.6 per cent. 7 hybrids recorded significant positive heterosis and 21 hybrids recorded significant negative heterosis. Of which, cross 1x3 and cross 7x8 had the highest positive and negative (d1 and d2) values respectively. In the second season d1

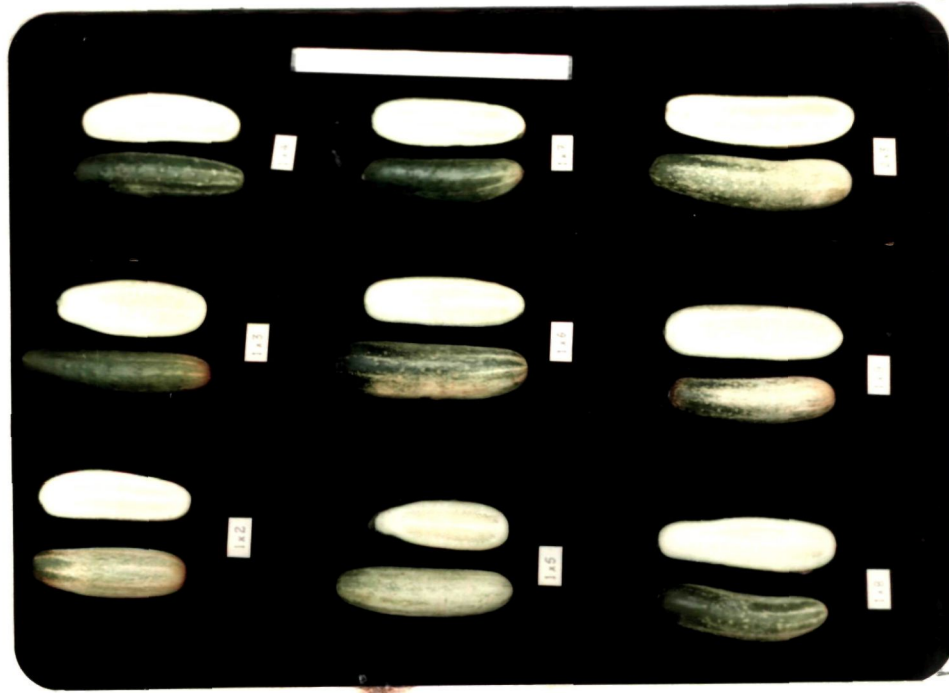


Plate.1

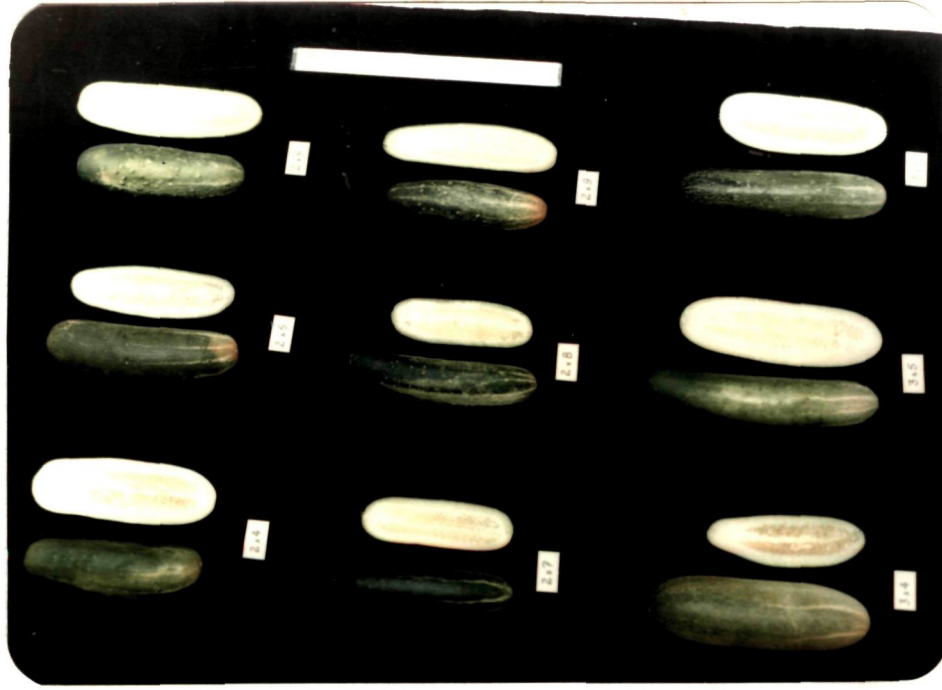


Plate.2

Plates.1 and 2: Fruit of cucumber F_1 hybrids (whole and longitudinal section).

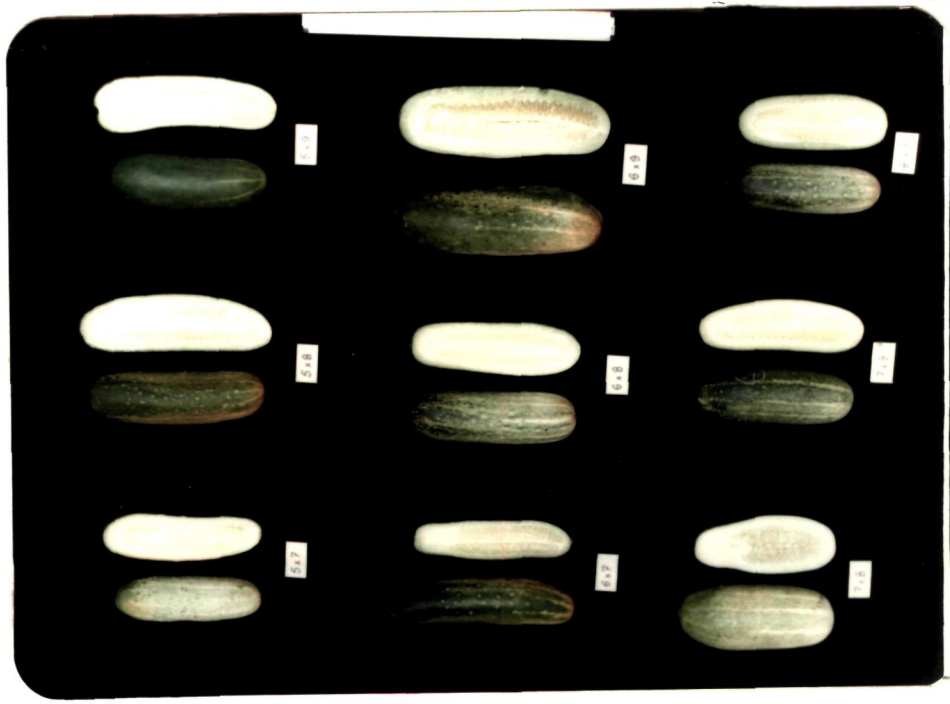


Plate.4

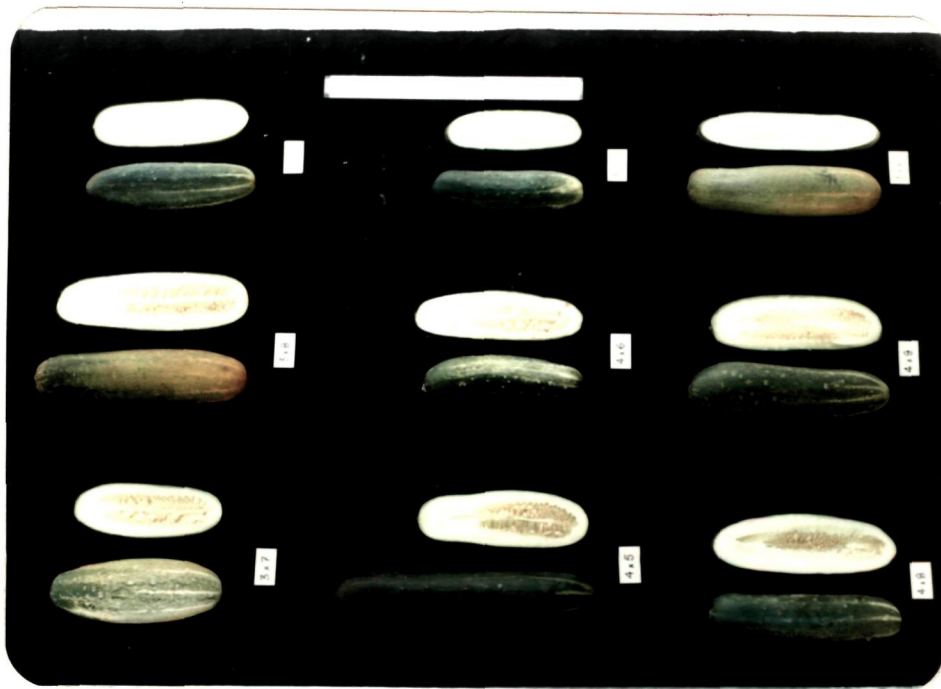


Plate.3

Plates 3 and 4: Fruit of cucumber F_1 hybrids (whole and longitudinal section).

Table 15 (Contd.)

	Seed maturity at harvest (11 DAF)						Seed maturity at harvest (16 DAF)						Fruit fresh weight loss at storage (5 DAS)						Fruit fresh weight loss at storage (10 DAS)					
	S1			S2			S1			S2			S1			S2			S1			S2		
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1x2	17.6	5.3	0.0	0.0	0.0	0.0	22.0**	13.6	12.5	8.0	52.9**	18.2	13.6	-7.4	8.5	10.0	0.2	-21.9**						
1x3	105.5**	97.4**	12.5	-18.2	26.3	-14.3	42.9**	31.6**	6.7	-4.0	26.2	7.3	20.0*	13.3	31.2**	1.4	28.1	0.4	-20.4**					
1x4	29.6	0.0	26.3	-14.3	26.3	4.3	35.1**	31.6**	23.8*	4.0	8.2	-4.5	30.0**	5.9	9.7	-15.0	10.5	-38.1**						
1x5	74.6*	44.7	100.0*	83.3	14.3	4.3	20.0*	20.0*	20.0*	20.0*	-36.8*	-44.5**	-17.3	-32.6**	-7.4	-31.4**	-14.1	-38.1**						
1x6	61.8	44.7	220.0**	220.0**	31.8**	16.0*	17.6*	15.4	-14.2	-27.2**	-5.1	-12.5	15.6*	-11.9	-5.5	-10.7								
1x7	68.7**	55.6*	50.0	28.6	14.3*	-6.7	1.9	-3.6	-16.2	-27.3*	-2.1	-14.8	-11.3	-30.5**	-24.2**	-43.7**								
1x8	76.5**	57.9*	100.0**	62.5	-22.0**	-27.3**	-20.0*	-28.0**	-25.1*	-27.4*	-15.3	-20.0	-5.5	-17.3*	-30.7**	-38.1**								
1x9	-12.6	-30.8	-23.8	-50.0**	-7.0	-16.7*	-17.1	-32.0**	-26.9*	-36.7**	-4.0	-11.1	-15.8*	-21.6**	-37.4**									
2x3	146.2**	128.6**	25.0	-9.1	31.6**	13.6	25.6*	17.4	-5.1	-15.6	-22.0*	-33.3**	-4.2	-12.4	-19.1	-19.6								
2x4	20.0	-14.3	15.8	-21.4	30.0**	18.2*	20.0	4.3	6.9	-8.3	18.8	12.8	3.4	25.9*	12.6									
2x5	45.5	33.3	45.5	33.3	6.7	4.3	16.7	12.0	165.7**	128.9**	111.8**	125.5**	95.2**	88.9**	68.9**									
2x6	33.3	33.3	40.0	40.0	2.1	-4.0	-14.3	-19.2*	0.9	-30.4**	6.1	-18.8*	0.0	-19.0**	51.4**	23.3								
2x7	60.0*	33.3	66.7	42.9	-23.1**	-33.3**	-5.9	-14.3	102.8**	76.5**	116.2**	100.0**	81.5**	68.9**	111.3**	97.4**								
2x8	83.3*	83.3*	130.8**	87.5**	-13.6	-13.6	2.3	-4.3	154.2**	92.3**	104.9**	75.0**	91.0**	79.4**	64.2**	40.6								
2x9	5.3	-23.1	4.7	-31.3*	-17.4*	-20.8*	2.6	-13.0	-76.2**	23.3*	70.0**	47.8**	65.7**	41.5**	71.2**	65.8								
3x4	-23.8	43.9**	-36.0*	-42.9*	5.9	0.0	2.7	-5.0	41.6	35.7*	26.8*	8.3	95.0**	94.2**	66.2**	47.7**								
3x5	66.7*	42.9	9.4	0.0	-17.9*	-30.4**	-24.4*	-32.0**	-5.0	-8.4	-17.1	-29.2**	46.9	38.3**	26.5*	12.4								
3x6	23.1	14.3	12.5	-18.2	-17.1*	-32.0**	-26.1**	-34.6**	-26.0*	-44.9**	-35.7**	-43.8**	22.3*	-7.7	-21.1*	-35.4								
3x7	62.5*	44.4	-44.4	-54.5*	-17.4*	-36.7**	-25.0**	-35.7	1.3	-1.2	0.0	-8.3	59.2**	56.0**	44.4**	34.0								
3x8	-7.7	-14.3	-47.4*	-54.5*	-10.5	-22.7	-20.0	-20.0	16.5	-3.2	-16.7	-16.7	22.8*	6.1	-12.3	-24.5**								
3x9	-40.0*	-53.8**	-11.1	-25.0	-30.0**	-41.7**	-16.7	-25.0*	-9.3	-31.3**	10.6**	8.3	0.9	-20.0**	36.9**	33.5**								
4x5	-15.8	-42.9**	-10.0	-35.7*	-31.7**	-39.1**	-33.3**	-44.0**	-1.8	-1.2	36.5*	36.5**	57.7**	47.9**	59.7**	59.7**								
4x6	60.0**	14.3	78.9**	21.4	-30.2**	-40.0**	-30.2**	-42.3**	-29.8**	-46.2**	-14.3**	-34.4**	2.2	-22.6**	-3.1	-27.5**								
4x7	-21.7	-35.7*	4.8	-21.4	-41.7**	-53.3**	-28.9**	-42.9**	33.3*	31.0	26.5*	17.0	66.7**	64.0**	52.8**	45.8**								
4x8	30.0	-7.1	45.5*	14.3	-35.0**	-40.9**	-18.9	-25.0*	-27.4*	-37.6**	2.4	-12.5	33.6**	15.8	14.8	-10.4								
4x9	-11.1	-14.3	-13.3	-18.8	-33.3*	-41.7**	-21.2	-23.5	-39.3**	-52.7**	5.0	-8.7	18.4	-5.9	17.9	2.5								
5x6	227.3**	200.0**	81.8*	66.7	-33.3**	-36.0**	-25.5**	-26.9**	-4.6	-27.2**	12.7	-13.8	11.4	-19.1**	-0.3	-25.4**								
5x7	71.4*	33.3	84.6*	71.4*	-9.4	-20.0**	-1.9	-7.1	13.4	12.0	35.1**	25.0*	87.0**	72.8**	57.6**	50.4**								
5x8	81.8*	66.7	142.9	112.5**	-15.6*	-13.6	-2.2	-12.0	-3.0	-17.1	41.5**	20.8	61.6**	32.7**	26.9**	-0.9								
5x9	0.0	-30.8	36.4	-6.3	-40.4**	-41.7**	-21.9*	-36.0**	-27.9*	-44.0**	15.0	0.0	33.1**	1.0	28.6**	11.8								
6x7	46.7	22.2	83.3*	57.1	-45.5**	-50.0**	-37.0**	-39.3**	-11.3	-32.9	7.7	-12.5	20.0*	-8.1	3.5	-20.0**								
6x8	66.7*	66.7	23.1	0.0	-40.4**	-44.0**	-34.8**	-42.3**	16.4	1.3	-7.1	-18.8*	13.5	-3.4	-19.0**	-13.7								
6x9	57.9**	15.4	14.3	-43.8**	-34.7**	-36.0**	-28.6	-42.3**	-37.6**	-39.2**	-9.1	-21.9**	-0.5	-6.8	-8.7	-23.8**								
7x8	-20.0	-33.3	-46.7	-50.0	-50.0**	-56.3**	-45.8**	-53.6**	-24.2	-7.4	18.2	8.3	75.9**	-54.5**	59.8**	29.2**								
7x9	-45.5*	-53.8**	-56.5**	-68.8**	-48.1**	-53.3**	-36.4**	-50.0**	-48.1**	-25.9	-7.0	-13.0	21.2*	-2.4	32.9**	20.5								
8x9	-15.8	-38.5*	-50.0**	-62.5**	-39.1**	-41.7	0.0	-10.0	-32.6**	-23.1	14.9	12.5	8.1	-2.4	5.1	-7.5								

*Significant at P=0.05; **Significant at P=0.01.

values ranged from -45.8 to 25.6 per cent and d2 values from -53.6 to 17.4 per cent. 4 hybrids recorded significant positive heterosis, whereas, 17 hybrids recorded significant negative heterosis, of which, cross 2x3 and cross 7x9 recorded the highest positive and negative heterosis respectively.

Comparing S1 and S2, parents 1 and 2 when crossed with other parents resulted in positive heterosis. On the other hand parents 3, 4, 5, 6, 7, 8 and 9 resulted in negative heterosis.

4.2.6.18. Fruit fresh weight loss at storage (5 DAS): The 36 hybrids had storage loss in the range of -48.1 to 165.7 per cent (d1) and -52.7 to 128.9 per cent (d2) in the first season, whereas, it ranged from -35.7 to 111.8 per cent (d1) and -43.8 to 111.8 per cent in the second season. 6 hybrids exhibited a significant positive heterosis and 16 hybrids exhibited a significant negative heterosis in the first season. It was true with 12 and 9 hybrid combinations in the second season, of which, crosses 4x9 (S1) and 3x6 (S2) recorded highest negative d1 and d2 values, whereas cross 2x5 (S1 and S2) recorded the highest positive d1 and d2 values.

4.2.6.19. Fruit fresh weight loss at storage (10 DAS): First season data revealed d1 and d2 values to range from

-11.3 to 125.0 per cent and -54.5 to 95.2 per cent respectively, whereas, it ranged from -30.7 to 111.3 per cent and -43.7 to 97.4 per cent in the second season. 20 and 11 hybrid combinations had significant positive and negative heterosis respectively in the first season. In the second season, it was true with 16 and 11 hybrid combinations. Crosses 1x7 (d1) and 7x8 (d2) recorded the highest negative values in S1. In S2, cross 1x7 recorded highest negative d1 and d2 values. Crosses 2x5 (S1) and 7x8 (S2) recorded the highest positive values (d1 and d2).

4.2.6.20. Average fruit weight: Heterosis for average fruit weight ranged from -4.6 to 94.9 per cent (d1) and -7.9 to 90.0 per cent (d2) in the first season. It was true with -17.2 to 23.9 per cent and -29.1 to 20.0 per cent in the second season. Nearly all the values in S1 were positive, of which 16 d1 values were significant and only one d2 value was significant. None of the values in S2 were significant. S1 data revealed crosses with parent 2 resulted in high positive d1 and d2 values, whereas, crosses with parent 7, 8 and 9 resulted in low d1 and d2 values. Comparing S1 and S2, the crosses exhibited a higher degree of heterosis than in S2.

4.2.6.21. Number of marketable fruit per vine: The extent of heterosis in S1 ranged from -36.2 to 212.3 per cent

Table 15(Contd.)

		Number of fruit/vine																Total			
		Marketable								Unmarketable											
		S1		S2		S1		S2		S1		S2		S1		S2					
MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP		
1x2	29.5	11.6	5.3	2.4	18.8	17.1	135.6**	103.8**	13.8	-12.4	219.0**	219.0**	17.4	1.1	175.9**	155.3**					
1x3	47.3**	44.7	12.7	1.4	77.0**	48.1	63.1**	35.9**	69.1**	51.7*	89.5**	50.0**	86.2**	68.8**	75.4**	42.7**					
1x4	22.3	1.1	8.9	-3.1	175.9**	126.6	108.6**	65.9**	9.4	-19.3	64.1**	52.4**	72.5**	50.0**	92.7**	69.4**					
1x5	19.3	0.7	-7.9	-14.3	93.3**	65.7	69.5**	51.5**	64.6**	25.6	74.6**	30.9**	75.7**	56.6**	80.3**	46.7**					
1x6	40.1**	22.3	3.7	-5.6	62.3	22.9	80.8**	54.2**	43.9*	23.1**	3.2	59.3**	44.6*	51.9**	38.6*						
1x7	18.5	16.2	-17.2	-29.1	-25.8	-48.3	3.4	-27.0**	52.3*	32.2	157.9**	133.3**	-2.3	-22.5*	65.4**	31.3*					
1x8	57.5**	55.2	-1.2	-3.7	-25.3	-35.4	9.4	-7.9	62.1*	29.6	10.6	0.0	6.9	6.1	9.9	-4.7					
1x9	67.9**	62.3	6.5	-9.1	82.5*	48.6	52.5**	36.4**	-43.0*	-50.2**	-35.5**	-51.2**	10.9	9.2	7.4	-12.2					
2x3	41.5*	23.8	-1.2	-13.3	41.9	17.3	58.6**	17.9**	26.7	6.4	75.4**	38.9**	42.4*	34.4	67.0**	28.0					
2x4	68.4**	60.1	14.1	-1.0	212.3**	161.8**	115.9**	54.5**	-40.6**	-44.1**	12.8	4.8	40.4*	38.9**	76.5**	45.2**					
2x5	94.9**	90.0	-16.0	-23.9	59.3	38.2	69.2**	33.3**	-27.4*	-28.2*	-1.6	-26.2**	2.9	-1.1	30.4	0.0					
2x6	65.1**	27.1	23.9	9.9	76.9**	35.3	60.0**	38.5**	-36.8*	-48.8**	-3.8	-19.4**	4.9	-16.7	25.8	7.0					
2x7	58.9**	39.4	1.1	-15.3	-20.3	-44.9**	19.5**	-22.2**	-19.8	-44.0**	121.1**	100.0**	-19.4	-27.0*	51.7**	13.8					
2x8	78.2**	51.7	-5.3	-10.2	43.9	22.9	86.0**	39.5**	-6.4	-38.1**	61.7**	46.2**	21.8	5.6	75.0**	42.2*					
2x9	27.9	7.1	4.9	-12.6	110.7**	73.5*	119.2**	72.7**	-3.3	-16.7	3.2	-21.9**	38.6	17.8	56.1**	20.3					
3x4	37.8	15.5	14.2	12.8	60.0*	15.4	3.6	-2.3	10.5	-11.7	70.4**	27.8**	39.3*	32.9*	29.9*	18.7					
3x5	52.7*	30.7	-16.3	-19.3	42.9	5.8	-2.8	-10.2	23.9	3.1	17.9**	9.5	42.3*	39.8*	8.0	8.0					
3x6	8.0	-7.2	3.7	2.4	25.7	-15.4	38.5**	15.4**	56.7**	50.1	37.3**	27.8**	38.3	15.0	37.9**	21.3					
3x7	16.1	15.8	2.4	-3.0	-36.2**	-49.4**	-19.6**	-34.9**	68.0**	33.2	88.7**	38.9**	0.5	-13.5	17.4	13.8					
3x8	29.8	25.6	-0.7	-8.5	26.0	21.2	19.5**	17.9**	117.0**	60.1	45.2**	25.0**	71.2**	56.3*	30.9*	21.3					
3x9	40.6*	33.6	-16.5	-21.3	97.3**	40.4	33.3	23.1**	-3.9	-6.9	3.9	-2.4	55.2**	38.8*	18.1	17.3					
4x5	55.4*	51.5	-3.7	-8.3	191.7**	180.0**	-1.3	-13.6**	-2.0	-6.9	23.3**	-11.9*	52.0**	47.7**	9.5	0.0					
4x6	33.4	-0.9	23.1	20.0	197.6**	165.2**	48.6**	18.2**	-42.5**	-55.5	-2.0	-22.6**	27.7	2.3	27.7	22.6					
4x7	15.2	-3.2	-3.3	-7.4	37.5*	-13.5	10.3*	-6.3	-6.4	-36.8**	82.9**	77.8**	18.6	6.3	28.2*	13.8					
4x8	12.9	-7.8	15.2	4.9	77.5**	31.3	12.2*	4.5	-32.2*	-56.5**	27.3**	7.7	18.2	3.4	17.5	15.6					
4x9	25.9	1.2	21.6	15.9	197.8**	191.3**	-6.5	-18.2**	-9.8	-26.2*	15.3*	-17.1**	51.0**	29.5*	2.9	-5.4					
5x6	-4.5	-27.8	7.8	5.2	48.8	28.0	66.1**	48.5**	78.9**	43.8**	15.1**	0.0	69.1**	38.6**	37.9**	21.3					
5x7	35.7	16.4	2.0	-6.6	-28.1	-53.9**	8.3	-17.5**	-18.4	-43.3**	32.2**	-7.1	-23.7	-33.3**	17.4	13.8					
5x8	35.0	12.6	-2.3	-6.8	132.9*	77.1**	46.5**	36.8**	-9.9	-40.7**	-32.4**	-45.2**	59.7**	43.4**	7.9	0.0					
5x9	12.0	-8.1	-12.3	-20.2	168.1**	152.0**	-3.0	-3.0	54.3**	31.7*	1.2	0.0	90.4**	67.5**	-0.7	-1.3					
6x7	32.3*	13.4	-2.0	-8.4	45.8**	-12.4	5.6	-25.4**	-7.8	-24.5	16.7	-9.7	28.0	-5.4	9.5	-6.3					
6x8	46.1**	29.2*	-1.0	-7.7	39.4	-4.2	9.4	-7.9	-43.7	-57.3**	-12.3	-19.4*	0.8	-9.1	-0.8	-6.3					
6x9	13.2	1.8	20.7	12.4	165.0**	140.1**	42.4**	27.3**	-28.3	-33.3	22.2**	7.3	55.2*	42.9*	31.3*	16.2					
7x8	-4.6	-7.9	-6.0	-17.6	8.0	-16.9	-22.8**	-38.1	153.2**	129.5**	20.9*	0.0	42.4*	13.5	-9.7	-18.8					
7x9	17.2	11.1	3.2	2.6	94.6**	21.3	54.2**	17.5**	31.3	1.7	41.4**	0.0	60.9*	26.1*	49.4	43.8**					
8x9	38.4**	35.7	12.1	-2.2	42.9	4.2	26.8**	18.4**	-41.4	-57.6**	-55.2**	-63.4**	5.4	3.0	-13.0	-18.9					

*Significant at P=0.05; **Significant at P=0.01.

(d1) and from -53.9 to 191.3 per cent (d2). 15 crosses exhibited significant positive heterosis, whereas, only one cross (3x7) had significant negative heterosis. Crosses 2x4 (d1) and 4x9 (d2) recorded the highest positive heterosis. In the second season, d1 and d2 values ranged from -22.8 to 135.6 per cent and -38.1 to 103.8 per cent respectively. 20 hybrids had significant positive heterosis, of which, cross 1x2 followed by 2x9 and 2x4 had higher values.

In general, crosses involving parent 7 showed low positive and/or high negative heterosis, whereas, crosses involving parent 4 showed high positive and/or low negative heterosis.

4.2.6.22. Number of unmarketable fruit per vine: In S1, d1 and d2 ranged from -43.7 to 153.2 per cent and -57.3 to 129.5 per cent respectively. 10 d1 values and 5 d2 values were significantly positive, whereas, 6 d1 values and 13 d2 values were significantly negative, of which, crosses 7x8 (d1) and 6x8 (d2) recorded high positive and negative values respectively. In S2, d1 and d2 values ranged from -55.2 to 219.0 per cent and -63.4 to 219.0 per cent respectively. 23 d1 and 13 d2 values were significantly positive, whereas 3 d1 and 9 d2 values were

significantly negative, of which, cross 8x9 and 1x2 recorded the lowest and highest d1 and d2 values respectively. In general, crosses involving parents 1, 3 and 7 recorded high positive heterosis, whereas crosses involving parents 2 and 9 had high negative heterosis.

4.2.6.23. Total number of fruit per vine: Heterosis (d1 and d2) for number of fruit per vine in the first season ranged from -23.7 to 90.4 per cent and -33.3 to 68.8 per cent respectively. 11 and 7 hybrid combinations had significant positive d1 and d2 values respectively. Cross 5x9 (d1) and 1x3 (d2) recorded the highest positive values. In the second season, d1 and d2 values ranged from -13.0 to 175.9 per cent and -18.9 to 155.3 per cent respectively. 12 and 6 hybrid combinations recorded significant positive d1 and d2 respectively. Cross 1x2 followed by 1x3 and 1x4 had the highest positive d1 and d2 values, whereas, crosses 8x9 and 7x8 had significant negative d1 and d2 values.

Comparing S1 and S2, cross 5x9 had positive heterosis in S1, whereas, negative in S2. Heterosis was in general highly positive in crosses 1x2, 1x3, 1x4, 1x5 and 1x6. The extent of heterosis exhibited in both the seasons was uniform.

4.2.6.24. Per cent deshaped fruit: Significant decrease was observed in 18 (d1) and 30 (d2) hybrid combinations, whereas 4 (d1) and 3 (d2) hybrids exhibited a significant increase in per cent deshaped fruit in the first season, with d1 and d2 values ranging from -57.9 to 72.5 per cent and -61.0 to 48.1 per cent respectively. Cross 2x4 followed by 6x9 and 6x8 had the highest negative d1 values, whereas, cross 6x7 followed by 6x8 and 5x8 had the highest negative d2 values. In the second season, d1 and d2 values ranged from -46.6 to 61.2 per cent and -54.5 to 24.1 per cent respectively. 6 d1 values and 1 d2 value were significantly positive, whereas, 7 d1 values and 17 d2 values were significantly negative, of which cross 8x9 followed by 1x9 and 2x9 recorded the highest negative d1 and d2 values.

Comparing S1 and S2, S1 resulted in lower percentage of deshaped fruit than S2. Crosses with increased percentage of deshaped fruit behaved uniformly in both the seasons.

4.2.6.25. Marketable fruit yield per vine: In the first season, d1 and d2 values ranged from -20.9 to 295.1 per cent and -40.8 to 262.3 per cent respectively. 75 per cent of the crosses had significant positive d1 values

Table 15 (Contd.)

		Fruit yield/vine											
		Per cent deshaped fruit						Markettable					
		S2			S1			S2			S1		
		MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
		Unmarkettable						Total					
		S2	S1	MP	BP	S2	S1	S2	S1	MP	BP	S2	S1
1x2	-0.3	-14.1*	13.1	5.1	64.6*	51.3	83.2**	67.3**	53.8**	21.2	139.1**	130.1**	58.6**
1x3	-2.3	-5.8	9.1	6.4	91.6**	65.5	67.3**	62.7**	86.5**	72.5**	94.6**	81.8**	89.3**
1x4	-33.1**	-45.4**	-17.3	-30.6**	295.1**	206.3**	67.7**	57.1**	67.9**	31.9	24.1	-1.2	157.2**
1x5	-3.2	-19.6**	-2.3	-12.4	86.6**	56.3	22.0	9.1	56.0**	21.1	53.8*	45.8	63.7**
1x6	-5.3	-20.0**	-15.3	-22.4*	134.3**	105.0**	68.4**	63.1**	103.3**	61.7**	18.1	-1.6	116.7**
1x7	42.7**	2.9	43.3**	3.7	9.2	-22.5	29.2	4.1	115.4**	85.2**	80.6**	40.7	41.2**
1x8	53.4**	21.7**	3.2	-3.7	40.7	31.5	45.8*	35.5	186.0**	125.0**	32.5	27.9	97.1**
1x9	-47.6**	-54.7**	-37.8**	-43.6**	191.3**	171.3**	52.9*	52.9*	-7.9	-28.1*	-26.5	-38.8**	79.9**
2x3	-6.6	-22.0**	-2.4	-7.1	59.3*	28.2	71.4**	52.7*	39.4**	16.9	58.3**	53.5**	48.8**
2x4	-57.9**	-60.6**	-41.7**	-53.8**	188.3**	138.8**	114.6**	84.8	-38.4**	-38.7**	-2.8	-24.7	48.3**
2x5	-30.5**	-33.5**	-24.9**	-27.8**	129.8**	107.5**	37.6	13.6	-7.9	-9.8	9.0	7.3	38.1**
2x6	-41.2**	-42.5**	-22.4**	-23.6**	100.0**	89.6**	24.9	10.8	-33.0**	-33.9**	-20.7	-31.8	13.9
2x7	-7.1	-38.7**	25.0*	-13.5	24.0	-16.2	0.0	-24.7	-23.4	-12.7	51.8	15.1	23.8
2x8	-18.4	-41.9**	-11.0	-22.4*	106.3**	78.3	109.7**	79.3*	26.1	-16.1	68.8**	57.0*	68.3**
2x9	-30.2**	-30.4**	-32.7**	-34.5**	141.2**	137.7	86.3**	70.2*	7.9	6.6	-11.7	-24.0	56.3**
3x4	-16.2	-33.5**	30.2**	7.9	90.9**	33.6	5.7	1.7	39.7**	16.8	69.3*	28.3	62.0**
3x5	-9.2	-26.8**	8.4	-0.6	104.9**	52.7	-42.1*	-47.0	69.5**	39.8**	-4.6	-6.1	85.3**
3x6	1.8	-16.5**	-1.3	-7.5	60.0*	23.6	8.6	8.1	72.3**	46.1**	4.4	-7.8	66.6**
3x7	72.5**	27.3**	61.2**	14.9	-20.9	-37.7	-14.3	-29.4*	117.1**	75.0**	97.3**	46.5	20.5
3x8	41.6**	15.6	12.1	24.1*	92.1**	76.4	25.5	19.8	215.9**	135.0**	48.6	34.3	137.5**
3x9	-20.1**	-33.2**	-10.5	-17.0*	146.9**	100.9	-2.8	-5.5	62.2**	34.7**	-26.3	-34.9	102.1**
4x5	-36.3**	-37.6**	12.3	-13.6	273.5**	238.9**	-21.9	-25.8	22.3*	20.3	25.2	-4.2	94.7**
4x6	-54.1**	-55.9**	-15.9	-34.2**	282.7**	231.7**	13.0	9.2	-21.4	-22.7	-31.1	-51.9**	72.2**
4x7	-26.2	-52.8**	39.1*	15.4	25.1	-23.0	8.7	-7.6	9.5	-22.7	73.7	68.6	33.5*
4x8	-37.8**	-57.3**	10.1	-1.7	101.5**	48.9	10.8	9.9	-22.8	-48.7**	20.6	-1.3	35.2*
4x9	-42.2**	-45.9**	13.3	-12.1	202.7**	147.8**	10.3	3.4	2.5	1.7	33.3	-7.0	66.6**
5x6	5.6	3.3	-13.9	-16.0	35.1	28.3	21.8	12.1	63.9**	58.5**	15.6	0.8	54.5**
5x7	-3.7	-37.8**	0.4	-32.0**	-7.8	-40.8**	7.3	-4.7	1.2	-29.3*	65.3	23.9	-4.1
5x8	-40.7**	-58.9**	-34.7**	-45.0**	232.9**	164.1**	44.7**	38.6	18.5	-21.9	-14.8	-21.9	120.8**
5x9	-19.8**	-23.4**	1.8	0.6	155.3**	127.5**	-46.6**	-52.3**	47.5**	46.3**	-28.9	-38.0*	83.7**
6x7	-42.5**	-62.5**	1.4	-30.4**	90.4**	25.1*	-18.1	-32.4	-4.9	-32.2*	-26.6	-49.6**	52.8**
6x8	-44.5**	-61.0**	-10.5	-23.0**	153.9**	109.8**	-10.3	-14.0	-15.6	-43.5**	-32.1	-45.0*	69.2**
6x9	-53.3**	-54.5**	-6.1	-7.3**	287.6**	262.3**	-10.7	-13.5	-10.2	-12.4	-22.5	-22.5	90.7**
7x8	69.0**	48.1**	39.8**	6.0	15.2	77.2**	-27.8	-38.2**	142.2**	118.4**	3.1	-17.5	45.9**
7x9	-28.3**	-52.6**	-5.8	-35.8**	77.7**	20.9	39.4*	12.4	15.3	-19.0	17.5	-19.4	53.0**
8x9	-44.6**	-60.5**	-46.6**	-54.5**	102.5**	77.2**	11.1	3.3	-31.3	-54.5**	-52.2*	-61.2	36.3*

*Significant at P=0.05; **Significant at P=0.01.

and 45 per cent of the crosses had significant positive d2 values. Only one cross (4x7) had significant negative d2 value. Cross 6x9 followed by 6x9, 4x6, 4x5, 5x8, 1x9 and 2x4 had high positive d1 values, whereas, cross 6x9 followed by 4x5, 1x4 and 1x9 had high positive d2 values. In the second season, d1 and d2 values ranged from -44.6 to 114.6 per cent and -52.3 to 84.8 per cent respectively. 33 per cent of the crosses had significant positive d1 values, whereas, 25 per cent of the crosses had significant positive d2 values. 2 crosses recorded significant negative d1 values and 3 crosses recorded significant negative d2 values. Of which, cross 2x4 followed by 1x2, 2x3, 1x4 and 1x3 had highest positive d1 values, whereas cross 2x4 followed by 2x8, 2x9, 1x2, 1x6 and 1x4 had highest positive d2 values.

Comparing S1 and S2, cross 2x4 behaved consistently, whereas crosses 4x5, 6x7, 6x8, 6x9 and 3x9 behaved in contrasting manner. In general, crosses with parent 7 resulted in low marketable fruit yield per vine. Whereas crosses involving parents 6 and 4 resulted in high marketable yield per vine.

4.2.6.26. Unmarketable fruit yield per vine: The range of d1 and d2 values were from -38.4 to 215.9 per cent and -54.5 to 135.0 per cent respectively in the first season,

with, 17 d1 values and 12 d2 values being significantly positive and 2 d1 values and 8 d2 values being significantly negative. Crosses 2x4, 2x6, 4x8 and 4x6 recorded high negative d1 values, whereas cross 8x9, 6x8, 2x4 and 2x6 recorded high negative d2 values. In the second season, d1 and d2 values ranged from -52.2 to 139.1 per cent and -61.2 to 130.1 per cent respectively. 8 d1 values and 4 d2 values were significantly positive, whereas, only one d1 value and 5 d2 values were significantly negative, of which, crosses 1x2 and 8x9 had the highest positive and negative values respectively.

In general, crosses with parents 1 and 3 as one of the parents resulted in higher unmarketable yield. The performance of the crosses was nearly uniform over seasons, with a higher degree of unmarketable yield in the second season.

4.2.6.27. Total fruit yield per vine: IN the first season, d1 and d2 values ranged from -4.1 to 157.2 per cent and -16.7 to 145.4 per cent respectively. 89 per cent of the crosses had significant positive d1 values, whereas 75 per cent of the crosses had significant positive d2 values, of which, cross 1x4 followed by 3x8, 5x8, 1x6 and 1x8 had highest positive d1 and d2 values.

None of the crosses recorded significant negative heterosis. In the second season, d1 and d2 values ranged from -42.0 to 107.5 per cent and -45.0 to 99.5 per cent respectively. 28 per cent of the crosses had significant positive d1 values, whereas, 3 crosses each had significant negative d1, significant negative and positive d2 values, of which, crosses 1x2 and 5x9 had the highest positive and negative d1 and d2 values respectively.

Comparing S1 and S2, the crosses exhibited only 25 per cent positive heterosis in S2 of that observed in S1. Crosses with parent 1 resulted in high positive heterosis in both the seasons, whereas, crosses involving parents other than parent 1 resulted in a low positive or high negative heterosis in S2, in contrast to high positive heterosis in S1.

DISCUSSION

V. DISCUSSION

Cucumber is regarded as an economic crop in India. The present status of the crop is spelt through the modified cultural practices and plant production measures. Evidence to show the genetic increases in the economic yield is meagre and ways to push back the yield or productivity barriers is still a need. The first step for achieving genetic improvement in yield is understanding the genetic parameters via., variability, heritability pattern, genetic gain achievable, and correlation between characters. The second step being, selection of genotypes with desired genetic background and its involvement in a definite procedural pattern. The third step would be the analysis of the results obtained through the procedural handling of the genotypes with desired genetic background. The last step would be charting out breeding programmes based on the information on combining ability, gene action and the heterosis patterns obtained through the analysis of the resultant data.

5.1. VARIABILITY

Cucumber breeders althrough have observed limited variability in the germplasm. However, it sounds

pertinent to look into the available germplasm for variability. Hallauer and Miranda (1982) opine, the choice of germplasm, either fortuitous or planned to play an important role in any breeding programme, whether an applied programme for inbred development or population improvement or a selection study comparing breeding methods. There are certainly differences among breeding populations and the particular choice of germplasm deciding the ultimate success or failure of selection. In the present study, 22 accessions of cucumber representing both of indigenous and exotic origin were evaluated for their genetic potential.

The analysis of variance revealed a wide range of variability among the 22 accessions for all the characters studied excepting number of branches per vine and flesh thickness. This was confirmed by the wide range of phenotypic and genotypic coefficient of variability observed for all the characters. The results were in partial confirmation with the works of Solanki and Seth (1980). Among the characters observed marketable fruit yield per vine had the highest genotypic coefficient of variation. Other parameters such as number of unmarketable fruit per vine, number of marketable fruit per vine, per cent deshaped fruit and fruit fresh weight loss at

storage had moderate coefficient of genotypic variation, indicating the heritable portion of the total variation existing in the population. The phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters indicating greater role of environment played in the manifestation of these characters.

5.2. HERITABILITY AND GENETIC GAIN

Heritability estimates in the broad sense include both additive and non-additive gene effects and in the narrow sense includes only additive effects. Since, heritability estimates fluctuate in interaction with the environment as well as genetic background, it should be studied along with the genetic gain for characters in concern for effective and a pin point selection (Johnson et al., 1955b; Swarup and Chaugale, 1962; Hanson, 1963; Panse, 1942).

In the present study, characters such as marketable fruit yield per vine, per cent deformed fruit and number of marketable fruit per vine had high heritability and genetic gain. It shows genotypic variance for these characters to be due to high additive gene effect (Panse, 1957). Selection based on phenotypic performance

of these characters would be useful for achieving desired results. Total fruit yield per vine had moderate heritability value coupled with a moderate genetic gain suggesting the role of both additive and non-additive gene action in the expression of the trait. Characters fruit size, cavity shape, number of nodes per vine, seed maturity rate, fruit fresh weight loss at storage (10 DAS), days to first harvest, total number of fruit per vine, average fruit weight, cavity size, fruit shape, specific leaf area, node of first female flower emergence, internodal length, specific leaf weight, number of branches per vine and flesh thickness had moderate to low heritability values with relatively low genetic gain indicating the predominant role of non-additive gene action, suggesting, selection based on these characters to be very slow.

5.3. CORRELATION OF CHARACTERS

Genotypic correlation between different traits may arise because of linkage, pleiotrophy or developmentally induced functional relationships (Harland, 1939). It is only natural, therefore that attention is given to associations among traits during selection and testing of genotypes. Indirect selection will be effective if (a) heritability of the secondary trait is greater than that

of the primary trait and (b) the genetic correlation between them is substantial (Hallauer and Miranda, 1982).

5.3.1. Association of total fruit yield and other traits

Total fruit yield had significant positive genotypic correlation and high coheritability with number of nodes per vine, number of branches per vine, number of marketable fruit per vine, total number of fruit per vine and marketable fruit yield per vine, whereas, it had negative genotypic correlation coupled with high coheritability for characters internodal length, cavity size and per cent deshaped fruit.

Total fruit yield per vine had high significant positive phenotypic correlation with characters such as number of marketable fruit per vine, total number of fruit per vine and marketable fruit yield per vine. This finding was in confirmation of the works of ChouWdhary and Mandal (1987). Whereas, environmental correlations were significant with total number of fruit per vine and, marketable and unmarketable fruit yield per vine indicating the influence of environment in expression of these traits. This confirmed with the findings of Rastogi and Deep (1990).

The results indicate that vines with profuse branching, more number of nodes and yielding higher

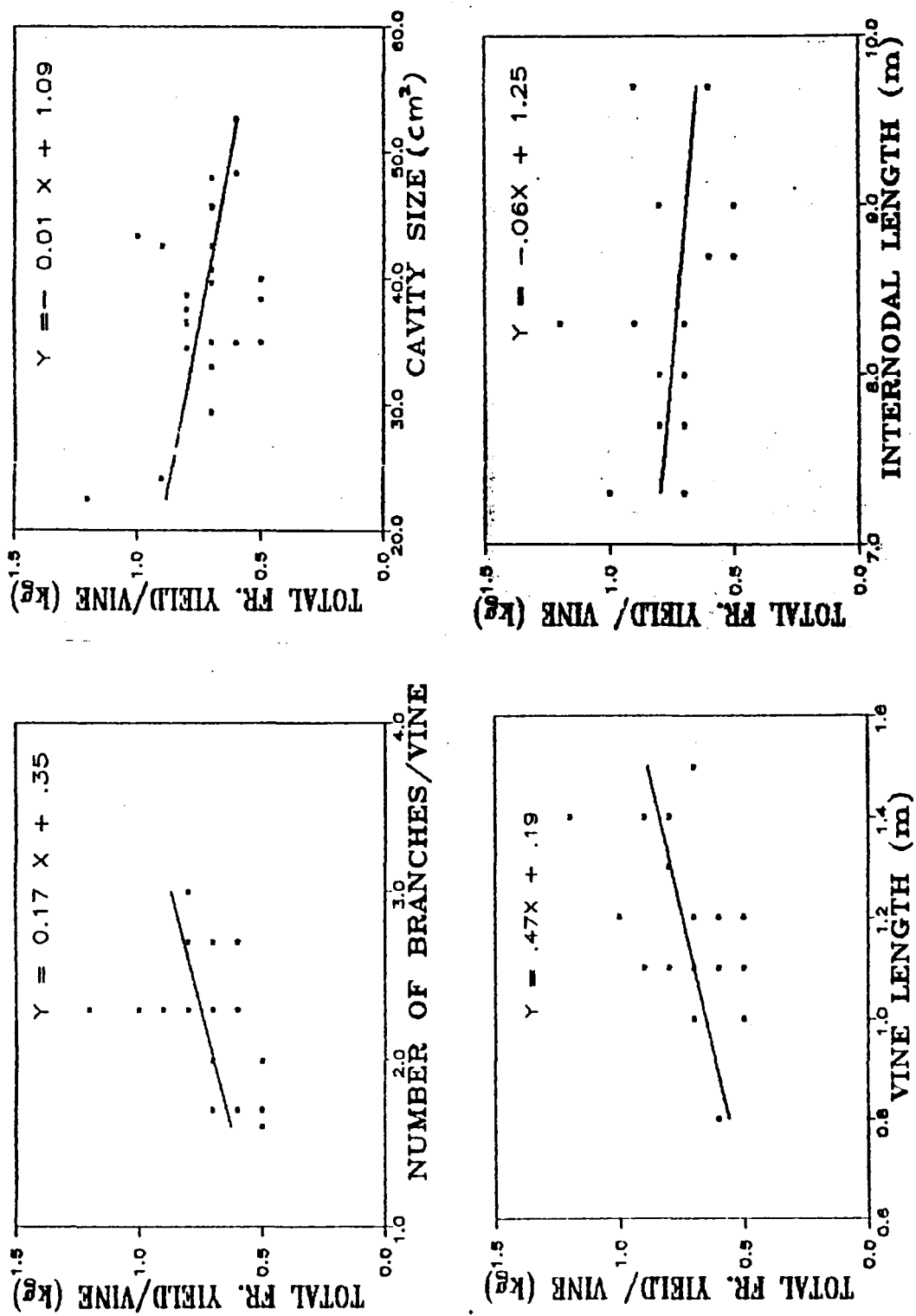


Fig. 1: Relationship between the yield and yield components in 22 genotypes of cucumber.

number of marketable fruit would result in higher fruit yield per vine. Selection for these traits would thus result in high yielding vines.

5.3.2. Association of per cent deshaped fruit and other traits

The need to study the importance of per cent deshaped fruit in cucumbers, arises from the fact that, the increase in yield gained in terms of breeding elite inbreds or through heterosis in the hybrids, is nullified by the high proportion of deshaped fruit in inbreds/hybrids with the ability to putforth more number of fruit per vine. Deshaped fruit constitutes the unmarketable proportion of the total yield keeping in view the total absence of any other damage (external or internal) rendering it to be unfit for marketability. In the present study, every possible care was taken so as to reflect the intrinsic capacity of the inbred/hybrid to result in deshaped fruit synonymous to unmarketable fruit. The parameter per cent deshaped fruit is discussed giving prime importance and no earlier reports are available in this direction.

Highly significant and positive genotypic correlations and coheritability was observed with characters

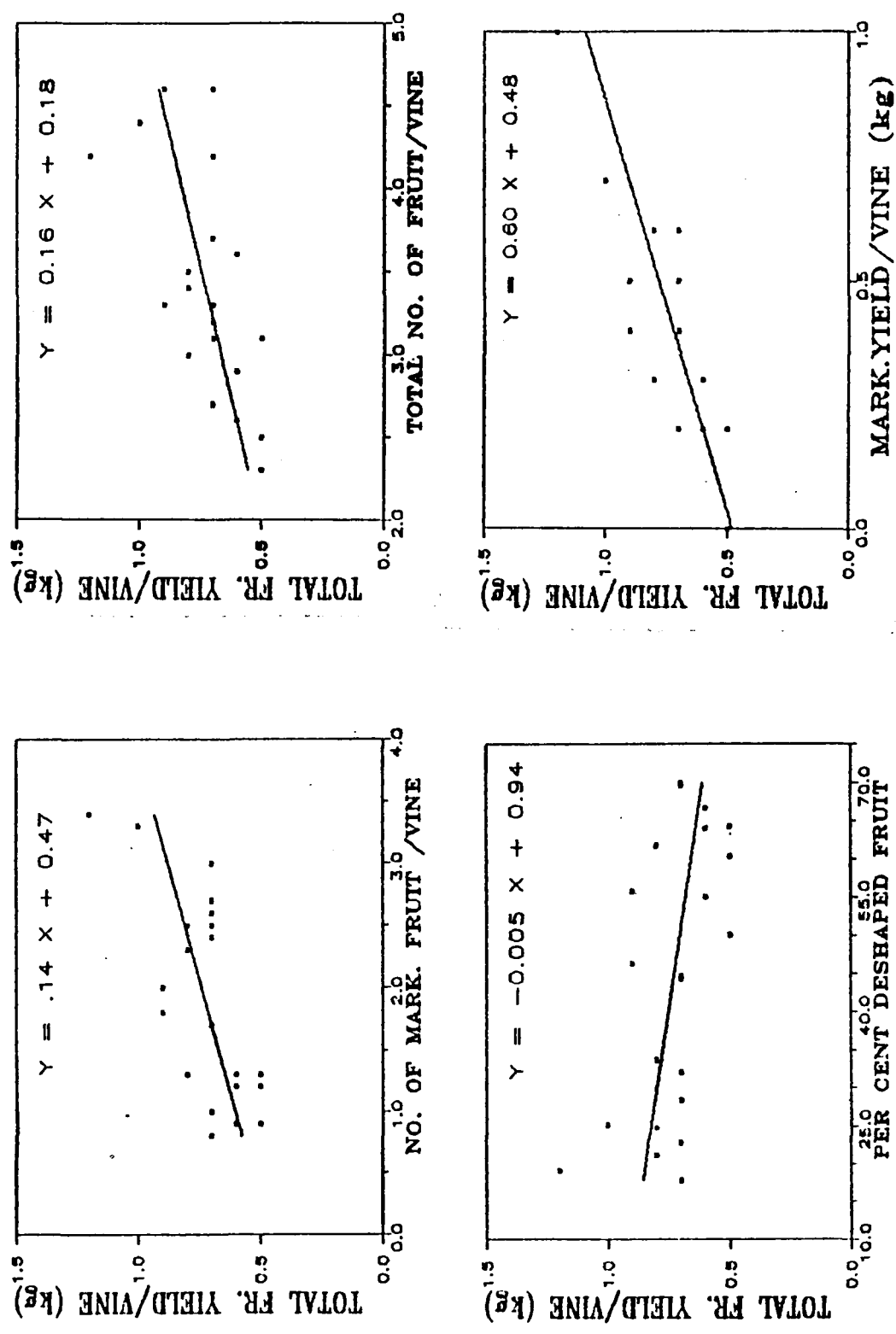


Fig. 2: Relationship between the yield and yield components in 22 genotypes of cucumber.

internodal length, specific leaf weight and fruit fresh weight loss at storage (10 DAS). Per cent deshaped fruit had negative genotypic correlation coupled with coheritability with the yield.

Environmental correlation was negative and significant with the trait fruit shape, whereas, genotypic correlation were negative with character number of node per vine, number of marketable fruit per vine, marketable fruit yield and total yield of fruit per vine.

Thus, vines with high internodal length lesser number of nodes per vine and high specific leaf weight after the second harvest resulted in more number of deshaped fruit per vine. Deshaped fruits were found to lose weight to a higher degree than the marketable fruit under storage conditions. More deshaped fruit indicated a low marketable yield thus varieties with very low deshaped fruit percentage would result in more number of marketable fruit per vine resulting in higher fruit yield per vine.

5.3.3. Association of earliness (days to first harvest) with other traits

The genotypic correlation coefficient was positive coupled with high coheritability with traits like

internodal length, cavity shape, average fruit weight and fruit fresh weight loss at storage, whereas, the genotypic correlation coefficient was negative with rind toughness, flesh thickness, number of unmarketable fruit per vine and total number of fruit per vine.

Phenotypic correlation coefficient was positive and significant with characters average fruit weight and environmental correlation was not significant with any of the trait.

The results indicate that early varieties have lower internodal length and cavity shape coupled with low average fruit weight. Also, early varieties bear fruit with tough rind, high flesh proportion, and more number of unmarketable fruit per vine.

5.3.4. Association of seed maturity rate with other traits

Seed maturity in cucumbers, is associated with loss in flesh firmness, crispness, taste and the edible cavity portion of the fruit. Presence of immature seeds is the primary concern in salad cucumbers. Many earlier workers have also reported the presence of seeded fruit to inhibit the growth of other fruit on the vines (Lower and Edwards, 1986). However, there are no reports

available correlating seed maturity rate with other parameters. Thus, an effort has been made in the present study to look into the possibility of identifying slow seed maturing types.

Number of nodes per vine and number of branches per vine had positive genotypic correlation with seed maturity rate, whereas, characters like internodal length, specific leaf weight, fruit size, cavity size, fruit fresh weight loss at storage and average fruit weight had high negative genotypic correlation.

Seed maturity rate did not have significant phenotypic and environmental correlation with any of the traits, indicating environment to play a very meagre role in the expression of the trait.

The findings reveal that vines with profound branching and more number of nodes result in faster seed maturity, whereas, vines with longer internodes and higher specific leaf weight result in slower seed maturity of fruit. It is also evident that larger fruit size, cavity size and average fruit weight would result to slow seed maturity.

5.3.5. Association of fruit characters with other traits

Genotypic correlation for fruit size was highly significant and positively coupled with high

coheritability for traits like fruit shape, cavity size, cavity shape and flesh thickness, whereas, the genotypic correlation was negative with seed maturity rate. The results were suggestive of larger fruit size to be contributed by the length of the fruit and consequent increased cavity size and cavity shape. Larger the fruit size higher was the flesh thickness.

Cavity size and cavity shape had positive genotypic correlation coupled with high coheritability with flesh thickness and fruit size, whereas, cavity size had negative genotypic correlation with seed maturity rate, indicating faster seed maturing genotypes to have smaller sized cavity and a resultant smaller sized fruit.

Rind toughness showed positive genotypic correlation and high coheritability with flesh thickness and total number of fruit per vine, but, negatively correlated with days to first harvest and average fruit weight. Flesh thickness had negative genotypic correlation and high coheritability with days to first harvest and fruit fresh weight loss at storage.

Environmental correlation was significant and negative between characters like fruit shape and per cent deshaped fruit. This fact suggested that longer fruit

resulted in lower per cent deshaped fruit and strongly controlled by environment.

5.4. DIALLEL ANALYSIS

Jinks and Hayman (1953) and Hayman (1954a) developed diallel cross method to evaluate systematically the inbred performance in F_1 combination. This technique also provides an analytical tool to estimate the combining ability of the parents under selection and to evaluate the selection potential of individual crosses (Griffing, 1956a). The diallel analysis also provides information on heterosis.

General and specific combining ability effects were estimated in the present study under method 2 and model I. In model I, the parents are a sample of genotypes under consideration and the estimates apply only to the genotypes included and cannot be extended to some hypothetical reference population (Griffing, 1956b).

Baker (1978) observed two assumptions to be critical in attempting to interpret the results of diallel analysis. The assumption concerning the independent distribution of genes in the parents is most important to proper interpretation and seems to be least acceptable in actual practice. The second assumption that there is no

epistasis, may frequently be incorrect. Epistasis, affects estimates of gca and sca mean squares, variances and its effects in an unpredictable manner. As an alternative to genetic interpretation, the statistical description provided by diallel analysis can be used to help answer questions concerning the importance of SCA and the predictability of hybrid performance using GCA or parental performance.

5.4.1. Validity of assumptions

The assumptions developed by Hayman (1954b) were diploid segregation, no reciprocal differences, homozygous parents, no multiple alleles, uncorrelated gene distribution and no epistasis.

Cucumber (Cucumis sativus L.) is a true diploid with a basic chromosome number $n=7$. It has seven pairs of chromosomes ($2n=2x=14$), cytologically stable, with no natural polyploids present in the species (Whitaker and Davis, 1962; Deakin et al., 1971; Robinson et al., 1976). Works have revealed the absence of any reciprocal differences (Della Veechia, 1982; El-Shawaf and Baker, 1981a, 1981b; Miller and Quisenberry, 1976; Staub and Kupper, 1985). Cucumber is a highly cross pollinated crop. The homozygosity of the parental lines used in the present

study was achieved to a considerable level by following selfing over several generations. The germplasm maintained at the Division of Vegetable crops, Indian Institute of Horticulture Research, Hesaraghatta, Bangalore was used in the present study. Jinks and Hayman (1953) proposed homozygosity of parents as an essential assumption to diallel analysis. Dickinson and Jinks (1956) who generalised the method of analysis of diallel crosses showed that parental heterozygosity was not likely to be serious enough to distract the genetic interpretations. Kempthorne (1956) also stated that it is not essential that the parents should be homozygous and it is enough if the parents have the same coefficient of inbreeding. The other three assumptions are fulfilled, looking into the t^2 estimates for all the characters observed (which proved non-significant for all characters). However, Kempthorne (1956) is of the opinion that absence of multiple allelism and uncorrelated gene distribution have little effect over the estimates of the gene frequency. Partial failure of certain of these assumptions seems unlikely to be large enough to disturb the genetic analysis of the data (Crumpaker and Allard, 1962). When a trait exhibits partial failure of assumptions, analysis and interpretation of the population parameters are still possible, although estimates for such a trait are probably less precise (Hayman, 1954b).

Presence of gene action based on the genetic analysis for the traits studied presently is not of much concern considering the views put forth by various earlier workers (However, the gene action involved in the expression of the traits considered in the present study are presented below). Thus, the focus is diverted to the information drawn from the mean performance, combining ability and heterosis. The genetic nature of the crop is considered in this context.

5.4.2. Gene action

Diallel analysis in both the seasons revealed the importance of both additive and non-additive gene action for all the yield and yield components. However, predominant role of non-additive gene action was recorded for characters like fruit yield per vine (marketable, unmarketable and total), number of fruit per vine (marketable, unmarketable and total), per cent deshaped fruit, node of first female flower emergence, days to first flowering, days to first harvest, vegetative and growth characteristics, seed maturity at harvest, fruit fresh weight loss at storage, and other fruit characteristics. Average fruit weight, cavity size and cavity shape on the other hand had predominant non-additive gene action in the first season, whereas, additive gene action predominated

in the second season in the expression of these traits. These results were in confirmation with the earlier reports of Shifriss and George (1965), Ghaderi and Lower (1979a, 1979b), Wang and Wang (1980), El Shawaf and Baker (1981a), Dolgikh and Sidonova (1983), Owens et al. (1985b), Prudek (1986) and Fredrick and Staub (1989). Whereas, it contradicted from the findings of Smith et al. (1978), Tasdighi and Baker (1981), Solanki and Seth (1981), Lower et al. (1982), Neinhuis (1982), Prudek and Wolf (1985), Kupper and Staub (1988) and Fredrick and Staub (1989). Earlier studies reported by various workers have focussed on one season data, whereas, in the present study the gene action is reported for two seasons. The shift from additive to non-additive gene action has been observed depending on the favourable environment for growth and productivity in sorghum (Bijapur, 1979). The present work has also shown the predominance of non-additive gene action for most of the characters. Predominance of additive gene action for the expression of characters like average fruit weight, cavity size and cavity shape in the second season reveals the poor performance of the F_1 s.

5.4.3. Per se performance, combining ability and heterosis

The performance of an inbred line can be determined from yield test per se. However, a high yielding

inbred may not necessarily be able to transmit its superiority in cross combinations. The average performance of a line in a number of cross combinations provides an estimate of the general combining ability which is a more reliable test. Further, specific combining ability provides an idea of the performance of a particular cross combination against the expectation from the performance of the parent. Combining ability analysis would therefore be useful in the proper choice of parents and secondly in identifying a particular cross combination. Heterosis observed in such selected cross combinations would further add to the usefulness of selecting specific cross combinations. The summarised data of the present findings based on per se performance, combining ability and heterosis has been presented in Tables 16 and 17.

Combining ability estimates for all the yield and yield components has revealed that cross combinations exhibiting significant specific combining ability involved parents with either high x high gca, high x low gca or low x low gca. In the first season, 14 per cent of the crosses had high x high gca, 57 per cent of the crosses had high x low gca and 29 per cent of the crosses had low x low gca. In the second season, 12 per cent, 58 per cent and 30 per cent of the crosses had high x high,

Table 16. F₁ crosses showing significant sca effects

Characters	Parents with gca					
	High x High		High x Low		Low x Low	
	S1	S2	S1	S2	S1	S2
Node of first female flower emergence	2x7	2x8	1x5, 1x7, 2x3, 2x4, 3x5, 3x7, 4x6, 6x9	2x3, 2x5, 4x8, 6x9	4x8, 4x9, 8x9	-
Days to first flowering	2x6, 6x8	1x7	1x2, 2x9, 4x6, 4x8, 5x8, 6x7	4x6	1x4, 1x5, 3x9, 4x5, 5x7, 5x9	4x8
Days to first harvest	6x8, 6x9, 8x9	-	1x2, 1x5, 2x6, 2x8, 2x9, 3x9, 4x6, 4x8, 5x8, 6x7	1x9, 2x6, 4x6, 4x7	3x4, 5x7	2x5, 2x9, 4x8, 5x9
Vine length	6x7	1x2	4x7, 5x6, 7x9	1x5	5x8, 8x9	5x9, 6x9
No. of nodes/vine	-	6x7	4x5, 5x8	1x2, 2x5	1x4, 8x9	5x9
Internodal length	1x6	-	1x3, 1x4	-	2x3, 2x8, 5x9	6x7
No. of branches/vine	-	-	-	4x8, 5x6, 5x7	-	-
Specific leaf area	-	3x6	4x7	2x7, 4x5, 4x9, 5x8	-	1x2, 1x8, 6x7
Specific leaf weight	-	1x4	6x7	1x7, 2x3, 2x6, 3x4, 4x6	-	3x5, 6x8, 6x9
Fruit size	3x6, 4x5, 4x6	-	2x6, 3x7, 4x8, 6x9	6x9	1x9	-
Fruit shape	-	-	4x9, 5x6	4x8, 5x6	-	-
Cavity size	-	2x4	2x9	6x8	-	-
Cavity shape	-	-	2x5, 5x9	-	6x7	1x6
Rind toughness	-	-	-	3x5, 4x8, 4x9, 5x6	2x7, 3x9, 6x9	2x7, 2x8, 3x7, 3x8, 6x7, 6x9
Flesh thickness	-	-	1x3, 4x6, 4x8, 5x8	1x4	-	1x2
Seed maturity at harvest (11 DAS)	-	4x5, 8x9	-	3x8, 7x8, 7x9	-	1x2
Seed maturity at harvest (16 DAS)	2x9	-	-	1x8, 1x9, 3x5, 4x5, 5x6, 6x7, 7x8, 7x9	-	6x8, 8x9
Fresh fruit weight loss at storage (5 DAS)	-	1x8	-	1x5, 2x3, 2x4, 3x6, 3x8	-	3x5, 7x9
Fresh fruit weight loss at storage (10 DAS)	-	1x2, 1x8, 6x8	-	1x5, 1x7, 1x9, 2x3, 2x4, 3x6, 3x8	-	-
Average fruit weight	-	2x6	6x7	-	-	-
Per cent deshaped fruit	-	2x5	2x4, 4x5	1x4, 1x9, 2x4, 2x9	4x6, 6x7, 6x9	4x6, 8x9
No. of marketable fruit/vine	-	-	1x4, 2x4, 7x8, 7x9	1x4, 2x4, 7x9	1x3, 5x8, 6x9	1x3, 2x8, 2x9, 5x8
No. of unmarketable fruit/vine	8x9	-	5x7	1x9, 2x5, 5x8	2x4	2x4, 2x6, 8x9
Total No. of fruit/vine	-	1x7	1x3, 1x4, 1x5, 5x8, 7x8, 7x9	1x2, 1x3, 1x4, 1x5, 3x8, 7x9	-	2x8
Marketable fruit yield/vine	6x7	2x4, 2x5	4x6, 5x8, 6x9	1x3, 1x6, 2x3, 2x9, 5x8	1x4	5x6, 7x9
Unmarketable fruit yield/vine	-	3x5	2x5, 5x7	1x9, 2x4, 2x6, 3x9	-	6x7, 8x9
Total fruit yield/vine	1x2, 1x3	3x9	1x6, 2x4, 2x8	1x4, 1x6, 3x5, 3x8, 5x9, 6x9, 7x9	5x6, 5x7, 7x9	4x5, 5x8, 6x7

Table 17. Best general combiners and best specific crosses for 27 characters in cucumber

Characters	Parents with high mean performance (in desired direction)		Parents with significant gca		Hybrids with significant sca effect and heterosis over mid-parental value in favourable direction	
	S1	S2	S1	S2	S1	S2
Node of first female flower emergence	4, 1, 3, 8	3, 1, 4, 8	4	4	4x9, 6x9	6x9
Days to first flowering	5, 3, 1, 7, 9	9, 1, 8	5	9	1x5, 4x6, 5x8, 6x7, 6x8 and 10 other crosses	-
Days to first harvest	5, 3, 2, 7, 9	9, 1, 3	5	2, 9	1x5, 4x6, 6x7, 6x8 and 10 other crosses	1x9, 2x5, 2x6, 2x9, 4x6, 4x7, 4x8, 5x9
Vine length	1, 2, 3, 7	5, 8	6	2	4x7, 5x6, 5x8, 6x7, 7x9, 8x9	1x2, 2x5, 5x9, 6x9
No. of nodes/vine	7, 3, 6, 2	8, 7, 5	7	7, 8	1x4, 4x5, 5x8, 8x9	1x2, 6x7
Internodal length	7, 9, 5	9, 8	8, 3	-	1x3, 1x4, 1x6, 2x3, 2x8	6x7
No. of branches/vine	1, 3, 4, 5, 7	1, 3, 5, 9	-	-	-	4x8
Specific leaf area	3, 5, 8, 6	9, 6, 4, 5	4	5, 9	4x7	2x7, 5x8, 6x7
Specific leaf weight	4, 2, 7, 9	7, 5	-	1, 2	-	1x4, 2x3, 2x6, 4x6
Fruit size	1, 3, 5	2, 8, 1	3, 6	-	2x6, 3x6, 3x7, 4x5, 4x6, 4x8, 6x9	6x9
Fruit shape	3, 5, 4	2, 3, 5, 9	7, 4, 5, 3	-	4x9, 5x6	4x8, 5x6
Cavity size	6, 7, 4	4, 5	-	7	2x9	6x8
Cavity shape	2, 7	1, 7, 9	7, 2	7	-	-
Rind toughness	4, 5, 1	4, 5	4, 5	4, 5	2x7, 6x9	2x7, 2x8, 3x8
Flesh thickness	7, 1, 3, 5	4, 5, 6	5, 3	1, 3	1x3, 4x6, 4x8, 5x8	-
Seed maturity at harvest (11 DAS)	5, 2, 6, 8	1, 2, 6	-	7, 2	-	3x8, 7x9, 8x9
Seed maturity at harvest (16 DAS)	3, 4, 1	9, 4, 3, 8	-	9, 4, 8	2x9	3x5, 4x5, 5x6, 6x7, 6x8, 7x8, 7x9
Fresh fruit weight loss at storage (5 DAS)	2, 7, 5	2, 4, 5	4	4, 3, 5	-	2x3, 3x6
Fresh fruit weight loss at storage (10 DAS)	5, 3, 4, 7	4, 5, 7	3, 9	4, 5, 3, 9	-	1x7, 1x8, 1x9, 3x6, 6x8
Average fruit weight	6, 9, 8, 1	2, 1, 5	6	2, 1	6x7	-
Per cent deshaped fruit	7, 8, 3, 1	7, 4, 8	8, 7	4, 7, 8	2x4, 4x5, 4x6, 6x7, 6x9	1x9, 2x4, 2x5, 2x9, 8x9
No. of marketable fruit/vine	7, 8, 3, 1	7, 4, 3, 8	7	7, 4	1x3, 1x4, 2x4, 5x8, 6x9, 7x9	1x3, 1x4, 2x4, 2x8, 2x9, 5x8, 7x9
No. of unmarketable fruit/vine	8, 7, 1	7, 4, 1, 2	8, 7, 6	8, 4	2x4	1x9, 5x8, 8x9
Total No. of fruit/vine	7, 4, 5, 3	7, 9, 3, 5	4, 3	3, 7	1x3, 1x4, 1x5, 5x8, 7x8, 8x9	1x2, 1x3, 1x4, 1x5, 1x7, 2x8, 3x8
Marketable fruit yield/vine	7, 3, 1, 8	7, 1, 3, 4, 5, 6, 8	7	1, 2	1x4, 4x6, 5x8, 6x7, 6x9	1x3, 1x6, 2x3, 2x4, 2x8, 5x8, 7x9
Unmarketable fruit yield/vine	8, 7, 1	7, 4	7, 8	7, 8, 4	-	8x9
Total fruit yield/vine	7, 2, 3, 5, 6, 9	3, 5, 9, 6, 7	1, 2	3, 9	1x2, 1x3, 1x6, 2x4, 2x8, 5x6, 7x9	1x4, 1x6

high x low and low x low gca respectively. High x high GCA indicated additive x additive type of interaction to be predominant and a portion of the heterosis was fixable. High x low gca indicated the favourable additive effect of the high parent in addition to the manifestation of the complimentary interaction effects which give high specific combining ability effects. Such combinations might throw out desirable transgressive segregants if the additive genetic system permits in the high combiner and complimentary epistatic effect present in the cross, acted in the same direction so as to maximise the desirable plant attributes. Low x low gca indicated the complementary interaction in the cross (dominant x dominant) responsible for its superior performance (Griffing, 1956a, 1956b).

The combining ability analysis over seasons indicated the presence of general/specific combiners specific to each season. This is a clear indication of the importance of conducting such studies in more number of locations and seasons. This is in confirmation with the works of Wehner et al. (1989) who opined the development of 'specialists' rather than 'generalists' to suit to very specific environmental conditions.

Heterosis (over mid parent and better parent) studies conducted for the yield and yield components

have been considered in conjunction with significant specific combiners. The present investigations revealed that, in the first season 55 per cent and 58 per cent of the crosses had heterosis over mid parent and better parent respectively, in the desired direction. Whereas, in the second season, 45 per cent and 42 per cent of the crosses had heterosis over mid parent and better parent respectively, in the desired direction. Out of the total cross combinations having significant sca and heterosis over mid parent in both the seasons, 84 per cent of the crosses had heterosis over better parent. Moll and Stuber (1974) point out that from a plant breeder's point of view, heterosis estimates should indicate whether heterozygotes or homozygotes represent the more ideal genotype. If heterosis above the better parent (over dominance) is important, then the best genotype is a heterozygote, with partial to complete dominance, the best genotype would be a homozygote. When estimates of heterosis fall above the better parent, it is tempting to conclude that this is due to over dominant type of gene action. Heterosis estimates above the better parent do not, however, necessarily indicate over dominance. Moll and Stuber (1974) found three possible genetic causes of heterosis; partial to complete dominance, over dominance and epistasis. Also, linkage between loci with partial

to complete dominance result in heterozygous effects that may mimic effects of over dominance for several generations after a cross. In addition to possible genetic causes, apparent heterozygote advantage might be a result of genotype x environment interactions (Knight, 1971).

Total fruit yield per vine recorded a mean heterosis of 66.1 per cent and 52.2 per cent over mid parent and better parent respectively in the first season. This heterotic nature reduced to 15.2 per cent and 5.2 per cent in the second season.

Mean heterosis over mid parent (MP) and better parent (BP) in two seasons (S1 and S2)

Character	S1		S2	
	MP	BP	MP	BP
Total fruit yield/vine	66.1	52.2	15.2	5.2
Total No.of fruit/vine	35.0	19.8	36.1	19.8
Per cent deshaped fruit	-14.5	-30.0	-0.8	-15.1
Average fruit weight	35.7	20.7	2.6	-5.2

The mean heterosis for number of fruit per vine remained uniform over seasons. Thus, it is clear that, considering the low negative heterosis for per cent deshaped fruit and low positive to low negative heterosis for average fruit weight in the second season, the decrease in heterosis for fruit yield in the second season

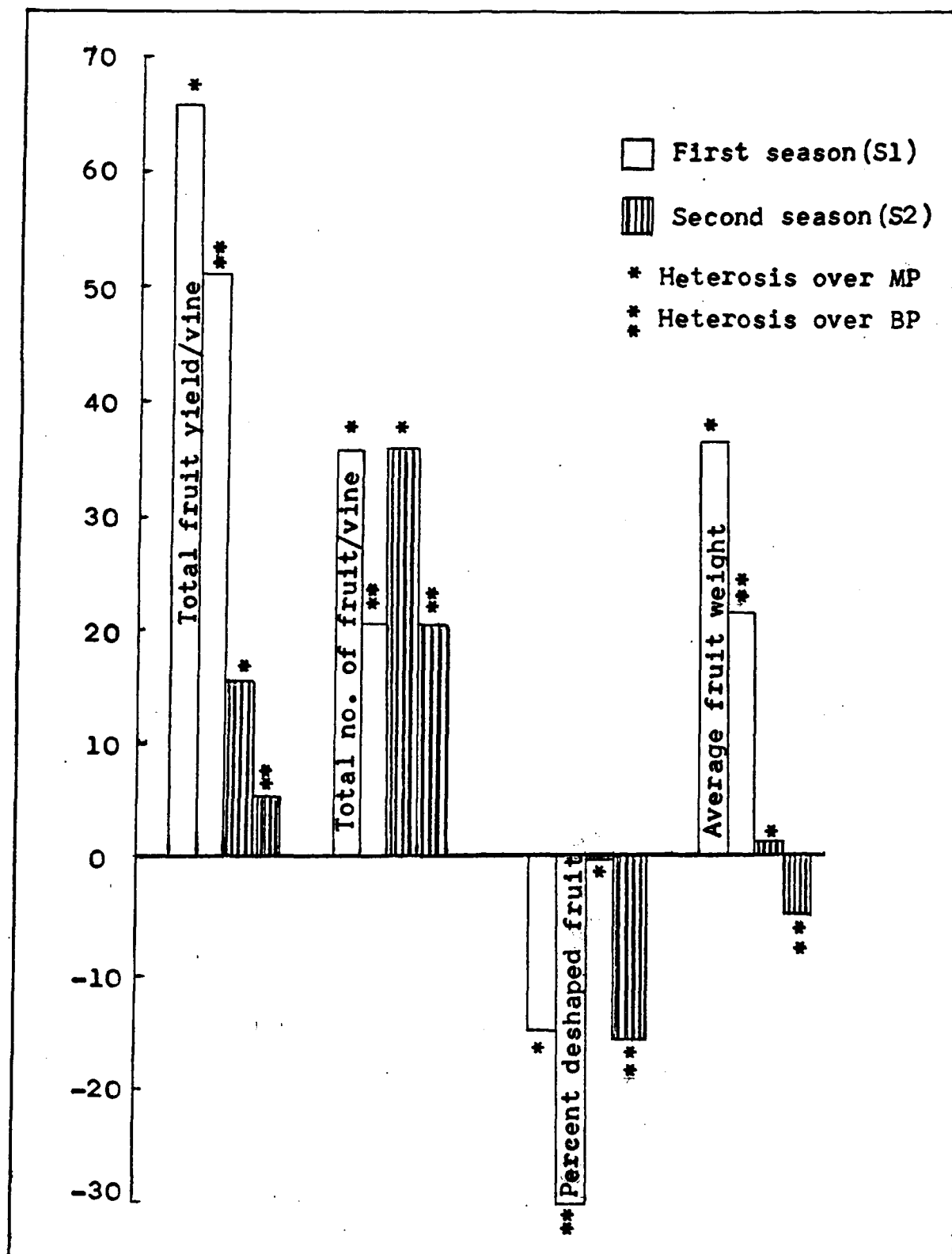


Fig. 3: Mean heterosis (%) over mid parent (MP) and better parent (BP) in two seasons (S1 and S2).

is primarily due to high percentage of deshaped fruit and low average fruit weight. However, number of fruit per vine appears to be a more stable character to be considered as a selection criterion.

Considering the contribution of each parent for the yield and yield components recorded, it was evident that parent 1 contributed for 14 characters (in desired direction), parent 2 for 17 characters, parent 3 for 15 characters, parent 4 for 19 characters, parent 5 for 15 characters, parent 6 for 21 characters, parent 7 for 18 characters, parent 8 for 22 characters and parent 9 for 19 characters in 40, 41, 23, 45, 39, 55, 32, 49 and 40 cross combinations respectively with significant sca and heterosis over mid parent in the desired direction.

Six cross combinations in the first season and two cross combinations in the second season expressed significant sca and heterosis (over MP) for total yield per vine. Crosses 1x2, 1x3, 1x4, 2x4 and 2x8 were observed to have higher yield due to more number of marketable fruit per vine. Cross 1x6 on the other hand recorded higher yields as a result of increased marketable fruit yield, consequent of high average fruit weight recorded in the parents. Cross 2x4 had low per cent deshaped fruit in addition to high number of marketable

fruit per vine. Parent 2 recorded high average fruit weight, whereas, parent 4 recorded more number of marketable fruit per vine. Thus, the balance between average fruit weight and fruit number resulted in higher yields. Hayes and Jones (1916) and Singh and Amarchandra (1970) reported that the most important character in cucumbers which may be considered as the measure of increased vigour is the number of fruit per vine.

In cucumbers, a large portion of yield gained due to heterosis is nullified by the presence of higher proportion of unmarketable fruit. Considering the total absence of any other damage caused to the fruit reducing its marketability, deshaping of cucumber fruit is considered to constitute the unmarketable portion of the total fruit yield in cucumbers in the present study. Five crosses recorded significant sca and negative heterosis, for deshaped fruit in the first and second season. The cross 2x4 behaved consistently over seasons. The other crosses had a contrasting behaviour. Cross 2x4 had high x low gca indicative of throwing out transgressive segregants in the advanced generation. Cross 2x5 had high x high gca, crosses 1x9, 2x9 and 2x4 had high x high gca and crosses 4x6, 6x7, 6x9 and 8x9 had low x low gca for the said parameter.

Considering the per se performance and general combining ability, the parents 4, 7 and 8 appeared to contribute towards low per cent deshaped fruit. However, parents 6, 9, 5, 2 and 1 with higher average fruit weight when crossed with parents with either lower per cent deshaped fruit or higher number of marketable fruit per vine recorded lower percentage of deshaped fruit, thus, indicating the optimum balance between average fruit weight and the number of fruit per vine to be a prerequisite for a genotype with low percentage of deshaped fruit.

The harvesting stage in cucumbers is decided by the fall of the spines present on the fruit, when the fruit is gently touched. Harvest after the fall of the spines leads to over maturity, whereas, intact stage of the spines results in immature fruit. Efforts have been made to reach near accuracy in deciding the harvesting dates from the day of fruit set. Seed maturity is a prime factor in deciding the quality of the fruit. Mature seeds would mean loss of flesh firmness, crispness, taste and the loss of the edible cavity portion of the fruit. The primary requirement in salad cucumbers is presence of immature seeds. Thus, in the present study an effort has been made to look into slow seed maturing

types, which would be of great help. Slow seed maturing types are beneficial not only from the quality point of view but also the yielding ability of the vine. Faster seed maturity would mean strong sink activity and thereby an inhibition of the successive fruit growth on the vine.

Post harvest quality of cucumber fruit is a complex trait to be defined. The retention of green colour of the skin (in green types) is of prime importance. Secondly, on storage the fruit starts ripening, which would result in the loss in the crispness of the flesh. The flesh becomes elastic and loses taste. The seeds reach maturity and results in splitting of the carpels. This would lead to a hollow cavity and puffy fruits. Yellowing of the skin is considered to be due to release of ethylene during storage. Fresh weight loss of fruits is one character which is causative to a chain of events explained above. In the present study, an attempt has been made to look into this aspect of post harvest quality. Fresh weight loss would mean loss in turgid nature of the fruit thus its marketability. Any fruit beyond 10 days of storage was found to lose its marketable quality. Thus, fresh weight loss after 5 days and 10 days of storage was considered in the present study. However, it calls for a critical look in this

line. Per se performance showed parents 2, 3, 4 and 6 to be slow seed maturing types in both the seasons. Although, none of the parents had significant gca in the first season, the best general combiner for both the seasons was parent 7 apart from parents 2, 4 and 9 (for second season). During the first season cross 2x9 showed significant sca and negative heterosis, whereas, in the second season 10 crosses showed significant sca and negative heterosis. Crosses 4x5, 6x7, 7x8, 7x9 and 8x9 had atleast one of the parents with significant gca. With the exception of crosses 3x8 and 5x6 the other crosses involved either two exotic lines or two indigenous lines which exhibited slow seed maturity.

Per se performance for fruit fresh weight loss at storage showed parents 2, 4, 5 and 7 to have reduced fresh weight loss at storage in both the seasons. The best general combiners for both the seasons were 3, 4 and 9. None of the crosses showed significant sca and heterosis in the first season, whereas, 14 crosses showed significant sca and negative heterosis. Crosses 1x5, 2x3, 3x5, 1x9 and 7x9 had one of the parents as best general combiners.

Earliness in cucumbers is expressed in terms of early flowering and early date to harvest. Node of first

female flower emergence is also worth considering here for discussion. Parents 1 and 9 flowered early in both the seasons, whereas, parents 3 and 9 reached harvest stage early in both the seasons. Parents 5 and 9 recorded early flowering and early harvest in first and second season respectively. In the first season 15 crosses recorded significant early flowering and early harvest, whereas, none of the crosses in the second season had early flowering, but 8 crosses recorded significant early harvest. Five crosses had high x high gca and the other crosses had high x low gca or low x low gca. Per se performance and combining ability studies put forth the fact that early flowering hybrids or hybrids reaching harvest stage at an early date had at least one parent which flowered or reached harvest date early.

The very basic need for the plant yielding ability is the vegetative growth (vine length, number of nodes per vine, internodal length, number of branches per vine, specific leaf area and specific leaf weight) put forth by the plant. Optimum vine length is essential for a resultant higher marketable and total yield potential of the vine. Six crosses in the first season and five crosses in the second season exhibited significant sca and heterosis for vine length, whereas, only one cross

(4x8 in second season) recorded significant sca and heterosis for number of branches per vine. Crosses 1x2 and 6x7 had high x high gca (vine length), whereas, cross 4x8 (number of branches) had high x low gca. The best general combiners in the first season were, parents 6 and 7 (vine length), parent 7 (number of nodes per vine), parents 8 and 3 (internodal length) and parent 4 (specific leaf area). In the second season, the best general combiners were parent 2 (vine length), parents 7 and 8 (number of nodes per vine), parents 1 and 2 (specific leaf weight) and parents 5 and 9 (specific leaf area). Apart from the cross 6x7, crosses involving parents 6 and 7 are worth considering for vigorous vine growth.

In cucumbers, the parameters like fruit size, fruit shape, cavity size, cavity shape, rind toughness and flesh thickness are considered vital in deciding the desired fruit type. Larger fruit size, fruit shape (2.8 to 3.3), rind toughness and flesh thickness, smaller cavity size and cavity shape are desirable traits in a cucumber fruit. It is evident that, in the first season the extent of heterosis for fruit size (7 crosses) was greater than in the second season (only one cross). Apart from the cross 6x9, crosses involving parent 6 in combination with other parents contributed towards desirable fruit characteristics. Cross 2x4 with low cavity

size is worth considering, keeping in view the high yielding ability of this cross as well as the high x high gca (second season) observed for cavity size. Crosses 2x9 and 6x8 had high x low gca for fruit cavity size.

The present study included both exotic and indigenous collections in the diallel crossing programme. Parents 1, 2, 6, 7, 8 and 9 were indigenous collections, whereas, parents 3, 4 and 5 were exotic collections. Indigenous x indigenous lines involved 15 crosses, in indigenous x exotic lines involved 18 crosses and exotic x exotic lines involved 3 crosses.

Heterosis is known to be a result of geographic diversity or genetic distance. High degree of heterosis manifested in the F_1 s as a result of the crosses between two indigenous lines (1x2, 1x6, 2x8, 7x9) or between indigenous and exotic lines (1x3, 2x4, 1x4) could be due to the intense artificial or natural selection carried out over the years at different locations geographically isolated from different base populations without exchange of genetic material at any stage. This had resulted in widening the genetic distance between them. Cress (1966) referred this genetic distance to the frequency of various alleles at a given locus rather than the frequency of different genotypes, to be associated positively with heterosis.

5.5. SCOPE FOR HETEROSIS BREEDING

The present study revealed the presence of a considerable amount of heterosis for the number of marketable fruit, total fruit yield, per cent deformed fruit and other characters in the desired direction. In addition, the inbreds involved in the diallel crossing were monoecious in nature. The ease with which the crossing work can be taken up and the number of seeds (150-200) obtained per cross adds to the importance of heterosis breeding. The availability of other sex types in cucumbers and its judicious use in the crossing programme by the manipulation of the sex expression, by the use of silver thiosulphate*(500-1000 ppm) further emphasises the exploitation of heterosis in cucumbers.

5.6. CHOICE OF PARENTS

The basic considerations in selecting parents for a breeding programme are the per se performance of the parents as well as their performance in hybrid combinations. Although, differences were observed over seasons, there was similarity in the performance of the parents and hybrids also. Thus, considerations are made for both the seasons simultaneously with precise mention of the parents for both the seasons separately.

*To induce maleness.

The present study revealed parents 4 and 7 to be promising parents for further consideration. These parents performed better in both the seasons. Crosses involving parents 4 and 7 as one of the parents resulted in vines bearing fruit at lower nodes, earlier harvest date, fruit with slow seed maturity rate, lower percentage of deshaped fruit and a resultant higher marketable yield and total yield per vine. Considering the marketable fruit yield, the parents 1, 2, 6 and 8 were found promising, whereas, for more number of marketable fruit per vine parents 3, 4, 5 and 7 were promising.

5.7. FUTURE BREEDING PROGRAMME

Combining ability analysis and the components of variance analysis revealed the presence of both additive and non-additive gene action in the expression of all the characters in concern. Over seasons, majority of the crosses with significant sca had either high x low gca (57-58%) or low x low gca (29-30%). This suggests to look in for transgressive segregants in the advanced generations or the direct exploitation of the hybrid vigour respectively. The proportion of the crosses with significant sca involving parents with high x high gca (12-14%) could be involved in a reciprocal recurrent selection

programme. Reciprocal recurrent selection programme could be efficient in utilising the lines with high yield potential in terms of fruit number (3, 4 and 5), fruit weight (1, 2 and 6), high vigorous plants (1, 2, 3 and 5), large fruit size and shape index (1, 2, 3 and 5), low cavity size and shape (6, 7 and 4), slow seed maturity rate (3, 4, 6 and 8), low fresh weight loss at storage (2, 4, 5 and 7) and low percentage of deshaped fruit (4, 7 and 8) with gene actions both additive and non-additive involving the expression of these traits.

5.8. CONCLUSIONS

*Correlation studies showed yield to be positively correlated with vine length, number of nodes per vine, number of marketable fruit per vine, total number of fruit per vine and marketable fruit yield per vine and negatively correlated with internodal length, cavity size and per cent deshaped fruit. Hence, a simultaneous improvement of these characters proves to be a possibility.

*Per cent deshaped fruit had a positive correlation with characters, internodal length, fruit fresh weight loss at storage and total number of fruit per vine, whereas, a negative correlation with vine length, number of

nodes per vine and specific leaf weight. Thus, consideration of these characters in selection would help reduce the proportion of deshaped fruit.

*Seed maturity rate was positively correlated with flesh thickness, whereas, negatively correlated with fruit fresh weight loss at storage and average fruit weight. Negative correlation of seed maturity rate and average fruit weight is an undesirable association. Since, higher average fruit weight had little contribution towards yield compared to the number of fruit per vine, it is essential to look for plant selections in the F_2 generations to recover plants with optimum fruit size and slow seed maturity rate.

*Combining ability studies revealed parents 9, 4, 8, 7 and 2 to be the best combiners resulting in slow seed maturing genotypes. However, parent 9 exhibited a significant general combining ability resulting in slow seed maturing types.

*Parents 7 and 8 were found to be the best combiners resulting in lower per cent deshaped fruit. However, for higher marketable yield, besides parents 7 and 8, parents 1, 2, 6 and 9 were found to be promising. For number of marketable fruit per vine parents 7, 8 and 4

were considered to be promising, the same being true for the total number of fruit per vine. Parents 1 and 2 were considered the best for improving the total fruit yield per vine.

*Considering the over all picture through heterosis, gene action and combining ability studies, it was difficult to pickout parents for all the desirable traits. Thus, parents 1, 2 and 6 for high yield, parents 7, 8, 4 and 9 for slow seed maturity rate and parents 7, 8 and 4 for reduced per cent deshaped fruit were ideal. Thus, use of these parents through a strategic breeding programme would yield various segregants. Efficient screening in future generations would thus yield the desired genotype.

*Hybrids 2x4 and 1x6 were found promising considering the significant sca and heterosis. Cross 1x6 had a consistent behaviour over seasons, whereas, cross 2x4 yielded significantly only in the first season, but was of great importance considering the manifestation of both average fruit weight and number of marketable fruit per vine at optimum level, in contrast to manifestation of heterosis in 1x6 only due to average fruit weight (marketable yield).

*Both additive and non-additive gene action was involved in majority of the traits studied in two seasons. However, in the second season, cavity size, cavity shape and average fruit weight showed predominance of additive gene action.

*Expression of traits in both the seasons involved over dominance operating with the exception of average fruit weight which showed over all dominance.

*The distribution of positive and negative alleles in the parents was found to be unequal for all the characters in both the seasons, except for fruit shape and flesh thickness in the second season.

*In the first season the ratio KD/KR exceeded the value of one suggesting the presence of more dominant genes than recessive genes for all the characters except for number of branches per vine, seed maturity at harvest (11 DAF) and average fruit weight. In the second season, the ratio exceeded the value of one for all parameters except for characters, vine length, internodal length, cavity shape, flesh thickness, seed maturity at harvest (16 DAF) and average fruit weight.

*For all the characters under consideration additive as well as non-additive gene actions were important,

suggesting reciprocal recurrent selection and biparental mating as effective tool in handling the population.

*In crosses where high x high gca resulted in high sca, heterosis breeding is possible. Also characters could be fixed in the later generations in presence of additive x additive gene action.

*When high x low gca results in high sca and heterosis in desired direction, reciprocal recurrent selection or any method of using both additive and non-additive gene action could be followed for fixing characters in advanced generations.

*The variation in the gene action over the environments may be attributed to different sets of gene responsible for expression of these characters in different environments. Performance of F_1 s is found to vary with the environment, the most ideal environment maximising the expression of the characters. Thus, hybrids evolved are very specific to a particular season.

SUMMARY

VI. SUMMARY

Cucumber improvement programme is a complex process. At the outset, one needs to scan through the available genetic variability, followed by the task of widening this variability. The present study was taken up in two stages (a) variability and associated studies (involving 22 genotypes), (b) diallel analysis (in two seasons, involving 9 genotypes) at IIHR, Bangalore, during 1988-1990 are summarised below.

6.1. VARIABILITY AND ASSOCIATED STUDIES

1. Analysis of variance revealed significant difference for all the characters except for the number of branches per vine and flesh thickness.

2. A considerable degree of variability for all the characters was observed in genotypes under investigation. Marketable yield per vine had the highest amount of phenotypic coefficient of variance and genotypic coefficient of variance.

3. Heritability (broad sense) ranged from 90.1 to 15.6 per cent among the characters studied. Per cent deshaped fruit had the highest heritability value.

4. Genetic gain varied from 95.0 to 3.0 per cent among all the characters. Marketable yield, per cent

deshaped fruit, number of marketable fruit, fruit fresh weight loss at storage and unmarketable fruit yield recorded the highest genetic gain coupled with high heritability value, indicating improvement to be faster through selections.

5. 'Genotypic correlations' among all the yield and yield components studied revealed that:

- *Vigorous vines with short internodal length bearing more number of marketable fruit, high marketable yield and low percentage of deshaped fruit resulted in high yielding genotypes.
- *Vines with poor vigour, higher internodal length and bearing lesser number of marketable fruit per vine to result in genotypes with higher per cent deshaped fruit.
- *Vines with lesser number of nodes and branches, higher internodal length, bearing fruit with higher average fruit weight, and fruit size to result in slow seed maturing genotypes.
- *Vines with the first female flower at the lowest node, early flowering and early harvest date resulted in vines with profuse branching, higher internodal length, bearing fruit with higher average fruit

weight, flesh thickness, rind toughness and total number of fruit per vine.'

6. Phenotypic correlations were found to be significant (positive/negative) for per cent deshaped fruit, number and yield of fruit per vine, vigour of the vines, fruit size and fruit shape. Whereas, environmental correlations were found to be significant (positive/negative) for vigour of the vines, number and yield of fruit per vine, fruit size and shape, and cavity size and shape, revealing the significant role of the environment in expression of these characters.

7. Coheritability studies coupled with significant genotypic correlations revealed that:

*Total fruit yield had high coheritability and was significantly negatively correlated genotypically with characters internodal length, cavity size and per cent deshaped fruit, whereas, significantly positively correlated with number of nodes, number of branches, number and yield of marketable fruit and total number of fruit per vine.

*Per cent deshaped fruit had high coheritability and was significantly negatively correlated genotypically with

characters, vine length, number of nodes, specific leaf weight, number of marketable fruit, total number of fruit, marketable and total yield per vine, whereas, significantly positively correlated with, internodal length, unmarketable number of fruit and unmarketable yield per vine.

*Seed maturity at harvest had high coheritability and significant negative genotypic correlation with vigour of the vine, fruit size, cavity size and average fruit weight.

*Number of marketable fruit per vine had high coheritability and significant negative genotypic correlation with internodal length, specific leaf weight, number and yield of unmarketable fruit per vine, whereas, significantly positively correlated with vigour of the vine, total number of fruit, marketable yield and total yield per vine.

*Earliness had high coheritability and significant negative genotypic correlation with characters, number of branches per vine, internodal length, average fruit weight, rind toughness and total number of fruit per vine, whereas, significant positive genotypic correlation with characters, flesh thickness, vine

length, number of nodes per vine, average fruit weight and cavity shape.

6.2. DIALLEL ANALYSIS

8. Analysis of variance revealed significant difference for all the characters except number of branches, specific leaf weight, specific leaf area and marketable yield in the first season and internodal length, number of branches per vine and fruit shape in the second season.

9. Analysis of variance for combining ability revealed significant difference for all the characters except, number of branches per vine and specific leaf area in the first season and days to first flowering, vine length, internodal length, number of branches per vine, fruit shape, flesh thickness and average fruit weight in the second season.

10. In the first season GCA:SCA ratio was less than one for all the characters indicating the predominant role of non-additive gene action. Node at which first female flower emerged had the highest value of 0.75 indicating the relative role of additive and non-additive genes. In the second season, cavity size, cavity shape

and average fruit weight had the ratio more than one indicating the predominant role of additive genes. The rest of the characters had the value less than one.

11. In the first season the value $(H_1/D)^{1/2}$ was more than one for all the characters indicating the role of over dominance. In the second season, except for average fruit weight the rest of the characters had the value more than one. For average fruit weight over all dominance was found to operate.

12. The distribution of positive and negative alleles in the parents was found to be unequal for all the characters, except for fruit shape and flesh thickness in the second season.

13. In the first season the ratio KD/KR exceeded the value of one for all the characters except number of branches, seed maturity at harvest (11 DAF) and average fruit weight. In the second season the ratio exceeded the value of one except for characters, vine length, internodal length, cavity shape, flesh thickness, seed maturity at harvest (16 DAF) and average fruit weight. Indicating the difference in the number of dominant and recessive genes to vary in the expression of characters.

14. Considering the per se performance, combining ability and heterosis values, parents 7, 8, 4 and 6 were

found to be superior for slow seed maturity rate, parent 1, 2, 4, 6, 7 and 9 for higher yields, parents 4, 7 and 8 for low per cent deshaped fruit and parents 1, 2 and 9 for vegetative growth factors. In totality parents 1, 2, 4, 6 and 7 were worth considering for further crop improvement programmes.

15. Both additive and non-additive gene action was found to control the expression of all the characters. However, the predominance of non-additive gene action was observed in almost all the characters, except for cavity size, cavity shape and average fruit weight (second season) with predominant additive gene action.

16. The shift from non-additive gene action to additive gene action was observed for the characters cavity size, cavity shape and average fruit weight over seasons indicating different sets of genes to operate in different environments for the trait expression.

17. Among the crosses with significant sca for all the characters, 14 per cent of the crosses had high x high gca, 57 per cent of the crosses had high x low gca and 29 per cent of the crosses had low x low gca. It was true with 12, 58 and 30 per cent of the crosses in the

second season, indicating the relative role of additive and non-additive gene action in the trait expression.

18. Good general combiners (parents 1, 2 and 6 for fruit yield and 4 and 7 for fruit number) had favourable genes accumulated by the virtue of selections carried out for yield over generations.

19. Performance of F_1 s like 2x8, 1x2, 1x3 and 2x4 for total yield, 6x7, 1x4, 4x6 and 5x8 for marketable yield, 4x5, 4x6 and 2x5 for per cent deshaped fruit 2x9 and 3x8 for seed maturity rate, 1x2 and 7x9 for vine length was found to vary with the environment, indicating the most ideal environment to maximise the expression of characters. Thus, breeding cucumbers to suit all the seasons is futile. Instead evolving cucumber genotypes to suit to a particular season is desirable.

20. Yield was found to be contributed by the high number of marketable fruit per vine rather than the high average fruit weight. However, a balance between these two traits was found essential to result in high yielding genotypes.

21. Hybrids 1x6, 1x2 and 2x8 were superior performers owing to the high marketable yield, whereas, crosses 2x4, 1x3 and 1x4 were superior performers owing

to a balance in the marketable yield and marketable number of fruit per vine.

22. Heterosis for all the characters in the desired direction was in general higher in the first season than the second season.

23. Heterosis over the mid parent in the first season, ranged from -17.5 to 47.9 per cent (vine length), -50.0 to 227.3 per cent [seed maturity at harvest (11/16 DAF)], -57.9 to 72.5 per cent (per cent deshaped fruit), -23.7 to 90.4 per cent (total number of fruit per vine) and -4.1 to 157.2 per cent (total fruit yield per vine). Whereas, in the second season it ranged from -29.4 to 34.2 per cent (vine length), -56.5 to 220.0 per cent [seed maturity at harvest (11/16 DAF)], -46.6 to 61.2 per cent (per cent deshaped fruit), -13.0 to 175.9 per cent (total number of fruit per vine) and -42.0 to 107.5 per cent (total fruit yield per vine).

24. Mean heterosis over the mid parent and the better parent revealed, number of fruit per vine to be a more stable character than the average fruit weight over seasons.

25. Per se performance, combining ability and heterosis studies revealed, high yielding genotypes to be

defined through, vigorous vine growth, slow seed maturity, lower percentage of deshaped fruit and a optimum balance between the average fruit weight and the number of marketable fruit per vine.

26. Heterosis is known to be a result of geographic diversity or genetic distance. Heterosis in F_1 s like 1x2, 1x6, 2x8, 7x9, 6x7, 6x9 and other crosses from indigenous lines could be due to intense selection carried over years at different locations geographically isolated from different base populations without exchange of genetic material at every stage, this widens the genetic distance between them.

27. The promising parental lines 4 and 7 for most of the yield and yield components, 6 for average fruit weight, 1 and 2 for fruit yield and plant vigour or the hybrids 1x6 for high fruit yield, 2x4 for high marketable fruit number and low per cent deshaped fruit, 6x9 for high fruit size, could thus be utilised straight away or carried through advanced generations applying suitable breeding strategy resulting in transgressive segregants. In addition suitable plant types could be fixed in later generations. Pooling of this wide genetic variability would broaden the base population, resulting in overall improvement of the crop.

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VII. REFERENCES

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*Original not seen.

APPENDICES

Appendix I. Mean performance of 22 genotypes of cucumber for 27 characters

Character/Genotypes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
DHR 5.1.2	4.0	40.0	56.0	1.1	13.7	8.3	2.7	5.6	180.3	56.7	2.3	33.0	2.7	9.6	1.0	1.7	4.0	26.0	13.7	175.3	69.7	0.8	1.8	2.7	0.2	0.5	0.7
DHR 13.2.1	3.7	46.3	59.3	1.4	17.3	8.0	2.3	5.1	196.6	73.7	3.3	37.6	4.1	9.1	1.0	1.0	3.3	26.3	17.3	242.7	24.7	2.5	0.9	3.4	0.6	0.2	0.8
DHR 23.2.2	3.0	43.3	59.3	1.3	16.0	8.0	2.7	5.6	176.9	66.3	3.0	88.7	3.9	9.8	0.8	1.0	2.7	35.0	21.7	250.0	21.0	2.3	0.7	3.0	0.6	0.2	0.8
DHR 34.3.1	3.7	46.0	57.7	1.1	12.3	8.7	1.6	4.6	217.6	78.7	2.6	38.4	3.4	10.0	0.9	1.3	2.7	33.3	18.3	195.0	64.3	0.9	1.5	2.5	0.2	0.3	0.5
DHR 27.2.2	3.7	40.0	56.0	1.0	14.0	7.7	2.0	4.5	224.3	71.2	2.6	42.6	3.4	11.2	1.1	1.3	3.0	16.0	8.3	187.7	32.0	2.5	1.2	3.7	0.5	0.2	0.7
DHR 67.2.3	3.3	45.0	59.3	1.2	12.7	9.0	1.7	6.0	175.4	67.1	2.9	40.0	3.0	9.1	1.0	2.0	2.7	18.3	13.3	178.0	60.3	1.2	1.8	3.1	0.2	0.3	0.5
DHR 31.1.1	3.7	40.0	56.0	1.1	14.7	7.7	2.3	4.4	231.1	80.6	2.6	40.7	3.3	10.8	1.0	2.0	3.3	19.3	11.7	161.3	44.7	2.6	2.1	4.6	0.4	0.3	0.7
DHR 32.1.2	4.0	40.0	56.0	1.1	13.6	8.3	2.3	5.3	187.7	51.4	3.1	24.1	3.0	11.3	1.0	1.0	3.0	29.0	16.7	193.7	55.7	2.0	2.6	4.6	0.4	0.5	0.9
DHR 33.1.1	2.7	40.7	56.0	1.4	17.7	8.3	2.3	5.7	175.9	58.0	2.2	22.5	2.9	9.7	1.0	2.0	3.3	25.0	16.7	211.7	19.0	3.4	0.8	4.2	1.0	0.2	1.2
DHR 45.6.1	3.3	45.0	61.0	1.4	16.3	9.0	2.3	5.0	201.2	61.9	2.7	34.5	3.6	10.5	0.8	1.0	3.3	48.3	36.7	258.7	61.7	1.3	2.2	3.5	0.3	0.5	0.8
DHR 48.3.1	4.0	40.0	56.0	1.1	13.3	8.0	1.7	4.8	208.8	69.3	3.4	35.0	4.6	9.7	1.0	1.0	2.7	30.0	18.3	205.0	44.3	1.7	1.4	3.1	0.4	0.3	0.7
DHR 50.1.1	4.3	40.0	56.0	1.2	15.3	7.3	2.3	4.5	221.4	96.9	3.1	43.4	3.6	10.3	1.1	2.0	3.0	14.3	13.3	219.3	25.0	3.3	1.10	4.4	0.7	0.2	1.0
DHR 51.1.1	3.7	45.0	56.0	1.5	18.7	7.7	2.0	4.7	198.6	74.3	3.6	39.7	4.5	11.2	1.2	2.3	4.3	12.0	8.3	224.0	22.7	2.4	0.7	3.2	0.6	0.2	0.7
DHR 56.1.1	3.3	40.0	56.0	1.1	14.0	7.7	3.0	5.0	203.7	75.7	3.3	36.5	4.1	10.8	1.1	1.0	3.7	20.0	14.3	194.7	33.7	2.3	1.3	3.5	0.6	0.3	0.8
DHR 60.1.1	3.3	40.3	57.7	1.2	15.7	7.3	1.7	4.5	225.6	59.9	3.4	29.4	3.9	10.4	0.9	1.0	4.0	22.7	10.0	172.3	28.3	3.0	1.2	4.2	0.5	0.2	0.7
DHR 61.1.1	2.7	42.0	63.0	1.0	14.0	7.7	2.3	4.8	209.7	105.1	3.5	48.0	4.8	10.8	1.0	2.0	2.7	25.0	10.0	206.0	17.7	2.7	0.6	3.3	0.6	0.1	0.7
DHR 90.2.1	3.7	40.3	64.0	1.0	12.0	8.7	2.0	5.3	188.9	68.0	2.7	35.0	3.3	6.8	1.0	1.0	3.7	37.7	21.0	246.3	50.0	1.3	1.0	2.3	0.3	0.3	0.5
DHR 66.2.3	2.7	40.0	56.0	1.0	12.7	8.0	2.3	5.2	195.6	78.3	3.1	45.7	3.7	10.4	1.0	1.3	3.0	18.7	21.7	221.3	70.0	1.0	2.3	3.3	0.2	0.5	0.7
DHR 74.1.2	4.0	40.0	56.0	1.1	11.3	9.7	1.7	6.0	168.1	95.7	3.2	52.7	4.3	11.1	1.1	1.0	2.3	38.3	14.0	222.7	55.0	1.3	1.6	2.9	0.3	0.4	0.6
DHR 79.3.2	3.7	45.7	61.0	1.4	14.7	9.7	2.3	4.9	203.5	90.2	2.8	42.6	3.4	9.2	0.9	1.0	2.7	25.0	17.0	268.0	46.3	1.8	1.5	3.3	0.5	0.4	0.9
DHR 81.1.1	4.3	40.0	56.0	0.8	9.7	8.7	2.3	6.0	165.7	71.7	3.3	34.9	3.8	9.8	1.1	1.7	3.0	27.3	21.7	158.7	66.7	1.2	2.4	3.6	0.2	0.4	0.6
DHR 82.1.1	3.0	40.0	57.7	1.2	13.3	9.7	2.7	5.5	182.7	94.3	3.1	48.4	4.2	10.7	1.2	1.3	2.7	42.0	28.3	235.0	64.0	0.9	1.7	2.6	0.2	0.4	0.6
General Mean	3.5	41.9	57.8	1.2	14.2	8.3	2.2	5.1	197.2	74.9	3.0	38.3	3.7	10.1	1.0	1.4	3.1	26.8	16.9	211.2	44.4	1.9	1.5	3.4	0.4	0.3	0.7
CD at 5%	0.8	1.7	3.6	0.3	3.0	1.2	-	0.9	31.5	17.5	0.6	11.2	0.8	1.2	-	0.7	0.7	8.8	9.4	45.9	9.8	0.6	0.6	1.0	0.1	0.1	0.2

1. Node of first female flower emergence
2. Days to first flowering
3. Days to first harvest
4. Vine length
5. Number of nodes/vine
6. Internodal length
7. Number of branches/vine
8. Specific leaf weight
9. Specific leaf area
10. Fruit size
11. Fruit shape
12. Cavity size
13. Cavity shape
14. Rind toughness
15. Flesh thickness
16. Seed maturity at harvest (11 DAF)
17. Seed maturity at harvest (16 DAF)
18. Fruit fresh weight loss at storage (5 DAS)
19. Fruit fresh weight loss at storage (10 DAS)
20. Average fruit weight
21. Per cent dehydrated fruits
22. No. of mark. fruit/vine
23. No. of unmark. fruit/vine
24. Total no. of fruit/vine
25. Mark. fruit yield/vine
26. Unmark. fruit yield/vine
27. Total fruit yield/vine

Appendix II. Mean performance of parents and F₁ hybrids for 27 characters in 9x9 diallel crosses of cucumber (first season)

Parents/ Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27		
1. Node of first female flower emergence	HR 82.1.1	3.0	36.0	50.0	1.6	16.7	10.6	2.7	5.3	190.0	106.2	3.0	60.2	3.8	10.9	1.4	1.3	3.2	36.7	73.3	249.7	46.0	1.2	1.0	2.2	0.3	0.2	0.5	
2. Days to first flowering	HR 79.3.1	3.7	37.3	49.3	1.6	19.0	8.9	2.0	5.5	183.7	96.2	2.4	57.0	2.8	9.3	1.0	1.0	3.6	20.0	48.3	180.7	63.7	1.1	1.9	3.0	0.2	0.4	0.6	
3. Days to first harvest	HR 68.3.1	3.0	35.7	49.0	1.6	21.0	7.7	2.7	4.9	212.0	97.8	3.2	58.0	3.8	10.3	1.3	1.2	2.7	25.7	40.0	241.0	42.7	1.7	1.3	2.7	0.4	0.3	0.6	
4. Vine length (m)	HR 61.1.1	2.7	37.0	49.7	1.3	16.3	8.2	2.7	6.5	172.7	82.2	3.1	45.3	3.4	11.5	1.0	1.0	3.3	3.0	28.0	40.3	163.0	72.7	0.8	2.1	2.9	0.2	0.4	0.5
5. Number of nodes/vine	HR 56.1.1	3.7	35.3	48.3	1.3	18.0	7.2	2.7	4.9	210.3	97.7	3.2	50.3	4.6	11.8	1.3	1.0	3.8	27.7	35.3	171.7	69.7	0.8	1.9	2.8	0.2	0.4	0.6	
6. Internodal length (cm)	HR 45.6.1	3.7	38.3	51.0	1.5	20.7	7.5	2.3	5.2	198.0	70.2	2.8	39.3	3.5	9.8	0.8	1.0	4.2	52.7	78.3	335.0	66.7	0.8	1.2	1.8	0.2	0.4	0.6	
7. Number of branches/vine	HR 33.1.1	3.7	36.3	49.7	1.6	22.7	7.0	2.7	5.4	188.3	87.3	2.3	43.0	3.1	9.3	1.5	1.5	5.0	27.0	41.7	239.7	20.3	3.0	0.8	3.7	0.6	0.2	0.8	
8. Specific leaf weight (g/cm ²)	HR 33.2.2	3.0	38.0	50.7	1.3	18.0	7.2	2.3	5.0	201.3	80.3	3.0	46.7	3.8	9.3	0.9	1.0	4.3	39.0	55.0	257.3	27.0	1.6	0.6	2.2	0.3	0.1	0.4	
9. Specific leaf area (cm ² /g)	HR 51.2	3.7	36.0	50.0	1.1	16.3	7.0	2.0	5.4	187.7	92.0	2.5	53.0	3.3	9.2	1.5	1.2	4.0	50.0	68.3	267.7	63.3	0.7	1.4	2.1	0.2	0.4	0.6	
10. Fruit size (cm ²)	1 x 3	3.3	32.7	46.3	1.3	19.3	7.0	2.3	4.6	216.3	98.3	3.4	52.7	4.4	9.0	1.6	2.5	4.2	39.3	74.3	361.3	43.3	2.6	1.9	4.5	0.6	0.5	1.1	
11. Fruit shape	1 x 4	2.7	31.7	46.0	1.5	20.3	7.2	2.7	4.5	226.7	101.0	3.3	50.4	4.4	9.9	1.3	2.3	4.2	35.0	62.3	352.3	39.7	2.7	1.7	4.4	0.8	0.5	1.3	
12. Cavity size (cm ²)	1 x 5	3.0	29.7	42.7	1.5	16.3	9.0	2.7	5.4	194.0	99.0	3.6	49.0	5.4	10.9	1.5	1.8	4.0	20.3	50.3	251.3	50.0	1.9	2.4	4.3	0.4	0.5	0.9	
13. Cavity shape	1 x 6	3.3	33.3	46.3	1.4	19.0	7.6	2.7	4.8	211.7	105.7	3.1	48.7	4.7	10.0	1.2	1.8	4.8	38.3	87.7	409.7	53.3	1.4	1.7	3.3	0.6	0.6	1.2	
14. Rind toughness (kg/cm ²)	1 x 7	3.0	33.0	46.3	1.4	18.7	7.6	2.0	4.6	217.7	71.0	3.8	51.6	4.4	9.4	1.2	2.3	4.7	26.7	51.0	290.0	47.3	1.5	1.3	2.9	0.5	0.4	0.9	
15. Flesh thickness (cm)	1 x 8	3.0	34.0	47.0	1.5	19.7	7.4	2.0	4.7	212.0	82.0	3.3	46.0	4.6	9.7	0.9	2.0	2.7	28.3	60.7	399.3	56.0	1.0	1.3	2.3	0.4	0.5	0.9	
16. Seed maturity at harvest (11 DAF)	1 x 9	3.0	34.0	47.7	1.4	16.7	8.6	2.3	5.4	188.0	119.7	2.8	51.0	4.3	9.8	1.2	1.5	3.3	31.7	59.7	434.3	28.7	1.7	0.7	2.4	0.7	0.3	1.0	
17. Seed maturity at harvest (16 DAF)	2 x 3	3.0	32.7	45.3	1.6	23.7	6.8	2.3	5.2	193.0	126.2	3.0	57.4	4.9	8.8	1.3	2.7	4.2	21.7	42.3	298.3	49.7	2.0	2.0	4.0	0.5	0.5	0.9	
18. Fruit fresh weight loss at storage (5 DAS)(g)	2 x 4	2.7	33.3	46.3	1.5	21.0	7.3	2.3	5.0	204.0	115.1	3.4	59.0	4.5	10.6	1.3	2.0	4.3	25.7	50.0	289.3	28.7	3.0	1.2	4.2	0.5	0.2	0.9	
19. Fruit fresh weight loss at storage (10 DAS)(g)	2 x 5	3.3	32.7	46.0	1.7	21.3	7.8	2.7	5.3	192.3	109.4	3.1	55.7	4.3	10.6	1.4	1.3	4.0	63.3	94.3	343.3	46.3	1.6	1.4	3.0	0.5	0.4	0.8	
20. Average fruit weight (g)	2 x 6	4.0	33.0	46.0	1.7	22.3	7.7	2.3	5.4	186.7	132.5	3.0	69.9	3.7	9.7	1.4	1.3	4.0	36.7	63.3	425.7	38.3	1.5	1.0	2.5	0.4	0.3	0.7	
21. Per cent deshaped fruit	2 x 7	3.3	32.7	46.0	1.7	22.7	7.4	2.3	4.1	243.0	117.2	2.9	54.8	4.7	11.2	1.3	1.7	2.7	25.3	55.3	315.0	39.0	1.6	1.1	2.7	0.5	0.3	0.9	
22. Number of marketable fruit/vine	2 x 8	3.3	33.0	46.0	1.4	21.0	6.7	2.3	5.1	200.0	106.0	3.1	53.4	4.1	9.5	1.0	1.8	3.2	75.0	98.7	390.3	37.0	2.0	1.2	3.2	0.6	0.3	0.9	
23. Number of unmarketable fruit/vine	2 x 9	3.3	31.7	46.0	1.4	17.7	8.3	2.0	4.6	215.7	99.8	2.9	47.0	4.2	9.3	1.2	1.7	3.2	61.7	96.7	286.7	44.3	2.0	1.6	3.5	0.6	0.4	1.0	
24. Total number of fruit/vine	3 x 4	3.3	32.7	44.7	1.4	18.7	7.5	2.3	4.4	230.3	106.8	3.4	55.7	4.3	9.9	1.2	1.3	3.0	38.0	78.3	278.3	48.3	2.0	1.9	3.9	0.5	0.5	1.0	
25. Marketable fruit yield/vine (kg)	3 x 5	3.0	32.7	45.3	1.4	20.0	6.9	2.0	4.6	216.7	111.7	3.3	52.3	4.7	11.2	1.3	1.7	2.7	25.3	55.3	315.0	31.0	1.8	2.0	3.9	0.6	0.6	1.1	
26. Unmarketable fruit yield/vine (kg)	3 x 6	3.3	33.0	47.0	1.6	20.7	7.6	2.3	5.2	199.3	152.5	3.2	69.0	4.7	9.3	1.4	1.3	2.8	29.0	72.3	311.0	55.7	1.5	1.9	3.1	0.5	0.6	1.1	
27. Total fruit yield/vine (kg)	3 x 7	3.0	32.7	46.0	1.6	20.7	7.6	2.0	5.4	185.3	136.9	3.1	59.1	4.3	10.6	1.5	2.2	3.2	26.7	65.0	279.0	54.3	1.5	1.7	3.2	0.4	0.5	0.9	
	3 x 8	4.0	32.7	48.0	1.4	19.0	7.2	2.3	4.6	220.0	97.3	3.2	51.3	4.7	10.7	1.3	1.0	2.8	37.7	98.3	323.3	49.3	2.1	2.0	4.2	0.7	0.6	1.3	
	3 x 9	3.0	31.7	45.7	1.5	19.0	7.7	2.0	4.9	205.7	119.2	3.0	57.3	4.4	10.2	1.3	1.0	2.3	34.3	94.7	357.7	42.3	2.4	1.3	3.7	0.7	0.5	1.3	
	4 x 5	3.0	31.7	45.3	1.6	22.3	7.3	2.3	4.8	208.0	138.5	3.7	68.0	5.1	10.5	1.4	1.3	2.3	27.3	95.7	260.0	45.3	2.3	2.0	4.3	0.6	0.5	1.1	
	4 x 6	2.7	31.3	44.7	1.6	18.7	8.5	2.0	4.4	227.0	161.5	3.3	72.0	4.9	10.3	1.6	2.7	2.5	28.3	60.7	332.0	32.0	2.0	1.0	3.0	0.7	0.3	1.0	
	4 x 7	3.3	32.7	46.7	1.8	22.3	8.0	2.3	5.9	264.7	89.8	2.8	55.0	3.7	10.2	1.3	1.5	2.3	36.7	88.3	232.0	34.3	2.6	1.4	3.9	0.5	0.3	0.9	
	4 x 8	2.7	32.7	46.0	1.3	17.0	7.7	2.7	5.4	189.7	127.6	3.2	64.8	4.8	10.7	1.3	2.2	2.2	24.3	63.7	237.3	31.0	2.1	0.9	3.0	0.5	0.2	0.7	
	4 x 9	2.3	32.7	46.7	1.6	20.7	7.8	2.7	4.5	227.3	100.0	3.5	60.7	4.5	10.7	1.1	2.0	2.3	23.7	64.3	271.0	39.3	2.2	1.6	3.8	0.6	0.4	1.0	
	5 x 6	3.3	34.0	46.7	1.9	23.3	8.4	2.3	5.7	175.3	113.3	3.7	62.7	5.1	11.2	1.3	3.0	2.7	38.3	63.3	242.0	72.0	1.1	2.8	3.8	0.3	0.7	0.9	
	5 x 7	3.7	31.3	44.3	1.7	24.0	7.2	2.7	4.8	210.0	102.3	2.9	47.5	4.1	10.7	1.1	2.0	4.0	31.0	72.0	279.0	43.3	1.4	1.1	2.5	0.4	0.3	0.7	
	5 x 8	4.0	30.7	43.7	1.7	23.7	7.6	2.0	4.9	204.3	114.5	3.1	53.2	4.2	8.9	1.6	1.7	3.2	32.3	75.0	289.7	28.7	2.8	1.1	4.0	0.8	0.3	1.1	
	5 x 9	3.3	31.3	45.3	1.4	21.3	6.7	2.0	4.7	214.3	118.8	3.0	55.7	4.0	10.0	1.5	1.5	2.5	28.0	69.0	246.0	53.3	2.1	2.5	4.6	0.5	0.6	1.1	
	6 x 7	3.7	31.7	45.0	2.0	24.7	8.2	2.0	5.4	186.3	103.7	3.2	59.9	3.3	9.5	1.2	1.8	2.5	35.3	72.0	380.0	25.0	2.6	0.9	3.5	0.8	0.3	1.1	
	6 x 8	3.7	30.7	45.3	1.6	18.7	8.5	2.3	6.1	186.0	102.0	3.2	59.6	4.2	9.3	1.1	1.7	2.3	53.3	75.7	432.7	26.0	1.5	0.5	2.0	-0.6	0.2	0.9	
	6 x 9	2.7	33.0	46.0	1.7	20.0	8.5	2.3	5.4	186.0	133.7	3.1	64.3	4.4	10.7	1.4	2.5	2.7	32.0	75.0	341.0	30.3	1.8	0.9	3.0	0.8	0.4	1.2	
	7 x 8	3.3	32.0	46.0	1.7	20.3	7.1	2.3	5.2	199.7	97.0	2.8	49.3	3.6	9.1	1.0	2.2	2.5	20.8	85.0	237.0	40.0	2.5	1.7	4.2	0.5	0.4	0.9	
	7 x 9	3.3	32.0	46.3	1.9	22.7	8.4	2.0	5.5	182.0	109.2	2.9	49.1	4.1	9.3	1.2	1.0	2.3	20.8	66.7	297.3	30.0	3.6	1.4	4.7	0.8	0.3	1.1	
	8 x 9	3.0	32.0	45.3	1.8	23.0	7.8	2.3	4.6	220.3	109.2	3.0	64.0	4.0	9.3	1.1	1.3	2.3	30.0	66.7	363.3	25.0	1.7	0.6	2.3	0.5	0.2	0.8	
General	3.2	33.2	46.7	1.5	20.1	7.8	2.3	5.0	202.9	107.4	3.1	55.0	4.2	10.0	1.3	1.7	3.3	34.6	65.3	299.0	44.2	1.8	1.5	3.3	0.5	0.4	0.9		
SD	at 5x	0.7	1.5	1.3	0.3	3.6	1.4	0.8	1.2	45.8	27.1	0.5	14.7	0.8	1.0	0.3	0.8	0.7	10.9	12.1	107.3	9.9	0.7	0.5	0.9	0.2	0.1	0.2	

Appendix III. Mean performance of parents and F₁ hybrids for 27 characters in 9x9 diallel crosses of cucumber (second season)

Parents/ Crosses	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
HR 82.1.1	3.0	38.7	53.0	1.4	16.3	0.0	3.0	5.0	201.4	118.6	2.9	66.0	3.4	10.7	1.2	0.8	4.2	45.0	90.0	386.3	44.7	0.9	0.7	1.6	0.3	0.3	0.6
HR 79.3.1	3.7	39.3	53.3	1.5	16.0	9.1	2.0	4.5	225.1	130.7	3.1	69.0	3.7	8.0	1.1	0.8	3.8	28.3	50.3	409.3	52.0	0.6	0.7	1.3	0.3	0.3	0.6
HR 68.1.1	2.7	39.3	53.0	1.5	17.9	8.4	2.7	4.3	238.2	114.4	3.0	51.9	3.8	10.8	1.8	1.8	3.3	40.5	51.3	308.8	47.0	1.3	1.2	2.5	0.4	0.3	0.9
HR 61.1.1	3.0	39.3	53.3	1.4	15.8	8.9	2.3	4.4	227.4	112.4	2.9	44.7	4.7	11.7	1.3	2.3	2.8	28.3	39.1	301.1	30.3	1.5	0.6	2.1	0.4	0.2	0.6
HR 56.1.1	3.3	39.0	53.3	1.6	19.5	8.7	2.7	4.5	227.3	103.5	3.0	45.5	3.9	11.3	1.3	1.0	4.2	28.3	39.7	332.4	56.3	1.1	1.4	2.5	0.4	0.3	0.9
HR 45.6.1	3.7	40.0	55.0	1.4	16.7	8.1	2.3	4.4	228.1	111.3	2.8	71.4	3.7	9.7	1.0	0.8	4.3	53.3	80.0	316.8	53.7	0.9	1.0	1.9	0.4	0.4	0.8
HR 33.1.1	3.3	39.7	55.0	1.4	21.0	8.0	2.3	6.0	154.4	83.0	2.5	51.1	3.5	8.8	1.1	1.2	4.7	33.3	43.7	275.9	20.0	2.1	0.6	2.7	0.6	0.2	0.8
HR 23.2.2	3.0	39.0	54.7	1.6	22.8	7.9	2.3	4.7	215.3	126.0	2.9	63.0	3.8	9.0	1.3	3.3	4.0	70.7	366.5	38.7	1.3	0.9	2.1	0.4	0.3	0.7	
HR 5.1.2	4.0	35.8	52.0	1.3	16.4	7.8	2.7	3.6	276.4	92.2	3.0	54.5	3.5	9.7	1.0	2.7	2.7	38.3	53.7	272.9	55.0	1.1	1.4	2.5	0.3	0.4	0.8
1 x 3	3.7	38.7	54.7	2.0	24.2	8.1	2.7	4.5	223.7	129.2	2.9	68.3	4.3	9.7	1.5	0.8	4.5	41.7	70.3	419.0	54.7	1.8	2.2	4.0	0.6	0.7	1.3
1 x 2	3.3	38.7	54.3	1.7	19.6	8.7	2.7	4.5	197.4	104.4	2.9	52.9	3.9	8.8	1.3	1.5	4.0	51.0	90.3	391.7	50.0	1.8	1.8	3.6	0.6	0.6	1.2
1 x 4	2.3	42.3	57.0	1.5	17.3	9.0	2.7	5.1	169.7	140.2	3.2	56.1	4.6	9.8	1.4	2.0	4.3	47.7	71.7	374.4	31.0	2.4	1.1	3.5	0.6	0.3	0.9
1 x 5	2.6	39.0	55.0	1.5	17.8	8.4	2.3	4.4	231.9	102.0	3.1	51.2	4.1	10.5	1.1	1.8	5.0	37.3	55.7	331.1	14.3	1.7	1.8	3.7	0.5	0.5	0.9
1 x 6	3.7	38.3	53.3	1.5	16.4	9.3	3.0	4.7	213.3	99.1	2.6	50.5	2.9	9.8	1.1	2.7	5.9	46.7	80.3	364.7	43.7	1.6	1.1	2.6	0.6	0.4	1.0
1 x 7	2.7	37.3	52.7	1.1	21.6	8.6	2.3	6.2	162.6	103.4	2.8	51.7	3.2	9.0	1.1	1.5	4.5	38.3	50.7	274.0	46.3	1.5	1.6	3.5	0.6	0.4	1.0
1 x 8	3.0	38.0	52.0	1.6	20.3	8.0	2.3	4.4	230.9	100.2	3.2	53.4	3.7	8.9	1.1	2.2	3.0	36.0	55.7	371.9	43.0	1.2	0.9	2.0	0.5	0.4	0.9
1 x 9	2.7	38.7	50.7	1.6	19.2	8.4	2.3	4.9	208.0	89.5	3.1	48.1	3.9	9.9	1.2	1.3	2.8	40.0	56.3	351.1	31.0	1.5	0.7	2.2	0.5	0.3	0.8
2 x 3	2.7	39.0	51.7	1.6	19.1	8.0	2.7	5.7	178.0	111.9	2.8	55.6	4.7	8.7	1.3	1.7	4.5	26.7	41.0	354.7	48.3	1.5	1.7	3.2	0.6	0.5	1.1
2 x 4	3.0	37.7	51.3	1.7	20.5	8.6	2.3	4.6	221.6	95.6	2.8	46.1	4.0	10.7	1.1	1.8	4.0	33.7	56.7	405.2	24.0	2.3	0.7	3.0	0.7	0.2	1.0
2 x 5	2.7	37.3	50.0	1.9	23.2	8.1	2.3	4.8	210.7	93.0	2.8	44.6	3.9	10.3	1.0	1.3	4.7	60.0	85.0	311.5	40.7	1.5	1.0	2.5	0.5	0.3	0.8
2 x 6	4.0	37.3	50.0	1.6	20.6	7.7	2.7	5.7	177.5	123.3	3.1	66.3	3.5	9.7	1.2	1.2	3.5	43.5	98.7	449.7	41.0	1.2	0.8	2.0	0.4	0.3	0.7
2 x 7	3.3	45.0	52.0	1.8	18.7	9.1	2.7	3.8	260.6	101.0	2.9	56.0	3.8	10.2	1.0	2.5	3.7	70.0	99.3	367.4	40.3	1.8	1.3	3.0	0.7	0.3	1.2
2 x 8	2.7	36.7	50.3	1.7	22.0	7.8	2.0	5.2	191.5	102.6	3.0	55.6	4.0	10.2	1.0	2.5	3.7	70.0	99.3	367.4	36.0	1.9	1.1	2.9	0.6	0.3	0.9
2 x 9	3.3	36.7	49.7	1.4	20.3	7.4	2.7	6.6	153.6	102.0	2.9	53.6	3.8	9.2	1.0	1.8	3.3	56.7	99.0	357.7	50.3	1.4	1.5	3.0	0.4	0.4	0.8
3 x 5	3.3	40.7	53.3	1.3	18.7	8.7	2.7	5.3	191.0	120.3	2.7	62.6	3.7	8.5	1.3	1.3	3.2	47.3	75.3	348.4	45.0	1.6	1.4	3.0	0.4	0.4	0.8
3 x 6	2.7	38.0	52.0	1.1	14.3	7.8	2.0	5.0	200.7	86.1	2.7	42.4	3.3	11.3	1.1	1.8	2.8	28.3	57.3	268.4	56.0	1.2	1.5	2.7	0.2	0.3	0.5
3 x 7	3.7	39.0	52.0	1.3	17.1	7.7	2.3	3.9	258.3	112.5	3.2	67.0	4.1	9.1	1.1	1.5	72.8	30.0	51.7	324.5	49.7	1.5	1.5	3.0	0.4	0.4	0.8
3 x 8	4.0	40.7	53.3	1.4	17.9	7.6	2.3	4.4	229.3	105.5	2.9	48.1	3.8	11.3	1.4	0.8	2.7	33.3	53.3	335.3	48.0	1.5	1.5	3.0	0.5	0.4	0.9
3 x 9	3.0	38.3	52.3	1.4	15.7	9.0	2.3	4.1	245.5	93.4	2.7	50.4	3.1	8.0	1.0	2.0	2.5	43.3	71.7	243.0	45.7	1.6	1.3	2.9	0.3	0.3	0.6
4 x 5	3.0	38.3	52.3	1.2	13.8	8.8	2.3	4.0	250.6	102.9	3.1	50.6	4.1	11.0	1.1	1.5	2.3	38.7	63.3	304.9	48.7	1.3	1.2	2.5	0.3	0.3	0.6
4 x 6	3.0	37.0	50.7	1.6	20.6	7.8	2.3	5.6	182.7	103.7	3.1	54.2	4.0	10.7	1.1	2.8	2.5	35.0	58.0	380.3	35.3	1.7	0.8	2.5	0.4	0.2	0.6
4 x 7	2.7	37.3	51.7	1.6	18.9	8.4	2.3	4.4	228.1	97.5	2.8	52.5	3.7	10.1	1.1	1.8	2.7	39.0	63.7	278.9	35.0	2.0	1.1	3.0	0.5	0.3	0.8
4 x 8	2.1	34.8	49.3	1.7	21.1	7.9	3.3	5.1	195.1	115.1	3.4	61.2	4.3	10.7	1.1	2.7	2.5	35.0	63.3	384.5	38.0	1.5	0.9	2.5	0.4	0.3	0.7
4 x 9	2.7	39.7	52.7	1.6	20.5	7.9	3.0	4.0	252.2	103.4	3.1	54.7	4.0	10.9	1.0	2.2	2.2	35.0	55.0	349.1	48.3	1.2	1.1	2.3	0.4	0.4	0.8
5 x 6	3.3	39.7	52.7	1.5	19.9	7.8	3.0	4.6	215.7	117.2	3.4	61.3	4.6	11.2	1.1	1.7	3.2	46.0	59.7	349.8	47.3	1.6	1.4	3.0	0.5	0.4	0.9
5 x 7	3.7	38.3	53.0	1.7	19.7	8.5	3.0	3.9	255.1	110.7	3.0	46.9	4.0	10.9	1.0	2.0	4.3	41.7	65.7	310.3	38.3	1.7	1.3	3.0	0.5	0.4	0.9
5 x 8	3.7	36.7	50.7	1.8	19.1	8.7	2.7	3.7	267.8	93.4	2.9	51.4	3.8	4.4	1.2	2.8	3.7	48.3	70.0	341.5	31.0	1.7	0.8	2.5	0.6	0.3	0.9
5 x 9	2.7	36.0	49.3	1.8	22.0	8.7	2.0	5.0	201.6	109.3	2.8	52.7	4.1	10.0	1.1	2.5	2.7	38.3	60.0	265.4	56.7	1.1	1.4	2.5	0.2	0.3	0.6
6 x 7	3.7	39.7	53.0	1.7	25.5	6.6	2.7	3.0	343.3	95.0	2.8	49.8	3.7	9.8	1.0	1.8	2.8	46.7	64.0	290.3	41.3	1.2	0.8	2.0	0.3	0.2	0.6
6 x 8	3.7	39.7	52.7	1.5	19.1	8.5	2.3	4.6	217.1	102.0	2.7	49.4	3.8	9.1	1.2	1.3	2.3	43.3	61.0	338.3	37.3	1.6	0.9	2.5	0.4	0.2	0.6
6 x 9	2.7	39.3	53.0	1.7	20.5	8.5	2.7	5.2	195.3	133.7	3.0	74.9	4.1	10.3	1.0	1.5	2.5	41.7	61.0	356.1	51.0	1.4	1.5	2.9	0.3	0.3	0.6
7 x 8	3.3	39.3	53.7	1.6	20.5	8.0	2.7	5.0	201.9	90.9	2.7	49.1	3.2	9.9	0.9	0.7	2.2	43.3	91.3	301.8	41.0	1.3	0.9	2.2	0.2	0.2	0.6
7 x 9	3.3	40.3	54.0	1.6	22.0	8.0	3.0	3.7	271.5	90.9	2.5	48.2	3.2	8.9	1.1	0.8	2.3	33.3	64.7	289.1	35.3	2.5	1.4	3.8	0.6	0.3	1.0
8 x 9	3.3	39.0	53.3	1.7	21.1	8.3	3.0	5.0	201.5	112.9	2.5	56.7	3.4	9.8	1.1	1.0	3.0	45.0	65.3	358.2	25.0	1.5	0.5	2.0	0.4	0.2	0.6
General mean	3.2	39.6	54.5	1.6	19.2	8.3	2.5	4.7	218.6	106.1	2.9	55.1	3.8	9.9	1.1	1.6	3.4	41.1	65.8	336.7	43.0	1.5	1.2	2.7	0.5	0.3	0.8
CO at 5%	1.0	3.4	2.7	0.6	4.6	1.4	0.8	0.9	37.7	29.7	0.5	15.9	0.9	0.8	0.3	0.8	0.0	8.5	12.1	105.9	9.4	0.5	0.4	0.7	0.2	0.2	0.3

APPENDIX- IV

Meteorological data recorded during the crop growth period

Month/ Year	Temperature Maximum	Temperature Minimum	Relative humidity 7h. 14h.	Monthly Rainfall (mm)
1988				
Nov.	26.7	15.3	76.7	80.4
Dec.	25.3	14.5	79.2	60.9
1989				
Jan.	25.3	12.9	77.7	60.6
Apr.	33.2	23.8	79.9	46.0
May.	32.6	21.3	72.3	55.0
Jun.	29.4	20.6	72.6	57.0
1990				
Jan.	27.0	11.8	74.7	61.2
Feb.	29.7	13.8	75.9	65.7
Mar.	35.1	20.6	75.6	62.2
				7.0

APPENDIX- V

Laboratory environmental conditions recorded during the fruit storage studies

Month/ Year	Relative humidity(%)	Temperature (°C)
1988		
Nov.	64 - 68	20 - 22
Dec.	70 - 72	20 - 22
1989		
Jan.	64 - 68	19 - 21
Apr.	70 - 75	22 - 25
May.	70 - 72	20 - 24
Jun.	64 - 70	20 - 24
1990		
Jan.	64 - 68	19 - 20
Feb.	64 - 68	19 - 20
Mar.	55 - 60	20 - 21

ပြည်သူ့ဆေးကုရေးဦးစီးဌာန
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ကဏ္ဍ၊ ဝန်ကြီးရုံး၊ ဘဏ္ဍာရေးဌာန၊
514/1532
Th. 2735
ဆေးကုရေးဦးစီးဌာန
ပြည်သူ့ဆေးကုရေးဦးစီးဌာန