COMBINING ABILITY IN VEGETABLE COWPEA
(Vigna unguiculata var-sesquipedalis)

By

V. REJATHA

THESIS
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DECLARATION

I hereby declare that this thesis entitled "**Combining ability in Vegetable Cowpea (Vigna unguiculata var. sesquipedalis)**" is bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any University or Society.

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V. REJATHA

CERTIFICATE

Certified that this thesis entitled **"Combining ability in Vegetable Cowpea (Vigna unguiculata var. sesquipedalis)"** is a record of research work done independently by **Kumari V.REJATHA,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

25/7/92

N. RAMACHANDRAN NAIR
(Chairman, Advisory Committee)
Department of Plant Breeding.

Vellayani,

APPROVED BY:

Chairman

Sri. N. RAMACHANDRAN NAIR

Members

Dr. V. GOPINATHAN NAIR

Dr. S.G. SREEKUMAR

Shri. R. BALAKRISHNAN ASAN

External Examiner

18/12/92

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Vellayani,

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INTRODUCTION

INTRODUCTION

The world-wide shortage of protein is leading nutritionists and agriculturalists to consider more closely the contribution that plant protein can make the human diet. Since pulse crops can produce more protein in their seeds than cereals, they are of prime importance in any strategy to make more direct use of plant proteins. More effective utilisation and exploitation of pulse crop could provide a stimulous to agricultural development in the tropics. As yet these crops have not received the attention which they merit.

In India, pulses are grown on about 23.3 million hectares with an annual production of nearly 12.2 million tonnes. In order to attain high economic yield, a pulse crop should have high biological yield coupled with high harvest index. Genetic restructuring of the plant types to give higher harvest index may lead to the development of types with high economic yield(Jeswani,1986).

Cowpea is an important vegetable and a major pulse crop of South India. It occupies nearly 75% of the total area under pulses in Kerala ie., about 28,500 ha. (Anon, 1985). In Kerala, Cowpea is grown in uplands during the rainy season and in the rice fallows during the summer months.

The breeder of vegetable cowpea has to aim at the production of high yield of good quality green pods. Most of the economic characters in crop plants are under polygenic control. The breeding of such quantitative characters is guided by various biometric methods which unravel the inheritance pattern of those characters.

The only breeding work so far undertaken for the improvement of this crop is selection. No concentrated efforts were hitherto made to study the nature and magnitude of gene action governing the different economic characters. A study in this line will help the breeder to choose the appropriate breeding approach for the improvement of economic traits.

In all breeding procedures that involve hybridisation, it is desirable to study and compare the performance of parental lines for combining abilities. The combining ability analysis furnishes not only information regarding selection of suitable parents for hybridisation, but also elucidates, to some extent the nature and magnitude of gene action involved.

Diallel crossing is an important mating system enjoying universal application in plant breeding. The present investigation was undertaken to study the combining ability, gene action and heterosis in vegetable

cowpea. A basic understanding of the genetic phenomena underlining the mode of inheritance of different characters and the sorting out of elite parents and superior combinations based on general combining ability (g.c.a) and specific combining ability (s.c.a) effects will help for launching any plant breeding programme.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Griffing (1956) demonstrated the methods for working out g.c.a and s.c.a effects along with their variances. The assumptions involved in this technique are (i) The parent population must be random mating population in equilibrium. (ii) The experimental set of lines must be a random sample from the population of inbred lines which were derived from the parent population by the imposition of an inbreeding system free from the forces which give frequencies, and (iii) a modified diallel crossing system must be used in which the lines themselves are not achieved in the experimental set. Griffings pointed out that twice the g.c.a variance contains not only the additive genetic variance but also a portion of the epistatic variance (additive x additive) and that s.c.a include all the dominance and the remaining epistatic variance.

Griffing, (1956) reported a mathematical treatment of the problems of estimating the general and specific combining abilities from diallel crosses involving four methods, depending upon whether or not the parental inbreds or the reciprocal F_1's or both are included. The four methods are the following (i) parents, one set of F_1's and reciprocal F_1's are included. (all p^2

combinations); (ii) Parents and one set of F_1's are included, but not the reciprocals (½ p (p+1) combinations); (iii) one set of F_1's and reciprocals are included, but not the parents p (p-1) and (iv) one set of F_1's but neither parents nor reciprocal F_1's are included(½ p (p-1) combinations). Each method necessitated a different form of analysis.

Nandpuri et al. (1973) conducted diallel analysis of yield and no. of pods in Pisum Sativum. Variance due to general and specific combining abilities were significant for both the characters. Epistasis, overdominance and additive effects were evident for both characters and interaction effects were more important than additive effects.

Genetic studies in cowpea was undertaken inorder to assess the combining ability of 8 parental lines to examine the inheritance of 10 economic characters and to probe into the feasibility of formulating a hybrid breeding programme by Kamalam (1975). According to her study the parent Calicut 78 (1) showed good g.c.a. for yield and its components. The parents S.58 (4), S.51 (3) and Pannithodan S.25 (B) were the best general combiners for yield.

The F1 of a set of diallel crosses between 6 varieties were measured for eight yield component characters and days to maturity by Lal. et al. (1975). The variety 5226 B 2 was the best general combiner and the cross 5715 x 5226 B 2 give relatively high estimates of s.c.a. effects.

Observations on a five parent diallel cross over two years conducted by Brahmappa and Singh (1977) revealed significant differences among genotypes for number of days to flowering, primary branches, number of pods / plant pod weight / plant, seed number/pod and 100 seed weight. Variances due to both specific and general combining ability was found in little marvel and progress, while high s.c.a. effects were observed in progress, Burpiana for earliness of flowering and in little marvel x progress for pod yield.

Four characters studied in a diallel cross of 6 cultivers by Dahiya and Brar (1977) in pigeon pea revealed that additive inheritance was important in determining flowering time, but the dominance component was greater than the additive component, and over dominance was observed for pod number, 100 seed weight and yield. Heretability for all traits except flowering time was low and the bulk population method of breeding was suggested for early segregating generations. It is suggested that

to improve earliness, the best cross would be between parents with low general combining ability for flowering time and high general combining ability for other characters.

Diallel analysis by Agarkova et al. (1979) revealed several forms of pea with good combining ability for yield. A comparison of four diallel crossing methods for determining the coefficient of heretability and combining ability showed that any of the incomplete diallel methods can be used for evaluating a population but if it is necessary to evaluate each parental form individually, than the method involving direct hybrids and parental forms.

Epikhov and Flerova (1979) studied combining ability of some varieties of garden pea from a 6 x 6 diallel. The varieties Miragrin, Victor G33 and Early Giboro 11 had the best combining ability for yield. Several specific combiners for yield were also identified.

Combining ability study conducted by Reddy et at. (1979) in Cajanus cajan revealed that selection for yield should be based on height, Seed weight, length of pod, pod bearing region and number of pod bearing branches.

A study of combining ability for number of seeds/ plant in pea in different ecological regions was done by

Syreva (1979). According to him the number of seeds/plant was controlled mainly by genes with additive effects. The extend to which these expressed depended on growing conditions.

Inheritance of seed weight per plant was studied under field conditions in six varieties of pea which were crossed using a complete diallel scheme by Syreva et al.(1979). The parental varieties and the F_1 hybrids were grown at three sites. The highest positive g.c.a effects were obtained at orel for the varieties success Uladovo Jubilee and Usach and Omsk for varieties omsk 1 and usach.

In a diallel cross involving varieties of Cajanus cajan conducted by Chaudhari et al. (1980), g.c.a variance was high for the six quantitative characters studied, thus indicating additive gene effects. The best combining ability was shown by BS 1 for earliness and by C 11 for most characters. The cross C11 x 148 showed s.c.a effects for yield and number of secondary branches. Early segregates were obtained from the cross 148 x Hyderabad. Parentala ranking on the basis of g.c.a agreed with mean performance for all characters except yield.

Analysis of variance of all the possible crosses without reciprocals of 8 diverse strains of Vigna unguiculata undertaken by Jatasra (1980) showed that seed

weight was predominantly correlated by additive gene action, but that some nonadditive action was also involved. HFC 20. C28 and Fos 1 all bold-seeded varieties had the highest general combining ability effects for seed weight. Results from the use of array means and g.c.a. effects to select the best parents were similar.

Combining ability analysis in pigeon pea conducted by Reddy et. al. (1980) revealed that additive gene action predominated for most of the characters studied. However, highly significant s.c.a variances were noticed for yield in all diallels. In general, high rank correlation was observed between mean performance and g.c.a of parents. Variances due to g.c.a were affected relatively more than s.c.a variances by parental diversity.

In a diallel of five varieties of Dolicos lablab by Singh and Gupta, (1980) four crosses showed heterosis over the better parent for leaf size. The g.c.a. variance was seven times higher than s.c.a variance. The variety KT2 was a good general combiner for highest number of dominant genes. Additive gene effect were more important than non additive gene effects.

Combining ability for grain yield in green gram Vigna radiata (L) studied by Basaeerudin and Nagur (1981). In the F2 of crosses involving 13 varieties Jawahar 45 and

Bl showed the highest g.c.a. Heterosis over better parent was highest in 51 x 751. In this cross and in Jawahar 45 x Pusa Baisathi additive and non additive gene action were important in the control of seed yield.

Jains et al. (1980) conducted combining ability analysis for quality traits in forage cow pea. The analysis was carried out on data from 10 lines, four testers and their hybrids grown in 2 environments. Among lines HFC 354 and HSC 617 and among testers HFC 4-2-1 and 10 were the best general combiners in both environments. Crosses HFC 637 x 10, HFC 617 x 42-1 and HFC 354 x COl were best in both environments.

Combining ability analysis of certain productive traits in pea (Pisum sativun (L) was conducted by Kumar and Agarwal in (1981). In a 10 x 10 diallel involving lines from Germany,Sweden, India and UK, the number of pods per plant, their length, the number of seeds / pod and 25 seed weight were predominantly controlled by additive gene action Yield / plant and height were principally controlled by non additive gene action.

Combining ability for yield components in black gram was studied by Phundan Singh and Srivastava (1982). Data are presented on the general and specific combining ability variance of yield and three yield related traits in 90 F_1 Vigna mungo hybrids.

In a 10 variety diallel cross in soybean conducted by Ram Nath and Madhava Menon (1982) revealed that both g.c.a. and s.c.a variances were found to be highly significant for 6 developmental characters. Parental performance as judged by g.c.a effects indicated that EC 7043, EC 27500, Hernon 49, EC 39822 and EC 39821 were good general combiners for different characters. The superior combinations involved atleast one high general combining parent.

Based on the study conducted by Singh and Saini (1982) in seven varieties of French bean, data are tabulated on general and specific combining abilities for seed yield per plant, 6 related characters, habit and protein content.

Combining ability analysis of 10 diverse cultivars of pigeonpea conducted by Venkateswaralu and Singh (1982) indicated the importance of both additive and non additive gene effects for pods/plant, seeds/pod, 100 seed weight and seed yield/plant. However, the additive gene effects were predominent. The performance of parents was highly associated with their g.c.a effects. Parents NP(WR) 15 and T7 were the best general combiners for yield. Most of the crosses showing significant s.c.a effects involved are good and poor or even negetive general combiners. Relatively higher estimates of s.c.a effects were usually recorded in those crosses which involved diverse interacting parents.

Analysis of data on 7 yield related characters in a 9 x 9 diallel set excluding reciprocals in pea, Gupta et al.(1984) indicated that additive as well as non additive gene action was important for all characters, but the magnitude of non additive genetic variance was greater than that of additive genetic variance. Another study conducted by Miloseric (1984) for studying the combining ability for plant weight and seed weight per plant in a diallel cross of pea indicated that additive effects were the main contributers to the variance of both the characters.

Seed yield per plant and 9 yield related traits were analysed by Csizmadia (1985) in a 10 x 10 diallel in pea without reciprocals. The results revealed that the g.c.a variances are higher than s.c.a variances with a predominence of additive gene variance for most characters. Parents with high g.c.a were generally above average in phenotypic performance, but s.c.a effects were generally not proportional to F_1 performance.

Diallel analysis in field pea conducted by Singh et al. in (1985) revealed that both g.c.a and s.c.a effects were significant for all traits.

Singh et al. (1985) conducted analysis of general and specific combining ability in pea. The results revealed both significant additive and non additive gene

effects for all traits, the additive component being more important. He concluded that the best crosses involving atleast one parent with good combining ability should produce transgressive segregants.

Data are tabulated on general and specific combining ability effects for seed yield per plant, seeds/pod and 100 seed weight in a diallel cross in field pea. (Singh et al. 1985). Both g.c.a and s.c.a effects were significant for all traits.

The combining ability study conducted by Singh et al. (1985) in pea revealed that multiple crossing among suitable hybrids can bring out improvement in seed yield / plant and also revealed that both additive and non additive gene effects were significant for traits like plant height, pods/plant and seed yield/plant.

According to Chaudhary (1986) the g.c.a was significant for all characters in mung bean and s.c.a was significant for height, pods / plant and seed yield/ plant. The mung bean variety ML. 26 was the best Combiner and ML 26 x PS 19 was the best crosses for seed yield and pods / plant.

A study on combining ability for yield and some other characters in pigeompea were done by Lakhan et al. (1986). Data are tabulated on general combining ability

for seed yield per plant and 5 related characters in a half diallel cross of 8 varieties. The parents K.41, 1258 and GWL-3 were good combiners for yield and its components.

High combining ability was associated with good performance in both parents and hybrids in case of cowpea (Patil and shete, 1986 and Patil and Bhapkar, 1986). According to Patil and Bhapkar (1986) additive effects alone were involved in determining days to flowering days to maturity and 100 seed weight, but non additive effects were of minor importance for other characters.

Diallel analysis of yield and yield components of winged bean done by Silva and Omran (1986) indicated that high genetic variability existed for all traits. With respect to seed size, g.c.a effects alone were adequate to predict the performance of hybrids for number of pods/plant and seeds/pod. Both g.c.a and s.c.a effects were of equal importance while the performance of hybrids for seed yield was mainly depend on s.c.a effects.

In French bean, yield/plant, 100 seed weight and protein content were studied by Singh and Saini (1986) in a diallel cross without reciprocals. Both g.c.a and s.c.a

variances were significant for all these characters. General Combining ability variances predominated for seed yield and 100 seed weight.

Combining ability analysis in pegeon pea was studied by Patil et al. (1987). Analysis of 39 hybrids from crosses involving 3 female parents and 13 male parents indicated that S5, 8863, ICPL 100, T-15-15 NP (WR) 75, 7065 and 8647 were good general combines for pods/plant. and seed yield. The female parent B12 was a good general combiner for pod length, 100 seed wt. and seed yield. The cross T15-15 x 7065 and S5 x 8865 had positive s.c.a effects for seed yield and desirable s.c.a effects for days to maturity.

Data from an 8 line x 4 tester analysis of Cajanus cajan conducted by Hazarika et al. (1988) indicated that both g.c.a and s.c.a variances were significant for yield and yield components.

Data from a combining ability analysis involving 9 diverse pigeon pea parents and 36 F_1 hybrids by Mehetre et al. (1988) were taken to indicate that both additive and non-additive gene effects were important for all the traits studied except seeds/pod. Additive gene effects were predominant. Cultivars N 134, 28-17-1-9 and 4839-3 were the best general combiners for seed yield/plant. Seven crosses exhibited high s.c.a for seed yield.

Combining ability analysis in Soy bean was done by Sharma and Sharma in 1988. Information on combining ability is derived from data on 10 characters in 10 cultivars or lines and their F_1 hybrids grown during 1988-84. Cocker stuart was the best general combiner for 6 out of 10 characters.

Combining ability for yield and its components in black gram conducted by Singh et al. (1988) showed that among 10 diverse Vigna mungo cultivers, the best general combiners in both the F_1 and F_2 were H76 - 1 and T9 for days to maturity, G 104 and 45-2 for clusters/plant, plant 419 and 4-5-2 for pods/plant, Tl for harvest index and TKg for grain yield.

H E T E R O S I S

Heterosis was observed by various workers in peas. Ibarbia (1968) reported that when double and triple poded lines were crossed to single poded lines, an increased mean seed number and seed weight per peduncle was observed in the F_1's. The differences from single poded types were due to three genes in triple poded types and 8 to 9 genes in double poded types.

In a diallel cross involving eight varities of peas, Gritton (1969) reported that dry seed weight of the Fl plants exceeded that of the better parent by 26

percent. In 1968, the corresponding increase over the parents were 17 percent and 21 percent. Thirteen F_1 hybrids showed high heterosis in both localities in both years. Five of three exceeded the value of highest yielding parent.

Singh and Singh Santhoshi (1989) reported in pea that seventeen crosses produced significant positive heterosis over economic parent for yield and all of them had positive specific heterotic effect. The extend of heterosis was highest for yield and it was closely followed by pods per plant, seeds/pod,pod length, 100 seed weight, primary branches and harvest index.

The presence of heterosis was reported by various workers in cowpea. From the study of a cross of 'California black eye' X 'Blue goose'. Holfman(1962) reported heterosis for flowering time. The F_1 hybrid flowered earlier than that of the better parent. Premsekar (1964) reported manufestation of heterosis in respect of flowering duration, length of pod and 100 seed weight. With respect to flowering duration, the F_1 hybrid showed 6.[illegible] percent heterosis over the better parent. But for the length of pod the F_1 showed an intermediate position. Singh and Jain (1972) from the study of diallel set involving 5 parents, observed that heterosis manifested for seed yield which resulted from heterosis for pod length and seeds/pod.

Singh and Jain (1970) reported considerable heterosis in yield in mung bean. Their study showed that hybrid vigour over mid parent was present for grain yield, pod length etc. Although heterosis was found for cluster number and seeds/pod, the mean difference were insignificant. Negative heterosis was also observed for seed size. Singh and Jain (1971) also reported that in mung beans heterosis in hybrids over better parent was observed for cluster number and pod number, while over all negative heterosis was noted for 100 grain weight and pod length.

According to Salimath and Bahl (1985) in chick pea, only two crosses showed significant better parent heterosis with respect to days to flowering seven crosses showed better parent heterosis for days to maturity. Though additive and non-additive variances were important for days to first flowering, the former was more predominant. Rao and Chopra (1988) reported in chick pea that high positive values of average heterosis and heterobeltiosis were observed for seed yield, primary branches, secondary branches, whole plant, pods/plant, seeds per plant and plant weight.

The presence of heterosis was also demonstrated in grams by various workers. In Bengal gram, Ramanujam et al. (1964) reported heterosis in the F_1, their observation

restricted to single plant grown in plots. The study of heterosis in Bengal gram revealed that the degree of heterosis varied from character to character, a maximum being 9.91 percent in yield, the minimum being 9.91 percent in primary branches, when compared with the better parent. A critical examination of hybrid vigour in the crosses revealed that the number of pods per plant and the number of seeds/plant influenced higher yield to some extent.

In French beans Durate (1966) observed heterosis in leaf size and number of leaf per plant. Heterosis was also observed for the number of flowers, pods and seeds/ plant. Miranda Colin (1967) reported that crosses between Lima bean varieties of Similar pod and seed size showed heterosis in F_1 for these characters. But crosses between varieties of different pod and seed size generally give intermediate values for these characters. Heterosis was also observed for the number of flowers, pods and seeds/ pod and seed yield/plant. In Soy bean Weber et al.(1970) reported heterosis. The hybrid showed an average of 13.4 percent heterosis for seed yield over their respective high parent in the 85 crosses evaluated.

Prem Sagar and Chandra (1977) reported heterosis for height and pod number / plant in F_1 hybrids of Urd bean.

According to Samia (1977) the broad bean hybrids NA47 x Romi and Roni X 253/556/03 exceeded their better parents in seed yield/plant by 158% and 157% respectively, while the comparable figures for all other combinations ranged between -25 and 90%. No combination surpassed its better parent in 100 seed weight and the greater part of the heterosis in yield observed depending on the increase in number of pods/plant. Reddy et al. (1979) in pegeon pea reported that out of seven yield components, only pod number per plant and seed yield showed positive heterosis. Heterosis was also reported for number of seeds/pod and seed yield in winged bean by Silva and Omran (1986).

MATERIALS AND METHODS

MATERIALS AND METHODS

A . MATERIALS

The experimental material consisted of six selections of vegetable cowpea (Vigna unguiculata var sesquipedalis) collected from the germplasm maintained in the Dept. of Plant Breeding, at the college of Agriculture, Vellayani. These selections showed much variability in their morphological characters. They were used as parents for the hybridisation programme.

The performance of the six selections are given in table 1. The six parents and fifteen F_1 hybrids obtained by crossing them in all possibsle combinations without reciprocals, were used for the present study. The selections and their crosses are given in table 1.

Table. 1

Sl.No.	Treatment No.	Name of variety / cross.
1.	T_1	Selection 145.
2.	T_2	Selection 145 X Kurutholapayar.
3.	T_3	Selection 145 X Selection 129.
4.	T_4	Selection 145 X Selection 104.
5.	T_5	Selection 145 X Selection 7.
6.	T_6	Selection 145 X Selection 123.
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar X Selection 129.
9.	T_9	Kurutholapayar X Selection 104.
10.	T_{10}	Kurutholapayar X Selection 7.
11.	T_{11}	Kurutholapayar X Selection 123.
12.	T_{12}	Selection 129.
13.	T_{13}	Selection 129 X Selection 104.
14.	T_{14}	Selection 129 X Selection 7.
15.	T_{15}	Selection 129 X Selection 123.
16.	T_{16}	Selection 104.
17.	T_{17}	Selection 104 X Selection 7
18.	T_{18}	Selection 104 X Selection 123.
19.	T_{19}	Selection 7.
20.	T_{20}	Selection 7 X Selection 123.
21.	T_{21}	Selection 123.

B. METHODS

The experiment was laid out at the Instructional farm, college of Agriculture, Vellayani during Kharif 1990. The Experiment I consisted of crossing the six parental lines in all possible combinations, without reciprocals.

Inter Varietal hybridisation programme

The selected six lines were sown in two batches during May 1990. Each line was grown in two rows with twenty plants per row. They were crossed in all possible combinations without reciprocals, so as to get fifteen combinations. The female parent was emasculated on the previous day evening. The female flower buds were emasculated by the following methods. Removed all opened and immature flower buds from the inflorescence. The standard petal was split opened by using a sharp needle. Gently held back the standard and wing petals in between the thumb and fore finger. Carefully split opened the keel and removed the anthers one by one. Care was taken not to cause any injury to the anther and stigma. After emasculation, the standard and wing petals were placed in position and protected the flower bud using a butter paper cover. Next day morning, pollen from the desired male

parent was collected and dusted on the receptive stigmatic surface of the emasculated flowers between 06.30 and 07.30 hrs. The crossed flowers were then tagged and again protected by butter paper cover. The cover was retained for one more day. The tagged pods were separatly collected on maturity and hybrid seeds were obtained.

Estimation of combining ability, gene action and heterosis

The experimental material consisted of the six parental lines and (15) hybrids. They were grown in a Randomised Block Design, with three replications. The plot size was 4m x 3m. The experiment was conducted during Rabi 1990 at the Instructional farm, College of Agriculture, Vellayani.

The seeds were sown at a spacing of 60 x 20cm. Cultural and manurial practices as per the package of practice recommendations (1989) / adhoc recommendations of the T & V monthly Trivandrum workshop.

In all the varieties and (15) hybrids, observations were taken from 10 plants marked at random, from each plot. The observational plants were harvested separately. Pods from the remaining plants were collected as bulk.

Nine characters were studied and the mean values were used for statistical computations.

Observations recorded

In each replication, ten plants were selected at random from each genotype and tagged for taking observations. From each observational plant, 5 pods were selected at random. The same pods were used for taking observation for the characters like length of pod, mean weight of pod, number of seeds / pod and seed/pod ratio. The observations recorded are the following.

(i) Days to flowering

Number of days from sowing of the seeds to the appearance of first flower.

(ii) Number of pods / cluster

Five clusters were chosen randomly from each observational plant and counted the number of pods/cluster and the mean value was taken.

(iii) Number of pods/plant

The total number of pods produced per observational plant was counted.

(iv) Mean weight of pod

From each observational plant five pods were selected at random and the mean weight was worked out at vegetable stage.

(v) Mean length of pod

Five pods were selected randomnly from each observational plant and mean length was measured in centimenters.

(vi) Number of seeds/pod

Five pods were selected and the number of seeds present in each pod was found out and their mean worked out.

(vii) Length of internod

Internodal length at five positions were measured and their mean worked out in centimetres, in each observational plant.

(viii) Seed / Pod ratio

Five pods were selected randomly and seeds were extracted from the pods. The ratio of seed weight to pod weight was calculated at vegetable stage.

(ix) Fruit yield / plant

Green pods harvested from each of the observational plant and the weight recorded in grams.

C. STATISTICAL TECHNIQUES

Data from the parents and hybrids were subjected to Diallel analysis. The following parameters were estimated.

(1) Combining Ability

- (a) General Combining ability
- (b) Specific combining ability

(2) Gene action

- (a) Additive gene action
- (b) Non-additive gene action

(3) Heterosis.

- (a) Heterosis over mid-parent
- (b) Heterosis over better parent

Initially, analysis of variance for each character was carried out.

Analysis of Variance for each character

Source of Variation	df	MS	F.
Replication	(r-1)	MSR	MSR/MSE
Treatments	(v-1)	MSV	MSV/MSE
Error	(r-1)(v-1)	MSE	
Total	(rv-1)		

Where,

r = number of replications

v = number of treatments

MSR = Replication Mean Square

MSV = Treatment Mean Square

MSE = Error Variance

and

Critical difference (C.D) at 5% level of significance $= t_{(r-1)(v-1), 0.05} \times \sqrt{\frac{2MSE}{r}}$

Combining abilaity analysis

Combining ability analysis was carried out by following the method 2 under model 1 as suggested by Griffing (1956). The statistical model it follows is,

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

Where,

i,j = 1,2.....p

k = 1,2.....b

l = 1,2.....c.

μ = general mean

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

g_j = General combining ability (g.c.a) effect of j^{th} parent

S_{ij} = Specific combining abilaity (s.c.a) effect of ij^{th} cross such that $s_{ij} = s_{ji}$.

e_{ijkl} - environmental component pertaining to $ijkl^{th}$ obervation

p - number of parents involved in the diallel mating system

i and j - male and female parents respectively for producting the ij^{th} hybrid.

b - number of blocks or replications

c - number of observational plants

The sum of squares due to g.c.a and s.c.a were calculated as follows.

sum of squares due to g.c.a.

$$S_g = \frac{1}{p+2} \left[\sum_{i=1} (y_i. + y_{ii})^2 - \frac{4}{n} Y..^2 \right]$$

Sum of square due to s.c.a.

$$SS = \sum_{i \leq j} \sum Y_{ij}^2 - \frac{1}{p+2} (Y_{i.} + Y_{ii})^2 + \frac{2}{(p+1)(p+2)} \times Y..^2$$

Where, p = number of parents

Y_i = Total of i^{th} array in the diallel table

Y_{ii} = Mean value of i^{th} parent

Y_{ij} = Mean value of $(i \times j)^{th}$ cross

Y.. = Grand total of 'p' parental lines and $\frac{p(p-1)}{2}$ progenies of the diallel table

The mean squares due to g.c.a and s.c.a were obtained by dividing the respective sum of squares by the corresponding degrees of freedom. In combining ability analysis, the error mean square obtained in the analysis of variance is divided by the number of replications to get the adjusted error variance (M'e).

$$M'e = MSE/r$$

Where r = number of replications

Analysis of variance for combining ability

Source of Variation	df	SS	MSS	EMS
g.c.a	$(p-1)$	S_g	M_g	$\sigma^2 e + \frac{p+2}{p-1} g_i^2$
g.c.a	$\frac{p(p-1)}{2}$	S_s	M_s	$\sigma^2 e + \frac{p}{p(p-1)} \sum\sum_{i<j} s_{ij}^2$
Error	m	Se	M'e	$\sigma^2 e$

Where m = degrees of freedom for error

Mg = g.c.a. mean square

Ms = s.c.a mean square

M'e = Adjusted error variance

Test of significance

(i) g.c.a. effects

$$F\ (p-1)m = \frac{Mg}{M'e}$$

(ii) s.c.a. effects

$$F\ P\ \frac{(p-1)}{2}, m = \frac{Ms}{M'e}$$

(i) Estimation of g.c.a effects

The general combining ability (g.c.a) effects of theparents were calculated as follows.

$$g_i = \left[\frac{1}{p+2} \left[\Sigma (y_{i.} + y_{ii}) - \frac{2}{p} y.. \right] \right]$$

(ii) Estimation of s.c.a. effects

The s.c.a. effects for all the fifteen cross combinations for the different characters were estimated as:

$$S_{ij} = Y_{ij} - \frac{1}{(p+2)}(y_{i.} + y_{ii} + y_{.j} + y_{jj}) + \frac{2}{(p+1)(p+2)} y..$$

Where S_{ij} = s.c.a. effects of ij^{th} cross

Y_{jj} = Mean value of j^{th} parent

Y_{ij} = Total of j^{th} array in the diallel table

(iii) Estimation of standard errors

The standard errors for g.c.a effects were estimated using the formulae.

$$SE(gi) = [(p-1)\ \sigma e^2 / p\ (p+2)]^{\frac{1}{2}}$$

$$SE(gi - gj) = (2\ \sigma^2 e / p+2)^{\frac{1}{2}}$$

The standard errors of s.c.a effects were estimated as:

$$SE(S_{ij}-S_{ik}) = [2(p+1)\ \sigma^2 e / P + 2]^{\frac{1}{2}}$$

$$SE(S_{ij}) = [P(p-1)\ \sigma^2 e / (p+1)\ (p+2)]^{\frac{1}{2}}$$

$$SE(S_{ij}-S_{kl}) = [2(p\ \sigma^2 e / p+2)]^{\frac{1}{2}}$$

Each g.c.a and s.c.a estimate was subjected to 't' test

$$t = \frac{\hat{gi}}{SE(\hat{gi})} \quad \text{and}$$

$$t = \frac{\hat{Sij}}{SE(\hat{sij})}$$

For testing the significance of difference between two effects, the critical difference was calculated by multiplying the respective standard error of difference with 't' value at 'm' degrees of freedom.

Gene action

The analysis of variance for combining ability was used to decide the type of gene action controlling a character. Griffings (1956) demonstrated the method of working out g.c.a and s.c.a variances and pointed out that

twice the g.c.a variance was related to additive or additive x additive or higher order interactions and s.c.a variance included all of the dominance and the remaining epistatic variance.

Heterosis

The overall mean value of each parent and hybrid in all the three replications for each character was taken for the estimation of heterosis. Heterosis was calculated as the percent deviation of the mean performance of F_1's from its mid parent (M.P.) and better parent (B.P.) for each cross combination.

(i) Deviation of hybrid mean from the mind parents value (Relative heterosis)

$$= \frac{F_1 - \overline{M.P}}{\overline{M.P}} \times 100$$

(ii) Deviation of hybrid mean from the better parental value(Hetero beltiosis)

$$= \frac{F_{1-\overline{B.P}}}{\overline{B.P}} \times 100$$

For each character, the average valaue of the two parents involved in each cross combination was taken as the mid parental value (M.P) and the superior between those of the parents in each cross as better parental value (B.P.).

To test the significance of difference of F_1 mean over mid and better parent, critical difference (C.D) was calculated from their standard error of differences as mentioned below (Briggle, 1963).

To test the significance over mid parent

$$C.D.(0.05) = t_e, 0.05 \times \sqrt{\frac{3 \times MSE}{2r}}$$

To test significance over better parent

$$C.D.(0.05) = t_e, 0.05 \times \sqrt{\frac{2 \times MSE}{r}}$$

Where,

e = error degrees of freedom

MSE = error variance

r = number of replications

RESULTS

RESULTS

The data relating to the experiment were analysed statistically and the results are presented below.

Mean performance

The mean values of the nine characters studied for the twentyone treatments, best parents and hybrids are presented in Table 2 and 3.

For the character days to flowering, the mean values recorded by the parents ranged from 48.37 days for kurutholapayar to 55.93 days for selection 104, whereas, it ranged from 46.87 to 54.40 days in the hybrids kurutholapayar x selection 129 and selection 104 x selection 123 respectively. The number of days to flowering is intermediate among hybrids, to those of the parents except for two hybrids, selection 145 x kurutholapayar (47.43) and kurutholapayar x selection 129 (46.87). The variation shown by the parents and hybrids for this character is represented in figure 1 (a).

The highest value for the number of pods per cluster among the parents was shown by selection 129 (2.13) and lowest for selection 104 (1.90). Among the hybrids it ranged from 2.20 for selection 129 x selection 104 to 1.866 for selection 129 x selection 7. The variation for number of pods per cluster in the parents and hybrids is represented in figure 1 (b).

Table 2. Phenotypic expression for 9 characters in parents and F_1s

Treatment	Days to flowering	No.of pods/ cluster	No.of pods/ plant	Mean weight of pod (g)	Mean length of pod (cm)	No.of seeds/ pod	Length of inter-node (cm)	Seed/pod ratio	Fruit yield/ plant (g)
(1) (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. Selection 145	52.50	2.033	17.20	10.80	36.96	17.76	19.37	0.2212	176.60
2. Selection 145 x Kurutholapayar	47.43	2.033	23.20	11.94	35.80	17.83	19.92	0.2199	259.66
3. Selection 145 x Selection 129	50.13	2.000	18.70	11.11	35.72	17.31	16.48	0.2498	205.60
4. selection 145 x Selection 104	53.53	2.000	25.33	12.14	38.08	18.85	15.63	0.2610	304.47
5. Selection 145 x Selection 7	51.00	2.000	18.00	10.85	35.26	16.00	17.07	0.2355	183.87
6. Selection 145 x Selection 123	52.73	2.000	14.53	10.79	35.43	15.80	17.63	0.2155	150.40
7. Kurutholapayar	48.37	1.900	24.27	10.96	32.07	15.03	18.70	0.1585	276.10
8. Kurutholapayar x Selection 129	46.87	2.000	22.53	12.08	35.28	17.27	18.70	0.2293	254.47
9. Kurutholapayar x Selection 104	52.07	2.000	21.20	12.21	36.18	17.64	16.40	0.2323	239.87
10. Kurutholapayar x Selection 7	51.37	2.066	17.73	11.41	37.23	14.92	18.50	0.2032	201.86
11. Kurutholapayar x Selection 123	51.83	2.000	19.37	11.96	34.53	16.89	17.87	0.2019	224.67
12. Selection 129	49.03	2.130	16.80	10.32	34.04	15.87	19.37	0.2330	171.43

(Table 2 Contd)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
13.	Selection 129 x Selection 104	50.40	2.200	25.12	11.32	36.14	17.29	17.50	0.2702	236.87
14.	Selection 129 x selection 7	51.03	1.866	27.30	10.58	33.78	15.67	18.80	0.2168	276.93
15.	Selection 129 x Selection 123	48.97	1.966	19.63	10.10	33.77	16.67	18.13	0.2367	190.63
16.	Selection 104	55.93	1.900	9.27	11.25	40.22	16.60	15.13	0.1972	101.47
17.	Selection 104 x Selection 7	52.93	1.966	17.73	12.50	36.35	15.25	15.37	0.1810	181.33
18.	Selection 104 x Selection 123	54.40	2.000	21.83	11.95	35.76	17.47	13.67	0.2605	238.33
19.	Selection 7	52.83	1.933	21.10	11.05	35.25	16.88	18.57	0.2362	221.07
20.	Selection 7 x Selection 123	51.70	2.033	17.93	11.03	34.00	16.44	19.83	0.2109	184.07
21.	Selection 123	51.00	1.966	12.67	10.34	31.68	17.00	19.07	0.2074	121.10
	CD(0.05)	2.401	4.870	NS	1.467	2.614	1.417	2.090	0.047	NS

Table 3. Phenotypic expression for 9 characters in best parents and F_1s

Sl. No.	Characters	Best parents		Best hybrids	
		Variety	Mean value	Cross combination	Mean value
1.	Days to flowering	Kurutholapayar	48.37	Kurutholapayar x Selection 129	46.87
2.	Number of pods/ cluster	Selection 129	2.133	Selection129 x Selection 104	2.20
3.	Number of pods/plant	Kurutholapayar	24.27	Selection 129 x Selection 7	27.20
4.	Mean weight of pod	Selection 104	11.259	Selection 104 x Selection 7	12.50
5.	Mean length of pod	Selection 104	40.22	Selection 145 x Selection 104	38.08
6.	No.of seeds/pod	Selection 145	17.765	Selection 145 x Selection 104	18.85
7.	Length of internode	Selection 104	15.133	Selection 104 x Selection 123	13.67
8.	Seed/pod ratio	Selection 7	0.2362	Selection 129 x Selection 104	0.27
9.	Fruit yield/plant	Kurutholapayar	276.10	Selection 145 x selection 104	304.47

Figure 1 (a)

Mean Values of parents and hybrids for days to flowering in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

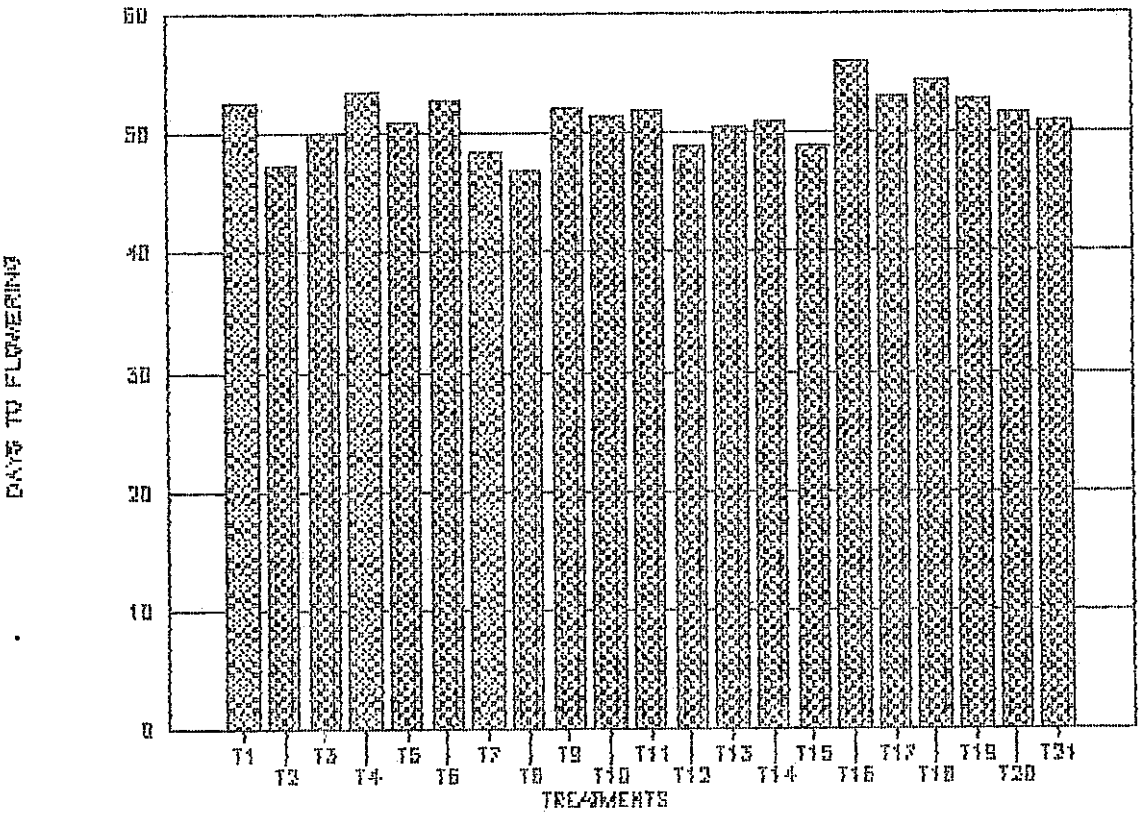


FIG. 1(a)

Mean values of parents and hybrids for days to flowering in a 6 x 6 diallel.

Figure 1 (b)

Mean Values of parents and hybrids for Number of Pods/Cluster in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

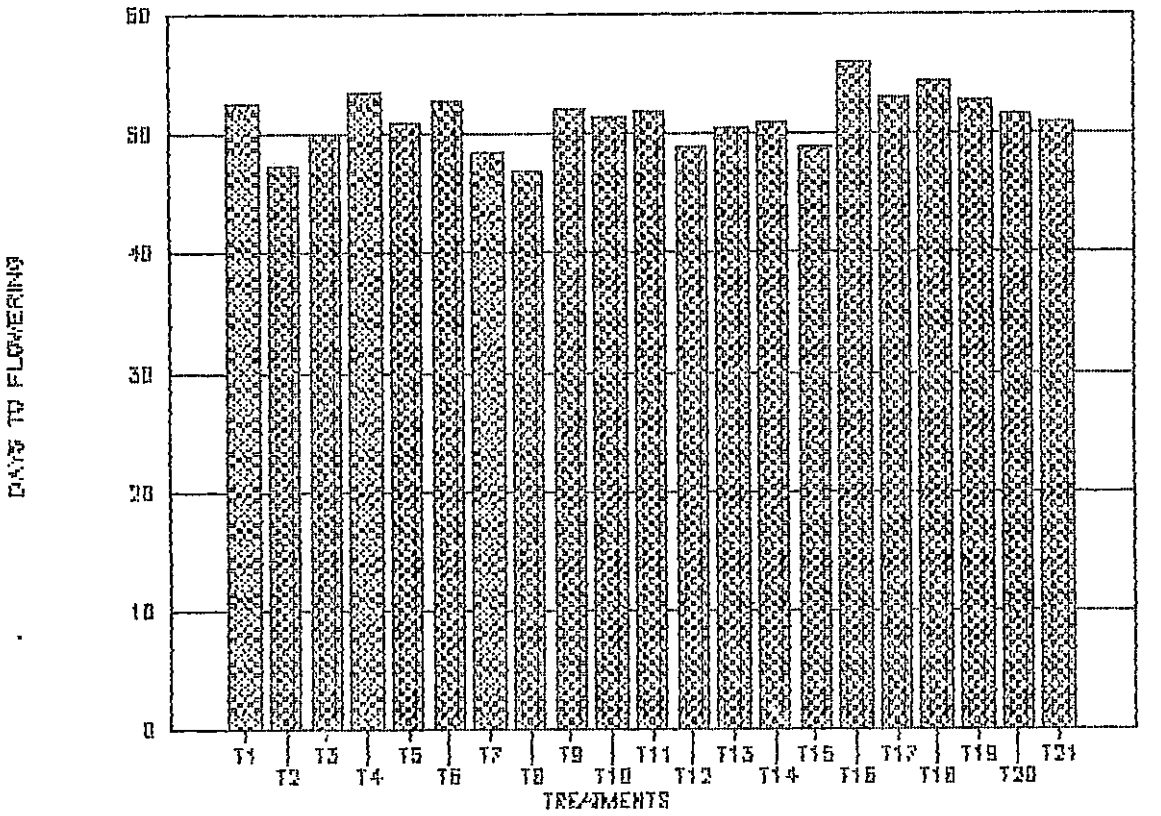


FIG. 1(a)

Mean values of parents and hybrids for days to flowering in a 6 x 6 diallel.

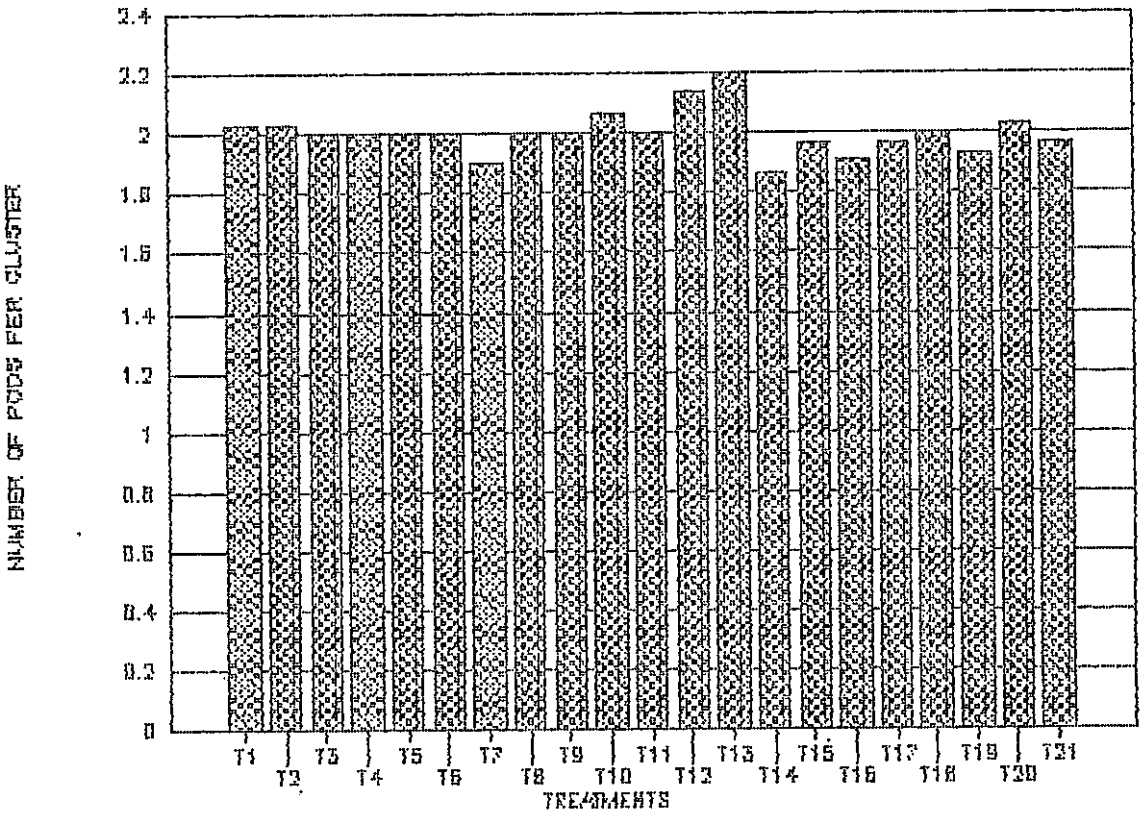


FIG. 1 (b)

Mean values of parents and hybrids for Number of pods/cluster in a 6 x 6 diallel.

For the charactr number of pods per plant, the mean values recorded by the parents ranged from 24.27 for kurutholapayar to 9.27 for selection 104. In hybrids it ranges from 27.30 for selection 129 x selection 7 to 14.53 for selection 145 x selection 123. The variation shown by parents and hybrids for this character is represented in figure 1 (c).

The highest value for mean weight of pod among the parents was shown by selection 104 (11.25 g) and the lowest for selection 129 (10.32 g). The hybrids showed a wide range of variability between 12.50 to 10.10 for selection 104 x selection 7 and selection 129 x selection 123 respectively. The variation for mean weight of pod in the parents and hybrids is represented in Figure 1 (d).

The parents showed a wide range of variability for mean length of pod ranging from 40.22 cm for selection 104 to 31.68 cm for selection 123. Whereas the hybrids showed a variation from 38.08 cm for selection 145 x selection 104 to 33.77 cm for selection 129 x selection 123. The variation exhibited by the parents and hybrids for this character is represented in Figure 1 (e).

The maximum value for the character number of seeds/ pod among the parents was shown by selection 145 (17.76)

Figure 1 (c)

Mean Values of parents and hybrids for Number of Pods/Plant in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

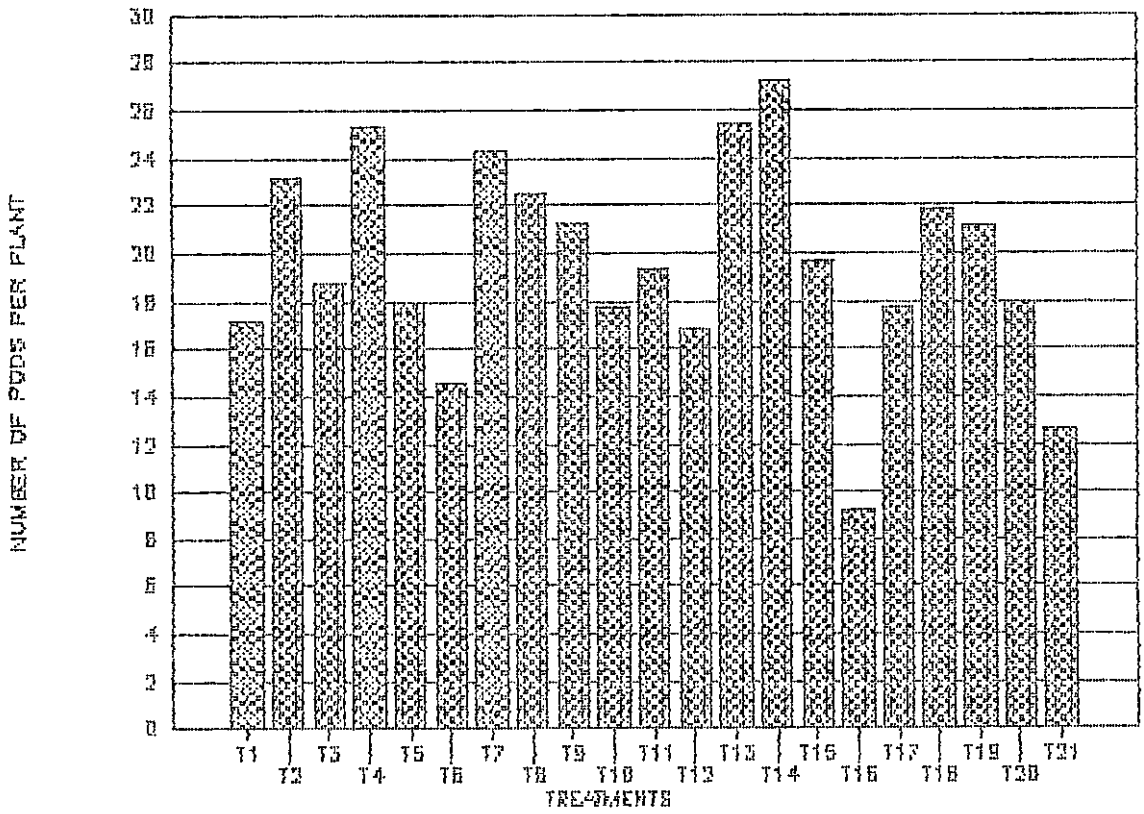


FIG. 1(c)

Mean values of parents and hybrids for Number of pods/Plant in a 6 x 6 diallel.

Figure 1 (d)

Mean Values of parents and hybrids for Mean weight of Pod in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

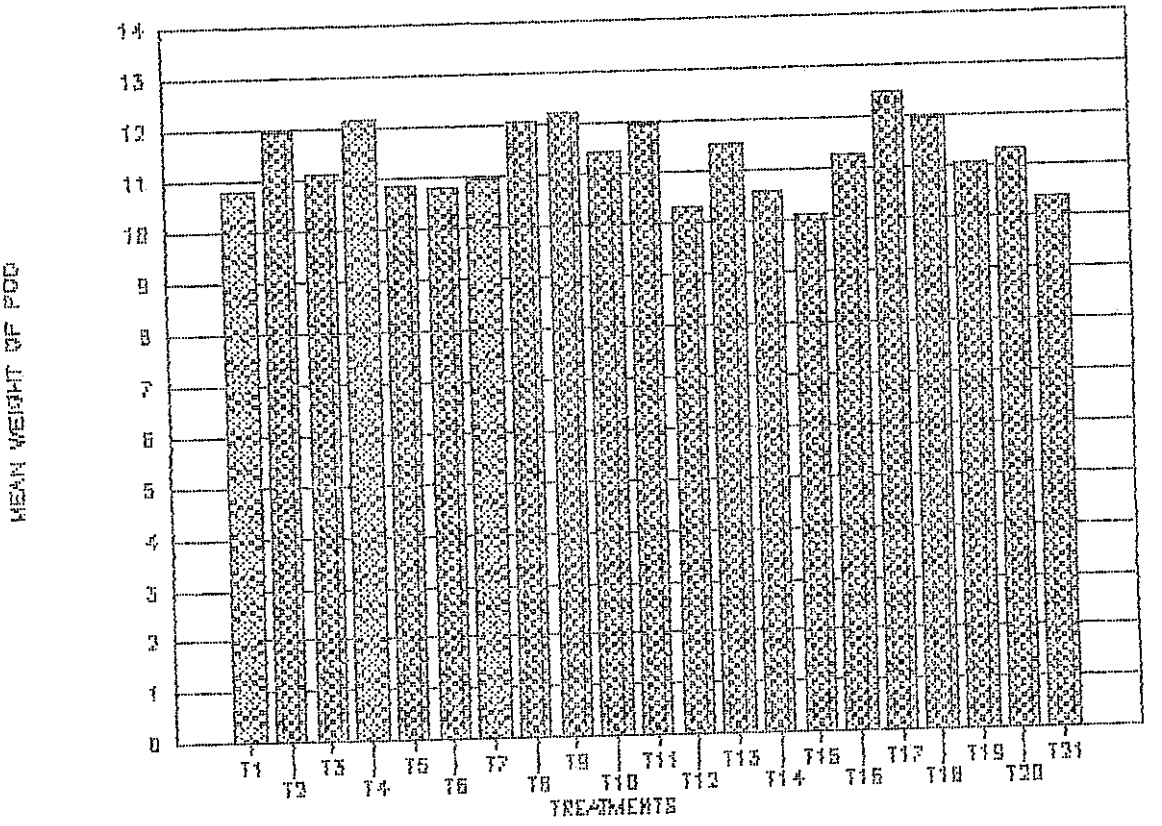


FIG. 1 (d)

Mean values of parents and hybrids for Mean weight of pod in a 6 x 6 diallel.

Figure 1 (e)

Mean Values of parents and hybrids for Mean length of Pod in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

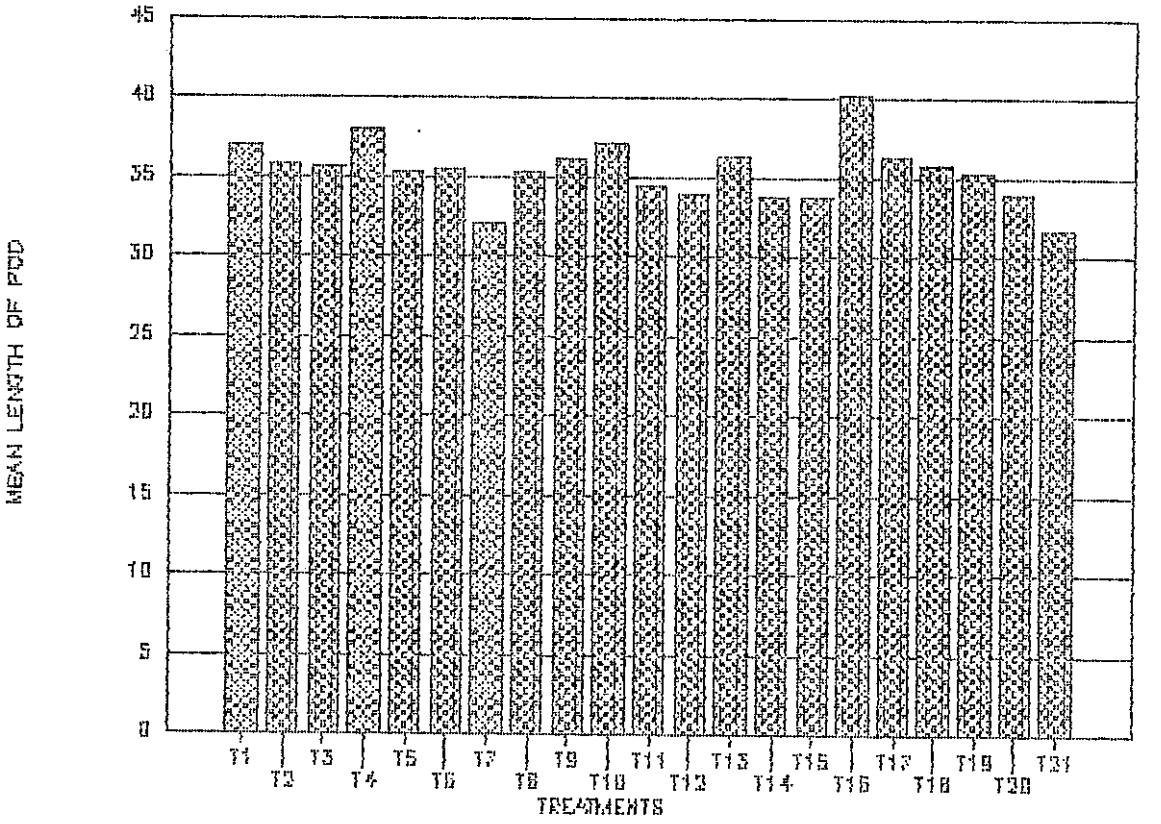


FIG. 1 (e)

Mean values of parents and hybrids for Mean length of pod in a 6x6 diallel.

and the lowest by kurutholapayar (15.03). Among the hybrids, the range was from 18.85 for selection 145 x selection 104 to 14.92 for kurutholapayar x selection 7. The variation in number of seeds / pod of parents and hybrids is represented in Figure 1 (f).

For length of internode, minimum value was shown by the parent selection 104 (15.13 cm) whereas the maximum value was shown by selection 129 (19.37 cm). Hybrids showed a variation between 13.67 for selection 104 x selection 123 and 19.92 for selection 145 x kurutholapayar. The variation in length of internode in parents and hybrids is represented in Figure 1 (g).

For the character seed/pod ratio the maximum value recorded by the parents ranged from 0.1585 for kurutholapayar to 0.2362 for selection 7, whereas it ranges from 0.2702 to 0.1810 in hybrids, selection 129 x selection 104 and selection 104 x selection 7. The variation shown by parents and hybrids for this character is presented in Figure 1 (h).

The highest mean value for the character yield/plant was shown by the parent kurutholapayar (276.10 g) and the lowest by selection 104 (101.47 g). In the hybrids it ranged from 304.47 to 150.40 g for selection 145 x selection 104 and selection 145 x selection 123 respectively. The variation in fruit yield / plant of parents and hybrids is represented in Figure 1 (i).

Figure 1 (f)

Mean Values of parents and hybrids for Number of Seeds/pod in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

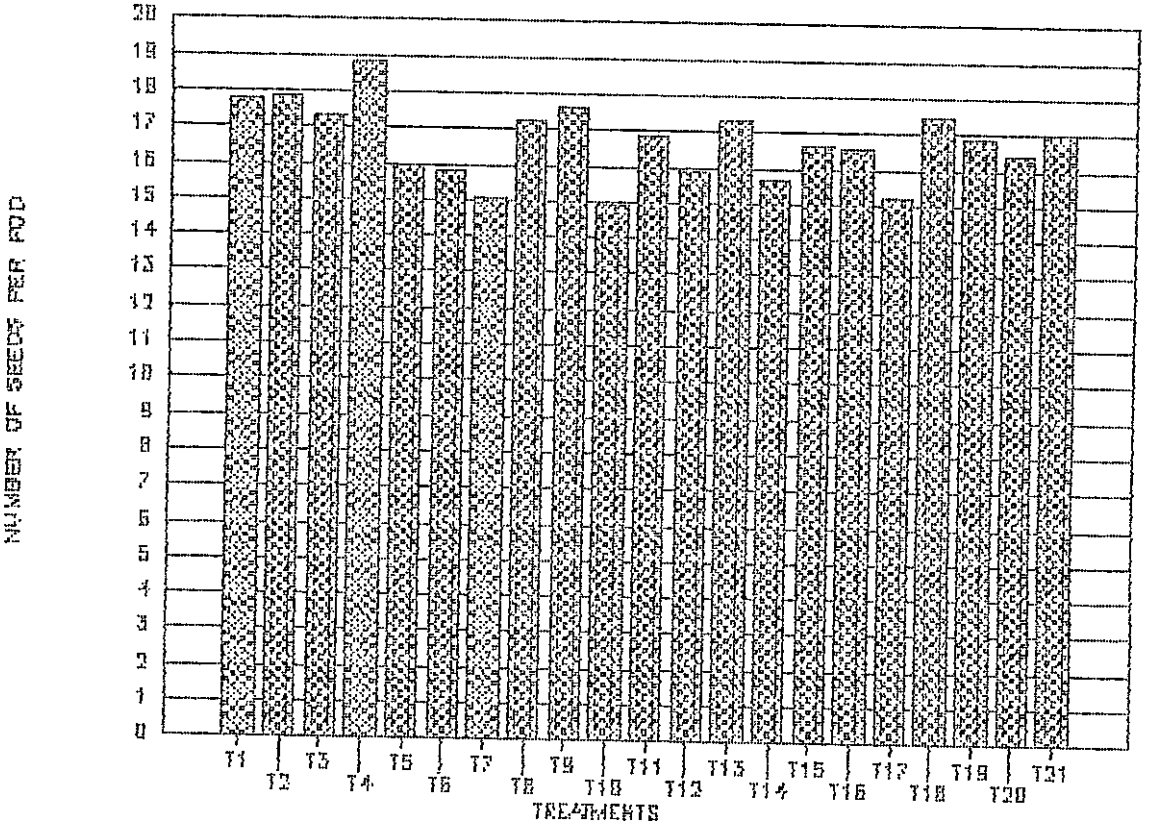


FIG. 1 (f)

Mean values of parents and hybrids of Number of Seeds/pod in a 6 x 6 diallel.

Figure 1 (g)

Mean Values of parents and hybrids for length of Internode in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

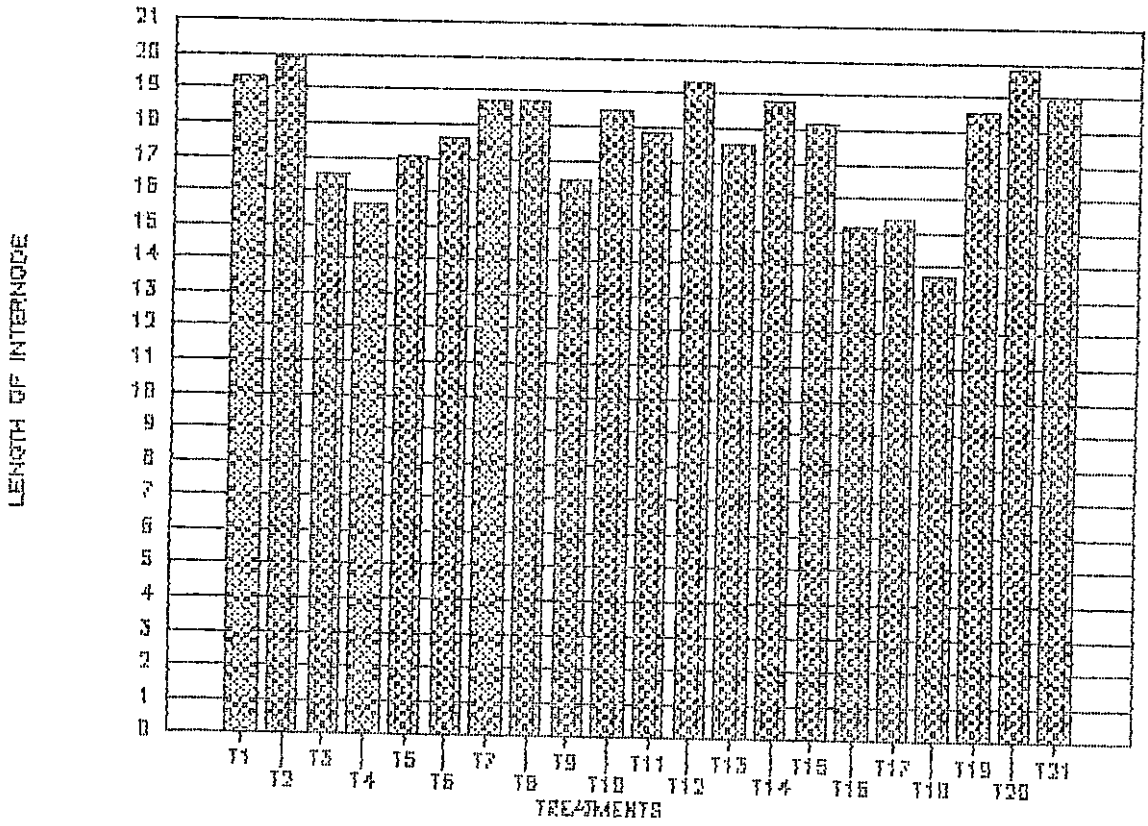


FIG. 1 (g)

Mean values of parents and hybrids for Length of Internode in a 6 x 6 diallel.

Figure 1 (h)

Mean Values of parents and hybrids for Seed/Pod Ratio in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

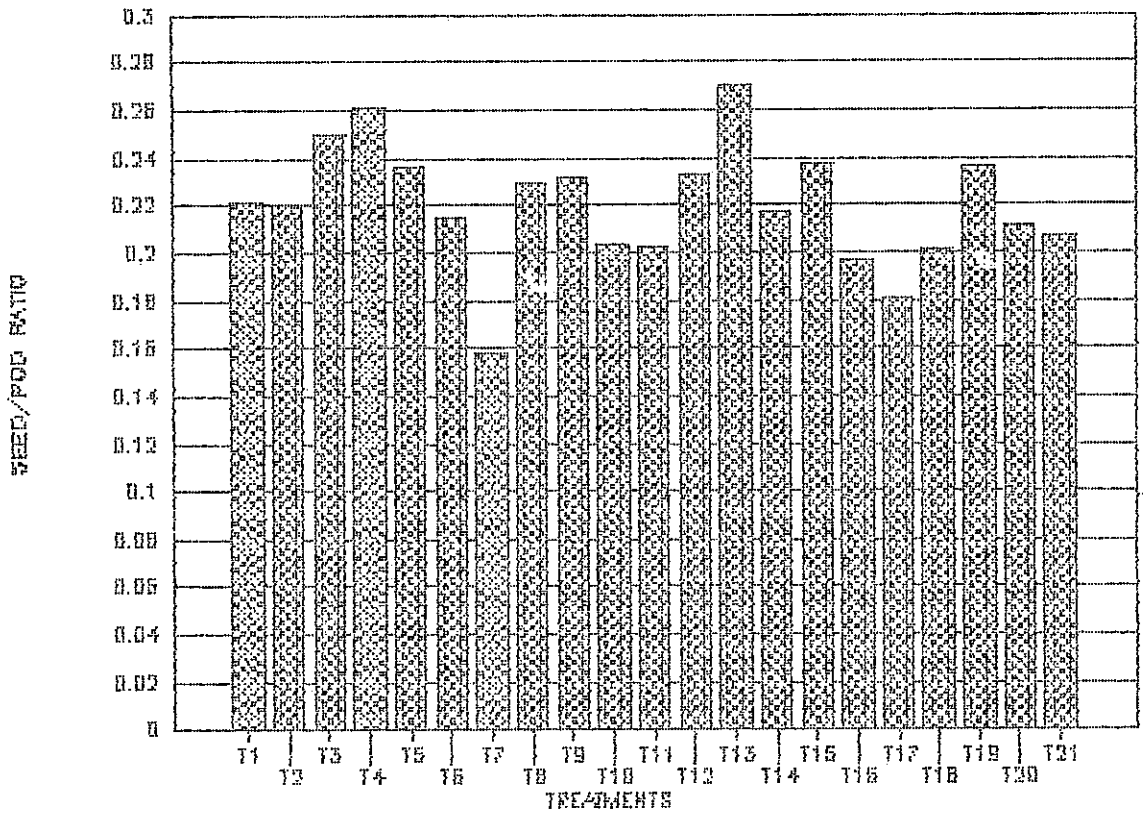


FIG. 1 (h)

Mean values of parents and hybrids for Seed/Pod Ratio in a 6 x 6 diallel.

Figure 1 (i)

Mean Values of parents and hybrids for Fruit Yield/Plant in a 6 x 6 diallel.

Sl.No.	Treatment No.	Variety / Hybrids
1.	T_1	Selection 145
2.	T_2	Selection 145 x Kurutholapayar
3.	T_3	Selection 145 x Selection 129
4.	T_4	Selection 145 x Selection 104
5.	T_5	Selection 145 x Selection 7
6.	T_6	Selection 145 x Selection 123
7.	T_7	Kurutholapayar
8.	T_8	Kurutholapayar x Selection 129
9.	T_9	Kurutholapayar x Selection 104
10.	T_{10}	Kurutholapayar x Selection 7
11.	T_{11}	Kurutholapayar x Selection 123
12.	T_{12}	Selection 129
13.	T_{13}	Selection 129 x Selection 104
14.	T_{14}	Selection 129 x Selection 7
15.	T_{15}	Selection 129 x Selection 123
16	T_{16}	Selection 104
17.	T_{17}	Selection 104 x Selection 7
18.	T_{18}	Selection 104 x Selection 123
19.	T_{19}	Selection 7
20.	T_{20}	Selection 7 x Selection 123
21.	T_{21}	Selection 123

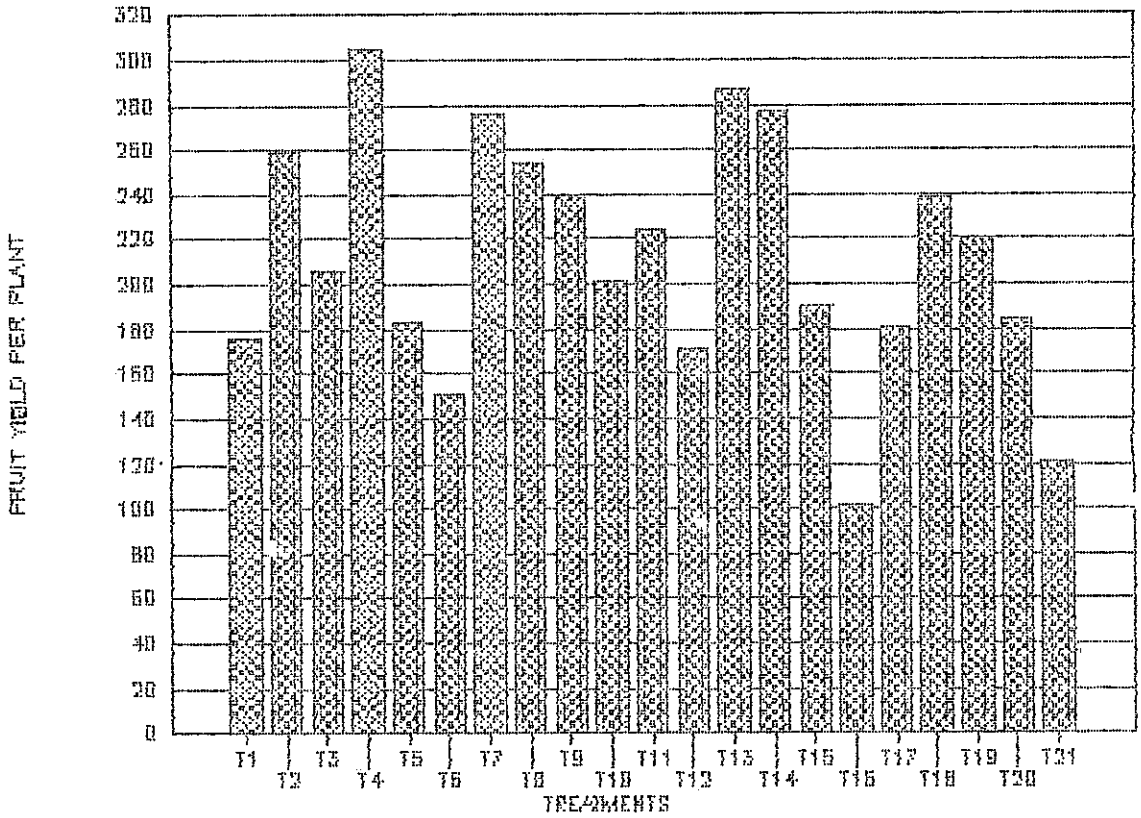


FIG. 1(i)

Mean values of parents and hybrids for Fruit Yield/Plant in a 6 x6 diallel.

It was seen that in general among the parents, kurutholapayar had the highest mean values for number of pods/plant and fruit yield/plant and it was the early flowering one and selection 104 for mean weight of pod and mean length of pod. Among the hybrids selection 145 x selection 104 exhibited the highest mean values for mean length of pod, number of seeds/pod and fruit yield/plant.

Combining ability

The analysis of variance of the 9 characters are presented in the Table 4. Combining ability analysis were carried out following the method 2 under Model 1 as suggested by Griffing (1956). The analysis of variance for combining ability is presented in Table 5.

The mean squares due to general combining ability (g.c.a.) were significant for the characters, viz. days to flowering, mean weight of pod, mean length of pod, number of seeds/pod, length of internode and seed/pod ratio. The mean squares due to specific combining ability was significant for the character days to flowering, number of pods/cluster, number of seeds/pod, length of internode and seed/pod ratio.

The estimates of the g.c.a. effects of six parents and s.c.a. effects of the 15 F_1 population for the 9 characters are presented in the Table 6.

Table 4. Analysis of variance for 9 characters in a 6 x 6 diallel cross of vegetable cowpea.

Sl. No.	Characters	Mean squares		
		Treatment	Error	$F_{(20,40)}$
1.	Days to flowering	15.264	2.118	7.205**
2.	No.of pods/cluster	0.0167	0.00871	1.9122*
3.	No.of pods/plant	58.05	50.96	1.139 NS
4.	Mean weight of pod	1.465	0.79	1.860*
5.	Mean length of pod	11.097	2.51	4.409**
6.	No.of seeds/pod	3.133	0.737	4.2492**
7.	Length of internode	8.684	1.605	5.409**
8.	Seed/pod ratio	0.002	0.0008	2.560**
9.	Fruit yield/plant	8733.162	6747.394	1.30167 NS

** Significant (P<0.01)

* Significant (P<0.05)

Days to flowering

The combining ability analysis for days to flowering showed that the variances due to g.c.a. and s.c.a. were significant but g.c.a. variance was higher in magnitude than the s.c.a. variance. This suggested the importance of general combining ability for this character. The g.c.a. and s.c.a. effects for this character is presented in Table 6 (i). The parents kurutholapayar, selection 129, Selection 104 and Selection 7 showed significant g.c.a. effect. Among this, significant positive g.c.a. effects were shown by Selection 104 (2.0639) and Selection 7 (0.6264), while kurutholapayar (-1.5486) and Selection 129 (-1.6528) showed significant negative g.c.a. effects. Thus Selection 129 is the best general combiner for earliness follolwed by kurutholapayar.

The crosses Selection 145 x kurutholapayar, Selection 145 x Selection 129, Selection 145 x Selection 104 and Selection 104 x Selection 123 showed significant s.c.a. effects. Among this positive s.c.a. was shown by the cross Selection 104 x Selection 123 (1.7726) while negative s.c.a. was shown by the crosses, Selection 145 x kurutholapayar (-2.4024), Selection 145 x Selection 129 (-1.1732), Selection 145 x Selection 104 (-1.2524). This indicates that the cross Selection 145 x kurutholapayar is the best specific combiner for the character days to flowering.

Table 6(i). General Combining ability (g.c.a) and specific combining ability (s.c.a) effects for days to flowering.

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	0.1430	-2.4024*	-1.1732*	-1.2524*	-0.9982	-0.5357
Kurutholapayar		-1.5486*	0.4018	0.3101	0.8184	0.7268
Selection 129			-1.6528*	0.0851	1.0476	-0.9898
Selection 104				2.0639*	-1.0107	1.7726**
Selection 7					0.6264*	0.9809
Selection 123						0.3681

Diagonal elements give the g.c.a and off-diagonal elements the s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

SE (g_i) = 0.2712 SE $(S_{ij}-S_{kl})$ = 1.0292

SE (g_i-g_j) = 0.4202 SE (S_{ij}) = 0.6150

SE $(S_{ij}-S_{ik})$ = 1.1116

Number of pods/cluster

The combining ability analysis for number of pods/ cluster showed significant g.c.a. variance. This indicates the importance of general combining ability for this character.

The g.c.a. and s.c.a. effects for this character is presented in the Table 6(ii). Selection 129 showed significant general combining ability. Significant specific combining ability was shown by the hybrids Selection 145 x Selection 104 (0.1667) Kurutholapayar x Selection 7 (-0.1458) and Selection 129 x Selection 7 (0.1042). Thus Selection 129 (0.0375) is the best general combiner for the character number of pods per cluster and the hybrids Selection 145 x Selection 104 is the best specific combiner Table 6(ii).

Number of pods/plant

The combining ability analysis for the character number of pods/plant showed that the variances due to g.c.a. and s.c.a. were not significant.

The g.c.a. and s.c.a. effects for this character is presented in the Table 6 (iii). None of the parents showed significant g.c.a. effects. But the crosses Kurutholapayar x Selection 7 and Selection 129 x Selection 104

Table 6(ii) General combining ability (g.c.a.) and specific combining ability (s.c.a) effects for number of pods/cluster

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	0.0125	0.0333	-0.025	0.1667*	-0.0041	0.0666
Kurutholapayar		-0.0125	0.5	0.0167	-0.1458*	0.0125
Selection 129			0.0375*	-0.0083	0.1042*	-0.0625
Selection 104				0.0042	0.0125	0.0208
Selection 7					-0.025	0.0042
Selection 123						0.0083

Diagonal elements give the g.c.a. and off diagonal elements the s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

$SE(g_i)$ = 0.0174 $SE(S_{ij})$ = 0.0394

$SE(g_i-g_j)$ = 0.0269 $SE(S_{ij}-S_{kl})$ = 0.0713

$SE(S_{ij}-S_{ik})$ = 0.0660

Table 6(iii). General Combining ability (g.c.a.) and specific combining ability (s.c.a) effects for number of pods/plant.

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	-0.3875	2.0055	-0.2346	5.5072	-1.4345	0.1988
Kurutholapayar		1.9125	-1.7678	0.5738	5.9905*	5.4488
Selection 129			1.2458	7.007*	-4.2429	1.1071
selection 104				-0.8958	-1.6762	0.1738
Selection 7					0.4542	-2.3595
selection 123						-2.3292

Diagonal elements give the g.c.a. and off diagonal elements the s.c.a.

** Significant(P<0.01)

* Significant(P<0.05)

$SE(g_i)$ = 1.3302 $SE(S_{ij}-S_{ik})$ = 5.4521

$SE(g_i-g_j)$ = 2.0607 $SE(S_{ij}-S_{kl})$ = 5.0477

$SE(S_{ij})$ = 3.0166

showed significant s.c.a. effects. Both these crosses showed positive s.c.a. effects. Highest s.c.a. effect was for the cross Selection 129 x Selection 104 (7.007) whereas the value for the cross kurutholapayar x Selection 7 was 5.9905. This indicates that the cross Selection 129 x Selection 104 is the best specific combiner for the character number of pods/plant.

Mean weight of pod

The combining ability analysis for the character mean weight of pod showed significant g.c.a. variance. This reveals the importance of general combining ability for this character.

The g.c.a. and s.c.a. effects for this character is presented in the Table 6 (iv). The parents kurutholapayar, Selection 129 and Selection 104 showed significant g.c.a. effect. Among this significant positive g.c.a. effects were shown by kurutholapayar (0.3199) and Selection 104 (0.4813), whereas Selection 129 (-0.3681) showed significant negative g.c.a. effect. This result indicates that Selection 104 is the best general combiner for mean weight of pod followed by kurutholapayar. The crosses Selection 145 x Selection 129 and Selection 145 x Selection 7 showed significant s.c.a. effects. Both hybrids showed significant positive s.c.a. effects.

Table 6(iv). General Combining ability(g.c.a.) and specific combining ability (s.c.a.) effects for mean weight of pod

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	-0.0668	0.4082	0.8482*	0.1247	0.7989*	0.1173
Kurutholapayar		0.3199*	0.2642	0.1247	-0.2703	0.4911
Selection 129			-0.3681*	0.4491	-0.1280	-0.5131
selection 104				0.4813*	-0.3056	0.6732
Selection 7					-0.0613	-0.1162
Selection 123						-0.3051

Diagonal elements give the g.c.a and off diagonal elements the s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

SE (g_i) = 0.1656 SE ($S_{ij}-S_{ik}$) = 0.6787

SE (g_i-g_j)= 0.2565 SE ($S_{ij}-S_{kl}$) = 0.6283

SE (S_{ij}) = 0.3755

Highest s.c.a. value 0.8482 is for the cross Selection 145 x Selection 129 followed by 0.7989 for Selection 145 x Selection 7. This indicates that the cross Selection 145 x Selection 129 is the best specific combiner for the character mean weight of pod.

Mean length of pod

The combining ability analysis for mean length of pod showed significant g.c.a. variance. This indicates the importance of general combining ability for mean length of pod. However the s.c.a. variance was not significant.

The g.c.a. and s.c.a. effects for this character is presented in Table 6 (v). The parents Selection 145, kurutholapayar, Selection 129, Selection 104 and Selection 123 showed significant g.c.a. effects. Among this Selection 145 (0.7831) and Selection 104 (1.9144) showed significant positive g.c.a. effects and kurutholapayar (-0.5983), Selection 129 (-0.6096) and Selection 123 (-1.3856) showed significant negative g.c.a. effects. Thus Selection 104 is the best general combiner for mean length of pod followed by Selection 145.

The crosses Selection 129 x Selection 7 showed significant positive s.c.a. effects. This indicates that the cross Selection 129 x selection 7 (2.507) is the best specific combiner for the character mean length of pod.

Table 6(iv). General Combining ability (g.c.a.) and specific Comnbining ability (s.c.a) effects for mean length of pod

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	0.7831*	0.1917	0.0627	-0.2817	-0.8840	0.0726
Kurutholapayar		-0.5983*	0.129	-0.558	-0.924	-0.1857
Selection 129			0.6096*	-0.036	2.507*	0.2433
Selection 104				1.9144*	-0.8427	1.0970
Selection 7					-0.1039	0.6073
Selection 123						-1.3856*

Diagonal elements give the g.c.a. and off diagonal elements the s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

$SE(g_i) = 0.2956$ $SE(S_{ij}-S_{ik}) = 1.2117$

$SE(g_i-g_j) = 0.4580$ $SE(S_{ij}-S_{kl}) = 1.1218$

$SE(S_{ij}) = 0.6704$

Number of seeds/pod

The combining ability analysis for number of seeds per pod showed that the variances due to g.c.a. and s.c.a were significant, but g.c.a. variance was higher in magnitude than the s.c.a. variance. This suggested the importance of general combining ability for the character number of seeds/pod.

The g.c.a. and s.c.a. effects for this character is presented in Table 6 (vi). The parents Selection 145, Selection 104 and Selection 7 showed significant g.c.a. effect. Among this, significant positive g.c.a. effects were shown by Selection 145 (0.5611) and Selection 104 (0.3612), while Selection 7 (-0.5956) showed significant negative g.c.a. effect. Thus Selection 145 is the best general combiner for character number of seeds/pod followed by Selection 104.

The crosses Selection 145 x kurutholapayar, Selection 145 x Selection 129, selection 145 x Selection 104, kurutholapayar x Selection 104, Selection 129 x Selection 7 and Selection 104 x Selection 123 showed significant s.c.a. effects. Among this positive s.c.a. was shownn by the crosses Selection 145 x kurutholapayar (0.8583), Selection 145 x Selection 129 (0.9624), Selection 145 x
/Selection 104 (0.3528) and kurutholapayar x Selection 104 (0.8677). whereas negative s.c.a. was shown by the

Table 6(vi). General Combining ability (g.c.a) and specific combining ability (s.c.a) effects for number of seeds/pod.

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
selection 145	0.5611*	0.8583*	0.9624*	0.3528*	-1.2029	0.2865
Kurutholapayar		-0.2743	0.1729	0.8677*	-0.3132	0.3614
Selection 129			-0.1086	1.2404	-0.8940	0.0328
Selection 104				0.3612*	-0.6528	0.4190
Selection 7					-0.5956*	-0.5099*
selection 123						0.0564

Diagonal elements give the g.c.a and off diagonal elements the s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

SE (g_i) = 0.1600

SE (g_i-g_j) = 0.2479

SE (S_{ij}) = 0.4394

SE (S_{ij}-S_{ik}) = 0.6558

SE (S_{ij}-S_{kl}) = 0.6072

crosses Selection 129 x Selection 7 (-0.8940) and Selection 104 x Selection 123 (-1.5099). This indicates that the cross Selection 145 x Selection 129 is the best specific combiner for the character number of seeds/pod followed by kurutholapayar x Selection 104.

Length of internode

The combining ability analysis for the character length of internode, showed that the g.c.a. and s.c.a variance were significant. But g.c.a. variance was higher in magnitude than the s.c.a. variance. This indicates the importance of general combining ability for this character.

The g.c.a. and s.c.a. effects for this character is presented in the Table 6 (vii). The parents kurutholapayar, Selection 129 and Selection 104 showed significant g.c.a. effect. Kurutholapayar (0.6104) and Selection 129 (0.5562) showed significant positive g.c.a. effect and Selection 104 (-1.8833) showed significant negative g.c.a. effect. This result indicates that the parent Selection 104 is the best general combiner for the character length of internode.

Significant s.c.a. effects were shown by the crosses Selection 145 x Kurutholapayar (1.4104), Selection 145 x

Table 6(vii).General Combining ability (g.c.a) and specific Combining ability (s.c.a) effects for length of internode.

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	0.1958	1.4104*	-0.1667	1.1271*	-0.80	1.6125*
Kurutholapayar		0.6104*	-1.9688*	-0.0271	0.1937	-2.3208*
Selection 129			0.5562*	-0.3792	-0.1604	-0.2938
Selection 104				-1.8833*	-1.1791*	-0.6146
Selection 7					0.35	-0.4334
Selection 123						0.1708

Diagonal elements give the g.c.a. and off diagonal elements s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

SE (g_i) = 0.2361 SE ($S_{ij}-S_{ik}$) = 0.9677

SE (g_i-g_j)= 0.3657 SE ($S_{ij}-S_{kl}$) = 0.8959

SE (S_{ij}) = 0.5354

Selection 104 (1.1271), Selection 145 x Selection 123 (1.6125), kurutholapayar x Selection 129 (-1.9688), Kurutholapayar x Selection 123 (-2.3208) andd Selection 104 x Selection 7 (-1.1791). The crosses Selection 145 x kurutholapayar, Selection 145 x Selection 104 and Selection 145 x Selection 123 showed significant positive g.c.a effects whereas crosses kurutholapayar x Selection 129, kurutholapayar x Selection 123 and Selection 104 x Selection 7 showed significant negative s.c.a effect. This indicates that the cross kurutholapayar x Slection 123 is the best specific combiner for the character length of internode.

Seed/pod ratio

The results of combining ability analysis for seed/ pod ratio showed significant g.c.a. and s.c.a. variance. The magnitude of variance due to g.c.a. was higher than the s.c.a. variance. This indicates the importance of general combining ability.

The Table 6 (viii) shows the g.c.a. and s.c.a. effects for this character. The parents Selection 145, kurutholapayar and Selection 129 showed significant positive g.c.a. effect. The parents Selection 145 (0.0106) and Selection 129 (0.0162) showed significant positive g.c.a. effect and kurutholapayar (-0.0170) showed significant negative g.c.a. effect. This result reveals

Table 6(viii) General Combining ability (g.c.a) and specific Combining ability (s.c.a) effects for seed/pod ratio

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	0.0106*	0.0064	0.0102	0.0341*	-0.0365*	0.0007
Kurutholapayar		-0.0170*	0.0031	0.0293*	-0.0168	-0.012
Selection 129			0.0162*	0.0305	0.0027	0.008
Selection 104				0.000	0.0075	0.0064
Selection 7					-0.0025	-0.0076
Selection 123						-0.0074

Diagonal elements give the g.c.a and off diagonal elements the s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

SE (g_i) = 0.0052

SE $(g_i - g_j)$ = 0.0081

SE (S_{ij}) = 0.0143

SE $(S_{ij} - S_{ik})$ = 0.0214

SE $(S_{ij} - S_{kl})$ = 0.0198

that the parent Selection 129 is the best general combiner for the character seed/pod ratio.

Significant s.c.a. effects were shown by the crosses Selection 145 x Selection 104, Selection 145 x Selection 7, kurutholapayar x Selection 104 and Selection 129 x Selection 104. Among this the crosses Selection 145 x Selection 104 (0.0341), kurutholapayar x Selection 104 (0.0293) and Selection 129 x Selection 104 (0.0305) showed significant positive s.c.a. effect and the cross Selection 145 x Selection 7 (-0.0365) showed significant negative s.c.a. effect. This reveals that the cross Selection 145 x Selection 104 is the best specific combiner for the character seed/pod ratio.

Fruit yield/plant

The combining ability analysis for fruit yield per plant showed that the g.c.a. and s.c.a. variances were not significant. The only parent that showed significant g.c.a.effect was kurutholapayar (31.1419). This indicates that the parent kurutholapayar was the best general combiner for yield. The crosses Selection 145 x Selection 104 (69.428) and Selection 129 x Selection 104 (99.5489) showed significant positive s.c.a. effect. This result indicates that the cross Selection 129 x Selection 104 is the best specific combiner for fruit yield/plant.

Table 6(ix). General Combining ability (g.c.a) and specific Combining ability (s.c.a) effects for fruit yield/plant

Parents	Selection 145	Kurutholapayar	Selection 129	Selection 104	Selection 7	Selection 123
Selection 145	-3.30	19.8522	2.1614	69.428*	-25.2095	5.4614
Kurutholapayar		31.1419*	-12.2637	0.5072	57.4446	61.778
Selection 129			0.2208	99.549*	-39.5428	1.1321
Selection 104				-3.7250	-23.1011	13.2447
Selection 7					- 1.675	-26.5804
Selection 123						-31.6825

Diagonal elements give the g.c.a and off diagonal elements the s.c.a.

** Significant (P<0.01)

* Significant (P<0.05)

SE (g_i) = 15.3066

SE (g_i-g_j)= 23.7129

SE (S_{ij}) = 42.0384

SE (S_{ij}-S_{ik}) = 62.7383

SE (S_{ij}-S_{kl}) = 58.0844

Gene Action

Griffing (1956) and Sprague (1966) demonstrated the method of working out g.c.a. and s.c.a. effects along with their variances. They pointed out that high g.c.a. variance contained not only the additive variance, but also a portion of the epistatic variance (additive x additive) and that s.c.a. included all the dominance and the remaining epistatic variance.

If the variance due to g.c.a. and s.c.a. showed significance for characters, it indicated the importance of both additive and non additive gene action. The estimate of g.c.a. variance, if higher than their respective s.c.a. variance, indicated predominance of additive gene action and vice-versa.

For the character days to flowering both g.c.a. and s.c.a. variance were found significant. This implies that both additive and non-additive gene action were important in governing this character. But g.c.a. variance was more than twice the s.c.a. variance indicating the predominance of additive gene action.

While considering the character number of pods/ cluster, s.c.a. variance was found significant. This suggests the importance of non-additive gene action for this character. The s.c.a. variance was more than the

g.c.a. variance indicating the predominance of non-additive gene action.

For number of pods/plant both g.c.a. and s.c.a. variances were not significant.

The g.c.a. variance was found significant for the character mean weight of pod. This indicates the importance of additive genetic variance. The magnitude of g.c.a. variance was higher than the s.c.a. variance.

For length of pod, the g.c.a. variance was found significant at 1% level of probability. The g.c.a. variance was more than twice the s.c.a. variance indicating the predominance of additive gene action.

Both g.c.a. and s.c.a. variance were found significant at 1% level of probability for the character number of seeds/pod. This suggests the importance of both additive and non-additive type of gene action. The g.c.a. variance was found higher than s.c.a. variance. This implies the predominance of additive type of gene action.

For the character length of internode, both g.c.a. and s.c.a. variance were found significant at 1% level of probability. This implies that both additive and non-additive gene action were important in governing this

character. But g.c.a. variance was more than twice the s.c.a. variance indicating the predominance of additive gene action.

The variance due to g.c.a. and s.c.a. was found significant for seed/pod ratio. This indicates the importance of both additive and non additive type of gene action. The g.c.a. varicance was found more than twice the s.c.a. variance. Thiis indicates the predominance of additive type of gene action for this character.

While considering the character fruit yield/plant, both g.c.a. and s.c.a. variances were not significant. But g.c.a. variance was found higher in magnitude than s.c.a. variance. This indicates some amount of additive type of gene action for this character.

Heterosis

Statistical analysis of the data relating to six parents and fifteen hybrids were analysed and presented.

The extent of heterosis was calculated in percentage in comparison with the mean value of the mid-parent (relative heterosis) and better parent (heterobeltiosis). In estimation of heterosis for days to flowering, the early flowering parent was considered as better parent. The [illegible] percentage of heterosis over mid and better Parental values with respect to various characters are presented in Table 7.

Days to flowering

Table 7 (i) shows the percentage of heterosis exhibited by the fifteen hybrids over their mid parental and better parental values. Compared to the mid parental values, the percentage of heterosis in the fifteen hybrids ranged from -5.95 to 4.33. Positive heterosis was found in five hybrids, viz. Selection 145 x Selection 123 (1.89), kurutholapayar x Selection 7 (1.52), Kurutholapayar x Selection 123 (4.33), Selection 129 x selection 7 (0.20) and Selection 104 x Selection 123 (0.75) whereas negative heterosis was found in 10 hybrids viz. Selection 145 x kurutholapayar (-5.95), Selection 145 x Selection 129 (-1.25), Selection 145 x Selection 104 (-1.25), Selection 145 x Selection 7 (-3.17), kurutholapayar x Selection 129 (-3.76), kurutholapayar x Selection 104 (-0.16), Selection 129 x Selection 104 (-3.97), Selection 129 x Selection 123 (-2.10), Selection 104 x Selection 7 (-2.66) and Selection 7 x Selection 123 (-0.42). Among these crosses significant heterosis over mid parent was shown by the crosses Selection 145 x kurutholapayar, Selection 145 x Selection 7, Selection 145 x Selection 123, kurutholapayar x Selection 129, kurutholapayar x Selection 123, Selection 129 x Selection 104, Selection 129 x Selection 123 and Selection 104 x Selection 7. The maximum heterosis was shown by Selection 145 x kurutholapayar followed by Selection 129 x Selection 104. Compared

Table 7. Percentage heterosis over mid and better parental values for 9 characters in a 6 x 6 diallel.

Table: 7(i) Days to flowering

Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	-5.95*	-1.93
2.	"	x Selection 129	-1.25	-3.26*
3.	"	x Selection 104	-1.25	-1.97
4.	"	x Selection 7	-3.17*	-9.65*
5.	"	x Selection 123	1.89*	-6.99*
6.	Kurutholapayar	x Selection 129	-3.76*	-3.10*
7.	"	x Selection 104	-0.16	7.65*
8.	"	x Selection 7	1.52	6.20*
9.	"	x Selection 123	4.33*	7.16*
10.	Selection 129	x Selection 104	-3.97*	2.28*
11.	"	x Selection 7	0.20	4.00*
12.	"	x Selection 123	-2.10*	-0.14
13.	Selection 104	x Selection 7	-2.66*	0.18
14.	"	x Selection 123	0.75	0.60*
15.	Selection 7	x Selection 123	-0.42	13.72*
	CD (0.05)		1.733	2.001

* Significant (P<0.05)

Figure 2 (a)

Estimation of heterosis for days to flowering in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

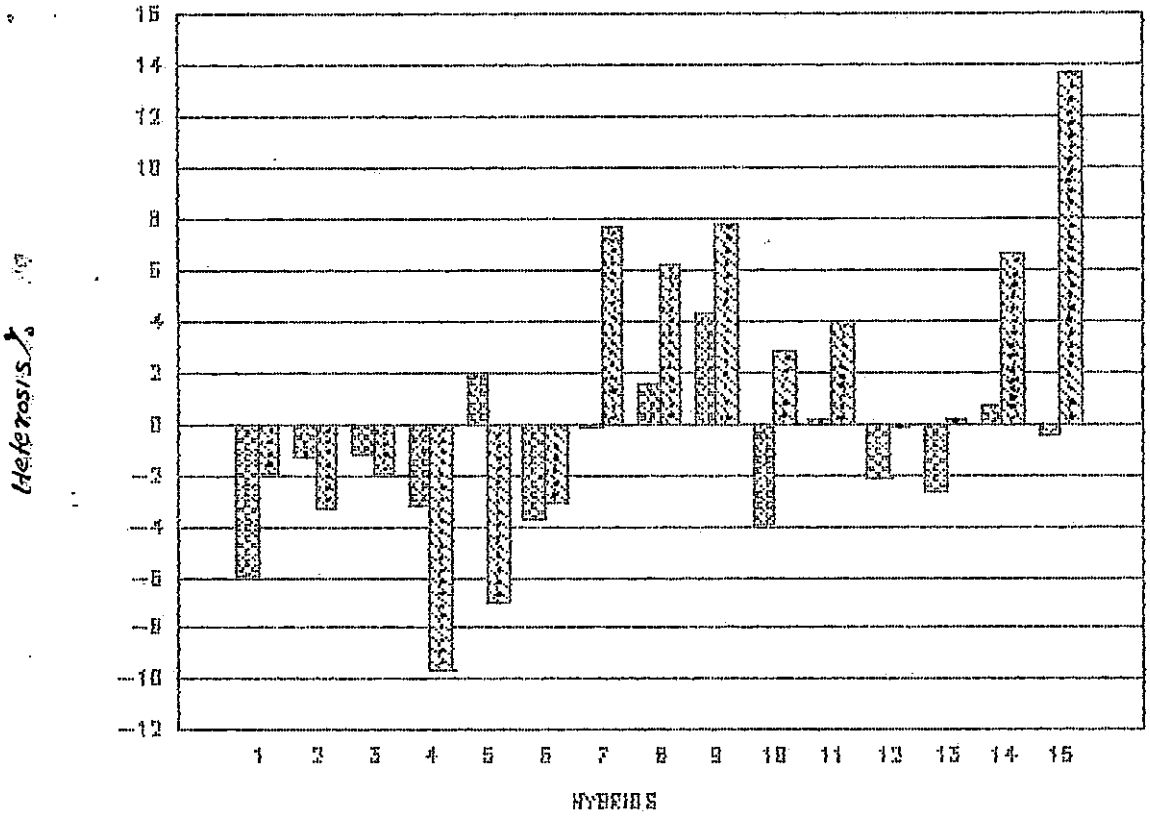


FIG.2(a)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Days to flowering in a 6 x 6 diallel.

to the better parental values, the percentage of heterosis in the fifteen hybrids ranged from -9.65% to 13.72. Positive heterosis was shown by eight hybrids, viz. kurutholapayar x Selection 104 (7.65), kurutholapayar x Selection 7 (6.20), kurutholapayar x Selection 123 (7.16), Selection 129 x Selection 104 (2.78), Selection 129 x Selection 7 (4.00), Selection 104 x selection 7 (0.18), Selection 104 x Selection 123 (6.60) and Selection 7 x Selection 123 (13.72). Negative heterosis was shown by seven hybrids. They are Selection 145 x kurutholapayar (-1.93), Selection 145 x Selection 129 (-3.26), Selection 145 x Selection 104 (-1.97), Selection 145 x Selection 7 (-9.65), Selection 145 x Selection 123 (-6.99), kurutholapayar x Selection 129 (-3.10) and Selection 129 x Selection 123 (0.14). Among them, significant heterosis was shown by all the hybrids except Selection 145 x kurutholapayar, Selection 145 x Selection 104, Selection 129 x Selection 123 and Selection 104 x Selection 7. This result reveals that the maximum heterobeltiosis for the character days to flowering was shown by the hybrid Selection 145 x Selectionn 7 followed by Selection 145 x Selection 123. The hetrosis percentage over, mid and better parent value is represented in Figure 2(a).

Number of pods/cluster

The percentage of heterosis exhibited by the fifteen hybrids over mid parental and better parental values were shown in the Table 7(ii). Compared to the mid parental values, the percentage of heterosis in the fifteen hybrids ranged from -8.20 to 9.09. Positive heterosis was found in 11 hybrids. They are Selection 145 x kurutholapayar (3.39), Selection 145 x Selection 104 (1.70), Selection 145 x Selection 7 (0.84), Selection 145 x Selection 123 (0.00), kurutholapayar x Selection 104 (5.26), kurutholapayar x Selection 7 (7.83), kurutholapayar x Selection 123 (3.45), Selection 129 x Selection 104 (9.09), Selection 104 x Selection 7 (22.61), Selection 104 x Selection 123 (3.45) and Selection 7 x Selection 123 (4.27). The hybrids showed negative heterosis are Selection 145 x Selection 129 (-4.00), kurutholapayar x Selection 129 (-0.83), Selection 129 x Selection 7 (-8.20) and Selection 129 x Selection 123 (-4.07). Significant heterosis over mid parent was shown by all the hybrids except Selection 145 x Selection 123. The maximum positive heterosis was shown by the hybrid Selection 129 x Selection 104 followed by kurutholapayar x Selection 7.

Compared to the better parental values, the percentage of heterosis in the fifteen hybrids ranged from

Table 7(ii). Number of pods/cluster

Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	3.39*	0.00
2.	"	x selection 129	-4.00*	-6.25*
3.	"	x Selection 104	1.70*	-1.64*
4.	"	x Selection 7	0.84*	1.64*
5.	"	x Selection 123	0.00	-1.64*
6.	Kurutholapayar	x Selection 129	0.83*	-6.25*
7.	"	x Selection 104	5.26*	5.26*
8.	"	x Selection 7	7.83*	6.90*
9.	"	x Selection 123	3.45*	1.70*
10.	Selection 129	x Selection 104	9.09*	3.13*
11.	"	x Selection 7	-8.20*	-12.50*
12.	"	x Selection 123	-4.07*	- 7.81*
13.	Selection 104	x Selection 7	2.61*	1.72*
14.	"	x selection 123	3.45*	1.70*
15.	Selection 7	x Selection 123	4.27*	3.39*
	CD (0.05)		0.111	0.128

* Significant (P<0.05)

Figure 2 (b)

Estimation of heterosis for Number of Pods/Cluster in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

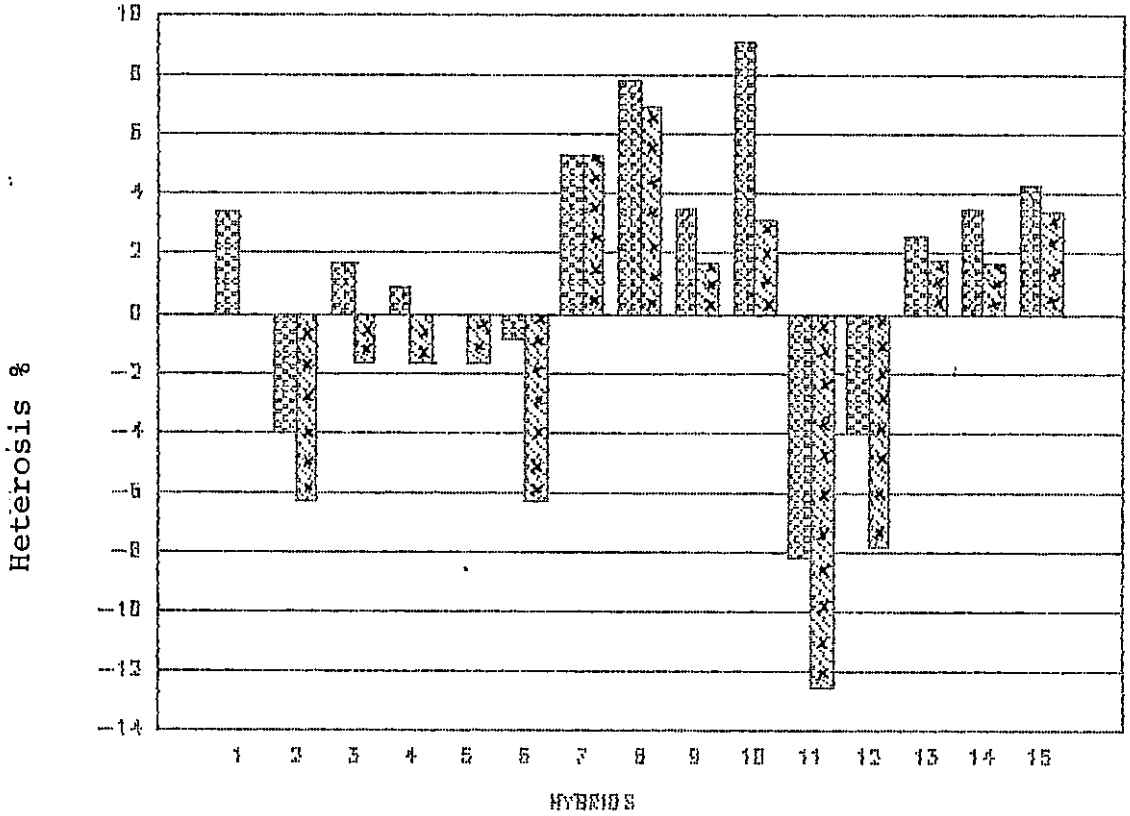


FIG. 2 (b)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Number of pods/ cluster in a 6 x 6 diallel.

-12.50 to 6.90. Positive heterosis shown by 8 hybrids viz. Selection 145 x kurutholapayar (0.00), kurutholapayar x Selection 104 (5.26), kurutholapayar x Selection 7 (6.90), kurutholapayar x Selection 123 (1.70), Selection 129 x Selection 104 (3.13), Selection 104 x Selection 7 (1.72), Selection 104 x Selection 123 (1.70) and Selection 7 x Selection 123 (3.39). Negative heterosis was shown by hybrids Selection 145 x Selection 129 (-6.25), Selection 145 x Selection 104 (-1.64), Selection 145 x Selection 7 (1.64), kurutholapayar x Selection 129 (-6.25), Selection 129 x Selection 7 (-12.50) and Selection 129 x Selection 123 (-7.81). All hybrids except Selection 145 x kurutholapayar showed significant heterobeltiosis. This result shows that the maximum percentage heterosis over better parental value for the character number of pods/ cluster was shown by the hybrid kurutholkapayar x Selection 7 followed by kurutholapayar x Selection 104. The heterosis percentage exhibited by the fifteen hybrids over their mid and better parental values is represented in figure 2 (b).

Number of pods/plant

The table 7(iii) shows the percentage of heterosis exhibited by the fifteen hybrids over their mid parent and better parental values. While considering relative heterosis, the percentage of heterosis compared to mid

Tabale 7(iii). Number of pods/plant

Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	11.90*	-4.39
2.	"	x Selection 129	10.00*	8.72
3.	"	x Selection 104	91.41*	47.27*
4.	"	x Selection 7	- 6.01	-14.69*
5.	"	x Selection 123	- 2.68	-15.51*
6.	Kurutholapayar	x Selection 129	9.74*	- 7.14
7.	"	x Selection 104	26.44*	-12.63*
8.	"	x Selection 7	-21.82*	-26.92*
9.	"	x Selection 123	4.87	-20.19*
10.	Selection 129	x Selection 104	95.40*	51.58*
11.	"	x Selection 7	44.06*	29.38*
12.	"	x Selection 123	32.61	16.86*
13.	Selection 104	x Selection 7	16.79*	-15.95*
14.	"	x Selection 123	99.09*	41.65*
15.	Selection 7	x Selection 123	6.22	-15.01*
	CD(0.05)		8.50	9.815

* Significant (P<0.05)

parental values in the fifteen hybrids ranged from -2.68 to 99.09 for number of pods/plant. Positive heterosis was found in 12 hybrids. They are Selection 145 x kurutholapayar (11.90), Selection 145 x Selection 129 (10.00), Selection 145 x Selection 104 (91.41), kurutholapayar x Selection 129 (9.74), kurutholapayar x Selection 104 (26.44), kurutholapayar x Selection 123 (4.87), Selection 129 x Selection 104 (95.40), Selection 129 x Selection 7 (44.06), Selection 129 x Selection 123 (32.61), Selection 104 x Selection 7 (16.79), Selection 104 x Selection 123 (99.09) and Selection 7 x Selection 123 (6.22). Three hyhrids showed negative heterosis. They are Selection 145 x Selection 7 (-6.01), Selection 145 x Selection 123 (-2.68) and kurutholapayar x Selection 7 (-21.82). All hybrids except 4 viz. Selection 145 x Selection 7, Selection 145 x Selection 123, kurutholapayar x Selection 123 and Selection 7 x Selection 123 showed significant heterosis. This result reveals that the maximum relative heterosis was shown by the hybrid Selection 104 x Selection 123 followed by Selection 129 x Selection 104.

While considering heterobeltiosis, the percentage of heterosis ranged from -26.00to 51.58%. Among fifteen hybrids six showed positive heterosis. They are Selection 145 x Selection 129 (8.72), Selection 145 x Selection 104 (47.27), Selection 129 x Selection 104 (51.58), Selection

Figure 2 (c)

Estimation of heterosis for Number of Pods/Plant in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

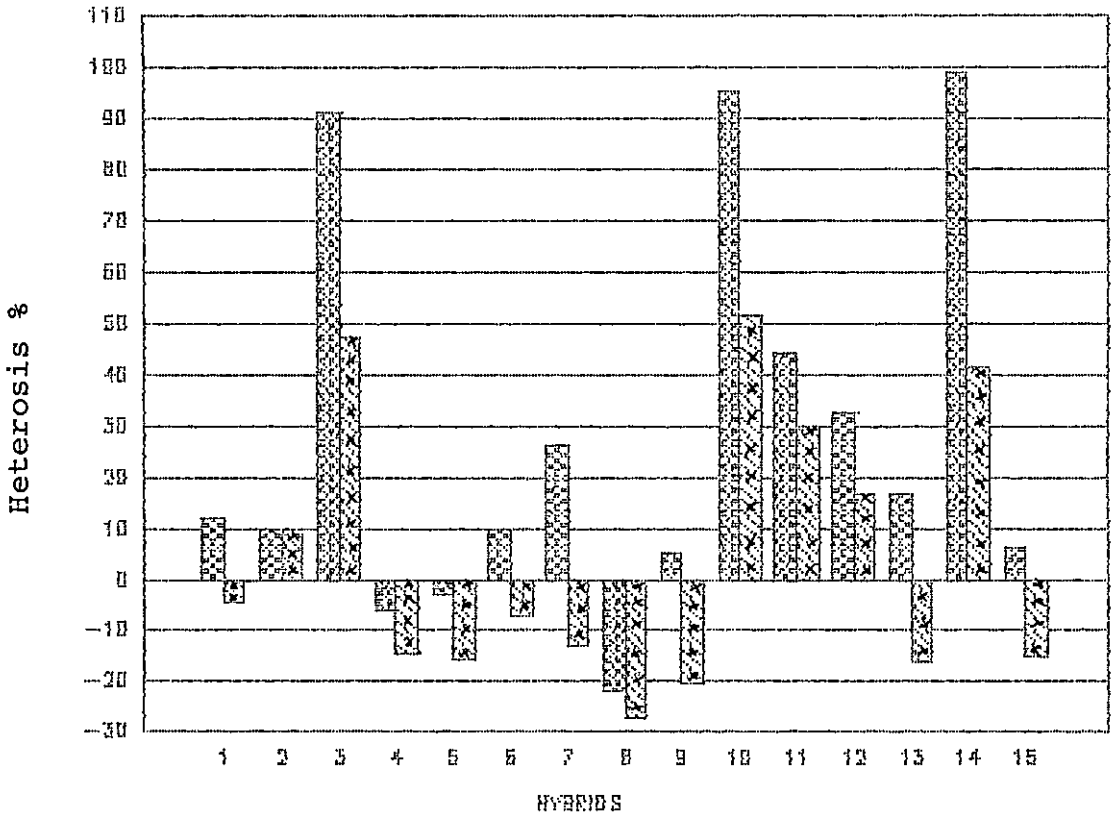


FIG. 2 (c)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Number of pods/ plant in a 6 x 6 diallel.

129 x Selection 7 (29.38), Selection 129 x Selection 123 (16.86) and Selection 104 x Selection 123 (41.65). Negative heterosis was shown by the crosses Selection 145 x kurutholapayar (-4.39), Selection 145 x Selection 7 (-14.69), Selection 145 x Selection 123 (-15.51), kurutholapayar x Selection 129 (-7.14), kurutholapayar x Selection 104 (-12.63), kurutholapayar x Selection 7 (-26.92), kurutholapayar x Selection 123 (-20.19), Selection 104 x Selection 7 (-15.95) and Selection 7 x Selection 123 (-15.01). Among the fifteen hybrids, except three viz. Selection 145 x kurutholoapayar, Selection 145 x Selection 129, kurutholapayar x Selection 129, all showed significant heterobeltiosis. Thus the hybrid Selection 129 x Selection 104 is the best one showed maximum heterobeltiosis, followed by Selection 145 x Selection 104. The percentage heterosis over mid and better parental values for this character is represented in figure 2 (c).

Mean weight of pod

The percentage of heterosis exhibited by the fifteen hybrids over their mid parent and better parental values are shown in the Table 7(iv). The percentage of relative heterosis ranged from -2.29 to 13.57. Among fifteen hybrids, 12 hybrids showed positive heterosis and three showed negative heterosis. Hybrids showed positive

Table 7(iv). Mean weight of pod

Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	9.79*	8.99*
2.	"	x Selection 129	5.23*	2.90*
3.	"	x Selection 104	10.17*	7.96*
4.	"	x Selection 7	- 0.71	-1.86*
5.	"	x Selection 123	2.10*	-0.04
6.	Kurutholapayar	x Selection 129	13.57*	10.25*
7.	"	x Selection 104	9.97*	8.51*
8.	"	x Selection 7	3.70*	3.25*
9.	"	x Selection 123	12.37*	9.23*
10.	Selection 129	x Selection 104	6.82*	2.40*
11.	"	x Selection 7	-0.97	-4.26*
12.	"	x Selection 123	-2.29	-2.42*
13.	Selection 104	x selection 7	12.10*	11.62*
14.	"	x Selection 123	10.66*	6.21*
15.	Selection 7	x Selection 123	3.12*	-0.17
	CD (0.05)		1.058	1.221

* Significant (P<0.05)

heterosis are Selection 145 x kurutholapayar (9.79), Selection 145 x Selection 129 (5.23), Selection 145 x Selection 104 (10.17), Selection 145 x Selection 123 (2.10), kurutholapayar x Selection 129 (13.57), kurutholapayar x Selection 104 (9.97), kurutholapayar x Selection 7 (3.70),kurutholapayar x Selection 123 (12.37), Selection 129 x Selection 104 (6.82), Selection 104 x Selection 7 (12.10), Selection 104 x Selection 123 (10.66) and Selection 7 x Selection 123 (3.12). Hybrids Selection 145 x Selection 7 (-0.71), Selection 129 x Selection 7 (-0.97) and Selection 129 x Selection 123 (-2.29) showed negative heterosis. Significant relative heterosis was shown by the hybrids Selection 145 x kurutholapayar, Selection 145 x Selection 129, Selection 145 x Selection 104, Selection 145 x Selection 123, kurutholapayar x Selection 129, kurutholapayar x Selection 104, kurutholapayar x Selection 7, kurutholapayar x Selection 123, Selection 129 x Selection 104, Selection 129 x selection 123, Selection 104 x Selection 7, Selection 104 x Selection 123 and Selection 7 x Selection 123. This indicates that maximum relative heterosis was shown by the hybrid kurutholapayar x Selection 129 followed by kurutholapayar x Selection 123.

Compared to the better parental value the percentage of heterobeltiosis in the fifteen hybrids ranged from -4.26 to 11.12. Ten hybrids showed positive heterosis

Figure 2 (d)

Estimation of heterosis for Mean weight of Pod in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

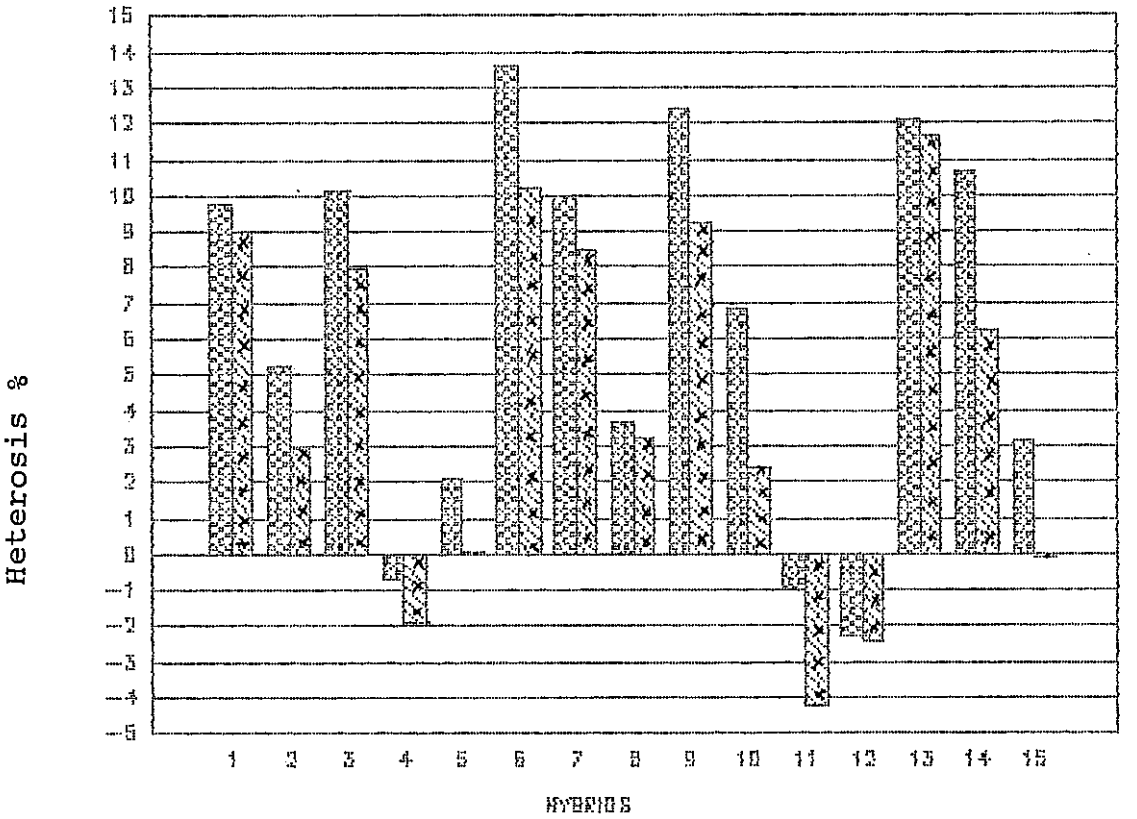


FIG. 2 (d)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis or Mean Weight of pod in a 6 x 6 diallel.

and 5 showed negative heterosis. The hybrids showed positive heterosis are Selection 145 x kurutholapayar (8.99), Selection 145 x Selection 129 (2.90), Selection 145 x Selection 104 (7.96), kurutholapayar x Selection 129 (10.25), kurutholapayar x Selection 104 (8.51), kurutholapayar x Selection 7 (3.25), kurutholapayar x Selection 123 (9.23), Selection 129 x Selection 104 (2.40), Selection 104 x Selection 7 (11.62) and Selection 104 x Selection 123 (6.21). Hybrids showed negative heterosis are Selection 145 x Selection 7 (-1.86), Selection 145 x Selection 123 (-0.04), Selection 129 x Selection 7 (-4.26) Selection 129 x Selection 123 (-2.42) and Selection 7 x Selection 123 (-0.18). All hybrids except Selection 145 x Selection 123 and Selection 7 x Selection 123 showed significant heterobeltiosis. This reveals that the hybrid Selection 104 x Selection 7 showed maximum heterosis for mean weight of pod followed by kurutholapayar x Selection 123. The percentage of heterosis over mid and better parental values for mean weight of pod is represented in figure 2 (d).

Mean length of pod

Percentage of heterosis over mid parental and better parental values for fifteen hybrids were shown in the Table 7 (v). Compared to the mid parental values, the

Table 7(v). Mean length of pod

Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	3.71*	-3.15*
2.	"	x Selection 129	0.63	-3.35*
3.	"	x Selection 104	-1.32	-5.32*
4.	"	x Selection 7	-2.35*	-4.61*
5.	"	x Selection 123	3.22*	-4.16*
6.	Kurutholapayar	x Selection 129	6.71*	3.64*
7.	"	x Selection 104	0.09	-10.05*
8.	"	x Selection 7	10.59*	5.61*
9.	"	x Selection 123	8.33*	7.67*
10.	Selection 129	x Selection 104	-1.85	- 9.39*
11.	"	x Selection 7	-2.49*	- 4.16*
12.	"	x Selection 123	2.77*	- 0.79
13.	Selection 104	x Selection 7	-3.68*	- 9.63*
14.	"	x Selection 123	-0.52	-11.08*
15.	Selection 7	x Selection 123	1.61*	- 3.53*
	CD (0.05)		1.889	2.181

* Significant (P<0.05)

Figure 2 (e)

Estimation of heterosis for Mean length of Pod in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

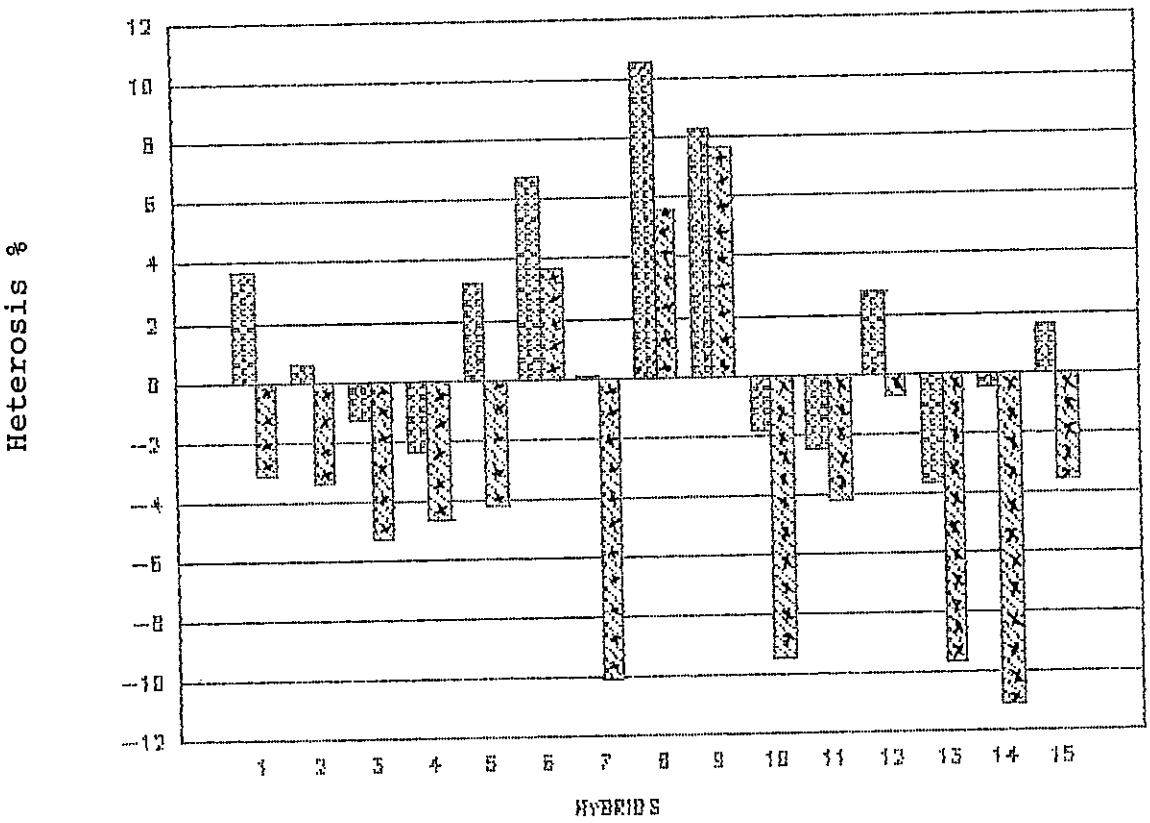


FIG. 2 (e)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Mean Length of pod in a 6 x 6 diallel.

percentage of relative heterosis in the fifteen hybrids ranged from -3.68 to 8.33.

Nine hybrids showed positive relative heterosis. They are Selection 145 x kurutholapayar (3.71). Selection 145 x Selection 129 (0.63), Selection 145 x Selection 123 (3.22), kurutholapayar x selection 129 (6.72), kurutholapayar x Selection 104 (0.09), kurutholapayar x Selection 123 (8.33), Selection 129 x Selection 123 (2.77) and Selection 7 x Selection 123 (1.61). The six hybrids showed negative heterosis are Selection 145 x Selection 104 (-1.32), Selection 145 x Selection 7 (-2.35), Selection 129 x Selection 104 (-1.85), Selection 129 x Selection 7 (-2.49), Selection 104 x Selection 7 (-3.68) and Selection 104 x Selection 123 (-0.52). Among these significant heterosis was shown by the hybrids Selection 145 x kurutholapayar, Selection 145 x Selection 123, Selection 145 x Selection 7, kurutholapayar x Selection 129, kurutholapayar x Selection 7, kurutholapayar x Selection 123, Selection 129 x Selection 7, Selection 129 x Selection 123 and Selection 104 x Selection 7. This indicates that the hybrid kurutholapayar x Selection 123 showed maximum relative heterosis for the character mean length of pod followed by kurutholapayar x Selection 129.

While considering heterobeltiosis, the percentage of heterosis in the fifteen hybrids ranged from -11.08 to

7.67. Three hybrids viz. kurutholapayar x Selection 129 (3.64), kurutholapayar x Selection 7 (5.61) and kurutholapayar x Selection 123 (7.67) showed positive heterosis. The hybrids showed negative heterosis are Selection 145 x kurutholapayar (-3.15), Selection 145 x Selection 129 (-3.35), Selection 145 x Selection 104 (-5.32), Selection 145 x Selection 7 (-4.61), Selection 145 x Selection 123 (-4.16), kurutholapayar x Selection 104 (-10.05), Selection 129 x Selection 104 (-9.39), Selection 129 x Selection 7 (-4.16), Selection 129 x Selection 123 (-0.79), Selection 104 x Selection 7 (-9.63) Selection 104 x Selection 123 (-11.08) and Selection 7 x Selection 123 (-3.53). All hybrids except Selection 129 x Selection 123 showed significant heterobeltiosis for the character mean length of pod. The maximum heterobeltiosis was exhibited for mean length of pod by kurutholapayar x Selection 123 folowed by kurutholapayar x Selection 7. The percentage of heterosis over mid and better parental values is represented in figure 2 (e).

Number of seeds/pod

The percentage of heterosis exhibited by the hybrids over their mid and better parental values are shown in the figure 7(vi). The percentage of relative heterosis in the fifteen hybrids ranged from -9.12 to 11.77. Among these

Table 7(vi). No.of seeds/pod

Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	8.78*	0.44
2.	"	x Selection 129	2.99*	-2.49*
3.	"	x Selection 104	9.74*	6.17*
4.	"	x Selection 7	-7.62*	-9.89*
5.	"	x Selection 123	-9.12*	-11.04*
6.	Kurutholapayar	x Selection 129	11.77*	8.83*
7.	"	x Selection 104	11.54*	6.28*
8.	"	x Selection 7	-6.48*	-11.61*
9.	"	x Selection 123	5.44*	- 0.68
10.	Selection 129	x Selection 104	6.53*	4.17*
11.	"	x Selection 7	-4.30*	-7.19*
12.	"	x Selection 123	1.43*	-1.96*
13.	Selection 104	x Selection 7	-8.91*	-9.67*
14.	"	x Selection 123	3.96*	2.72*
15.	Selection 7	x Selection 123	-2.99*	-3.33*
	CD (0.05)		1.022	1.180

* Significant (P<0.05)

Figure 2 (f)

Estimation of heterosis for Number of Seeds/Pod in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

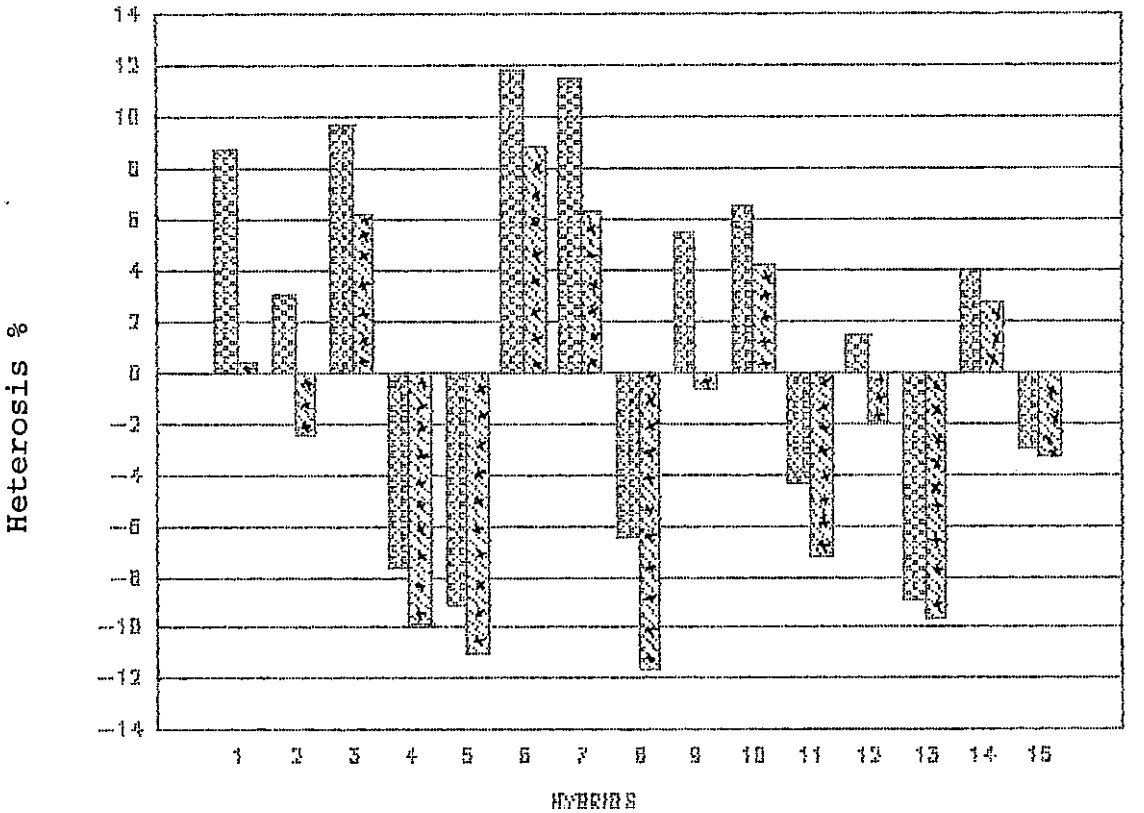


FIG. 2 (f)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Number of seeds/ pod in a 6 x 6 diallel.

9 hybrids showed positive heterosis and six showed negative heterosis. Hybrids showed positive heterosis are Selection 145 x kurutholapayar (8.78), Selection 145 x Selection 129 (2.99), Selection145 x Selection 104 (9.74), kurutholapayar x Selection 129 (11.77), kurutholapayar x Selection 104 (11.54), kurutholapayar x Selection 123 (5.44), Selection 129 x Selection 104 (6.53), Selection 129 x Selection 123 (1.43) and Selection 104 x Selection 123 (3.96). Crosses showed negative heterosis are Selection 145 x Selection 7 (-7.62), Selection 145 x Selection 123 (-9.12), kurutholapayar x Selection 7 (-6.48), Selection 129 x Selection 7 (-4.30), Selection 104 x Selection 7 (-8.91) and Selection 7 x Selection 123 (-2.99). All hybrids showed significant relative heterosis. The maximum relative heterosis for the character number of seeds/pod was shown by the hybrid kurutholapayar x Selection 129 followed by kurutholapayar x Selection 104.

Compared to the better parental values, the percentage of heterosis in the fifteen hybrids ranged from -11.61 to 8.83. All hybrids except Selection 145 x kurutholapayar and kurutholapayar x Selection 123 showed significant heterosis. Among the hybrids six hybrids showed positive heterosis viz. Selection 145 x kuruthola-payar (0.44), Selection 145 x Selection 104 (6.17), kurutholapayar x Selection 129 (8.83), kurutholapayar x

Selection 104 (6.28), Selection 129 x Selection 104 (4.17) and Selection 104 x Selection 123 (2.72) and nine hybrids showed negative heterosis viz. Selection 145 x Selection 129 (-2.49), Selection 145 x Selection 7 (-9.89), Selection 145 x Selection 123 (-11.04), kurutholapayar x Selection 7 (-11.61), kurutholapayar x Selection 123 (-0.68), Selection 129 x Selection 7 (-7.19), Selection 129 x Selection 123 (-1.96), Selection 104 x selection 7 (-9.67) and Selection 7 x Selection 123 (-3.33). This result reveals that the maximum heterobeltiosis for number of seeds per pod was shown by the hybrid kurutholapayar x Selection 129 followed by kurutholapayar x Selection 104. The percentage of heterosis over mid and better parental vaues for this character is presented in Figure 2 (f).

Length of internode

Table 7(vii) shows the percentage of heterosis exhibited by the fifteen hybrids over their mid parental and better parental values. Compared to the mid parental values, the percentage of heterosis in the fifteen hybrids ranged from -20.08 to 5.40. Among the hybrids, 3 showed positive heterosis viz. Selection 145 x kurutholapayar (4.64), Selection 129 x Selection 104 (1.45) and Selection 7 x Selection 123 (5.40) and 12 showed negative heterosis viz. Selection 145 x Selection 129 (-14.89), Selection 145

Table 7(vii). Length of internode

Sl. No.	Parents and hybride		Percentage aof heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	4.64*	6.50*
2.	"	x Selection 129	-14.89*	-14.89*
3.	"	x Selection 104	- 9.37*	3.30*
4.	"	x Selection 7	-10.02*	- 8.08*
5.	"	x Selection 123	- 8.24*	- 7.58*
6.	Kurutholapayar	x Selection 129	- 1.75*	0.00
7.	"	x Selection 104	- 3.05*	8.37*
8.	"	x Selection 7	- 0.72	- 0.36
9.	"	x Selection 123	- 5.38*	- 4.46*
10.	Selection 129	x Selection 104	1.45*	15.64*
11.	"	x Selection 7	-0.88	1.25
12.	"	x Selection 123	-5.64*	- 4.89*
13.	Selection 104	x Selection 7	-8.80*	1.54
14.	"	x Selection 123	-20.08*	-9.69*
15.	Selection 7	x Selection 123	5.40*	6.82*
	CD (0.05)		1.5087	1.7421

* Significant (P<0.05)

x Selection 104 (-9.37), Selection 145 x Selection 7 (-10.02), Selection 145 x Selection 123 (-8.24), kurutholapayar x Selection 129 (-1.75), kurutholapayar x Selection 104 (-3.05), kurutholapayar x Selection 7 (-0.72), kurutholapayar x Selection 123 (-5.38), Selection 129 x Selection 7 (-0.88), Selection 129 x Selection 123 (-5.64), Selection 104 x Selection 7 (-8.80) and Selection 104 x Selection 123 (-20.08). Maximum percentage of heterosis for the character length of internode was shown by hybrid Selection 104 x Selection 123 followed by Selection 145 x Selection 129.

Compared to the better parental values, the percentage of heterosis in the hybrids ranged from -14.89 to 15.64. Among the hybrids eight hybrids showed positive heterobeltiosis viz. Selection 145 x kurutholapayar (6.50), Selection 145 x Selection 104 (3.30), kurutholapayar x Selection 129 (0.00), kurutholapayar x Selection 104 (8.37), Selection 129 x Selection 104 (15.64), Selection 129 x Selection 7 (1.25), Selection 104 x Selection 7 (1.54) and Selection 7 x Selection 123 (6.82) and seven hybrids showed negative heterosis viz. Selection 145 x Selection 129 (-14.89), Selection 145 x Selection 7 (-8.08), Selection 145 x Selection 123 (-7.58) kurutholapayar x Selection 7 (-0.36), kurutholapayar x Selection 123 (-4.46), Selection 129 x Selection 123 (-4.89) and Selection 104 x Selection 123 (-9.69). Among

Figure 2 (g)

Estimation of heterosis for length of Internode in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

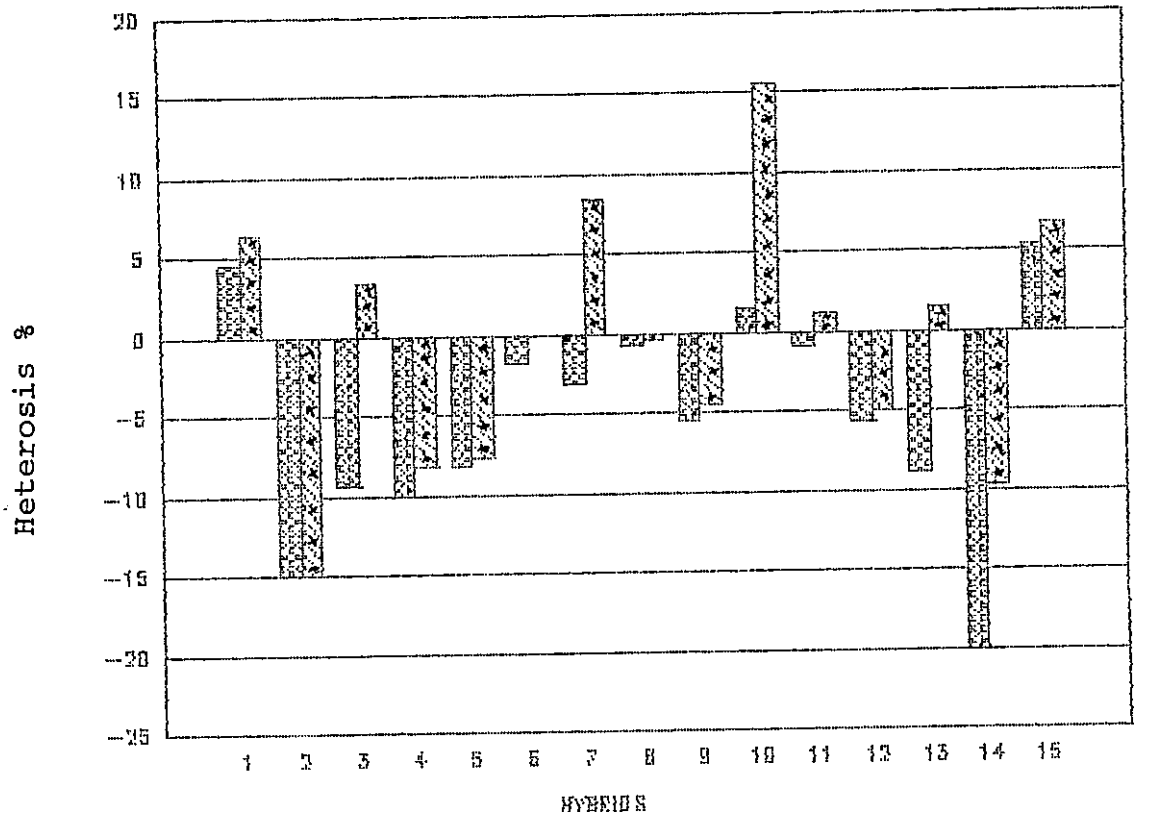


FIG. 2 (g)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Length of Internode in a 6 x 6 diallel.

these hybrids 11 showed significant heterosis. They are Selection 145 x kurutholapayar, Selection 145 x Selection 129, Selection 145 x Selection 104, Selection 145 x Selection 7, Selection 145 x Selection 123, kurutholapayar x Selection 104, kurutholapayar x Selection 123, Selection 129 x Selection 104, Selection 129 x Selection 123, Selection 104 x Selection 123 and Selection 7 x Selection 123. The hybrid Selection 145 x Selection 129 showed maximum percentage of heterobeltiosis for the character length of internode followed by Selection 104 x Selection 123. The percentage of heterosis over mid and better parental values for this character is presented in figure 2(g).

Seed/pod ratio

Table 7(viii) shows the percentage of heterosis exhibited by the fifteen hybrids over their mid and better parental values. Compared to the mid parental value, the percentage of heterosis ranged from -16.47 to 25.63. All showed significant heterosis. Among this positive heterosis was shown by 11 hybrids viz. Selection 145 x kurutholapayar (15.86), selection 145 x Selection 129 (10.01), Selection 145 x Selection 104 (24.79), Selection 145 x Selection 7 (2.78), Selection 145 x Selection 123 (0.56), kurutholapayar x Selection 129 (17.17), kurutholapayar x Selection 104 (30.66), kurutholapayar x Selection 7 (2.95), kurutholapayar x Selection 123 (10.39)

Table 7(viii). Sed/pod ratio

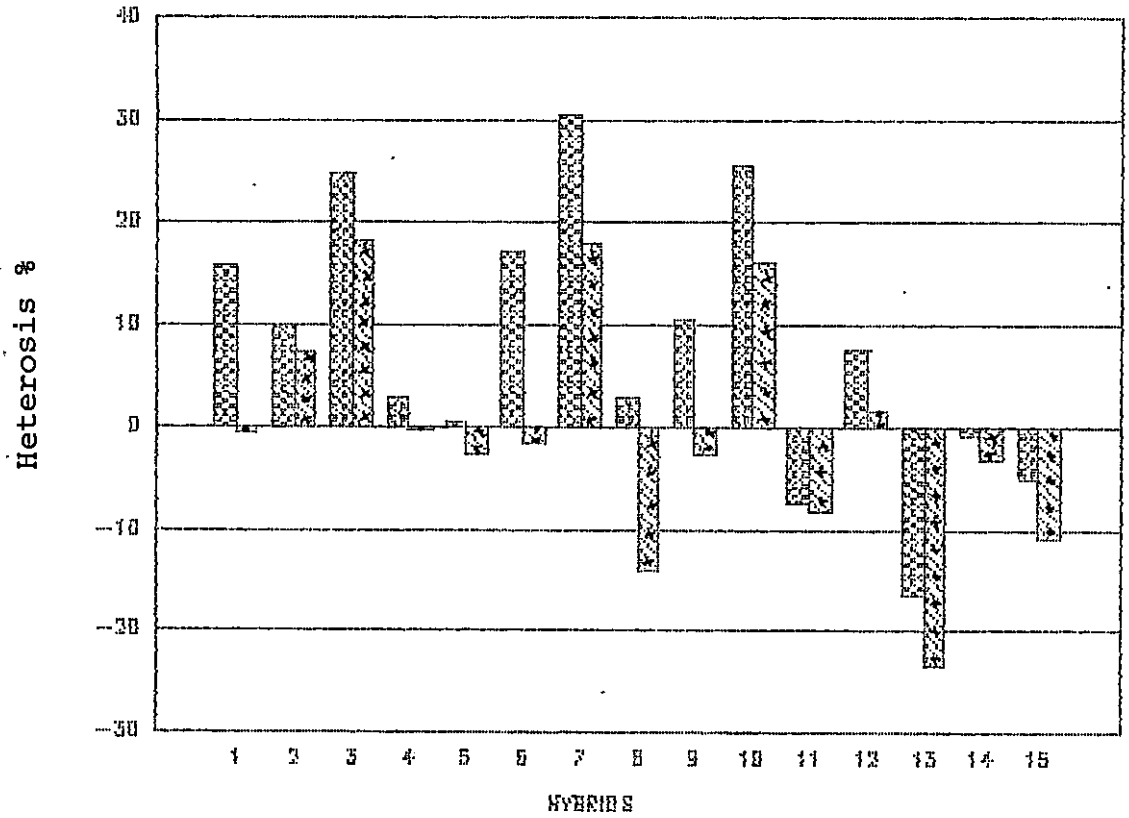
Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	15.86*	-0.57*
2.	"	x Selection 129	10.01*	7.23*
3.	"	x Selection 104	24.79*	18.01*
4.	"	x Selection 7	2.78*	-0.30*
5.	"	x Selection 123	0.56*	-2.58*
6.	Kurutholapayar	x Selection 129	17.17*	-1.57*
7.	"	x Selection 104	30.66*	17.84*
8.	"	x Selection 7	2.95*	-14.00*
9.	"	x Selection 123	10.39*	- 2.64*
10.	Selection 129	x Selection 104	25.63*	15.97*
11.	"	x Selection 7	-7.58*	- 8.21*
12.	"	x Selection 123	7.48*	1.57*
13.	Selection 104	x Selection 7	-16.47*	-23.38*
14.	"	x Selection 123	- 0.87	- 3.31*
15.	Selection 7	x Selection 123	- 5.03*	-10.82*
	CD (0.05)		0.0336	0.0388

* Significant (P<0.05)

Figure 2 (h)

Estimation of heterosis for Seed/pod Ratio in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123



FIG> 2 (h)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Seed/Pod Ratio in a 6 x 6 diallel.

Selection 129 x Selection 104 (25.63) and Selection 129 x Selection 123 (7.48) and negative heterosis was shown by four hybrids viz. Selection 129 x Selection 7 (-7.58), Selection 104 x Selection 7 (-16.47), Selection 104 x Selection 123 (-0.87) and Selection 7 x Selection 123 (-5.03). This result reveals that the hybrid kurutholapayar x Selection 104 showed maximum percentage of heterosis over mid parental value for the character seed pod ratio, followed by Selection 129 x Selection 104.

While considering the percentage of heterosis over better parental value, it ranged from -23.38 to 18.01%. Hybrids showed positive heterobeltiosis are Selection 145 x Selection 129 (7.23), Selection 145 x Selection 104 (18.01), kurutholapayar x Selection 104 (17.84), Selection 129 x Selection 104 (15.97), Selection 129 x Selection 123 (1.57) and those showed negative heterobeltiosis are Selection 145 x kurutholapayar (-0.57), Selection 145 x Selection 7 (-0.30), Selection 145 x Selection 123 (-2.58), kurutholapayar x Selection 129 (-1.57), kurutholapayar x Selection 7 (-14.00), kurutholapayar x Selection 123 (-2.64), selection 129 x Selection 7 (-8.21), Selection 104 x Selection 7 (-23.38), Selection 104 x Selection 123 (-3.31) and Selection 7 x Selection 123 (-10.82). All hybrids showed significant heterobeltiosis. Maximum heterobeltiosis was exhibited

Table 7(ix). Fruit Yield/plant

Sl. No.	Parents and hybrids		Percentage of heterosis over	
			Mid parent	Better parent
1.	Selection 145	x Kurutholapayar	14.72	-5.95
2.	"	x Selection 129	18.15	16.42
3.	"	x Selection 104	118.99*	72.41
4.	"	x Selection 7	-7.52	-16.83
5.	"	x Selection 123	1.04	-14.89
6.	Kurutholapayar	x Selection 129	13.72	- 7.84
7.	"	x Selection 104	27.71	-13.12
8.	"	x Selection 7	-18.79	- 8.69
9.	"	x Selection 123	13.13	-18.63
10.	Selection 129	x Selection 104	110.24*	67.33
11.	"	x Selection 7	41.12	25.27
12.	"	x Selection 123	30.33	11.20
13.	Selection 104	x Selection 7	12.44	-17.97
14.	"	x Selection 123	114.17*	96.66
15.	Selection 7	x Selection 123	7.59	-16.74
	CD (0.05)		97.81	112.94

* Significant (P<0.05)

Figure 2 (i)

Estimation of heterosis for Fruit Yield/Plant in a 6 x 6 diallel.

Treatment No.	Hybrid
1.	Selection 145 x Kurutholapayar
2.	Selection 145 x Selection 129
3.	Selection 145 x Selection 104
4.	Selection 145 x Selection 7
5.	Selection 145 x Selection 123
6.	Kurutholapayar x Selection 129
7.	Kurutholapayar x Selection 104
8.	Kurutholapayar x Selection 7
9.	Kurutholapayar x Selection 123
10.	Selection 129 x Selection 104
11.	Selection 129 x Selection 7
12.	Selection 129 x Selection 123
13.	Selection 104 x Selection 7
14.	Selection 104 x Selection 123
15.	Selection 7 x Selection 123

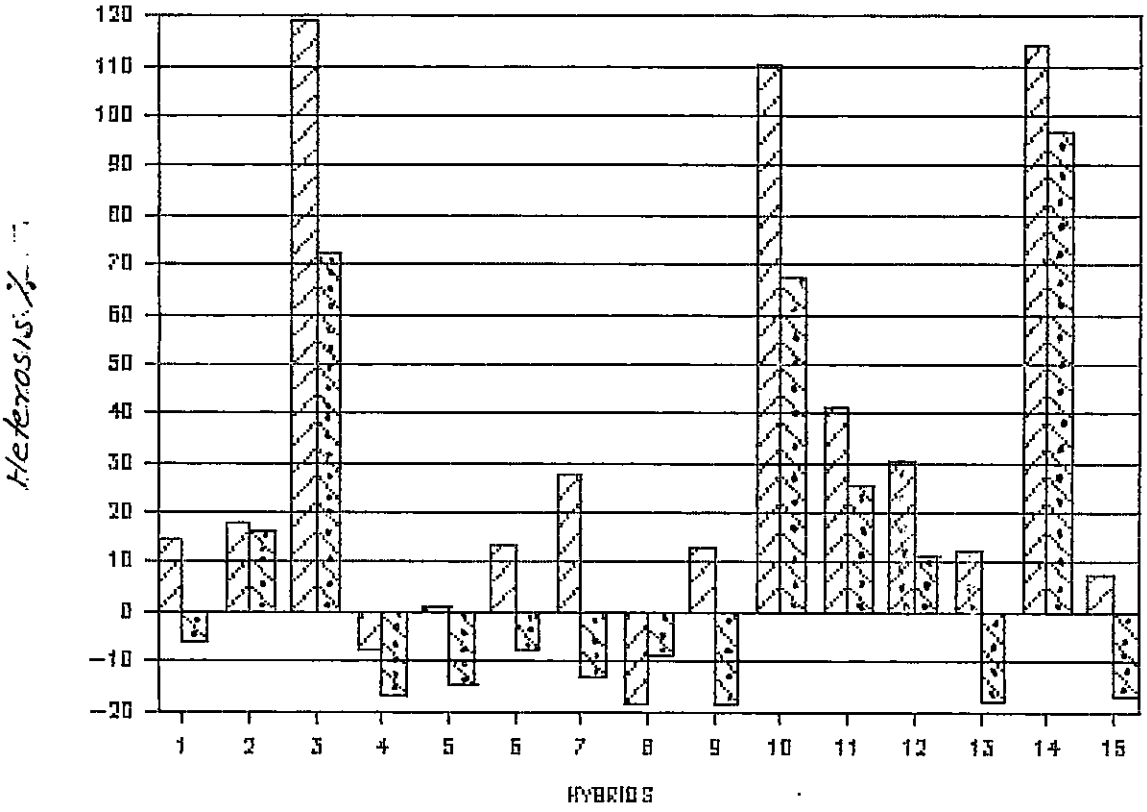


FIG. 2 (i)

Relativeheterosis

Heterobeltiosis

Estimation of heterosis for Fruit Yield/ Plant in a 6 x 6 diallel.

Selection 145 x Selection 104 followed by Selection 104 x Selection 123 showed maximum relative heterosis for fruit yield/plant.

While considering, heterobeltiosis, the percentage of heterosis ranged from -18.63 to 96.66. Positive heterosis was shown by the hybrids Selection 145 x Selection 129 (16.42), Selection 145 x Selection 104 (72.41), Selection 129 x Selection 104 (67.33), Selection 129 x Selection 7 (25.27), Selection 129 x Selection 123 (11.20) and Selection 104 x selection 123 (96.66). Negative heterosis was shown by the hybrids Selection 145 x kurutholapayar (-5.95), Selection 145 x Selection 7 (-16.83), Selection 145 x Selection 123 (-14.89), kurutholapayar x Selection 129 (-7.84), kurutholapayar x Selection 104 (-13.12), kurutholapayar x Selection 7 (-8.69) kurutholapayar x Selection 123 (-78.63), Selection 104 x Selection 7 (-17.97) and Selection 7 x Selection 123 (-16.74). But none of these hybrids showed significant heterobeltiosis. The percentage of heterosis over mid and better parental value for this character is presented in figure 2(i).

DISCUSSION

DISCUSSION

The diallel cross technique which involved the crossing of lines in all possible combinations is an efficient method for the study of combining ability and the nature of gene action governing the expression of various characters. This enables the choice of appropriate parental material for employing the most suitable breeding methodology. The present experiment was undertaken to study the combining ability, gene action and heterosis in vegetable cowpea. Six lines and the fifteen hybrids obtained by crossing them in all possible combinations excluding reciprocals, were subjected to diallel analysis. The results obtained are discussed below.

Combining ability

The combining ability analysis furnishes the information regarding selection of suitable parents for hybridisation and desirable cross combinations. Result of combining ability analysis of the six selected parents and the fifteen hybrids obtained by crossing them are discussed below.

The analysis of variance for combining ability revealed that both g.c.a. and s.c.a. variances were significant for the characters days to flowering, number of seeds/pod, length of internode and seed/pod ratio.

Similar results were reported for days to flowering and seeds/pod in pea by Brahmappa and Singh (1977). Only g.c.a. variance were significant for the characters, mean weight of pod and mean length of pod. Kumar and Agrawal (1981) also suggested similar result for length of pod in pea. In the present study predominance of s.c.a. variance was found for the characters number of pods/cluster and number of pods/plant. for the character pods/plant, this result is confirmed with the findings of Chowdhary (1986) in Mung bean. In the present study most of the characters showed preponderance of g.c.a. variance except for number of pods/cluster and number of pods/plant.

For the character days to flowering, the g.c.a. variance was found higher than s.c.a. variance. This is in confirmity with the findings of Patil and Bhapkar (1986) in cowpea and cheralu et al. (1989) in pigeonpea. The g.c.a. effects were significant in four parents and s.c.a. effects in four hybrids. For this character negative g.c.a. effect is considered as the best. In this maximum positive g.c.a. was expressed by the parent selection 104 and negative g.c.a. by selection 129. Among the different cross combinations selection 104 x selection 123 showed maximum positive s.c.a effect and negative s.c.a. effect by the crosses Selection 145 x kurutholapayar followed by Selection 145 x Selection 104.

While considering this character the best general combiner is the parent Selection 129 followed by kurutholapayar and best specific combiner is Selection 145 x kurutholapayar. The best specific combiner was a combination involving poor female general combiner and a good male general combiner. High s.c.a. effect were manifested in the combination involving a poor general combiner and a good general combiner. In general the superior combinations involved atleast one high general combining parent. Similar result was reported by Ram Nath and Madhavamenon (1982) in soybean.

The g.c.a. of the parents were in general directly related to their mean performance ie., the parents with high means showed high g.c.a. effect. The combination between high general combiners were not necessarily producing high s.c.a. effects. In general for this character both g.c.a. and s.c.a. effects were significant suggesting the importance of both g.c.a. and s.c.a. variance respectively.

The s.c.a. variance was found significant for the character number of pods/cluster. The g.c.a. effect was significant for only one parent ie. selection 129, which showed positive g.c.a. effect. The s.c.a. effect was significant in three hybrids. Among these, two showed positive s.c.a. effect and one negative s.c.a. effect.

Maximum positive s.c.a. effect was shown by the hybrid Selection 145 x Selection 104 which is a combination of poor x good general combiner. Negatice s.c.a. effect was shown by the hybrid kurutholapayar x Selection 7, which was a combination of 2 poor general combiners. The hybrid Selection 129 x Selection 7 was also a combination of 2 poor general combiners. The best general combiner for this character showed high mean performance also.

For number of pods/plant both g.c.a. and s.c.a. variance were not significant. This is contridicting with the work of Venkateswaralu and Singh (1982) in pigeonpea and Singh et al. (1985) in pea and Salinath and Bahl (1989) in chickpea. The magnitude of s.c.a. variance was higher than g.c.a. variance. This was in accordance with the findings of Patil and Shete (1986). None of the parents showed significant positive g.c.a. effect. Two hybrids showed significant s.c.a. effects are kurutholapayar x Selection 7 and Selection 129 x Selection 104. Maximum positive s.c.a. effect was shown by hybrid Selection 129 x Selection 104 which was a combination between two poor general combiners. The mean performance of the hybrids was not in accordance with the s.c.a. effect.

Variance due to g.c.a. was significant for mean weight of pod. According to Brahmappa and Singh (1977)

both g.c.a. variance was significant in pea. The g.c.a. effects were significant in three parents and s.c.a. efect in two hybrids. Positive g.c.a. effect was found for the parents kurutholapayar and Selection 104. Whereas negative g.c.a. effect was found for Selection 129. Maximum positive g.c.a. was shown by the parent selection 104 followed by kurutholapayar. Significant positive s.c.a. effects were shown by hybrids Selection 145 x Selection 129 and Selection 145 x Selection 7. Maximum s.c.a. effect was found in the hybrid Selection 145 x Selection 129 which was a combination of a poor and good general combiners. The hybrid kurutholapayar x Selection 104 which was a combination of two good general combiners had not produced high s.c.a. effect. Here significant s.c.a. effects were found in hybrids between poor x good and poor x poor general combiners. The g.c.a. effect of the parents were in general directly related to their mean performance. In this character, the g.c.a. variance was found higher than s.c.a. variance indicating the importance of general combining ability.

The g.c.a.variance was found significant for mean length of pod. This is in agreement with the findings of Bak (1977) in french bean and Kumar and Agrawal (1981) in Pisum satinum. The g.c.a. effects were significant for five parents. Among this maximum positive g.c.a. effect

was shown by parent selection 104 followed by selection 145. Significant negative g.c.a. effects were found in parents kurutholapayar, Selection 129 and selection 123. There was only one cross combination that showed significant positive s.c.a. effect ie. Selection 129 x Selection 7. while discussing this character, it was found that the parent Selection 104 is the best general combiner and the cross selection 129 x Selection 7, the best specific combiner. Here the best specific combiner was a combination between two poor negative general combiners. The cross Selection 145 x Selection 7 which was a combination between two good general combiners had not produced high s.c.a.effect. In general good general combiners may not perform as good specific combiners.

The performance of the parents were related to their general combining ability effects. The significance of g.c.a. effect suggests the importance of g.c.a. variance. Both g.c.a. and s.c.a. variance was found significant for the character number of seeds/pod. The g.c.a. variance was found higher than s.c.a. variance. This is according to the findings of Syreva (1979) and Kumar and Agarwal (1981) in pea and Venkateswaralu and Singh (1982) in pigeonpea. According to Silva and Omran (1986) both g.c.a. and s.c.a. variance was important for this character in winged bean. The g.c.a. effects were

significant in 3 parents and s.c.a. effect in seven hybrids. Positive g.c.a. effects were found in two parents viz, Selection 145 and Selection 104. Significant negative g.c.a. effect was found in parent Selection 7. Maximum g.c.a. effect was shown by the parent Selection 145. Significant s.c.a. effects were shown by the hybrids Selection 145 x kurutholapayar, Selection 145 x Selection 129, Selection 145 x Selection 7, kurutholapayar x Selection 104, Selection 129 x Selection 104, Selection 129 x Selection 7 and Selection 7 x Selection 123. Significant positive s.c.a. effects were shown by hybrids Selection 145 x kurutholapayar, Selection 145 x Selection 129 and Selection 129 x Selection 104. Maximum s.c.a. effect was shown by hybrids Selection 145 x Selection 129 followed by kurutholapayar x Selection 104.

Selection 129 x Selection 104 was a combination between a poor female general combiner and a good male general combiner. The hybrid Selection 145 x Selection 129 was also a combination of good and poor general combiner. In general the superior combinations involved one high general combiner. Similar result was reported by Venkateswaralu and Singh (1982) in pigeonpea. The hybrid Selection 145 x Selection 104 which was a combination between two good general combiners failed to produce high s.c.a. effect. In general the combination between two good general combiners may not produce high s.c.a. effect.

The mean performance of the parents and hybrids were not related to their general and specific combining ability effects. In general for this character both g.c.a. and s.c.a. effects were significant suggesting the importance of both g.c.a. and s.c.a. variance.

For length of internode, both g.c.a. and s.c.a. variance was found significnat. The magnitude of g.c.a. variance was higher than the s.c.a. variance. Three parents showed significant g.c.a. effect. Among these, two showed positive g.c.a. effect and one showed negative g.c.a. effect. For this character negative g.c.a. effect is considered as the best. Positive g.c.a. effects were shown by parents kurutholapayar and Selection 129. Negative g.c.a. effect was shown by Selection 104. Thus the best general combiner is Selection 104. Among the hybrids, six, showed significant s.c.a. effect. Positive s.c.a. effects were shown by hybrids selection 145 x kurutholapayar and Selection 145 x Selection 129 and Selection 145 x Selection 123. Negative s.c.a. effects were shown by hybrids kurutholapayar x Selection 129, kurutholapayar x Selection 123 and Selection 104 x Selection 7. Among these the best specific combiner is kurutholapayar x Selection 123 which was a combination between a positive good female general combiner and a poor male specific combiner, followed by kurutholapayar x

selection 129 which was a combination between two positive general combiners.

The mean performance of the parents was found related to their general combining ability effects. The significance of both g.c.a and s.c.a. effects indicates the importance of both g.c.a. and s.c.a. variance.

For the character seed/pod ratio, g.c.a. variance was found higher than s.c.a. variance. The g.c.a. effects were significant for 3 parents and s.c.a. effects were significant for four hybrids. Positive g.c.a. effects were shown by two parents, selection 145 and selection 129. Maximum g.c.a. effect was shown by selection 129. Among hybrids with significant s.c.a. effects, three showed positive s.c.a. effect and one showed negative s.c.a. effect. Maximum positive s.c.a. effect was shown by hybrid selection 145 x selection 104 folowed by selection 129 x selection 104. While considering this character, the best general combiner is slection 129 and best specific combiner is selection 145 x selection 104. The best specific combiners were a combination between good and poor general combiners. In general the superior combinations involved atleast one high general combining parent. This is in agreement with the findings of Ram Nath and Madhavamenon (1982) in Soy bean.

The g.c.a. of the parents were in general directly related to their mean performance. The significance of both g.c.a. and s.c.a. indicates the importance of both g.c.a. and s.c.a. variance.

Both g.c.a. and s.c.a. variance were not significant for fruit yield per plant. This was contrast to the findings of Dahiya and Brar (1977) in pigeonpea, Nandpuri et al. (1973) in pea, Kumar and Agrawal (1981) in pea, Singh et al. (1985) in pea, Cheralu et al. (1989) in pigeonpea and Salimath and Bahl (1989) in chickpea. The g.c.a. variance was found higher than s.c.a. variance. The only parent that showed significant positive g.c.a. effect was kurutholapayar. Two hybrids showed significant positive s.c.a. effect which were combinations between poor general combiners. Highest s.c.a. effect was shown by the hybrid selection 129 x selection 104, followed by selection 145 x selection 104. Their per se performance of the parent was found directly related to their g.c.a. effects. The performance of hybrids also found directly proportional to their s.c.a. effect. The treatments did not differ significantly for the character fruit yield/plant and hence g.c.a. and s.c.a. variance was not significant.

Gene Action

Griffings (1956) pointed out that high g.c.a. contains not only the additive genetic variance but also a portion of the epistatic variance (additive x additive) and the s.c.a. includes all of the dominance and the remaining epistatic variance. The analysis of variance in the present study for combining ability revealed the preponderance of g.c.a. variance for all the characters studied except for number of pods/cluster and number of pods/plant. This suggests the relative significance of additive and non-additive gene effect.

For days to flowering, the variance due to g.c.a. and s.c.a. were significant. This denotes the importance of additive and non-additive gene action in governing this character. But g.c.a. variance was found higher in magnitude than s.c.a. variance revealing the predominant role of additive gene action for days to flowering. This is in line with the findings of Bak (1977) in French bean and Patil and Shapkan (1986) in cowpea.

For the character number of pods/cluster, only s.c.a. variance was found significant indicating that non-additive gene action was important for this character.

The variation due to g.c.a. and s.c.a. was not significant for number of pods/plant, but the s.c.a. variance was higher in magnitude. Venkateswaralu and

Singh (1982) suggested additive gene action for this character in pigeonpea. Singh et al. (1985) in pea and Salimath and Bahl (1989) in chickpea also suggested the importance of additive gene action. Nandpuri et al. (1973) suggested the importance of both additive and non-additive gene action in pea.

For the character mean weight of pod, variance due to g.c.a. was found significant, indicating the importance of additive type of gene action. Brahmappa and Singh (1977) suggested the importance of both additive and non-additive type of gene action in pea.

The g.c.a. variance was found significant for mean length of pod. This suggests the importance of additive type of gene action for this character. Bak (1977) in french bean and kumar and Agrawal (1981) in pea also suggested the importance of additive type of gene action for this character.

For number of seeds/pod, both g.c.a. and s.c.a. variance was found significant, indicating that both additive and non-additive type of gene action was important for this character. But the magnitude of g.c.a. variance was higher than s.c.a. variance indicating the predominance of non-additive type of gene action. This was according to the findings of Silva and Omran (1986) in winged bean. Syreva (1979) suggested additive gene action

for this character. Agrawal (1981) in pea and Venkateswaralu and singh (1982) in pigeonpea also suggested additive type of gene action for this character.

Both g.c.a. and s.c.a. variance were found significant for the character length of internode. This suggested the importance of both additive and non-additive gene action. But the magnitude of g.c.a. variance was higher than the s.c.a. variance indicating the predominance of additive type of gene action.

For seed/pod ratio, both g.c.a. and s.c.a. variance were found significant indicating the importance of both additive and non-additive type of gene action for this character. The g.c.a. variance was found higher than s.c.a. variance establishing the predominance of additive type of gene action.

The variance due to g.c.a. and s.c.a. were not significant for the character fruit yield/plant, but g.c.a. variance was higher in magnitude. Dahiya and Bran (1977) suggested non-additive type of gene action for this character in pigeonpea. Nandpuri et al. (1973) suggested the importance of both additive and non-additive gene action in pea. Kumar and Agrawal (1981) suggested the importance of non-additive gene action in pea.

In general, it was seen that additive gene action predominated in all characters except number of pods/

cluster and number of pods/plant. Non-additive gene action was also significant for some characters like days to flowering, number of pods/cluster, number of seeds/pod, length of internode and seed/pod ratio. Conventional breeding methods exploit that portion of genetic variability which is due to additive x additive type of gene interaction. The predominance of non- additive gene action would require maintenance of hetero zygosity in the population. Additiveness played a major role in most of characters, which indicated that improvement for these characters can be made through selection.

Heterosis

In the present study, marked heterosis was observed in various hybrids for some of the characters studied.

Negative heterosis was desirable for days to flowering (earliness). Maximum negative heterosis of -5.955 percent over mid parental and -9.65 percent over better parental value were recorded for this character. Holfman (1962) reported heterosis for flowering time in cowpea. Among the hybrids, six hybrids expressed negative heterosis over mid parent and four hybrids expressed positive heterosis over better parent were statistically significant. Salimath and Bahl (1985) also reported heterosis over better parent with respect to days to flowering in chickpea. The cross combinations selection

145 x kurutholapayar showed maximum negative heterosis over mid parent followed by selection 129 x selection 104. The hybrid selection 145 x selection 7 followed by selection 145 x selection 123 showed maximum negative heterosis over better parent.

A maximum of 9.09 percent and 6.90 percent heterosis over mid and better parent was observed for the character number of pods/cluster. Significant positive heterosis was reported by ten hybrids over mid parent and seven hybrids over better parent. In this study the hybrid selection 129 x selection 104, showed maximum heterosis over mid parental value folowed by kurutholapayar x selection 7. The hybrids showed maximum heterosis over better parental value were kurutholapayar x selection 7 followed by kurutholapayar x selection 104.

As regard to number of pods per plant, maximum heterosis of 99.09 percent over mid parent and 51.00 percent over better parent was observed. Duarte (1966) reported heterosis in french bean for this character. Among hybrids twelve exhibited positive heterosis over mid parent and six hybrids over better parent. Among the hybrids showed positive heterosis, all except two showed significant heterosis over mid parent and all except one showed significant heterosis over better parent. Rao and Chopra (1989) in chickpea also reported high positive value of average heterosis and heterobeltioris for this

character. Maximum heterosis over mid parent was shown by hybrid selection 104 x selection 123 followed by selection 129 x selection 104, whereas maximum heterosis over better parent was shown by hybrids selection 129 x selection 104, followed by selection 145 x selection 104. Reddy et al. (1979) also found positive heterosis for this character in pigeonpea. Singh and Jain (1971) reported negative heterosis for this character in mung bean.

For the character mean weight of pod, a maximum positive heterosis of 13.67 percent over mid parental and 11.12 percent over better parental values were recorded. This is in agreement with the findings of Kamalam (1975) in cowpea. Among the hybrids, twelve showed significant positive heterosis over mid parental value and ten hybrids over better parental value. The maximum heterosis over mid parent was shown by the hybrid kurutholapayar x selection 129, followed by kurutholapayar x selection 123. The hybrid selection 104 x selection 7 followed by kurutholapayar x selection 123 showed maximum positive heterosis over better parental value.

While discussing the character mean length of pod, it was revealed that a maximum positive heterosis of 10.59 percent over mid parental value was observed for the hybrid kurutholapayar x selection 7, followed by kurutholapayar x selection 123. Singh and Jain (1970) reported hybrid vigour over mid parent for this character

in mung bean. A maximum positive heterosis of 7.67 percent over better parental value was observed for the hybrid kurutholapayar x selection 123 followed by kurutholapayar x selection 7. Kamalam (1975) in cowpea and Singh and singh Santhoshi (1989) in pea also reported heterosis for this character. Among nine hybrids showed positive heterosis over mid parent, six were statistically significant. But all hybrids were statistically significant among these hybrids which showed positive heterosis over better parental value. Singh and Jain (1971) reported negative heterosis for this character in mung bean. Prem Sagar in 1964 reported that for this character, the F_1 showed an intermediate position in urd bean.

A maximum of 11.77 percent and 8.83 percent heterosis over mid and better parent was observed for the character number of seeds/pod. Silva and Omran (1986) in winged bean, Singh and Jain (1970) in mungbean and Singh and Jain (1972) in cowpea also reported heterosis for this character. Positive significant heterosis were reported by nine hybrids over mid parent and four over better parental value. In this study the hybrid kurutholapayar x selection 129 showed maximum heterosis over mid parental value followed by kurutholapayar x selection 104. The hybrids showed maximum heterosis over better parental

value were kurutholapayar x selection 129 followed by kurutholapayar x selection 104. Heterosis was also reported by Duarte (1966) in french bean. singh and Jain (1971) reported heterosis in hybrids over better parent for this character in mung bean.

For the character length of internode, negative heterosis was desirable for obtaining maximum number of productive branches. Maximum negative heterosis of -20.08 percent over mid parental and -14.89 over better parental value were recorded for this character. Twelve hybrids showed negative heterosis over mid parent and seven over better parent. Among the 12 hybrids showed negative heterosis over mid parent, ten were statistically significant. All hybrids were statistically significant which showed negative heterosis over mid parent. The cross combination selection 104 x selection 123 followed by selection 145 x selection 129 showed maximum negative heterosis over better parent and selection 145 x selection 129 folowed by selection 104 x selection 123 showed negative heterosis over better parent.

A maximum heterosis of 30.66 percent on mid parent and 18.01 percent over better parent was observed for the character seed/pod ratio. Eleven hybrids showed significant positive heterosis over mid parent and five hybrids showed significant positive heterosis over better

parent. Maximum heterosis over mid parent was shown by hybrid kurutholapayar x selection 104 followed by selection 129 x selection 104, whereas maximum heterosis over better parent was shown by hybrids selection 145 x selection 104 folowed by kurutholapayar x selection 104.

For fruit yield/plant, thirteen hybrids showed positive heterosis over mid parent and six hybrids over better parent. Singh and Jain (1970) reported considerable heterosis for this character in mung bean. A maximum heterosis of 118.99 percent over mid parent and 96.66 percent over better parent was observed for this character. Among thirteen hybrids showed positive heterosis over mid parent, only six hybrids were statistically significant. But one of the hybrids was statistically significant among those which showed positive heterosis over better parent. The maximum positive heterosis over mid parent was shown by hybrid selection 145 x selection 104 followed by selection 104 x selection 123, whereas heterosis over better parent was shown by corss selection 104 x selection 123. Singh and Jain (1970) in mung bean and Kamalam (1977) in cowpea also reported considerable relative heterosis in yield. Singh and Singh (1970) reported in field pea that three crosses gave significantly greater yield than their respective better parents. According to Singh et al. (1972) the

number of pods/plant and the number of seeds/plant influenced higher yield to some extent. Since considerable heterosis was found in most of characters, heterosis breeding can be attempted in this crop.

SUMMARY

SUMMARY

The present study was carried out in the Department of Plant Breeding, College of Agriculture, Vellayani. Six vegetable cowpea lines were selected from the germplasm maintained in the Department of Plant Breeding. They were crossed in all possible combinations, excluding reciprocals, in Experiment I, so as to get fifteen hybrids. The main experiment consisted of evaluation of the parents and hybrids for combining ability, gene action and heterosis. Nine characters were studied. They are days to flowering, number of pods/cluster, number of pods/plant, mean weight of pod, mean length of pod, number of seeds/pod, length of internode, seed/pod ratio and fruit yield/plant. The data collected were subjected to statistical analysis and the combining ability analysis was carried out as per the Method 2 under Model 1 suggested by Griffing (1956). The results obtained are summarised below.

The analysis of variance study revealed that the treatments differ significantly for all the characters studied except for number of pods/plant and fruit yield/plant.

The analysis of variance for combining ability revealed that the variance due to g.c.a and s.c.a. were

significant for the characters days to flowering, number of seeds/pod, length of internode and seed/pod ratio. For the character mean weight of pod and mean length of pod only g.c.a. was significant whereas only s.c.a. was significant for the character number of pods/cluster. The g.c.a. variance was predominant for all the characters except number of pods/cluster and number of pods/plant suggesting the importance of general combining ability. The parent selection 129 showed significant general combining ability effect for the characters days to flowering, number of pods per cluster, length of internode and seed/pod ratio. The parent selection 104 showed significant g.c.a. effects for the characters mean weight of pod, mean length of pod, number of seeds/pod and length of internode. The parent selection 145 showed significant g.c.a. effect for the characters mean length of pod, number of seeds/pod and seed/pod ratio. Kurutholapayar showed high g.c.a. effect for yield. Selection 129 was the best general combiner for earliness and pods/cluster. Selection 145 was the best general combiner for length of pod and number of seeds/pod.

The hybrid selection 145 x selection 104 was the best specific combiner for the characters number of pods/ cluster and seed/pod ratio. The cross selection 145 x selection 129 was the best specific combiner for mean weight of pod and number of seeds/pod. The hybrid

selection 145 x kurutholapayar was the best specific combiner for earliness. The cross selection 129 x selection 104 was the best specific combiner for the characters number of pods per plant and fruit yield/plant. For the character mean length of pod, the hybrid selection 129 x selection 7 and for length of internode, kurutholapayar x selection 123 were the best specific combiners.

Both additive and non-additive type of gene action were found for characters days to flowering, number of seeds/pod, length of internode and seed/pod ratio. Additive gene action was present in the characters mean weight of pod and mean length of pod. Non-additive gene action was found in the character number of pods/cluster.

Marked heterosis was found in various hybrids for some of the characters. The heterosis percent was calculated over mid and better parental values. A maximum heterosis of 118.99 percent was observed for the character fruit yield/plant followed by number of pods/ plant. The cross combination selection 145 x kurutholapayar showed maximum relative heterosis and selection 145 x selection 7 showed maximum heterobeltiosis for the character days to flowering. The hybrid selection 129 x selection 104 showed maximum relative heterosis for number of

pods/cluster and heterobeltiosis for number of pods/plant. The hybrid selection 104 x selection 123 showed maximum relative heterosis for number of pods/ plant and length of internode and heterobeltiosis for fruit yield/plant. For the character mean weight of pod, the cross selection 104 x selection 7 showed maximum heterobeltiosis. The hybrid kurutholapayar x selection 129 showed maximum relative heterosis for the characters mean weight of pod and number of seeds/pod. The maximum relative heterosis for mean length of pod and heterobeltiosis for number of pods/plant were shown by hybrid kurutholapayar x selection 7. The hybrid kurutholapayar x selection 123 showed maximum heterobeltiosis for the characters mean length of pod and number of seeds/pod. The hybrids kurutholapayar x selection 104 and selection 145 x selection 129 showed maximum relative heterosis and heterobeltiosis for seed/pod ratio and length of internode respectively. The hybrid selection 145 x selection 104 showed maximum relative heterosis for fruit yield/plant and heterobeltiosis for seed/pod ratio.

In general, the g.c.a. variance was found higher in all characters except number of pods/cluster, revealing the importance of additive type of gene action governing these characters. The importance of additive gene effects in most of characters indicated that improvement for these characters can be made through selection.

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COMBINING ABILITY IN VEGETABLE COWPEA
(Vigna unguiculata var-sesquipedalis)

By

V. REJATHA

THESIS

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ABSTRACT

A 6 x 6 diallel analysis was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani, during 1990, aimed at analysing the combining ability, gene action and heterosis of six vegetable cowpea (Vigna unguiculata var. Sesquipedalis) lines collected from the germplasm maintained in this department.

The experiment I consisted of crossing the six parental lines in all possible combinations, without reciprocals. The material for experiment II consisted of the six parental lines and fifteen hybrids. They were grown in a Randomised Block Design with three replications. The combining ability analysis was carried out based on method 2 under model I as suggested by Griffing (1956). The treatments showed significant differences in most of characters except number of pods/plant and fruit yield/plant.

The variance due to general combining ability was significant and higher in magnitude than specific combining ability for the characters days to flowering, mean weight of pod, mean length of pod, number of seeds/ pod, length of internode and seed/pod ratio. It was found that the parent selection 104 and selection 145 were the best general combiners for most of the characters studied. The parent selection 129 was the best general

combiner for earliness. The hybrids selection 145 x selection 129 was the best specific combiner for mean weight of pod and number of seeds/pod. The hybrid selection 145 x kurutholapayar was the best specific combiner for earliness.

The significance of g.c.a. and s.c.a. variances for most of characters indicate the importance of additive and non-additive gene action in controlling the inheritance of these characters. But additive gene action played a major role suggesting that improvement could be made through selection.

Heterosis was calculated over mid and better parental values. Maximum positive heterosis was found for the character fruit yield/plant. Since considerable heterosis was evident in most of the characters, heterosis breeding can be attempted in cowpea.