

**HETEROSIS AND COMBINING ABILITY STUDIES
IN CUCUMBER {Cucumis sativus , Linn. }**

By
Ramesh Nathsaheb Kate
B.Sc.{Agri}

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI, DIST : AHMEDNAGAR
MAHARASHTRA STATE, (INDIA)**

in partial fulfillment of the requirements for the degree
of

MASTER OF SCIENCE (Agriculture)

in

HORTICULTURE

DEPARTMENT OF HORTICULTURE
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413722
1997

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CANDIDATE'S DECLARATION

**I hereby declare that this thesis or part there of has not been
submitted by me or any other person to any other
University or Institute for a degree
or Diploma**

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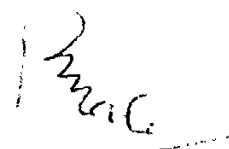
Maharashtra

CERTIFICATE

This is to certify that the thesis entitled "Heterosis and Combining ability studies in cucumber, (Cucumis sativus , Linn.)" submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri for the award of Degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE, embodies the results of bona fide research work carried out by Shri R. N. KATE, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or publication.

Rahuri/Pune

Dated :)) MAY, 1997




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CERTIFICATE

This is to certify that the thesis entitled "Heterosis and Combining ability studies in cucumber, (Cucumis sativus , Linn.)" submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist : Ahmednagar (Maharashtra) in partial fulfillment of requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE, embodies the results of a piece of bona fide research work carried out by Shri R. N. KATE, under the guidance and supervision of Dr. P.N.Kale, the then Professor of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri and that no part of the thesis has been submitted for any other degree or publication.

Rahuri
Dated : MAY, 1997


(V. M. Pawar)

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RAHURI

DATED : 15th MAY, 1997



(R. N. KATE)

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ABSTRACT

HETEROSIS AND COMBINING ABILITY STUDIES IN CUCUMBER (Cucumis sativus, Linn.)

By

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MASTER OF SCIENCE (Agriculture)

MAHATMA PHULE KRISHI VIDYAPEETH

RAHURI - 413722

1997

Major Professor : Dr. P. N. Kale

Department : Horticulture

The present investigation entitled, "Heterosis and combining ability studies in cucumber. (Cucumis sativus, Linn.)" was undertaken to study the magnitude of heterosis, combining ability, nature of gene action and heritability for twelve characters including earliness, fruiting and yield contributing characters, through 8 parent diallel analysis (excluding reciprocal) during 1983-84.

A high magnitude of heterosis was observed for all the characters studied. The highest percentage heterosis (75.91) over mid parent was recorded for fruit yield per vine in combination $P_3 \times P_7$ (BA \times P). The same combination also exhibited the highest heterosis of 55.13, 43.93 and 37.45 percent for vine length, weight of fruit and length of fruit respectively. It also exhibited maximum heterosis over better parent for the characters fruit yield per vine (52.80%), weight of fruit (32.30%) and length of fruit (27.38%). However, the maximum heterosis over better parent was recorded in cross combination $P_2 \times P_5$ (B \times LC) (61.67%) for number of fruits per vine.

The variance due to s.c.a. effects was higher than the variance due to g.c.a. effects for almost all the characters studied, indicating the predominance of non-additive gene action for these characters.

High heritability (N.S.) was observed for length of fruit and fruit size index. It was medium for flesh thickness, vine length, sex ratio, maturity, yield per vine, weight of fruit, earliness and number of fruits per vine, whereas heritability was low for days to first fruit picking and diameter of fruit.

From the estimates of g.c.a. effects it was observed that the parents P₁ (PK) and P₈ (JLG) were good combines for most of the characters. The parents P₃ (BA) and P₇ (P) exhibited next highest g.c.a. effects for most of the characters under study. As regards to fruit yield per vine it was observed that P₈ (JLG) followed by P₃ (BA) and P₅ (LC) were good combines.

The best specific combinations were P₁ X P₂ (PK X B) for earliness and maturity, P₁ X P₈ (PK X WLC) for sex-ratio, P₄ X P₇ (LG X P) for early fruit picking, P₄ X P₈ (LG X JLG) for weight of fruit, P₃ X P₇ (BA X P) for length of fruit, yield per vine and final vine length, P₂ X P₅ (B X LC) for number of fruits per vine.

Considering the overall performance, particularly the higher yield, green fruit colour, taste and crispness of fruit (Table - 12) it may be concluded that, the hybrid P₃ X P₇ (BA X P) was most outstanding, which recorded the highest yield. It was followed by hybrids P₈ X P₈ (WLC X JLG), P₄ X P₈ (LG X JLG), P₅ X P₇ (LC X P), P₅ X P₈ (LC X WLC), and P₂ X P₈ (B X WLC). These hybrids gave higher fruit yield than the highest yielding parent P₈ (JLG).

It may be concluded that, the cross combinations P₃ X P₇ (BA X P) and P₈ X P₈ (WLC X JLG) possessed high potential for yield contributing characters. Incidentally the hybrid P₃ X P₇ had dark green fruit colour with crisp flesh and good shelf life under ambient temperature. Thus, commercial exploitation of hybrid vigour in cucumber is possible from these cross combinations.

1 INTRODUCTION

Cucumber (Cucumis sativus L) is one of the important members of family Cucurbitaceae and it is a very popular and relished vegetable. Fruit is consumed as raw with pinch of salt and pepper both at mature and immature stages. It is also an important ingredient of Salads, Sandwiches and other food recipes. Cucumber is a rich source of minerals viz. Ca, Mg, Na, P, Fe, S, Si, Cl and also vitamins B and C.

Cucumber possesses good medicinal properties, since it has cooling effects and prevents Constipation, Jaundice and allied diseases. It is also used in Cosmetic preparations.

It is considered to be native of Asia and Africa and it has been grown there as a food crop for last 3000 years. This crop was cultivated by ancient Greeks and Romans during 300 BC. Later on it found its way to China in 100 BC and to France during nineteenth century. According to Vavilov (1926) cucumber is originated from Indo-Burma (Mynmar) region. There are reports of its cultivation by Indians before Columbus and in addition, settlers grew other varieties also (Splittstoesser, 1979). There are some reports about its origin from India and of its spread from there to other Asian countries, Africa and Europe. Plausibility of its origin in India is attributed to availability of cucumber fruits in tremendous array of size, shape, skin colour, ornamentation and vegetable properties. Such strains were also noticed in adjoining countries (Whitaker & Gemis, 1979).

Cucumber is short duration vine crop and cultivated in almost all parts of the country. Further more, it is grown during summer as well as in rainy / kharif season in India.

Cucumber belongs to the genus Cucumis which encompasses fifty or more species from Asia and Africa (Cobley, 1963). Notwithstanding this, only two species viz. Cucumis sativus L. i.e. Cucumber and Cucumis melo L. i.e. Muskmelon are of more economic importance to the farmers. Cucumber is characterized by monoecious sex-expression, but this is not a rule and forms of andromonoecious, gynodioecious, hermaphrodite and even trimonoecious are not uncommon. Sex-expression in cucumber though a genetic character is generally influenced by the environmental factors. Under the conditions of long days and high light intensity male flowers

(Staminate) predominate, whereas under the situations of short days and low light intensity female flowers (Pistillate) predominate. Advantage of this genetic expression , despite the availability of arrays of variability in shape, size, colour of cucumber in India, has not been explored to the fullest extent by undertaking systematic studies on these desirable and beneficial aspects of this crop. As such the research work on this major aspect is very meager especially in India. Most of the recommended varieties are the introduction from the temperate countries. Under the influence of weather conditions of tropical regions of high temperature and high light intensity these varieties though promising produce more male flowers owing to their evolution at cooler place and hamper the harvest prospects as the yield of cucumber is directly co-related with the number of female flowers produced on the vine.

Hays and Jones (1916) were the first to report heterosis in cucumber. Several investigators have confirmed that hybrid vigour was manifested in cucumber. It is believed that the hybridization compensates for the added seed cost by way of high yield. But in cucumber , if all female i.e. Gynoecious lines are employed in the hybridization programme for seed production, the practice/ process becomes easier which obliterate the rouging and thus involving very less cost.

The development of gynoecious cucumber lines like MSU 713-5 and the evolution of procedure for maintaining such lines had made it possible to obtain 'F₁' hybrids in Cucumis sativus L. at reasonable cost (Peterson and Weigle, 1958). The first ever hybrid in pickling cucumber which had gynoecious line was released in 1961 as Spartan Dawn (Peterson and DeZeeuw, 1963). Apart from this, even with the available monoecious lines in cucumber, it is possible to produce 'F₁' hybrid seed at comparatively low cost as it requires less manual labour at actual production stage.

Coming to consumers preference in the state of Maharashtra, it is observed that the majority of them prefer cucumber having yellowish or creamy white fruit colour with medium long (12-15 cm) fruit size. These traits are found in Poona Khira variety and that may be one of the reasons for its popularity in the Maharashtra, besides it's good fruit quality and moderate yield per unit area. Notwithstanding this, it suffers from few drawbacks like poor vigour of vine, short fruiting period, poor keeping quality, large seed cavity and susceptibility to powdery mildew and anthracnose diseases. To improve upon these demerits of the Poona Khira, attempts were made through heterosis breeding.

In the past studies Cucumber varieties/lines used were mostly from temperate region. However, recently Musmade (1981) diverted the efforts to investigate the degree of manifestation of heterosis using 7 monoecious cucumber cultivars/lines coming mostly from tropical region. These investigations indicated the possibilities of exploitation of heterosis in tropical cucumber for higher productivity and quality.

In view of the results of earlier investigations, present studies were planned to make further advances in exploitation of heterosis in cucumber by using eight monoecious lines / cultivars possessing large genetic diversity. Griffing's (1956 b) method of diallel analysis was followed for the estimation of degree of heterosis and combining ability with under listed objectives :

- i) To study the extent of manifestation of heterosis and genetic architecture for the yield.
- ii) Estimation of General and Specific Combining ability of Parental lines.
- iii) Estimation of variance due to G.C.A. and S.C.A. effects with a view to obtain the best combiners for the yield and good horticultural characters or traits.
- iv) To study the type of gene action involved in controlling the qualitative/quantitative characters.
- v) Estimation of narrow sense heritability.

2 REVIEW OF LITERATURE

Hybrid vigour has been explored commercially in several vegetable crops including Water Melon, Musk Melon, Pumpkin and Cucumber. Heterosis is usually manifested in yield contributing characters like large size or weight of fruit, number of fruits mainly resulting from early maturity. A review of the work done so far is presented below.

1. Heterosis :

Hays and Jones (1916) were the first to report heterosis in cucumber. Later on Hutchins (1938) showed rather conclusively that the F_1 cucumber displayed a marked amount of hybrid vigour. Peterson and Welgle (1958) devised a scheme for production of F_1 hybrid seed at a reasonable cost by the use of "Gynomonoecious lines". Subsequently several investigators have confirmed that hybrid vigour was manifested in cucumber in respect of earliness (Petkova, 1971; Mikhov and Petkova, 1971; Avakyan and Hirapetyan, 1974; Zavadskaya, 1975; Airapetyan, 1981; Pyzhenkov and Kosareva, 1981); increased yield per plant. (Alexandrova, 1975; Klossowska and Kubicki, 1970; Kas'yanova, 1971; Pasin, 1974; Schutte, 1974; and Solanki et al, 1982); increased number of fruits per plant. (Lower and Nenhuit, 1982); heterosis for fruit weight per plant and main stem (vine) length. (Boos and Kocheneva, 1971; Schulte, 1974; Pyzhenkov and Kosareva, 1979; Airapetyan, 1981 and Solanki et al, 1982); (Barnes, 1966; Airapetyan, 1969) observed increase in the yield of heterotic hybrids which ranged from 83.6 to 176.0 c/ha. These hybrids were also early and were not inferior in taste, external appearance, colour and dry matter content. In order to obtain heterotic hybrids, Airapetyan (1972), advocated a particular attention in choosing the parents in respect of time of formation of female flowers, the number of fruits formed and the duration of fruit formation. Jakubokova (1974) obtained highest yields with heterosis between 35 % and 40% in the F_1 combination. Kolyukaeva (1979) reported that the gynoecious lines ZhL2 and ZhL9 together with six other forms were crossed with four monoecious pollen parents

viz. C7-63, SmR-15, MSU-165-1 and MSU61-116 and obtained the best hybrid ZhL1 X C7-63 with marked heterosis.

Musmade (1981), observed the maximum heterosis in the yield per vine (61.91%), followed by yield per hectare (57.14%) and diameter of fruit (38.10%) in cucumber (Cucumis sativus, L.). Lu and Hon, 1981 observed hybrid vigour for early maturity and high yield but not resistant to Pseudoperonospora cubensis and Fusarium oxysporium. Solanki et al, 1981 revealed that heterosis over better parent was the highest for the primary branch numbers per plant (25.26%) secondary branch numbers per plant (43.6%), number of female flowers (50.95%) and average fruit weight (33.34%) in Hinreka X Balamkhira, while it was the highest for harvested fruit number per plant (42.12%) in Chaubattia local X Solan Local and for fruit yield per plant (83.81%) in Furkin Riesenschel X solan local. Rubino and Wehner (1986) obtained many hybrids by crossing the S_8 with gynocious inbred line Gy-14A which showed heterosis over the mid-parental value and some over superior parental value.

Abhang, A.G.; 1987 revealed that the highest heterosis (158.45%) over better parent was noted in a combination Gy 664 X Poona Khira. The same combination also exhibited the highest heterosis for yield per vine (158.38%) and number of fruits per vine (116.79%).

Earliness :

Hutchins (1938) reported that the F_1 between Mincu and an early maturing cultivar produced very early yield which were much larger than those of the earliest yielding parent. Tulupov (1970) showed that early x late crosses approached the early maternal parent in date of flowering than the late parental parent.

Earliness in flowering and fruiting has also been recorded by Singh and Gill (1970), Guseinov (1970), Kas'Yanova (1971), Boos and Kocheneva (1971), Petkova (1971) and Marchenkova (1971) in cucumber.

Mikhov and Petkova (1971) crossed Wisconsin, SMR-18, Pide and Model with tester Posrednik 97 as the female parent and observed heterosis for earliness and yield.

Gill, et. al. (1973) reported that the F_1 hybrid Pusa Sanyog out yielded Japanese long green by 23.05 - 128.78% and was ten days earlier. Avasthi (1974) recorded more pronounced earliness and productivity in F_1 hybrid.

Miller (1975) studied two early and two late flowering cultivars and their F₁, F₂ and back cross populations and concluded that dominance effects were important in the inheritance of time of flowering. Miller and Quisenberry (1976) studied early and late flowering cultivars and their progenies. They observed that the genetic variance was primarily by additive effects. However, partial dominance for early flowering and low nodal position of first flower was noted. Zavadskaya (1975) also reported that the F₁ hybrid showed earliness and higher yield as compared to parents. Musmade (1981) studied heterosis in cucumber and revealed that the best performing hybrid over better parent was Turkish long green X Parval for earliness (- 4.59) and first fruit picking (-6.45%).

Abhang, (1987) studied heterosis in cucumber and revealed that the hybrid Poona Khira X Improved long green showed maximum percent heterosis for earliness (-23.65).

Sharma and Lebedeva (1987) reported that a large leaf area lead to early yields. Seedlings with long hypocotyls (8-10cm) flowered and fruited 5-29 days earlier than those with short hypocotyls (1.5-4.5 cm).

Sex Ratio (Sex Expression) :

Boos and Kocheneva (1971) observed that increased yield was due to the number of female flowers per plant. He showed that in six out of twelve hybrids there were 73 to 105.1% more female flowers per plant than in the seed parent and in ten hybrids 44 to 97.8 % more pistillate flowers than in the pollen parent. Pike and Mulkey (1971) crossed hermaphrodite line TAMU 950 as a male parent with the gynoecious lines MSU 2059 and GY-3, the resultant F₁ hybrid population were 100 % gynoecious and the fruits were similar to the female parent in size and shape. These hybrids exhibited heterosis for longer vine length. Airapetyan (1972) observed that in some intervarietal hybrids, heterosis took the form of an acceleration of male flowering while in others an increase was observed in the number of female flowers or fruits and in average fruit weight. Kubicki (1972) suggested that the development of male and female flowers in cucumber (Cucumis sativus) is controlled by the level of an ovary inducing substance in plant. High content of this substance leads to the development of pistillate flowers, while low level of this substance leads to the development of staminate flowers. Where level is intermediate, hermaphrodite flowers

were developed. The level of this substance is controlled by activity of number of genes.

Galun (1973) has described the genetics of sex expression in the cucumber and exploitation of the several forms in hybrid seed production. It has been shown by Jakubkova-Novakova (1973) that the number of female flowers increased with the number of dominant genes and that the distribution of male and female flowers on the plant affected fruit set per plant.

Avakyan and Hirapetyan (1974) studied the ratio of male and female flowers in five varieties and their F_1 hybrids in the first 15 days of mass flowering. They observed that in three varieties male flowers dominated, but in Plodovityi 147 (fertile 147) and Izobilny 131 (abundant 131) the reverse was true. The hybrids generally occupied an intermediate position in this respect. The parents which had more female flowers and the hybrids resulting from such parents had more pronounced earliness and productivity.

Sott and Baker (1974) observed gynoecious and more predominantly female plants when they crossed gynoecious lines with andromoenious lines of cucumber. The gynoecious and predominantly female, monoecious and androecious phenotypes segregated approximately in the ratio 6 : 6 : 3 : 1 respectively in F_2 . Ramalho (1975) recorded pistillate flowers on the lateral branches in variety Aodai and on the main stem in gynoecious lines Gy3. Further he concluded that the number of pistillate flowers was positively correlated phenotypically and genotypically with fruit number but negatively with fruit weight, length and fruit set. The occurrence of pistillate flowers on main stem was negatively correlated with number of fruit set, fruit weight, length and total fruit yield.

Sachuk (1975) found difference in the inheritance of sex expression in female plant of the gynodioecious varieties and concluded that these differences in sex expression appeared to cause variation in the yield of their F_1 heterotic hybrids. Later on Zavadskaya (1974) studied sex expression in the variety Productive 37 (713) after open pollination within the population. The male plants were removed before flowering. In the initial population, the percentage of female plants was 56.3, after two years, reproductivity fell to 46.1%. Then he used the back cross complex material forms, which maintained the proportion of 50 % female and 50% andromonoecious. This was considered to be promising in the production of heterotic hybrids.

Tkachenko (1979) examined characteristics of gynoecious and hermaphrodite plants and their importance in the production of heterotic hybrids. He noted that the female sex expression in partially dioecious forms is governed by a single major gene and several minor genes. When partially dioecious varieties were crossed with normal monoecious varieties, the gynoecious plants were predominant in F₁. Yang and Xiao (1980) studied several F₁ crosses between gynoecious and hermaphrodite lines and observed only gynoecious and sub-gynoecious plants which flowered a few days earlier than the gynoecious plants. EL-Shawaf and Baker (1981) observed that non additive genetic variance was more important for gynoecious expression.

Musmade (1981) observed a high female to male sex ratio in hybrid 1 X 4 (1:4). Abhang (1987) concluded that female to male sex ratio was in general increased in the hybrids.

Fruit Characters and Yield :

Hays and Jones (1916) were the first investigators to report the heterosis in cucumber. They found that F₁ from crosses between unrelated cultivars of cucumber exceeded in yield over the highest yielding parent by as much as 25 to 39 %. They also showed that F₁ exceeded the most prolific parent by an average of 1.6 to 8 fruit per plant. Later on Hutchins (1938) concluded that cucumber displayed a hybrid vigour chiefly through increased yield per plant and increased number of fruits per plant.

Ajrapetjan (1969) studied the productivity in the first generation of hybrid cucumber and concluded that increase in yield in cucumber hybrids was 83.6 to 176 cents per hectare. Singh and Gill (1970) reported that F₁ hybrids involving seven cucumber cultivars with a pistillate line (female plant) produced significantly higher, early and total yield than did the standard cultivars. Guseinov (1970) used the promising cucumber cultivars for hybridization and made a selection of high yielding F₁ hybrid. He further observed that, when hybrids were planted in summer they surpassed the standard cultivar in early yield by 42.7 to 117.2 % and in total yield by 87 to 108.7 %. Borgi and Vandoni (1970) made an attempt to transfer the character "absence of bitterness" to the twelve most useful varieties, the F₂ segregation data confirmed the monofactorial basis of the character and its good penetrance. Boos and Kocheneva (1971) and Petkova (1971) showed that heterotic combination gave upto 40 % higher, early and 22% higher total yield. In the same year Mikhov and

Petkova reported that crosses of Wisconsin, SMR 18 and Pixie were distinguished by marked heterosis for yield.

Kas'yanova (1971) concluded that the best hybrid combination proved to be Parinkovyxklin and Virovskissalathyl (Virov -Salad x Klin) which exceeded the yield of parental varieties by 22.3 to 38.1 % and ripened earlier. Marchenko (1971) observed that multilateral evaluation and selection of progeny for high yield, earliness and other valuable characters made it possible to obtain high yielding hybrid varieties which retained their heterosis over several generations. Quseva & Demakova (1973) observed that the highest concentration of cucurbitacins causing bitterness in cucumber occurred at 11000 IX during 9-12 hr. day with a soil water content of 60-90% of full field capacity and with simultaneous application of P and K but not N.

Tkachenko (1974) advocated a new method of obtaining high yielding heterotic hybrids by using purely female forms and also the hermaphrodite varieties as female parent. Schulte (1974) studied diallel crosses involving 64 varieties from 12 countries and concluded that high yield (number of fruits per plant) reflected a distance between the parents based on a chronological separation on the evolutionary scale rather than upon their geographical or ecological separation which was considered analogous to heterosis.

In 1975 Mescherov and Malychenko⁽¹⁹⁷⁵⁾ obtained high yielding hybrids using as female parent, triple complex forms obtained from a cross of type (Female x hermaphrodite or andromonecious) x dioecious form or male line. Pasin (1975) evaluated a number of cross combinations which out yielded the recommended varieties by 20 to 25 %. Zavadskaya (1975) compared the F₁ hybrids with their parental forms and concluded that high yielding heterotic hybrids were suitable for pickling and out yielded the recommended variety Zolzhik by 50 to 70 % and the hybrid VIR-507 by 12 to 20 %. In the same year Haribabu from India found that crosses between Dosa (Cucumis sativus) X Budama (Cucumis Pubiseus) gave more heterosis for yield per plant than the crosses between Budama X Dosa. He obtained a high yielding desirable type from the former cross. Prend and John (1976) introduced the characteristics, determinate small vine from Minnesota 82.59 into gynoeious hybrids which gave significantly increased yields in the resultant dwarf hybrids than the standard size gynoeious hybrid Pioneer. Paponov and Beridze (1977) reported high degree of heterosis for different yield and yield contributing

characters. Imam et al (1977) reported that the short fruits were dominant over long, small diameter was dominant over large and broad seed cavities were dominant over narrow. Further they found correlation between fruit length and diameter of seed cavity.

Horst and Lower (1978) observed that crosses between an intermediate Cucumis hardwickii line and the gynoecious Intermediate line Gy 14 and monoecious determinate line P.G. of Cucumis sativus resulted in the average number of fruits and the range of the number of fruits produced in the F_1 , F_2 and BC1 as compared with the Cucumis sativus parent. In the same year Charderi and Lower found that hybrids showed greater growth and produced more top and root fresh weight than the better parents under varying environmental conditions. They also observed that the hybrids showed greater phenotypic stability under varying environments than the parents.

Heterosis from early fruit yield, total yield and total number of fruits per plant was also reported by Om et. al. (1978) from a diallel set.

Kolyukaeva (1979) crossed three gynoecious lines and six other forms including some which were obtained by crossing and had over 50% female plants, with four monoecious pollen parents from the USA. The best hybrid out yielded its parents and the standard variety Signal 235. Lower and Nienhuis (1979) crossed isogenic monoecious line Addis with gynoecious line Gy 14. Those from crosses involving the determinate type in a spring trial had more number of fruits per plant. They further concluded that hybrids from determinate parent had small fruit length.

Timofeev (1979) used promising inbred lines 189 and 192 from Plouvtiyi 147 X Vladivostock 155 as seed parents in crosses with high yielding, disease resistant varieties such as Mid. The hybrid obtained exceeded Avanguard 121 (Avantgrade 121) in total yield by 44.1% in Primore region of Soviet far east. Ellis and McSay (1981) recommended that the value for number of fruits harvested is most accurate measure of yield. Yields from hand picked trials indicated 35 to 40 % heterosis. Ghaderi and Lower (1981) obtained significant additive or dominance variance in certain crosses for all the three yield characters, viz fruit weight per plant, fruit number per plant and average weight of fruit. Jiang (1982) reported that the F_1 hybrids showed vigorous growth and higher resistance to powdery mildew and fusarium wilt than their parents and the control. Bulatova (1986) showed that short fruited hybrids were superior to long fruited ones when planted in January. Early yields were also higher in short

fruited hybrids. Pyzlenkov (1986) showed that spine colour is controlled by alleles of a single gene with black (B) dominant over brown (B¹) which in turn is dominant over white (b). Similarly large surface Protuberances (S) being dominant over small Protuberances (S¹) which in turn is dominant over smooth fruit surface (s). Sardar and Mukherjee (1987) showed that deep green colour of fruit was dominant over green, yellow, and white; green dominant over yellow and white, yellow dominant over white in Trichosanthes Sp.. Abhang (1987) showed that the highest heterosis (158.45%) over better parent was noted in Gy 664 X Poona Khira for per hectare yield. The same combination exhibited highest heterosis for per vine yield (158.38%) and number of fruits per vine (116.79%).

II. Combining ability :

The concept of combining ability for the evaluation of parents in a crossing programme is of immense significance. It has been originated through intensive hybridization work in maize. It is especially useful in connection with testing procedure in which it is desired to study the comparative performance of lines in hybrid combinations. The term general and specific combining ability were originally defined by Sprague and Tatum (1942) in relation to diallel crossing system. They defined the term as follows " The term general combining ability is used to designate the average performance of a line in hybrid combination. The term specific combining ability is used to designate those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the lines involved."

Griffing (1956 b) examined critically the concept of combining ability and concluded that when a set of inbred lines is used in a diallel crossing system a genetic interpretation in terms of quantitative inheritance is made possible by the fact that the analysis is really a 'gamete' combining analysis. Thus, the genetic properties of the two gametes which unite, to form the individual.

According to Griffing (1956a) s.c.a. involved both dominance and epistasis whereas g.c.a. composed of additive X additive type epistasis.

Mikhov and Petkova (1971) concluded that cucumber cultivars Wisconsin SMR - 18, Pixie and Model had the best general combining ability among the ten varieties studied. The crosses of all the three varieties with the tester Pasreolnik 97 as the

female parent, inherited the tester's character of producing mainly female flowers, while crosses of Wisconsin SMR -18 and Pixie showed marked heterosis for yield and earliness. In the trials of ten hybrids with a view to select those having a fruit of regular size and weight, the cucumber varieties Alberello Sarzanese Scuro di Milane (Milan dark) and Striato Di Vittoria (Victoria Stiped) showed the best general combining ability and heterosis for yield (Anonymous, 1971).

Strel'Nikova and Mashtakova (1975) studied general and specific combining ability in cucumber in two cycles of selection and obtained 5 to 10 % increased yield in a number of crosses.

Borgi and Vandoni (1976) tested combining ability in 21 varieties of cucumber by means of a top cross with Evergreen. They observed that the varieties with medium sized fruit were in general superior to those with short fruit. Almost all the hybrids with Evergreen as parent, out yielded Evergreen.

Paponov and Beridze (1977) estimated general and specific combining ability of cucumber variety with several varieties of female flowering type and noted a high degree of heterosis. El Shawaf and Baker (1981) studied F_1 hybrids from crosses between four gynocious and five hermaphrodite lines. These hybrids had greater additive genetic variance for yield and associate components except for gynocious expression, where, non-additive variance was more important. The general combining ability (g.c.a) effects for time to harvest, gynocious expression and yield of the female parents was greater than that of the male parents. The converse was true for days to flowering. Complete dominance was indicated for early flowering and over dominance for gynocious expression. Tasdighi and Baker (1981) reported that parental lines 551 F, 368 G, 581 H and 5802A exhibited the highest general combining ability effects in both single and three way crosses for total yield and marketable yield. They further concluded that the best hybrid combination for yield could be predicted from g.c.a of parental lines.

Prudek and Wolf (1985) showed high g.c.a. effects for all characters & greatest stability over the period of three years. Heterosis was significant for all characters except fruit weight. s.c.a. variance and interaction of s.c.a. with years were significant only for fruit weight. High and significant correlations ($r = 0.87-0.95$) were found between the values of yield components in parents and those in the F_1 progenies.

Prudek (1986) showed that both general and specific combining abilities were of significance in determining both the number and weight of fruits per plant, but g.c.a. was more important whereas specific combining ability has no importance with regards to earliness and mean single fruit weight. The line PS-66 which displayed male sterility obtained by a single recessive gene and high g.c.a. values for all the above mentioned characters. Heterosis for both number and weight of fruit per plant was high in some F_1 populations and depended on over dominance. Correlation between parental lines and F_1 progenies for all four characters were high enough to indicate that good all round performance in the F_1 might be obtained after choosing the parents solely on the basis of their performance.

3 MATERIAL AND METHODS

The present investigations were undertaken at Instructional cum Research Orchards, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist : Ahmednagar, during the period from October 1982 to May 1984. The details of the materials used and the statistical procedures followed during the course of investigations are described below:

3.1 MATERIAL

The parental material consisted of eight lines viz. Poona Khira, Budgi 1192092, Beta Alfa, Long Green A, Long Cucumber, Poinsett, White Long Cucumber (Pandhari lamb Kakadi) and Japanese Long Green of Cucumber. These lines were selected from the germplasm collection of All India Co-ordinated Vegetable Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. The lines were selected on the basis of large variation in their yield contributing and horticultural traits.

Eight parental lines listed earlier were used in a non reciprocal diallel crosses to study the combining ability and heterosis for days to flowering, node of first female flower, days to first picking, number and weight of fruits per vine, average fruit weight, length and diameter of fruit, fruit size index and thickness of flesh. In addition to this to record observations on horticultural traits viz. fruit colour, fruit surface, presence of spines and their colour, size of fruit and its keeping quality were also recorded.

3.2 METHODS

During the year 1982 eight selected parental lines were sown and self seeds of these lines were obtained.

During the year, 1983-84, eight parental lines were crossed in all possible combinations without reciprocals giving a total of 28 F₁ hybrids. In order to get the crossed seed, the procedure of bagging buds of female flowers in the evening and hand pollinating the female flower buds in the next morning with the pollen grains taken from previously bagged male flowers was adopted. At the same time selfed seed of parental lines was obtained by controlled pollination. Thus, the seeds of eight parents and 28 F₁ hybrids were obtained to undertake further studies.

3.2.1 EXPERIMENTAL DESIGN

The trail was laid out in a randomized block design with three replications. The parents and F_1 hybrids were sown directly in the field on 30th January, 1984 in single row having ten plants each with a spacing of 2 m between rows and 60 cm between two plants within the row. The observations were recorded from five randomly selected plants in each row. The recommended cultivation practices were followed during the experimentation.

3.2.2 OBSERVATIONS RECORDED

The following growth and fruiting observations were recorded on individual plant basis :

1. Quantitative Characters

1. Earlyness (days to flowering) :

Number of days required for the appearance of first female flower from the sowing was recorded for each observational plant and means were calculated.

2. Node of first female flower i.e. maturity :

The number of node at which the first female flower appears, gives an indication of maturity in cucurbits (Swarup, 1977). Therefore, the node at which the first pistillate flower appeared was noted for all the observational plants and means were calculated for the parent and hybrids.

3. Sex Ratio :

A high female to male ratio (Sex Ratio) is desirable in monoecious cucurbits like cucumber. Hence, number of male and female flowers produced by each observational vine during its life cycle was recorded and the ratio of female to male flowers of each parent and F_1 hybrid was calculated.

4. Days to first fruit picking :

The number of days required for first fruit picking from the date of sowing was recorded for each parent and F_1 hybrid.

5. Average Weight of Fruit (g) :

The weight of five individual fruits harvested at the edible stage was recorded and the average weight of the fruit was calculated for each parent and F_1 hybrid.

6. Length of fruit (cm) :

Length of the same five edible fruits from each parent and F_1 hybrid plants was recorded from stalk end to the apex of the fruit and averages were calculated.

7. Diameter of fruit (cm) :

Diameter of the same five fruits was measured with the help of vernier caliper at the maximum thickness / breadth of the fruits.

8. Thickness of flesh (cm) :

The fruits were cut into two halves at the maximum diameter and the flesh thickness was measured with the help of scale in centimeter.

9. Fruit size Index (cm²) :

Fruit size index was calculated by multiplying length into the breadth of the fruit.

10. Number of fruits per vine :

Number of fruits were recorded at each picking from all the observational plants separately and summed up after final harvesting and mean number of fruits per plant / vine, was worked out for each parent and F₁ hybrid.

11. Yield per vine (kg) :

Weight of all the fruits harvested periodically from each observational plant was recorded separately and summed up after final picking and the mean weight of fruit per plant /vine was calculated for each parent and F₁ hybrid.

12. Length of vine (m) :

The final length of five observational vines was measured from ground level to the growing tip of the vine at the end of the life cycle of each parent and F₁ hybrid and average length of vine was calculated.

II. Qualitative Characters :

1. Colour of fruit :

Colour of fruit at edible maturity stage was visually observed and recorded for parents and F₁ hybrids as dark green, green, light green, creamy, greenish yellow, etc.

2. Surface of fruits :

Surface of fruit was observed visually and recorded as smooth or rather smooth, rough or rather rough, both for parents and F₁ hybrids.

3,4. Spinyess and Colour of Spines :

Presence of spines on the fruits and their colour at the edible maturity was recorded for parents and F₁ hybrids.

5. Size of fruit :

On the basis of fruit size index, the fruit size of parents and F₁ hybrids was grouped as under :

<u>Size</u>	<u>Fruit Size Index (cm²)</u>
a. Very Small	50 - 80
b. Small	81 - 110
c. Medium	111-140

6. Keeping Quality (shelf life) :

Freshly harvested five fruits at edible maturity stage from each treatment were kept at room temperature to study the keeping quality and shelf life of the fruits. The colour, crispiness, taste of the freshly harvested fruits and also after storage were recorded for each of the parents and F₁ hybrids. Number of days fruit could remain in good condition and percent loss in weight in storage were also recorded for parents and F₁ hybrids.

3.2.3. STATISTICAL ANALYSIS :

A. Heterosis :

Heterosis was estimated in terms of two parameters i.e. heterosis expressed over mid parent and better parent. The parents exhibiting earliness in flowering and fruiting, having more vine length, more fruit length, greater diameter of fruit, more number of fruits per vine, heavier in mean fruit weight and with high yield per vine were taken as the better parent in respective cases.

Heterosis (percent) over mid-parent :

$$MP = \frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$$

where, \overline{MP} = mean of mid parent
 $\overline{F_1}$ = mean of F₁.

Heterosis (percent) over better parent :

$$BP = \frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

where, \overline{BP} = mean of better parent
 $\overline{F_1}$ = mean of F₁

Test of Significance :

Test of significance was carried out for evaluating the heterosis over MP and BP as follows :

i) For testing the heterosis over \overline{MP}

$$SE = \sqrt{\frac{3 \times Ve}{2 \times r}}$$

CD = SE x 't' value at 5 and 1 % levels for error degrees of freedom.

ii) For testing heterosis over \overline{BP}

$$SE = \sqrt{\frac{2 \times Ve}{r}}$$

CD = SE x 't' value at 5 and 1 % levels for error degrees of freedom.

where, Ve = the error mean square of the RBD

r = number of replication

CD = Critical differences

C. Analysis of Variance for combining ability :

Data obtained was subjected to the combining ability analysis. This analysis was done according to procedures detailed by Griffing (1956 b). The method 2 (parents and one set of F₁'s excluding reciprocals) model (Mixed effect model) were used. In model - 1, the experimental material is to be regarded as the population about which inferences are to be made with an object to compare combining abilities of the parents, when the parents themselves are used as testers and to identify the high yielding combinations. In this, it was intended to estimate combining ability effects and computing appropriate standard errors for the differences between the effects. According to Model -1, the error is assumed to be independently distributed with mean zero and variance $\sigma^2 e$.

The mathematical model for the combining ability analysis is assumed to be :

$$X_{ijk} = \mu + g_i + g_j + S_{ij} + 1/bc \sum_k e_{ijki}$$

$i, j = 1, \dots, p$
 $k = 1, \dots, b$
 $l = 1, \dots, c$

where,

μ = population mean.

g_i = g.c.a. effect of i th parent.

g_j = g.c.a. effect of j th parent.

S_{ij} = s.c.a. effect of the cross between i th and j th parents.

e_{ijk1} = environmental effect pertaining to $ijk1$ th observation on ij th individual in k th block with i th as female parent and j th as male parent.

The following restrictions are imposed in the utility of this model :

$$g_i = 0 \text{ and } S_{ij} + S_{ji} = 0 \text{ (for each } i)$$

ANOVA table for combining ability.

Source	d.f.	S.S.	M.S.	Expectation of mean square
g.c.a.	$(p-1)$	S_g	M_g	$\sigma^2 + 1/(p+2)(p-1)\sum g_i$
s.c.a.	$p(p-1)/2$	S_s	M_s	$\sigma^2 + 2/p(p-1)\sum_i \sum_j S_{ij}$
error	m	S_e	M^1_e	σ^2

The sum of squares were calculated as follows :

$$S_g = 1/(p+2) [\sum (X_i + X_{ii})^2 - 4X^2 / p \text{ --- }]$$

$$S_s = \sum_i \sum_j X_{ij}^2 - 1/(p+2) \sum (X_i + X_{ii}) + [2/(p+1)(p+2)] X^2 \text{ ---}$$

where,

S_g = Sum of squares due to g.c.a.

S_s = Sum of squares due to s.c.a.

p = number of parents.

m = degrees of freedom for error mean squares, $(r-1)(t-1)$.

X_i = row total of the array involving i^{th} parent, $\sum_j X_{ij}$

X_{ii} = mean values of the i^{th} parent.

$X_{..}$ = grand total of $1/2p(p-1)$ progenies $\sum_i \sum_j X_{ij}$

X_{ij} = the mean value of ij^{th} cross.

The mean sum of squares of g.c.a. and s.c.a. were obtained by dividing their sum of squares by their respective degrees of freedom. Whereas, the error mean

squares (M_e) was obtained by dividing error mean squares (m_e) obtained in simple R.B.D. analysis, by the number of replications. ($M^1_e = m_e/r = \sigma^2 e$).

The following 'F' ratios were used to test for g.c.a. and s.c.a. effects.

1. To test for differences among g.c.a. effects.

$$\sigma^2 g = 0$$

$$F = [(p-1), m] = Mg/M^1_e \text{ and}$$

2. To test for differences among s.c.a. effects.

$$\sigma^2 s = 0$$

$$F = [p(p-1)/2, m] = Ms/M^1_e$$

Estimation of general and specific combining ability effects :

These effects were estimated as follows :

General combining ability effect of i th parent.

$$\text{Population mean } = \mu = 2/p(p+1) X \text{ ---}$$

$$\text{g.c.a. effect } g_i = 1/(p+2) \{ X_i + X_{ii} - 2X/p \text{ ---} \}$$

s.c.a. effects S_{ij} i.e. Specific combining ability effects of ij th cross.

$$S_{ij} = X_{ij} - 1/(p+2) \{ X_i + X_{ii} + X_j + X_{jj} \} + 2/(p+1)(p+2) X \text{ ---}$$

Standard error of the estimates :

Standard error of an estimate was calculated by taking the square root of variance of the estimate, variance of effects were estimated as follows :

1. Variance of g.c.a. effects

$$\text{Var, } \hat{g}_i = (p-1)/p(p+2) \hat{\sigma}^2$$

2. Variance of s.c.a. effects

$$\text{Var, } \hat{S}_{ij} = \{ (p^2 + p + 2) / (p+1) (p+2) \} \sigma^2 \quad (i \neq j)$$

where ,

P = number of parents.

$$\sigma^2 = M^1_e.$$

Each g.c.a. and s.c.a. value was tested against zero for its significance by 't' test as

$$t = g_i - 0 / \text{S.E. } (g_i);$$

$$t = S_{ij} - 0 / \text{S.E. } (S_{ij}).$$

Some additional variance for testing differences between the two estimates were calculated as follows :

4 EXPERIMENTAL RESULTS

The present investigation was undertaken during the year ~~1983-84~~ to study the manifestation of heterosis, to determine the variance due to g.c.a. and s.c.a., to estimate general and specific combining ability effects among the genetic stock of cucumber. Following eight parents were used for diallel crosses without reciprocals and twenty-eight crosses (F_1 hybrids) were obtained.

1. P_1 : Poona Khira (PK)
2. P_2 : Budgi 1192092 (B)
3. P_3 : Beta Alfa (BA)
4. P_4 : Long Green-A (LG)
5. P_5 : Long Cucumber (LC)
6. P_6 : White Long Cucumber (WLC)
7. P_7 : Poinsett (P)
8. P_8 : Japanese Long Green (JLG)

Twenty-eight crosses involving above eight parents were evaluated in diallel analysis for twelve quantitative characters. Besides, observations on qualitative characters were also recorded; with a view to ascertain whether, the hybrids will have consumer's acceptability in Maharashtra state. The results obtained are presented under appropriate heads, viz. mean performance of parents and their hybrids, heterosis, combining ability, gene action and heritability.

The analysis of variance was done to test significant differences among the replications and their partitioning sources of variation.

The analysis of variance (Table 1) revealed that the treatment effects for all the characters studied were highly significant. The block differences were nonsignificant for the characters studied except days to first fruit picking and vine length.

Heridity in narrow sence is computed as follows :

$$h^2 = \frac{\sigma^2g}{\sigma^2g + \sigma^2s + \sigma^2e}$$

where,

h^2 = heritability in narrow sence.

σ^2g = estimated variance due to g.c.a.

σ^2s = estimated variance due to s.c.a.

σ^2e = error mean sum of squares.

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TABLE 1 : ANALYSIS OF VARIANCE FOR DIFFERENT CHARACTERS

SR NO	CHARACTERS	BLOCKS		TREATMENTS		ERROR		SE DIFF.		
		D.F.	M.S.	F	D.F.	M.S.	D.F.		M.S.	
1	Eatiness (days to first female flowering)	2	0.367	0.321	35	42.689	37.309***	70	1.144	0.873
2	Maturity (Node of first female flowering)	2	0.019	0.958	35	0.083	107.589***	70	0.019	0.113
3	Sex-ratio (female : male flowers)	2	0.279	0.216	35	18.154	14.029***	70	1.294	0.929
4	Days to first fruit picking	2	5.468	5.491*	35	34.240	34.378***	70	0.996	0.815
5	Average weight of fruit (g)	2	47.500	1.361	35	2206.564*	63.206***	70	34.911	4.824
6	Length of fruit (cm)	2	0.295	1.988	35	41.328	278.629***	70	0.148	0.314
7	Diameter of fruit (cm)	2	0.012	1.912	35	0.146	22.785**	70	0.006	0.063
8	Thickness of flesh of fruit (cm)	2	0.001	0.875	35	0.005	5.520***	70	0.001	0.026
9	Fruit size index (cm ²)	2	0.750	0.162	35	517.098	112.01***	70	4.617	1.754
10	Number of fruits per vine	2	0.315	2.563	35	23.178	188.228***	70	0.123	0.286
11	Yield of fruits per vine (kg)	2	0.108	2.811	35	1.124	29.274***	70	0.038	0.159
12	Length of vine (m)	2	0.024	3.789*	35	0.248	39.731***	70	0.006	0.063

* Significant at the 0.05 level.

** Significant at the 0.01 level.

4.1 Mean Performance of parents and their hybrids :

The mean values of parents and their F_1 hybrids for twelve characters under study were averaged over replications and presented in Tables 2 and 4. The differences in mean values of the parents and hybrids for the characters were significant.

4.1.1 Earliness (Days to Female Flowering) :

Highly significant differences were observed for this character. The parents P_3 (BA)(43.73) and P_1 (PK)(47.53) were the earliest, while P_4 (LG)(58.13) and P_2 (B)(55.57) were late to flower.

Among the hybrids, $P_1 \times P_2$ (PK X B)(40.0) was earliest followed by $P_1 \times P_7$ (PK X P) (42.83) and $P_1 \times P_8$ (PK X WLC)(43.00).

4.1.2 Maturity (Low nodal position of pistillate flower) :

The parent P_1 (PK) was earliest to mature since it produced female flower at 5.67 node followed by P_5 (LC) (6.30) and P_3 (BA) and P_7 (P) (both at 6.53th node).

Among hybrids $P_1 \times P_2$ (PK X B) was earliest to mature (4.13) followed by $P_1 \times P_7$ (PK X P) (4.80) and $P_1 \times P_8$ (PK X WLC)(4.93).

4.1.3 Sex-Ratio (female : male flowers) :

Among the eight parents (Table-3 & 4) P_5 (LC) (1:13.56), P_2 (B) (1:11.43), P_4 (LG) (1:10.35) and P_8 (JLG) (1:10.29) showed lowest Sex-ratio, while, P_1 (PK) (1:5.22) and P_7 (P) (1:6.26) showed highest Sex-ratio.

Among hybrids $P_2 \times P_4$ (B X LG) showed lowest Sex-ratio (1:13.04), followed by $P_5 \times P_8$ (LC X JLG)(1:12.63), $P_3 \times P_5$ (BA X LC)(1:12.12) and $P_3 \times P_7$ (BA X P) (1:11.68). The hybrids $P_1 \times P_8$ (PK X WLC) (1:2.90) and $P_1 \times P_7$ (PK X P) (1:3.91) showed the highest sex-ratio.



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4.1.4 Days to first fruit picking :

The earliest fruit harvest was recorded in parents P₃ (BA) (59.00), P₇ (P) (59.00) and P₁ (PK) (60.33).

Among hybrids P₁ X P₂ (PK X B) (54.00) was earliest followed by P₁ X P₇ (PK X P) (57.33), P₄ X P₇ (LG X P) (57.33) and P₁ X P₃ (PK X BA) (57.66).

4.1.5 Average weight of fruit (g) :

The highest fruit weight was recorded by parents P₈ (JLG)(203.00) followed by P₄ (LG) (188.33) and P₅ (LC) (183.33).

Among the hybrids studied P₄ X P₈ (LG X JLG) recorded the highest fruit weight (252.66) followed by P₃ X P₇ (BA X P) (226.66), P₁ X P₈ (PK X JLG) (212.33) and P₅ X P₇ (LC X P) (205.33).

4.1.6 Length of fruit (cm) :

The parents P₈ (JLG) (26.48) and P₇ (P)(17.53) had maximum fruit length at edible maturity. Among hybrids P₂ X P₈ (B X JLG) exhibited maximum fruit length(23.10) followed by P₃ X P₇ (BA X P) (22.33), P₄ X P₈ (LG X JLG) (21.94) and P₇ X P₈ (P X JLG) (20.68).

4.1.7 Diameter of fruit (cm) :

The parents P₃ (BA)(4.15), P₅ (LC)(4.14), P₄ (LG) (3.97) and P₂ (B)(3.90) had maximum fruit diameter. Among the hybrids P₁ X P₄ (PK X LG) (4.04), P₈ X P₇ (WLC X P) (4.02) and P₁ X P₂ (PK X B)(4.00) exhibited maximum fruit diameter.

4.1.8 Thickness of flesh (cm) :

The parents P₃ (BA)(1.07), P₅ (LC)(1.02), P₆ (WLC)(1.01) and P₈ (JLG) (1.00) had maximum flesh thickness. While, hybrids P₃ X P₆ (BA X WLC) (1.06), P₆ X P₈ (WLC X JLG) (1.05), P₃ X P₄ (BA X LG) (1.04) and P₃ X P₇ (BA X P)(1.03) recorded maximum flesh thickness.

4.1.9 Fruit size Index (cm²) :

Among the parents P₈ (JLG)(97.27), P₇ (P)(67.27) and P₅ (LC)(62.61) recorded maximum fruit size Index, whereas hybrids P₂ X P₈ (B X JLG) (81.97), P₄ X P₈ (LG X JLG)(79.94), P₃ X P₇ (BA X P)(75.34) and P₂ X P₄ (B X LG)(74.31) exhibited maximum fruit size Index.

4.1.10 Number of fruits per vine :

The parents P₃ (BA)(17.57) and P₈ (WLC)(17.00) recorded maximum number of fruits per vine. Among the hybrids P₂ X P₅ (B X LC)(19.40), P₈ X P₈ (WLC X JLG) (19.27), P₂ X P₈ (B X WLC)(18.80) and P₅ X P₈ (LC X WLC) (18.33) recorded maximum number of fruits per vine.

4.1.11 Yield of fruits per vine (kg) :

The parents P₈ (JLG)(2.813), P₃ (BA)(2.609) and P₅ (LC)(2.240) recorded maximum yield of fruits per vine. Among the hybrids P₃ X P₇ (BA X P) (3.986), P₈ X P₈ (WLC X JLG)(3.344), P₄ X P₈ (LG X JLG)(3.125) and P₅ X P₇ (LC X P) (3.095) recorded maximum yield of fruits per vine.

4.1.12 Vine length (m) :

The parents P₅ (LC)(2.12), P₈ (JLG)(2.08) and P₂ (B)(1.95) had maximum vine length, whereas hybrids P₃ X P₇ (BA X P) (2.32), P₇ X P₈ (P X JLG) (2.21), P₂ X P₈ (B X JLG) (2.07) and P₁ X P₈ (PK X JLG)(2.06) exhibited maximum vine length.

4.2 Heterosis :

The heterosis was computed as percentage increase or decrease over mid and better parental values.

The mean values in respect of various characters of eight parents involved in the half diallel set are presented in Tables 2 & 4. Mean values for the same characters in respect of 28 F₁ hybrids, their heterosis percentage over mid and better parent are given in Table-4.

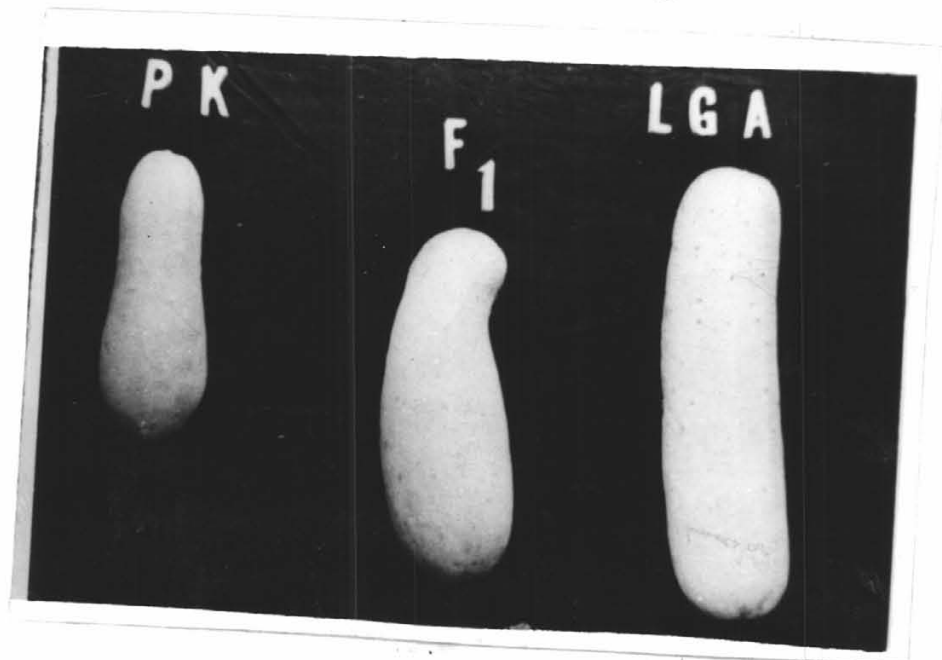
PLATE-1

27a



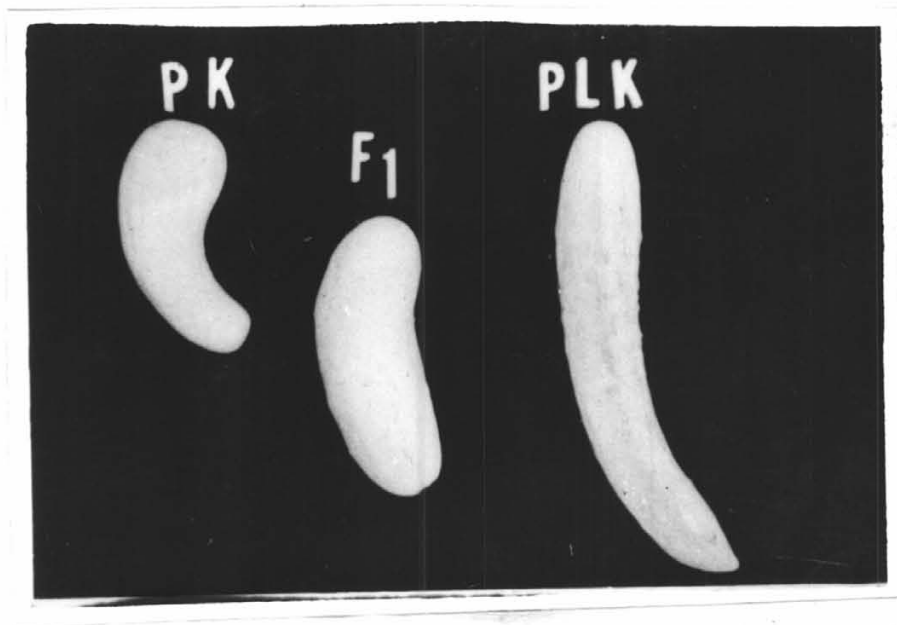
F₁ hybrid.

a) Budgi-1192092 X Japanese Long Green.



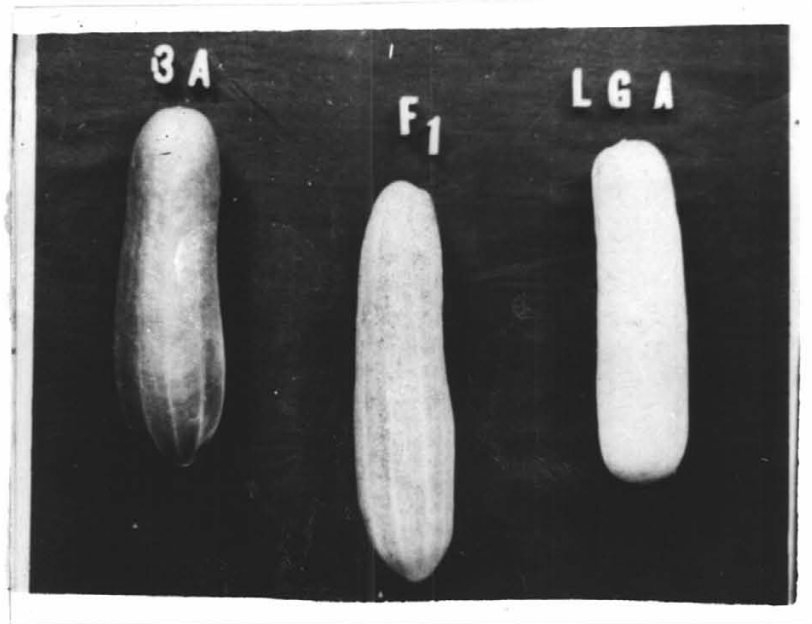
F₁ hybrid.

b) Poona Khira X Long Green-A



F1 hybrid

a) Poona Khira X White Long Cucumber
i.e. Pandhari Lamb Kakadi



F1 hybrid

b) Beta Alfa X Long Green-A

TABLE 2 : THE MEAN PERFORMANCE OF PARENTS FOR THE CHARACTERS STUDIED

SR NO	CHARACTERS	PARENTS				LONG GREEN
		POONA KHIRA	BUDGI-	BETA-ALFA		
		P1 (PK)	P2 (B)	P3 (BA)	P4 (LG)	~ A
1	Earliness (days to first female flowering)	47.530	55.570	43.730	58.130	
2	Maturity (Node of first female flowering)	5.670	7.100	6.530	7.430	
3	Sex-ratio (female : male flowers)	5.220	11.430	8.570	10.350	
4	Days to first fruit picking	60.330	62.330	59.000	66.660	
5	Average weight of fruit (g)	160.330	170.000	150.330	168.330	
6	Length of fruit (cm)	10.530	13.970	14.960	15.070	
7	Diameter of fruit (cm)	3.490	3.900	4.150	3.970	
8	Thickness of flesh of fruit (cm)	0.920	0.990	1.070	0.990	
9	Fruit size index (cm ²)	36.500	54.480	62.080	59.800	
10	Number of fruits per vine	9.400	12.000	17.570	11.470	
11	Yield of fruits per vine (kg)	1.047	2.177	2.609	2.130	
12	Length of vine (m)	1.240	1.950	1.440	1.630	
						continued..

TABLE 2 : THE MEAN PERFORMANCE OF PARENTS FOR THE CHARACTERS STUDIED .. contd.

SR NO	CHARACTERS	PARENTS			
		LONG CUCUMBER	WHITE LONG CUCUMBER	POINSETT	JAPANESE LONG GREEN
		P5 (LC)	P6 (WLC)	P7 (P)	P8 (JLG)
1	Earliness (days to first female flowering)	49.100	49.660	49.360	52.730
2	Maturity (Node of first female flowering)	6.300	7.530	6.530	7.530
3	Sex-ratio (female : male flowers)	13.540	7.620	6.260	10.290
4	Days to first fruit picking	62.330	63.660	59.000	61.000
5	Average weight of fruit (g)	183.330	111.330	171.330	203.000
6	Length of fruit (cm)	15.140	14.720	17.530	26.480
7	Diameter of fruit (cm)	4.140	3.490	3.840	3.670
8	Thickness of flesh of fruit (cm)	1.020	1.010	0.960	1.000
9	Fruit size index (cm ²)	62.610	51.310	67.270	97.270
10	Number of fruits per vine	10.600	17.000	12.400	12.900
11	Yield of fruits per vine (kg)	2.240	2.205	1.923	2.813
12	Length of vine (m)	2.120	1.450	1.550	2.080

The range of heterosis, percentage of heterotic crosses and the best hybrids for various characters are presented in Table 7. It may be seen that there was considerable heterosis in almost all the characters studied. While presenting the results in respect of various characters, only significant heterosis in the desirable directions has been considered. In cucumber the desirable characters considered were early flowering, early maturity, lower female to male sex-ratio, early fruit picking, greater fruit length and breadth, more flesh thickness, higher average number of fruits per vine, higher yield per vine/per hectare and better vigour of vine.

4.2.1 Earliness (Days to flowering) :

Out of 28 F_1 hybrids studied, 20 hybrids exhibited significant heterosis in desirable direction over mid parent, while 13 hybrids were significantly superior over better parent. The maximum heterosis percentage over mid parent was -22.41 in hybrid $P_1 \times P_2$ (PK X B) followed by -15.85 in cross $P_4 \times P_6$ (LG X WLC), -14.20 in cross $P_1 \times P_4$ (PK X LG), -13.31 in cross $P_1 \times P_6$ (PK X WLC) and -13.15 in cross $P_2 \times P_7$ (B X P). The highest heterosis percentage over better parent observed was -15.84 in hybrid $P_1 \times P_2$ (PK X B) followed by -9.89 in cross $P_1 \times P_7$ (PK X P) and -9.53 in cross $P_1 \times P_6$ (PK X WLC).

4.2.2 Maturity (Node of first female flower) :

As many as 16 hybrids recorded significant heterosis over mid parent, while 11 hybrids exhibited significant heterosis over better parent for this trait. The highest heterosis percent over mid parent exhibited was -35.25 in cross $P_1 \times P_2$ (PK X B) followed by -25.25 in cross $P_1 \times P_6$ (PK X WLC), -21.31 in cross $P_1 \times P_7$ (PK X P) and -18.49 in cross $P_4 \times P_6$ (LG X WLC). The hybrid $P_1 \times P_2$ (PK X B) showed the maximum heterosis percentage of -27.16 over better parent, followed by hybrids $P_4 \times P_6$ (LG X WLC) -17.90, $P_6 \times P_6$ (WLC X JLG) -15.94 and $P_1 \times P_7$ (PKXP) -15.34.

4.2.3 Sex-Ratio (female to male flowers) :

Out of 28 hybrids studied 17 hybrids exhibited significant heterosis over mid parent, while 8 hybrids recorded significant heterosis over better parent for the trait. The maximum percent heterosis over mid parent was - 54.84 in hybrid $P_1 \times P_6$ (PK X WLC) followed by - 48.07 in cross $P_1 \times P_2$ (PK X B), -32.62 in cross $P_2 \times P_5$

(B X LC) and -31.98 in cross $P_1 \times P_7$ (PK X P). The highest heterosis percentage over better parent observed was -44.44 in cross $P_1 \times P_8$ (PK X WLC) followed by -26.33 in cross $P_2 \times P_5$ (B X LC), -25.10 in hybrid $P_1 \times P_7$ (PK X P) and -17.24 in cross $P_1 \times P_2$ (PK X B).

4.2.4 Days to first fruit picking :

Out of 28 hybrids studied 11 hybrids showed significant heterosis over mid parent, whereas 9 hybrids showed significant heterosis over better parent. The maximum heterosis percent over mid parent exhibited was -11.96 in hybrid $P_1 \times P_2$ (PK X B), followed by -11.00 in cross $P_4 \times P_8$ (LG X WLC), -8.75 in cross $P_4 \times P_7$ (LG X P), -4.84 in cross $P_1 \times P_8$ (PK X WLC) and -4.46 in cross $P_1 \times P_4$ (PK X LG). The highest heterosis percentage over better parent recorded was -10.49 in hybrid $P_1 \times P_2$ (PK X B) followed by -8.89 in cross $P_4 \times P_8$ (LG X WLC) and -2.83 in the crosses $P_1 \times P_7$ (PK X P) and $P_4 \times P_7$ (LG X P).

4.2.5 Average Weight of fruit (g) :

Out of 28 hybrids, 15 hybrids exhibited significant heterosis over mid parent while 6 hybrids exhibited significant heterosis over better parent. The maximum heterosis percent over mid parent exhibited was 40.93 in hybrid $P_3 \times P_7$ (BA X P) followed by 35.54 in cross $P_3 \times P_8$ (BA X WLC), 29.38 in cross $P_2 \times P_8$ (B X WLC) and 29.13 in hybrid $P_4 \times P_8$ (LG X JLG). The maximum heterosis percent recorded over better parent by hybrids was 32.30 in cross $P_3 \times P_7$ (BA X P) followed by 24.47 in cross $P_4 \times P_8$ (LG X JLG), 17.96 in cross $P_3 \times P_8$ (BA X WLC) and 13.82 in cross $P_5 \times P_7$ (LC X P).

4.2.6 Length of fruit (cm) :

Significantly high heterosis was exhibited by 10 and 6 hybrids over mid and better parents respectively. The maximum heterosis percent recorded by the hybrids over mid parent was 37.45 in the cross $P_3 \times P_7$ (BA X P) followed by 30.64 in hybrids $P_2 \times P_4$ (B X LG) and 14.22 in $P_2 \times P_8$ (B X JLG). Whereas maximum heterosis percent recorded by the hybrids over better parent was 27.38 in the cross $P_3 \times P_7$ (BA X P) followed by 25.85 in hybrids $P_2 \times P_4$ (B X LG) and 8.80 in cross $P_2 \times P_3$ (B X BA).

4.2.7 Diameter of fruit (cm) :

Out of 28 hybrids 6 hybrids exhibited significant heterosis over each of the mid and better parents. The maximum heterosis percentage recorded by the hybrids over mid parent was 12.55 in the cross $P_1 \times P_8$ (PK X WLC) followed by 9.70 in hybrid $P_8 \times P_7$ (WLC X P) and 8.17 in cross $P_1 \times P_4$ (PK X LG). Whereas maximum heterosis per cent recorded over better parent was 12.39 in hybrid $P_1 \times P_8$ (PK X WLC) followed by 4.69 in cross $P_8 \times P_7$ (WLC X P) and 4.45 in cross $P_6 \times P_8$ (WLC X JLG).

4.2.8 Thickness of flesh (cm) :

Out of 28 hybrids studied, as many as 10 hybrids recorded significant heterosis over mid parent, while only two hybrids exhibited significant heterosis over better parent for this trait.

The highest significant heterosis exhibited over mid parent was 4.31 in the cross $P_6 \times P_8$ (WLC X JLG) followed by 2.19 in hybrid $P_2 \times P_4$ (B X LG) and 2.14 in cross $P_3 \times P_7$ (BA X P). Whereas the maximum heterosis over better parent recorded by the hybrid $P_6 \times P_8$ (WLC X JLG) was 3.96 percent followed by the cross $P_2 \times P_4$ (B X LG) was 2.01 percent.

4.2.9 Fruit size Index (cm^2) :

Significantly high heterosis was recorded by 8 and 3 hybrids over mid and better parents respectively. The hybrid $P_2 \times P_4$ (B X LG) recorded highest heterosis percentage of 30.05 over mid parent followed by hybrids $P_2 \times P_6$ (B X WLC)(16.85), cross $P_3 \times P_7$ (BA X P)(16.53) and hybrid $P_1 \times P_8$ (PK X WLC) (10.46). The hybrid $P_2 \times P_4$ (B X LG) showed the highest heterosis percentage of 24.26 over better parent followed by cross $P_2 \times P_6$ (B X WLC)(13.45) and $P_3 \times P_7$ (BA X P)(12.00).

4.2.10 Number of fruits per vine :

Number of fruits per vine/ plant is considered as an important yield component. The desirable heterosis for fruit number was perceived in 18 and 12 hybrids over mid and better parents respectively.

The maximum heterosis percentage of 71.68 over mid parent was exhibited by a hybrid $P_2 \times P_5$ (B X LC) followed by 49.86 by hybrid $P_5 \times P_7$ (LC XP), 43.33 by cross $P_1 \times P_5$ (PK X LC) and 32.85 by cross $P_5 \times P_8$ (LC X WLC). The same hybrid $P_2 \times P_5$ (B X LC) recorded the maximum heterosis 61.67 percent over better parent followed by 38.98 in cross $P_5 \times P_7$ (LC XP), 35.22 by hybrid $P_1 \times P_5$ (PK X LC) and 26.34 by hybrid $P_2 \times P_7$ (B X P).

4.2.11 Yield of fruits per vine (kg) :

As many as 14 and 9 hybrids exhibited significant heterosis over mid and better parents respectively for yield per vine.

The highest heterosis percentage of 75.91 over mid parent was exhibited by the hybrid $P_3 \times P_7$ (BA X P) followed by 48.70 in cross $P_5 \times P_7$ (LC X P), 36.71 in hybrid $P_1 \times P_5$ (PK X LC), 33.31 in cross $P_6 \times P_8$ (WLC X JLG) and 30.13 in hybrid $P_2 \times P_8$ (B X WLC). The same hybrid $P_3 \times P_7$ (BA X P) recorded the highest percentage heterosis of 52.80 over better parent, followed by the cross $P_5 \times P_7$ (LC X P) (38.19), cross $P_2 \times P_8$ (B X WLC) (29.30), hybrid $P_5 \times P_8$ (LC X WLC) (27.54) and cross $P_2 \times P_5$ (B X LC) (22.81).

4.2.12 Vine length (m) :

As many as 9 and 3 hybrids exhibited significant heterosis over mid and better parents respectively for this trait.

The hybrid $P_3 \times P_7$ (BA X P) recorded the highest heterosis percent of 55.13 over mid parent followed by 24.22 percent in the hybrid $P_1 \times P_8$ (PK X JLG) and 21.49 in cross $P_7 \times P_8$ (P X JLG). The same hybrid $P_3 \times P_7$ (BA X P) expressed the maximum heterosis percentage of 49.78 over better parent followed by 9.20 percent in cross $P_3 \times P_8$ (BA X WLC) and 6.09 percent in cross $P_7 \times P_8$ (P X JLG).

TABLE 3 : SEX-RATIO IN PARENTS AND HYBRIDS

PARENTS AND HYBRIDS	FEMALE FLOWERS PER VINE	MALE FLOWERS PER VINE	SEX-RATIO (FEMALE:MALE)
Parents			
P1	11.00	57.42	1 : 5.22
P2	14.67	167.68	1 : 11.43
P3	19.33	166.66	1 : 8.57
P4	14.00	144.90	1 : 10.35
P5	14.00	189.84	1 : 13.56
P6	19.33	147.29	1 : 7.62
P7	14.66	91.77	1 : 6.26
P8	15.00	154.35	1 : 10.29
Hybrids			
P1 X P2	15.00	64.80	1 : 4.32
P1 X P3	17.33	149.04	1 : 8.60
P1 X P4	13.66	100.81	1 : 7.38
P1 X P5	16.66	115.45	1 : 6.93
P1 X P6	14.00	40.60	1 : 2.90
P1 X P7	15.33	59.94	1 : 3.91
P1 X P8	14.33	147.46	1 : 10.29
P2 X P3	18.33	186.23	1 : 10.16
P2 X P4	13.33	173.82	1 : 13.04
P2 X P5	22.33	188.02	1 : 8.42
P2 X P6	22.00	189.86	1 : 8.63
P2 X P7	18.66	146.67	1 : 7.86
P2 X P8	16.33	145.66	1 : 8.92
P3 X P4	16.00	149.28	1 : 9.33
P3 X P5	16.66	201.92	1 : 12.12
P3 X P6	17.00	169.45	1 : 9.97
P3 X P7	15.66	182.90	1 : 11.68
P3 X P8	16.00	145.78	1 : 9.11
P4 X P5	13.33	116.77	1 : 8.76
P4 X P6	15.00	149.40	1 : 9.96
P4 X P7	12.66	74.19	1 : 5.86
P4 X P8	16.00	143.66	1 : 8.98
P5 X P6	22.00	200.64	1 : 9.12
P5 X P7	19.33	138.00	1 : 7.14
P5 X P8	14.66	185.16	1 : 12.63
P6 X P7	12.33	124.78	1 : 10.12
P6 X P8	22.66	194.20	1 : 8.57
P7 X P8	14.66	125.64	1 : 8.57

Table 4 : Mean values of F1 hybrids and their heterosis percentage over									
Mid parent (MP) and Better parent (BP)									
Treatments	{1}			{2}			{3}		
	Earliness(days to female flowering)			Maturity(Node of first female flowering)			Sex-ratio (female:male flowers)		
	Heterosis % over			Heterosis % over			Heterosis % over		
	Mean	MP	BP	Mean	MP	BP	Mean	MP	BP
Parents									
P1	47.53			5.67			5.22		
P2	55.57			7.10			11.43		
P3	43.73			6.53			8.57		
P4	58.13			7.43			10.35		
P5	49.10			6.30			13.56		
P6	49.66			7.53			7.62		
P7	49.36			6.53			6.26		
P8	52.73			7.53			10.29		
Hybrids									
P1 X P2	40.00	-22.41**	-15.84**	4.13	-35.25**	-27.16**	4.32	-48.07**	-17.24**
P1 X P3	44.60	-2.26**	1.99	6.46	6.01	13.93	8.60	24.75	64.75
P1 X P4	45.33	-14.2**	-4.63**	5.60	-14.50**	-1.23**	7.38	-5.24**	41.38
P1 X P5	49.10	1.62	3.30	6.10	1.95	7.58	6.93	-26.23**	32.76
P1 X P6	43.00	-13.31**	-9.53**	4.93	-25.25**	-13.05**	2.90	-54.84**	-44.44**
P1 X P7	42.83	-11.59**	-9.89**	4.80	-21.31**	-15.34**	3.91	-31.98**	-25.10**
P1 X P8	47.26	-5.72**	-0.57	6.53	-1.01**	15.17	10.29	35.64	197.23
P2 X P3	48.06	-3.19**	9.90	6.03	-11.49**	-7.66**	10.16	1.58	18.55
P2 X P4	53.20	-6.42**	-4.26**	7.43	2.29	4.65	13.04	19.71	25.99
P2 X P5	49.26	-5.86**	0.20	7.26	8.46	15.24	8.42	-32.62**	-26.33**
P2 X P6	46.93	-12.47**	-5.50**	6.26	-14.35**	-11.83**	8.63	-9.38**	13.23
P2 X P7	45.56	-13.15**	-7.70**	6.80	-3.18**	1.07	7.86	-11.10**	25.56
P2 X P8	49.73	-8.16**	-5.69**	6.86	-6.15**	-3.38**	8.92	-16.53**	-13.31**
P3 X P4	49.67	-2.49**	13.58	6.60	-5.49**	1.07	9.33	-1.36**	8.87
P3 X P5	48.20	3.84	10.22	6.93	8.05	10.00	12.12	9.55	41.42
P3 X P6	47.86	-0.07	8.99	6.33	-9.95**	-3.06**	9.97	23.2	30.84
P3 X P7	52.00	11.71	18.91	7.60	16.33	16.39	11.68	57.48	86.58
P3 X P8	48.96	1.52	11.96	7.20	2.37	10.26	9.11	-1.67**	6.30
P4 X P5	47.60	-11.22**	-3.17**	5.63	-17.96**	-10.63**	8.76	-26.75**	-15.36**
P4 X P6	46.20	-15.85**	-6.97**	6.10	-18.49**	-17.90**	9.96	10.83	30.71
P4 X P7	48.87	-9.09**	-0.99*	6.80	-2.63**	4.13	5.86	-29.43**	-6.39**
P4 X P8	55.73	0.54	5.69	7.73	3.34	4.04	8.98	-11.56**	-12.73**
P5 X P6	49.33	-2.08**	0.35	6.80	-1.69**	7.94	9.12	-13.90**	19.69
P5 X P7	50.66	2.91	3.05	7.33	14.29	16.35	7.14	-27.92**	14.06
P5 X P8	50.40	-1.02**	2.65	6.93	0.24	10.00	12.63	7.42	22.74
P6 X P7	53.53	5.97	8.45	7.06	0.47	8.12	10.12	45.79	61.66
P6 X P8	47.40	-9.20**	-4.55**	6.33	-15.93**	-15.94**	8.57	-2.47**	12.47
P7 X P8	48.13	-5.71**	-2.49**	7.40	5.21	13.32	8.57	5.69	36.90
C.D.at 5%		0.856	0.988		0.111	0.129		0.910	1.051
C.D.at 1%		1.125	1.299		0.146	0.169		1.196	1.381

* Significant at the 0.05 level .

** Significant at the 0.01 level

Table 4 : Mean values of F1 hybrids and their heterosis percentage over									
Mid parent (MP) and better parent (BP) ...contd.									
Treatments	(4)			(5)			(6)		
	Days to first fruit picking			Average weight of fruit (g)			Length of fruit (cm)		
		Heterosis % over			Heterosis % over			Heterosis % over	
	Mean	MP	BP	Mean	MP	BP	Mean	MP	BP
Parents									
P1	60.33			160.33			10.53		
P2	62.33			170.00			13.97		
P3	59.00			150.33			14.96		
P4	66.66			188.33			15.08		
P5	62.33			163.33			15.14		
P6	63.66			111.33			14.72		
P7	59.00			171.33			17.53		
P8	61.00			203.00			26.48		
Hybrids									
P1 X P2	54.00	-11.96**	-10.49**	144.66	-12.41	-14.90	10.70	-12.69	-23.43
P1 X P3	57.66	-3.35**	-2.27**	153.33	-1.29	-4.37	13.13	3.02**	-12.23
P1 X P4	60.66	-4.46**	0.05	145.00	-16.83	-23.01	12.08	-5.64	-19.85
P1 X P5	59.33	-3.26**	-1.66**	189.00	9.99**	3.09	13.48	5.05**	-10.92
P1 X P6	59.00	-4.84**	-2.21**	135.66	-0.12	-15.39	12.34	-2.26	-16.15
P1 X P7	57.33	-3.91**	-2.83**	158.00	-4.72	-7.78	10.93	-22.14	-37.68
P1 X P8	60.66	-0.01	0.55	212.33	16.66**	4.60	17.60	-4.89	-33.53
P2 X P3	63.66	4.95	7.90	160.00	-0.10	-5.88	16.26	12.54**	8.80**
P2 X P4	67.33	4.39	8.02	200.33	11.81**	6.37*	16.97	30.64**	25.85**
P2 X P5	63.00	1.08	1.08	152.33	-13.77	-16.91	15.63	7.42**	3.28**
P2 X P6	62.66	-0.53	0.53	182.00	29.38**	7.06**	15.65	9.09**	6.32**
P2 X P7	60.33	-0.55	2.25	166.00	-2.73	-3.11	14.78	-6.19	-16.72
P2 X P8	63.33	2.70	3.82	167.00	-10.46	-17.73	23.10	14.22**	-12.75
P3 X P4	62.33	-0.80	5.64	178.33	5.32*	-5.31	14.97	-0.33	-0.71
P3 X P5	61.66	1.65	4.51	164.00	-1.70	-10.55	15.65	4.01**	3.41**
P3 X P6	60.00	-2.17**	1.70	177.33	35.54**	17.96**	13.91	-6.24	-7.02
P3 X P7	69.33	17.51	17.51	226.66	40.93**	32.30**	22.33	37.45**	27.38**
P3 X P8	64.00	6.67	8.48	201.66	14.15**	-0.66	19.37	-6.53	-26.82
P4 X P5	61.66	-4.39**	-1.06*	164.33	-0.81	-2.12	11.66	-22.71	-22.86
P4 X P6	59.00	-11.00**	-8.89**	186.66	24.58**	-0.89	13.49	-9.44	-10.52
P4 X P7	57.33	-8.75**	-2.83**	190.00	5.65*	0.89	13.50	-17.20	-23.00
P4 X P8	69.00	8.09	13.12	252.66	29.13**	24.47**	21.94	5.62**	-17.12
P5 X P6	63.00	0.01	1.08	161.66	9.73**	-11.82	13.66	-7.15	-8.43
P5 X P7	64.33	6.04	9.03	205.33	17.67**	13.82**	13.39	-18.01	-23.61
P5 X P8	66.00	8.20	8.75	153.00	-20.79	-24.63	19.49	-6.34	-26.40
P6 X P7	66.00	7.61	11.86	170.00	20.28**	-0.78	15.55	-3.57	-11.31
P6 X P8	60.00	-3.74**	-1.64**	160.00	1.80	-21.18	18.33	-10.99	-30.76
P7 X P8	62.66	4.44	6.20	196.66	5.07*	-3.12	20.66	-7.52	-23.14
C.D.at 5%		0.798	0.922		4.728	5.453		0.308	0.356
C.D.at 1%		1.050	1.212		6.214	7.175		0.405	0.468

* Significant at the 0.05 level .

** Significant at the 0.01 level

Table 4 : Mean values of F1 hybrids and their heterosis percentage over									
Mid parent (MP) and better parent (BP) contd.									
Treatments	{10}			{11}			{12}		
	Number of fruits per vine			Yield of fruits per vine (kg)			Length of vine (m)		
	Mean	Heterosis % over		Mean	Heterosis % over		Mean	Heterosis % over	
MP		BP	MP		BP	MP		BP	
Parents									
P1	9.40			1.047			1.24		
P2	12.00			2.177			1.95		
P3	17.57			2.609			1.44		
P4	11.47			2.130			1.83		
P5	10.60			2.240			2.12		
P6	17.00			2.205			1.45		
P7	12.40			1.923			1.55		
P8	12.90			2.813			2.08		
Hybrids									
P1 X P2	12.53	17.13**	4.44**	1.504	-6.66	-30.89	1.30	-18.62	-33.50
P1 X P3	15.42	14.34**	-12.24	2.179	19.22**	-16.47	1.41	5.60**	-1.85
P1 X P4	11.53	10.54**	0.58**	1.455	-8.42	-31.71	1.54	0.22**	-16.03
P1 X P5	14.33	43.33**	35.22**	2.230	36.71**	0.30**	1.70	1.39**	-19.69
P1 X P6	12.08	-8.46	-28.92	1.620	-0.37	-26.54	1.16	-13.65	-20.00
P1 X P7	12.68	16.36**	2.29**	1.370	-7.72	-28.75	1.27	-8.50	-17.67
P1 X P8	11.32	1.50**	-12.27	1.895	-8.80	-32.63	2.06	24.22**	-0.96
P2 X P3	15.27	3.27**	-13.09	2.163	-9.61	-17.10	1.60	-5.61	-17.95
P2 X P4	11.65	-0.71	-2.92	2.157	0.19**	-0.89	1.80	-4.59	-7.52
P2 X P5	19.40	71.68**	61.67**	2.751	24.57**	22.81**	1.91	-6.23	-9.92
P2 X P6	18.80	29.66**	10.59**	2.851	30.13**	29.30**	1.89	11.37**	-2.91
P2 X P7	15.67	28.42**	26.34**	2.250	24.39**	17.15**	1.53	-12.30	-21.37
P2 X P8	15.13	21.55**	17.31**	2.642	5.89**	-6.08	2.07	2.56**	-0.64
P3 X P4	13.35	-8.04	-24.00	1.982	-16.35	-24.02	1.52	-7.24	-17.12
P3 X P5	14.47	2.77**	-17.61	2.581	6.45**	-1.07	1.75	-1.41	-17.17
P3 X P6	14.00	-19.00	-20.30	2.218	-7.83	-14.96	1.58	9.57**	9.20**
P3 X P7	13.20	-11.90	-24.86	3.986	75.91**	52.80**	2.32	55.13**	49.78**
P3 X P8	12.03	-21.01	-31.50	2.457	-9.37	-12.66	1.63	-7.20	-21.47
P4 X P5	10.33	-6.34	-9.88	1.563	-28.45	-30.21	1.35	-31.76	-36.38
P4 X P6	12.17	-14.52	-28.43	2.080	-4.03	-5.66	1.58	-3.46	-13.48
P4 X P7	10.07	-15.64	-18.82	1.567	-22.70	-26.45	1.61	-4.84	-12.20
P4 X P8	13.60	11.63**	5.43**	3.125	26.45**	11.11**	1.89	-3.50	-9.30
P5 X P6	18.33	32.85**	7.84**	2.856	28.53**	27.52**	1.67	-6.17	-20.95
P5 X P7	17.23	49.86**	38.98**	3.095	48.7**	38.19**	1.69	-7.55	-20.00
P5 X P8	12.73	8.37**	-1.29	2.144	-15.12	-23.76	1.97	-6.28	-7.09
P6 X P7	9.33	-36.51	-45.10	1.693	-17.96	-23.19	1.49	-0.78	-3.88
P6 X P8	19.27	28.87**	13.33**	3.344	33.31**	18.90**	1.74	-1.42	-16.35
P7 X P8	12.80	1.19**	-0.78	2.673	12.89**	-4.95	2.21	21.49**	6.09**
C.D.at 5%		0.281	0.324		0.157	0.181		0.063	0.073
C.D.at 1%		0.369	0.426		0.206	0.238		0.083	0.096

* Significant at the 0.05 level .

** Significant at the 0.01 level

4.3 Qualitative Characters :

Some of the important qualitative characters such as colour, surface of fruit, spinyness, colour of spines, size of fruits, etc and keeping quality of fruits in respect of both parents and hybrids were studied. These observations are presented in Table 5 & Table 6.

4.3.1 Colour of fruit :

Out of eight parents two parents (P_4 , P_8) had fruits of green colour, while one parent each had Yellowish white (P_1), Dark green (P_2), Dark green with yellow strips (P_3), Green with yellow strips (P_5) and Creamy White (P_6) coloured fruits. *Land greenish (P7)*

Out of 28 hybrids, 12 hybrids produced green fruits, 8 hybrids produced light green fruits, 4 hybrids produced dark green fruits while among the remaining 4 hybrids one each produced Yellowish green, Creamy white, Dark green with yellowish strips and greenish coloured fruits.

4.3.2 Surface of fruits :

Of the 8 parents , 4 parents had fruits with smooth surface, 3 parents had fruits with medium smooth surface and one had fruits with medium rough surface.

Out of 28 hybrids, 10 hybrids had smooth fruit surface and 18 hybrids had medium smooth fruit surface.

4.3.3 Spinyness :

Out of 8 parents 6 parents had non-spiny fruits, two parents (P_4 , P_5) had sparse spiny fruits. As many as 14 hybrids showed non spiny fruits, while, 14 hybrids showed fruits with less spines (sparse spines).

4.3.4 Colour of spine :

Out of 8 parents, one parent (P_4) had Black coloured spines on fruit surface and one had (P_5) Blackish brown spines on fruit surface. Out of 28 hybrids, 14

hybrids were having sparse spines, 7 had Black coloured spines, 6 had Blackish brown coloured spines and one had white coloured spines on fruits.

4.3.5 Size of fruit :

Out of 8 parents, 7 parents had very short fruit size and only one (P_8) had short fruit size.

Out of 28 hybrids, 26 hybrids had very short fruit size and only two hybrids ($P_2 \times P_8$ and $P_3 \times P_7$) had short fruit size.

4.3.6 Keeping quality (shelf life) :

Eight parents and their 28 hybrids were kept at room temperature for keeping quality studies. Out of 8 parents, 2 parents (P_3 & P_8) showed rather good keeping quality as their fruits remained for 4 and 3 days respectively without deterioration in taste, less deterioration in external appearance and crispiness of fruit. Other parents except P_1 (PK) showed rather poor keeping quality, while, P_1 showed very poor keeping quality after 4 days of storage.

Out of 28 hybrids, 6 hybrids namely $P_1 \times P_3$ (PK X BA), $P_1 \times P_8$ (PK X JLG), $P_3 \times P_7$ (BA X P), $P_4 \times P_7$ (LG X P), $P_4 \times P_8$ (LG X JLG) and $P_7 \times P_8$ (P X JLG) showed rather good keeping quality, since their fruits remained rather in good condition for 4 to 5 days. Hybrid $P_3 \times P_7$ (BA X P) showed better keeping quality as the fruits remained rather in good condition after 6 days of storage with moderate loss in weight (20.90%) in storage.

4.4 Analysis of variance for combining ability :

The analysis of variance for combining ability in the F_1 generation of 8 x 8 diallel cross for twelve characters was carried out with a view to test the combining ability of parents and their hybrids (Table - 8).

It may be observed that, the variances due to general combining ability (g.c.a.) and specific combining ability (s.c.a.) were highly significant for all the characters studied.

Table 5 : Qualitative Characters (fruit characters) of parents and hybrids					
Treatments	Colour (Aerial)	Surface	Spinyness	Spine colour	Fruit size
1	2	3	4	5	6
Parents					
P1	Yellowish white	Medium smooth	Non Spiny	~	Very Short
P2	Dark green	Smooth	Non Spiny	~	Very Short
P3	Darkgreen with yellow strips	Smooth	Non Spiny	~	Very Short
P4	Green	Medium smooth	Less Spiny	Black	Very Short
P5	Green with yellow strips	Medium smooth	Less Spiny	Blackish brown	Very Short
P6	Creamy white	Smooth	Non Spiny	~	Very Short
P7	Greenish	Smooth	Non Spiny	~	Very Short
P8	Green	Medium rough	Non Spiny	~	Short
Hybrids					
P1 X P2	Light green	Medium smooth	Non Spiny	~	Very Short
P1 X P3	Green	Smooth	Non Spiny	~	Very Short
P1 X P4	Light green	Medium smooth	Less Spiny	Black	Very Short
P1 X P5	Light green	Smooth	Less Spiny	Black	Very Short
P1 X P6	Yellowish green	Medium smooth	Non Spiny	~	Very Short
P1 X P7	Creamy with light green shade	Medium smooth	Non Spiny	~	Very Short
P1 X P8	Light green	Medium smooth	Non Spiny	~	Very Short
P2 X P3	Green	Smooth	Non Spiny	~	Very Short
P2 X P4	Green	Medium smooth	Less Spiny	Blackish brown	Very Short
P2 X P5	Green	Smooth	Less Spiny	Black	Very Short
P2 X P6	Dark green	Smooth	Less Spiny	White	Very Short
P2 X P7	Green	Smooth	Non Spiny	~	Very Short
P2 X P8	Dark green	Medium smooth	Non Spiny	~	Short
P3 X P4	Light green	Medium smooth	Less Spiny	Black	Very Short
P3 X P5	Dark green	Smooth	Less Spiny	Black	Very Short
P3 X P6	Green	Smooth	Non Spiny	~	Very Short
P3 X P7	Dark green	Smooth	Non Spiny	~	Short
P3 X P8	Green	Medium smooth	Non Spiny	~	Very Short
P4 X P5	Dark green with yellow strips	Medium smooth	Less Spiny	Blackish brown	Very Short
P4 X P6	Green	Medium smooth	Less Spiny	Blackish brown	Very Short
P4 X P7	Green	Medium smooth	Less Spiny	Black	Very Short
P4 X P8	Green	Medium smooth	Less Spiny	Blackish brown	Very Short
P5 X P6	Green	Medium smooth	Less Spiny	Black	Very Short
P5 X P7	Light green	Medium smooth	Less Spiny	Blackish brown	Very Short
P5 X P8	green	Medium smooth	Less Spiny	Blackish brown	Very Short
P6 X P7	Greenish	Smooth	Non Spiny	~	Very Short
P6 X P8	Light green	Medium smooth	Non Spiny	~	Very Short
P7 X P8	Light green	Medium smooth	Non Spiny	~	Very Short

Table 6 : Keeping quality (Shelf life) of fruit of parents and hybrids

Parents and F1 Hybrids	Colour of freshly harvested fruit	Fruit colour after storage	Organoleptic taste of freshly harvested fruit
Parents			
P1	Yellowish white	Brick red with yellowish shade	Good, Crispy
P2	Dark green	Dark green at apex, yellowish at base	Good, Crispy
P3	Dark green with yellow strips	Dark green at apex, yellowish at base	Good, very crispy
P4	Green	Brick red with yellowish shade	Good, Crispy
P5	Green with yellow strips	Dark green at apex, light green at base	Good, Crispy
P6	Creamy white	Whitish with light yellow shade	Good, Crispy
P7	Greenish	Light green with yellowish shade	Good, Crispy
P8	Green	Green with light yellow shade	Good, Crispy
Hybrids			
P1 X P2	Light green	Green with light yellow shade	Good, Crispy
P1 X P3	Green	Green with light yellow shade	Good, Crispy
P1 X P4	Light green	Dark green with yellowish shade	Good, Crispy
P1 X P5	Light green	Green with yellowish shade	Good, Crispy
P1 X P6	Yellowish green	Greenish	Good, Crispy
P1 X P7	Creamy with light green	Brick red with yellowish shade	Good, less Crispy
P1 X P8	Light green	Light green with yellowish shade	Good, Crispy
P2 X P3	Green	Green with yellowish at base	Skin slight bitter, crispy
P2 X P4	Green	Green with light yellow shade	Rather Good, Crispy
P2 X P5	Green	Green with light yellow at base	Good, less Crispy
P2 X P6	Dark green	Dark green with light yellow shade	Skin slight bitter, less crispy
P2 X P7	Green	Green with yellowish at base	Good, rather Crispy
P2 X P8	Dark green	Green with yellowish shade	Good, Crispy
P3 X P4	Light green	Greenish with yellow shade	Good, less Crispy
P3 X P5	Dark green	Dark green with yellow shade	Good, Crispy
P3 X P6	Green	Light green with redish at apex	Good, Crispy
P3 X P7	Dark green	Dark green with light green at base	Good, Crispy
P3 X P8	Green	Green with light yellow shade	Good, Crispy
P4 X P5	Dark green with yellow strips	Dark green with yellow strips	Good, Crispy
P4 X P6	Green	Dark green with yellowish shade	Skin slightly bitter, crispy
P4 X P7	Green	Brick red with light green shade	Good, Crispy
P4 X P8	Green	Golden yellow with light green shade	Good, Crispy
P5 X P6	Green	Light green with yellow shade	Good, Crispy
P5 X P7	Light green	Light green with yellow shade	Good, Crispy
P5 X P8	green	Green with light yellow shade	Rather Good, Crispy
P6 X P7	Greenish	Yellowish at apex, light green base	Rather Good, Crispy
P6 X P8	Light green	Yellowish with light green shade	Good, Crispy
P7 X P8	Light green	Light green with yellow shade	Good, Crispy

Table 6 : Keeping quality (Shelf life) of fruit of parents and hybrids ...contd.				
Parents and F1 Hybrids	Organoleptic taste of fruit after storage	External appearance of fruit after storage	Shelf life Days	Percent weight loss in storage
Parents				
P1	Rather good ,pulpy	Not attractive	4	23.08
P2	Good,not crispy	Not so attractive	5	13.46
P3	Good,rather crispy	Rather attractive	4	30.77
P4	Good,not crispy	Not attractive	4	21.21
P5	Good,not crispy	Rather attractive	4	25.00
P6	Skin slight bitter,less crispy	Not so attractive	4	28.35
P7	Good, pulpy	Rather attractive	4	20.00
P8	Good, crispy	Rather attractive	3	21.74
Hybrids				
P1 X P2	Good, pulpy	Not so attractive	3	15.31
P1 X P3	Good,rather crispy	Rather attractive	4	26.19
P1 X P4	Good,rather crispy	Not attractive	4	21.43
P1 X P5	Good,not crispy	Rather attractive	4	28.95
P1 X P6	Good,not crispy	Rather attractive	4	21.89
P1 X P7	Good,not crispy	Not attractive	4	26.05
P1 X P8	Good,rather crispy	Rather attractive	5	13.45
P2 X P3	Skin slight bitter,not crispy	Not attractive	5	21.59
P2 X P4	Not Good,pulpy	Rather attractive	4	16.39
P2 X P5	Not Good,pulpy	Not attractive	3	19.64
P2 X P6	Skin slight bitter, pulpy	Not attractive	4	26.03
P2 X P7	Skin slight bitter, pulpy	Not attractive	4	26.03
P2 X P8	Good,rather pulpy	Rather attractive	4	18.28
P3 X P4	Good, pulpy	Rather attractive	4	24.05
P3 X P5	Good,not crispy	Rather attractive	4	21.62
P3 X P6	Good,not crispy	Not attractive	5	16.36
P3 X P7	Good,less crispy	Rather attractive	6	20.90
P3 X P8	Good, pulpy	Attractive	3	23.08
P4 X P5	Skin slight bitter,less crispy	Rather attractive	5	23.45
P4 X P6	Skin slight bitter,not crispy	Not attractive	3	23.81
P4 X P7	Good,less crispy	Rather attractive	4	21.25
P4 X P8	Good,less crispy	Rather attractive	5	20.73
P5 X P6	Good,not crispy	Rather attractive	4	32.35
P5 X P7	Good, pulpy	Not attractive	3	14.58
P5 X P8	Rather Good,not crispy	Rather attractive	4	22.73
P6 X P7	Skin slight bitter,less crispy	Not attractive	4	16.09
P6 X P8	Rather Good,less crispy	Not attractive	3	22.72
P7 X P8	Good,less crispy	Attractive	4	22.64

Table 7 : The range of heterosis, percentage of heterotic crosses and the best hybrids						
	Earliness (Days to first female flowering)	Maturity (nodal position of flower)	Sex ratio (female:male flowers)	Days to first fruit picking	Average weight of fruit (g)	Length of fruit (cm)
1 (a)	{1}	{2}	{3}	{4}	{5}	{6}
● Range a) Parents	43.73 - 58.13	5.67 - 7.53	1:13.56 - 1:5.22	59.00 - 66.66	111.33 - 203.00	10.53 - 26.48
b) hybrids	40.00 - 55.73	4.13 - 7.73	1:13.04 - 1:2.90	54.00 - 69.33	136.66 - 252.66	10.70 - 23.10
● Mean a) Parents	50.73	6.83	1:9.16	61.79	167.247	16.05
b) hybrids	48.19	6.74	1:8.69	61.95	177.936	15.82
● Mean Heterosis(%)	-5.248	-3.58	-3.907	0.344	6.884	-1.119
over Mid parent (MP)						
● Mean Heterosis(%)	-0.595	0.875	22.565	2.511	-2.842	-12.284
over better parent (BP)						
● Best performing F1	1 x 2	1 x 2	1 x 6	1 x 2	4 x 8	2 x 8
Hybrids						
● Significantly heterotic crosses (%) over better parent (BP)	46.43	39.29	28.57	32.14	21.43	41.43
parent (BP)						
● Maximum heterosis(%)	-15.840	-27.160	-44.444	-16.745	32.296	27.376
over better parent (BP)	(1 x 2)	(1 x 2)	(1 x 6)	(4 x 6)	(3 x 7)	(3 x 7)
						contd..

Table 7 : The range of heterosis, percentage of heterotic crosses and the best hybrids. ...contd

1 (a)		Diameter of fruit (cm)	Thickness of flesh of fruit (cm)	Fruit size index (cm ²)	Number of fruits per vine	Yield of fruit per vine (kg)	Final length of vine (m)
		{ 7 }	{ 8 }	{ 9 }	{ 10 }	{ 11 }	{ 12 }
● Range a) Parents	3.49 - 4.15	0.92 - 1.07	36.50 - 97.27	9.40 - 17.57	1.047 - 2.813	1.24 - 2.12	
b) hybrids	3.37 - 4.04	0.88 - 1.06	38.42 - 81.97	9.33 - 19.40	1.370 - 3.986	1.16 - 2.32	
● Mean a) Parents	3.83	0.995	61.41	12.92	2.143	1.71	
b) hybrids	3.76	1.052	58.30	13.88	2.325	1.69	
● Mean Heterosis(%) over Mid parent (MP)	-2.898	-1.459	-4.668	8.971	7.749	-0.339	
● Mean Heterosis(%) over better parent (BP)	-6.667	-3.848	-16.356	-3.732	-4.784	-10.726	
● Best performing F1 Hybrids	1 x 4	3 x 6	2 x 8	2 x 5	3 x 7	3 x 7	
● Significantly heterotic crosses (%) over better parent (BP)	21.43	7.140	10.710	42.860	32.140	10.710	
● Maximum heterosis(%) over better parent (BP)	12.393	3.960	24.264	61.667	52.788	49.784	
	(1 x 6)	(6 x 8)	(2 x 4)	(2 x 5)	(3 x 7)	(3 x 7)	

Table 8 : Analysis of variance table for combining ability

SR NO	CHARACTERS	G.C.A			S.C.A			ERROR		COMPONENTS OF VARIANCE	
		D.F	M.S.S	F	D.F	M.S.S	F	D.F	M.S.S	V(G)	V(S)
1	Earliness (days to first female flowering)	7	28211	73.988**	28	10738	28148**	70	0.381	1747	10364
2	Maturity (Node of first female flowering)	7	1680	257.174**	28	0.453	70.198**	70	0.008	0.121	0.447
3	Sex-ratio (female : male flowers)	7	15839	36.719**	28	3.604	8.366**	70	0.431	1.223	3.173
4	Days to first fruit picking	7	15596	46.978**	28	10.367	31.228**	70	0.332	0.523	10.035
5	Average weight of fruit (g)	7	1518.429	130.484**	28	539.795	46.386**	70	11.637	97.863	528.158
6	Length of fruit (cm)	7	53.846	1089.088**	28	3.758	76.016**	70	0.049	5.009	3.709
7	Diameter of fruit (cm)	7	0.034	15.795**	28	0.052	24.529**	70	0.002	-0.002	0.05
8	Thickness of flesh of fruit (cm)	7	0.005	15.789**	28	0.001	2.959**	70	0.0003	0.0004	0.0006
9	Fruit size index (cm ²)	7	640.721	416.367**	28	55.274	35.919**	70	1.539	58.545	53.735
10	Number of fruits per vine	7	14.214	346.463**	28	6.104	148.791**	70	0.041	0.911	6.063
11	Yield of fruits per vine (kg)	7	0.995	69.112**	28	0.247	19.315**	70	0.013	0.064	0.234
12	Length of vine (m)	7	0.215	103.549**	28	0.049	23.776**	70	0.002	0.017	0.047

Combining ability effects :

The estimates of general combining ability (g.c.a.) effects of the parents and Specific combining ability (s.c.a) effects of hybrid combinations under study are presented in Tables 9 and 10 respectively. (\hat{g}_i and \hat{S}_{ij} respectively).

The general combining ability effects of 8 parents tested for twelve characters in the present investigation and specific combining ability effects for 28 hybrids in favourable direction are described below :

4.4.1 Earliness (Days to Flowering) :

It is revealed from Table - 9 that 3 parents (P_1 , P_3 and P_8) expressed negative and highly significant g.c.a. effects for this trait. The parent, P_1 / PK expressed the highest g.c.a. effects (-3.207) followed by the parents P_3 / BA (-1.264) and P_8 / WLC (-0.188).

Of the 28 hybrids studied, 12 hybrids showed negative and highly significant s.c.a. effects. The highest s.c.a. effects (-6.063) were recorded by hybrid $P_1 \times P_2$ (PK X B) followed by -4.780 in the cross $P_4 \times P_8$ (LG X WLC), -3.917 in $P_4 \times P_5$ (LG X LC), -3.810 in $P_2 \times P_7$ (B X P) and -2.873 in $P_1 \times P_7$ (PK X P) hybrids.

4.4.2 Node of First Female Flower (maturity) :

The negative and highly significant g.c.a. effects for this trait were observed in 3 parents (P_1 , P_2 & P_8). The parent P_1 (PK) exhibited maximum g.c.a. effects (-0.922) followed by the parents P_2 (B) (-0.032) and P_8 (WLC) (-0.022).

As many as 15 cross combinations exhibited negative and highly significant specific combining ability effects. The hybrid $P_1 \times P_2$ (PK X B) exhibited the highest s.c.a. effect (-1.482) followed by -1.149 in the cross $P_4 \times P_5$ (LG X LC), -1.002 in the cross $P_1 \times P_7$ (PK X P) and -0.709 in $P_8 \times P_8$ (WLC X JLG).

4.4.3 Sex - ratio (female : male flowers) :

The negative and highly significant g.c.a. effects for this character were observed in 3 parents (P_1 , P_8 & P_7). The parent P_1 (PK) exhibited maximum g.c.a. effects (-2.428) followed by the parent P_7 (P)(-1.139) and P_8 (WLC)(-0.455).

Among the 28 hybrids studied, 10 hybrids exhibited negative and highly significant s.c.a. effects, while 2 hybrids showed negative and significant s.c.a. effects. The

hybrid $P_1 \times P_8$ (PK X WLC) exhibited the highest s.c.a. effects (-3.001) followed by the hybrids $P_1 \times P_2$ (PK X B)(-2.547), $P_4 \times P_7$ (LG X P)(-2.278), $P_2 \times P_5$ (B X LC) (-2.198) and $P_4 \times P_5$ (LG X LC)(-1.839).

4.4.4 Days to First Fruit Picking :

Out of 8 parents, 3 parents exhibited negative and highly significant g.c.a. effects for this trait. The highest g.c.a. effects (-2.783) were exhibited by parent P_1 (PK) followed by P_7 (-0.183) and P_8 (-0.117).

Among the hybrids studied, 11 hybrids showed negative and highly significant s.c.a. effects for this trait. The hybrid $P_4 \times P_7$ (LG X P) exhibited the highest s.c.a. effects (-5.641) followed by the hybrids $P_1 \times P_2$ (PK X B) (-5.307), $P_4 \times P_8$ (LG X WLC) (-5.041) and $P_8 \times P_8$ (WLC X JLG) (-2.841).

4.4.5 Average Weight of Fruit (g) :

Out of 8 parents, 3 parents exhibited positive and highly significant g.c.a. effects for this trait. The parent P_8 (JLG) exhibited the highest g.c.a. effects (17.050) followed by the parent P_4 (LG) (13.517) and P_7 (P) (7.983).

Highly significant and positive s.c.a. effects were observed in 6 hybrids, while significant and positive s.c.a. effects were exhibited by 1 hybrid. The hybrid $P_4 \times P_8$ (LG X JLG) recorded maximum s.c.a. effects (46.674) followed by hybrids $P_3 \times P_7$ (BA X P)(44.941), $P_1 \times P_8$ (PK X JLG) (31.874), $P_2 \times P_8$ (B X WLC) (31.507) and $P_1 \times P_5$ (PK X LC)(25.507).

4.4.6 Length of fruit (cm) :

Three parents out of 8 exhibited highly significant positive g.c.a. effects for this trait. The highest g.c.a. effects were exhibited by parent P_8 (JLG)(5.041) followed by P_7 (P)(0.317) and P_2 (B)(0.032).

Out of 28 hybrids, 11 hybrids exhibited highly significant and positive s.c.a. effects while 1 hybrid exhibited significant and positive s.c.a. effects. The hybrid $P_3 \times P_7$ (BA X P) recorded the highest s.c.a. effects (5.873) followed by the hybrids $P_2 \times P_4$ (B X LG) (3.676), $P_2 \times P_8$ (B X JLG)(2.169) and $P_1 \times P_5$ (PK X LC) (1.691).

4.4.7 Diameter of fruit (cm) :

Four parents exhibited highly significant positive g.c.a. effects. The parent P₄ (LG) exhibited the highest g.c.a. effects (0.062) followed by the parents P₅ (LC) (0.059), P₃ (BA)(0.042) and P₂ (B)(0.026).

Out of 28 hybrids studied , 10 hybrids exhibited highly significant s.c.a. effects. The hybrid P₈ X P₇ (WLC X P) showed the highest s.c.a. effects (0.332) followed by the hybrids P₁ X P₄ (PK X LG)(0.266), P₁ X P₂ (PK X B)(0.265), P₁ X P₆ (PK X WLC) (0.241) and P₈ X P₈ (WLC X JLG)(0.224).

4.4.8 Thickness of flesh (cm) :

Five parents exhibited highly significant and positive g.c.a. effects for this character. The parent P₃ (BA) showed maximum g.c.a.effects (0.036) followed by the parents P₈ (WLC)(0.014) and P₅ (LC)(0.007).

As many as 13 hybrids exhibited highly significant positive and one hybrid showed significant positive s.c.a. effects. The maximum s.c.a. effects were recorded by hybrid P₆ X P₈(WLC X JLG)(0.051), P₃X P₇(BAXP)(0.033), P₇X P₈(P X JLG)(0.032) and by the hybrid P₁ X P₄ (PK X LG)(0.030).

4.4.9 Fruit size Index (cm²) :

Four parents exhibited highly significant and positive g.c.a. effects for this trait. The maximum g.c.a. effects were showed by the parents P₈ (JLG)(16.726) and P₃ (BA)(1.618).

As many as 8 hybrids expressed highly significant and 2 hybrids showed significant s.c.a. effects. The hybrid P₂ X P₄ (B X LG) exhibited the highest s.c.a. effects (15.799) followed by the hybrids P₃ X P₇ (BA X P) (14.208), P₆ X P₇ (WLC X P) (6.842) and P₂ X P₈ (B X WLC)(6.159).

4.4.10 Number of fruits per vine :

Four parents showed highly significant and positive g.c.a. effects for this character. Maximum g.c.a. effects were exhibited by the parents P₆ (WLC)(1.496) followed by the P₃ (BA)(0.985), P₂ (B)(0.943) and P₅(LC)(0.502).

Of the 28 hybrids studied, 13 hybrids showed highly significant and positive s.c.a. effects. The maximum s.c.a. effects were recorded by the hybrids P₂ X P₅ (B X LC)(4.286), P₆ X P₈ (WLC X JLG)(4.135), P₅ X P₇ (LC X P)(3.786) and P₂ X P₆ (B X WLC)(2.692), in that order.

4.4.11 Yield of fruits per vine (kg) :

Highly significant g.c.a. effects in positive direction were exhibited by 5 parents for this trait. Maximum g.c.a. effects were recorded by the parents P₈ (JLG) (0.343), P₃ (BA)(0.231) and P₅ (LC)(0.124).

Highly significant and positive s.c.a. effects were recorded in 11 hybrids and significant and positive s.c.a. effects in one hybrid. The maximum s.c.a. effects were exhibited by the hybrid P₃ X P₇ (BA X P) (1.449), followed by hybrids P₄ X P₈ (LG X JLG) (0.735), P₆ X P₈ (WLC X JLG) (0.666), P₅ X P₇ (LC X P) (0.665) and P₂ X P₆ (B X WLC)(0.466).

4.4.12 Vine length (m) :

Highly significant and positive g.c.a. effects were found in 3 parents (P₂, P₅ and P₈). Highest g.c.a. effects were exhibited by the parent P₈ (JLG)(0.250) followed by P₅ (LC)(0.105) and P₂ (B)(0.078).

Out of 28 cross combinations studied, 12 hybrids exhibited highly significant s.c.a. effects in positive direction. While one hybrid showed significant s.c.a. effects. The highest s.c.a. effects were noticed in hybrids P₃ X P₇ (BA X P)(0.679) followed by the hybrids P₁ X P₈ (PK X JLG)(0.350), P₇ X P₈ (P X JLG) (0.267) and P₂ X P₆ (B X WLC)(0.244).



TABLE 9 : ESTIMATES OF G.C.A. EFFECTS OF THE PARENTS

SR. NO.	CHARACTERS	PARENTS							
		POONA KHIRA P1 (PK)	BUDGI- 1192092 P2 (B)	BETA-ALFA P3 (BA)	LONG GREEN - A P4 (LG)	LONG CUCUMBER P5 (LC)	WHITE LONG CUCUMBER P6 (WLC)		
1	Earliness (days to first female flowering)	-3.207**	0.463	-1.264**	2.359	0.349	-0.188**		
2	Maturity (Node of first female flowering)	-0.922**	-0.032**	0.112	0.165	0.048	-0.022**		
3	Sex-ratio (female : male flowers)	-2.428**	0.514	0.905	0.495	1.316	-0.455**		
4	Days to first fruit picking	-2.783**	0.183	-0.050	1.250	0.650	-0.117**		
5	Average weight of fruit (g)	-12.017	-6.650	-1.683	13.517**	0.083	-18.283		
6	Length of fruit (cm)	-3.140	0.032**	0.285	-0.593	-0.927	-1.016		
7	Diameter of fruit (cm)	-0.030	0.026**	0.042**	0.062**	0.059**	-0.020		
8	Thickness of flesh of fruit (cm)	-0.038	0.002**	0.036**	-0.003	0.007**	0.014**		
9	Fruit size index (cm ²)	-11.951	0.556**	1.618**	-1.033	-2.546	-3.893		
10	Number of fruits per vine	-1.432	0.943**	0.985**	-1.739	0.502**	1.496**		
11	Yield of fruits per vine (kg)	-0.611	0.050	0.231**	-0.228	0.124**	0.060**		
12	Length of vine (m)	-0.231	0.078**	-0.053	-0.028	0.105**	-0.120		
							CONTINUED		

TABLE 9 : ESTIMATES OF G.C.A. EFFECTS OF THE PARENTS ... contd

SR NO	CHARACTERS	PARENTS		S.E. $\hat{\sigma}(\hat{g})$	S.E. $\hat{\sigma}(\hat{g}_i - \hat{g}_j)$	DESCENDING ORDER OF MERIT
		POINSETT	JAPANESE			
		P7 (P)	P8 (JLG)			
1	Earliness (days to first female flowering)	0.106	1.383	0.033	0.076	1,3,6,7,5,2,8,4
2	Maturity (Node of first female flowering)	0.155	0.495	0.001	0.001	1,2,6,5,3,7,4,8
3	Sex-ratio (female : male flowers)	-1.139**	0.791	0.038	0.086	1,7,6,4,2,8,3,5
4	Days to first fruit picking	-0.183**	1.050	0.029	0.066	1,7,6,3,2,5,8,4
5	Average weight of fruit (g)	7.983**	17.050**	1.018	2.327	8,4,7,5,3,2,1,6
6	Length of fruit (cm)	0.317**	5.041**	0.004	0.010	8,7,3,2,4,5,6,1
7	Diameter of fruit (cm)	-0.034	-0.106	0.0002	0.0004	4,5,3,2,6,1,7,8
8	Thickness of flesh of fruit (cm)	-0.020	0.001**	0.00003	0.00006	3,6,5,2,8,4,7,1
9	Fruit size index (cm ²)	0.523**	16.726**	0.135	0.308	8,3,2,7,4,5,6,1
10	Number of fruits per vine	-0.724	-0.034	0.004	0.008	6,3,2,5,8,7,1,4
11	Yield of fruits per vine (kg)	0.031**	0.343**	0.001	0.003	8,3,5,6,2,7,4,1
12	Length of vine (m)	-0.001	0.250**	0.0002	0.0004	8,5,2,7,4,3,6,1

Table 10 : Estimates of s.c.a. effects of the hybrids				
Hybrids	Earliness (days to female flowering)	Maturity	Sex-ratio (female: male)	Days to first fruit picking
	1	2	3	4
Hybrids				
P1 X P2	-6.063**	-1.482**	-2.547**	-5.307**
P1 X P3	0.263	0.708	1.342	-1.407**
P1 X P4	-2.627**	-0.212**	0.528	0.293
P1 X P5	3.150	0.405	-0.746*	-0.441
P1 X P6	-2.413**	-0.692**	-3.001**	-0.007
P1 X P7	-2.873**	-1.002**	-1.311**	-1.607**
P1 X P8	0.283	0.391	3.145	0.493
P2 X P3	0.060	-0.615**	-0.047	1.626
P2 X P4	1.570	0.731	3.242	3.993
P2 X P5	-0.353	0.681	-2.198**	0.259
P2 X P6	-2.150**	-0.249**	-0.214	0.693
P2 X P7	-3.810**	-0.092**	-0.297	-1.574**
P2 X P8	-0.920**	-0.165**	-1.167**	0.193
P3 X P4	-0.237	-0.245**	-0.852*	-0.774**
P3 X P5	0.307	0.205	1.114	-0.841**
P3 X P6	0.310	-0.325**	0.739	-1.741**
P3 X P7	4.350	0.765	3.129	7.659
P3 X P8	0.040	0.025	-1.375**	1.093
P4 X P5	-3.917**	-1.149**	-1.839**	-2.141**
P4 X P6	-4.780**	-0.612**	1.135	-5.041**
P4 X P7	-2.407**	-0.089**	-2.278**	-5.641**
P4 X P8	3.183	0.505	-1.092**	4.793
P5 X P6	0.363	0.205	-0.529	0.559
P5 X P7	1.403	0.561	-1.818**	1.959
P5 X P8	-0.140	-0.179**	1.735	2.393
P6 X P7	4.807	0.365	2.929	4.393
P6 X P8	-2.603**	-0.709**	-0.551	-2.841**
P7 X P8	-2.163**	0.181	0.133	-0.107
S.E. (Sij)	0.314	0.005	0.355	0.273
S.E. (Sij - Sik)	0.687	0.012	0.776	0.598
S.E. (Sij - Skl)	0.610	0.010	0.690	0.531

Table 10 : Estimates of s.c.a. effects of the hybrids ...contd.				
Hybrids	Average fruit weight (g)	Average fruit length (cm)	Diameter of fruit (cm)	Thickness of flesh(cm)
	5	6	7	8
Hybrids				
P1 X P2	-12.093	-2.054	0.265**	0.001*
P1 X P3	-8.393	0.129**	-0.038	0.004**
P1 X P4	-31.926	-0.042	0.266**	0.030**
P1 X P5	25.507**	1.691**	-0.151	-0.003
P1 X P6	-9.459	0.637**	0.241**	0.013**
P1 X P7	-13.393	-2.109	-0.158	-0.047
P1 X P8	31.874**	-0.16	-0.062	-0.014
P2 X P3	-7.093	0.104*	-0.071	-0.016
P2 X P4	18.041	3.676**	0.090**	0.030**
P2 X P5	-16.526	0.669**	-0.381	0.007**
P2 X P6	31.507**	0.772**	0.205**	0.010**
P2 X P7	-10.759	-1.431	-0.214	-0.02
P2 X P8	-18.826	2.169**	-0.112	-0.017
P3 X P4	-8.926	-0.58	0.124**	0.026**
P3 X P5	-9.826	0.436**	0.063**	-0.024
P3 X P6	21.874*	-1.214	-0.144	0.026**
P3 X P7	44.941**	5.873**	-0.373	0.033**
P3 X P8	10.874	-1.818	-0.208	-0.071
P4 X P5	-4.693	-2.662	-0.166	-0.045
P4 X P6	16.007	-0.759	-0.410	-0.045
P4 X P7	-6.926	-2.082	-0.063	-0.005
P4 X P8	46.674**	1.638**	-0.051	-0.022
P5 X P6	4.441	-0.056	-0.024	-0.008
P5 X P7	25.174**	-1.856	0.163**	0.022**
P5 X P8	-39.559	-0.486	-0.065	0.005**
P6 X P7	4.874	0.390**	0.332**	-0.042
P6 X P8	-14.193	-1.55	0.224**	0.051**
P7 X P8	-3.793	-0.866	-0.021	0.032**
S.E. (Sij)	9.568	0.041	0.002	0.0004
S.E. (Sij - Sik)	20.946	0.089	0.004	0.0006
S.E. (Sij - Skl)	18.619	0.079	0.003	0.0005

Table 10 : Estimates of s.c.a. effects of the hybrids ...contd.				
Hybrids	Fruit size Index(cm ²)	Number of fruits per vine	Fruit yield per vine(kg)	Length of vine (m)
	9	10	11	12
Hybrids				
P1 X P2	-4.806	-0.647	-0.209	-0.242
P1 X P3	0.219	2.194**	0.284**	0.005*
P1 X P4	2.749*	1.035**	0.019	0.104**
P1 X P5	4.290**	1.594**	0.458**	0.134**
P1 X P6	5.353**	-1.650	-0.104	-0.180
P1 X P7	-9.140	1.170**	-0.324	-0.186
P1 X P8	-1.486	-0.887	-0.112	0.350**
P2 X P3	-0.322	-0.331	-0.393	-0.117
P2 X P4	15.799**	-1.223	0.061**	0.062**
P2 X P5	-3.184	4.286**	0.302**	0.032**
P2 X P6	6.159**	2.692**	0.466**	0.244**
P2 X P7	-8.110	1.778**	0.195**	-0.235
P2 X P8	5.700**	0.555**	-0.026	0.048**
P3 X P4	-0.183	0.434**	-0.295	-0.094
P3 X P5	3.037*	-0.683	-0.050	0.009**
P3 X P6	-6.383	-2.151	-0.347	0.065**
P3 X P7	14.208**	-0.731	1.449**	0.679**
P3 X P8	-10.195	-2.587	-0.392	-0.255
P4 X P5	-12.289	-2.099	-0.608	-0.422
P4 X P6	-8.603	-1.260	-0.026	0.040**
P4 X P7	-8.485	-1.140	-0.511	-0.055
P4 X P8	5.258**	1.703**	0.735**	-0.026
P5 X P6	-0.526	2.666**	0.397**	-0.003
P5 X P7	-6.328	3.786**	0.665**	-0.102
P5 X P8	-2.421	-1.404	-0.598	-0.080
P6 X P7	6.842**	-5.108	-0.672	-0.083
P6 X P8	-3.062	4.135**	0.666**	-0.081
P7 X P8	-3.451	-0.112	0.024*	0.267**
S.E. (Sij)	1.265	0.033	0.011	0.002
S.E. (Sij - Sik)	2.770	0.074	0.023	0.004
S.E. (Sij - Skl)	2.462	0.066	0.020	0.003

4.5 Gene Action and Heritability :

The estimates of general and specific combining ability and gene action and narrow sense heritability are presented in Table 11.

4.5.A Gene Action :

From Table 11 it is seen that s.c.a. variance (σ^2_s) was greater than g.c.a. variance for almost all the characters studied except for the characters, length of fruit and fruit size index.

The σ^2_g / σ^2_s ratio was less than 1 for all the characters except the character, length of fruit and fruit size index, where it was more than 1 which indicated predominant role of non additive gene action in the inheritance of most the characters studied. There is predominant role of additive gene action where the ratio is more than 1.

4.5.B Narrow sense heritability :

Narrow sense heritability estimates were made from g.c.a and s.c.a. variance. High heritability estimates were observed for characters, length of fruit (57.135) and fruit size index (51.437), while medium heritability was observed for 8 characters, viz; thickness of flesh (30.769), length of vine (25.758), sex ratio (25.337), maturity (21.080), fruit yield per vine (20.579), average weight of fruit (15.347), earliness (13.996) and average number of fruits per vine (11.728).

Low heritability estimates were observed for days to first fruit picking (4.807) and diameter of fruit (-4.000).

Table 11 : Estimates of General and Specific Combining ability, Gene action and narrow sense heritability						
SR	CHARACTERS	$\sigma^2 g$	$\sigma^2 s$	Gene Action = $\sigma^2 g / \sigma^2 s$	$h^2 = 100 \times$ $\sigma^2 g / (\sigma^2 g + \sigma^2 s + \sigma^2 e)$	
NO						
1	Earliness (days to first female flowering)	1.747	10.354	0.169	13.996	
2	Maturity (Node of first female flowering)	0.121	0.447	0.271	21.080	
3	Sex-ratio (female : male flowers)	1.223	3.173	0.385	25.337	
4	Days to first fruit picking	0.523	10.035	0.052	4.807	
5	Average weight of fruit (g)	97.863	528.158	0.185	15.347	
6	Length of fruit (cm)	5.009	3.709	1.350	57.135	
7	Diameter of fruit (cm)	-0.002	0.050	-0.040	-4.000	
8	Thickness of flesh of fruit (cm)	0.0004	0.0006	0.667	30.769	
9	Fruit size index (cm ²)	58.545	53.735	1.090	51.437	
10	Number of fruits per vine	0.811	6.063	0.134	11.728	
11	Yield of fruits per vine (kg)	0.064	0.234	0.274	20.579	
12	Length of vine (m)	0.017	0.047	0.362	25.758	

5 DISCUSSION

The genetic improvement of a crop depends upon the correct choice of parents from available gene pool. Such a selection is not an easy task; since phenotypic expression is determined not only by genotype but is influenced by environment and interaction between genotype and environment. It therefore necessitates critical assessment of the material with which breeder is working. The Statistical tools in this respect are of immense help in plant breeding programme based on a sound biometrical background. It provides a precise explanation of the genetic phenomenon providing a greater confidence to plant breeder in genetic interpretation. Diallel analysis is the most commonly used statistical tool in understanding the genetic make-up of the parental lines and their evaluation in a crossing programme.

In the present investigation eight diverse cucumber cultivars / lines were used to study the extent of heterosis, general and specific combining ability, variances, their effects, gene action and narrow sense heritability and to find out the best combiners which would give F_1 hybrids with higher fruit yields having desirable horticultural characters and consumer's acceptability. From the genetic analysis presented in the previous chapter, it is evident that there was appreciable heterosis in cucumber in almost all the characters studied. The results obtained in this respect are discussed below :

5.1 Sex Expression :

In cucurbits, sex-expression is an important factor from yield point of view. The increase in total number of female (pistillate) flowers per vine directly influences the yield. Kubicki (1972) suggested that development of male and female flowers in cucumber is controlled by the level of an ovary inducing substance. High content of this substance leads to the development of pistillate flowers.

It is of interest to note that in general, the female to male ratio increased in the hybrids as compared to the parents (Table 3). Thus, the hybrids $P_1 \times P_6$ (PK X WLC) (1: 2.90); $P_1 \times P_7$ (PK X P) (1: 3.91); $P_1 \times P_2$ (PK X B) (1: 4.32) and $P_4 \times P_7$ (LG X P) (1: 5.86) showed the high female to male sex ratio in a desirable direction as compared to the parental lines involved in these crosses (Table 3).

Considerable heterosis was observed for character sex-ratio (female:male), since as many as 17 and 8 hybrids recorded negative and significant heterosis over mid and better parents respectively. The maximum heterosis percentage over better parent was recorded by hybrid $P_1 \times P_6$ (PK X WLC) (-44.44); $P_2 \times P_5$ (B X LC) (-26.33); $P_1 \times P_7$ (PK X P)(-25.10) and $P_1 \times P_2$ (PK X B)(-17.24) Heterosis expressed by these hybrids may be attributed to per se performance of parental lines P_1 (PK), P_6 (WLC) and P_7 (P) and highly significant s.c.a. effects of these hybrids, except the hybrid $P_2 \times P_5$. The parents of $P_2 \times P_5$ hybrid though exhibited poor per se performance for this trait the hybrid showed high percent heterosis. Thus, it may be inferred that manifestation of heterosis for this trait was governed by both additive and non-additive genetic variance. Considering the components of variance for this trait, it is seen that there was predominant role of non-additive genetic variance. The medium heritability (25.337%) was observed for this trait. Similar results were obtained by Avakyan and Hirapetyan (1974). Solanki et al (1982) reported that number of female flowers per plant increased in F_1 progeny by 50 - 95 percent.

5.2 Earliness :

Earliness is one of the most vividly expressed and economically valuable characteristics of cucumber hybrid. The characters earliness (days to flowering), low nodal position of pistillate flower, length of vine at flowering and days to first fruit picking contribute towards earliness in cucumber.

Considerable heterosis was exhibited for character earliness (days to flowering), since as many as 20 and 13 hybrids exhibited significant heterosis in desirable direction over mid and better parents respectively. The hybrids $P_1 \times P_2$ (PK X B) (-15.84), $P_1 \times P_7$ (PK X P)(-9.89) and $P_1 \times P_6$ (PK X WLC)(-9.53) were the most heterotic. It is observed that the heterosis expressed by these hybrids was due to earliness and highly significant g.c.a. effects of parental lines P_1 (PK) and P_6 (WLC) and also high s.c.a. effects of these hybrids. These parents had good per se performance and highly significant g.c.a. effects and thus heterosis expressed was due to additive genetic variance. The early flowering parent P_1 (PK) when crossed with late flowering parents like P_4 (LG), P_2 (B) and P_8 (JLG) the resultant hybrids were found to be early flowering. Thus it may be inferred that manifestation of heterosis for early flowering was governed by both additive and non-additive genetic

variance. Considering the components of variance for this trait, it is seen that there was predominant role of non-additive genetic variance and the heterosis for earliness could be exploited in cucumber. The medium heritability (13.99%) was observed for early flowering.

Several Researchers have reported marked heterosis for earliness in cucumber (Arapetyan,1981; Pyzenkov and Kasareva,1981; Prudek,1986).

For character low nodal position of pistillate flowers as many as 16 and 11 hybrids exhibited negative and significant heterosis over mid and better parents respectively. Considering the first six early maturing hybrids (over better parents) viz. $P_1 \times P_2$ (PK X B), $P_4 \times P_6$ (LG X WLC), $P_4 \times P_8$ (WLC X JLG), $P_1 \times P_7$ (PK X P), $P_1 \times P_8$ (PK X WLC) and $P_2 \times P_8$ (B X WLC) it was observed that the heterosis expressed by the hybrids $P_1 \times P_2$, $P_1 \times P_7$ and $P_1 \times P_8$ was due to better per se performance and highly significant g.c.a. effects of parental line P_1 (PK) which was due to additive genetic variance; while late maturing parents namely P_2 (B) and P_8 (WLC) having highly significant g.c.a. effects when crossed with early maturing parents like P_1 , the resultant hybrids were early maturing. These early maturing hybrids also exhibited high s.c.a. effects. The components of variance for this trait revealed that that there was a predominant role of non-additive genetic variance. Thus, it may be concluded that the manifestation of heterosis for low nodal position of female flowers (earliness) was governed by both additive and non-additive genetic variances. The heritability estimate was medium (21.08%) for this character.

A high magnitude of heterosis was exhibited for character, days to first fruit picking, since as many as 11 and 9 hybrids exhibited negative and significant heterosis over mid and better parent respectively. The first four best hybrids which gave earlier picking as compared to better parent were $P_4 \times P_8$ (LG X WLC) (-8.83%), $P_1 \times P_2$ (PK X B) (-10.49%), $P_1 \times P_7$ (PK X P) and $P_4 \times P_7$ (LG X P) (-2.83%). It was observed that heterosis expressed by these hybrids was due to earliness of parents P_1 and P_7 and highly significant g.c.a. effects of parental lines P_1 , P_8 and P_7 . Evidently the heterosis was expressed due to additive genetic variance, when these early parents were crossed with late maturing parents like P_4 (LG); the resultant hybrids were found to give early fruit picking.

Considering the components of variance for this trait, it is seen that there was predominant role of non-additive genetic variance. Evidently the manifestation of

heterosis for early fruit picking was governed by both additive and non-additive genetic variances. The low heritability estimates (4.807%) was observed for days to first fruit picking.

Several researchers have recorded pronounced earliness and productivity in cucumber hybrids (Klossowska and Kubicki, 1970; Mikhov and Patkova, 1971; Avakyan and Hrapetyan, 1974; Alrapetyan, 1981; Pyzenkov and Kosareva, 1981; Prudek, 1986 and Rubino and Wehner, 1986).

The parents P₁ and P₈ showed significant g.c.a. effects for early flowering early maturity and days to first fruit picking.

5.3 Fruit Characters :

These characters include average weight of fruit, length of fruit, diameter of fruit, thickness of flesh and fruit size index. All these characters exhibited considerable heterosis over mid and better parent except the characters flesh thickness and fruit size index, where the heterosis over better parent was expressed by small number of hybrids.

For the characters average weight of fruit as many as 15 and 6 hybrids exhibited significant heterosis over mid and better parent respectively. The first two best hybrids which had high average fruit weight as compared to better parent were P₃ X P₇ (BA X P)(32.30%) and P₄ X P₈ (LG X JLG)(24.47%). It is observed that the heterosis expressed by these hybrids was due to highly significant g.c.a. effects of parental lines P₄ (LG), P₇ (P) and P₈ (JLG). These parents also had good per se performance; thus, the heterosis expressed was due to additive genetic variance. These crosses also exhibited significantly high s.c.a. effects. The parents P₄ (LG) and P₈ (JLG) which had more fruit weight when crossed with the parents like P₇ (P) and P₃ (BA) having comparatively less fruit weight resulted into hybrids with high average fruit weight.

However, the components of variance for this trait revealed that there was a predominant role of non-additive genetic variance. Thus, the manifestation of heterosis for average fruit weight was governed by both additive and non-additive genetic variances.

Similar results in respect of fruit weight have been reported by Ramalho (1975), Lower and Nienhuis (1979), Musmade (1981) and Solanki et al (1982).

However, Smith et al (1978) reported that genetic variance was additive for fruit weight. The medium heritability estimate (15.347%) was noticed for this trait indicating the possibility of improving this trait by selection.

For the character length of fruit 10 and 6 hybrids showed significant heterosis over mid and better parents respectively. The first three best hybrids which gave longer fruits as compared to better parent were $P_3 \times P_7$ (BA X P)(27.38%), $P_2 \times P_4$ (B X LG) (25.85%) and $P_2 \times P_3$ (B X BA)(8.80%). It is observed that the heterosis expressed by these hybrids was due to high g.c.a. effects of parental lines P_2 (B) and P_7 (P). The parent P_7 had fairly good per se performance and g.c.a. effects also. While other parent P_2 had poor per se performance and significant g.c.a. effects. All these three best hybrids also showed significant s.c.a. effects which indicates that there was non-additive genetic variance. However, parent P_8 (JLG) having best per se performance and high g.c.a. effects also transmitted this trait to hybrids over mid parent.

Considering the components of variance for fruit length. it is seen that there was also predominant role of additive genetic variance. The high heritability (57.135%) was observed for this trait. Similar results were reported by Abhang (1987); while Imam et al (1977) reported that short fruit was dominant over long fruit.

For the character diameter of fruit, 6 hybrids each exhibited significant heterosis over mid and better parents respectively. The first three best hybrids which gave bigger fruit diameter as compared to better parents were $P_1 \times P_6$ (PK X WLC) (12.39%), $P_8 \times P_7$ (WLC X P)(4.69%) and $P_8 \times P_8$ (WLC X JLG) (4.45%).

The parents involved in these crosses viz.; P_1 , P_6 , P_7 and P_8 did not show significant g.c.a. effects. The first three best hybrids also exhibited significant s.c.a. effects. Thus it can be inferred that there was predominance of non-additive genetic variance.

The components of variance for this character also showed that there was non-additive genetic variance. The low and negative heritability (-4.00%) was observed for the character which showed that the character may not respond to simple selection. Imam et al (1977) reported that small fruit diameter was dominant over large fruit diameter.

Low seed content and maximum flesh thickness is considered to be an important quality attribute in cucumber. In the present study as many as 10 and 2

hybrids recorded significant heterosis for character flesh thickness over mid and better parents respectively. The two hybrids which gave more flesh thickness as compared to better parents were $P_8 \times P_8$ (WLC X JLG) (3.96%) and $P_2 \times P_4$ (B X LG) (2.01%). The heterosis expressed by these hybrids was due to better per se performance of parents P_2 , P_4 , P_6 , and P_8 . These parents had significant g.c.a. effects except the parent P_4 . Both these hybrids also showed significant s.c.a. effects for the character, which indicated that there was predominance of non-additive genetic variances.

The components of variance for thickness of flesh indicated that there was predominant role of non-additive genetic variance. Thus the manifestation of heterosis for this character was governed by both additive and non-additive genetic variance. The medium heritability (30.769%) was noticed for this trait. Similar results have been reported by Musmade (1981) and Abhang (1987).

Out of 28 crosses significantly high heterosis was recorded by 8 and 3 hybrids over mid and better parents respectively for the character fruit size index. The three best hybrids which gave higher fruit size index as compared to better parent were $P_2 \times P_4$ (B X LG) (24.26%), $P_2 \times P_8$ (B X WLC) (13.45%) and $P_3 \times P_7$ (BA X P) (12.00%). The heterosis expressed by these hybrids may be attributed to per se performance of parents P_3 and P_7 and g.c.a. effects of parents P_2 , P_3 and P_7 which showed the dominance of additive genetic variance. All these three best hybrids also showed significant s.c.a. effects for the trait. The parent P_8 (JLG) though had the highest per se performance and significant g.c.a. effects failed to give hybrids with significant heterosis over better parent.

This was further confirmed since the components of variance for this trait revealed the predominant role of additive genetic variance. It may therefore, be concluded that manifestation of heterosis for fruit size index was governed by additive genetic variance. The high heritability estimates (51.437%) was noticed for this trait which suggested the scope for improvement of this trait through selection in the segregating population. These results were in conformity with those reported by Musmade (1981) and Abhang (1987) in cucumber.

In the present study it has been observed that with high female to male sex-ratio there was negative correlation with number of fruits per vine. In case of number of fruits per vine and fruit weight per vine, there was positive correlation. While in

case of more number of fruits per vine (in respect of first 12 significant hybrids) there was generally decrease in average fruit weight (except crosses $P_1 \times P_8$ and $P_5 \times P_7$), fruit size index (except cross $P_2 \times P_8$), flesh thickness (except cross $P_6 \times P_8$), length of fruit (except crosses $P_2 \times P_5$ and $P_2 \times P_8$) and diameter of fruit (except crosses $P_1 \times P_2$, $P_1 \times P_4$, $P_2 \times P_8$ & $P_6 \times P_8$). Similar results were reported by Ramalho (1975), who concluded that occurrence of pistillate flowers was negatively correlated with fruit weight, fruit length and fruit set.

The parents P_2 (B) and P_8 (JLG) showed highly significant g.c.a. effects each for maximum (four) fruit characters. Parent P_2 (B) exhibited significant g.c.a. effects for length of fruit, diameter of fruit, flesh thickness and fruit size index. But it has not exhibited the highest g.c.a. effects for any of the fruit characters. Similarly another parent P_8 (JLG) exhibited significant g.c.a. effects for average fruit weight, fruit length, flesh thickness and fruit size index, While the same parent exhibited the highest g.c.a. effects for average fruit weight, fruit length and fruit size index. Parent P_3 (BA) and P_7 (P) showed highly significant g.c.a. effects for maximum three fruit characters. Parent P_3 (BA) exhibited significant g.c.a. effects for diameter of fruit, flesh thickness and fruit size index. While it exhibited the highest g.c.a. effects for flesh thickness. Similarly parent P_7 (P) exhibited significant g.c.a. effects for average fruit weight, fruit length and fruit size index. The parents P_2 and P_8 were the best combiners for diameter of fruits. Evidently these parents P_2 (B) and P_8 (WLC) were good general combiners for most of the fruit characters and could be exploited in improving these traits.

5.4 Yield :

It has been reported that heterosis for yield in cucumber is mainly expressed as an increase in number of fruits and an earliness. Om et al (1978) observed heterosis from early fruit yield, total yield and total number of fruits per plant in a diallel set of cucumber. In the present study the major yield components, number of fruits per vine and total fruit yield per vine exhibited highly significant heterosis over mid parent and better parent.

Considerable heterosis was exhibited for character number of fruits per vine, since as many as 18 and 12 hybrids expressed significant heterosis over mid and better parent respectively. The four hybrids which gave more heterosis

for number of fruits per vine as compared to better parent were $P_2 \times P_5$ (B X LC) (61.67%), $P_5 \times P_7$ (LC X P) (38.98%), $P_1 \times P_5$ (PK X LC) (35.22%) and $P_2 \times P_7$ (B X P) (26.34%). The heterosis expressed by these hybrids could be attributed to high g.c.a. effects of parental lines P_2 (B) and P_5 (LC) and s.c.a. effects of the hybrids. Parents P_2 and P_7 involved in these hybrids had good per se performance but only parent P_2 had significant g.c.a. effects. While the other two parents P_1 and P_5 involved in these hybrids had poor per se performance and parent P_1 (PK) had non significant g.c.a. effects and thus heterosis expressed was due to additive and non-additive genetic variances. This was further confirmed since the components of variance revealed the predominant role of non-additive genetic variance. Medium heritability estimates (11.728%) was observed for this trait.

The present investigation exhibited a fairly high degree of heterosis (maximum 61.67%) for number of fruits per vine. Singh and Gill (1970), Jakabokova and Novakova (1973), Lower and Nienhuls (1979), Ghaderi and Lower (1981), Airapetyan (1981), Solanki et al (1982) and Prudek (1986) also reported similar results in cucumber.

Of the 28 crosses, as many as 14 and 9 hybrids showed significant heterosis for yield per vine over mid and better parents respectively. The four hybrids which gave higher heterosis for yield per vine as compared to better parent were $P_3 \times P_7$ (BA X P) (52.80%), $P_5 \times P_7$ (LC X P) (38.19%), $P_2 \times P_8$ (B X WLC) (29.30%) and $P_5 \times P_8$ (LC X WLC) (27.14%). It is observed that heterosis expressed by these hybrids was due to good per se performance of parents P_3 , P_5 and P_8 and significant g.c.a. effects of parental lines P_2 , P_3 , P_5 , P_8 and P_7 . These hybrids also showed significant s.c.a. effects for the trait. Hence, it is inferred that there was predominant role of additive genetic variance. The parent P_8 though had good per se performance and significant g.c.a. effects for the trait, mostly failed to produce hybrids with significant s.c.a. effects. Evidently, there was predominant role of non-additive genetic variance. This was further confirmed from components of genetic variance for the trait that there was predominant role of non-additive genetic variance.

It is observed that the manifestation of heterosis for fruit number and yield of fruits per vine in cucumber was governed by both additive and non-additive genetic variances. The heritability estimates for yield of fruit was medium (20.579%). Evidently the characters number of fruits per vine and yield of fruits per vine could be

improved by production of F_1 hybrids in cucumber. Several researchers have reported heterosis for fruit yield in cucumber (Klossowska and Kubucki, 1970; Kas'yanova, 1971, Meshcherov and Melychenko, 1975; Zavadskaya, 1975; Pyzenkov and Kosareva, 1981; Solanki et al, 1982).

The parent P_2 (B) showed highly significant g.c.a. effects for eight different characters including maturity; in which 7 characters were yield contributing characters i.e. length of fruit, diameter of fruit, flesh thickness, fruit size index, number of fruits per vine, yield per vine and final vine length in desirable direction. Similarly parent P_8 (JLG) also exhibited highly significant g.c.a. effects for 6 yield contributing characters, while the parent P_3 (BA), P_7 (P) and P_5 (LC) showed highly significant g.c.a. effects for 5 yield contributing characters. The first three best parents which exhibited higher g.c.a. effects for yield per vine were P_8 (JLG), P_3 (BA) and P_5 (LC). The parents P_2 (B), P_3 (BA), P_5 (LC) and P_8 (JLG) were good general combiners for yield and its component characters and per se performance was also close to their g.c.a. effects except the parent P_2 (B) which exhibited good g.c.a. effects though its per se performance was poor for most of the yield contributing characters.

Of the 28 crosses 9 and 3 hybrids exhibited significant heterosis over mid and better parents respectively, for the character final vine length. The three best hybrids which gave higher vine length as compared to better parent were $P_3 \times P_7$ (BA \times P) (49.78%), $P_3 \times P_8$ (BA \times WLC)(9.20%) and $P_7 \times P_8$ (P \times JLG)(6.09%). It is observed that the heterosis expressed by these hybrids was due to parent P_8 (JLG) which exhibited highly significant g.c.a. effects and good per se performance. The other parents involved in these crosses were P_3 (BA), P_7 (P) and P_6 (WLC) which showed non-significant g.c.a. effects and poor per se performance for this trait. All these hybrids showed significant s.c.a.effects. It may be inferred that the heterosis manifested for this trait was due to additive and non-additive genetic variances.

Considering the components of variance for this trait, it was observed that there was predominant role of non-additive genetic variance. Thus, the manifestation of heterosis for final vine length was governed by both additive and non-additive genetic variances. The medium heritability estimate (25.758%) noticed for this character suggested that this trait could be improved by selection.

5.5 Qualitative Characters :

In respect of colour of fruit (Table 5) two parents (P_4 and P_8) had fruits of green colour, while one parent each had yellowish white (P_1), dark green (P_2), dark green with yellow strips (P_3), green with yellow strips (P_5), creamy white (P_6) and greenish (P_7) coloured fruits.

As many as 12 hybrids produced green coloured fruits, 8 hybrids produced light green fruits, 4 hybrids produced dark green fruits; of the remaining four hybrids one hybrid each produced yellowish green, creamy white, dark green with yellowish strips and greenish coloured fruits. Smith et al (1978) observed that genetic variance was additive for all traits except fruit colour; while Sardar and Mukherjee (1987) showed that deep green colour of fruit was dominant over green, yellow and white; green dominant over yellow and white; yellow dominant over white.

In respect of surface of fruit (Table 5) it was observed that, of the 8 parents, 4 parents had fruits with smooth surface (P_2 , P_3 , P_6 and P_7), 3 parents had fruits with medium smooth surface (P_1 , P_4 and P_5), and 1 had fruits with medium rough surface (P_8).

Out of 28 hybrids, 10 hybrids had smooth fruit surface and 18 hybrids had medium smooth surface. Pyzhenkov (1986) reported that large surface protuberances (S) being dominant over small protuberances (S_1) which in turn is dominant over smooth fruit surface (s).

Out of 8 parents (Table 5), 6 parents (P_1 , P_2 , P_3 , P_6 , P_7 and P_8) had non spiny fruits, only 2 parents (P_4 and P_5) had sparse spiny fruit surface. Among the hybrids as many as 14 hybrids showed non-spiny fruits while 14 hybrids showed fruits with less spines (sparse spines). In case of colour of spines (Table 5) out of 8 parents 1 parent (P_4) had black coloured spines on fruit surface and 1 had (P_5) blackish brown spines. Out of 28 hybrids, 14 hybrids having non-spiny surface, 7 had black coloured spines, 6 had blackish brown coloured spines and 1 had white coloured spines on fruits. Pyzhenkov (1986) reported that in cucumber black (B) spine colour was dominant over brown (B₁) which in turn was dominant over white(b).

Out of 8 parents, 7 parents had very short fruit size and only one (P_8) had short fruit size. Out of 28 hybrids, 26 hybrids had very short fruit size and only 2 hybrids ($P_2 \times P_8$ and $P_3 \times P_7$) had short fruit size. Jakubokova⁴-Novakova (1973)

reported similar results. Imam et al (1977) observed that short fruits were dominant over long fruits.

In respect of keeping quality (shelf life) observations (Table 6), out of 8 parents, 2 parents (P_3 & P_8) showed rather good keeping quality as their fruits remained in good condition for 4 and 3 days respectively without deterioration in taste, less deterioration in external appearance and crispness of fruit. Out of 28 hybrids, 6 hybrids viz. $P_1 \times P_3$ (PK X BA), $P_1 \times P_8$ (PK X JLG), $P_3 \times P_7$ (BA X P), $P_4 \times P_7$ (LG X P), $P_4 \times P_8$ (LG X JLG) and $P_7 \times P_8$ (P X JLG) showed good keeping quality; since their fruits remained in good condition for 4 to 5 days. Among these 6 hybrids, the hybrid $P_3 \times P_7$ (BA X P) showed better keeping quality as the fruits remained in good condition with moderate loss in weight (20.90%) after 6 days of storage at room temperature.

Considering the overall performance of the crosses over better parents; it was observed that the cross $P_1 \times P_2$ (PK X B) exhibited maximum and significant heterosis percent for days to first flowering and maturity; while, the cross $P_4 \times P_8$ exhibited maximum and significant heterosis for days to first fruit picking. Similarly the cross $P_1 \times P_2$ also exhibited significant s.c.a. effects for days to flowering and maturity; while the cross $P_4 \times P_8$ also exhibited significant s.c.a. effects for days to first fruit picking.

Taking into Consideration the yield contributing characters it was observed that the cross $P_3 \times P_7$ exhibited maximum and significant heterosis over better parent for the characters weight of fruit, length of fruit, yield per vine and vine length. The same hybrid, $P_3 \times P_7$ also recorded significant s.c.a. effects for weight of fruit, length of fruit, flesh thickness, fruit size index, yield per vine and vine length. While, cross $P_2 \times P_5$ exhibited maximum and significant heterosis for number of fruits per vine and exhibited significant s.c.a. effects for sex-ratio, length of fruit, flesh thickness, number of fruits per vine and vine length.

Considering the overall performance, particularly the higher yield, green fruit colour, taste and crispness of fruit (Table - 12) it may be concluded that, the hybrid $P_3 \times P_7$ (BA X P) was most outstanding, which recorded the highest yield (3.986 kg/vine). It was followed by hybrids $P_8 \times P_8$ (WLC X JLG)(3.344 kg/vine), $P_4 \times P_8$ (LG X JLG)(3.125 kg/vine), $P_5 \times P_7$ (LC X P)(3.095 kg/vine), $P_5 \times P_8$ (LC X WLC) (2.856 kg/vine), and $P_2 \times P_8$ (B X WLC) (2.851 kg/vine). These hybrids gave higher fruit yield than the highest yielding parent P_8 (JLG) (2.813 kg/vine).

It may be concluded that, the cross combinations P₃ X P₇ (BA X P) and P₈X P₉ (WLC X JLG) possessed high potential for yield contributing characters. Incidentally the hybrid P₃ X P₇ had dark green fruit colour with crisp flesh and good shelf life under ambient temperature. Thus, commercial exploitation of hybrid vigour in cucumber is possible from these cross combinations.

Table 12 : Best performing hybrids over top parent				
Sr	Hybrid	Mean	Heterosis % over BP	Quality of fresh fruit
1	BA X P (P3XP7)			Dark green colour,
	a) Yfv (kg)	3.986	52.80	good taste & crisp
	b) Nfv	13.20	-24.86	
2	WLC X JLG (P6XP8)			Light green colour,
	a) Yfv (kg)	3.344	18.90	good taste, crisp.
	b) Nfv	19.27	13.33	
3	LG X JLG (P4XP8)			Green colour,
	a) Yfv (kg)	3.125	11.11	good taste, crisp
	b) Nfv	13.60	5.43	
4	LC X P (P5XP7)			Light green colour,
	a) Yfv (kg)	3.095	38.19	good taste & crisp
	b) Nfv	17.23	38.98	
5	LC X WLC (P5XP6)			Green colour, good
	a) Yfv (kg)	2.856	27.52	taste and crisp
	b) Nfv	18.33	7.84	
6	B X WLC (P2XP6)			Dark green colour,
	a) Yfv (kg)	2.851	29.30	skin slight bitter, crisp
	b) Nfv	18.80	10.59	
Top parent - P8 (JLG) (yield 2.813 kg/vine)				
Legend :- Yfv : Yield of fruits per vine				
Nfv : No. of fruits per vine				

6. SUMMARY

In the present investigations, "Heterosis and Combining ability studies in Cucumber. (Cucumis sativus Linn)" a diallel analysis utilizing eight cucumber cultivars (having diverse characters) was employed to study the extent of heterosis, combining ability, gene action and heritability for twelve characters in cucumber.

ANOVA for the design of experiment, revealed considerable magnitude of genetic variability among the parental lines and their hybrids for the characters studied.

The mean performance of the parents and hybrids studied for all the traits was found to be highly significant.

A high magnitude of heterosis was observed in many crosses for the characters studied in the present investigation.

The highest heterosis (75.91%) over mid parent was noted in a combination of $P_3 \times P_7$ (BA X P) for fruit yield per vine. The same combination also exhibited the highest heterosis for vine length (55.13%), weight of fruit (43.93%) and for length of fruit (37.45%). It also exhibited maximum heterosis over better parent for the characters yield per vine (52.80%), vine length (49.78%), weight of fruit (32.30%) and length of fruit (27.38%). However, the maximum heterosis over better parent was recorded in $P_2 \times P_5$ (B X LC)(61.67%) for number of fruits per vine. The same combination also exhibited high heterosis (71.68%) over mid parent for the same character.

Majority of the combinations involving parental lines P_1 (PK), P_2 (B), P_4 (LG) and P_8 (WLC) had high magnitude of heterosis for earliness. The combinations involving parents P_2 (B), P_3 (BA), P_5 (LC) and P_7 (P) exhibited high degree of heterosis for number of fruits per vine as well as yield per vine. Evidently, the heterosis breeding for the most important economic characters like yield per vine and number of fruits per vine as well as for other horticultural characters appeared to be highly promising.

The components of variance due to both g.c.a. and s.c.a. were highly significant for all the characters studied. The magnitude of s.c.a. variance was higher

than the g.c.a. variance for all the characters studied, except for the characters length of fruit and fruit size index, indicating the predominance of non-additive gene action for majority of the characters studied.

The heritability estimates in narrow sense were high for the attributes namely length of fruit and fruit size index and moderate heritability estimates (N.S.) were obtained for eight characters, namely flesh thickness, vine length, sex-ratio, maturity, yield per vine, weight of fruit, earliness and number of fruits per vine. The low heritability estimates were observed for days to first fruit picking and diameter of fruit.

Among the parents P_2 (B), P_8 (WLC) were good combiners for most of the characters studied. The parents P_1 (PK) and P_8 (JLG) exhibited highest g.c.a. effects for most of the characters studied. Parent P_1 (PK) exhibited maximum g.c.a. effects for the characters earliness, maturity, sex-ratio and days to first fruit picking; while, parent P_8 (JLG) exhibited maximum g.c.a. effects for the characters weight of fruit, length of fruit, fruit size index, yield per vine and vine length. Parent P_3 (BA) and P_7 (P) exhibited next highest g.c.a. effects for most of the characters under study. Parent P_3 (BA) ranked second best in respect of maximum g.c.a. effects for the characters earliness, fruit size index, number of fruits per vine and yield per vine; while, parent P_7 (P) expressed (ranked 2nd) maximum g.c.a. effects for the characters sex-ratio, days to fruit picking and length of fruit. As regards to most important economic character of the cucumber i.e. yield per vine, it is observed that maximum and significant g.c.a. effects were exhibited by the parent P_8 (JLG) followed by the parent P_3 (BA) and P_5 (LC).

The best cross combinations observed for various characters were $P_1 \times P_2$ (PK X B) for earliness and maturity, $P_1 \times P_8$ (PK X WLC) for sex-ratio, $P_4 \times P_7$ (LG X P) for first fruit picking, $P_4 \times P_8$ (LG X JLG) for weight of fruit, $P_3 \times P_7$ (BA X P) for length of fruit, yield per vine and final vine length, $P_6 \times P_7$ (WLC X P) for diameter of fruit, $P_8 \times P_8$ (WLC X JLG) for flesh thickness, $P_2 \times P_4$ (B X LG) for fruit size index and $P_2 \times P_5$ (B X LC) for number of fruits per vine. Both the parents or at least one of the parents involved in these crosses had exhibited significant g.c.a. effects except for the crosses $P_3 \times P_7$ (BA X P) for final vine length and $P_6 \times P_7$ (WLC X P) for diameter of fruit. Thus, it is possible to pick up the best specific combinations for exploitation of heterosis for various characters in cucumber.

In respect of keeping quality (shelf life) of parents and their hybrids for storage at room temperature it was observed that only two parents P₃ (BA) and P₈ (JLG) showed rather good keeping quality, while 6 hybrids (P₁ X P₃, P₁ X P₈, P₃ X P₇, P₄ X P₇, P₄ X P₈ and P₇ X P₈) exhibited rather good keeping quality since their fruits remained in good condition for 4 to 5 days in storage at ambient temperature.

Considering the over all performance, it is evident that the cross combinations P₁ X P₂ (PK X B) and P₄ X P₈ (LG X WLC) had high potential for earliness. Whereas cross combinations P₃ X P₇ (BA X P) and P₈ X P₈ (WLC X JLG) possessed high potential for yield contributing characters (Table 12). Incidentally the hybrid P₃ X P₇ had dark green fruit colour with crisp flesh and good shelf life under ambient temperature. Thus, commercial exploitation of hybrid vigour in cucumber is possible from these cross combinations.

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: Original not seen.

8 VITA

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