GENETIC STUDIES IN COWPEA

BY

P. CHANDRIKA

THESIS

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DECLARATION

I hereby declare that this thesis entitled "GENETIC STUDIES IN COWPEA" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

P. Chandrika

Vellanikkara,
20th June, 1979.

(P. Chandrika)

CERTIFICATE

Certified that this thesis is a record of research work done independently by Smt. P. Chandrika 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.

Vellanikkara,
20th June, 1979.

Dr. K.M. Narayanan Namboodiri,
Professor of Agrl. Botany,
College of Horticulture,
Vellanikkara.

CERTIFICATE

We, the undersigned, members of the advisory committee of Smt. P. Chandrika, a candidate for the degree of Master of Science in Agriculture with major in Agricultural Botany, agree that the thesis entitled "GENETIC STUDIES IN COWPEA" may be submitted by Smt. P. Chandrika in partial fulfilment of the requirements for the degree.

(Dr. K.M. Narayanan Namboodiri)
Chairman of the Advisory Committee.

(Dr. K. Kumaran)
Member.

(Dr. P.C. Sivaraman Nair) 18/7/89
Member

(Shri. P.V. Prabhakaran)
Member.

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P. Chandrika

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INTRODUCTION

INTRODUCTION

The average yield of pulses in Kerala which works out to about 340 Kg per hectare, is rather poor and is the lowest among the Indian States. With the increasing cost of almost all the agricultural inputs this group of crop plants calls for highly intensified research to produce really high yielding varieties to attract more farmers to the cultivation of these crops. The massive development programme for pulses in Kerala aims at stepping up the present production of about 14,000 tonnes to 5,00,000 tonnes by the end of the Sixth Plan period.

While most of the pulse crops have not proved very promising under the widely varying soils and heavy rainfall of Kerala, cowpea (Vigna unguiculata L.) due to its adaptability has turned up as a choice catch crop in the State. Out of the total estimated area of about 38 thousand hectares under pulses in Kerala, cowpea alone accounts for about 26 thousand hectares.

Cowpea in Kerala is a distinct pulse crop which is cultivated under certain highly contrasting situations. In the summer rice fallows where there

is vast scope for area increase the requirement is for early, erect varieties giving very high grain yields and with highly synchronised flowering to avoid huge expenditure on harvests.

The specialised system of cowpea cultivation in summer rice fallows specifically for vegetable purpose alone as practiced in certain areas like Manjeri in the state would require trailing varieties with long fleshy pods and a good flowering spread to assure vegetable over a longer period. Varieties with large number of small pods but giving high grain yields will be of no use at all for this situation.

In the third main system of cowpea culture in the state the crop is grown during the rainy kharif season in uplands and homesteads. Varieties preferred for this situation are dual purpose types with tolerably good yields both as tender vegetable pod and as vegetable grain.

As the different systems of cultivation in the state require varieties with different combinations of plant, pod and seed characters it has become necessary to identify proper donor varieties for these important

characters to enable the planning of fruitful breeding programmes.

With this background in view, the present study was taken up with the following main objectives:-

i) To estimate the variability for important economic characters in the cowpea germplasm available at the College of Horticulture, Vellanikkara,

ii) To work out the heritable components of variability for the various plant, pod and seed characters using genetic parameters like genotypic coefficient of variation, heritability and genetic gain,

iii) To identify promising donor varieties for improvement of the important economic characters and

iv) To estimate the genetic divergence among the varieties and to group them into clusters according to the magnitudes of genetic distances using Mahalanobis D^2-statistic.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Though cowpea is an important crop extensively grown in the tropical countries, studies estimating the extent of genetic divergence in its germplasm are found to be relatively few.

Karthikeyan (1963) appears to be the first to report in some detail the results of genetic studies with special reference to correlations between yield and its components, based on data from 20 cowpea varieties. Results of these studies showed that the number of pods exhibited the strongest association with yield, followed in order by the number of fruiting nodes, number of branches and number of leaves. Genotypic variability was found to be the largest with the number of fruiting nodes and this was followed in order by number of pods per plant, number of branches and seed yield.

Studies of Singh and Mehndiratta (1969) have shown that number of pods per plant had the highest genotypic coefficient of variation (52.52 per cent) and that high values of heritability estimates were exhibited by 100-seed weight (95.89 per cent), days to flowering

(88.79 per cent), pod length (80.45 per cent) and days to maturity (78.29 per cent). Expected genetic advance was found to be appreciable for number of branches, 100-grain weight, pod number, pod length and yield.

Borida et al. (1973) found that 100-seed weight exhibited the highest heritability followed by number of days to flowering and pod length. The highest genotypic coefficient of variation and genetic advance were shown by pod number per plant.

Results of a study of eight characters in twelve varieties by Veeraswamy et al. (1973) showed that the highest heritability was exhibited by pod length and the lowest by number of grains per pod. Genetic advance was found to be high in the case of weight of pods, length of pods, number of pods and grain yield. High values of both heritability and genetic advance were shown by pods per plant, weight of pods per plant and pod length.

Gopal Singh et al. (1977) have observed heritability to be low for number of seeds per pod and high for yield, number of pods and 100-seed weight.

Lakshmi and Goud (1977) reported that the genotypic coefficient of variation was higher for plant height, grain yield, number of pods per plant and 100-grain weight. They also observed high heritability accompanied by high genetic advance in the case of plant height, 100-seed weight and length of pod. Number of pods per plant and grain yield per plant were also reported to have comparatively low heritability and high genetic advance.

High heritability and genetic advance were noticed for 100-grain weight, yield of grain and yield of haulms by Sreekumar et al. (1978). The lowest heritability was recorded by number of grains per pod, while total duration showed the lowest value of genetic advance.

Significant positive association of grain yield with number of pods per plant has been reported by Singh and Mehndiratta (1969), Doku (1970) Borida et al. (1973) and Gopal Singh et al. (1977). Borida et al. (1973) have also reported positive correlation of grain yield with pod length and number of seeds per pod.

Studies of Kumar et al. (1976) have shown that pod yield was positively associated with branches per plant (0.561), pods per plant (0.844), pod length (0.532),

thickness of pod (0.576), days to flowering (0.613) and days taken to maturity (0.518). Analysing the regression values, these workers have also shown that the clusters per plant, pods per plant and 100-seed weight were the important characters in determining the pod yield.

Published works on grouping of cowpea varieties into clusters using Mahalanobis D^2-technique are very few; and such studies are not seen reported at all in this crop from any of the South Indian States.

Mehndiratta and Singh (1971) studied 40 varieties of cowpea mainly selected from Punjab for their genetic divergence using Mahalanobis D^2-technique. Among the six traits studied, seed size was found to be the most important character contributing towards genetic diversity while remaining traits made little contribution. The importance of seed size (100-grain weight) as a basis for grouping was also established by nonoverlapping of the clusters. Based on the genetic distances the 40 varieties studied could be grouped into eight clusters.

Reporting the results of their studies with sixty cowpea strains from 12 different countries Jayaprakash *et al.* (1974) grouped the varieties into 21 clusters

based on the genetic divergence estimated using Mahalanobis D^2 statistic. These studies revealed that wide genetic diversity was present in the material even from the same geographical region, and that genetic diversity was not related to geographical distribution. Seven out of the 21 clusters were each represented only by a single strain. The clusters were found to differ in all the characters from one another; particularly days to flowering and maturity showing large differences.

MATERIALS AND METHODS

MATERIALS AND METHODS

The investigations reported herein were carried out in the Department of Agricultural Botany, College of Horticulture, Vellanikkara during the years 1977-79.

A. Materials:

Two hundred and two cowpea varieties of diverse origin and plant characters collected from various sources like the Indian Agricultural Research Institute, New Delhi, the Tamil Nadu Agricultural University, Coimbatore and the Rice Research Station, Pattambi and maintained in the germplasm collection of the Botany Department of the College of Horticulture, Vellanikkara, were made use of for the present study.

B. Methods:

1. Experimental: Two field experiments were conducted during the khariff seasons of 1977-78 and 1978-79 at the Rice Research Station and Instructional Farm, Mannuthy, attached to the College of Horticulture, Vellanikkara.

In the preliminary field evaluation trial of 1977-78 season, an experiment in the Randomised Block

Design with two replications was laid out with 202 cowpea varieties, each variety with one single plant per replication. Sowing was done on ridges and a spacing of 1M x 1M was followed. Farm Yard Manure at the rate of 1000 kg/ha was applied and incorporated while ploughing, before the formation of the ridges. Ammonium sulphate, Super phosphate and Muriate of potash to supply NPK at the rate of 10:30:10 Kg/ha respectively were also applied after the final ploughing and before the ridge formation. The experimental plots were carefully maintained with timely spraying, earthing up, propping etc. At the time of earthing up which was done 20 days after sowing, a top dressing with ammonium sulphate to supply N at the rate of 10 Kg/ha was also given. Two border rows of the variety, C.152 were grown alround each of the two replications to avoid any border effect and also to assure protection to the experimental crop.

Observations were taken from each of the plants under the experiment on the following fifteen characters:-

1. Habit of growth
2. Number of primary branches
3. Days to commence flowering

4. Flowering spread (days from commencement to completion)
5. Number of flowers per plant
6. Number of pods per plant
7. Length of pod
8. Weight of pod
9. Number of seeds per pod
10. 100-seed weight
11. Length of seed
12. Breadth of seed
13. Thickness of seed
14. Pod yield per plant
15. Seed yield per plant

The following procedures were followed in taking observations on the various characters studied:-

Habit of growth: The plant habit, whether erect, semi-erect or trailing was specifically recorded.

Number of primary branches per plant: Total number of primary branches per plant was recorded after full maturity of the plants.

Days to commence flowering: Date of opening of the first flower in each plant was recorded and from

these the number of days from sowing to commencement of flowering was computed.

Flowering spread: The number of days between the date of opening of the first flower and that of the last flower was taken as the flowering spread.

Number of flowers per plant: The total number of flowers produced by each plant was worked out by counting the total number of flowers opened per day from the first day of flowering upto 45 days thereon in each variety.

Number of pods per plant: Pods harvested periodically from each plant was separately kept and counted to obtain the total number of pods per plant.

Length of pod: From each plant, 10 random pods selected after the harvest and drying were measured with an ordinary scale and length recorded in cm.

Weight of pod: The same 10 pods used for length measurements were used for recording pod weight also. The pod weight in g was recorded using an electric balance.

Number of seeds per pod: The average number of seeds per pod in each plant was worked out by counting seeds in the 10 pods used for length and weight recording.

100-seed weight: One hundred seeds from each plant after drying and seed extraction from the pods were weighed using an electric precision balance and weight recorded in g.

Length, breadth and thickness of seed: Length, breadth and thickness of 10 seeds per plant were measured using a Mitutoyo micrometer and recorded in mm.

Pod yield per plant: Weight of the total pods harvested was recorded in the case of each plant in g after drying before threshing and extraction of seeds.

Seed yield per plant: The total pods harvested from each plant were dried and threshed and seeds extracted and weight of these seeds recorded in g.

Based on the results of the preliminary field evaluation trial of 1977-78 season, 56 types were selected from among the 202 types studied, the selection being based on the principle of assuring representation for the types showing the maximum, minimum and mid values of all the important characters studied. The brief details about these 56 types are furnished below in Table 1.

Table 1. Brief particulars of the 56 cowpea varieties selected for detailed study

No.	Name of the variety	Source of collection	Growth habit
1	GP. M.S. 9314	T.N.A.U., Coimbatore	Erect
2	GP. PLS. 63	do.	Trailing
3	GP. M.S. 9082/2	do.	Semi-erect
4	GP. PLS. 139	do.	Erect
5	GP. J.C. 5	do.	Semi-erect
6	GP. ECR. 1548	do.	Trailing
7	GP. C. 2110	do.	Trailing
8	GP. PLS. 26	do.	Erect
9	GP. African	do.	Trailing
10	GP. C. 13	do.	Trailing
11	GP. PLS. 110	do.	Semi-erect
12	GP. M.S. 9804	do.	Trailing
13	GP. M.S. 8970/1	do.	Semi-erect
14	GP. C. 57	do.	Erect
15	GP. T. 536	do.	Erect
16	GP. M.S. 9760	do.	Semi-erect
17	GP. M.S. 9081	do.	Semi-erect
18	GP. C. 152	do.	Semi-erect
19	IC. 20729	I.A.R.I., New Delhi	Semi-erect
20	IC. 20419	do.	Erect
21	Red Seeded Selection	do.	Erect
22	Calicut-78	R.R.S., Pattambi	Semi-erect
23	Palghat Vellapayar	do.	Erect
24	Pattambi local - 1	do.	Semi-erect
25	Moovatupuzha - 1	do.	Erect

(Continued)

Table 1 (Continued)

No.	Name of the variety	Source of collection	Growth habit
26	Branca	R.R.S., Pattambi	Erect
27	Manjeri local	do.	Trailing
28	C. 152 x New Era - 1	do.	Trailing
29	No. 51	do.	Trailing
30	Manjeri mottled - dark	do.	Trailing
31	Culture-1	do.	Semi-erect
32	P. 118	do.	Erect
33	Kayamkulam	do.	Semi-erect
34	Pannithodan - early	do.	Erect
35	T. 20	do.	Erect
36	Calicut-21	do.	Erect
37	Pannithodan - late	do.	Erect
38	Kolinjipayar	do.	Erect
39	Nedumangad-1	do.	Semi-erect
40	Kazhakkootam-4	do.	Erect
41	Sasthamcottah-2	do.	Trailing
42	Sasthamcottah-6	do.	Trailing
43	Thodupuzha-3	do.	Semi-erect
44	Mississippi x Iron Grey	do.	Erect
45	No. 2-1 x Dixibe	do.	Semi-erect
46	No. 2-1 x Iron Grey	do.	Erect
47	C. 152 x N.E.-I (Bangalore)	do.	Semi-erect
48	C. 152 x N.E.-II (Bangalore)	do.	Semi-erect
49	C. 152 x No. 2-1	do.	Trailing
50	N. 62	do.	Trailing
51	Kolinjipayar - white	do.	Erect
52	Mayyanad local	do.	Trailing
53	Manjeri - brown	do.	Trailing

(Continued)

Table 1 (Continued)

No.	Name of the variety	Source of collection	Growth habit
54	Manjeri mottled - light	R.R.S., Pattambi	Trailing.
55	Manjeri - black	do.	Trailing
56	Pusa Phalguni	do.	Erect

In the second field trial of 1978-79 season, an experiment with the above 56 types was laid out in a Randomised Block Design with two replications and a plot size of 1 M x 10 M with eleven single plants in each plot. The spacing, manuring and other cultural operations were the same as those followed for the first season. Two border rows of the variety C. 152 were grown alround each of the two replications to avoid any border effect and also to assure protection to the experimental crop.

Observations on the 15 characters mentioned earlier were recorded adopting the same procedure as in the previous case, the observation being confined to nine individual plants in each treatment leaving two border plants on either side.

2. Statistical analysis: The analyses of the data were done in a Micro 2200 computor of the Department of Statistics, College of Agriculture, Vellayani.

Though data on 15 characters were recorded, only those on 14 characters other than the growth habit were subjected to statistical analysis for estimation of variance, heritability and genetic gain. For the working out of genetic divergence using Mahalanobis D^2 statistic, only 12 characters excluding the two characters viz., number of flowers and pod yield, were used.

While procedures outlined by Singh and Choudhary (1976) were followed for the calculation of all other parameters, the calculation of Mahalanobis D^2 and the grouping of the varieties into clusters were done following Tocher's method (Rao, 1952).

RESULTS

RESULTS

The data on the general variability among the 202 cowpea varieties evaluated during the khariff season of 1977-78 are presented in Appendix II, an abstract of which is given in Table 2. The data about the 56 varieties evaluated during the khariff season of 1978-79 with regard to 14 characters are presented in Tables 3 to 20. The 56 varieties are ranked based on their mean values in the descending order separately for each of the characters in Tables 3 to 16. Analysis of variance for the 14 characters showed that the differences between the 56 varieties for all the characters were highly significant even at a probability level of one per cent. An abstract of the analysis of variance is furnished in Table 17. The ranges and the general mean values of the different characters among the varieties are given in Table 18. In Table 19 the estimates of phenotypic variance (Vp) and its genetic (Vg) and environmental (Ve) components are given. Estimated phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (H) and genetic gain (GG) are furnished in Table 20. Characteristics of the six high

yielders and six poor yielders among the 56 varieties are furnished in Table 21.

Results of grouping of the 56 varieties into clusters using Mahalanobis D^2 statistic in respect of 12 characters are furnished in Tables 22 to 26. In Table 22 the details of the varieties constituting the different clusters and the average intra-cluster distances are given. The average inter-cluster distances between the different clusters are furnished in Table 23. Grouping of clusters according to average inter-cluster distances is done in Table 24. Table 25 gives the cluster means for the 12 characters on the basis of which the varieties were grouped into clusters. Details of varietal clusters of promise as donors for improvement of some important plant, pod and seed characters are given in Table 26. In the cluster diagram given in Fig. 1 eight varietal clusters showing high distances are plotted bringing out the relative genetic distances between each of them.

General variability

Results of the preliminary evaluation of 202 cowpea varieties presented in Appendix II and Table 2 reveal the high amount of variability present in the varietal collection.

Table 2. Range of variability for different characters among the 202 cowpea varieties studied in Khariff 1977-78

S.No.	Character	Range and the varieties showing the maximum and minimum values			
		Maximum		Minimum	
		Value	Variety	Value	Variety
1	Number of primary branches per plant	13	Type No. 14	1	Type No.206
2	Days to commence flowering	73	" 10	34	" 88
3	Flowering spread (days)	44	" 214	8	" 74
4	Number of pods per plant	143	" 109	1	" 28
5	Length of pod (cm)	26.1	" 80	8.2	" 28
6	Weight of pod (g)	4	" 96	0.6	" 69
7	Number of seeds per pod	16.2	" 194	6.7	" 106
8	Seed yield per plant (g)	115	" 109	1	" 28
9	100-seed weight (g)	18.3	" 80	4.0	" 66
10	Length of seed (mm)	11.0	" 83	4.6	" 41
11	Breadth of seed (mm)	7.4	" 103	3.6	" 41
12	Thickness of seed (mm)	6.2	" 190	2.6	" 124
13	Number of flowers per plant	193	" 109	17	" 24
14	Pod yield per plant (g)	165	" 109	1.5	" 28

Results of the final evaluation trial with the selected 56 varieties are presented character-wise below.

Number of primary branches per plant

The mean number of primary branches per plant among the cowpea varieties under study ranged from 2.89 to 8.22 with a general mean of 5.33. Among the varieties, variety 9 recorded the maximum number of branches (8.22), whereas variety 56 had the minimum number of branches (2.89) per plant. The differences among the varieties were highly significant (Tables 3, 17 and 18).

The estimated phenotypic variance (Vp) for this character was 2.41, and could be apportioned between genotypic variance (Vg) and environmental variance (Ve) as 0.68 and 1.73 respectively, indicating marked influence of environmental effect on this character. The phenotypic and genotypic coefficients of variation (PCV=29.11 and GCV=15.45) also confirmed that the major part of variation for this character was due to environmental effect. Heritability (28.16 per cent) and genetic gain (17.78 per cent) were also found to be low for this character (Tables 19 and 20).

Table 3. Ranking of the varieties for number of primary branches per plant

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	9	8.22	29	8	5.28
2	26	7.95	30	22	5.28
3	16	7.56	31	51	5.23
4	14	7.28	32	17	5.06
5	29	6.95	33	37	5.06
6	15	6.94	34	46	5.06
7	12	6.73	35	21	5.00
8	2	6.45	36	40	5.00
9	48	6.45	37	44	4.84
10	53	6.45	38	35	4.73
11	55	6.45	39	31	4.61
12	18	6.34	40	23	4.56
13	11	6.23	41	41	4.56
14	42	6.22	42	27	4.45
15	24	6.17	43	50	4.39
16	6	6.11	44	33	4.11
17	38	6.06	45	1	4.06
18	54	6.06	46	10	3.95
19	4	5.89	47	36	3.89
20	7	5.89	48	43	3.84
21	52	5.89	49	20	3.73
22	28	5.84	50	34	3.72
23	47	5.78	51	45	3.67
24	49	5.78	52	32	3.61
25	3	5.72	53	13	3.50
26	25	5.67	54	39	3.45
27	30	5.45	55	19	3.23
28	5	5.28	56	56	2.89
		General Mean	5.33		
		C.D.(P = 0.05)	2.63		

Days to commence flowering

The general mean for this character was 53.09 with a range of 39.78 to 67.84 among the varieties. Variety 4 recorded the maximum value for this character (67.84), while variety 32 was the first to commence flowering taking only an average of 39.78 days from sowing. The differences among the varieties for this character were highly significant (Tables 4, 17 and 18).

Phenotypic variance, genotypic variance and environmental variance for this character among the varieties were estimated to be 36.17, 34.21 and 1.96 respectively. Phenotypic and genotypic coefficients of variation (PCV and GCV) were 11.33 and 11.02 respectively, showing that the predominant influence on variability for this character was of the genetic component. Heritability for this character was found to be very high (94.60 per cent) and the genetic gain was 22.08 per cent (Tables 19 and 20).

Flowering spread (days from commencement to completion)

Among the varieties under trial the maximum flowering spread was noted in the case of variety 21 (41.72 days) and the minimum in the case of variety 18

Table 4. Ranking of varieties for days to commence flowering

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	4	67.84	29	8	51.89
2	5	67.84	30	42	51.62
3	24	63.67	31	1	51.34
4	38	63.64	32	17	51.11
5	33	60.73	33	35	51.00
6	55	60.22	34	51	50.84
7	27	60.00	35	41	50.78
8	40	59.95	36	3	50.28
9	10	59.17	37	50	50.12
10	36	58.67	38	12	50.06
11	43	58.67	39	39	49.78
12	54	57.84	40	34	49.62
13	7	57.28	41	30	49.50
14	6	57.06	42	49	49.39
15	9	57.06	43	44	49.34
16	52	56.72	44	21	48.67
17	53	55.94	45	20	48.61
18	15	55.72	46	31	48.50
19	22	55.34	47	56	48.12
20	29	55.06	48	2	48.06
21	26	54.95	49	28	47.95
22	25	54.28	50	23	47.61
23	37	54.28	51	45	47.50
24	46	54.11	52	13	47.11
25	18	53.23	53	11	44.45
26	16	52.78	54	47	42.06
27	14	52.56	55	48	41.51
28	19	52.11	56	32	39.78
		General Mean		53.09	
		C.D.(P = 0.05)		2.79	

(13.28 days). Differences between the varieties under study for this character were found to be highly significant, with a range of variability between 13.28 and 41.72 days and a general mean of 25.02 days (Tables 5, 17 and 18).

The genetic component of variance for this character was found to be high with a high heritability of 82.75 per cent and genetic gain of 44.32 per cent (Vp = 42.31; Vg = 35.01; Ve = 7.30; PCV = 26.00 and GCV = 23.65) (Tables 19 and 20).

Number of pods per plant

The range of variability for this character was from 7.45 (variety 6) to 95.72 (variety 38) with a general mean of 31.46. The varietal differences for this character were found to be highly significant (Tables 6, 17 and 18).

The genetic component of the total variance for this character was very high (Vp = 455.93; Vg = 417.68; PCV = 67.87 and GCV = 64.96). The heritability and genetic gain for this character were estimated as 96.61 per cent and 128.08 per cent respectively (Tables 19 and 20).

Table 5. Ranking of the varieties for flowering spread (days from commencement to completion)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	21	41.72	29	14	24.34
2	24	36.73	30	40	23.95
3	19	35.28	31	48	23.56
4	5	35.11	32	56	23.39
5	17	33.67	33	34	23.17
6	55	33.06	34	43	23.00
7	2	32.95	35	51	23.00
8	54	32.62	36	50	22.62
9	9	32.22	37	35	22.50
10	10	31.67	38	45	22.50
11	1	30.72	39	7	22.34
12	53	30.28	40	29	22.22
13	49	30.00	41	11	21.22
14	16	29.56	42	31	20.78
15	20	29.56	43	38	20.78
16	33	29.33	44	47	20.11
17	27	28.34	45	28	19.72
18	25	28.00	46	41	19.17
19	23	27.67	47	39	19.12
20	46	26.62	48	13	18.67
21	22	26.56	49	42	17.84
22	52	26.11	50	44	17.56
23	3	26.00	51	8	17.50
24	37	25.95	52	32	15.91
25	12	25.12	53	15	15.84
26	4	24.73	54	6	15.12
27	30	24.67	55	26	13.34
28	36	24.45	56	18	13.28
		General Mean		25.02	
		C.D.(P = 0.05)		5.40	

Table 6. Ranking of the varieties for number of pods per plant

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	38	95.72	29	9	24.95
2	51	83.12	30	28	24.89
3	46	79.95	31	7	23.45
4	47	78.23	32	29	22.50
5	26	72.39	33	23	22.28
6	54	65.78	34	40	21.84
7	42	61.89	35	55	21.84
8	16	55.44	36	49	20.83
9	18	53.89	37	17	20.56
10	14	48.12	38	3	19.89
11	50	47.36	39	8	19.83
12	25	38.84	40	1	19.34
13	5	38.45	41	11	18.67
14	39	38.23	42	10	17.06
15	41	37.34	43	15	16.67
16	31	35.67	44	20	16.22
17	24	35.28	45	4	16.17
18	43	34.73	46	27	15.67
19	2	33.84	47	45	15.50
20	22	33.78	48	35	15.11
21	44	31.67	49	37	10.78
22	30	31.50	50	34	10.56
23	48	29.61	51	21	10.28
24	52	29.17	52	19	10.00
25	53	27.18	53	56	8.73
26	12	26.84	54	32	8.50
27	36	25.22	55	33	7.56
28	13	25.06	56	6	7.45
		General Mean		31.46	
		C.D.(P = 0.05)		12.37	

Length of pod

The varieties under study showed good amount of variation for this character with variety 19 showing the maximum pod length (27.32 cm) and the variety 42 showing the minimum (9.37 cm). The overall mean pod length of the varieties was 15.45 cm and the varietal differences were found to be highly significant (Tables 7, 17 and 18).

Out of the phenotypic variance of 16.23 for this character 15.30 was constituted by the genetic component. Heritability for this character was also found to be high (PCV = 26.08; GCV = 25.32 and H = 94.23) and genetic gain was estimated as 50.62 per cent (Tables 19 and 20).

Weight of pod

With the variety 19 ranking as the first and variety 51 as the last, the range of varietal mean values was found to be from 0.69 g to 3.09 g with an overall mean of 1.60 g. The differences between the varieties were highly significant (Tables 8, 17 and 18)

The genetic component of variance for this character was found to be high with high estimates of

Table 7. Ranking of the varieties for length of pod (cm)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	19	27.32	29	14	14.46
2	20	23.89	30	18	14.28
3	52	22.71	31	2	14.03
4	30	22.22	32	12	13.75
5	56	21.65	33	6	13.69
6	53	20.66	34	46	13.58
7	54	20.52	35	32	13.56
8	55	20.37	36	11	13.49
9	33	19.60	37	21	13.45
10	22	19.14	38	7	13.43
11	36	18.89	39	8	13.30
12	34	18.81	40	25	13.23
13	29	18.60	41	3	12.89
14	28	18.28	42	17	12.86
15	31	17.92	43	47	12.55
16	43	17.54	44	26	12.53
17	48	17.43	45	35	12.46
18	49	17.29	46	5	12.09
19	44	17.28	47	4	11.98
20	27	16.92	48	13	11.64
21	45	16.79	49	50	11.41
22	1	16.68	50	9	10.56
23	24	15.91	51	39	10.56
24	23	15.18	52	41	10.40
25	10	14.99	53	38	10.04
26	37	14.74	54	40	9.63
27	15	14.67	55	51	9.59
28	16	14.54	56	42	9.37
		General Mean		15.45	
		C.D.(P = 0.05)		1.94	

Table 8. Ranking of the varieties for weight of pod (g)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	19	3.09	29	2	1.48
2	30	2.92	30	8	1.48
3	20	2.69	31	18	1.48
4	24	2.65	32	7	1.45
5	53	2.49	33	46	1.45
6	55	2.42	34	47	1.43
7	34	2.39	35	28	1.42
8	54	2.23	36	25	1.41
9	56	2.20	37	37	1.38
10	22	2.14	38	11	1.34
11	15	2.12	39	32	1.29
12	49	2.12	40	4	1.19
13	52	2.11	41	23	1.10
14	48	2.10	42	50	1.07
15	33	2.09	43	16	1.04
16	36	2.09	44	5	1.00
17	29	2.08	45	26	0.99
18	1	2.05	46	9	0.95
19	6	1.79	47	35	0.90
20	44	1.76	48	41	0.86
21	31	1.74	49	17	0.85
22	27	1.71	50	21	0.85
23	10	1.63	51	39	0.83
24	3	1.61	52	42	0.82
25	45	1.57	53	38	0.81
26	14	1.56	54	40	0.81
27	43	1.56	55	13	0.79
28	12	1.49	56	51	0.69
		General Mean		1.60	
		C.D.(P = 0.05)		2.24	

heritability and genetic advance (Vp = 0.37; Vg = 0.36; PCV = 38.17; GCV = 37.50; H = 96.51 per cent and GG = 75.89 per cent) (Tables 19 and 20).

Number of seeds per pod

The range of variability for this character was found to be between 7.91 (Variety 17) and 16.66 (Variety 19) and the overall mean value of the 56 varieties was found to be 12.33. The varietal differences were found to be highly significant (Tables 9, 17 and 18).

The apportionment of the total variance for this character between the genetic and environmental components was found to be with a predominance for the genetic component (Vg = 6.45). The heritability was found to be high (96.89 per cent) and the estimated genetic gain was 41.75 per cent (Tables 19 and 20)

Seed yield per plant

The variability for this ultimate economic character was found to be very high among the varieties studied, the highest yield of 97.00 g (Variety 38) being almost 25 times the lowest yield of 4.00 g

Table 9. Ranking of the varieties for number of seeds per pod

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	19	16.66	29	20	12.04
2	30	16.44	30	37	11.81
3	52	16.22	31	39	11.69
4	47	16.23	32	50	11.55
5	36	16.15	33	43	11.45
6	34	16.07	34	9	11.41
7	49	15.82	35	55	11.41
8	15	15.25	36	16	11.22
9	18	15.17	37	24	11.09
10	29	15.07	38	2	11.08
11	44	14.82	39	26	10.98
12	53	14.43	40	28	10.86
13	56	14.42	41	10	10.44
14	14	14.38	42	8	10.31
15	48	14.19	43	51	10.26
16	22	14.09	44	13	10.08
17	33	14.05	45	3	9.96
18	12	13.99	46	23	9.94
19	6	13.96	47	5	9.62
20	11	13.69	48	4	9.59
21	1	13.42	49	40	9.41
22	46	13.27	50	32	9.39
23	7	13.05	51	41	9.31
24	25	13.05	52	35	8.64
25	27	12.75	53	21	8.53
26	31	12.71	54	38	8.35
27	54	12.41	55	42	8.22
28	45	12.22	56	17	7.91
		General Mean		12.33	
		C.D.(P = 0.05)		0.91	

(Variety 56). The overall mean yield was found to be 29.89 g and the varietal differences were highly significant (Tables 10, 17 and 18).

This character was found to show high estimates of heritability and genetic gain (H = 81.57 per cent and GG = 109.76 per cent) (Tables 19 and 20).

100-seed weight

The mean 100-seed weight among the varieties ranged from 4.53 g (Variety 51) to 18.50 g (Variety 19) with an overall mean of 8.82 g. The differences between the varieties were highly significant (Tables 11, 17 and 18).

Genetic component of variance for this character was found to be very high (Vp = 8.36; Vg = 8.13) and the heritability was found to be of the order of 97.19 per cent. Genetic gain for this character was estimated to be 65.65 per cent (Tables 19 and 20).

Length of seed

Mean length of seed among the varieties under study ranged between 4.56 mm (Variety 51) and 11.20 mm (Variety 20) with an overall mean of 7.05 mm. The

Table 10. Ranking of the varieties for seed yield per plant (g)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	38	97.00	29	23	26.88
2	47	71.74	30	28	25.17
3	46	71.66	31	1	24.39
4	54	69.61	32	3	24.05
5	26	50.83	33	8	23.94
6	44	47.44	34	39	23.22
7	43	46.50	35	52	23.11
8	18	45.06	36	11	22.89
9	30	43.94	37	20	22.39
10	31	43.61	38	13	19.56
11	7	42.89	39	45	17.72
12	24	42.16	40	15	17.11
13	12	42.05	41	9	15.94
14	22	41.75	42	19	15.94
15	51	40.50	43	55	15.00
16	2	40.44	44	17	14.61
17	14	38.05	45	27	13.28
18	29	37.28	46	40	12.72
19	48	36.27	47	34	11.83
20	50	36.11	48	4	11.44
21	16	34.67	49	35	9.44
22	53	31.77	50	32	9.00
23	36	31.33	51	33	8.05
24	42	30.50	52	37	8.00
25	5	30.39	53	10	7.67
26	41	29.22	54	21	7.11
27	49	28.38	55	6	6.11
28	25	26.94	56	56	4.00
		General Mean		29.89	
		C.D.(P = 0.05)		16.76	

Table 11. Ranking of the varieties for 100 - seed weight (g)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	19	18.50	29	11	8.47
2	20	16.47	30	7	8.23
3	1	15.67	31	17	8.10
4	45	13.47	32	8	8.07
5	32	11.90	33	26	7.96
6	29	11.60	34	18	7.91
7	43	11.50	35	24	7.84
8	30	11.15	36	49	7.81
9	53	10.97	37	25	7.53
10	33	10.89	38	14	7.24
11	10	10.75	39	37	7.20
12	52	10.54	40	38	6.90
13	36	10.52	41	42	6.75
14	27	10.35	42	47	6.58
15	34	10.04	43	22	6.24
16	3	10.06	44	13	6.23
17	44	10.03	45	28	6.23
18	6	10.00	46	40	6.19
19	16	9.92	47	9	6.07
20	31	9.75	48	15	5.87
21	41	9.61	49	21	5.61
22	2	9.50	50	5	5.47
23	46	9.50	51	56	5.47
24	55	9.49	52	4	5.45
25	48	9.47	53	39	5.44
26	54	9.15	54	50	5.43
27	35	8.75	55	23	4.59
28	12	8.56	56	51	4.53
		General Mean		8.82	
		C.D.(P = 0.05)		0.97	

varietal differences for this character were found to be highly significant (Tables 12, 17 and 18).

Major part of the variance for this character was found to be genetic (Vp = 2.26 and Vg = 2.23) and the heritability was estimated as 98.85 per cent. The phenotypic and genotypic coefficients of variation were 21.32 and 21.20 respectively and the estimated genetic gain for this character was 43.41 per cent (Tables 19 and 20).

Breadth of seed

Maximum breadth of seed (8.14 mm) was recorded in the case of variety 34, and the minimum (3.63 mm) in the case of variety 51. The overall mean for this character among the varieties studied was 5.25 mm. Differences among the varieties for this character were seen to be highly significant (Tables 13, 17 and 18).

The genetic component of total variance for this character was found to be quite high and the heritability was also found to be high (Vp = 0.72; Vg = 0.63; PCV = 16.14; GCV = 15.07; H = 87.19 per cent and GG = 28.99) (Tables 19 and 20).

Table 12. Ranking of the varieties for length of seed (mm)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	20	11.20	29	37	6.74
2	19	10.51	30	6	6.52
3	34	10.08	31	26	6.50
4	53	9.42	32	42	6.48
5	52	9.41	33	15	6.43
6	55	9.35	34	9	6.37
7	54	9.15	35	12	6.32
8	30	8.62	36	2	6.31
9	27	8.59	37	17	6.31
10	56	8.56	38	8	6.30
11	36	8.37	39	38	6.27
12	22	8.25	40	11	6.22
13	45	8.09	41	44	6.22
14	33	8.04	42	3	6.11
15	31	8.01	43	18	6.00
16	43	7.81	44	25	5.90
17	1	7.80	45	13	5.63
18	21	7.66	46	49	5.56
19	46	7.48	47	40	5.53
20	32	7.36	48	50	5.52
21	29	7.32	49	39	5.47
22	23	7.21	50	5	5.42
23	41	7.14	51	28	5.28
24	14	7.13	52	4	5.24
25	48	7.05	53	16	5.14
26	35	6.99	54	47	5.02
27	10	6.94	55	7	4.76
28	24	6.74	56	51	4.56
		General Mean		7.05	
		C.D.(P = 0.05)		0.32	

Table 13. Ranking of the varieties for breadth of seed (mm)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	34	8.14	29	12	5.23
2	27	7.53	30	41	5.21
3	56	6.32	31	31	5.19
4	52	6.29	32	55	5.16
5	32	6.23	33	24	5.14
6	1	6.21	34	23	5.11
7	14	6.07	35	25	5.08
8	22	5.93	36	9	5.07
9	43	5.93	37	11	5.05
10	26	5.83	38	47	5.01
11	29	5.73	39	30	4.76
12	45	5.70	40	16	4.72
13	15	5.67	41	17	4.69
14	19	5.64	42	28	4.57
15	53	5.64	43	21	4.53
16	2	5.61	44	50	4.48
17	20	5.58	45	49	4.45
18	48	5.57	46	4	4.44
19	10	5.54	47	38	4.42
20	33	5.52	48	35	4.41
21	8	5.47	49	7	4.36
22	5	5.44	50	13	4.36
23	54	5.44	51	37	4.35
24	6	5.42	52	40	4.32
25	44	5.42	53	42	4.25
26	36	5.40	54	39	4.20
27	46	5.40	55	18	3.71
28	3	5.39	56	51	3.63
		General Mean		5.25	
		C.D.(P = 0.05)		0.61	

Thickness of seed

The varietal differences for this character were highly significant and the mean values ranged from 3.25 mm (Variety 18) to 5.51 mm (Variety 20) with an overall mean of 3.98 mm (Tables 14, 17 and 18).

Phenotypic and genotypic variances for this character were 0.26 and 0.22 respectively and the heritability was estimated to be 84.41 per cent. The estimated genetic gain for this character was 22.41 and the phenotypic and genotypic coefficients of variation were 12.39 and 11.84 respectively (Tables 19 and 20).

Number of flowers per plant

The varieties under study showed wide variability for the total number of flowers produced, the maximum being 148.94 (Variety 2) and the minimum 21.11 (Variety 56). The varietal differences for this character were highly significant (Tables 15, 17 and 18).

The total variance for this character (Vp = 988.69) was mostly contributed by genetic component (Vg = 792.93) and the phenotypic and genotypic coefficients of variation for this character were 43.82 and 39.24 respectively. The estimates of heritability (80.20 per cent) and

Table 14. Ranking of the varieties for thickness of seed (mm)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	20	5.51	29	32	4.03
2	34	5.20	30	47	4.03
3	14	5.17	31	3	3.98
4	49	5.15	32	52	3.72
5	23	4.81	33	9	3.70
6	45	4.55	34	5	3.69
7	15	4.50	35	28	3.66
8	10	4.48	36	31	3.64
9	2	4.42	37	30	3.63
10	22	4.41	38	17	3.63
11	6	4.40	39	33	3.60
12	48	4.31	40	21	3.56
13	46	4.29	41	53	3.55
14	43	4.28	42	25	3.52
15	8	4.27	43	37	3.51
16	16	4.27	44	13	3.50
17	19	4.21	45	54	3.50
18	1	4.19	46	26	3.49
19	56	4.18	47	40	3.49
20	44	4.16	48	50	3.48
21	11	4.15	49	55	3.47
22	41	4.15	50	4	3.44
23	35	4.14	51	38	3.42
24	7	4.13	52	39	3.42
25	24	4.11	53	27	3.33
26	12	4.09	54	42	3.31
27	35	4.09	55	51	3.30
28	29	4.07	56	18	3.25

General Mean 3.98

C.D.(P = 0.05) 0.40

Table 15. Ranking of the varieties for number of flowers per plant

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	2	148.94	29	12	71.67
2	38	137.94	30	27	69.44
3	26	128.11	31	40	69.00
4	25	124.89	32	44	68.28
5	24	123.28	33	9	67.55
6	46	114.67	34	22	66.61
7	1	110.50	35	39	64.72
8	47	108.94	36	32	64.33
9	51	107.71	37	7	61.00
10	23	101.39	38	43	52.72
11	36	95.66	39	52	51.38
12	16	95.33	40	30	51.11
13	42	95.33	41	13	51.00
14	54	91.16	42	53	50.61
15	14	90.45	43	49	48.00
16	18	89.11	44	45	45.88
17	50	88.27	45	35	42.89
18	8	85.05	46	55	42.55
19	29	81.72	47	37	40.94
20	17	78.05	48	19	40.66
21	31	77.67	49	15	38.52
22	5	77.50	50	20	35.28
23	48	77.33	51	33	32.61
24	10	75.89	52	6	30.89
25	41	74.83	53	21	30.56
26	3	74.45	54	34	30.33
27	4	74.34	55	11	28.17
28	28	72.83	56	56	21.11
		General Mean		71.76	
		C.D.(P = 0.05)		27.98	

genetic gain (72.40 per cent) were also high for this character (Tables 19 and 20).

Pod yield per plant

Around an overall mean of 42.18 g the variability for pod yield among the 56 varieties studied ranged from 7.27 g (Variety 56) to 109.11 g (Variety 38). The varietal differences for this character were found to be highly significant (Tables 16, 17 and 18).

Genetic component appeared to contribute very highly to the total variance for this character (Vp = 635.22 and Vg = 490.07). Heritability and genetic gain for this character were estimated as 77.15 per cent and 94.96 per cent respectively (Tables 19 and 20).

While each of the Tables from 3 to 16 gives only information about one single character in respect of all the varieties, information on all the characters in respect of 12 selected types representing the two extremes of yield potential is furnished in Table 21.

Genetic divergence among the varieties

The 56 varieties under study fell into 17 clusters, out of which seven clusters were each

Table 16. Ranking of the varieties for pod yield per plant (g)

Rank No.	Var. No.	Mean value	Rank No.	Var. No.	Mean value
1	38	109.11	29	28	38.72
2	47	104.11	30	52	37.00
3	54	101.72	31	1	36.00
4	46	89.11	32	41	36.00
5	26	78.50	33	55	35.05
6	30	78.11	34	3	34.94
7	22	63.55	35	8	34.67
8	18	59.94	36	15	34.61
9	31	58.00	37	19	31.77
10	43	57.17	38	11	30.17
11	44	56.66	39	27	30.00
12	16	56.44	40	13	26.55
13	51	55.50	41	45	24.44
14	7	55.28	42	9	24.22
15	2	54.33	43	17	21.50
16	12	53.11	44	39	20.38
17	14	52.88	45	23	20.32
18	36	52.77	46	34	20.11
19	48	51.28	47	40	19.66
20	53	49.61	48	4	18.06
21	29	48.83	49	33	16.83
22	25	48.11	50	35	15.44
23	50	46.50	51	37	14.50
24	42	46.11	52	6	13.55
25	24	39.66	53	32	13.50
26	20	39.55	54	10	12.00
27	5	39.33	55	21	10.22
28	49	38.83	56	56	7.27
		General Mean		42.18	
		C.D.(P = 0.05)		24.10	

Table 17. Abstract of Analysis of Variance for the different characters

S.No.	Characters	Mean square values		F value * for varieties	C.D.	
		Varieties (d.f.=55)	Error (d.f.=55)		P=0.05	P=0.01
1	Number of primary branches per plant	3.17	1.73	1.83	2.63	3.50
2	Days to commence flowering	70.38	1.95	36.03	2.79	3.72
3	Flowering spread (days from commencement to completion)	77.33	7.30	10.60	5.40	7.19
4	Number of pods per plant	873.60	38.25	22.84	12.37	16.34
5	Length of pod (cm)	31.53	0.94	33.65	1.94	2.58
6	Weight of pod (g)	0.73	0.01	58.56	2.24	2.98
7	Number of seeds per pod	13.10	0.21	58.52	0.91	1.21
8	Seed yield per plant (g)	692.13	70.27	9.85	16.76	22.32
9	100-seed weight (g)	16.49	0.23	70.17	0.97	1.29
10	Length of seed (mm)	4.49	0.03	171.89	0.32	0.43
11	Breadth of seed (mm)	1.34	0.09	14.59	0.61	0.81
12	Thickness of seed (mm)	0.48	0.04	11.81	0.40	0.53
13	Number of flowers per plant	1781.61	195.76	9.10	27.98	37.27
14	Pod yield per plant (g)	1125.29	145.16	7.75	24.10	32.10

* All P values significant at 1 per cent level

Table 18. Range, mean and standard error of mean of the different characters

S.No.	Character	Range		Mean	Standard error of mean
		From	To		
1	Number of primary branches per plant	2.89	8.22	5.33	0.124
2	Days to commence flowering	39.78	67.84	53.09	0.132
3	Flowering spread (days from commencement to completion)	13.28	41.72	25.02	0.255
4	Number of pods per plant	7.45	95.72	31.46	0.584
5	Length of pod (cm)	9.37	27.32	15.45	0.091
6	Weight of pod (g)	0.69	3.09	1.60	0.011
7	Number of seeds per pod	7.91	16.66	12.33	0.043
8	Seed yield per plant (g)	4.00	97.00	29.89	0.792
9	100-seed weight (g)	4.53	18.50	8.82	0.046
10	Length of seed (mm)	4.56	11.20	7.05	0.015
11	Breadth of seed (mm)	3.63	8.14	5.25	0.029
12	Thickness of seed (mm)	3.25	5.51	3.98	0.019
13	Number of flowers per plant	21.11	148.94	71.76	1.322
14	Pod yield per plant (g)	7.27	109.11	42.18	1.296

Table 19. Phenotypic, genotypic and environmental variance for the different characters

S.No.	Character	Phenotypic variance (Vp)	Genotypic variance (Vg)	Environmental variance (Ve)
1	Number of primary branches per plant	2.41	0.68	1.73
2	Days to commence flowering	36.17	34.21	1.96
3	Flowering spread (days from commencement to completion)	42.31	35.01	7.30
4	Number of pods per plant	455.93	417.68	38.25
5	Length of pod (cm)	16.23	15.30	0.93
6	Weight of pod (g)	0.37	0.36	0.01
7	Number of seeds per pod	6.65	6.45	0.20
8	Seed yield per plant (g)	381.20	310.93	70.27
9	100-seed weight (g)	8.36	8.13	0.23
10	Length of seed (mm)	2.26	2.23	0.03
11	Breadth of seed (mm)	0.72	0.63	0.09
12	Thickness of seed (mm)	0.26	0.22	0.04
13	Number of flowers per plant	988.69	792.93	195.76
14	Pod yield per plant (g)	635.22	490.07	145.15

Table 20. Phenotypic and genotypic coefficients of variation, heritability and expected genetic gain of the different characters

S.No.	Character	Phenotypic coefficient of variation (PCV)	Genotypic coefficient of variation (GCV)	Heritability (%) (H)	Genetic gain (%) (GG)
1	Number of primary branches per plant	29.11	15.45	28.16	17.78
2	Days to commence flowering	11.33	11.02	94.60	22.08
3	Flowering spread (days from commencement to completion)	26.00	23.65	82.75	44.32
4	Number of pods per plant	67.87	64.96	91.61	128.08
5	Length of pod (cm)	26.08	25.32	94.23	50.62
6	Weight of pod (g)	38.17	37.50	96.51	75.89
7	number of seeds per pod	20.92	20.59	96.89	41.75
8	Seed yield per plant (g)	65.32	58.99	81.57	109.76
9	100-seed weight (g)	32.79	32.33	97.19	65.65
10	Length of seed (mm)	21.32	21.20	98.95	43.41
11	Breadth of seed (mm)	16.14	15.07	87.19	28.99
12	Thickness of seed (mm)	12.89	11.84	84.41	22.41
13	Number of flowers per plant	43.82	39.24	80.20	72.40
14	Pod yield per plant (g)	59.75	52.48	77.15	94.96

Table 21. Characteristics of the six high yielders and the six poor yielders among the 56 cowpea varieties under study

Rank No. for seed yield	Variety No.	Variety Name	Characters (1) Growth habit	(2) Seed yield per plant (g)	(3) Pod yield per plant (g)	(4) No. of pods per plant	(5) No. of flowers per plant
1	38	Kolinjipayar	Erect	97.00	109.11	95.72	137.94
2	47	C.152 x M.E.1 (Bangalore)	Semi-erect	71.74	104.11	78.23	108.94
3	46	No.2-1 x Iron Grey	Erect	71.66	89.11	79.95	114.67
4	54	Manjeri mottled - light	Trailing	69.61	101.72	65.78	91.16
5	26	Branca	Erect	50.83	78.50	72.39	128.11
6	44	Mississippi x Iron Grey	Erect	47.44	56.66	31.67	68.28
51	33	Kayamkulam	Semi-erect	8.05	16.83	7.56	32.61
52	37	Pannithodan - late	Erect	8.00	14.50	10.78	40.94
53	10	GP. C. 13	Trailing	7.67	12.00	17.06	75.89
54	21	Red seeded selection	Erect	7.11	10.22	10.28	30.56
55	6	GP. ECR. 1548	Trailing	6.11	35.05	7.45	30.89
56	56	Pusa Phalguni	Erect	4.00	7.27	8.73	21.11
	General Mean			29.89	42.18	31.46	71.76

(Continued)

Table 21 (Continued)

Rank No. for seed yield	Variety No.	Variety Name	Characters (6) Days to commence flowering	(7) Flowering spread (days)	(8) Length of pod (cm)	(9) Weight of pod (g)	(10) No. of seeds per pod
1	38	Kolinjipayar	63.64	20.78	10.04	0.81	8.35
2	47	C.152 x N.E.1 (Bangalore)	42.06	20.11	12.55	1.43	16.23
3	46	No.2-1 x Iron Grey	54.11	26.62	13.58	1.45	13.27
4	54	Manjeri mottled - light	57.84	32.22	20.52	2.23	12.41
5	26	Branca	54.95	13.34	12.53	0.99	10.98
6	44	Mississippi x Iron Grey	49.34	17.56	17.28	1.76	14.82
51	33	Kayamkulam	60.73	29.33	19.60	2.09	14.05
52	37	Pannithodan - late	54.28	25.95	14.74	1.38	11.81
53	10	GP. C. 13	59.17	31.67	14.99	1.63	10.44
54	21	Red seeded selection	48.67	41.72	13.45	0.85	8.53
55	6	GP. ECR. 1548	57.06	15.12	13.69	1.79	13.96
56	56	Pusa Phalguni	43.12	23.39	21.65	2.20	14.42
		General Mean	53.09	25.02	15.45	1.60	12.33

(Continued)

Table 21 (Continued)

Rank No. for seed yield	Variety No.	Variety Name	Characters (11) 100-seed weight (g)	(12) Length of seed (mm)	(13) Breadth of seed (mm)	(14) Thickness of seed (mm)	(15) No. of primary branches per plant
1	38	Kolinjipayar	6.90	6.27	4.42	3.42	6.06
2	47	C.152 x N.E.1 (Bangalore)	6.58	5.02	5.01	4.03	5.78
3	46	No.2-1 x Iron Grey	9.50	7.48	5.40	4.29	5.06
4	54	Manjeri mottled - light	9.15	9.15	5.44	3.50	6.06
5	26	Branca	7.96	6.50	5.83	3.49	7.95
6	44	Mississippi x Iron Grey	10.03	6.22	5.42	4.16	4.84
51	33	Kayamkulam	10.89	8.04	5.52	3.60	4.11
52	37	Pannithodan - late	7.20	6.74	4.35	3.51	5.06
53	10	GP. C. 13	10.75	6.94	5.54	4.48	3.95
54	21	Red seeded selection	5.61	7.66	4.53	3.56	5.00
55	6	GP. ECR. 1548	10.00	6.52	5.42	4.40	6.11
56	56	Pusa Phalguni	5.47	8.56	6.32	4.18	2.89
		General Mean	8.82	7.05	5.25	3.98	5.33

represented by one single variety (Clusters XI to XVII and varieties 47, 24, 28, 34, 32, 51 and 55 respectively). Cluster II comprised of the maximum number of varieties; the twelve varieties included being 11, 12, 2, 8, 44, 48, 16, 41, 14, 49, 35 and 3. The next large cluster was cluster I with seven varieties (Varieties 39, 50, 13, 42, 40, 9 and 25). Cluster III had six varieties (Varieties 22, 56, 36, 31,54 and 29) and cluster IV five (Varieties 52, 53, 33, 27 and 30). Clusters V, VII and VIII consisted of four varieties each. Varieties 4, 5, 37 and 7 made cluster V, while cluster VII was comprised of varieties 1, 45, 43 and 10. The four varieties in cluster VIII were varieties 26, 38, 46 and 18. Cluster VI consisted of the varieties 21, 23 and 17. The remaining four varieties fell into two clusters, varieties 6 and 15 in cluster IX and varieties 19 and 20 in cluster X (Table 22).

The average intra-cluster distances in the 10 clusters with more than one variety ranged from 10.3 (Cluster X) to 14.9 (Cluster VIII) (Table 22). The range of average inter-cluster distances among the 17 clusters was found to be from 13.8 (IV - XVII) to 57.9 (X - XVI). The lower values of inter-cluster

Table 22. Details of varieties constituting different clusters

Cluster No.	Varieties included				Average intra-cluster distance
	No.	Name	Growth habit	Total No.	
I	39	Nedumangad - 1	SE		
	50	No. 62	T		
	13	GP. M.S. 6970/1	SE		
	42	Sasthamcottah -6	T		
	40	Kazhakkoottam - 4	E		
	9	GP. African	T		
	25	Moovatupuzha - 1	E	7	11.5
II	11	GP. PLS. 110	SE		
	12	GP. M.S. 9804	T		
	2	GP. PLS. 63	T		
	8	GP. PLS. 26	E		
	44	Missisippi x Iron grey	E		
	48	C. 152 x N.E.II (Bangalore)	SE		
	16	GP. M.S. 9760	SE		
	41	Sasthamcottah - 2	T		
	14	GP. C. 57	E		
	49	C. 152 x No. 2-1	T		
	35	T. 20	E		
	3	GP. M.S. 9082/2	SE	12	14.0
III	22	Calicut - 78	SE		
	56	Pusa Phalguni	E		
	36	Calicut - 21	E		
	31	Culture - 1	SE		
	54	Manjeri mottled - light	T		
	29	No. 51	SE	6	13.7

(Continued)

Table 22 (Continued)

Cluster No.	Varieties included				Average intra-cluster distance
	No.	Name	Growth habit	Total No.	
IV	52	Mayyanad local	T		
	53	Manjeri - brown	T		
	33	Kayamkulam	SE		
	27	Manjeri local	T		
	30	Manjeri mottled - dark	T	5	13.1
V	4	GP. PLS. 139	E		
	5	GP. J.C. 5	SE		
	37	Pannithodan - late	E		
	7	GP. C. 2110	T	4	14.7
VI	21	Red-seeded selection	E		
	23	Palghat Vellapayar	E		
	17	GP. M.S. 9081	SE	3	11.6
VII	1	GP. M.S. 9314	E		
	45	No. 2-1 x Dixibe	SE		
	43	Thodupuzha - 3	SE		
	10	GP. C. 13	T	4	13.0
VIII	26	Branca	E		
	38	Kolinjipayar	E		
	46	No. 2-1 x Iron grey	E		
	18	GP. C. 152	SE	4	14.9
IX	6	GP. E.C.R. 1548	T		
	15	GP. T. 536	E	2	10.3

(Continued)

Table 22 (Continued)

Cluster No.	Varieties included				Average intra-cluster distance
	No.	Name	Growth habit	Total No.	
X	19	IC. 20729	SE		
	20	IC. 20419	E	2	14.8
XI	47	C. 152 x N.E.II (Bangalore)	SE	1	0.0
XII	24	Pattambi local - 1	SE	1	0.0
XIII	28	C. 152 x New Era - I	T	1	0.0
XIV	34	Pannithodan - early	E	1	0.0
XV	32	P. 118	E	1	0.0
XVI	51	Kolinjipayar - white	E	1	0.0
XVII	55	Manjeri - black	T	1	0.0

E = Erect

SE = Semi-erect

T = Trailing

distances ranged from 13.8 (IV - XVII) to 26.2 (X - XIV) and the higher values from 39.9 (VII - XVI) to 67.9 (X - XVI).

Cluster X was found to show the maximum average inter-cluster distance with any other cluster and it was found to be the cluster showing the maximum distances in 11 out of the total possible 16 combinations it could make. Cluster I showed the least average inter-cluster distances in the maximum number of cases (5 out of 16) (Tables 23 and 24).

Cluster means for the different characters

Number of primary branches per plant

Maximum mean value for this character was shown by cluster IX (6.52) and the minimum by cluster X (3.48) (Table 25).

Days to commence flowering

The cluster means for this character ranged between 39.78 (Cluster XV) and 61.81 (Cluster V).

Flowering spread (Days from commencement to completion

Cluster IX had the lowest (15.48) and cluster XII the highest (36.73) mean values for this character.

Table 25. Cluster means for different characters

Cluster No.	Characters			
	(1) No. of primary branches per plant	(2) Days to commence flowering	(3) Flowering spread (days)	(4) No. of pods per plant
I	5.21	52.85	23.20	36.31
II	5.96	49.34	24.12	29.77
III	4.95	53.92	25.00	31.95
IV	5.27	56.58	27.75	22.34
V	5.53	61.81	27.03	22.22
VI	4.87	49.13	34.35	17.71
VII	3.88	54.17	26.97	21.66
VIII	6.35	56.48	18.50	75.49
IX	6.52	56.39	15.48	12.06
X	3.48	50.36	32.42	13.11
XI	5.78	42.06	20.11	78.23
XII	6.17	63.67	36.73	35.28
XIII	5.84	47.95	19.72	24.89
XIV	3.72	49.62	23.17	10.56
XV	3.61	39.78	15.91	8.50
XVI	5.23	50.84	23.00	83.12
XVII	6.45	60.22	33.06	21.84
General Mean	5.33	53.09	25.02	31.46

(Continued)

Table 25 (Continued)

Cluster No.	Characters			
	(5) Length of pod (cm)	(6) Weight of pod (g)	(7) No. of seeds per pod	(8) Seed yield per plant (g)
I	10.91	0.95	10.77	23.57
II	14.28	1.48	12.28	31.40
III	19.45	2.08	14.14	37.93
IV	20.42	1.67	14.78	24.03
V	13.06	1.25	11.02	23.18
VI	13.83	0.93	8.79	16.20
VII	16.50	1.70	11.88	19.07
VIII	12.62	1.18	11.94	66.14
IX	14.18	1.95	14.60	11.61
X	25.60	2.89	14.35	19.16
XI	12.55	1.43	16.23	71.74
XII	15.91	2.65	11.09	42.16
XIII	18.28	1.42	10.86	25.17
XIV	18.81	2.39	16.07	11.83
XV	13.56	1.29	9.39	9.00
XVI	9.59	0.69	10.26	40.50
XVII	20.37	2.42	11.41	15.00
General Mean	15.45	1.60	12.33	29.89

(Continued)

Table 25 (Continued)

Cluster No.	Characters			
	(9) 100-seed weight (g)	(10) Length of seed (mm)	(11) Breadth of seed (mm)	(12) Thickness of seed (mm)
I	6.23	5.84	4.54	3.49
II	8.96	6.37	5.22	4.35
III	8.79	8.26	5.67	3.99
IV	10.78	8.82	5.95	3.56
V	6.59	5.54	4.65	3.69
VI	6.10	7.06	4.78	4.00
VII	12.85	7.66	5.84	4.37
VIII	8.07	6.56	4.84	3.61
IX	7.93	6.47	5.54	4.45
X	17.48	10.85	5.61	4.86
XI	6.58	5.02	5.01	4.03
XII	7.84	6.74	5.14	4.11
XIII	6.23	5.28	4.57	3.66
XIV	10.04	10.08	8.14	5.20
XV	11.90	7.36	6.23	4.03
XVI	4.53	4.56	3.63	3.30
XVII	9.49	9.35	5.16	3.47
General Mean	8.82	7.05	5.25	3.98

Number of pods per plant

The cluster mean range for this character was found to be from 8.50 (Cluster XV) to 83.12 (Cluster XVI).

Length of pod

Maximum mean pod length (25.60 cm) was seen in cluster X and the minimum (9.59 cm) in cluster XVI.

Weight of pod

Cluster means for this character ranged from 0.69 g (Cluster XVI) to 2.89 g (Cluster X).

Number of seeds per pod

The maximum and minimum mean values for this character were shown by cluster XI (16.23) and cluster VI (8.79) respectively.

Seed yield per plant

The cluster means for this character of ultimate economic importance were found to range between 9.00 g (Cluster XV) and 71.74 g (Cluster XI).

100-seed weight

The lowest and highest mean values for this character were shown by cluster XVI (4.53 g) and cluster X (17.48 g) respectively.

Length of seed

The cluster means for this character ranged from 4.56 mm (Cluster XVI) to 10.85 mm (Cluster X).

Breadth of seed

Maximum mean breadth of seed (8.14 mm) was shown by cluster XIV and minimum (3.63 mm) by cluster XVI.

Thickness of seed

The maximum and minimum mean values were shown by cluster XIV (5.20 mm) and cluster XVI (3.30 mm) respectively.

Clusters of promise as donors

Based on the cluster means for various plant, pod and seed characters five clusters have been ranked and listed for each of the important seven characters to serve as a guideline for selection of donor parents from among them for further breeding programmes (Table 26).

Table 26. Varietal clusters of promise as donors for improvement of some important plant, pod and seed characters of cowpea

Character	Clusters ranked from 1 to 5 along with their cluster means					General Mean for the character
	1	2	3	4	5	
Early flowering (days to flowering)	XV 39.78	XI 42.06	XIII 47.95	VI 49.13	II 49.34	53.09
Short flowering spread (days)	IX 15.48	XV 15.91	VIII 18.50	XIII 19.72	XI 20.11	25.02
Long flowering spread (days)	XII 36.73	VI 34.35	XVII 33.06	X 32.42	IV 27.75	25.02
High pod number per plant	XVI 85.12	XI 78.23	VIII 75.49	I 36.31	XII 35.28	31.46
High seed yield per plant (g)	XI 71.74	VIII 66.14	XII 42.16	XVI 40.50	III 37.93	29.89
Long pods (cm)	X 25.60	IV 20.42	XVII 20.37	III 19.45	XIV 18.81	15.45
Bold heavy seeds (100-seed Wt. in g)	X 17.48	VII 12.85	XV 11.90	IV 10.78	XIV 10.04	8.82

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DISCUSSION

DISCUSSION

General Variability

Results of the preliminary evaluation trial have indicated that there is great amount of variability in the varietal collection for the expression of all the characters studied.

Among the 14 characters for which the 56 selected varieties were evaluated in detail, the total phenotypic variance was found to be very high for number of flowers per plant, pod yield per plant, number of pods per plant and seed yield per plant. The total variance for these characters were found to very much exceed the general mean and also to exceed the maximum values among the varieties (Table 19).

Estimates of heritable (genetic) and non-heritable (environmental) components of the total phenotypic variance have also shown that the genetic components were very high with regard to these characters.

In general, except for the number of primary branches per plant in all the other 13 characters the

genetic component of variance was found to exceed the environmental component.

The phenotypic and genotypic coefficients of variation worked out (Table 20) indicated that the number of pods per plant, seed yield per plant, pod yield per plant, number of flowers per plant, weight of pod, 100-seed weight, length of pod, flowering spread, length of seed and number of seeds per pod showed high estimates (above 20 per cent). This suggests that these characters with high genetic variability could be improved by selection in this crop.

Number of pods per plant, seed yield per plant and pod yield per plant were the three characters with very high values (above 50 per cent) of phenotypic as well as genotypic coefficients of variation, indicating very good scope for selection for these characters among the varietal spectrum under study.

These findings are in general agreement with the earlier reports in this crop by Karthikeyan (1963), Singh and Mehndiratta (1969), Borida et al. (1973), Lakshmi and Goud (1977) and Sreekumar et al. (1979).

Though high genotypic coefficients for flowering duration and days to maturity have been recorded in cowpeabby Singh and Mehndiratta (1969), in the present study, days to commence flowering was the character showing the least phenotypic and genotypic coefficients of variation. The present findings on this point, however, are in agreement with the report of Sreekumar et al. (1979) based on studies in the same crop season as that of the present study and also conducted in Kerala itself.

The other characters for which the genotypic coefficients of variation among the varieties were low were thickness of seed, breadth of seed and number of primary branches per plant. These data suggest that there is only very little scope for selection for these characters among the varieties under the present study.

Estimates of heritability in the broad sense for the various characters (Table 20) showed that those values were very high and over 90 per cent in the cases of length of seed, 100-seed weight, number of seeds per pod, weight of pod, days to commence flowering, length of pod and number of pods per plant. The maximum heritability (98.85 per cent) was seen in the case of

length of seed and this was closely followed by 100-seed weight (97.19 per cent). The characters like flowering spread, seed yield per plant, breadth of seed, thickness of seed, number of flowers per plant and pod yield per plant also showed high heritability ranging between 77 and 87 per cent. The only character in this study which showed very low heritability (28.16 per cent) was number of primary branches per plant. High heritability for 100-seed weight has almost uniformly been reported by earlier workers in this crop (Singh and Mehndiratta, 1969; Borida et al., 1973; Gopal Singh et al., 1977; Lakshmi and Goud, 1977 and Sreekumar et al., 1979).

The expectable genetic gain was found to be the highest (128.08 per cent) in the case of number of pods per plant, closely followed by seed yield per plant (109.76 per cent). Pod yield per plant also showed high genetic gain of 94.96 per cent. Very high values of genetic gain for number of pods per plant and seed yield per plant were in confirmity with the findings in this crop by Singh and Mehndiratta (1969), Borida et al. (1973), Veeraswamy et al. (1973), Gopal Singh et al. (1977), Lakshmi and Goud (1977) and Sreekumar et al. (1979).

Other characters showing more than 50 per cent genetic gain were weight of pod, number of flowers per plant, 100-seed weight and length of pod. Flowering spread, length of seed and number of seeds per pod also showed more than 40 per cent genetic gain estimates. The lowest genetic gain in the present study (17.78 per cent) was estimated in the case of number of primary branches per plant. Days to commence flowering and thickness of seed also showed low genetic gain estimates. Comparatively low values of genetic gain for days to flowering, total duration and number of seeds per pod have been recently recorded by Sreekumar et al. (1979).

With regard to the six plant characters showing high heritability, the erect variety Kolinjipayar (Variety 38) was found to be the one producing the maximum number of pods and giving the highest pod yield as well as seed yield per plant. This variety was also found to be producing the maximum number of flowers, being only next to the trailing variety GP. PLS. 63 (Variety No. 2) with which it was on par statistically. While the earliest variety to commence flowering was the variety P. 118 (Variety 32), variety 18 (GP. C. 152) exhibited the shortest flowering spread.

Comparing the varieties for the three pod characters studied, the semi-erect variety IC. 20729 (Variety 19) was found to top all varieties in pod length, pod weight and number of seeds per pod. With regard to pod length and pod weight, the erect variety IC. 20419 (Variety 20) was also found to be on par with the variety 19. The trailing variety Manjeri mottled - dark (Variety 30) was found to show high pod weight and high number of seeds per pod on par with variety 19.

In respect of the four seed characters, the erect variety, Kolinjipayar - white (Variety 51) was found to show the lowest 100-seed weight, seed length, seed breadth and seed thickness. The semi-erect variety IC. 20729 (Variety 19) and the erect variety IC. 20419 (Variety 20) were found to share the first and second positions with regard to the highest seed weight and seed length. Variety 20 was also the one with the maximum seed thickness. The erect variety Pannithodan - early (Variety 34) which was on par with the variety 20 in seed thickness was the one with the broadest seeds.

It was seen that different varieties were found to be differently ranking for the most economically important plant, pod and seed characters, suggesting

the possibility of selecting different varieties as donors for effecting improvement in these characters through planned inter-varietal hybridization.

As the main objective of the present investigation was to assess the genetic diversity among the varieties and to group them into clusters based on their genetic distances, the correlations of the various plant, pod and seed characters with yield have not been worked out. Anyhow, an attempt is made with the use of data on all the characters in respect of the six highest yielding and the six lowest yielding varieties among the 56 types evaluated to find out the indications in this line.

The data presented in Table 21 have very strikingly brought out the fact that the number of pods per plant is a general indicator character to spot out high yielding types in cowpea. Positive correlation of number of pods with yield in cowpea is one point over which most of the earlier workers are in agreement (Karthikeyan, 1963; Singh and Mehndiratta, 1969; Doku, 1970; Borida et al., 1973; Kumar et al., 1976 and Gopal Singh et al., 1977).

Contrary to the report of Karthikeyan (1963) who found very significant negative correlation for the number of branches per plant with number of pods and

seed yield, in the present study almost all the top high yielding varieties had high number of branches. In the present study where each square metre area had only one plant and the crop was grown in the rainy season, the range of number of branches was from 2.89 to 8.22 with an overall mean of 5.33. Data of Karthikeyan loc. cit. were based on an irrigated summer crop adopting a close spacing of 25 cm x 30 cm where the varietal means for this character ranged between 1.52 and 3.60 only. These data could not also support the reports of Singh and Mehndiratta (1969) and Kumar et al. (1976) who found number of branches to be positively correlated with yield. The lowest yielders in the present study had very low or high number of branches. The influence of environment on the expression of this character as indicated by the high value of environmental variance and the low value of heritability obtained in the present study with a large number of varieties appear to indicate that this character cannot be depended upon as an indicator character for selection for high yield potential in cowpea.

With regard to pod length the present data appear to support Singh and Mehndiratta (1969) who found pod

length to be negatively correlated with number of pods and to contradict the finding of Singh and Jain (1972) that high seed yield resulted from pod length and also the reports of Borida et al. (1973) and Kumar et al. (1976) showing positive correlation of pod length with grain yield.

The present data as given in Table 21 also appear to show that high yielding varieties could be of short or long growth duration as also of any of the three growth habits namely, erect, semi-erect or trailing.

Genetic divergence among the varieties

Based on the genetic distances computed with reference to 12 characters, the 56 cowpea varieties in the present study could be grouped into 17 distinct clusters (Table 22). The distribution of the varieties into various clusters showed no regularity, seven (XI to XVII) out of the seventeen clusters containing only one variety each and one cluster (II) containing 12 varieties. The three largest clusters II, I and III together contained a total of 25 out of the 56 varieties. Mehndiratta and Singh (1971) who grouped 40 cowpea varieties into eight clusters have shown such irregular pattern of distribution. Fifteen out of the 40 varieties

were found to comprise just two clusters in their study. Sixty strains of cowpea grouped into 21 clusters by Jayaprakash et al. (1974) also showed such distribution. Seven of these 21 clusters were represented by a single strain each. Three of the clusters were also found to contain 22 out of the 60 strains.

Though the growth habit was not taken into account in the working out of the genetic distances between the varieties under study, this information is also furnished in Table 22. It is seen that among the eight clusters containing three or more varieties, clusters VI and VIII contained no trailing types, cluster IV had no erect type, and the other clusters contained all the three types of varieties.

It is interesting to note that among the five trailing types originating from Manjeri area (Malappuram District, Kerala State), the varieties Manjeri mottled - light and Manjeri - black belonged to two different clusters (III and XVII), both distinct from cluster IV containing the other types originating from the same area. Similarly, the three selections originating from the cross C. 152 x New Era (one trailing type selected at Pattambi and two semi-erect types selected at Bangalore) also fell into

three separate clusters (II, XI and XIII). It was also seen that while the erect variety Kolinjipayar (variety 38) was included in cluster VIII, the white-seeded selection from it (Variety 51, Kolinjipayar - white) which is also erect in habit stood as a distinct cluster by itself (cluster XVI). These data indicate that the varieties of the same region and also selections from the same variety could fall into different clusters. These findings are in agreement with the results of Mehndiratta and Singh (1971) and Jayaprakash et al. (1974) in this crop.

The average genetic distances between the different clusters of varieties in the present study as furnished in Tables 22 and 23 show that the two varieties included in cluster X (IC. 20729 and IC. 20419) showed on an average the maximum genetic distances from 37 out of the remaining 54 varieties. The variety Kolinjipayar - white which stood distinctly as cluster XVI is seen to be the next variety showing the average maximum genetic distances from other varieties. Nineteen varieties included in six clusters were showing maximum average distance with this variety.

The nine varieties included in clusters IV, X, XIV and XVII were found to show, in general, high average genetic distances from the 30 varieties comprising the clusters I, II, V, VI, XI, XIII, XV and XVI (Table 24).

Cowpea in Kerala is a distinct pulse crop which should have varieties suitable for some highly contrasting situations. The grain-production-oriented rice fallow culture would require high yielding erect varieties with early flowering and highly condensed flowering spread to make the cultivation economic avoiding huge expenditure for large number of harvests. Even varieties with small pods if they have large number of pods and good number of heavy seeds per pod will be highly suited for this system.

The specialised system of cowpea cultivation in summer rice fallows specifically for vegetable purpose as practiced in certain areas like Manjeri in the state would require trailing varieties with long fleshy pods and a good flowering spread to assure vegetable over a longer period. Here the highly synchronised flowering is of not much importance as a good amount of labour comes as self or family labour. Varieties with large

number of small pods giving good seed yields will be of no use at all for this situation.

In the third main system of cowpea culture in the rainy Khariff season the cultivation is mainly in the uplands and homesteads, where varieties with medium pod size, bold seeds and a medium flowering duration and flowering spread are useful. The varieties could be either erect, semi-erect or trailing; but should be dual purpose varieties with tolerably good yields both as tender vegetable pod and as vegetable grain.

The cluster means for 12 characters presented in Table 25 show that there is good amount of variation for all the characters among the clusters. The economically most important plant characters namely, seed yield, number of pods, days to commence flowering and flowering spread show particularly large diversities between the clusters. The outstanding clusters which could contribute to improvement of these characters as donors appeared to be cluster XVI with the highest mean pod number per plant (83.12), cluster IX with the maximum mean seed yield (71.74 g), cluster XV with the minimum days to flowering (39.78) and cluster IX with the minimum mean flowering spread (15.48 days).

It was found that for improvement of pod characters, varieties of cluster X with the maximum mean values for both length (25.60 cm) and weight (2.89 g) of pod could be of promise. Varieties of cluster X were also found to be promising donors for improvement of 100-seed weight (17.48 g) and seed length (10.85 mm) also.

Based on the data of the present study it has been possible to identify varietal clusters of promise as donors for the most important economic characters in this crop. In Table 26 five varietal clusters in respect of each of the seven important characters are indicated, ranking the clusters in the order of their cluster means.

As a cluster diagram showing all the seventeen clusters and their inter-cluster distances will be quite over-crowded, a partial cluster diagram only is furnished in Fig. 1. In this diagram only the clusters X and XVI and those clusters which show more than 50.0 as their inter-cluster distances with any of these two clusters are represented.

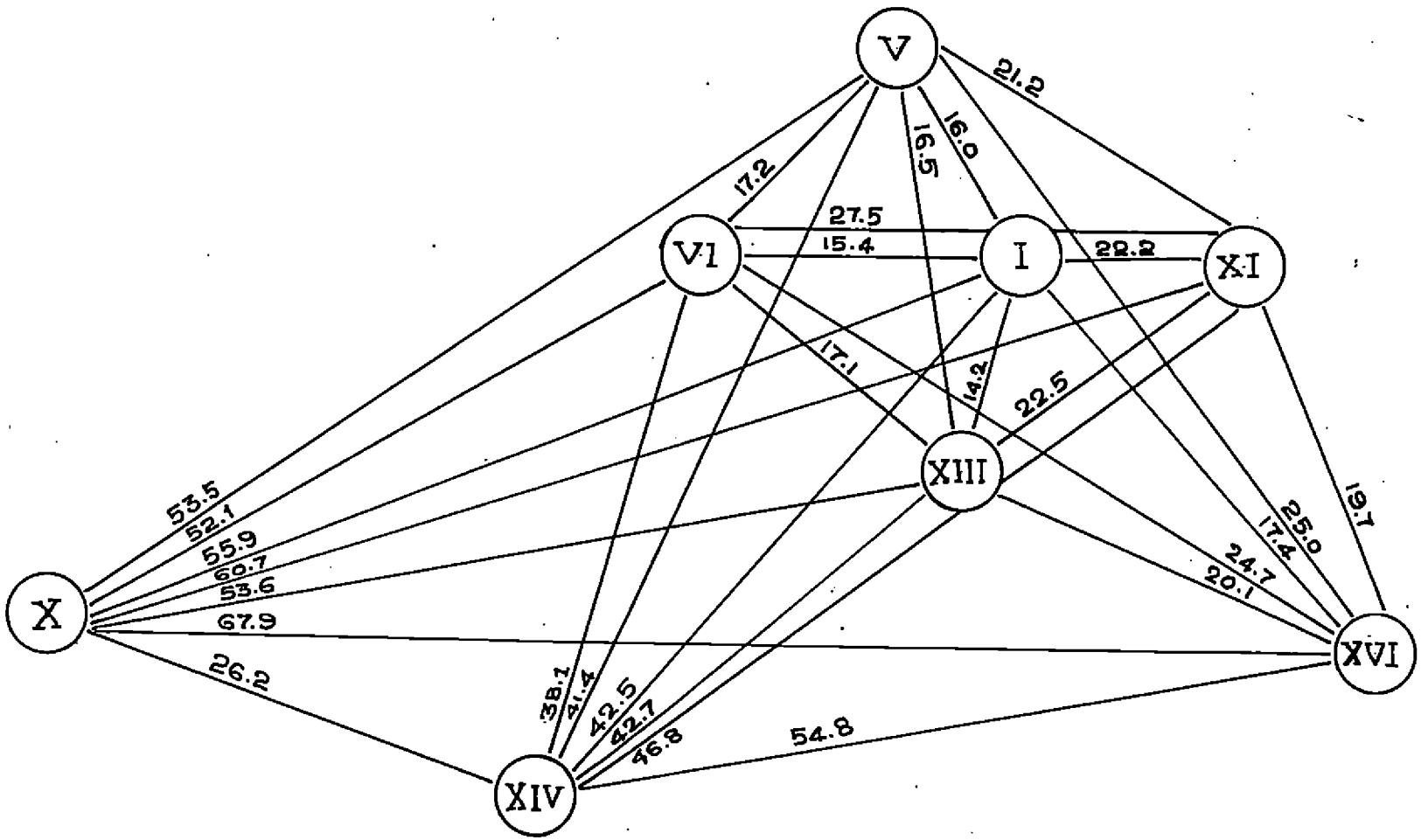

FIG.1: PARTIAL CLUSTER DIAGRAM OF CLUSTERS SHOWING HIGH GENETIC DISTANCES.

SUMMARY

SUMMARY

Genetic studies were undertaken with 202 varieties of cowpea (Vigna unguiculata L.) maintained in the germplasm collection of the Division of Agricultural Botany, College of Horticulture, Vellanikkara. The studies conducted during the two khariff seasons of 1977-78 and 1978-79 were mainly directed towards estimation of the variability available in the collection, working out of the heritable components of the variability, identification of promising donor varieties for important characters and grouping the varieties into clusters according to the estimated genetic distances following the Mahalanobis D^2-statistic.

Data from the preliminary evaluation of 202 varieties in the first season were used to obtain a general idea of the variability for different characters and to select 56 types representing varieties with maximum, minimum and mid values for each character for detailed investigation.

The important findings from the evaluation of the varieties were the following:-

1. The varietal collection was found to contain very high variability for number of flowers per plant, pod yield per plant, number of pods per plant and seed yield per plant.

2. Except for the number of primary branches per plant in all the other 13 characters studied, the genetic component of variance was found to exceed the environmental component.

3. Very high values (above 50 per cent) of phenotypic as well as genotypic coefficients of variation were obtained for number of pods per plant, seed yield per plant and pod yield per plant.

4. Heritability in the broad sense was found to be the maximum (98.85 per cent) for length of seed and this was closely followed (97.19 per cent) by 100-seed weight.

5. Number of ~~seeds~~ pods per ~~pod~~ plant showed the maximum genetic gain (123.08 per cent) and this was followed by seed yield per plant (109.76 per cent). Weight of pod, number of flowers per plant, 100-seed weight and length of pod also showed more than 50 per cent genetic gain.

6. Number of primary branches per plant was found to be the character showing the least heritability and genetic gain.

7. It was seen that different varieties ranked differently for the most important economic characters. This suggested the possibility of selecting different varieties as donors for effecting improvement in these characters.

8. The erect variety Kolinjipayar (Variety 38) was identified as the one producing maximum seed yield (97.00 g) and the maximum number of pods (95.72) per plant.

9. The erect variety P.118 (Variety 32) was identified as the earliest to flower (39.78 days) and the semi-erect variety GP. C. 152 as the one with the h shortest flowering spread (13.28 days).

10. The semi-erect variety IC. 20729 (Variety 19) topped all varieties in pod length (27.32 cm), pod weight (3.09 g) and number of seeds per pod (16.66).

11. The semi-erect variety IC. 20729 (Variety 19) was identified as the one with maximum 100-seed weight (18.50 g) and the erect variety IC. 20419 as the one

with the maximum seed length (11.20 mm). The erect variety Pannithodan - early (Variety 34) was found to have the broadest seed (8.14 mm).

12. The data indicated that the high number of pods per plant was a dependable indicator character to spot out high yielding types in cowpea.

13. It was possible to group the 56 varieties into 17 distinct clusters based on the genetic distances between them.

14. The study revealed that varieties of the same region could fall into different varietal clusters, thereby indicating their genetic divergence.

15. Based on the data collected it has been possible to identify varietal clusters of promise for choosing proper donor varieties for improvement of the important economic characters.

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Appendix I

Abstract of the Thesis

GENETIC STUDIES IN COWPEA

BY

P. CHANDRIKA

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the

Requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

Department of Agricultural Botany

College of Horticulture

VELLANIKKARA :: TRICHUR

1979

ABSTRACT

Cowpea (*Vigna unguiculata* L.) is the most important pulse crop of Kerala, accounting for about 70 per cent of the area under pulses in the state. The highly contrasting systems of cultivation of cowpea in the various parts and in the different seasons in the state call for varieties with different combinations of plant, pod and seed characters.

As a first step before launching an elaborate inter-varietal hybridization programme, the present study was undertaken in the College of Horticulture, Vellanikkara to assess the extent of variability in the germplasm already available, to apportion the variability into heritable and non-heritable components and to group the varieties into clusters according to the magnitudes of genetic distances using Mahalanobis D^2-statistic.

Two hundred and two varieties were studied in the 1977-78 *Khariff* season for 15 characters and based on the results 56 varieties representing the maximum, minimum and mid-values for all the characters were selected for further detailed evaluation.

The detailed study with 56 varieties conducted during the 1978-79 kharif season showed that the collection contained very high amount of variability for all the important economic characters. Except for the number of primary branches per plant in all other characters the major portion of the observed variability was found to be genetic indicating scope for selection.

Based on the genetic distances worked out, the 56 varieties could be grouped into 17 distinct clusters. From the results of the present study it has been possible to suggest varietal clusters and varieties of promise as donors for improvement of the important economic characters for planning inter-varietal hybridization programmes.

Appendix II

Performance particulars of the 202 cowpea varieties in the preliminary field evaluation studies in Khariff 1977-78

Varieties			Characters														
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	1	1	E	7	54	27	71	21	18.6	2.5	14.5	15.6	8.2	6.5	4.9	60	30
2	2	-	-	Not germinated													
3	3	-	-	Not germinated													
4	5	-	-	Not germinated													
5	6	-	T	Plant died													
6	7A	-	-	Not germinated													
7	7B	-	-	Not germinated													
8	7C	-	E	3	58	20	31	6	-	-	-	-	-	-	-	5	2
9	8	2	T	7	46	27	117	50	13.3	1.6	10.4	9.5	6.1	5.6	4.5	75	44
10	10	-	SE	8	73	14	51	13	13.5	1.5	11.3	9.3	6.8	5.8	4.3	25	20
11	11	3	SE	9	66	18	73	15	12.9	1.3	8.2	10.1	6.3	5.5	4.2	50	34
12	12	4	E	9	60	19	61	22	12.0	0.8	9.9	5.0	5.3	4.2	3.7	11	9
13	14	-	E	13	Not flowered till 5-9-77												
14	15	-	-	Not germinated													
15	16	-	-	Not germinated													

Varieties			Characters													
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
16	17	-	-	Plant died													
17	19	5	SE	9	62	28	59	26	12.0	0.8	9.9	5.6	5.8	4.6	3.7	20	8
18	20	-	E	4	57	21	61	10	14.6	1.6	11.5	8.8	6.2	6.0	4.1	14	9
19	21	-	-	Not germinated													
20	22	-	E	8	53	15	31	14	13.4	1.5	10.9	10.2	7.6	5.6	4.2	28	25
21	23	-	E	3	-	-	-	7	-	-	-	-	6.3	4.3	3.3	-	-
22	24	6	T	3	58	10	17	11	14.6	1.9	13.6	9.9	6.5	5.8	4.4	14	10
23	25	-	T	7	57	Plant died after flowering											
24	26	-	E	9	57	21	43	19	17.2	0.9	10.1	10.0	6.8	6.1	4.6	56	40
25	27	-	E	8	56	24	39	2	15.6	1.2	11.0	7.0	6.4	5.5	4.1	3	1
26	28	-	SE	3	53	17	51	1	8.2	1.0	9.2	4.6	7.2	5.5	3.9	2	1
27	29	-	E	4	57	13	39	3	11.1	1.2	9.1	6.9	5.4	4.8	3.9	5	3
28	30	-	E	7	57	29	63	5	13.2	1.3	11.2	6.1	6.7	5.5	3.6	11	3
29	31	7	T	5	56	11	53	14	14.1	1.4	13.8	8.2	6.0	5.4	4.1	17	9
30	32	8	E	4	47	12	41	10	13.2	1.2	10.4	8.0	6.4	5.8	4.4	14	9
31	33	-	SE	3	63	12	58	3	8.2	1.0	9.2	4.6	4.6	4.5	3.6	4	2
32	34	-	SE	4	54	14	61	17	12.6	1.0	10.5	7.4	7.1	4.6	4.2	11	8
33	35	9	T	3	55	23	79	30	10.6	0.8	11.4	6.1	6.9	4.8	3.6	26	12
34	36	10	T	2	60	37	111	59	15.4	1.8	14.7	10.6	7.1	5.3	4.4	59	46
35	38	11	T	6	59	21	71	42	13.6	1.3	14.6	8.4	6.3	5.1	4.0	60	34

Varieties			Characters													
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
36	40	-	T	7	57	21	34	10	14.6	1.5	13.7	9.0	5.7	5.9	4.4	20	11
37	41	-	T	7	65	20	53	6	11.6	0.9	9.0	6.1	4.6	3.6	3.3	6	3
38	42	-	T	4	55	15	83	33	12.6	1.1	13.2	7.0	6.0	4.6	3.6	36	24
39	43	12	T	4	49	19	137	24	13.8	1.6	15.1	8.5	6.2	5.5	4.2	122	93
40	44	13	SE	2	48	14	61	32	11.3	0.6	9.9	6.1	5.8	4.4	3.7	27	9
41	45	14	E	5	47	20	37	11	14.2	1.5	15.0	7.2	6.0	5.2	3.8	22	10
42	46	-	T	3	43	28	63	4	15.5	2.0	13.5	11.2	6.4	6.2	4.5	7	4
43	47	15	E	5	56	13	79	35	16.6	2.3	15.8	5.8	6.6	6.0	4.5	66	39
44	48	-	E	3	55	22	53	5	10.7	1.0	9.6	6.0	5.6	5.4	3.7	6	5
45	49	-	E	4	56	19	76	11	11.8	1.3	10.7	6.8	7.1	5.5	4.4	22	7
46	50	-	SE	3	54	29	91	15	10.6	0.9	13.7	5.7	5.2	4.5	3.6	14	5
47	51	-	SE	2	56	23	41	12	12.6	1.0	9.8	6.1	7.1	4.9	3.6	14	4
48	52	-	-	Not germinated													
49	53	-	E	5	49	35	71	25	14.4	1.6	15.3	7.2	6.0	5.7	4.2	38	21
50	54	-	SE	6	53	31	53	7	13.6	1.3	14.6	8.4	4.7	4.4	3.4	9	2
51	55A	-	-	Not germinated													
52	55B	16	SE	4	47	25	89	28	14.5	1.8	13.1	9.8	6.4	5.7	4.3	48	30
53	55C	-	-	Not germinated													
54	56	-	T	Not flowered till 5-9-77													
55	58	-	T	7	-	23	93	21	15.8	1.3	13.8	7.5	6.9	6.5	5.0	26	14

Varieties			Characters													
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
56	60	-	-	Not germinated													
57	61	-	-	Not germinated													
58	62	-	T	5	62	18	59	29	11.8	1.1	12.1	5.8	6.0	4.9	3.5	30	21
59	63	-	E	7	48	26	93	31	13.5	1.2	14.0	6.7	5.8	4.8	3.8	33	24
60	64	-	-	Not germinated													
61	65	-	-	Not germinated													
62	66	-	E	4	48	35	43	4	10.3	0.7	11.0	4.0	5.7	4.2	3.4	5	3
63	67	-	E	5	57	23	31	6	10.5	0.9	9.6	4.1	5.8	5.2	3.7	6	3
64	68	-	-	Not germinated													
65	69	17	SE	6	49	26	89	46	12.6	0.6	7.9	8.0	6.3	5.0	3.8	50	34
66	70	-	T	3	49	32	71	30	11.3	1.2	9.3	8.5	5.9	5.2	4.4	34	26
67	71	-	-	Not germinated													
68	72	-	-	Not germinated													
69	73	-	-	Not germinated													
70	74	18	SE	8	57	8	97	57	14.1	1.5	15.9	7.9	6.1	3.9	3.7	77	54
71	79	-	-	Not germinated													
72	80	19	SE	2	56	16	32	14	26.1	3.3	11.6	18.3	10.8	5.9	4.1	36	25
73	81	-	-	Not germinated													
74	82	-	-	Not germinated													
75	83	20	E	3	49	15	43	11	23.3	3.0	10.5	16.3	11.0	5.8	4.7	17	13

Varieties			Characters													
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
76	84	-	-	Not germinated													
77	85	-	-	Not germinated													
78	87	21	E	7	55	28	49	13	12.3	0.5	7.0	5.5	8.0	4.7	3.4	7	6
79	88	-	E	2	34	28	97	21	15.1	0.6	7.5	7.4	5.4	3.8	5.0	13	4
80	89	-	-	Not germinated													
81	92	-	E	4	49	18	74	23	16.1	1.8	12.7	6.6	6.7	5.1	4.3	37	24
82	93	22	SE	3	56	24	53	21	20.0	2.5	13.9	6.1	8.4	6.0	4.2	41	30
83	94	-	-	Not germinated													
84	95	23	E	7	57	22	44	18	14.6	0.9	9.9	4.3	7.4	5.1	3.6	11	8
85	96	24	SE	9	55	33	159	84	16.2	4.0	11.8	7.8	6.9	5.2	4.1	143	92
86	97	-	T	5	49	21	44	13	14.1	1.4	9.6	14.0	8.9	5.3	3.8	27	22
87	98	-	SE	5	50	29	61	13	11.1	0.9	8.4	5.8	5.4	4.1	3.6	19	11
88	99	-	T	2	59	23	41	8	13.4	0.9	12.1	9.0	7.3	5.2	4.1	23	17
89	100	25	E	9	58	24	128	41	13.8	1.3	13.5	7.4	5.9	5.0	3.7	61	31
90	101	26	E	4	47	11	49	22	12.7	1.0	10.5	8.0	7.0	4.8	3.8	33	24
91	102	-	E	7	57	14	73	38	14.1	1.1	13.8	7.0	6.3	5.1	3.8	35	26
92	103	27	T	3	65	16	93	10	17.8	1.7	12.8	10.2	8.7	7.4	4.3	39	35
93	104	-	T	3	59	23	51	16	16.5	1.8	13.8	6.8	6.8	5.1	4.0	19	14
94	105	-	T	3	51	29	121	6	12.5	1.0	10.1	5.3	6.4	5.0	3.6	55	2
95	106	-	E	6	49	32	69	6	12.7	1.2	6.7	5.4	8.0	6.9	5.1	6	4

Varieties			Characters													
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
96	107	-	T	4	51	27	73	27	13.5	1.4	14.8	6.7	5.4	5.0	3.7	69	44
97	108	-	SE	6	55	23	121	46	12.9	1.1	11.1	6.8	6.6	4.8	3.8	30	19
98	109	28	T	9	48	14	193	143	13.0	1.3	11.2	6.1	5.7	5.0	4.0	165	115
99	110	-	E	9	48	21	93	42	16.7	2.4	12.4	7.1	6.2	5.4	4.1	50	34
100	111	-	E	8	65	23	71	37	17.6	1.5	12.7	8.5	6.9	5.4	4.2	51	36
101	113	29	SE	4	51	23	19	18	18.4	1.9	15.8	9.1	7.7	5.9	4.0	22	14
102	114	-	SE	4	57	17	31	13	13.6	1.1	10.1	5.3	7.6	5.4	3.7	12	8
103	115	-	T	3	41	22	92	53	10.5	0.9	12.8	5.1	6.2	4.2	3.2	26	19
104	116	-	-	Not germinated													
105	117	-	E	6	59	24	39	3	11.6	0.9	7.7	7.5	6.4	4.8	3.9	4	2
106	118	-	-	Not germinated													
107	119	30	T	3	49	17	48	14	24.8	3.1	16.4	11.2	9.1	4.9	3.4	33	19
108	120	-	T	3	48	13	41	33	20.8	1.3	11.5	7.8	8.7	4.7	3.3	29	24
109	121	31	SE	4	47	15	19	13	18.9	2.0	12.0	9.7	8.2	5.1	4.0	20	11
110	122	-	E	6	47	20	39	11	16.4	2.0	15.6	9.2	6.1	6.1	4.2	55	30
111	123	32	E	2	38	29	37	21	13.7	1.2	8.8	11.7	7.4	6.2	4.4	21	14
112	124	-	E	6	38	32	63	34	11.5	0.8	9.3	5.3	6.6	4.2	2.6	20	14
113	125	-	-	Not germinated													
114	126	-	E	6	57	32	79	6	10.5	0.9	9.7	5.4	5.1	4.1	3.4	4	3
115	127	-	T	5	51	18	71	10	18.2	2.1	14.4	10.3	8.4	5.7	3.8	19	15

Varieties			Characters													
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
116	128	33	SE	6	59	28	67	13	20.2	2.3	14.1	10.9	8.2	5.5	3.9	21	13
117	129	-	-	Not germinated													
118	130	-	E	5	59	23	49	4	17.1	1.5	11.6	6.4	8.2	5.4	4.0	6	4
119	131	-	-	Not germinated													
120	132	-	E	4	61	20	62	3	11.2	2.2	11.1	8.1	8.2	5.7	3.8	7	5
121	133	-	T	2	53	20	49	7	17.4	1.7	12.3	9.1	7.5	4.7	4.3	11	8
122	134	-	T	3	57	24	32	16	18.1	1.8	13.2	10.0	8.1	5.9	4.0	25	14
123	135	-	T	2	59	16	29	2	12.3	1.1	11.1	7.1	8.2	5.2	3.8	2	1
124	136	-	T	3	48	31	43	9	15.2	1.0	9.1	5.5	7.6	5.5	3.9	12	5
125	137	-	T	8	70	27	37	3	10.6	0.9	8.6	5.1	7.3	5.1	4.1	2	1
126	138	-	-	Not germinated													
127	139	-	-	Not germinated													
128	140	-	SE	5	48	28	78	22	16.5	1.6	12.1	9.9	8.2	5.6	4.5	31	19
129	141	34	E	5	48	23	62	22	19.7	2.4	16.0	10.0	8.3	5.7	4.3	35	21
130	142	35	E	6	49	13	108	29	12.7	0.9	8.6	8.7	7.2	4.9	4.1	78	61
131	143	-	E	5	56	16	41	14	13.2	1.3	11.6	9.4	7.3	6.0	4.0	17	10
132	144	36	E	4	57	21	28	4	19.7	2.1	16.3	10.5	8.6	5.5	4.2	39	29
133	145	37	E	3	56	25	31	6	14.8	1.4	12.2	7.1	6.9	4.7	3.7	10	8
134	146	-	E	4	55	23	27	3	12.6	1.3	11.1	9.0	8.3	6.0	4.0	4	1
135	147	-	SE	5	56	14	39	33	20.1	1.6	13.9	8.2	8.9	6.2	4.1	49	30

Varieties			Characters													
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
136	148	-	SE	4	55	22	43	22	19.5	1.6	14.8	8.6	8.2	5.6	4.0	32	19
137	149	-	SE	6	65	24	62	6	16.5	1.4	11.7	5.4	8.1	5.9	3.9	11	4
138	150	-	E	4	57	23	46	5	12.5	0.6	7.8	8.5	7.5	4.6	3.3	4	1
139	151	-	E	2	65	17	41	10	14.1	1.2	9.6	9.1	6.4	5.1	4.3	13	5
140	152	-	-	Not germinated													
141	153	-	-	Not flowered till 5-9-77													
142	154	-	E	3	61	27	45	3	10.2	0.9	10.0	5.4	8.0	5.3	3.9	7	1
143	155	-	-	Not germinated													
144	156	-	E	2	52	23	49	6	13.4	1.4	9.7	8.1	6.1	5.1	4.1	9	3
145	157	38	E	3	65	19	37	8	9.1	0.8	8.4	6.8	6.1	4.7	3.8	20	14
146	158	-	SE	2	56	20	91	58	11.6	1.2	10.7	9.3	7.2	5.4	4.2	57	38
147	159	39	SE	3	49	17	53	26	10.7	0.9	12.0	5.2	5.7	4.1	3.9	31	18
148	160	40	E	8	59	19	47	27	10.0	0.7	9.6	6.1	6.0	4.2	3.7	32	10
149	161	-	-	Not germinated													
150	162	-	T	7	57	15	49	15	16.5	1.7	14.3	9.8	7.7	5.0	3.5	22	19
151	163	41	T	2	50	17	39	21	10.5	0.9	9.4	9.6	7.8	5.3	4.2	61	44
152	164	-	-	Not germinated													
153	165	-	T	3	49	17	37	35	15.0	1.8	12.7	7.2	7.6	5.2	3.8	46	29
154	166	42	T	8	51	14	34	18	9.6	0.8	8.0	6.7	6.3	4.5	3.4	27	17
155	167	-	SE	3	48	19	44	34	17.2	2.5	14.3	9.8	7.8	6.3	4.2	70	49

Varieties			Characters														
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
156	168	43	SE	4	59	20	51	21	17.9	1.7	11.9	11.4	8.9	5.9	4.3	21	5
157	169	-	T	4	42	16	32	21	12.6	1.1	11.2	8.0	6.8	5.1	3.9	65	44
158	170	-	E	7	50	25	67	38	11.5	1.0	10.9	7.5	6.1	5.0	3.8	40	27
159	171	-	E	5	59	14	27	29	12.1	1.2	11.1	6.6	6.3	4.6	3.9	33	19
160	172	-	E	7	49	15	48	6	12.9	1.5	10.9	5.3	7.0	4.5	3.5	53	20
161	173	-	SE	4	50	23	61	27	11.1	1.0	11.3	5.3	5.8	4.0	3.5	31	12
162	174	-	E	5	48	17	53	13	16.7	1.9	13.7	10.0	7.5	5.5	4.4	24	16
163	175	-	-	Not germinated													
164	176	-	-	Not germinated													
165	177	44	E	6	48	16	67	40	17.0	2.0	15.6	10.0	6.4	5.6	4.2	121	95
166	178	-	E	5	59	21	57	6	11.1	1.1	12.1	8.6	6.1	4.9	4.1	6	2
167	179	-	E	5	46	17	69	13	14.1	1.7	11.4	7.8	6.6	5.1	4.2	65	35
168	180	-	E	8	43	19	51	40	12.4	1.2	11.0	8.5	7.0	5.9	4.5	41	24
169	181	-	SE	6	57	25	73	1	11.0	1.3	10.0	5.0	7.1	5.6	4.2	2	1
170	182	-	E	6	48	15	43	47	16.2	1.8	11.7	10.4	7.6	5.8	4.4	89	66
171	183	45	SE	3	47	23	70	12	16.9	2.1	12.2	13.4	8.0	5.9	4.9	33	25
172	184	-	SE	4	39	27	65	36	17.5	2.2	14.7	10.3	7.8	6.0	4.8	71	54
173	185	46	E	5	57	24	54	60	13.9	1.9	15.2	9.5	7.4	5.8	4.3	91	70
174	186	-	E	7	59	17	63	65	15.1	1.9	13.0	8.2	5.3	4.8	4.2	105	74
175	187	-	SE	3	39	16	39	45	12.7	1.1	10.1	5.4	6.4	5.1	4.3	50	37

Varieties			Characters														
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
176	188	47	SE	2	41	17	43	45	12.7	1.5	16.2	6.4	5.0	5.2	4.1	151	110
177	189	48	SE	2	48	21	47	14	17.2	2.1	14.0	9.4	7.1	5.5	4.4	107	75
178	190	49	T	2	47	27	58	55	17.5	2.1	15.4	7.7	5.9	4.6	6.2	114	86
179	191	-	E	5	48	23	71	23	12.6	1.1	10.8	8.2	6.5	5.6	3.9	105	65
180	192	-	E	9	44	29	65	40	15.4	1.5	12.9	7.6	7.1	5.6	3.8	35	10
181	193	-	T	4	59	29	59	19	17.6	1.9	14.8	7.8	6.5	5.5	3.8	61	35
182	194	-	T	4	48	25	72	14	17.2	2.1	16.2	8.2	6.8	5.2	4.0	23	14
183	195	-	E	7	48	20	43	32	15.5	2.0	13.7	8.5	6.7	5.6	4.4	64	42
184	196	-	-	Not germinated													
185	197	-	E	6	57	31	36	3	16.4	1.7	14.3	8.4	7.6	5.2	3.9	8	5
186	198	-	T	2	49	27	49	20	13.5	1.2	12.9	7.5	6.6	4.3	3.7	19	14
187	199	50	T	3	51	23	38	27	11.4	1.0	12.0	5.0	5.8	4.3	3.6	20	14
188	200	-	T	3	51	24	51	9	13.1	1.1	8.7	9.6	8.7	5.6	4.0	37	25
189	201	-	T	2	51	29	47	14	11.9	1.1	8.7	8.5	7.1	4.6	4.1	10	8
190	202	-	T	2	43	28	63	10	23.6	1.5	14.3	7.7	8.8	4.9	3.5	35	25
191	203	-	T	4	43	26	72	15	22.7	1.8	13.4	7.7	8.2	4.9	3.4	19	12
192	204	51	E	2	49	23	54	15	9.9	0.7	10.4	4.3	4.8	3.8	3.1	25	15
193	205	-	T	3	47	22	41	12	18.5	1.7	13.4	10.0	8.9	5.2	4.0	24	15
194	206	52	T	1	58	21	39	5	23.1	2.0	16.0	10.3	9.6	6.3	3.9	8	6
195	207	-	SE	4	50	19	37	6	13.9	0.8	7.4	8.8	7.7	5.2	3.9	66	45

Varieties			Characters														
Sl. No. 77-78	Type No.	Sl. No. 78-79	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
196	208	-	T	2	43	23	43	7	11.9	1.1	12.7	4.8	6.5	4.7	4.1	11	5
197	209	53	T	2	58	31	65	15	20.9	2.6	14.2	11.9	9.6	6.0	4.0	29	20
198	210	54	T	2	59	35	77	14	20.2	2.2	12.5	11.1	9.1	5.7	4.0	23	15
199	211	55	T	2	57	36	79	4	20.6	2.5	11.2	9.8	9.5	5.0	3.8	25	20
200	212	-	E	5	48	28	47	12	15.5	1.5	11.8	6.8	6.9	4.5	3.7	15	11
201	213	-	E	2	47	20	38	17	14.3	1.6	10.6	11.5	7.4	6.2	4.5	22	16
202	214	56	E	3	46	44	88	18	21.8	2.2	14.7	4.7	9.1	6.4	4.1	13	9

Characters:

(1) Habit of growth (E = Erect; SE = Semi-erect and T = Trailing)
(2) Number of primary branches
(3) Days to commence flowering
(4) Flowering spread (days from commencement to completion)
(5) Number of flowers per plant
(6) Number of pods per plant
(7) Length of pod (cm)
(8) Weight of pod (g)
(9) Number of seeds per pod
(10) 100-seed weight (g)
(11) Length of seed (mm)
(12) Breadth of seed (mm)
(13) Thickness of seed (mm)
(14) Pod yield per plant (g)
(15) Seed yield per plant (g)