MODEL FOR SELECTING BLACK GRAM (*Phaseolus mungo* Roxb.) VARIETIES FOR YIELD AND ADAPTABILITY UNDER PARTIAL SHADE

BY

GEETHA PHILIP

THESIS
SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE
OF
MASTER OF SCIENCE IN AGRICULTURE
(PLANT BREEDING)
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF PLANT BREEDING
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1987

DECLARATION

I hereby declare that this thesis entitled "Model for selecting black gram (Phaseolus mungo Roxb.) varieties for yield and adaptability under partial shade" 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 University or Society.

Geetha Philip
GEETHA PHILIP

Vellayani,
7.8.1987

CERTIFICATE

Certified that this thesis entitled "Model for selecting black gram (Phaseolus mungo Roxb.) varieties for yield and adaptability under partial shade" is a record of research work done independently by Kumari GEETHA PHILIP, 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.

Dr. R. GOPIMONY
(Chairman, Advisory Committee),
Professor of Plant Breeding.

Vellayani,
7 8.1987

APPROVED BY:

Chairman:

Dr. R. GOPIMONY

Members:

1. Sri. S.G. SREEKUMAR

2. Sri. R. BALAKRISHNAN ASAN

3. Sri. M.R.C. PILLAI

External Examiner:

ACKNOWLEDGEMENT

I wish to express my sincere and deep sense of gratitude to Dr. R. Gopimony, Professor of Plant Breeding and Chairman of the Advisory Committee for his expert guidance, valuable suggestions, unstin ted support and sustained encouragement throughout the course of the investigation and preparation of the thesis.

I pay my grateful thanks to Sri. K. Gopakumar, Professor of Agricultural Botany and Dr. P. Manikantan Nair, Professor of Plant Breeding for the help and guidance they had rendered in the initial stages of this study.

My sincere thanks are due to Sri. S.G. Sreekumar, Assistant Professor of Plant Breeding, Sri. R. Balakrishnan Asan, Assistant Professor of Agricultural Statistics and Sri. M.R.C. Pillai, Professor of Agronomy, who as members of the Advisory Committee envinced keen interest and gave valuable suggestions during the course of the study and preparation of the thesis.

My whole hearted and profound thanks are due to

Dr. V. Gopinathan Nair, Professor and Head of the Department of Plant Breeding for having provided the necessary facilities and guidance during the course of this investigation.

I am grateful to Dr. M.M. Koshy, Dean i/c, for providing necessary facilities for completing the work.

I am obliged to Sri. C.E. Ajithkumar for the help rendered in the statistical analysis of the data.

Sincere thanks are due to Sri. P. Nataraja Pillai for his timely help and neat work in typing the thesis.

I am grateful to all my friends and other staff members of the Department of Plant Breeding for all their valuable help and kind co-operation during the course of the study.

I sincerely thank the Kerala Agricultural University for awarding me the University Merit Scholarship.

I am deeply indebted to my parents, brothers and sister for their consistent prayers, unfailing inspiration and sincere encouragement at every stage of the work.

Last, but certainly not the least, I thank God Almighty for having helped me to complete this small endeavour of mine.

Geetha Philip
GEETHA PHILIP

Vellayani,
7 8 1987

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

The grain legumes commonly known as pulses form an important and ancient component of Indian agricultural system. They are generally grown under rainfed and low input conditions. According to Aykroyd and Doughty (1964), a balanced diet should contain three ounces of pulses per day per adult to meet the protein requirement. But the present production of pulses in India is only 12.2 million tonnes with a per hectare yield of 537 kg (1984-'85) which is not sufficient to meet even the minimum needs. The area and production of pulses in Kerala are only 28.72 thousand hectares and 20.38 thousand tonnes respectively (1984-'85). This emphasizes the need for increasing the production of pulses.

Pulses have the unique built-in mechanism for directly using the inexhaustible stock of atmospheric nitrogen. These crops have been popular with farmers for centuries because they fit suitably in crop rotations and crop mixtures.

Black gram or urd bean (*Phaseolus mungo* Roxb. Syn. *Vigna mungo* (L) Hepper) is one of the most important and highly nutritious pulse crops. In India it is grown in about 2 million hectares with a total production of 0.66 million tonnes (1980-'81). It is consumed by all sections of the society in a variety of ways. It is of excellent quality and high digestibility containing about 24 per cent protein. Its calorific value is 340 per 100 g. Black gram is a good source of phosphorus and the major part of it is in the form of phytin. The bhusa, the husk and the small broken grains are used for feeding cattle. The crop is suitable for multiple or relay cropping and also as a green manure and cover crop. The average yield of pulses in Kerala is 700 kg/ha (1984-'85). The main reasons for the low productivity are high rainfall, low per capita available area, farmers preference for rice crop, lack of short duration high yielding varieties and occurrence of pests and diseases. There are immense possibilities for extending the area under pulses utilizing the rice fallows and by intercropping in coconut gardens.

Yield component analysis forms the basic step in the evaluation of existing gene pool of any crop variety. Genetic analysis in black gram has been attempted previously by many workers in Kerala and elsewhere.

But all those works were done under open field condition to suit the major commercial environment available for pulse cultivation in India. Under Kerala condition the major limitation in extending pulse cultivation is the non-availability of fresh land for the purpose. Under upland condition the only land available for this crop in Kerala is the partial shade of coconut gardens. Evaluation of black gram genotypes specifically for this environment has never been attempted previously. Hence the present work was undertaken with the prime objective of identifying through biometrical tests the important yield components that would help in the selection of superior black gram genotypes for yield and adaptability in uplands under partial shade.

The major objectives of the study were:

1. To find out the extent of variability present in the population by estimating the parameters like genotypic coefficient of variation, heritability, genetic advance and genetic gain.
2. To find out the association of different characters with yield and also among themselves.
3. To determine the direct and indirect influence of different component characters on yield using path coefficient analysis.
4. To formulate a model based on the above studies, for selecting black gram genotypes for yield and adaptability suited to partially shaded conditions in coconut gardens.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Variability, heritability, genetic advance, correlation responses and path analysis are the main parameters which help the selection of superior genotypes from genetically diverse population. A brief review of the work done on these aspects in relation to yield and its components in black gram and other pulse crops relevant to the present study are summarized below.

I. Variability

Plant breeding in the true sense relates to the efficient management and utilization of variability. Genetic variability in a crop forms the primary prerequisite for achieving genetic improvement. The most important genetic parameter which provides an efficient estimation of variability is the coefficient of variation.

Many workers studied the extent of variability in pulse crops by working out genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV). But the extent of genetic variability is more important than the total variation since greater the genetic diversity, wider would be the scope for selection.

Their findings are briefly reviewed below.

Black gram (Phaseolus mungo Roxb. Syn. Vigna mungo (L) Hepper)

Singh et al. (1972) studied variability in 25 varieties of black gram for six characters viz. seed yield, pod number per plant, number of fruiting nodes, number of primary branches, pod length and seed size. Their study revealed that seed yield and pods per plant showed high genotypic coefficient of variation.

Veeraswamy et al. (1973a) studied variability for plant height, number of branches, number of pod clusters, number of pods, length of pod, number of seeds per pod, seed weight and pod weight in 25 varieties of black gram. They found the highest value (90.73 per cent) for genotypic coefficient of variation for number of pods per plant.

Singh et al. (1975) reported maximum genotypic coefficient of variation in respect of plant height (26.18 per cent) and minimum for 100 seed weight (3.62 per cent).

Soundrapandian et al. (1975) reported a wide range of variability for plant height and number of pods per plant. Genotypic coefficient of variation was observed to be high for number of pods per plant, plant height and grain weight per plant. Variability was found very low for length of pod and seeds per pod.

Sagar et al. (1976) in their study with 27 lines of black gram reported maximum variation for yield per plant, pods per plant, days to 50 per cent flowering and branches per plant. For all these characters the phenotypic coefficient of variation was greater than their genotypic coefficient of variation indicating high influence of environment in the expression of these characters.

Goud et al. (1977) in their study with 12 varieties of black gram observed high genotypic coefficient of variation (23.00 per cent) for seed yield per plant and very low value for pod length (2.90 per cent).

Patel and Shah (1982) studied phenotypic and genotypic coefficients of variability in 20 varieties and reported high genotypic coefficient of variation for pod length (40.5 per cent) and plant height (35.8 per cent).

Singh and Misra (1985) conducted variability studies in 30 varieties and observed high genotypic and phenotypic variances for plant height and number of pods per plant.

Green gram (*Vigna radiata* (L) Wilczek)

Chowdhury *et al.* (1971) studied genetic variability in 21 varieties of green gram and found that days to 50 per cent flowering, plant height and 100 seed weight showed wide variability.

Joshi and Kabaria (1973) from a diallel cross of six varieties of green gram noticed wide range of variability for yield and yield contributing characters viz. number of pods per plant, number of seeds and 100 seed weight.

Veeraswamy *et al.* (1973b) studied the variability in 25 varieties of green gram and observed high genotypic coefficient of variation for branches per plant, pods per plant, clusters per plant and plant height. The highest GCV of 35.3 per cent was recorded for clusters per plant.

Paramasivan and Rajasekaran (1980) noticed wide range of variability for plant height and pod number in 90 varieties of green gram. The range of variability in plant height was 9.40 to 58.66 cm and the same for pod number was 6.88 to 76.55.

Liu *et al.* (1984) in a study of nine quantitative characters viz. plant height, pod number per plant, seeds per pod, seed yield per plant, 100 seed weight, days to 50 per cent flowering, stem diameter, number of branches per plant and number of nodes per plant, concluded that seed yield per plant and pod number showed high genetic coefficient of variation.

Red gram (*Cajanus cajan* L.)

Joshi (1973) noticed wide range of variation for seed yield (12 to 75 g), number of branches (7 to 37), number of pods (6 to 240) and plant height (97 to 120).

Gupta *et al.* (1975) reported high phenotypic variability for pod clusters per plant, pods per plant, seed yield, plant height, 100 seed weight, seeds per pod and pod length.

Godawat (1980) in a study with 26 varieties of pigeon pea found that genotypic coefficient of variation was highest for grain yield per plant and number of primary branches.

Bainiwal *et al.* (1981) observed maximum variability for number of secondary branches followed by primary branches and seed yield in 29 varieties. They found 22.35 per cent GCV for secondary branches, 11.68 per cent for primary branches and 18.15 per cent for seed yield.

Shoram (1983) worked out estimates of variability in 100 genotypes of pigeon pea and reported high GCVs for pods per plant, days to maturity, plant height and days to 50 per cent flowering.

Cowpea (*Vigna sinensis* (L) Savi)

Veeraswamy *et al*. (1973c) studied variability for plant height, number of branches per plant, number of clusters per plant, number of pods per plant, weight of pods per plant, number of grains per pod, pod length and grain yield per plant in 12 varieties of cowpea. They reported wide range of variability for plant height, number of clusters, number of pods, weight of pods and grain yield per plant.

Lakshmi and Goud (1977) reported high GCV for plant height, grain yield, number of pods per plant and 100 grain weight in 12 varieties of cowpea.

Tikka *et al*. (1977) reported high GCV for height, pods per plant and pod length based on their studies on

25 varieties of cowpea.

Dharmalingam and Kadambavanasundaram (1984) undertook variability studies on 40 genotypes of cowpea and observed high genotypic coefficient of variation for harvest index (35.69 per cent), number of pods (29.92 per cent) and seed yield (24.16 per cent). The least contribution of genetic variability was shown by number of seeds per pod (12.88 per cent).

Other pulses

Lal and Haque (1972) reported high phenotypic variability for days to flowering, days to maturity, number of leaves per plant, plant height and number of pods per plant in soybean. They reported that number of pods per plant, plant height, seed yield and 100 seed weight exhibited high genetic coefficient of variation.

Setty *et al.* (1977) found that in bengal gram genotypic coefficient of variation was high for number of branches, number of seeds, number of pods and seed yield.

Khorgade *et al.* (1985) conducted variability studies in 32 genotypes of bengal gram and observed highest genotypic coefficient of variation for 100 seed weight and lowest for plant height.

Singh (1985) reported high degree of genetic variability for grain yield, plant height, number of pods per plant and number of branches per plant among 30 varieties of pea.

II. Heritability and Genetic Advance

The extent to which the variability of a quantitative character is transferable to the progeny is referred to as heritability for that particular character. Lush (1940) has defined heritability both in broad and narrow senses According to him, heritability in the broad sense implies the percentage of total genotypic variance over phenotypic variance. In the narrow sense, heritability is the ratio of additive genetic variance to total variance and it takes into account only average effects of genes transmitted from parents to offsprings. While selecting for a character, consideration of mere phenotypic variability without estimating the heritable part of it will not be of much use. Heritability estimates along with genetic gain is usually more useful in predicting the resultant effect through selection of the best individual (Johnson et al. 1955).

Black gram

Soundrapandian et al. (1975) reported high heritability coupled with high genetic advance for plant height and number of pods per plant while it was medium for grain weight, number of clusters per plant and number of pods per plant.

Goud et al. (1977) noticed high heritability for pod length (96.00 per cent), plant height (93.00 per cent), 1000 seed weight (92.50 per cent) and number of seeds per pod (91.11 per cent). Lowest heritability was observed for grain yield (52.92 per cent).

Patel and Shah (1982) in their study with 20 strains of black gram reported high heritability and genetic advance for plant height (86.2 and 68.5 per cent respectively) and pod length (46.9 and 57.2 per cent respectively).

Sarkar et al. (1984) observed high heritability and genetic advance for plant height and days to maturity in 11 photo-period insensitive pure lines of black gram.

Pods per plant and 100 seed weight showed medium heritability and genetic advance.

Green gram

Empig *et al*. (1970) showed that heritability estimates in the F_2 generation of green gram had high values for number of days to flowering and maturity and low value for yield.

Chowdhury *et al*. (1971) found that days to flowering, plant height, pod length and 100 seed weight showed high estimates of heritability associated with high genetic gain.

Veeraswamy *et al*. (1973b) observed high heritability associated with high genetic advance for number of clusters and number of branches.

Paramasivan and Rajasekaran (1980) recorded the highest estimate of heritability for 100 seed weight (100 per cent) followed by pod length (97.18 per cent), cluster number (92.56 per cent) and seed yield (89.45 per cent). The genetic advance were also high for these characters.

Pigeon pea

Godawat (1980) reported high heritability for number of primary branches (89.05 per cent) and grain yield per plant (50.96 per cent). They observed highest genetic gain for grain yield (43.51 per cent) followed by number of primary branches (39.90 per cent).

Bainiwal *et al*. (1981) observed the genetic advance to be high for seed yield (29.24 per cent), secondary branches (22.68 per cent), plant height (15.11 per cent) and primary branches (13.10 per cent).

Cowpea

Singh and Mehndiratta (1969) in cowpea recorded the highest estimate of variability for 100 seed weight (95.89 per cent) followed by days to flowering (88.79 per cent) and days to maturity (78.29 per cent) and the lowest for seed yield (35.62 per cent). They observed highest genetic advance for 100 seed weight and moderate for seed yield and lowest for days to maturity.

Veeraswamy *et al*. (1973c) recorded highest heritability for pod length (99.5 per cent) and lowest for number of grains per pod (33.3 per cent). The genetic advance was high in the case of pod weight (59.4 per cent), pod length (53.8 per cent), number of pods (46.9 per cent) and grain yield (46.4 per cent). Pod length recorded high values for both heritability and genetic advance.

Lakshmi and Goud (1977) reported high heritability for plant height, pod length and 100 grain weight and low heritability for yield and pods per plant. According to them genetic advance was high for plant height, medium for yield and 100 grain weight and low for pod length and number of seeds per pod.

Other pulses

Srivastava and Sachan (1974) observed highest heritability (58.76 per cent) and genetic advance (18.10 per cent) for branches per plant in pea. Heritability was minimum for 100 seed weight (32.33 per cent).

Raut and Patil (1975) have reported high heritability and genetic advance for plant height, number of seeds per pod and seed weight per plant in soybean.

Shivasankar *et al*. (1977) have observed high heritability and genetic advance for number of secondary branches and nodes per plant in horse gram.

Khorgade *et al.* (1985) have observed high heritability for 100 seed weight (95.68 per cent), seeds per pod (94.21 per cent) and time to 50 per cent flowering (91.71 per cent) in chick-pea.

III. Correlation studies

Correlation studies provide estimates of the degree of association of a character with its components and also among the components. In a programme of breeding for improving the yield potential of a crop, information of the inter-relationship of yield with other traits is of immense value. This will facilitate selection of high yielding plants through other related components.

Correlation studies conducted by various workers in different pulses are reviewed below.

A. Association between yield and its components

Black gram

Verma and Dubey (1970) observed positive significant correlation of yield with number of seeds per pod, pod length, 1000 seed weight and number of pods per plant.

Tripathi and Singh (1975) showed that a positive and significant correlation existed between seed yield and total number of pods per plant and pod length.

Patel and Shah (1982) from their correlation studies in 20 strains of black gram recorded significant positive correlation of seed yield with number of branches (0.61), pods (0.86) and clusters per plant (0.88).

Sarkar et al. (1984) reported significant positive correlation of seed yield with pods per plant and 100 seed weight in their study with 11 photoperiod-insensitive pure lines of black gram.

Green gram

Singh and Malhotra (1970) recorded significant positive association of yield with number of branches, number of pods, pod length, number of seeds per pod and seed size. They also observed that genotypic correlations were higher than phenotypic and environmental correlations.

Joshi and Kabaria (1973) recorded high and positive genotypic correlation of seed yield with number of pods per plant, number of seeds per pod and days to 50 per cent flowering and maturity.

Tomar *et al*. (1973) found that yield was positively correlated with number of pods per plant, pod length, 100 seed weight and number of seeds per pod.

Giriraj and Vijayakumar (1974) recorded strong association of yield with days to flowering, height of the plant, number of pods per plant and number of seeds per pod.

Gupta *et al*. (1982) found that yield was positively associated with days to maturity, number of clusters per plant, number of pods per plant and number of grains per pod.

Pigeon pea

Joshi (1973) reported that seed yield was positively and significantly correlated with number of pods (0.665) and number of branches (0.537), whereas the same showed a weak negative correlation with seeds per pod (-0.086).

Godawat (1980) reported that grain yield per plant was significantly and positively correlated with number of primary branches per plant, 100 grain weight, number of pods per plant and pod length.

Bainiwal and Jatasra (1985) reported that seed yield was positively and significantly correlated with days to 50 per cent flowering, plant height and number of primary branches per plant.

Cowpea

Bordia *et al*. (1977) recorded positive correlation of seed yield with number of pods, pod length and seed number per pod.

Natarajarathnam *et al*. (1985) found that grain yield had strong positive association with pod weight per plant, pod clusters per plant and plant height.

Singh and Dabas (1985) reported significant and positive association of grain yield with plant height, pods per plant, pod length and grains per pod.

Other pulses

Srivastava *et al*. (1976) reported that seed yield exhibited positive and highly significant genotypic association with days to 50 per cent flowering and seeds per pod in soybean.

Pandey *et al*. (1980) found that yield was highly and positively correlated with leaflet area, days to 50 per cent flowering, 100 seed weight, pod width and protein content in Lab-lab bean.

Bajaj *et al*. (1984) reported that yield was significantly and positively correlated with plant height and number of pods per plant in chick-pea.

Singh (1985) reported in pea that days to 50 per cent flowering, days to maturity, plant height, number of pods per plant and number of primary branches per plant were positively associated with grain yield.

B. Inter-correlation among yield components

Black gram

Tripathi and Singh (1975) recorded significant positive correlation between plant height and number of pods per plant and seed size and between days to flowering and number of branches per plant.

Muthiah (1976) conducted correlation studies in 50 varieties of black gram involving nine characters viz. plant height, number of branches, number of clusters per plant, number of pods per plant, length of pod, number of seeds per pod, 100 seed weight, pod yield per plant and seed yield per plant. He observed positive association between all the pairs of characters in all combinations except pod number and 100 seed weight.

Sandhu et al. (1980) reported significant positive correlation among the characters such as number of clusters per plant, number of pods per plant, length of pod and number of seeds per pod.

Green gram

Tomar et al. (1973) found that pod length was positively correlated with seed number per pod and 100 seed weight, whereas these three characters showed low negative correlation with pod number per plant.

Malhotra et al. (1974) reported significant association between branch number, pod number, cluster number, seeds per pod and days to 50 per cent flowering.

Liu et al. (1984) reported positive correlation of seed weight with plant height and stem diameter whereas 100 seed weight was negatively correlated with pod number per plant.

Red gram

Joshi (1973) studied inter-correlations among yield components in red gram and reported that pod length and number of seeds per pod were positively correlated.

Singh *et al.* (1977) concluded from their correlation studies that leaf area per plant and leaf area index were positively associated with maturity. They have further stated that leaf area index was also positively correlated with 100 seed weight and duration of flowering, while leaf area per plant was similarly associated with days to 50 per cent flowering.

Cowpea

Positive inter-correlations among 100 seed weight, pod length and seeds per pod and between pods per plant and branches per plant was reported by Singh and Mehndiratta (1969). They also reported negative correlation between branches per plant and 100 seed weight, pod length and pods per plant and branches per plant and pod length.

Angadi (1976) reported that the clusters per plant was positively correlated with branches per plant. He found positive correlation between seeds per pod and plant height and between seeds per pod and pod length. But the correlation between branches per plant and plant height, pod length and branches per plant, pod length and clusters, pod length and pods per plant, seeds per pod and branches, seeds per pod and clusters and seeds per pod and pods per plant were negative.

Other pulses

Sengupta and Kataria (1971) have found significant negative correlation between pods per plant and 100 seed weight in soybean.

Joshi (1972) has observed strong positive correlation between number of pods per plant and 100 seed weight in chick-pea.

Chand *et al*. (1975) after correlation studies in chick-pea revealed that at phenotypic level pods per plant was highly and positively correlated with seeds per plant (0.9160). But they found strong negative correlation between seeds per pod and 100 seed weight (-0.4089).

IV. Path Analysis

The study of association of component characters with grain yield has been of immense help in selecting suitable plant types. When more number of characters are included in the correlation study, the direct association becomes more complex. In such a situation the path analysis devised by Wright (1921) provides an effective measure to find out the direct and indirect effects permitting a critical examination of the specific factors that produce a given correlation.

Path analysis has been done in different pulse crops by many workers and their reports are summarized below.

Black gram

According to Muthiah (1976), pod yield, pod number, seed yield and 100 seed weight exerted maximum direct positive effect on seed yield, while pod length and cluster number had direct negative effect on yield in black gram.

Soundrapandian *et al.* (1976) have reported that plant height and cluster per plant showed high positive direct effect on seed yield, while branches per plant, pods per plant and seeds per pod showed slight negative direct influence on seed yield.

Usha and Rao (1981) found that plant height had negligible direct effect on yield. But the number of pods per plant, 100 seed weight and seeds per pod had high direct effect on yield.

Patel and Shah (1982) concluded from their studies that clusters per plant followed by pods per plant had maximum positive direct effects on grain yield.

Green gram

Rathnaswamy *et al*. (1978) concluded from their study that 100 seed weight, seeds per pod and number of seeds per plant were the major yield components in green gram.

Boomikumaran and Rathinam (1981) reported that plant height, pods per cluster, and clusters per plant contributed directly for seed yield, while plant height contributed only indirectly for the same.

Misra (1985) reported that pods per plant, 1000 seed weight, seeds per pod, reproductive period and cluster per plant contributed directly to seed yield.

Presannakumari and George (1986) conducted path analysis in green gram and concluded that selection for number of pods per plant, 100 seed weight and number of nodes per plant are effective methods for increasing seed yield.

Red gram

According to Singh and Malhotra (1975), number of pod clusters per plant was the main yield component of pigeon pea.

Veeraswamy *et al*. (1975) reported that number of branches contributed maximum influence on seed yield both directly and indirectly. They also found that number of clusters and pods per plant did not show much direct influence on the seed yield, though they exerted an indirect influence through number of branches.

Cowpea

Choulwar and Borikar (1985) reported that number of seeds per pod and length of pod had greatest direct effect on seed yield per plant and hence, were important yield components in cowpea.

Other pulses

Veeraswamy and Rathnaswamy (1975) after path coefficient analysis in soybean found that number of pods per plant was the major yield contributing factor followed by 100 seed weight and number of nodes.

Agarwal and Kang (1976) found that pods per plant could be used to select for higher yield in horse gram based on path analysis.

In pea Narasinghani et al. (1978) reported maximum direct effect on yield by number of seeds per plant followed by 100 seed weight, number of days to maturity, height and protein percentage.

Natarajan and Arumugam (1980) found that in peas 100 seed weight had the maximum effect on yield followed by number of pods per plant.

According to Singh et al. (1985) seeds per pod had the highest direct effect on yield while most of the other characters affected yield indirectly via. pods per plant in chick-pea.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was carried out at the Department of Plant Breeding, College of Agriculture, Vellayani from May 1986 to November 1986.

Materials

Fifty diverse genotypes of black gram (*Phaseolus mungo* Roxb. Syn. *Vigna mungo* (L) Hepper) were collected from the germplasm maintained at the Rice Research Station, Kayamkulam. The names and sources of the varieties are given in Table 1.

The fifty varieties collected were evaluated in a preliminary observation trial for one season (kharif). On the basis of superiority in yield and adaptation, twenty promising types were selected for the main experiment. The salient morphological features of these twenty varieties are presented in Table 2.

Table 1. Name and source of varieties

Sl. No.	Name of the variety	Original source
1	TMV - 1	Tamil Nadu
2	Co - 2	"
3	Co - 3	"
4	Co - 4	"
5	Co - 5	"
6	Co - Bg - 1	"
7	Co - Bg - 8	"
8	Co - Bg - 9	"
9	Co - Bg - 10	"
10	Co - Bg - 282	"
11	Co - Bg - 300	"
12	Co - Bg - 301	"
13	Co - Bg - 302	"
14	Co - Bg - 303	"
15	Co - Bg - 304	"
16	Co - Bg - 305	"
17	Co - Bg - 306	"

Table 1 contd.

1	2	3
18	Co - Bg - 307	Tamil Nadu
19	ADT - 3	"
20	M - 3	"
21	KM - 2	Punjab
22	UG - 28	"
23	UG - 218	"
24	PDU - 1	Kaunpur
25	PDU - 3	"
26	PDU - 6	"
27	DU - 1	Madhya Pradesh
28	DU - 2	"
29	DU - 3	"
30	PU - 19	Uttar Pradesh
31	PU - 26	"
32	PU - 30	"
33	UPU - 9-40-4	"
34	UPU - 80-3-5	"

Table 1 contd.

1	2	3
35	T - 9	Uttar Pradesh
36	KB - 51	"
37	KB - 63	"
38	KB - 70	"
39	UH - 28	Hissar
40	UH - 80-4	"
41	UH - 80-7	"
42	UH - 80-9	"
43	UH - 87-11	"
44	PS - 1	IARI
45	Sel - 37	Orissa
46	TAU - 1	Trombay
47	Savala	West Bengal
48	Sasthancotta local	Kerala
49	B - 3-8-8	Andhra Pradesh
50	LBG - 20	"

Table 2. Salient morphological features of the twenty selected varieties

Sl. No.	Name of the variety	Stature	Habit	Flower colour	Maturity	Pod surface
1	2	3	4	5	6	7
1	PDU - 3	Medium	Erect	Yellow	Late	Pubescent
2	TMV - 1	Medium	Erect	Yellow	Late	Pubescent
3	Sel - 37	Dwarf	Erect	Yellow	Medium	Pubescent
4	UH - 80 - 4	Dwarf	Erect	Yellow	Medium	Pubescent
5	UH - 80 - 9	Tall	Spreading	Yellow	Medium	Pubescent
6	T - 9	Medium	Erect	Yellow	Medium	Glabrous
7	PU - 26	Tall	Erect	Yellow	Early	Pubescent
8	ADT - 3	Medium	Semi-spreading	Yellow	Early	Pubescent
9	UH - 87 - 11	Medium	Erect	Yellow	Medium	Pubescent
10	UG - 218	Dwarf	Erect	Yellow	Medium	Pubescent

Table 2 contd.

1	2	3	4	5	6	7
11	Co - 4	Medium	Erect	Yellow	Early	Glabrous
12	Sarala	Medium	Erect	Yellow	Medium	Pubescent
13	UPU - 9 - 40 - 4	Medium	Semi-spreading	Yellow	Medium	Pubescent
14	Co - 2	Dwarf	Erect	Yellow	Medium	Glabrous
15	Co - Bg - 282	Medium	Erect	Yellow	Early	Glabrous
16	KB - 51	Medium	Semi-spreading	Yellow	Early	Glabrous
17	PU - 19	Medium	Erect	Yellow	Early	Pubescent
18	LBG - 20	Medium	Erect	Yellow	Early	Pubescent
19	DU - 3	Dwarf	Erect	Yellow	Medium	Pubescent
20	Co - Bg - 305	Dwarf	Erect	Yellow	Medium	Pubescent

Methods

Primary evaluation

The fifty genotypes were grown during kharif (May to August 1986) under partial shade in coconut gardens at the College of Agriculture, Vellayani. Each variety was grown in a single row of 50 plants with a spacing of 30 x 20 cm. The varieties were evaluated mainly on the basis of seed yield, number of pods per plant and plant height. The top ranking twenty varieties were selected for detailed evaluation.

Detailed evaluation

The twenty selected types were raised under partial shade in coconut gardens at the College of Agriculture, Vellayani, during rabi (September to November 1986), in a randomized block design replicated thrice. In each plot of 2 x 1.5 m size, 50 plants were grown at 30 x 20 cm spacing. The crop was given cultural operations and plant protection measures as per package of practices of K.A.U. (1986).

Ten plants were selected at random per variety per replication for recording the following observations.

1. <u>Number of days to 50 per cent flowering</u>

The number of days from sowing to the appearance of flowers in 50 per cent of the plants in each plot was observed and recorded.

2. <u>Number of days to pod harvest initiation</u>

The number of days from sowing to the first pod harvest was observed and recorded.

3. <u>Number of days through which pod harvest continued</u>

The number of days from the first harvest to the last harvest was observed and recorded.

4. <u>Height of the plants</u>

The plant height was measured from the ground level to the tip of the main stem. The observation was taken after the last harvest.

5. <u>Number of branches per plant</u>

Total number of primary branches was counted after the last harvest and recorded.

6. <u>Number of nodes per plant</u>

Number of nodes per plant after the last harvest was counted and recorded.

7. <u>Length of root</u>

The plants were uprooted after the last harvest and root length measured from collar to the tip on the taproot.

8. <u>Number of pod clusters per plant</u>

Number of pod clusters at the time of the last harvest was counted and recorded.

9. <u>Number of pods per plant</u>

The total number of pods harvested from each plant till the last harvest was counted and recorded.

10. <u>Length of pods</u>

The length of ten pods selected at random from each plant was measured and recorded.

11. <u>Number of seeds per pod</u>

The number of seeds in the pods used for measuring length was counted and recorded.

12. Seed yield per plant

The seeds obtained from the total number of pods harvested from each plant were sun dried till consecutive weights taken on a sensitive triple beam balance agreed.

13. 100 seed weight

Random sample of 100 seeds taken from the total seeds collected from each plant was weighed on a sensitive triple beam balance and weight recorded.

14. Leaf area index (LAI)

For calculating the leaf area index the following formula suggested by William (1946) was employed.

$$LAI = \frac{\text{Total leaf area of the plant}}{\text{Ground area occupied}}$$

LAI was calculated at two stages viz. blooming and last harvest.

15. Light intensity

The light intensity in each plot was measured at 6 random spots at 10 A.M., 1 P.M. and 4 P.M. using a luxmeter (Photomet 300 x Remco India), and the average was worked out. The observation was taken, when most of the varieties showed 50 per cent flowering.

16. Cercospora leaf spot disease scoring

The plants were scored using the Cercospora leaf spot disease rating scale given in Table 3 as suggested by Mayee and Datar (1986).

Statistical Analysis

The data collected for the 10 biometric traits were tabulated and mean values were subjected to statistical analysis.

1. Analysis of variance (ANOVA)

It was worked out for all the traits to find out whether there were significant differences between the varieties in respect of the various traits.

For the computation of the analysis of variance, the following procedure proposed by Panse and Sukhatme (1957) were used.

ANOVA Table

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F
Replication	(r-1)	SS_R	MSR	$MSR/_{MSE}$
Treatment	(v-1)	SS_V	MST	$MST/_{MSE}$
Error	(v-1) (r-1)	SS_{VR}	MSE	..

where r = No. of replications

v = No. of treatments

The significance of the computed values for 'F' was tested with reference to the 'F' table (Panse and Sukhatme, 1957).

2. Variance

Components of variance for each character was worked out following the procedure of Johnson et al. (1955).

Genotypic variance

$$V_g = \frac{MST - MSE}{r}$$

where V_g = Genotypic variance

MST = Mean square for treatment

MSE = Mean square for error

r = The number of replications

Error (Environmental) variance

$$V_e = MSE$$

where

V_e = Error (Environmental variance)

MSE = Mean square for error

Phenotypic variance

$$V_p = V_g + V_e$$

where

V_p = Phenotypic variance

V_g = Genotypic variance

V_e = Error (Environmental variance)

3. <u>Coefficient of variation</u>

Both phenotypic and genotypic coefficients of variation were calculated as suggested by Burton (1952).

Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{V_p}}{Mean} \times 100$$

where V_p = Phenotypic variance

Genotypic coefficient of variation (GCV)

$$GCV = \frac{\sqrt{V_g}}{Mean} \times 100$$

where

V_g = Cenotypic variance

4. Heritability and Genetic advance

Heritability in broad-sense (Hanson *et al.*, 1956).

$$h^2 = \frac{V_g}{V_p} \times 100$$

where h^2 = Heritability coefficient

V_g = Genotypic variance

V_p = Phenotypic variance

Expected Genetic advance (G.A.) under selection (Lush, 1940 and Johnson *et al.*, 1955).

$$G.A. = K.h^2 \sqrt{V_p}$$

where

G.A. = Genetic advance

h^2 = Heritability in the broad-sense

V_p = Phenotypic variance

K = Selection differential expressed in phenotypic standard deviation

= 2.06 in the case of 5% selection in large samples (Miller *et al.*, 1958 and Allard, 1960).

Expected Genetic gain (G.G.) under selection (Johnson *et al.*, 1955).

$$G.G. = \frac{G.A}{\bar{x}} \times 100$$

where $\bar{x}$ = General Mean

5. Co-variance

Genotypic covariance

$$CoV_g = \frac{MSPT - MSPE}{r}$$

where

CoV_g = Genotypic covariance

MSPT = Mean sum of products for treatment

MSPE = Mean sum of products for error

r = The number of replications

Error (Environmental covariance)

$$CoV_e = MSPE$$

where

CoV_e = Error (Environmental covariance)

MSPE = Mean sum of products for error

Phenotypic covariance

$$CoV_p = CoV_g + CoV_e$$

where

CoV_p = Phenotypic covariance

CoV_g = Genotypic covariance

CoV_e = Error (Environmental covariance)

6. Correlation coefficients

Genotypic correlation coefficients (Al-jibouri *et al.*, 1958).

$$rg = \frac{CoV_g\,12}{\sqrt{V_g1 \times V_g2}}$$

where rg = Cenotypic correlation coefficient

CoV_g12 = Genotypic covariance of traits 1 & 2

V_g1 = Genotypic variance of trait 1

V_g2 = Genotypic variance of trait 2

Environmental correlation coefficient

$$re = \frac{CoV_e12}{\sqrt{V_e1 \times V_e2}}$$

where

re = Environmental correlation coefficient

CoV_e12 = Environmental covariance of traits 1 & 2

V_e1 = Environmental variance of trait 1

V_e2 = Environmental variance of trait 2

Phenotypic correlation coefficient

$$rp = \frac{CoV_p12}{\sqrt{V_p1 \times V_p2}}$$

where

rp = Phenotypic correlation coefficient

CoV_p12 = Phenotypic covariance of trait 1 & 2

V_p1 = Phenotypic variance of trait 1

V_p2 = Phenotypic variance of trait 2

7. <u>Path coefficient analysis</u>

The path coefficients were worked out by the method suggested by Dewey and Lu (1959). The simultaneous equations which express the base relationship between correlation and path coefficient were solved to obtain the value of path coefficients.

Among the traits studied, the variable X_{15} Cercospora leaf spot disease (rating) was not included in this part of the analysis .

$$r_{1y} = p_{1y} + r_{12}\, p_{2y} + \dots\dots\dots\dots + r_{1k}\, p_{ky}$$

$$\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$r_{ky} = r_{k1}\, p_{1y} + r_{k2}\, p_{2y} + \dots\dots + r\,(k-1),\, k^{p}(k-1),\, y + p_{ky}$$

where

r_{1y} to r_{ky} denote the genotypic correlation coefficients between causal factors 1 to K and dependent variable (Y), r_{12} to $r_{k-1,\,K}$ denote the correlation coefficients among all possible combinations of causal factors and p_{1y} to p_{ky} denote the direct effects of characters 1 to K on yield (Y).

The above equations can be written in the matrix form as shown below:

$$\begin{Bmatrix} r_{1y} \\ \vdots \\ r_{ky} \end{Bmatrix} = \begin{Bmatrix} 1 & r_{12} & r_{13} \cdots\cdots r_{ik} \\ & 1 & r_{23} \cdots\cdots r_{2k} \\ & & \quad\quad\quad\quad 1 \end{Bmatrix} \begin{Bmatrix} p_{1y} \\ p_{2y} \\ \vdots \\ p_{ky} \end{Bmatrix}$$

$$A \quad = \quad C \quad x \quad B$$

$A = CB$

Hence $B = C^{-1}A$

C^{-1} is the inverse matrix of C

The residual factor which measures the contribution of the traits not included in the causal scheme was obtained by the formula

$(1 - R^2)^{\frac{1}{2}}$ where,

$$R^2 = \sum_{i=1}^{K} p^2_{iy} + 2, \sum_{i} \neq \sum_{j} p_{iy} \; p_{jy} \; r_{ji}$$
$$i < j$$

Indirect effects of different characters on yield obtained as follows:

Indirect effect of the i^{th} character on yield through j^{th} character = $p_{iy}\ r_{ij}$.

Table 3. Cercospora Leaf Spot Disease Rating Scale

	Description of symptom	Rating scale
1	No symptoms on leaves	0
2	Small pinhead sized brown lesions on leaves covering less than one per cent leaf area.	1
3	Small, round, brown lesions covering 1-10 per cent of leaf area.	3
4	Bigger lesions on leaves, covering 11-25 per cent of leaf area.	5
5	Enlarging and coalescing lesions covering 26-50 per cent of leaf area leading to shot hole symptoms.	7
6	Coalescing lesions covering 51 per-cent or more of leaf area. Shot hole symptom produced. Lesions found on pod also.	9

RESULTS

RESULTS

From the fifty black gram genotypes grown in the initial unreplicated trial, twenty genotypes were selected for the main trial. The top ranking twenty varieties were selected for the main trial based on seed yield per plant and other morphological characters. The mean performance of the initial fifty genotypes in respect of yield and other characters are presented in Table 4.

The experimental data recorded in the main experiment were subjected to statistical analysis and the results presented below.

1. Variability Analysis

The mean of the data collected for the ten observational plants in each plot were subjected to analysis of variance and the ANOVA is presented in Table 5. The twenty varieties of black gram selected for the investigation exhibited significant differences for all the characters studied except number of pod clusters per plant, number of pods per plant, seed yield per plant and 100 seed weight. The light intensity observed in each plot at three different temporal phases

Table 4. Mean values of the characters observed in the fifty varieties of black gram

Cultivars	Seed yield per plant (g)	Plant height (cm)	No. of branches per plant	No. of nodes per plant	No. of clusters per plant	No. of pods per plant	Mean length of pods (cm)	Mean No. of seeds per pod	100 seed weight (g)
1	2	3	4	5	6	7	8	9	10
1. Co-3	1.60	39.2	1.2	9.6	2.7	9.2	4.25	4.1	4.3
2. Co-Bg-306	3.50	29.1	1.5	9.4	2.6	10.1	4.53	4.7	4.6
3. KM-2	1.04	39.4	1.5	11.5	3.3	15.2	4.20	4.7	4.6
4. UG-28	2.42	40.1	1.0	11.3	3.4	16.3	4.30	6.3	4.2
5. Sasthancotta local	1.60	32.5	1.6	11.1	2.8	8.7	4.40	3.9	4.4
6. PDU-3	4.50	31.9	2.2	10.9	2.4	9.2	4.20	5.0	4.4
7. DU-2	0.34	32.6	1.5	11.0	2.8	10.5	4.40	5.4	4.5
8. TMV-1	3.60	36.8	2.4	12.9	3.6	15.6	4.70	4.7	4.4
9. Sel-37	3.80	27.2	2.0	11.9	3.4	13.9	3.40	4.1	4.2
10. Co-Bg-8	3.10	40.4	2.1	13.1	4.6	22.8	4.10	5.0	4.5
11. Co-Bg-303	3.30	37.3	2.2	13.1	3.5	15.3	4.20	4.9	4.0
12. PU-30	3.30	27.3	1.0	8.2	3.6	13.5	3.90	5.0	4.1
13. UH-80-4	4.40	32.1	2.0	11.2	3.5	13.6	3.95	4.8	4.2
14. PS-1	3.60	34.7	1.7	11.9	4.9	12.6	4.61	4.9	3.4
15. UH-80-9	4.70	28.0	1.4	9.1	3.0	11.5	2.70	3.9	4.1
16. Co-Bg-9	3.40	39.5	2.5	13.8	3.9	16.6	4.10	3.9	4.1

Table 4 contd.

1	2	3	4	5	6	7	8	9	10
17. UPU-80-3-5	3.10	37.6	2.1	10.3	3.6	15.8	4.07	5.0	4.0
18. T-9	5.90	32.0	2.0	12.2	3.7	16.2	4.86	7.1	5.2
19. KB-63	2.90	36.4	1.9	13.5	3.4	15.9	4.15	5.9	4.7
20. PU-26	3.20	38.7	1.7	14.2	4.1	19.6	4.72	6.1	4.2
21. ADT-3	4.20	34.3	1.9	11.7	3.3	17.1	4.55	5.5	4.0
22. UH-87-11	3.70	38.0	2.1	12.0	3.5	17.5	4.20	5.9	4.5
23. UG-218	3.50	32.0	1.7	9.0	3.0	13.8	4.51	4.9	4.0
24. B-3-8-8	3.50	27.1	1.7	9.3	2.6	13.4	4.22	5.6	4.1
25. Co-Bg-304	3.20	37.5	2.0	11.0	3.3	15.9	4.28	6.0	4.3
26. Co-4	5.00	41.2	2.6	14.3	3.7	18.6	4.15	5.5	4.8
27. PDU-1	3.10	39.9	1.7	8.1	2.4	11.2	4.12	5.3	4.0
28. Sarala	4.60	38.0	1.4	11.4	3.1	12.7	3.20	5.4	4.8
29. UPU-9-40-4	4.50	41.4	1.9	10.9	3.7	16.7	4.11	4.6	4.6
30. Co-Bg-307	3.40	30.4	1.0	8.9	2.9	9.8	4.69	4.3	4.0
31. TAU-1	1.90	37.0	1.1	9.5	3.4	14.2	4.91	4.8	3.2
32. UH-80-7	2.70	31.5	1.1	8.9	2.9	10.3	4.96	6.4	3.8
33. Co-2	3.50	41.5	1.0	10.5	3.0	12.1	4.52	7.0	4.6

Table 4 contd.

1	2	3	4	5	6	7	8	9	10
34. Co-Bg-282	4.20	57.2	1.6	13.2	3.1	11.3	4.07	4.0	4.8
35. KB-51	3.60	49.7	1.8	11.9	3.8	14.0	4.32	4.8	4.3
36. PU-19	3.80	41.9	1.6	11.1	3.0	11.7	4.86	5.5	4.9
37. Co-Bg-301	1.90	48.9	1.3	9.7	2.9	10.5	4.27	4.9	3.1
38. Co-5	1.20	49.5	1.9	10.7	3.0	13.8	4.72	5.4	3.0
39. KB-70	1.80	34.9	1.6	8.9	2.5	9.6	4.13	5.0	3.2
40. DU-1	3.00	30.4	1.2	8.2	2.1	7.6	3.98	5.8	3.8
41. Co-Bg-302	2.60	41.4	2.2	12.6	3.9	16.4	4.54	5.6	3.2
42. Co-Bg-305	4.30	41.3	1.8	10.2	3.5	14.7	4.92	6.0	3.4
43. Co-Bg-300	4.10	31.6	1.8	9.8	2.7	12.0	4.72	6.2	4.2
44. UH-28	3.90	29.8	1.6	9.6	3.1	11.3	4.23	5.3	4.2
45. PDU-6	3.30	23.6	1.3	9.1	2.5	9.7	4.16	6.0	3.6
46. DU-3	3.70	32.7	1.7	10.8	2.8	12.2	4.11	6.5	4.0
47. Co-1	1.02	38.2	1.7	9.4	2.3	8.0	4.72	5.0	3.3
48. LBG-20	4.10	32.0	1.8	9.4	2.9	11.4	3.98	4.3	4.1
49. Co-Bg-10	2.10	36.0	2.2	10.4	3.2	10.5	3.41	3.7	3.8
50. M-3	2.30	36.3	2.1	9.8	4.7	13.1	4.12	5.2	4.1

Table 5. Analysis of variance for 16 characters studied

Sl. No.	Characters	Mean sum of squares			F value
		Replications d.f. = 2	Treatments d.f. = 19	Error d.f. = 38	
1.	Days to 50% flowering	0.617	7.328	1.213	6.041**
2.	Days to pod harvest initiation	0.234	17.370	0.638	27.226**
3.	Days through which pod harvest continued	4.965	18.058	0.772	23.391**
4.	Plant height	61.320	105.255	31.511	3.340**
5.	No. of branches/plant	0.054	0.440	0.041	10.732**
6.	No. of nodes/plant	0.098	2.553	0.402	6.351**
7.	Length of root	38.746	9.131	2.347	3.890**
8.	No. of pod clusters/plant	0.348	1.559	1.060	1.469
9.	No. of pods/plant	15.971	15.434	12.135	1.272
10.	Length of pods	0.033	0.104	0.034	3.059**
11.	No. of seeds/pod	1.177	0.353	0.274	1.288
12.	Seed yield/plant	1.642	1.865	1.095	1.703
13.	100 seed weight	0.047	0.205	0.030	6.833**
14.	LAI at blooming	0.010	0.730	0.015	48.667**
15.	LAI at harvest	0.0002	0.0843	0.0008	105.375**
16.	Cercospora leaf spot (rating) disease	3.697	11.073	2.070	5.349**

*Significant at 5 per cent level

**Significant at 1 per cent level

of the day also did not show any significant difference in magnitude as seen from Table 6. This indicated that uniform shade conditions prevailed in all the experimental plots. The mean values of light intensity measured in each plot presented in Table 7.

The mean performance of the twenty genotypes in respect of yield and other quantitative characters are furnished in Table 8. Though the analysis of variance revealed no significant difference among the twenty varieties for seed yield, the variety PDU-3 recorded the highest yield (5.94 g) followed by TMV-1 (4.54 g) and the lowest yield was recorded by the variety Co-Bg-305 (3.00 g).

The mean values for number of days to 50 percent flowering in the varieties varied from 32.33 in DU-3 to 38.33 in TMV-1. The varieties PDU-3, Sarala, Co-Bg-305, KB-51 and LBG-20 were on par with DU-3 having the shortest flowering duration. There was no variety on par with TMV-1 having the longest flowering duration.

TMV-1 also recorded the highest mean value for number of days to pod harvest initiation (72.43) followed

Table 6. Analysis of variance for light intensity

Sl. No.	Light intensity (per cent)	Mean sum of squares			F value
		Replication d.f. = 2	Treatments d.f. = 19	Error d.f. = 38	
1.	At 10 o' clock	1.925	0.146	0.175	0.834
2.	At 1 o' clock	0.009	0.016	0.036	0.444
3.	At 4 o' clock	1.425	0.025	3.450	0.007

Table 7. Mean values of light intensity measured

Treatments	Light intensity at 10 A.M. (per cent)	Light intensity at 1 P.M. (per cent)	Light intensity at 4 P.M. (per cent)
1. PDU-3	67.42	70.12	66.67
2. TMV-1	67.42	70.12	66.78
3. Sel-37	67.75	70.12	66.81
4. UH-80-4	67.42	70.00	66.67
5. UH-80-9	67.67	70.00	66.75
6. T-9	67.42	70.25	66.72
7. PU-26	67.33	70.12	66.72
8. ADT-3	67.33	70.12	66.89
9. UH-87-11	67.17	70.12	66.61
10. UG-218	67.00	70.12	66.81
11. Co-4	67.17	70.12	66.56
12. Sarala	67.33	70.12	66.86
13. UPU-9-40-4	67.42	70.12	66.72
14. Co-2	67.67	70.12	66.72
15. Co-Bg-282	67.17	70.12	66.61
16. KB-51	67.00	70.00	66.61
17. PU-19	67.17	70.00	66.72
18. LBG-20	67.17	70.25	66.58
19. DU-3	67.17	70.12	66.81
20. Co-Bg-305	67.17	70.00	66.72

Table 8. Mean values of 16 characters in twenty varieties of black gram

Cultivars	Seed yield per plant (g)	Days to 50 per cent flowering	No. of days to pod harvest initiation	No. of days through which pod harvest continued	Height of the plant (cm)	No. of branches per plant	No. of nodes per plant	No. of clusters per plant
1	2	3	4	5	6	7	8	9
1. PDU-3	5.94	33.33	70.37	13.37	34.63	2.23	11.49	4.50
2. TMV-1	4.54	38.33	72.43	10.00	41.07	2.20	12.83	4.90
3. Sel-37	5.47	34.67	68.10	18.00	33.33	2.03	11.53	5.23
4. UH-80-4	5.20	35.33	69.10	12.73	32.90	2.17	12.10	4.20
5. UH-80-9	4.94	33.67	67.40	13.73	55.67	2.90	10.10	6.00
6. T-9	3.91	36.00	68.77	11.70	33.00	2.47	11.83	4.57
7. PU-26	3.63	33.67	65.67	15.07	45.90	2.03	11.83	3.93
8. ADT-3	3.12	32.67	66.27	13.33	34.77	2.37	12.13	3.37
9. UH-87-11	4.52	34.67	68.97	13.93	35.07	2.67	11.67	4.47
10. UG-218	4.48	34.33	66.97	17.67	31.83	1.87	9.93	4.73
11. Co-4	4.80	34.33	65.93	15.13	44.30	3.17	12.77	5.06
12. Sarala	3.68	33.33	67.20	13.13	36.70	2.23	11.27	4.33
13. UPU-9-40-4	4.35	34.33	67.77	12.97	38.47	2.17	12.03	3.33
14. Co-2	4.35	35.00	67.50	12.40	33.43	1.47	10.77	4.73
15. Co-Bg-282	4.15	36.67	64.60	18.53	37.33	1.73	11.67	3.43
16. KB-51	4.34	33.00	66.10	16.93	41.00	2.00	11.30	4.27

Table 8 contd.

1	2	3	4	5	6	7	8	9
17. PU-19	5.11	36.67	62.50	17.47	40.80	2.50	10.73	4.47
18. LBG-20	3.25	32.67	62.13	18.33	34.23	2.37	10.33	2.97
19. DU-3	3.74	32.33	66.93	13.30	32.90	2.37	9.80	3.90
20. Co-Bg-305	3.00	33.33	68.43	15.70	32.87	2.20	9.97	4.23
General mean	4.33	34.42	67.16	14.67	37.51	2.26	11.30	4.33
C.D. (0.05%)	-	1.05	0.76	0.84	5.36	0.19	0.61	-

Cultivars	No. of pods per plant	Mean length of pods (cm)	Mean No. of seeds per pod	100 seed weight (g)	Length of roots (cm)	LAI at blooming	LAI at harvest	Cercospora leaf spot (rating)
1	10	11	12	13	14	15	16	17
1. PDU-3	14.87	4.50	6.78	4.37	14.09	0.98	0.42	0.80
2. TMV-1	17.40	3.99	5.85	4.23	15.75	1.93	0.64	3.57
3. Sel-37	16.63	4.20	6.20	3.91	14.62	1.61	0.75	1.60
4. UH-80-4	14.53	3.57	5.38	4.00	14.15	1.73	0.62	2.20
5. UH-80-9	18.87	4.07	5.84	4.15	13.48	1.08	0.50	2.97
6. T-9	14.50	4.06	5.49	3.80	12.38	1.45	0.50	6.17
7. PU-26	12.63	4.14	6.04	4.23	17.13	1.66	0.49	1.00

Table 8 contd.

1	10	11	12	13	14	15	16	17
8. ADT-3	10.20	3.89	5.82	4.35	13.77	1.47	0.42	3.33
9. UH-87-11	13.07	4.05	5.76	4.09	13.00	0.72	0.29	1.93
10. UG-218	14.40	4.06	5.93	3.91	18.64	0.62	0.30	4.90
11. Co-4	15.20	4.18	5.81	4.07	13.11	1.79	0.72	3.33
12. Sarala	10.73	3.95	5.86	4.28	17.05	0.70	0.28	5.27
13. UPU-9-40-4	12.00	4.03	5.82	4.48	12.66	2.26	0.81	4.63
14. Co-2	13.37	3.79	5.82	3.69	12.74	1.69	0.41	6.63
15. Co-Bg-282	13.87	4.00	5.85	3.49	13.18	2.11	0.80	1.93
16. KB-51	13.03	4.08	6.47	4.17	13.72	1.56	0.60	4.17
17. Pant-U-19	13.47	4.03	6.47	4.35	15.57	0.86	0.32	2.37
18. LBG-20	9.77	3.93	5.53	4.02	13.92	0.94	0.42	5.23
19. DU-3	12.43	3.85	6.06	4.02	14.23	0.90	0.44	4.50
20. Co-Bg-305	13.33	3.86	6.19	3.98	12.07	1.19	0.54	7.73
General mean	13.72	4.01	5.77	4.09	14.26	1.36	0.51	3.71
C.D. (0.05 per cent)	-	0.18	0.50	-	1.46	0.12	0.03	1.37

by PDU-3 (70.37) and UH-80-4 (69.10). The varieties UH-87-11, T-9 and Co-Bg-305 were statistically on par with the variety UH-80-4. LBG-20 recorded the lowest mean value for this character (62.13).

The mean value for number of days through which pod harvest continued varied from 10.00 in TMV-2 to 18.53 in Co-Bg-282. Varieties LBG-20 and Sel-37 were on par with Co-Bg-282 having the highest mean value for days through which pod harvest continued.

The mean value for plant height varied from 31.83 in UG-218 to 55.67 in UH-80-9. There was no variety on par with UH-80-9 but the varieties Co-2, Sel-37, T-9, UH-80-4, DU-3 and Co-Bg-305 were statistically on par with UG-218 being the shortest.

The mean value for number of branches per plant was highest for the variety Co-4 (3.17) followed by UH-80-9 (2.90) and UH-87-11 (2.67). It was lowest for the variety Co-2 (1.47). Variety Co-Bg-282 was on par with Co-2 and PU-19 was on par with UH-87-11.

In the case of number of nodes per plant the mean values varied from 9.80 in DU-3 to 12.83 in TMV-1.

Variety Co-4 was on par with TMV-1 while the varieties LBG-20, UH-80-9, Co-Bg-305 and UG-218 were on par with DU-3.

The mean values for number of clusters per plant was highest for UH-80-9 (6.00) followed by Sel-37 (5.23) and lowest for UPU-9-40-4 (3.33) though this character showed no significant difference among the varieties.

The variety PDU-3 had the highest mean value for length of pods (4.50) followed by Sel-37 (4.20) and the lowest mean value for UH-80-4 (3.57). There was no variety on par with PDU-3 or UH-80-4. Varieties Co-4, PU-26, KB-51, UH-80-9, T-9, UG-218, UH-87-11, UPU-9-40-4 and PU-19 were on par with Sel-37.

The mean values for number of seeds per pod varied from 5.38 in UH-80-4 to 6.78 in PDU-3. Varieties KB-51 and PU-19 were on par with PDU-3 while the varieties Sarala, TMV-1, Co-Bg-282, UH-80-9, ADT-3, UPU-9-40-4, Co-2, Co-4, UH-87-11, LBG-20 and T-9 were on par with UH-80-4.

Though 100 seed weight did not show significant differences among the varieties the mean value was highest for PDU-3 (4.57) and lowest for Co-Bg-282 (3.49).

The mean values for length of root varied from 12.07 in Co-Bg-305 to 18.64 in UG-218. The varieties UH-80-9, Co-Bg-282, Co-4, UH-87-11, Co-2, UPU-9-40-4 and T-9 were statistically on par with Co-Bg-305 but there was no variety on par with UG-218.

The mean values for LAI at blooming was highest for UPU-9-40-4 (2.26) followed by Co-Bg-282 (2.11) and TMV-1 (1.93) and lowest for UG-218 (0.62). Varieties UH-87-11 and Sarala were on par with UG-218.

The mean values for LAI at harvest varied from 0.28 in Sarala to 0.81 in UPU-9-40-4. Variety Co-Bg-282 was on par with UPU-9-40-4 and the varieties UH-87-11 and UG-218 were on par with Sarala.

The highest mean value for number of pods per plant was recorded by UH-80-9 (18.87) and lowest for LBG-20 (9.77) even though there was no significant differences among the varieties.

Mean values for Cercospora leaf spot disease rating varied from 0.80 in PDU-3 to 7.73 in Co-Bg-305.

Variety Co-2 was on par with Co-Bg-305 while the varieties UH-87-11, Co-Bg-282, Sel-37 and PU-26 were on par with PDU-3.

The phenotypic and genotypic coefficients of variation for the 16 characters studied are given in Table 9 and Figure 1. In general, the phenotypic coefficients of variation were always higher than their genotypic coefficient of variation for all the characters studied. Cercospora leaf spot disease (rating) showed the highest phenotypic coefficient of variation (60.70 per cent) followed by LAI at blooming (36.98 per cent), LAI at harvest (33.39 per cent), seed yield per plant (26.85 per cent), number of pods per plant (26.51 per cent) and pod clusters per plant (25.58 per cent). Days to pod harvest initiation had the lowest value (3.71 per cent). The highest genotypic coefficient of variation was also observed for Cercospora leaf spot disease rating (46.69 per cent) and lowest for days to pod harvest initiation (3.52 per cent).

II. <u>Genetic Analysis</u>

Estimates of heritability, genetic advance and

Table 9. Phenotypic and genotypic coefficient of variation (per cent) for 16 characters studied

Sl. No.	Characters	Phenotypic variance V_p	Phenotypic coefficient of variation PCV (per cent)	Genotypic variance V_g	Genotypic coefficient of variation GCV (per cent)
1.	Days to 50 per cent flowering	3.252	5.24	2.039	4.15
2.	Days to pod harvest initiation	6.215	3.71	5.577	3.52
3.	Days through which pod harvest continued	6.534	17.42	5.762	16.36
4.	Plant height	56.092	19.97	24.581	13.22
5.	No. of branches per plant	0.174	18.46	0.133	16.14
6.	No. of nodes per plant	1.119	9.36	0.717	7.49
7.	Length of root	4.608	15.05	2.261	10.54
8.	No. of pod clusters per plant	1.227	25.58	0.166	9.41
9.	No. of pods per plant	13.234	26.51	1.100	7.64
10.	Length of pods	0.057	5.95	0.023	3.78
11.	No. of seeds per pod	0.300	9.49	0.026	2.79
12.	Seed yield per plant	1.352	26.85	0.257	11.71
13.	100 seed weight	0.089	7.25	0.058	5.89
14.	LAI at blooming	0.253	36.98	0.238	35.87
15.	LAI at harvest	0.029	33.39	0.028	32.81
16.	Cercospora leaf spot disease (rating)	5.071	60.70	3.001	46.69

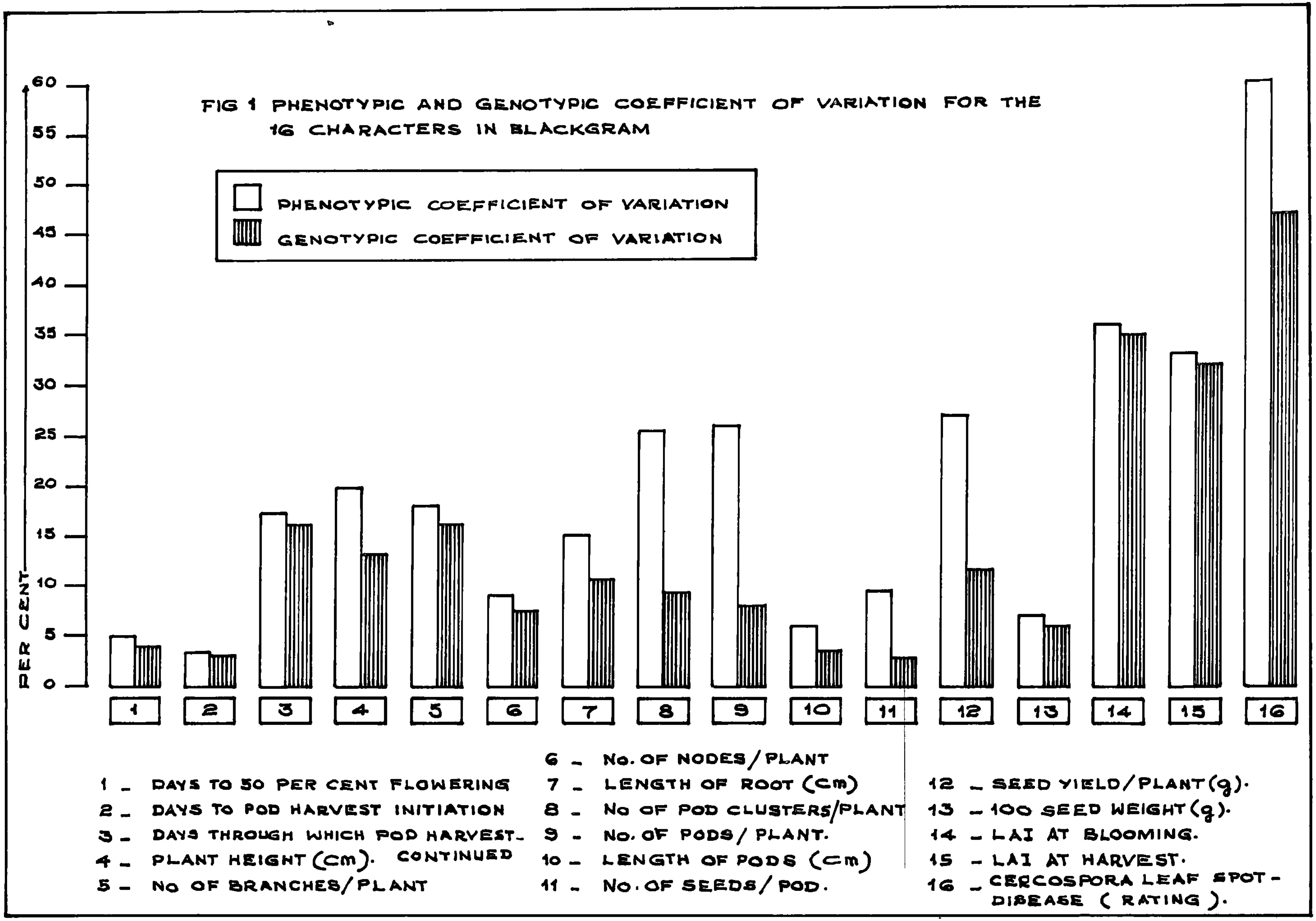


FIG 1 PHENOTYPIC AND GENOTYPIC COEFFICIENT OF VARIATION FOR THE 16 CHARACTERS IN BLACKGRAM

genetic gain are furnished in Table 10 and Figure 2. In general the heritability estimates were medium to high for most of the characters. Highest heritability estimate was recorded for days to pod harvest initiation (99.73 per cent) followed by LAI at harvest (97.05 per cent), LAI at blooming (94.10 per cent), days through which pod harvest continued (88.18 per cent) and number of branches per plant (76.53 per cent). Low values of heritability were recorded for number of pods per plant, number of seeds per pod and number of pod clusters per plant. Cercospora leaf spot disease (rating) recorded the maximum genetic gain (74.12 per cent) and seeds per pod the minimum (1.73 per cent). High values of heritability estimates coupled with high genetic gain was recorded for LAI at blooming and high heritability coupled with low genetic gain was recorded for days to pod harvest initiation.

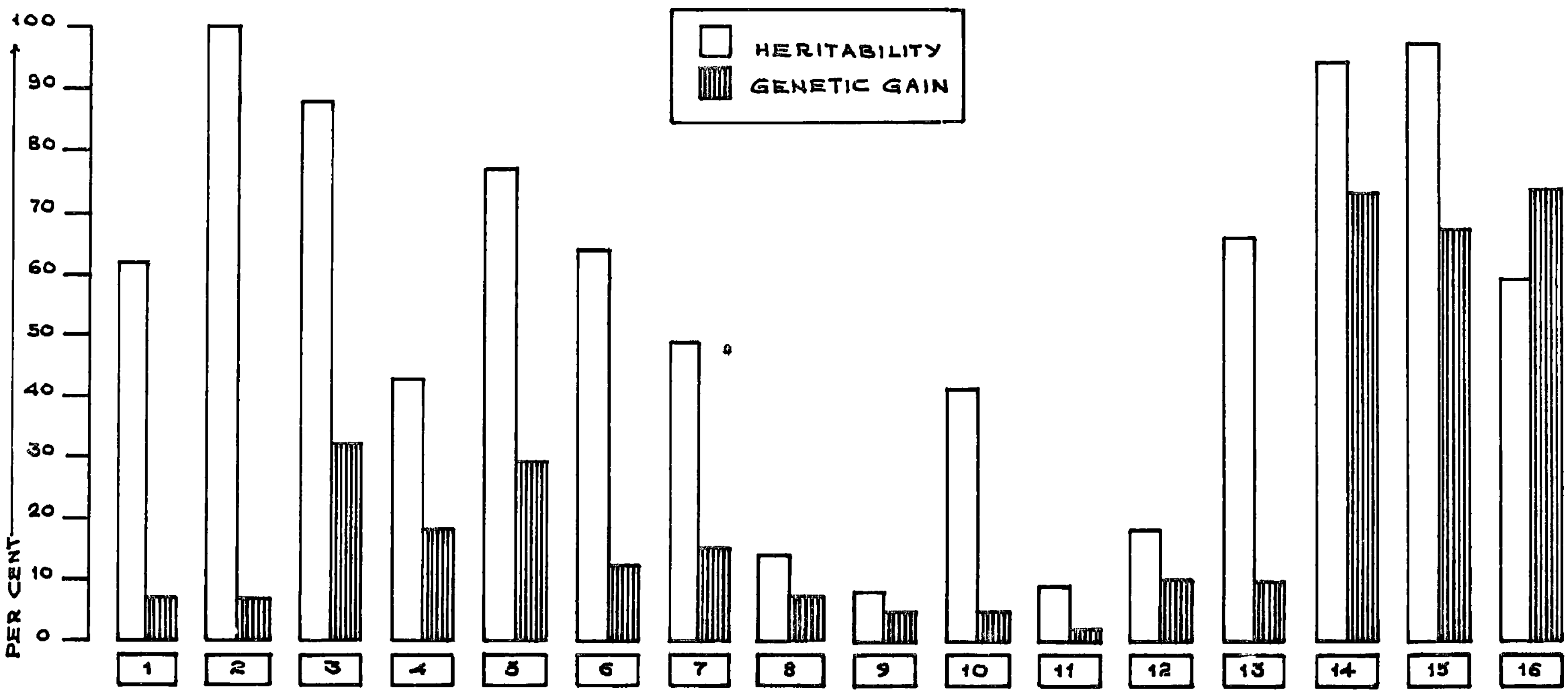
III. Correlation Analysis

The co-variance analysis was done for all the possible 120 ($16C_2$) pairs of characters. The genotypic and phenotypic co-variance components were computed in the same way as for the variance components and from these the genotypic and phenotypic correlation coefficients were

Table 10. Heritability, genetic advance and genetic gain for 16 characters studied

Sl. No.	Characters	Heritability in % (H^2)	Genetic advance (G.A.)	Genetic gain in % (G.G.)
1.	Days to 50 per cent flowering	62.69	2.33	6.77
2.	Days to pod harvest initiation	99.73	4.61	6.86
3.	Days through which pod harvest continued	88.18	4.64	31.63
4.	Plant height	43.82	6.76	18.02
5.	No. of branches/plant	76.53	0.66	29.20
6.	No. of nodes/plant	64.05	1.40	12.39
7.	Length of root	49.07	2.17	15.22
8.	No. of pod clusters/plant	13.57	0.31	7.16
9.	No. of pods/plant	8.31	0.62	4.52
10.	Length of pods	40.66	0.20	4.99
11.	No. of seeds/pod	8.77	0.10	1.73
12.	Seed yield/plant	18.99	0.45	10.39
13.	100 seed weight	65.60	0.40	9.78
14.	LAI at blooming	94.10	0.99	72.79
15.	LAI at harvest	97.05	0.34	66.67
16.	Cercosporan leaf spot disease (rating)	59.17	2.75	74.12

FIG 2 HERITABILITY AND GENETIC GAIN FOR THE 16 CHARACTERS IN BLACKGRAM



1 - DAYS TO 50 % FLOWERING.
2 - DAYS TO POD HARVEST INITIATION.
3 - DAYS THROUGH WHICH POD HARVEST CONTINUED.
4 - PLANT HEIGHT (cm).
5 - No OF BRANCHES / PLANT.
6 - No OF NODES / PLANT
7 - LENGTH OF ROOT (cm)
8 - No. OF POD CLUSTERS / PLANT.
9 - No OF PODS / PLANT.
10 - LENGTH OF PODS (cm)
11 - No OF SEEDS / POD.
12 - SEED YIELD / PLANT (g)
13 - 100 SEED WEIGHT (g).
14 - L A I AT BLOOMING.
15 - L A I AT HARVEST
16 - CERCOSPORA LEAF SPOT DISEASE (RATING)

estimated. The data on correlations have been split up for the sake of clarity and are presented under the following heads.

(i) Correlation between yield and other characters.
(ii) Correlation between pairs of characters, other than those with yield.

(i) Correlation between yield and other characters.

The estimates of correlation coefficients at the genotypic and phenotypic levels are given in Table 11. The genotypic correlations were higher in magnitude than their corresponding phenotypic correlations except for number of pods per plant and Cercospora leaf spot disease (rating). All the genotypic correlations between yield and other characters were positive except with Cercospora leaf spot disease (rating). Number of seeds per pod had the highest positive correlation with seed yield per plant (1.0894). Days to 50 per cent flowering, days to pod harvest initiation, number of nodes per plant, number of pod clusters per plant, number of pods per plant and length of pods also showed high positive correlations with seed yield per plant.

Table 11. Genotypic (G) and phenotypic (P) correlation coefficients between yield and other characters.

Sl. No.	Characters	Correlation coefficients	
		G	P
1.	Days to 50 per cent flowering	0.5715	0.2294
2.	Days to pod harvest initiation	0.4894	0.1973
3.	Days through which pod harvest continued	0.0136	-0.0377
4.	Plant height	0.2313	0.1406
5.	No. of branches/plant	0.2195	0.0130
6.	No. of nodes/plant	0.4111	0.0953
7.	Length of root	0.2387	-0.0327
8.	No. of pod clusters/plant	0.6820	0.5432
9.	No. of pods per plant	0.5949	0.6848
10.	Length of pods	0.6221	0.3486
11.	No. of seeds/pod	1.0894	0.1338
12.	100 seed weight	0.2586	0.1236
13.	LAI at blooming	0.0862	0.0413
14.	LAI at harvest	0.2937	0.1113
15.	Cercospora leaf spot disease (rating)	-1.0566	-0.3168

At the phenotypic level, number of pods per plant showed the highest positive correlation with seed yield per plant (0.6848). Cercospora leaf spot disease (rating), days through which pod harvest continued and length of root exhibited negative correlation with seed yield per plant.

(ii) Correlation between pairs of characters, other than those with yield.

Table 12 provides the data on correlation amongst the fifteen characters in all combinations.

Days to 50 per cent flowering showed high positive genotypic correlation with number of pods per plant, number of clusters per plant, number of nodes per plant, LAI at blooming and LAI at harvest. Its association with number of pods per plant was the highest (0.9895) and highest negative correlation with mean number of seeds per pod (-0.3270).

Days to pod harvest initiation exhibited highest positive correlation with number of pods per plant (1.0913) at genotypic level. Correlations of days to pod harvest initiation with number of clusters per plant was

Table 12. Genotypic and phenotypic correlation coefficients between other pairs of characters

Characters	Days to 50 per cent flowering	Days to pod harvest initiation	Days through which pod harvest continued	Height of the plant	No. of branches per plant	No. of nodes per plant	No. of clusters per plant	No. of pods per plant	Mean length of pods	Mean no. of seeds per pod	100 seed weight	Length of root	LAI at blooming	LAI at harvest	Cercospora leaf spot disease (rating)
Days to 50 per cent flowering	1	0.2652	-0.1971	0.1299	-0.1393	0.5086	0.4419	0.9805	-0.1153	-0.3270	-0.3057	0.0395	0.4295	0.3132	-0.1016
Days to pod harvest initiation	0.2362	1	-0.7520	-0.1205	-0.0423	0.3708	0.7463	1.0913	0.0836	0.0053	0.1517	-0.1083	0.1644	0.1333	0.0127
Days through which pod harvest continued	-0.1407	-0.6514	1	-0.0546	-0.1405	-0.4537	-0.3984	-0.3773	0.2258	0.5826	-0.3442	0.1338	-0.1778	0.0650	-0.1781
Height of the plant	-0.0231	-0.1313	-0.0287	1	0.6021	0.1577	0.6634	1.0672	0.4541	0.3511	0.3510	0.0962	0.1951	0.1893	-0.4518
No. of branches per plant	-0.1230	-0.0555	-0.1440	0.2986	1	0.1868	0.5528	0.5218	0.2984	-0.3239	0.3919	-0.2406	-0.2608	-0.0694	-0.1863
No. of nodes per plant	0.3536	0.2764	-0.2646	0.0795	0.0769	1	-0.1390	0.2142	0.2498	-0.6012	0.1868	-0.2333	0.6965	0.5126	-0.4[illegible]36
No. of clusters per plant	0.1597	0.2645	-0.0737	0.3236	0.1726	0.0059	1	1.2615	0.5249	0.4553	-0.2843	0.3107	-0.2712	-0.0767	-0.2435
No. of pods per plant	0.3324	0.2996	-0.0794	0.2404	0.0668	0.0811	0.7555	1	0.6125	0.6663	-0.1682	-0.0484	0.4040	0.7346	-0.8539
Mean length of pods	0.0013	0.0820	0.1568	0.1365	0.1393	0.0606	0.1926	0.2041	1	1.3908	0.5442	0.2216	-0.1294	0.0564	-0.5783
Mean no. of seeds per pod	-0.1285	-0.0170	0.1785	0.0062	-0.0406	-0.0622	0.0961	0.0188	0.3596	1	0.8310	0.3920	-0.4548	-0.2266	-0.5979
100 seed weight	-0.2232	0.1246	-0.1961	0.1960	0.3062	0.2092	0.0787	-0.0099	0.1767	0.2931	1	0.1872	-0.1771	-0.2164	-0.3366
Length of root	0.0517	-0.0472	0.1950	0.0219	-0.1681	0.0453	0.0040	-0.0099	0.0355	0.0665	-0.2771	1	-0.4362	-0.4624	-0.3206
LAI at blooming	0.3566	0.1440	-0.1686	0.1315	-0.2272	0.5751	-0.0990	0.1098	-0.0691	-0.1330	-0.2771	-0.2771	1	0.8802	-0.1176
LAI at harvest	0.2558	0.1330	0.0780	0.1693	-0.0609	0.4269	-0.0215	0.2053	0.0414	-0.0484	0.3060	-0.3060	0.8385	1	-0.1557
Cercospora leaf spot disease (rating)	-0.2260	-0.0354	-0.1172	-0.1927	-0.1136	-0.3453	-0.0335	-0.0755	-0.3181	-0.1731	-0.1465	-0.1465	-0.0907	-0.1598	1

Upper off diagonal elements = Genotypic correlation coefficients

Lower off diagonal elements = Phenotypic correlation coefficients also high and positive (0.7463). Its association with days through which pod harvest continued showed high negative correlation (-0.7520).

At the genotypic level days through which pod harvest continued showed highest positive association with mean number of seeds per pod (0.5826). Its association with number of nodes per plant, number of clusters per plant, number of pods per plant, 100 seed weight plant height, number of branches per plant, LAI at blooming and Cercospora leaf spot disease rating were negative.

Height of the plant exhibited highest positive correlation with number of pods per plant (1.0672) at the genotypic level. It showed low positive correlation with all other characters except Cercospora leaf spot disease (rating) (-0.4518).

At the genotypic level, number of branches per plant showed high positive correlation with number of clusters per plant (0.5528) followed by number of pods per plant (0.5218). It showed highest negative correlation with mean number of seeds per pod (-0.3239). Number of primary branches showed low positive correlation with number of nodes per plant, 100 seed weight and mean length of pods and low negative correlation with length of root, LAI at blooming, LAI at harvest and Cercospora leaf spot disease (rating).

Number of nodes per plant showed highest positive correlation with LAI at blooming (0.6965) followed by LAI at harvest (0.5126) at the genotypic level. It showed highest negative correlation with mean number of seeds per pod (-0.6012) followed by Cercospora leaf spot disease (rating) (-0.4536). Number of nodes per plant showed low negative correlation with length of root (-0.2333) and number of clusters per plant (-0.1390) and low positive correlation with number of pods per plant (0.2142), mean length of pods (0.2498) and 100 seed weight (0.1868).

Number of clusters per plant showed highest positive correlation with number of pods per plant (1.2615) at the genotypic level. It showed low positive correlation with mean length of pods, length of root and mean number of seeds per pod. 100 seed weight, LAI at blooming, LAI at harvest and Cercospora leaf spot disease (rating) exhibited low negative correlation with this character. Length of the root showed low positive correlation with number of clusters per plant.

At the genotypic level, number of pods per plant showed the highest positive correlation with LAI at harvest (0.7346). Number of pods per plant also showed positive correlation with mean length of pods, mean number of seeds per pod and LAI at blooming. It had high negative association with Cercospora leaf spot disease rating (-0.8539).

Mean length of pods showed a very high correlation with mean number of seeds per pod (1.3908) at the genotypic level. It also showed positive correlation with 100 seed weight (0.5442), length of root (0.2216) and LAI at harvest (0.0564) and highest negative correlation with Cercospora leaf spot disease rating (-0.5783).

Very high positive correlation was observed between mean number of seeds per pod and 100 seed weight (0.8310) at the genotypic level. It showed negative correlation with LAI at blooming, LAI at harvest and Cercospora leaf spot disease rating.

At the genotypic level 100 seed weight exhibited highest negative correlation with Cercospora leaf spot disease rating (-0.3366). It also showed low positive correlation with length of root (0.1872) and low negative correlation with LAI at blooming (-0.1771) and LAI at harvest (-0.2164).

Length of the root showed low negative correlation with LAI at blooming (-0.4362), LAI at harvest (-0.4624) and Cercospora leaf spot disease rating (-0.3206).

LAI at blooming showed high positive correlation with LAI at harvest (0.8802) and low negative correlation with Cercospora leaf spot disease rating (-0.1176) at the genotypic level.

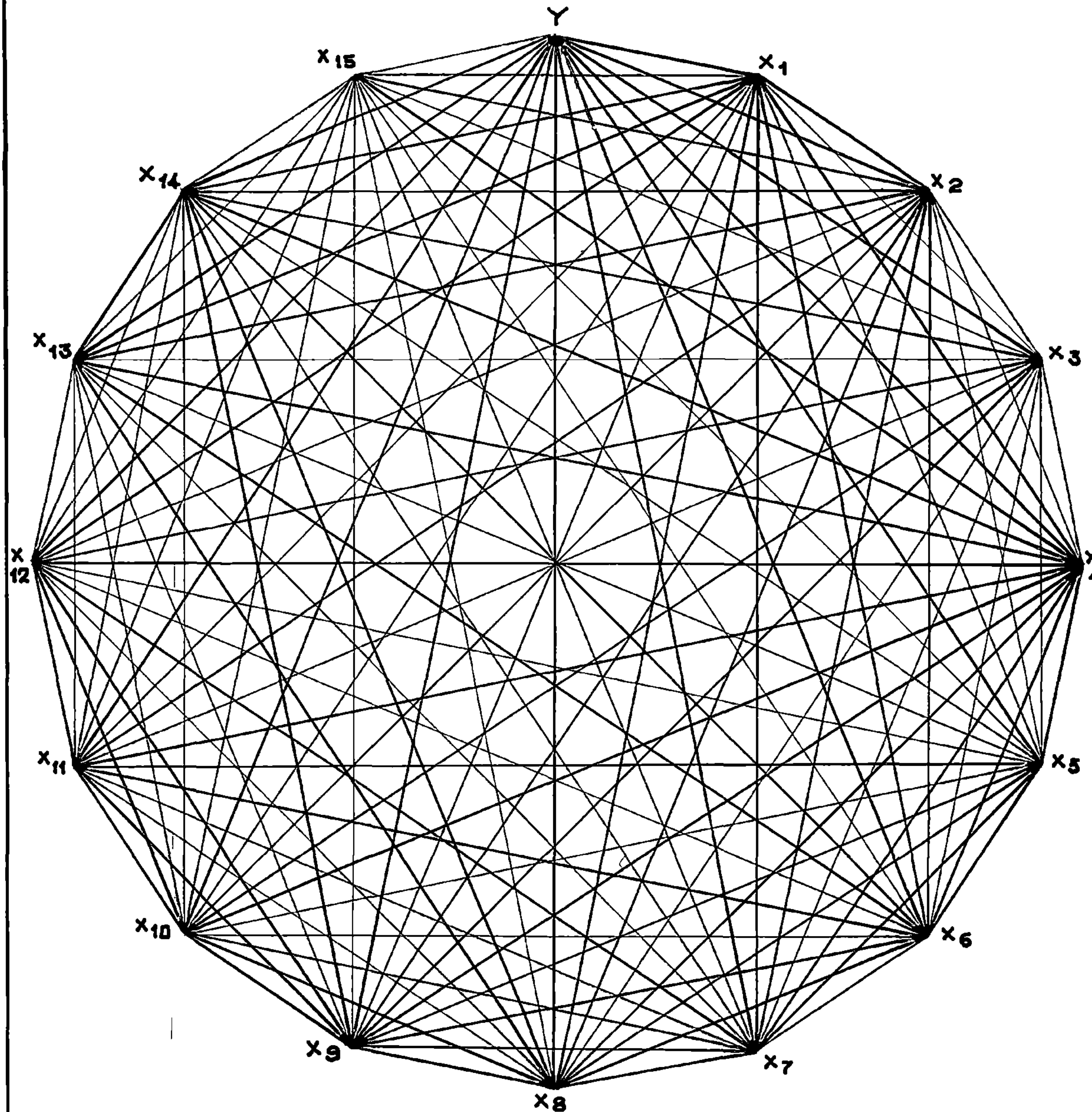
At the genotypic level, LAI at harvest showed low negative correlation with Cercospora leaf spot disease rating (-0.1557).

The genotypic relationship between yield and other characters are diagramatically represented in Figure 3.

IV. Path Analysis

Path coefficient analysis was undertaken so as to obtain a clear picture of the cause effect relationship of various characters and yield. This technique is effective in partitioning the observed genotypic correlation

FIG 3 CORRELATION DIAGRAM



——— POSITIVE CORRELATION. ——— NEGATIVE CORRELATION

Y -- SEED YIELD/PLANT (g).

X_1 - DAYS TO 50 % FLOWERING

X_2 - DAYS TO POD HARVEST INITIATION

X_3 - DAYS THROUGH WHICH POD HARVEST CONTINUED

X_4 - HEIGHT OF THE PLANT (cm)

X_5 - No OF BRANCHES / PLANT

X_6 - No. OF NODES / PLANT

X_7 - No OF CLUSTERS/PLANT

X_8 - No. OF PODS/ PLANT

X_9 - MEAN LENGTH OF PODS (cm)

X_{10} - MEAN No OF SEEDS/ POD.

X_{11} - 100 SEED WEIGHT (g)

X_{12} - LENGTH OF ROOT (cm)

X_{13} - LAI AT BLOOMING

X_{14} - LAI AT HARVEST

X_{15} - CERCOSPORA LEAF SPOT DISEASE (RATING) into direct and indirect effects. The results obtained by path coefficient analysis are presented in Table 13 and Figure 4.

From the table it is seen that the maximum direct effect on yield was contributed by days through which pod harvest continued (1.4228), but its genotypic correlation with seed yield was of low magnitude (0.0136). It exerted positive indirect effect via number of clusters per plant, length of root and LAI at blooming. The indirect effects via the other characters were negative.

Days for pod harvest initiation had the second highest positive direct effect on seed yield (1.3587) and it was dependent on its positive genotypic correlation with seed yield (0.4894). It had positive indirect effect via number of pods per plant, 100 seed weight, number of nodes per plant and days to 50 per cent flowering.

Hundred seed weight, an important yield attribute had a positive direct effect on seed yield (0.6019) but its genotypic correlation with seed yield was only 0.2586. The high direct effect was contributed by the positive indirect effect via most of the characters. It exerted negative indirect effects via days to 50 per cent

Table 13. Direct and indirect effect of the various characters on yield in black gram

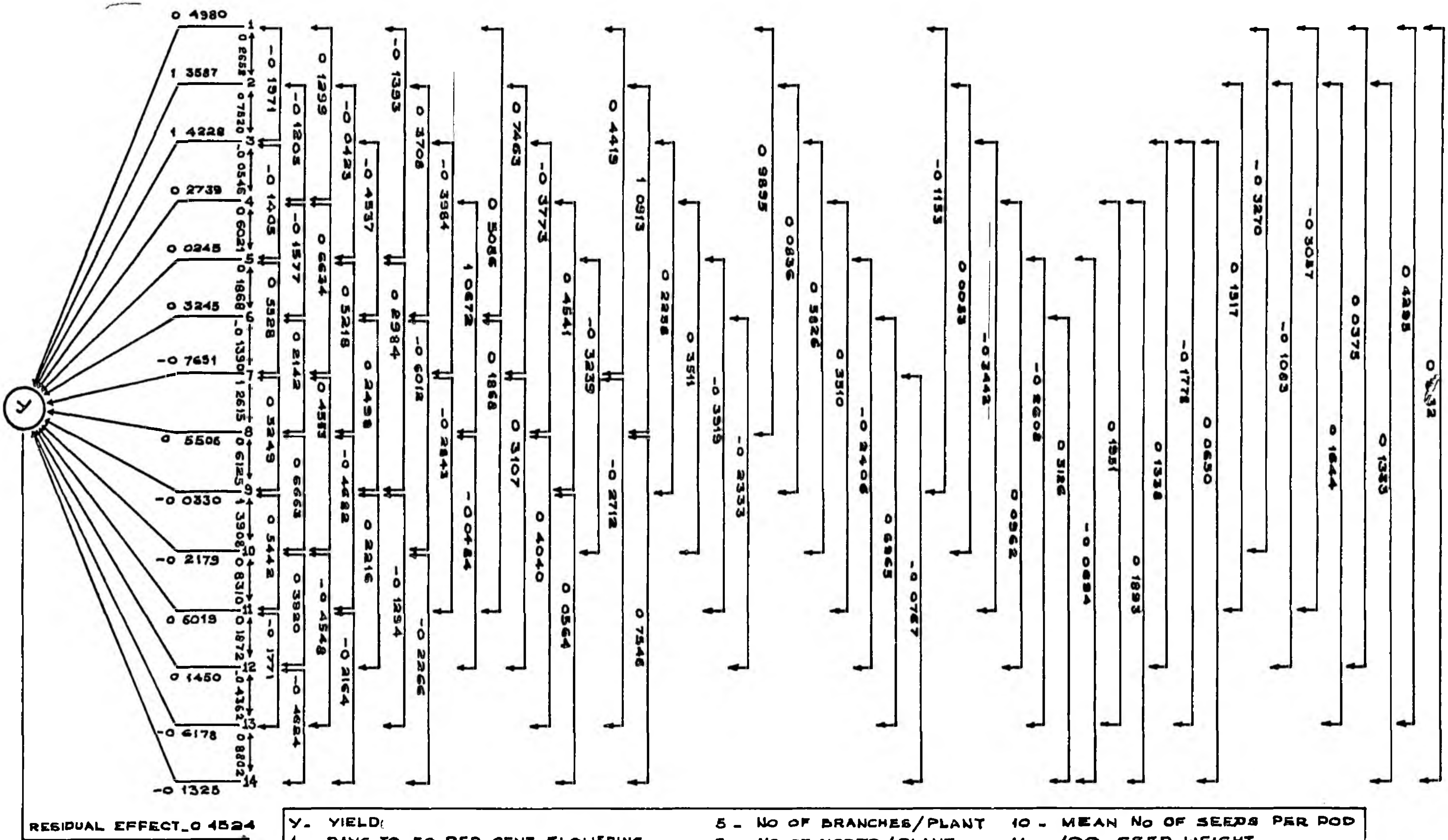
Characters	Days to 50 per cent flowering X_1	Days to pod harvest initiation X_2	Days through which pod harvest continued X_3	Height of the plant X_4	No. of branches per plant X_5	No. of nodes per plant X_6	No. of clusters per plant X_7	No. of pods per plant X_8	Mean length of pods X_9	Mean No. of seeds per pod X_{10}	100 seed weight X_{11}	Length of root X_{12}	LAI at blooming X_{13}	LAI at harvest X_{14}	Total correlation
Days to 50 per cent flowering (X_1)	0.4980	0.3604	-0.2805	0.0356	-0.0034	0.1650	-0.3381	0.5448	0.0038	0.0712	-0.1840	0.0055	-0.2653	-0.0415	0.571
Days to pod harvest initiation (X_2)	0.1321	1.3587	-1.0699	-0.0330	-0.0010	0.1203	-0.5710	0.6008	-0.0028	-0.0012	0.0913	-0.0156	-0.1016	-0.0177	0.489
Days through which pod harvest continued (X_3)	-0.0982	-1.0217	1.4228	-0.0150	-0.0034	-0.1472	0.3049	-0.2077	-0.0075	-0.1269	-0.2072	0.0195	0.1098	-0.0086	0.0136
Height of the plant (X_4)	0.0647	-0.1637	-0.0777	0.2739	0.0147	0.0512	-0.5076	0.5876	-0.0150	-0.0765	0.2113	0.0140	-0.1205	-0.0251	0.2313
No. of branches per plant (X_5)	-0.0694	-0.0575	-0.1999	0.1650	0.0245	0.0606	-0.4230	0.2873	-0.0099	0.0706	0.2359	-0.0350	0.1611	0.0092	0.2195
No. of nodes per plant (X_6)	0.2533	0.5039	-0.6455	0.0432	0.0036	0.3245	0.1063	0.1179	-0.0083	0.1310	0.1124	-0.0330	-0.4303	-0.0679	0.4111
No. of clusters per plant (X_7)	0.2201	1.0140	-0.5669	0.1817	0.0135	-0.0451	-0.7651	0.6945	-0.0173	-0.0992	-0.1711	0.0450	0.1676	0.0103	0.6820
No. of pods per plant (X_8)	0.4928	1.4827	-0.5368	0.2923	0.0128	0.0695	-0.9652	0.5506	-0.0202	-0.1452	-0.2818	-0.0070	-0.2496	-0.0999	0.5949
Mean length of pods (X_9)	-0.0574	0.1136	0.3213	0.1244	0.0073	0.0811	-0.4016	0.3372	-0.0330	-0.3030	0.3276	0.0320	0.0800	-0.0075	0.6221
Mean no. of seeds per pod (X_{10})	-0.1629	0.0072	0.8290	0.0962	-0.0079	-0.1951	-0.3484	0.3668	-0.0459	-0.3179	0.5002	0.5070	0.2811	0.0300	1.0894
100 seed weight (X_{11})	-0.1522	0.2062	-0.4897	0.0962	0.0096	0.0606	0.2176	-0.2578	-0.0180	-0.1810	0.6019	0.0270	0.1094	0.0288	0.2586
Length of root (X_{12})	0.0187	-0.1471	0.1910	0.0263	-0.0059	-0.0757	-0.2377	-0.0267	-0.0073	-0.0854	0.1127	0.1450	0.2695	0.0613	0.2387
LAI at blooming (X_{13})	0.2139	0.2234	-0.2529	0.0534	-0.0064	0.2260	0.2675	0.2224	0.0043	0.0991	-0.1066	-0.0630	-0.6178	-0.1166	0.0862
LAI at harvest (X_{14})	0.1560	0.1811	0.0925	0.0519	-0.0017	0.1663	0.0587	0.4154	-0.0019	0.0490	-0.1303	-0.0670	-0.5438	-0.1325	0.2937

Residual effect = 0.4524

Diagonal elements = Direct effects

Off-diagonal elements = Indirect effects

FIG 4 PATH DIAGRAM SHOWING DIRECT EFFECTS AND GENOTYPIC CORRELATIONS IN BLACKGRAM



Y - YIELD

1 - DAYS TO 50 PER CENT FLOWERING

2 - DAYS TO POD HARVEST INITIATION

3 - DAYS THROUGH WHICH POD HARVEST CONTINUED

4 - HEIGHT OF THE PLANT

5 - No OF BRANCHES/PLANT

6 - No OF NODES/PLANT

7 - No OF CLUSTERS/PLANT

8 - No OF PODS/PLANT

9 - MEAN LENGTH OF PODS

10 - MEAN No OF SEEDS PER POD

11 - 100 SEED WEIGHT

12 - LENGTH OF THE ROOTS

13 - LAI AT BLOOMING

14 - LAI AT HARVEST

flowering, days through which pod harvest continued, number of pods per plant, length of pods and number of seeds per pod.

Number of pods per plant, another important yield contributing attribute, had a positive direct effect on seed yield (0.5506). The magnitude of its direct effect was closely dependent on its strong positive correlation with seed yield (0.5949). It also exerted positive indirect effects on seed yield via number of nodes per plant, number of branches per plant, plant height, days to pod harvest initiation and days to 50 per cent flowering, but negative indirect effects through the other characters.

Days to 50 per cent flowering exerted a positive direct effect on seed yield (0.4980) and its correlation with seed yield was also high (0.5715).

Number of clusters per plant exhibited strong correlation with seed yield (0.6820) but on partitioning the total correlation, it was observed that direct effect of yield was negative (-0.7651). The indirect effects of number of clusters on seed yield via 100 seed weight, days through which pod harvest continued, number of nodes per plant, length of pods and number of seeds per pod were negative.

Number of seeds per pod showed a very strong correlation with yield (1.1894) but its direct effect on yield was observed to be negative (-0.2179). It showed high positive indirect effects on seed yield via days through which pod harvest continued, number of pods per plant and 100 seed weight.

Length of pods showed a negative direct effect on seed yield (-0.0330) which was independent of its significant positive correlation with seed yield (0.6221).

LAI at blooming and harvest also showed negative direct effect on seed yield (-0.6178 and -0.1325 respectively), though their correlations with seed yield were positive (0.0862 and 0.2937 respectively).

In this study the residual effect was worked out to be 0.4524.

DISCUSSION

DISCUSSION

Crop improvement, in general, depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable. For initiating an effective breeding programme evaluation of genetic variability on hand is indispensable. Such an evaluation can be done by suitable genetic parameters such as genotypic coefficient of variation, heritability estimates and association analysis. Only meagre information is available on the genetic variability present for various quantitative characters in black gram especially under partial shade environment. The present study was hence taken up to estimate some of the basic parameters of quantitative variability in black gram grown as intercrop in coconut garden.

Variability

Black gram is a self pollinated species with very limited intra-varietal variability. Intensive selection for yield and its component characters to suit local conditions and demands has further narrowed down the heterogeneity in the population.

Variance and coefficient of variation help to measure the variability of a population. Phenotypic variability cannot be utilized for varietal improvement. A knowledge of the extent of genetic variability is therefore important. So it is necessary to partition the overall variability into heritable and non-heritable components. In the present study the estimates of variance components indicated only little difference between phenotypic and genotypic variances for the characters viz. 100 seed weight, pod length, number of seeds per pod, number of branches per plant, LAI at blooming and harvest (see Table 9). This indicates that variations observed in these characters were mainly due to genetic causes and that environment had only negligible influence over them. On the other hand, the characters, seed yield per plant, plant height and number of clusters per plant showed wide difference between phenotypic and genotypic variance indicating the greater influence of environment over them.

Coefficient of variation is another means of expressing the amount of variability. In the present study, phenotypic and genotypic coefficients of variation were highest for Cercospora leaf spot disease rating. High values of phenotypic coefficient of variation with correspondingly high values of genotypic coefficient of variation were recorded for LAI at blooming and harvest, number of branches per plant and plant height. This suggests that there is scope for the improvement of these characters through selection. Similar trends were reported for number of branches per plant by Veeraswamy _et al_. (1973b) in green gram, Godawat (1980) in red gram and Setty _et al_. (1977) in bengal gram. Similar result in plant height was reported for black gram by Singh _et al_. (1975) and Patel and Shah (1982), for green gram by Chowdhury _et al_. (1971) and for red gram by Shoram (1983). Contrary to this result Khorgade _et al_. (1985) reported very low genotypic coefficient of variation for plant height in bengal gram.

Other characters, viz. days to 50 per cent flowering, days to pod harvest initiation, number of nodes per plant, length of pods, 100 seed weight and number of seeds per pod exhibited low phenotypic and genotypic coefficients of variation. Similar results were obtained in black gram for 100 seed weight by Singh _et al_. (1975) and for pod length by Soundrapandian *et al*. (1975) and Goud *et al*. (1977). Low genotypic coefficient of variation for number of seeds per pod was reported by Dharmalingam and Kadambavanasundaram (1984) in cowpea.

In the present study high values of phenotypic coefficient of variation with correspondingly low values of genotypic coefficient of variation were recorded for seed yield per plant, number of pod clusters per plant and number of pods per plant indicating the high influence of environment on the expression of these characters. Sagar *et al*. (1976) got the same results in black gram for the same characters.

Heritability, Genetic advance and Genetic gain

Heritability estimates provide an exact and precise information of the influence of environment on various characters. Johnson *et al*. (1955) have suggested that heritability estimates along with genetic gain is more useful than heritability value alone in predicting the resultant effect and selecting the best individuals.

The characters in the order of high heritability in the present study were days to pod harvest initiation

(99.73 per cent), LAI at harvest (97.05 per cent), LAI at blooming (94.10 per cent), days through which pod harvest continued (88.18 per cent), number of branches per plant (76.53 per cent), 100 seed weight (65.60 per cent) and number of nodes per plant (64.05 per cent). The high values indicate minimum influence of environment on these characters.

Sarkar et al. (1984) in black gram, Empig et al. (1970) in green gram and Singh and Mehndiratta (1969) in cowpea have got such high heritability values for days to pod harvest initiation.

High heritability estimates for number of branches per plant were obtained by Veeraswamy et al. (1973b) in green gram, Godawat (1980) in pigeon pea and Srivastava and Sachan (1974) in pea.

The high heritability values obtained in respect of 100 seed weight in the present study was in agreement with the findings of Goud et al. (1977) in black gram, Singh and Mehndiratta (1969) in cowpea, Chowdhury et al. (1971) and Paramasivan and Rajasekaran (1980) in green gram. However the findings of Srivastava and Sachan (1974) in pea with regard to this character was contrary to the present results whereas Shivasankar et al. (1977) got similar results of high heritability values for number of nodes in horse gram.

Moderate heritability estimates were observed for days to 50 per cent flowering, Cercospora leaf spot disease rating, length of root, plant height and length of pods (see Table 11). Singh and Mehndiratta (1969) in cowpea and Khorgade et al. (1985) in chick-pea reported high heritability for days to 50 per cent flowering. In black gram, Sarkar et al. (1984) and in cowpea, Lakshmi and Goud (1977) reported high heritability for plant height. Goud et al. (1977) in black gram reported high heritability for pod length while it was found to have only moderate heritability in the present study.

The other characters namely, number of clusters per plant, number of pods per plant, number of seeds per pod and seed yield per plant exhibited very low heritability values. Soundrapandian et al. (1975) in black gram reported medium heritability for number of clusters per plant and number of pods per plant. Goud et al. (1977) in black gram and Raut and Patil (1975) in soybean reported high heritability for number of seeds per pod. Low heritability values in respect of seed yield obtained by Goud *et al.* (1977) in black gram and Lakshmi and Goud (1977) in cowpea are in agreement with the present results. On the contrary, high heritability for seed yield was reported by Paramasivan and Rajasekaran (1980) in green gram and Godawat (1980) in pigeon pea.

Heritability estimates have been found to be helpful in making selection of superior genotypes on the basis of phenotypic performance of the quantitative characters. But, heritability does not give a clear picture of the genetic progress. For this, genetic advance and genetic gain should be considered along with heritability values (Johnson *et al.*, 1955).

Genetic gain was maximum for Cercospora leaf spot disease rating (74.12 per cent) followed by LAI at blooming (72.79 per cent) and LAI at harvest (66.67 per cent), and minimum for number of seeds per pod (1.73 per cent) (Table 11). This indicates that by selecting five per cent superior individuals the genetic improvement possible for number of seeds per pod will be only 1.73 per cent.

Among other characters studied, medium genetic gains were exhibited by days through which pod harvest continued (31.63 per cent), number of branches per plant (29.20 per cent) and plant height (18.02 per cent). The other characters viz. days to 50 per cent flowering, days to pod harvest initiation, number of nodes per plant, length of root, number of pod clusters per plant, number of pods per plant, pod length, number of seeds per pod, seed yield per plant and 100 seed weight exhibited low genetic gains (Table 11).

Veeraswamy et al. (1973b) in green gram, Srivastava and Sachan (1974) and Shivasankar et al. (1977) in horse gram, Godawat (1980) and Bainiwal et al. (1981) in pigeon pea obtained high genetic gain for number of branches per plant as against the medium values obtained in the present study.

In the case of plant height, Soundrapandian et al. (1975), Patel and Shah (1982) and Sarkar et al. (1984) in black gram, Raut and Patil (1975) in soybean and Lakshmi and Goud (1977) in cowpea got high values of genetic gain for this character. However only medium genetic gain was observed for plant height in the present study.

Low values of genetic gain were recorded for days to 50 per cent flowering, days to pod harvest initiation, number of nodes per plant, length of root, number of pod clusters per plant, number of pods per plant, pod length, number of seeds per pod, seed yield per plant and 100 seed weight in the present study. Contrary to this, Empig _et al_. (1970) have reported high values of genetic gain for days to flowering and days to pod harvest initiation in green gram, Shivasankar _et al_. (1977) for number of nodes per plant in horse gram, Soundrapandian _et al_. (1975) in black gram and Paramasivan and Rajasekaran (1980) in green gram for number of pod clusters per plant, Soundrapandian _et al_. (1975) in black gram and Veeraswamy _et al_. (1973c) in cowpea for number of pods per plant and Chowdhury _et al_. (1971) and Paramasivan and Rajasekaran (1980) for 100 seed weight in green gram.

Low genetic gain for seed yield obtained in the present study is in perfect agreement with the results obtained by Singh and Mehndiratta (1969) in cowpea.

Lakshmi and Goud (1977) obtained low genetic gains for pod length and number of seeds per pod in green gram similar to the results obtained in the present study.

Three characters, viz. Cercospora leaf spot disease rating, LAI at blooming and [illegible] harvest showed high heritability combined with high genetic gain. This indicates additive gene action for these characters which envisages great scope for selection (Panse, 1957).

Days to 50 per cent flowering, days to pod harvest initiation, number of nodes per plant and 100 seed weight had high heritability coupled with low genetic gain. This indicates non-additive gene action which greatly limit the scope for improvement of these characters through selection (Panse, 1957).

Plant height, number of branches per plant and days through which pod harvest continued showed moderate to high heritability in association with moderate genetic advance. Length of pods and length of roots showed medium heritability coupled with low genetic advance. The other characters viz. number of clusters per plant, number of pods per plant, number of seeds per pod and seed yield had low heritability and low genetic gain suggesting poor response for selection under normal situations.

Correlation

The association analysis in this study revealed that the genotypic correlations were in general of higher magnitude than the corresponding phenotypic correlations. These findings were in conformity with the results obtained by Soundrapandian *et al*. (1976) in black gram and Singh and Malhotra (1970) in green gram.

Seed yield had positive genotypic correlation with all the component characters except Cercospora leaf spot disease rating.

Seed yield was positively correlated with days to 50 per cent flowering. Similar results were reported by Giriraj and Vijayakumar (1974) in green gram, Bainiwal and Jatasra (1985) in pigeon pea and Srivastava *et al*. (1976) in soybean.

Days to pod harvest initiation showed high positive association with seed yield. This was in agreement with the findings of Joshi and Kabaria (1973) and Singh (1985) in pea. Plant height showed positive correlation with seed yield. Significant correlation of seed yield with plant height was reported by Bainiwal and Jatasra (1985) in pigeon pea, Natarajarathnam _et al_. (1985) and Singh and Dabas (1985) in cowpea and Bajaj _et al_. (1984) in chick-pea.

Seed yield showed positive correlation with number of branches per plant. Patel and Shah (1982) in black gram, Singh and Malhotra (1970) in green gram and Joshi (1973) and Godawat (1980) in pigeon pea also reported similar findings.

In the present study, number of nodes per plant, length of root and number of pod clusters per plant showed positive correlation with seed yield. Similar results were reported by Patel and Shah (1982) in black gram, Gupta _et al_. (1982) in green gram and Natarajarathnam _et al_. (1985) in cowpea.

Seed yield showed high positive correlation with number of pods per plant. These results are in conformity with those obtained by Verma and Dubey (1970), Tripathi and Singh (1975), Patel and Shah (1982) and Sarkar _et al_.

(1984) in black gram, Singh and Malhotra (1970) in green gram and Bajaj (1984) in chick-pea.

Seed yield showed very high positive correlation with pod length and number of seeds per pod as well. These findings are in agreement with those of Verma and Dubey (1970) in black gram, Singh and Malhotra (1970) and Tomar et al. (1973) in green gram and Bordia et al. (1977) and Singh and Dabas (1985) in cowpea. On the contrary, Joshi (1973) reported a weak negative correlation of seed yield with seeds per pod in pigeon pea.

100 seed weight showed positive correlation with seed yield. Similar results were reported by Verma and Dubey (1970) and Sarkar et al. (1984) in black gram and Tomar et al. (1973) in green gram.

LAI both at blooming and at harvest showed positive correlation with seed yield. Pandey et al. (1980) in Lab-lab bean reported that yield was highly and positively correlated with leaflet area. Cercospora leaf spot disease rating showed strong negative correlation with seed yield. Obviously this indicates the adverse effect of this disease on yield.

Among the yield components also, the genotypic correlations were higher than the corresponding phenotypic correlations.

Days to 50 per cent flowering showed positive correlation with days to pod harvest initiation, days through which pod harvest exists, plant height, number of nodes per plant, number of clusters per plant, number of pods per plant, length of root and LAI at blooming and harvest. These results indicate that the days taken for flowering could prove to be a good index for the number of days to pod harvest initiation. It also indicated that the late flowering lines were taller and had more number of nodes, clusters and pods, longer roots and greater leaf area. The other characters showed negative association with days to 50 per cent flowering. Tripathi and Singh (1975) recorded strong positive correlation between days to flowering and number of branches per plant contrary to the results obtained in the present study. Singh et al. (1977) obtained positive correlation between leaf area index and days to 50 per cent flowering as in the present study.

Days to pod harvest initiation was positively correlated with number of nodes per plant, number of clusters, number of pods, pod length, number of seeds per pod, 100 seed weight and LAI at blooming and harvest. It showed negative correlation with other characters. The results indicated that lines which took longer time for pod harvest initiation were high yielders with more number of leaves. Singh et al. (1977) also reported positive correlation between leaf area index and maturity.

Plant height showed positive correlation with number of branches, number of clusters, number of pods, pod length, number of seeds per pod and 100 seed weight. These results indicate that the taller lines produced more number of pods and pods having greater length and more number of seeds per pod. This also indicated that selection for plant height would result in the simultaneous improvement of the other characters. Tripathi and Singh (1975) reported significant positive correlation between plant height and number of pods per plant in black gram. Muthiah (1976) also got similar results in black gram.

Number of branches per plant showed positive correlation with number of nodes per plant, number of clusters per plant, number of pods per plant, pod length and 100 seed weight. Similar results were reported by Muthiah (1976) in the same crop. Malhotra et al. (1974) in green gram reported significant association of number of branches with number of pods and number of clusters. They also reported positive correlation between number of branches and number of seeds per pod which is contrary to the results of the present study. In cowpea, Singh and Mehndiratta (1969) reported positive correlation between branch number and 100 seed weight and also with pod length which is in agreement with the results of the present study.

Number of clusters per plant was positively correlated with number of pods per plant, pod length and number of seeds per pod. Similar results were obtained by Sandhu et al. (1980) in black gram. Angadi (1976), however, observed negative correlation between these traits in cowpea.

Number of pods per plant showed positive correlation with pod length and number of seeds per pod. Sandhu et al. (1980) also reported positive correlation between number of pods per plant and length of pods in black gram. Seed weight was found negatively associated with the number of pods per plant in the present study. Similar results were obtained by Muthiah (1976) in black gram, Liu _et al_. (1984) in green gram and Sengupta and Kataria (1971) in soybean. This finding indicates the negligible part played by 100 seed weight in improving grain yield in most of the pulses.

Length of pods had positive correlation with 100 seed weight indicating that simultaneous improvement in pod length and seed yield would take place if selection is made merely for 100 seed weight. This is in agreement with the findings of Muthiah (1976) in black gram, Singh and Mehndiratta (1969) in cowpea and Tomar _et al_. (1973) in green gram.

Number of seeds per pod had positive correlation with 100 seed weight. Singh and Mehndiratta (1969) in cowpea and Tomar _et al_. (1973) in green gram got similar results. Chand _et al_. (1975) in chick-pea, however, observed negative correlation between these traits.

Path Analysis

The path analysis revealed that days through which pod harvest continued had the highest positive direct effect on seed yield, followed by days to pod harvest initiation, 100 seed weight and number of pods per plant. Number of nodes per plant, plant height, number of branches per plant, days to 50 per cent flowering and pod length also had positive direct effect on yield. All the other characters included in the model showed a negative direct effect on yield.

The high positive direct effect of days to pod harvest initiation on seed yield found in this study is in agreement with the findings of Narasinghani et al. (1978) in peas. It was interesting to note that the direct effect of this character on seed yield was even more than its correlation coefficient. The correlation value of this character with yield was reduced probably due to its high negative indirect effect via. days through which pod harvest continued.

100 seed weight also showed positive direct effect on yield. This result is in agreement with the findings of Muthiah (1976) and Usha and Rao (1981) in black gram, Narasinghani et al. (1978) in pea and Rathnaswamy et al.

(1978) in green gram. This shows that selection of varieties with bolder seed size would be effective in improving yield in most of the pulses.

Number of pods per plant showed positive direct effect on seed yield. Since the direct effect was almost equal to its correlation with seed yield, direct selection for this character will be very useful for enhancing yield. The direct effect of number of pods per plant on yield was reported by Muthiah (1976) and Patel and Shah (1982) in black gram crop, Veeraswamy and Rathnaswamy (1975) in soybean, Agarwal and Kang (1976) in horse gram and Presanna and George (1986) in green gram. However, this result is not in agreement with the finding of Soundrapandian et al. (1976) in black gram.

Days to 50 per cent flowering showed positive direct effect on yield. It also exerted a substantial indirect positive effect on yield through number of pods per plant and number of clusters per plant. From this, it follows that the significant correlation between seed yield and days to 50 per cent flowering was mainly due to indirect effect via number of pods per plant and days to pod harvest initiation. This indicates the possibility of selecting late flowering and maturing plants for more number of pods per plant.

Plant height showed a positive direct effect on seed yield indicating that selection for tall varieties would enhance yield. This result is in conformity with the findings of Soundrapandian _et al_. (1976) in black gram and Boomikumaran and Rathinam (1981) in green gram. It was also found that the correlation was almost equal to its direct effect indicating that the direct selection through this character would enhance yield.

Number of branches per plant and number of nodes per plant showed positive direct effects on yield. Their correlations with seed yield was however higher than their respective direct effects. The higher correlations of seed yield with these characters were due to the high positive indirect effects via number of pods per plant and 100 seed weight for the former character and via number of days to which pod harvest initiation and days to 50 per cent flowering for the latter. Veeraswamy _et al_. (1975) in pigeon pea reported that number of branches per plant produced a positive direct effect on seed yield as in the present study. However, this result is not in conformity with the findings of Soundrapandian <u>et al</u>. (1976) in black gram, and in agreement with that of Veeraswamy and Rathnaswamy (1975) in soybean and Presanna and George (1986) in green gram.

It was interesting to note that number of clusters per plant, pod length and number of seeds per pod which had a strong positive correlation with seed yield had negative direct effect on seed yield. These negative direct effects were counter-balanced by high positive indirect effects via number of days to pod harvest initiation and number of pods per plant in the case of number of clusters per plant and via number of pods per plant 100 seed weight and days through which pod harvest continued in the case of pod length and number of seeds per pod.

The direct negative effect of number of clusters per plant on seed yield was in conformity with the finding of Muthiah (1976) in black gram. On the other hand, Soundrapandian <u>et al</u>. (1976) and Patel and Shah (1982) in black gram, Singh and Malhotra (1975) in red gram and Boomikumaran and Rathinam (1981) in green gram have reported that number of clusters per plant contributed directly to seed yield.

The direct negative effect of pod length on yield was in conformity with the finding of Muthiah (1976) in black gram. But, Choulwar and Borikar (1985) in cowpea reported that pod length had a positive direct effect on yield.

Number of seeds per pod had a negative direct effect on yield. This agrees with the finding of Soundrapandian et al. (1976) in black gram. However, Narasinghani et al. (1978) in pea and Choulwar and Borikar (1985) in cowpea reported that number of seeds per pod had the greatest direct effect on seed yield.

The model used in this analysis accounts for 80 per cent of the variability, leaving only 20 per cent for random variation. This is indicated by the residual factor of 0.4524 in the path diagram.

Therefore, it is recommended on the basis of the present investigation carried out in black gram, that for selection of a high yielding and adaptable variety under partial shaded conditions, the model for selection should be based on plant height, number of pods per plant, number of branches per plant and number of nodes per plant.

SUMMARY

SUMMARY

The present study was conducted at the Department of Plant Breeding, College of Agriculture, Vellayani during May to November 1986. Fifty varieties of black gram belonging to different agro-climatic regions were evaluated in an initial unreplicated trial and on the basis of yield and adaptability twenty varieties were selected and raised in a randomized block design. Data were collected on seed yield per plant and 15 other characters, viz., days to 50 per cent flowering, days to pod harvest initiation, days through which pod harvest continued, plant height, number of branches per plant, number of nodes per plant, length of root, number of pod clusters per plant, number of pods per plant, length of pods, number of seeds per pod, 100 seed weight, LAI at blooming, LAI at harvest and Cercospora leaf spot disease (rating). Observations were recorded on single plant basis.

The following are the important results obtained in this investigation:

1. Analysis of variance revealed significant differences among the varieties in respect of all characters studied except number of pod clusters per plant, number of pods per plant, seed yield per plant and 100 seed weight. The light intensity observed in each plot at three

different temporal phases of the day also did not show any significant differences in magnitude.

2. Of the 16 characters studied genotypic coefficient of variation was maximum for Cercospora leaf spot disease (rating) and minimum for days to pod harvest initiation. LAI at blooming and LAI at harvest also exhibited high genotypic coefficient of variation. For characters like days to 50 per cent flowering, days to pod harvest initiation, days through which pod harvest continued, number of branches per plant, number of nodes per plant, length of pods, LAI at blooming and LAI at harvest there was only little difference in phenotypic coefficient of variation and genotypic coefficient of variation. But for all other characters there was wide difference between phenotypic coefficient of variation and genotypic coefficient of variation indicating higher environmental influence.

3. Heritability was maximum for days to pod harvest initiation and minimum for number of pods per plant. Other characters like LAI at harvest, LAI at blooming, days through which pod harvest continued and number of branches per plant also had high heritability estimates indicating lesser influence of environment.

4. Genetic advance as percentage of mean showed that

Cercospora leaf spot disease (rating) had maximum genetic gain followed by LAI at blooming and LAI at harvest. High heritability coupled with high genetic gain was recorded for LAI at blooming and LAI at harvest indicating the presence of additive gene action. Days through which pod harvest continued, plant height and number of branches per plant showed moderate to high heritability and genetic gain.

5. At genotypic level, seed yield per plant showed positive correlation with all characters except Cercospora leaf spot disease (rating). Days to 50 per cent flowering, days to pod harvest initiation, number of nodes per plant, number of pod clusters per plant, number of pods per plant, length of pods and number of seeds per pod showed high positive correlation with seed yield per plant. The maximum positive association was found between length of pods and number of seeds per pod.

6. Path coefficient analysis at the genotypic level revealed that days to pod harvest initiation, days through which pod harvest continued, number of pods per plant and 100 seed weight exerted high direct influence on yield. Days to 50 per cent flowering, number of nodes per plant,

plant height, number of branches per plant and length of root also exerted positive direct effect on seed yield per plant. The model used in the path analysis is suitable as it accounts for about 80 per cent of the variability leaving only 20 per cent for random causes.

The above results thus shows that a model based on plant height, number of nodes per plant, number of branches per plant and number of pods per plant should be given due weightage by pulse breeders in making selection for high yielding and adaptable strains in black gram suitable for partially shaded conditions.

REFERENCES

REFERENCES

Agarwal, V.D. and Kang, M.S. (1976). Genetic variability, correlation and path analysis studies in horse gram (*Dolichos biflorus* L.). *Tropical Agric*., *53*: 335-340.

Al-Jibouri, H.A., Miller, P.A. and Robinson, H.F. (1958). Genotypic and environmental covariances in an upland cotton cross of interspecific origin. *Agron. J*., *50*: 633-636.

Allard, R.W. (1960). *Principles of Plant Breeding*. John Wiley and Sons, Inc., New York, 89-98.

Angadi, S.P. (1976). Correlation studies and D^2 analysis in cowpea (*Vigna sinensis* (L) Savi). *Madras Agric. J*., *60*: 1359-1360.

Anonymous (1986). *Package of Practices Recommendations*, Directorate of Extension Education, Kerala Agricultural University, Vellanikkara, pp. 7-7.

*Aykroyd, W.R. and Doughty Joyce (1964). Legume in human nutrition, FAO, Rome.

Bainiwal, C.R. and Jatasara, D.S. (1985). Component analysis in pigeon pea (*Cajanus cajan* (L) Millsp.). *Indian J. Heredity*, *15*: 1-7.

Bainiwal, C.R., Malhotra, N. and Jatasara, D.S. (1981). Studies on variability and correlations in pigeon pea. *Indian J. Agric. Res*., *15*: 161-165.

Bajaj, R.K., Sandhu, T.S. and SRA, S.S. (1984). Regressions, correlations and combining ability of some quantitative characters in chick pea. *J. Res. P.A.U*., Ludhiana, *21*: 155-158.

Boomikumaran, P. and Rathinam, M. (1981). Correlation and path analysis in green gram. *Madras Agric. J*., *68*: 643-647.

Bordia, P.C., Yadavendra, J.P. and Kumar, S. (1977). Genetic variability and correlation studies in cowpea. Rajasthan J. Agric. Sci., 4: 39-44.

*Burton, G.W. (1952). Quantitative inheritance in grasses. Proc. 6th inst. Grassld. Congr., 1: 277-283.

Chand, H., Srivastava, L.S., Trehan, K.B. (1975). Estimates of Genetic parameters, correlation coefficients and path analysis in gram (Cicer arietinum L.). Madras Agric. J., 62: 178-181.

Choudhury, J.B., Chowdhury, R.K. and Kakar, S.N. (1971). Studies on genetic variability in moong (Phaseolus aureus) J. Res. P.A.U., 8: 169-172.

Choulwar, S.B. and Borikar, S.T. (1985). Path analysis for harvest index in cowpea. J. Maharashtra Agric. Univ., 10: 356-357.

Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J., 51: 515-518.

Dharmalingam, V. and Kadambavanasundaram, M. (1984). Genetic variability in cowpea (Vigna unguiculata (L.) Walp). Madras Agric. J., 71: 640-643.

Empig, L.T., Lantican, R.M. and Escure, P.B. (1970). Heritability estimates of quantitative characters in mung bean (Phaseolus aureus Roxb.). Crop Sci.,

Giriraj, R.K. and Vijayakumar, S. (1974). Path coefficient analysis of yield attributes in mung bean. Indian J. Genet. 34: 27-30.

Godawat, S.L. (1980). Genetic parameters, correlation coefficient and path coefficient analysis in pigeon pea (Cajanus cajan (L.) Millsp). Madras Agric. J., 67: 14-18.

Goud, J.V., Viraktamath, B.C. and Laxmi, P.V. (1977). Variability and correlation studies in black gram. Mysore J. Agric. Sci., 11: 322-325.

Gupta, S.N., Lal, S., Lajpat Rai and Tomar, Y.S. (1982). Correlations and path analysis in mungbean (Vigna radiata (L) Wilczek). Haryana Agric. Univ. J. Res., 12: 287-291.

Gupta, V.P., Sethi, V.P. and Chandra, S. (1975). Variation, heritability and correlation among yield components in arhar (Cajanus cajan L.). Haryana Agric. Univ. J. Res., 5: 110-115.

Hanson, C.H., Robinson, H.F. and Comstock, R.E. (1956). Biometrical studies on yield in segregating population of korean lespedesa. Agron. J., 48: 268-272.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimation of genetic and environmental variability in soybean. Agron. J., 47: 314-318.

Joshi, S.N. (1972). Variability and association of some yield components in gram (Cicer arietinum L). Indian J. Agric. Sci., 42: 397-399.

Joshi, S.N. (1973). Variability and correlation studies in pigeon pea (Cajanus cajan L.). Madras Agric. J., 60: 412-414.

Joshi, S.N. and Kabaria, M.M. (1973). Interrelationship between yield and yield components in Phaseolus aureus Roxb. Madras Agric. J. 60: 1331-1335.

Khorgade, P.W., Narkhede, M.M. and Raut, S.K. (1985). Genetic variability and regression studies in chickpea (Cicer arietinum L) and their implications in selection. Punjabrao Krishi Vidyapeeth Res. J., 9: 9-13.

Lakshmi, P.V. and Goud, J.V. (1977). Variability in cowpea. Mysore J. Agric. Sci., 11: 144-147.

Lal, V.S. and Haque, M.D. (1972). Genotypic and phenotypic variability in quantitative characters in soybean (Glycine max (L) Merrill). Indian J. Agric. Sci. 42: 30-33.

*Liu, D.J., Zhou, Y.F., Liu, C.H. and Wu, B. (1984). Heritability, genetic correlations and path analysis of quantitative characters in local cultivars of Phaseolus aureus. Heriditas China, 6: 13-14.

*Lush, J.L. (1940). Intra-sine correlation and regression of offspring on dams as a method of estimating heritability of characters. Proc. Amer. Soc. Anim. Prod., 33: 293-301.

Malhotra, V.V., Singh, S. and Singh, K.B. (1974). Yield components in green gram (Phaseolus auxeus Roxb.). Indian J. Agric. Sci., 44: 136-141.

Mayee, C.D. and Datar, V.V. (1986). Phytopathometry - Technical Bulletin-1. Marathwada Agri. Univ., Parbhani, 23-24, 71.

Miller, P.A., Williams, V.C., Robinson, H.P. and Comstock, R.E. (1958). Estimates of genotypic and environmental variances and covariances in upland cotton and their implications in selection. Agron. J., 5: 126-131.

Misra, R.C. (1985). Selection indices in green gram. Madras Agric. J., 72: 311-316.

Muthiah, A.R. (1976). Variability and path analysis in black gram (Vigna mungo (L) Hepper). M.Sc. (Ag) Thesis, T.N.A.U., Coimbatore.

Narasinghani, V.G., Kanwal, K.S. and Singh, S.P. (1978). Character correlations in pea. Indian J. Agric. Sci., 48: 390-394.

Natarajan, S. and Arumugam, R. (1980). Correlation and path coefficient analysis in peas (Pisum sativum L.). Madras Agric. J., 67: 387-390.

Natarajarathnam, N., Venketeswara Rao, T. and Balakrishnan, K. (1985). Path analysis of yield components in cowpea (Vigna unguiculata (L) Walp). Madras Agric. J., 72: 259-262.

Pandey, R.P., Assawa, B.M. and Assawa, R.K. (1980). Correlation and path coefficient analysis in Dolichos lablab Linn. Indian J. Agric. Sci., 50: 481-484.

Panse, V.G. (1957). Genetics of quantitative characters in relation to plant breeding. Indian J. Genet. 17: 318-328.

Panse, V.G. and Sukhatme, P.V. (1957). Statistical Methods For Agricultural Workers, ICAR, New Delhi, pp. 63-69.

Paramasivan, J. and Rajasekaran, S. (1980). Genetic variability in green gram (Vigna radiata (L.) Wilczek). Madras Agric. J., 67: 421-424.

Patel, S.T. and Shah, R.M. (1982). Genetic parameters, associations and path analysis in black gram (Vigna mungo (L) Hepper). Madras Agric. J. 69: 535-539.

Presanna Kumari, K.T. and George, M.K. (1986). Correlation and path analysis in green gram. Agric. Res. J. Kerala, 20: 82-85.

Rathnaswamy, R., Krishnaswamy, S., Iyemperumal, S. and Marappan, P.V. (1978). Estimates of variability, correlation coefficients and path coefficient analysis in early maturing green gram (Vigna radiata (L) Wilczek). Madras Agric. J., 65: 188-190.

*Raut, V.M. and Patil, V.P. (1975). Phenotypic and genotypic variability in soybean. Biovigyanam, 1: 167-175.

Sugar, P., Chandra, S. and Arora, N.D. (1976). Analysis of diversity in some urd bean (Phaseolus mungo L.) cultivars. Indian J. Agric. Res. 10: 73-78.

Sandhu, T.S., Bhullar, B.S., Cheema, H.S. and Brar, J.S. (1980). Path coefficient analysis in urd bean. Indian J. Agric. Res., 14: 35-41.

*Sarkar, A., Wahhab, M.A., Doza, M.D., Sarwar and Begum, K. (1984). Genetic variability and inter-relationship in black gram. Bangladesh J. Agric. Res., 9: 108-111.

Sengupta, K. and Kataria, A.S. (1971). Path coefficient analysis for some characters in soybean. Indian J. Genet. 31: 290-295.

Setty, A.N., Patil, M.S. and Hiremath, K.G. (1977). Genetic variability and correlation studies in Cicer arietinum L. Mysore J. Agric. Sci., 11: 131-134.

Shivashankar, G., Jalikot, S.H., Chikkadevaiah and Shettar, B.I. (1977). Heritability and correlation studies in horse gram. Mysore J. Agric. Sci., 11: 211-214.

Shoram, J. (1983). Studies on genetic variability for some quantitative characters in pigeon pea. Madras Agric. J., 70: 146-148.

*Singh, A.K. and Misra, M.K. (1985). Genetic variability in quantitative traits of Rabi urd. Abstr. on Tropical Agric., 10: 52608.

Singh, I.B., Singh, H.G., Chauhan, Y.S. and Singh, K.N. (1985). Path coefficient analysis in chickpea (Cicer arietinum L.). Crop Improvement, 12: 62-63.

Singh, K.B., Bhullar, G.S., Malhotra, R.S. and Singh, J.K. (1972). Estimates of genetic variability, correlation and path coefficient in urd and their importance in selection. J. Res. P.A.U., Ludhiana, 9: 410-414.

Singh, K.B. and Malhotra, R.S. (1970). Inter-relationship between yield and yield components in mung bean. Indian J. Genet. 30: 244-249.

Singh, K.B. and Malhotra, R.S. (1975). Yield components in pigeon pea (Cajanus cajan L.). Madras Agric. J., 60: 364-366.

Singh, K.B. and Mehndiratta, P.D. (1969). Genetic variability and correlation studies in cowpea. Indian J. Genet. 29: 104-109.

Singh, R. and Dabas, B.S. (1985). Correlation and path analysis studies in cowpea (Vigna unguiculata (L) Walp). International J. Tropical Agric., 3: 114-118.

Singh, R.K. (1985). Genotypic and phenotypic variability correlations in pea. Indian J. Agric. Sci., 55: 147-150.

Singh, R.P., Singh, M.L., Singh, U. and Singh, I.P. (1977). Path analysis in red gram. Madras Agric. J., 64: 596-597.

Singh, U.P., Singh, U. and Singh, P. (1975). Estimates of variability, heritability and correlation for yield and its components in urd (Phaseolus mungo L.). Madras Agric. J. 62: 71-72.

Soundrapandian, G., Nagarajan, R., Mahudeswaran, K. and Marappan, P.V. (1975). Genetic variation and scope of selection for yield attributes in black gram (Phaseolus mungo L.). Madras Agric. J., 62: 318-320.

Soundrapandian, G., Nagarajan, R., Mahudeswaran, K. and Marappan, P.V. (1976). Genotypic and phenotypic correlation and path analysis in black gram (Vigna mungo (L.). Madras Agric. J., 63: 141-147.

Srivastava, L.S. and Sachan, S.C.P. (1974). Estimates of variability in some quantitative characters of pea (Pisum sativum L.). Indian J. Agric. Res., 8: 239-242.

Srivastava, R.L., Sahai, R.N., Saxena, J.K. and Singh, I.P. (1976). Path analysis of yield components in soybean (Glycine max L. Merr.). Indian J. Agric. Res., 10: 171-173.

Tikka, S.B.S., Jaimini, S.N., Asawa, B.M. and Mathur, J.R. (1977). Genetic variability, inter-relationship and discriminant function analysis in cowpea. Indian J. Heredity, 9: 1-9.

Tomar, G.S., Singh, L. and Mishra, P.K. (1973). Correlation and path coefficient analysis of yield characters in mung bean. SABRAO Newsletter, 5: 125-127.

Tripathi, I.D. and Singh, M. (1975). Association of yield components and their function in black gram (*Phaseolus mungo*). Haryana Agric. Univ. J. Res., 5: 260-265.

Usha, R.Y. and Rao, S.J. (1981). Path analysis of yield components in black gram. Indian J. Agric. Sci., 51: 378-381.

Veeraswamy, R., Palaniswamy, G.A. and Rathnaswamy, R. (1973 a). Yield attributes and heritability in some varieties of *Phaseolus mungo* L. Madras Agric. J. 60: 1834-1835.

Veeraswamy, R., Palaniswamy, G.A. and Rathnaswamy, R. (1973 c). Genetic variability in some quantitative characters of *Vigna sinensis*. Madras Agric. J., 60: 1359-1360.

Veeraswamy, R. and Rathnaswamy, R. (1975). Character association analysis in soybean. Madras Agric. J., 62: 534-536.

Veeraswamy, R., Rathnaswamy, R. and Murugesan, M. (1975). Path analysis in red gram. Madras Agric. J., 62: 166--168.

Veeraswamy, R., Rathnaswamy, R. and Palanisamy, G.A. (1973 b). Genetic variability in some quantitative characters of *Phaseolus aureus* Roxb. Madras Agric. J. 60: 1320-1322

Verma, S.N. and Dubey, C.S. (1970). Correlation studies in black gram (*Phaseolus mungo*). Allahabad Farming, 44: 419-422.

*William, R.F. (1946). The physiology of plant growth with special reference to the concept of net assimilation rate. Ann. Bot. N.S. 10: 41-72.

*Wright, S. (1921). Correlation and causation. J. Agri. Res., 20: 557-587.

*Originals not seen

ABSTRACT

A study on the parameters of variability, correlation and path coefficient were undertaken in twenty black gram varieties to formulate a model for selecting varieties having good yield and adaptability under partial shade. The study was conducted at the Department of Plant Breeding, Vellayani during May to November of 1986.

The varieties showed significant differences in most of the characters studied. Genotypic coefficient of variation was maximum for Cercospora leaf spot disease (rating) and minimum for days to pod harvest initiation. High heritability estimate was observed for days to pod harvest initiation. Genetic gain was maximum for Cercospora leaf spot disease (rating). LAI at blooming and LAI at harvest recorded high heritability and high genetic gain indicating the presence of additive gene action. Days through which pod harvest continued, plant height and number of branches per plant showed moderate to high heritability and genetic gain. At the genotypic level seed yield showed high positive correlation with days to 50 per cent flowering, days to pod harvest

initiation, number of nodes per plant, number of pod clusters per plant, number of pods per plant and number of seeds per pod. Path coefficient analysis projected days to pod harvest initiation, days through which pod harvest continued, number of pods per plant and 100 seed weight as the traits exerting high positive direct effect on seed yield. Days to 50 per cent flowering plant height, number of nodes per plant, number of branches per plant and length of root also exerted positive direct effect on yield.

The study indicated that the model for plant selection in black gram under partial shade should be of taller ones with more number of branches, nodes and pods per plant.