ESTIMATION OF GENETIC PARAMETERS IN GREEN GRAM (*Phaseolus aureus* Roxb.)

BY

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THESIS

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1980

DECLARATION

I hereby declare that this thesis entitled " Estimation of genetic parameters in green gram (*Phaseolus aureus* Roxb.)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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7-8-1980.

CERTIFICATE

Certified that this thesis entitled " Estimation of genetic parameters in green gram (*Phaseolus aureus* Roxb.)" is a record of research work done independently by Kum. Prasanna Kumari, K.T. 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.

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INTRODUCTION

INTRODUCTION

Cereals, oilseeds and pulses are the most important components of the food of man. Of these, pulses are important, particularly in the diet of man in the tropics and sub-tropics, as they meet most of his requirements of protein. Pulses contain 22-28 per cent protein on dry weight basis which is about 3 times that of cereals.

The important pulses and legumes of India are black gram (*Vigna mungo* L.) green gram (*Phaseolus aureus* Roxb. syn. *Vigna radiata* (L.) Wilzeck), cowpea (*Vigna sinensis* L.) gram (*Cicer arietinum* L.), pigeon pea (*Cajanus cajan* L) etc. The area under pulses in India is about 24 million hectares and the annual production is estimated at 12 million tons (1977-'78). Since a vast majority of people of India depend upon pulses for meeting their protein requirements, the cultivation and improvement of pulses assume considerable importance.

Green gram, occupying a pride place in the *Phaseolus* group, is a well known pulse crop of India and one of the cheapest sources of protein. It's protein content ranges from 22-25 per cent. It contains vitamins as well as minerals like calcium and sodium. The crop is so versatile, that, it always becomes an important plant in inter-cropping, rotation cropping and relay cropping. It is an excellent crop for green manuring and is grown in all most all the States of India. In Kerala, it is grown as a pure crop and also as an intercrop in tapioca and coconut gardens.

Inspite of the economic importance of this crop, the national average yield of green gram is very low. The yield ceiling of green gram seems to be only in the vicinity of 2 tons per hectare in comparison with rice which has an yield limit of 8-10 tons per hectare. Hence, in recent years, considerable efforts are underway to improve the situation. These consist of evolution of high yielding cultivars, development of suitable agronomic practices and evolution of suitable plant protection measures. Evolution of high yielding cultivars require a good knowledge of the mode of inheritance of the various component characters, particularly those that contribute to yield, and an under-standing of the various genetic components of yield. It is with this objective in mind that the present investigation was taken up.

A proper evaluation of the variability available for yield and yield attributes would go a long way in formulating sound breeding programmes. Selection, which is as old as cultivation, is an important part of all crop improvement programmes. For selection procedure to be effective, a sound knowledge of the variability present in the breeding population is necessary. A sizeable part of the variability observed in a population is due to environmental factors. But now, with the aid of genetic parameters like phenotypic co-efficient of variation, genotypic co-efficient of variation, heritability, genetic advance and genetic gain, the observed variability in the population can be partioned into heritable and non-heritable components. Hence, the study of genetic parameters is a pre-requisite for better understanding of the genetic make up of genotypes.

Until recently, there have been only few planned approaches to improve yield and to understand its contributing traits in green gram. Yield in green gram as in other crops, is a very complex character. Besides being polygenic in nature, yield is greatly influenced by environmental factors. Hence selection of superior types based on yield alone is not always as much effective as it would be if selection is based on component characters. Hence, in variety improvement programmes, it is necessary to know the relationship of these yield components among themselves and also with grain yield.

Correlations measure only mutual association and they do not provide information on direct and indirect effects. Due to mutual association, the development of a dependent variable is decided by the degree of direct effect of independent variable and indirect effects via other characters arising inevitably as an integral part of growth pattern. Under such situations, for an effective manipulation of characters, correlations are not able to explain the true association. They do not also provide a correct picture of the relative importance to yield, of the direct and indirect effects of each component character. To overcome these shortcomings and to improve the methodology for initial evaluation of the association between yield and component characters, Wright (1921) devised the method of path coefficient analysis. It is a standardised partial regression coefficient which permits separation of correlation coefficients into measures of direct and indirect effects and to study the specific forces acting to provide a given correlation in correlated variables (Dewey and Lu, 1959). In the present day crop improvement programmes, path coefficient analysis is increasingly used to bring about greater efficiency in the system.

It was in this background that the present investigation was undertaken in green gram with the following objectives.

(1) to identify the superior genotypes for yield and other component characters using the analysis of variance technique.

(2) to find out the extent of genetic variability in the population by estimating the genetic parameters like coefficients of variation, heritability, genetic advance and genetic gain.

(3) to determine the direct and indirect effects of each component on grain yield using path coefficient analysis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

An attempt has been made in this review to summarise the important works carried out on the biometrical aspects of yield and yield components in various pulse crops. They are being reviewed under the following headings. 1. Studies on variability; 2. Correlation studies and 3. Path coefficient analysis.

1. Studies on variability

The choice of the most suitable breeding method for rational improvement of yield and its components in any crop depends on the genetic variability. The genetic parameters like coefficient of variation, heritability and genetic advance provide an exact picture of the variability in a population. The extent of variability in various pulse crops have been studied by many workers by estimating the genetic parameters like genotypic coefficient of variation, genetic advance and genetic gain.

Lush (1949) and Johnson et al.(1955) devised an accurate procedure for the calculation of the genetic advance under specified intensity of selection.

Burton (1952) introduced a convenient procedure for the calculation of the phenotypic and genotypic coefficients of variation.

Johnson et al (1955) introduced the methodology for portioning the total variance into that due to genotype, phenotype and error in the analysis of variance. Error denotes the genotypic environmental interaction. They further substantiated the advantage of computing genetic gain under selection and its usefulness in relative comparison of variables.

Hanson et al (1956) reported the mathematical relationship of various estimates on computation of heritability. In the broad sense this attribute refers to the proportion of genotypic variance over the phenotypic variance, and is generally expressed as the percentage.

Gupta and Singh (1969) reported high genetic variability, medium heritability and low genetic advance for yield per plant in green gram. The number of pods had high genetic variability, maximum genetic advance, but moderate heritability. The length of the pod and average weight of 50 seeds had high heritability estimates.

Singh and Mehndiratta (1969) found high heritability values for 100 grain yield, days to flowering and pod length in cowpea. Genetic advance was appreciable for number of branches per plant, 100 grain weight, number of pods per plant, pod length and yield.

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. The number of well developed pods exhibited only low genetic variability.

Singh and Malhotra (1970a) studied 75 strains of green gram and concluded that selection based on 100 seed weight which had the highest genetic variability, heritability and genetic advance, would be the most effective. Genetic advance was high for number of pods and seed yield but heritability was low. Wide range of variability was observed for number of pods, 100 seed weight and seed yield. These characters had high genotypic coefficient of variation. Among the characters studied yield showed the lowest heritability.

Chowdhury et al (1971) studied genetic variability in 21 green gram varieties and found that days to flowering, plant height, pod length and 100 seed weight showed high estimates of heritability associated with high genetic gain.

Joshi (1971) observed a wide range of phenotypic variability for yield and component characters, viz., number of pods, number of seeds, number of branches and 100 seed weight in Indian beans.

Gupta et al.(1972) reported high heritability for number of seeds per pod and 100 seed weight in gram.

Lal and Haque (1972) observed high genotypic coefficient of variation for number of nodes per plant, number of pods per plant, plant height, seed yield, 100 seed weight and period of flowering in soybean. Heritability values were high for days to flowering, 100 seed weight, and number of nodes per plant, moderate for number of pods per plant and low for yield. High to moderate genetic advance was exhibited by number of nodes per plant, number of pods per plant, plant height, 100 seed weight, days to flowering and seed yield.

Srivastava et al.(1972), reported that days to flowering, pod length, and pod width had high heritability values in pea. Genetic advance was the highest for number of seeds per pod.

Joshi and Kabaria (1973) studied 6 varieties of green gram in a diallel cross and observed a wide range of variability in yield and yield contributing characters viz., number of pods per plant, number of seeds per plant and 100 seed weight and a low range in the case of number of branches and seeds per pod. High genotypic coefficient of variation was also observed for weight of seeds, number of pods and number of seeds per plant, and low value for days to flowering. High heritability and sufficiently large amount of genetic advance were noticed in the case of number of pods, number of seeds and yield per plant.

Kaw and Menon (1973) noticed in soybean high heritability but low genetic advance for days to flowering. High genetic advance was noticed for number of beans and number of pods. They obtained moderate to high heritability for bean yield, plant height and number of nodes.

Veeraswamy et al (1973a) studied 25 varieties of green gram and found high genotypic coefficients of variation for number of clusters, number of pods, number of branches and plant height. High estimates of heritability and genetic advance were observed for plant height, number of clusters and number of branches.

Veeraswamy et al (1973) observed that in cowpea number of grains per pod had the highest genetic coefficient of variation and number of clusters had the lowest. Number of grains per pod had the lowest heritability estimate whereas pod length had the highest. Yield per plant also had low heritability. A high genetic advance was noticed in respect of pod length, number of pods and grain yield per plant. In the case of number of branches per plant and clusters per plant, though the heritability was high genetic advance was low.

Koranne and Singh (1974) in pea reported high heritability for pods per plant, pod length, seeds per pods and 100 seed weight, but a low heritability for yield.

Srivastava and Sachan (1974) studied genetic variability in 35 varieties of peas and found high genotypic coefficient of variation for pods per plant. Genetic advance and heritability were high for branches per plant and grains per pod. Heritability was minimum for 100 grain weight.

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 in red gram. They also suggested that selection for higher yield should be based on pods per plant, branches per plant and pod clusters per plant.

Raut and Patil (1975) studied phenotypic and genotypic coefficients of variation, heritability and genetic gain in soybean and showed that height and number of seeds per plant and seed weight per plant had high heritability and genetic gain.

Soundrapandian et al (1975) reported high phenotypic and genotypic variance for pods per plant and plant height in black gram. Heritability was high for length of pod and plant height while it was medium for grain weight, number of clusters and number of pods per plant.

Ram et al (1976) showed that in red gram genotypic coefficient of variation was the highest for clusters per plant and the lowest for pods per plant. Clusters per plant had high heritability followed by grain yield, number of branches and pods per cluster. They also found that clusters per plant had the highest genetic advance, high heritability and genotypic coefficient of variation.

Sagar et al (1976) reported high heritability and genetic advance for pods per plant, yield, branches and days to flowering in black gram. According to them, seeds per pod, pod length, 100 seed weight, branches etc. had low genotypic coefficient of variation compared to phenotypic coefficient of variation.

Goud et al (1977) noticed high heritability for pod length, plant height, 100 seed weight and number of seeds per pod in black gram. However, lowest heritability was observed for grain yield. Genotypic coefficient of variation was low for pod length but high for seed yield per plant. Genetic advance was high for pod length and 1000 seed weight.

Lakshmi and Goud (1977) observed only little difference between phenotypic and genotypic coefficients of variation for plant height, length of pod and 100 grain weight in cowpea. But a wide difference was exhibited by number of of pods, seeds per pod and grain yield. Genotypic coefficient of variation was the highest for plant height followed by seed yield, pod number, pod length, 100 seed weight and seed number per plant. Heritability was high for plant height, pod length and 100 grain weight and low for yield and pods per plant. 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.

Setty et al. (1977) found that in Cicer heritability was high for characters like 100 seed weight, pods per plant, seed yield and pod length and moderate for number of branches, days to flowering and plant height. Genetic advance was high for pod yield and pods per plant and seed yield. Wide difference was seen between genotypic and phenotypic coefficients of variation for number of branches, number of seeds and number of pods per plant and seed yield.

Shivashankar et al.(1977) reported high heritability values for 100 seed weight, days to 50 per cent flowering, nodes per plant and branches per plant and low values for plant height, seeds per pod, pods per plant and yield in horse gram. Genotypic coefficient of variation was high for number of secondary branches per plant, moderate for nodes per plant, 100 seed weight, days to 50 per cent flowering, yield and pods per plant and low for height and seeds per pod. There was significant difference between phenotypic and genotypic coefficients of variation for plant height, pods per plant, and pod length. High genetic advance and heritability were predicted for number of secondary branches and nodes per plant.

Sikka et al.(1977) based on their studies on 25 varieties of cowpea concluded that height, pods per plant and pod length had high genotypic coefficient of variation and days to flowering, pod length, pods per plant and seeds per pod had high heritability values. High genetic advance was observed for yield and pods per plant.

2. Correlation studies

In practical plant breeding a knowledge of the association among the various yield contributing characters is useful in planning and evaluating a breeding programme. Correlation studies are meant to determine the inter-relationships among various traits, which are useful in making selection. Breeders are often interested in characters which result from the interaction of many variables inter-related generally. So it is important to know their association. Information on the association of plant characters to ultimate yield and also on the inter-correlations are available in pulses.

Galton (1889) conceived the idea of correlation of variables for the first instance.

Singh et al.(1968) observed negative association between yield and days to flowering, and between number of primary branches and pod length in green gram.

Gupta and Singh (1969) reported that number of pods, length of pod, 50 seed weight were the main components of yield in green gram.

Kambal (1969) in field beans obtained a high positive correlation between yield and pods per plant. Seed weight was negatively associated with pod number and seeds per pod.

Singh and Singh (1969) found that grain yield was significantly associated with branches per plant, seeds per pod, pods per plant and 100 seed weight in field pea. Pod length had significant positive correlation with seeds per pod and 100 seed weight.

Singh and Malhotra (1970b) in a study of 8 yield contributing characters in 75 strains of green gram found significant positive association of yield with pods per plant, pod length, seeds per pod and seed size.

Verma and Dwbev (1970) found that yield was highly and positively correlated with number of seeds per pod, length of pod, 1000 seed weight and number of pods per plant in black gram.

Lal and Haque (1971) reported high positive association of yield with plant height, number of nodes and number of pods per plant. But 100 seed weight and days to first flowering had no significant correlation with yield in soybean.

Sengupta and Kataria (1971) obtained strong positive association between yield per plant and number of pods, number of nodes and number of clusters in soybean. Significant negative correlation was obtained between pods per plant and 100 seed weight.

Joshi (1972) in a study on gram found positive association between 100 seed weight and yield. A strong positive correlation was found between number of pods per plant and 100 seed weight.

Kaw and Menon (1972) reported that in soybean, bean yield per plant showed a significant association with number of pods, number of beans, plant height and days to 50 per cent flowering. Significant positive correlations were also exhibited by number of pods and number of beans with plant height and days to 50 per cent flowering.

Malhotra et al.(1972) reported a strong positive association of yield with pods per plant and primary branches and negative association with 100 seed weight in soybean.

Srivastava et al.(1972) obtained significant positive genotypic correlations between yield and days to flowering and pod length and seeds per pod in pea.

Joshi and Kabaria (1973) in a study of diallel cross of 6 green gram varieties noticed a strong positive correlation of pods per plant, seeds per plant and seeds per pod with yield and among themselves. Seed weight had negative correlation with all characters.

Singh and Malhotra (1973) observed a strong positive association of yield with clusters per plant, pods per plant and secondary branches. Pods per plant had strong positive association with clusters per plant in pigeon pea.

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 in green gram.

Veeraswamy et al. (1973b) after a study on the segregating population of soybean revealed a very strong positive association of yield with number of pods, number of nodes, number of primary branches per plant and plant height.

Veeraswamy et al. (1973) indicated that in Cajanus cajan yield was positively and significantly correlated to clusters per plant, pods per plant, branches per plant, plant height and days to flowering. A close association was found to exist between number of branches per plant and pods per plant.

Chaudhary and Singh (1974) noticed high positive association of yield with plant height, number of pods, seeds per plant, number of nodes on the mainstem and primary branches in soybean. The number of days to flowering, plant height, primary branches and number of nodes on the main stem were positively correlated with pod number.

Giriraj and Kumar (1974) after their study on 55 varieties of green gram reported that yield was positively associated with days to flowering, plant height, pods per plant and seeds per pod. They also found that 100 seed weight was negatively correlated with seed yield, days to flowering and plant height but strongly and positively associated with pod length.

Malhotra et al.(1974) determined correlations in 60 strains of green gram and found that yield was strongly and positively associated with branches per plant, pods per plant, clusters, seeds per pod and days to flowering. Significant positive associations were obtained among these characters also.

Tripathi and Singh (1975) showed that a positive association existed between seed yield and total number of pods per plant and length of pod in black gram.

Goud et al.(1977) reported that seed yield per plant was positively correlated with height, pod length, seeds per pod and 1000 seed weight in black gram.

Oraon et al.(1977) reported that grain yield in gram was positively correlated with number of pods per plant and number of seeds per plant.

Setty et al.(1977) observed that seed yield was higly and positively correlated with branch number, pod number and seed number per plant and seed weight. The number of days to flowering had a significant negative correlation with yield in gram.

Shivashankar et al.(1977) noticed that yield was highly and positively correlated with number of nodes, plant height, seeds per pod and number of pods per plant in horse gram. Days to 50 per cent flowering and 100 seed weight had negative correlations with yield.

Singh et al.(1977) found that clusters per plant, pods per cluster and pods per plant had positive significant association with yield in green gram. Seeds per pod had lack of association with yield.

Singh and Srivastava (1977) found that seed yield per plant was positively correlated with height, pods per plant and 100 seed weight in pigeon pea.

Tikka et al.(1977) reported that height, number of primary branches and pods per plant were positively correlated with seed yield per plant in cowpea.

Singh et al.(1979) in lablab noticed a positive association of yield with length of the pod and number of seeds per pod. A negative association was found to exist between days to flowering and pod length.

Sandhu et al.(1980) reported that in black gram seed yield was positively associated with clustersper plant, pods per plant, pod length and seeds per pod.

3. Path coefficient analysis

The path coefficient analysis devised by Wright (1921, 1923, 1934) is an efficient technique which permits the separation of correlation coefficient into components of direct and indirect effects (Dewey and Lu, 1959). Working on crested wheat grass, Dewey and Lu (1959) demonstrated the application of the method of 'path coefficients' in the analysis of correlation, in a system of correlated variables, which was widely employed by animal breeders but only rarely by plant breeders till that time. After the pioneering work of Dewey and Lu (1959), the path coefficient analysis was extensively undertaken by many research workers in many crop plants including pulses.

Phadnis et al.(1970) reported that number of pods per plant, seeds per plant and 100 seed weight were the main yield components in gram. Plant height and branches had only little effect on yield.

Singh and Malhotra (1970b) indicated that pods per plant, seeds per pod and seed size influenced seed yield in green gram.

Singh and Mehndiratta (1970) after their study on 40 strains of cowpea concluded that pods per plant, grains per pod and 100 grain weight had appreciable direct effect on grain yield per plant.

Lal and Haque (1971) conducted path analysis in soybean and found that 100 seed weight, and number of pods had high positive direct effect on seed yield, but 100 seed weight had high negative indirect effect on yield via all other characters except period of flowering.

Malhotra et al. (1973) found that maximum genetic gain could be achieved by making selection on the basis of number of clusters, number of pods, seeds per pod and 100 seed weight in green gram.

Chaudhary and Singh (1974) noticed that number of pods per plant and seed size had high direct effect on yield. All other characters, number of seeds per plant, plant height, number of nodes on the mainstem, number of primary branches and days to flowering influenced seed yield through pods per plant and seed size in soybean.

Giriraj and Kumar (1974) carried out path analysis in green gram and found that length of the pod, days to flowering and plant height had positive direct effect on yield. Plant height and days to flowering had negative indirect effects via pod length and 100 seed weight.

Malhotra et al.(1974) conducted path analysis in 60 strains of green gram and came to the conclusion that pods per plant had the highest direct and indirect effects on seed yield. The direct contribution of seeds per pod towards yield was small but they influenced yield indirectly through pod number.

Pokle and Mohatkar (1975) observed that pods per plant had high direct effect on yield than shown by its correlation with yield in Cajanus cajan.

Tripathi and Singh (1975) reported that number of pods on the side branches, seed size and number of seeds per pod had the highest direct effect on yield in black gram.

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

Veeraswamy et al.(1975) observed that number of branches produced the maximum influence both directly and indirectly on seed yield in red gram. This study also showed that number of clusters per plant and pods per plant did not have much direct effect on seed yield, though they exerted an indirect influence through number of branches.

Wakanker and Yadav (1975) revealed that number of pods had positive direct effect on yield followed by number of secondary branches and 100 seed weight in arhar. Plant height and number of pods had also positive direct effect on yield.

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

Banerjee et al.(1976) reported that number of pods, pod length and days to flowering had high positive direct effect on yield in black gram.

Chandel and Joshi (1976) after their study on yellow-grained peas had shown that number of seeds per pod, number of pods per plant and 100 seed weight had a positive direct effect on yield.

Ram et al.(1976) found that primary branches per plant, clusters per plant and pods per plant contributed directly as well as indirectly to grain yield and were the major yield components in red gram.

Soundrapandian et al.(1976) made a critical evaluation of the association between yield and its components in black gram and found that height and number of clusters per plant were the only characters with positive direct and indirect effects on yield.

Kaloo and Dhankhar (1977) in peas had shown that number of pod clusters per plant, number of pods per plant and number of branches per plant had high positive direct effect on yield. Their indirect contributions to yield were also high.

Singh et al.(1977) found that pods per cluster and pods per plant contributed directly as well as indirectly to grain yield and were the most important yield contributing factors in green gram. Clusters per plant and primary branches exhibited indirect contributions to yield.

Jatasra et al.(1978) reported that direct effect of pods per plant on yield in chick pea was positive and highest followed by that of seeds per pod. Direct effect of days to flowering on seed yield was low and negative. Primary branches in addition to the direct effect also contributed to seed yield through pods per plant. The indirect effects of seeds per plant and seeds per pod via pods per plant were also high.

Narasinghani et al.(1978) reported that number of seeds per plant and 100 seed weight had positive direct effect on grain yield in peas. Most characters except 100 seed weight had positive indirect influence via number of seeds per plant.

Singh et al.(1978) after their work on chick pea concluded that number of primary branches and number of pods per plant had high positive direct effect as well as indirect effect through each other.

Patirana and Guzhov (1979) based on path analysis in 11 varieties of soybean found that number of seeds per pod and single seed weight were the most stable yield components.

Sandhu et al.(1980) revealed that in black gram selection based on plant height large pods and higher fruiting nodes was the most efficient for high grain yield.

MATERIALS AND METHODS

MATERIALS AND METHODS

Materials

For the present investigation 15 diverse elite genotypes of green gram available in the genetic collection of the Rice Research Station, Pattambi were chosen (Table 1).

Methods

The experiment was conducted in the fields of the College of Agriculture, Vellayani, during November - January, 1979-'80.

Design

The lay out employed was randomised block design with 15 treatments and 3 replications. Each plot was 2.1 m x 2.1 m in size and contained 49 plants spaced at 30 cm x 30 cm.

Field culture

The crop was given cultural operations and prophylatic plant protection measures as and when necessary. Fertilizers at the rate of 20:30:10 kg per hectare of N, P and K

Table 1

Names and origin of the chosen green gram varieties

Cultivar		Origin	Remarks
PIMS - 4	(V1)	India	Selection made in the Division of Plant Introduction at IARI
ML - 33	(V2)	India	ML series green gram varieties were developed at Ludhiana.
ML - 26	(V3)	India	
ML - 65	(V4)	India	
ML - 12	(V5)	India	
Co - 2	(V6)	India	Developed at Tamilnadu Agricultural University from a local line PLS 365/3.
Culture - 1	(V7)	India	Developed at Pudukottai.
Philippines	(V8)	Philippines	..
EC - 1653	(V9)	..	..
T - 44	(V10)	India	Selection made at Kanpur from Type 1 x Type 49.
HP - 36	(V11)	India	Local selection from land races in Bihar
HP - 40	(V12)	India	
PS - 10	(V13)	India	Selection made at IARI from P-469
S - 8	(V14)	India	Selection made at IARI from BR 2 x Type 2.
PIMS-1	(V15)	India	Selection made in the Division of Plant Introduction at IARI.

respectively were applied. The crop was given all the management care as given in Package of practices of Kerala Agricultural University (1978).

Collection of data

Ten representative plants in each plot were chosen and observations were recorded on the following ten characters.

1. Yield per plant

Seeds were extracted from the dry pods of each selected plant and weighed after cleaning and drying. The weight was expressed in grams.

2. Number of seeds per pod

All the seeds produced by each selected plant were collected and mean was computed.

3. Pod length

Length of 10 pods selected at random from each plant was measured, and expressed in centimeters.

4. Number of pods per plant

Harvesting was completed in 4-5 pickings and total number of pods in each plant was recorded.

5. <u>100 seed weight</u>

Hundred well developed seeds were taken at random from each treatment in all the 3 replications and weight was recorded accurately in grams.

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

Total number of clusters in each selected plant was counted.

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

Number of primary branches alone were recorded at the time of last picking.

8. <u>Plant height</u>

Height of the plant was measured from the ground level to the tip of the top most leaf at the time of last picking and recorded in centimeters.

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

Total number of nodes in each plant was counted and recorded.

10. Days to 50% flowering

The number of days taken by 50% of plants in each plot to produce flowers from the date of sowing was noticed.

Statistical analysis

The data collected for the ten metric traits was tabulated and mean values were subjected to statistical analysis.

1. Analysis of variance (ANOVA)

It was computed according to the methods of Panse and Sukhatme (1957). Significance of computed 'F' values were tested with reference to 'F' table (Panse and Sukhatme 1957).

ANOVA TABLE

Source	Degree of freedom	Sum of squares	Mean sum of squares	F
Replication	(r-1)	SS_R	S_R^2	S_R^2/S_{VR}^2
Treatment	(V-1)	SS_V	S_V^2	S_V^2/S_{VR}^2
Error	(r-1) (V-1)	SS_{VR}	S_{VR}^2	..

Where

r = number of replications
v = number of treatments

2. Variance

The observed variability for each character was partitioned into genetic and environmental, since the effect of environment on the expression of quantitative characters was enormous. Components of variance for each character were worked out following the procedure of Johnson et al.(1955).

Genotypic varience (Vg)

$$Vg = \frac{S_V^2 - S_E^2}{r}$$

Where

S_V^2 = Mean sum of squares due to variation

S_E^2 = Mean sum of squares due to error

r = number of replications

Phenotypic variance (Vp)

$$Vp = Vg + V_e$$

Where

V_g = genotypic variance

V_e = Error variance = Error mean sum of squares

3. Coefficient of Variation

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 = genotypic variance

4. Heritability, Genetic Advance and Genetic Gain

Heritability, Genetic Advance and Genetic Gain were worked out for each character to make meaningful deductions from the data

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

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

Where

h^2 = heritability

V_g = genotypic variance

V_p = phenotypic variance

Expected Genetic Advance (G.A.) under selection

(Lush, 1949 and Johnson et al.,1955)

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

Where

K, the selection differential, is 2.06 at 5% selection in large samples (Miller et al.,1958 and Allard, 1960).

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

$$G\,G = \frac{GA}{\bar{\bar{X}}} \times 100$$

Where $\bar{\bar{X}}$ = General mean

5. <u>Genotypic Correlation Coefficients</u> (rg)(Al-jibouri et al.,1958)

Analysis of covariance was done for all possible pairs of characters. The genotypic and phenotypic covariance components were computed in a similar manner as variance components. From these the genotypic correlation coefficients were worked out.

$$r_g = \frac{V_{g\,12}}{\sqrt{V_{g_1} \times V_{g2}}}$$

where r_g = genotypic correlation coefficient

V_g12 = genotypic covariance between first and second traits. V_{g1} and V_{g2} are the genotypic variances of first and second traits. Significance of r_g was tested by 't' test with 26 degrees of freedom.

6. Path Coefficient Analysis

Path coefficient methodology (Wright, 1921, 1923, 1934) was employed for evaluating the association between yield which is a complex entity, and the component characters. Equations evolved by Wright (1921) and later elaborated by Dewey and Lu (1959) were used to partition the direct as well as indirect effects via other characters on yield which is the dependent variable. Path coefficients were obtained by the simultaneous solution of the following equations

$$r_{1y} = P_{1y} + r_{12} P_{2y} + \cdots\cdots + r_{1k} P_{ky}$$
$$\vdots$$
$$r_{ky} = r_{k1} P_{1y} + r_{k2} P_{2y} + \cdots\cdots + r_{(k-1),k} P_{(k-1),y} + P_{ky}.$$

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

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

$$A \quad = \quad C \quad \times \quad B$$

$$A = C\ B$$

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

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

Let $C^{-1} = \begin{Bmatrix} C_{11} & C_{12} & \cdots\cdots & C_{1k} \\ & C_{22} & \cdots\cdots & C_{2k} \\ & & & \vdots \\ & & & C_{kk} \end{Bmatrix}$

Path coefficients are obtained as

$$P_{1y} = \sum_{i=1}^{K} C_{1i} \; r_{iy}$$

$$P_{2y} = \sum_{i=1}^{K} C_{2i} \quad r_{iy} \quad \text{etc.}$$

The residual factor (x) which measures the contribution of the rest of the characters not considered in the causal scheme and sampling errors was obtained as

$$P_{xy} = \sqrt{1-R^2}$$

where $R^2 = \sum_{i=1}^{K} P_{iy}^2 + 2 \sum_{i \neq} \sum_{j} P_{iy} P_{jy} r_{ji}$

$i < j$

Indirect effects of different characters on yield were obtained as follows:

indirect effect of the i^{th} character on yield through j^{th} character $= P_{iy} r_{ij}$.

RESULTS

RESULTS

Observations on ten different characters in fifteen varieties of green gram were recorded on single plant basis.

Each character is denoted by symbols.

Character	Symbol
1. Yield per plant	y
2. Number of seeds per pod	x_1
3. Pod length	x_2
4. Number of pods per plant	x_3
5. 100 seed weight	x_4
6. Number of clusters per plant	x_5
7. Number of branches per plant	x_6
8. Plant height	x_7
9. Number of nodes per plant	x_8
10. Days to 50% flowering	x_9

The values were statistically analysed to find out the various parameters of quantitative variability. Of the various parameters of quantitative variability, mean, range and coefficient of variation are the basic ones.

The mean performances of the 15 genotypes in respect of yield and other quantitative characters are furnished in Table 2 and Fig. 1 to 8.

The analysis of variance for 10 characters (Table 3) showed that differences among the different genotypes were significant for all characters.

Range and general mean for different characters are given in Table 4.

Table 3

Abstract of ANOVA for 10 characters in 15 cultivars of green gram

Character	Replication (df=2)	Treatment (df=14)	Error (df=28)	F value
	Mean sum of squares			
1. Yield per plant	3.022	7.221	3.289	2.196*
2. Seeds per pod	0.238	2.614	0.204	12.768**
3. Pod length	0.045	3.825	0.099	38.332**
4. Pods per plant	1.270	63.610	11.162	5.698**
5. 100 seed weight	0.146	3.335	0.152	21.918**
6. Clusters per plant	2.078	5.247	1.479	3.548**
7. Branches per plant	0.711	0.922	0.369	2.499*
8. Plant height	5.695	155.588	11.469	13.565**
9. Nodes per plant	14.384	13.077	5.271	2.481*
10. Days to 50% flowering	0.974	18.403	1.803	10.206**

* Significant at 5% level.

** Significant at 1% level.

Table 2. Mean values for 10 characters in 15 cultivars of green gram

Cultivars		Yield per plant (gm)	No.of seeds per pod	Pod length (cm)	No.of pods per plant	100 seed weight (gm)	No.of clusters per plant	No.of branches per plant	Plant height (cm)	No.of nodes per plant	Days to 50% flowering
PIMS-4	(V_1)	9.367	10.850	6.630	19.133	3.510	6.233	1.033	45.067	9.067	35.333
ML-33	(V_2)	6.717	9.917	6.020	15.400	2.790	6.167	1.200	49.267	10.500	33.333
MI-26	(V_3)	9.340	9.826	6.423	20.400	3.178	7.400	1.733	45.467	9.533	33.333
ML-65	(V_4)	10.400	10.406	6.527	28.533	2.793	9.067	3.033	43.467	14.300	36.667
ML-12	(V_5)	8.500	10.730	6.400	20.300	2.828	7.633	1.733	49.433	11.767	36.333
CO-2	(V_6)	11.733	11.597	6.943	30.367	3.228	10.200	2.033	50.200	13.567	34.667
Culture-1	(V_7)	7.903	9.730	6.620	18.567	3.272	7.133	1.667	47.900	9.867	33.000
Philippines	(V_8)	12.580	11.537	8.960	16.933	5.508	5.533	1.033	69.067	11.567	39.667
EC-1653	(V_9)	10.523	13.337	10.253	12.767	5.767	5.400	0.667	60.033	10.600	40.000
T-44	(V_{10})	8.937	10.960	6.577	18.400	2.918	6.467	1.300	42.200	9.767	36.667
NP-36	(V_{11})	11.563	10.303	8.140	19.700	4.990	6.467	1.200	58.733	8.533	34.667
NP-40	(V_{12})	9.783	10.920	7.810	16.433	4.950	5.800	1.333	49.367	8.233	37.000
P.S.10	(V_{13})	11.333	11.670	7.453	21.867	3.343	7.500	1.500	46.733	14.533	40.667
S-8	(V_{14})	10.137	11.743	7.223	23.233	2.790	7.533	1.867	49.500	13.167	33.667
PIMS-1	(V_{15})	10.077	10.671	7.237	18.833	3.387	6.067	1.300	41.433	9.733	36.333
Critical difference		3.032	0.757	0.528	5.537	0.652	2.033	1.015	5.663	3.839	2.245

FIG: 1 MEAN VALUES FOR YIELD PER PLANT IN 15 VARIETIES OF GREENGRAM

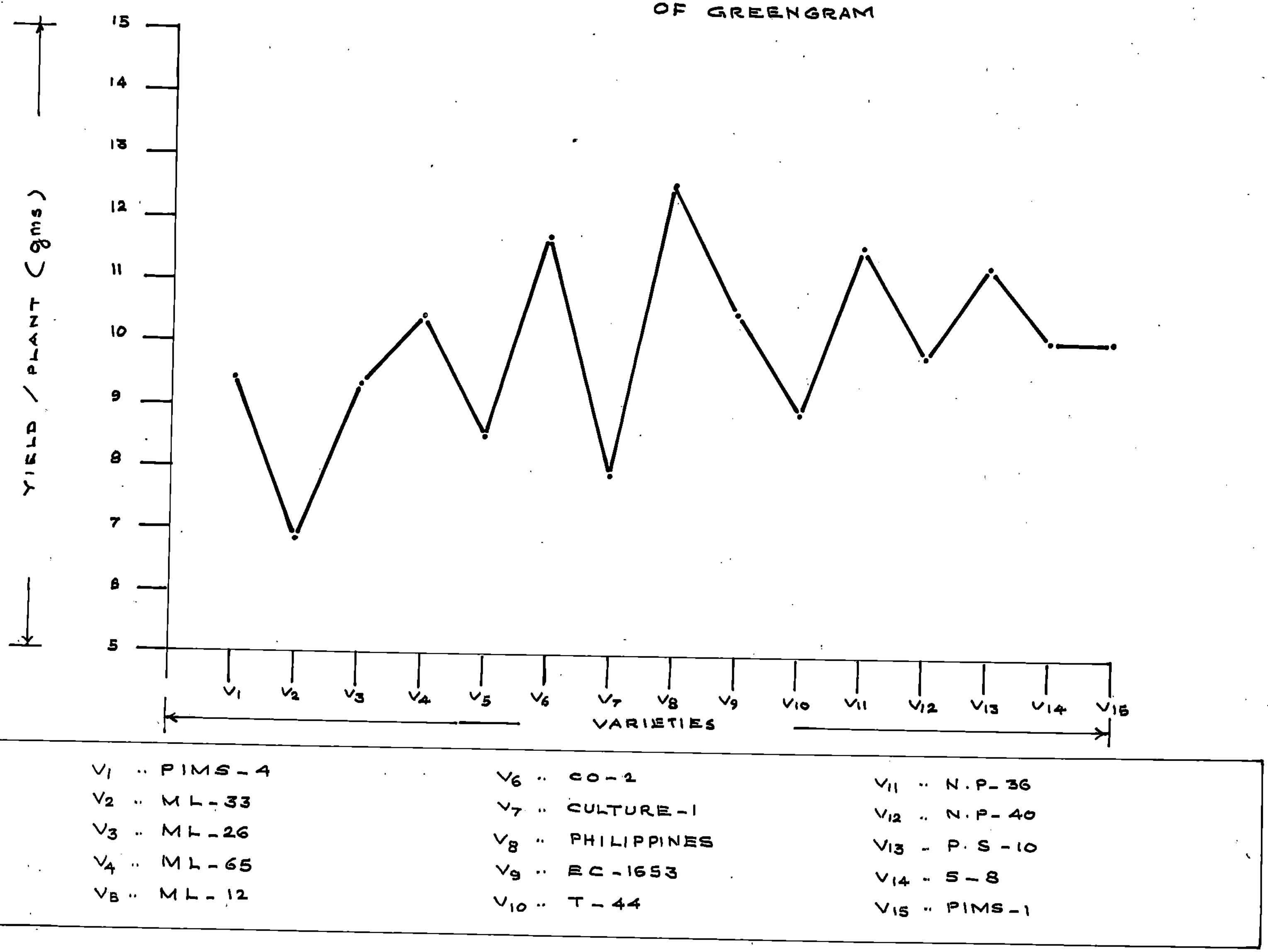
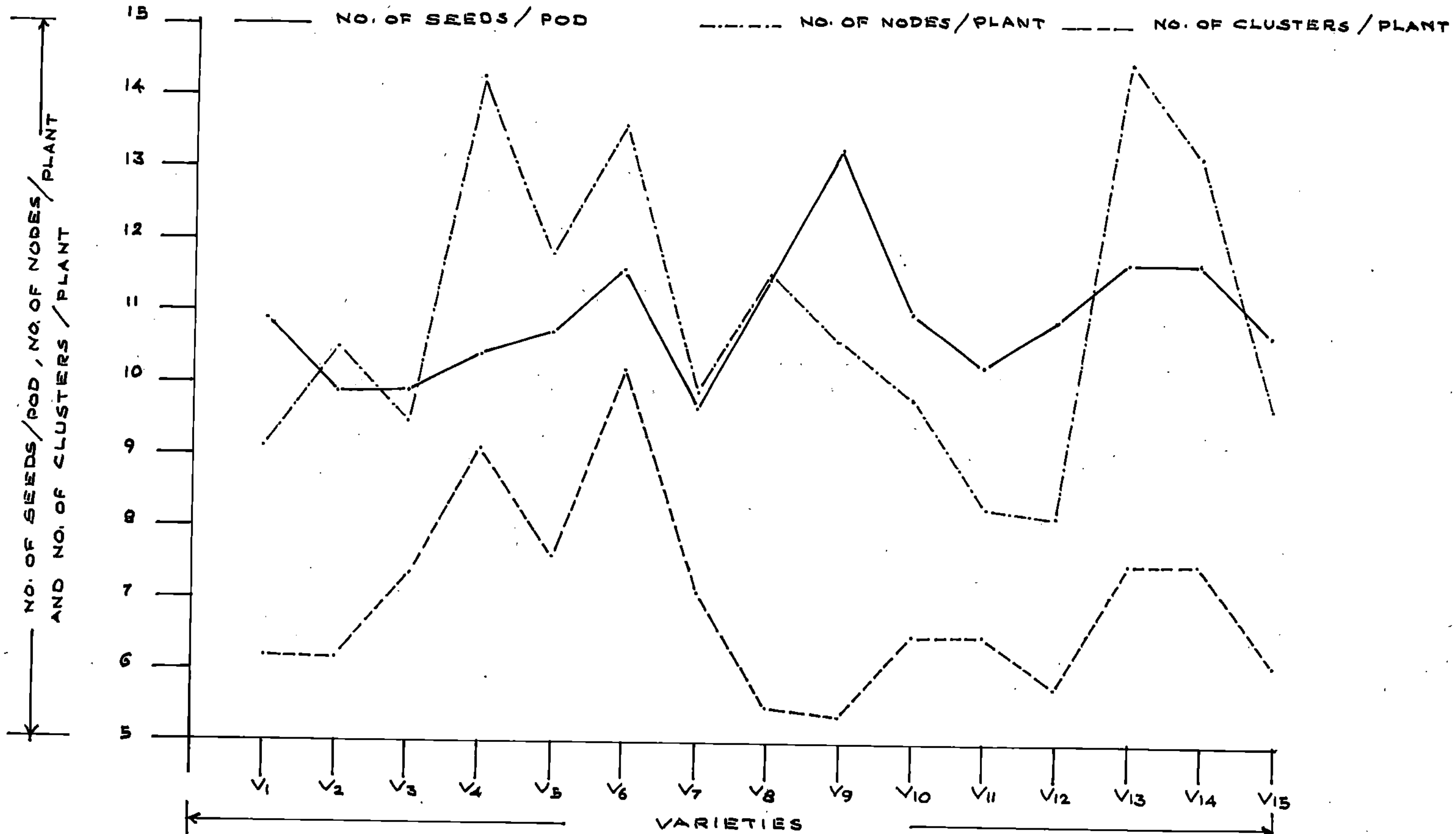


FIG: 2 MEAN VALUES FOR NUMBER OF SEEDS PER POD, NUMBER OF CLUSTERS PER PLANT AND NUMBER OF NODES PER PLANT IN 15 VARIETIES OF GREENGRAM



V1 .. PIMS-4	V6 .. CO-2	V11 .. N.P-36
V2 .. ML-33	V7 .. CULTURE-1.	V12 .. N.P-40
V3 .. ML-26	V8 .. PHILIPPINES.	V13 .. P.S-10
V4 .. ML-65	V9 .. EC.1653	V14 .. S-8
V5 .. ML-12	V10 .. T-44	V15 .. PIMS-1

FIG: 3 MEAN VALUES FOR POD LENGTH IN 15 VARIETIES OF GREENGRAM

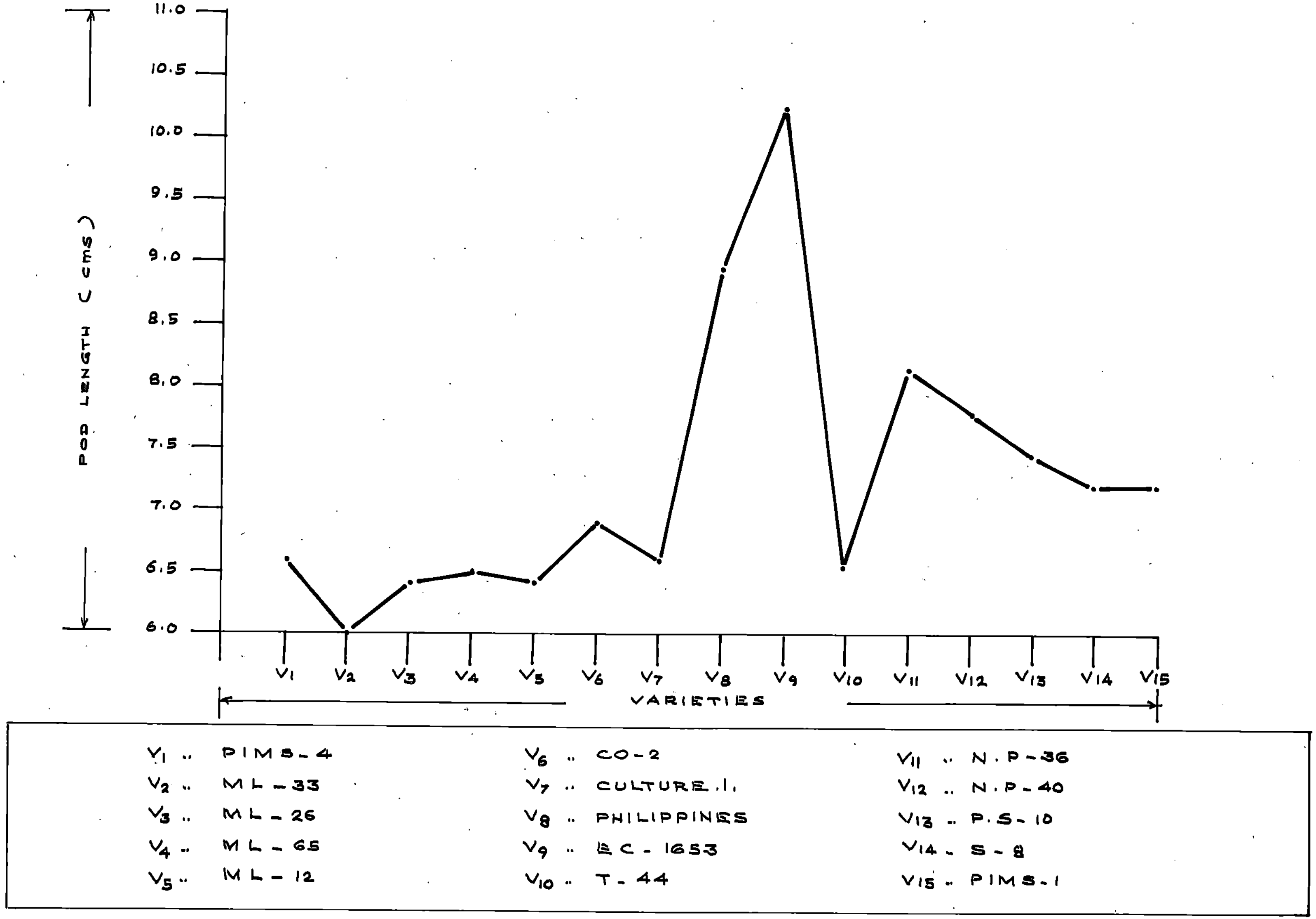
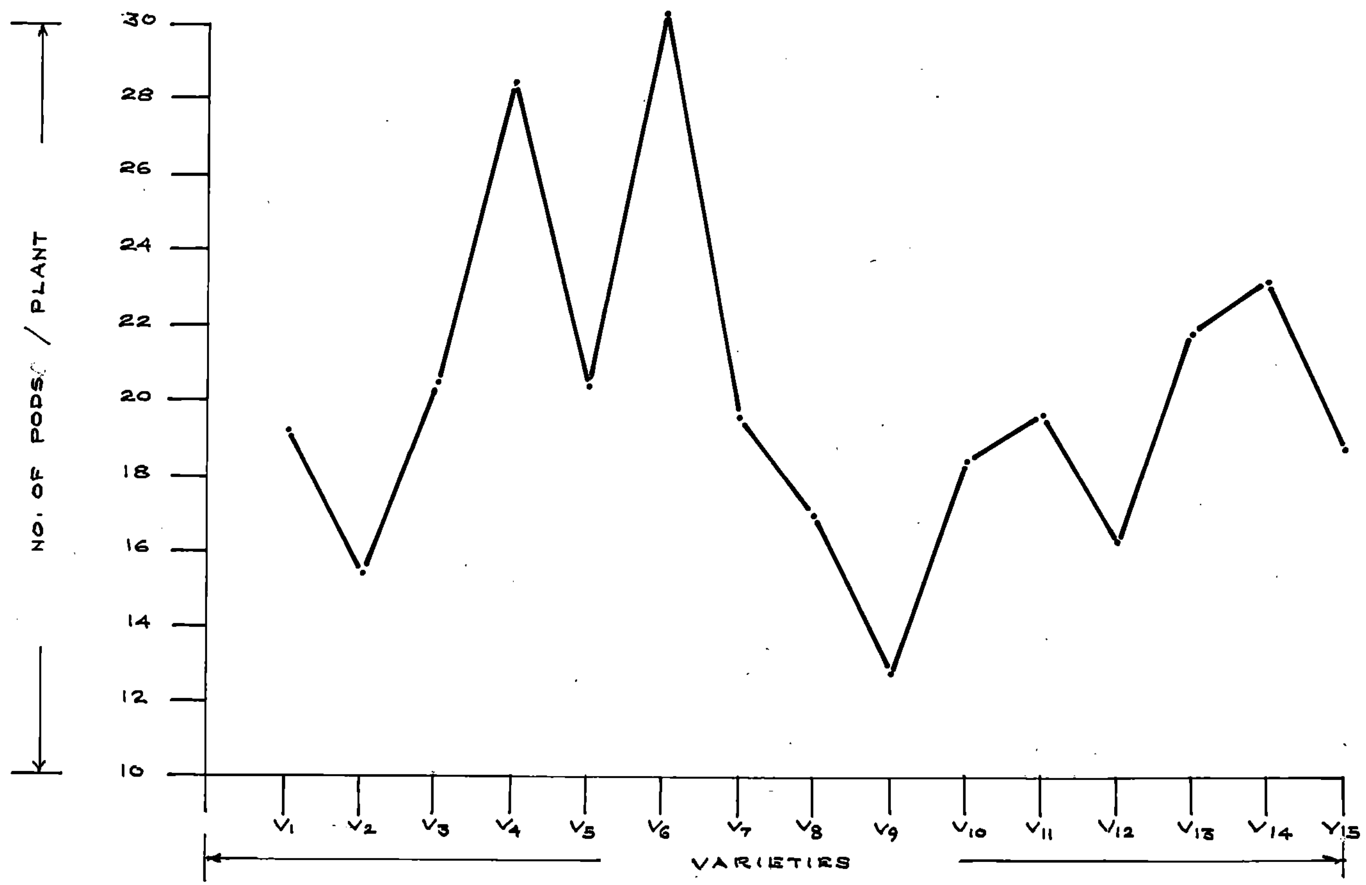


FIG: 4. MEAN VALUES FOR NUMBER OF PODS PER PLANT IN 15 VARIETIES OF GREENGRAM



V1	..	PIMS-4	V6	..	CO-2	V11	..	N.P-36
V2	..	ML-33	V7	..	CULTURE-1	V12	..	NP-40
V3	..	ML-26	V8	..	PHILIPPINES	V13	..	P.S-10
V4	..	ML-65	V9	..	EC-1653	V14	..	S-8
V5	..	ML-12	V10	..	T-44	V15	..	PIMS-1

FIG: 5. MEAN VALUES FOR 100 SEED WEIGHT IN 15 VARIETIES OF GREENGRAM

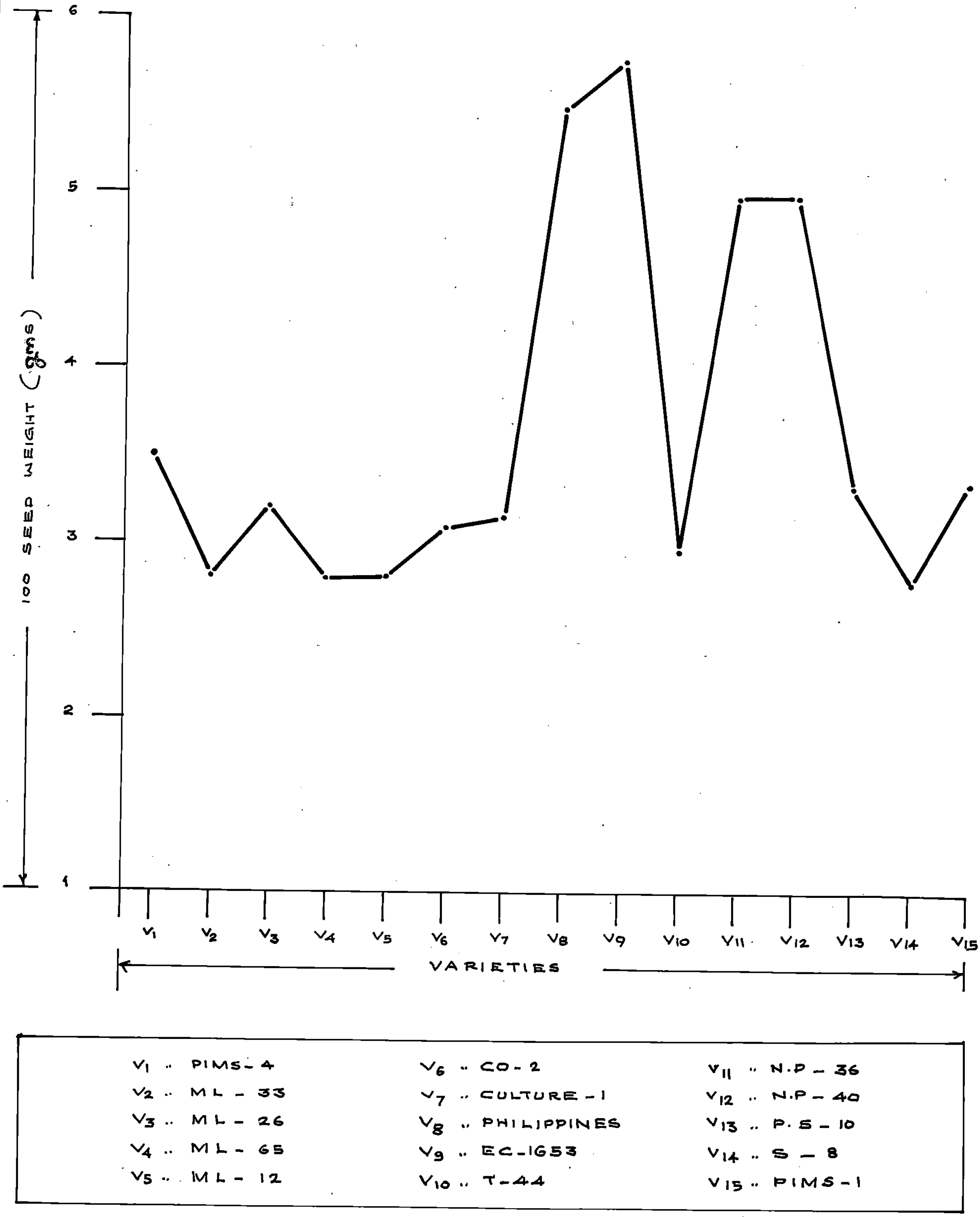
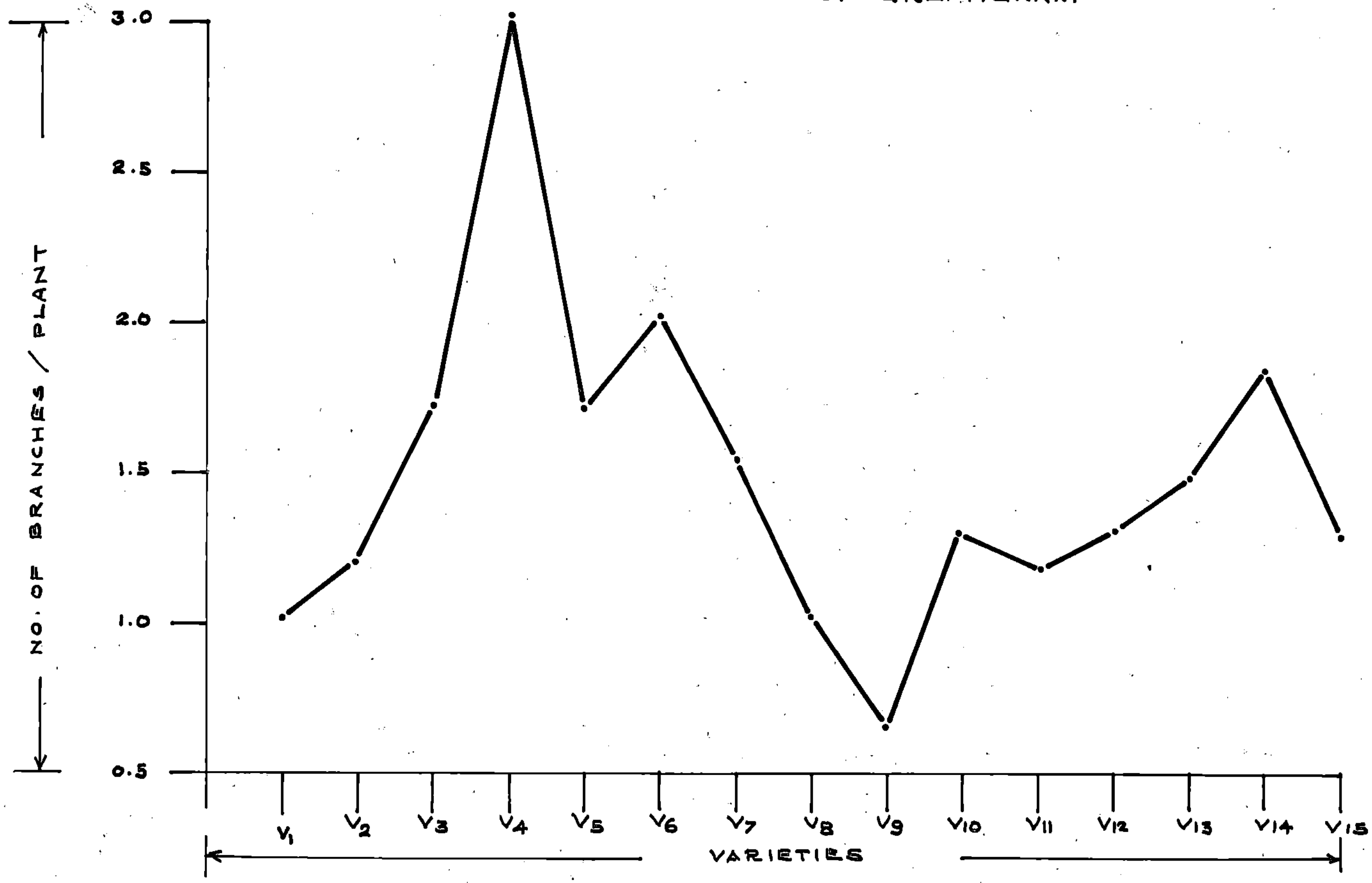


FIG: 6. MEAN VALUES FOR NUMBER OF BRANCHES PER PLANT IN 15 VARIETIES OF GREENGRAM



V_1 .. PIMS - 4	V_6 .. CO - 2	V_{11} .. N.P. - 36
V_2 .. ML - 33	V_7 .. CULTURE - 1.	V_{12} .. N.P. - 40
V_3 .. ML - 26	V_8 .. PHILIPPINES	V_{13} .. P.S - 10
V_4 .. ML - 65	V_9 .. EC. 1653	V_{14} .. S - 8
V_5 .. ML - 12	V_{10} .. T. 44	V_{15} .. PIMS - 1.

FIG : 7. MEAN VALUES FOR PLANT HEIGHT IN 15 VARIETIES OF GREENGRAM

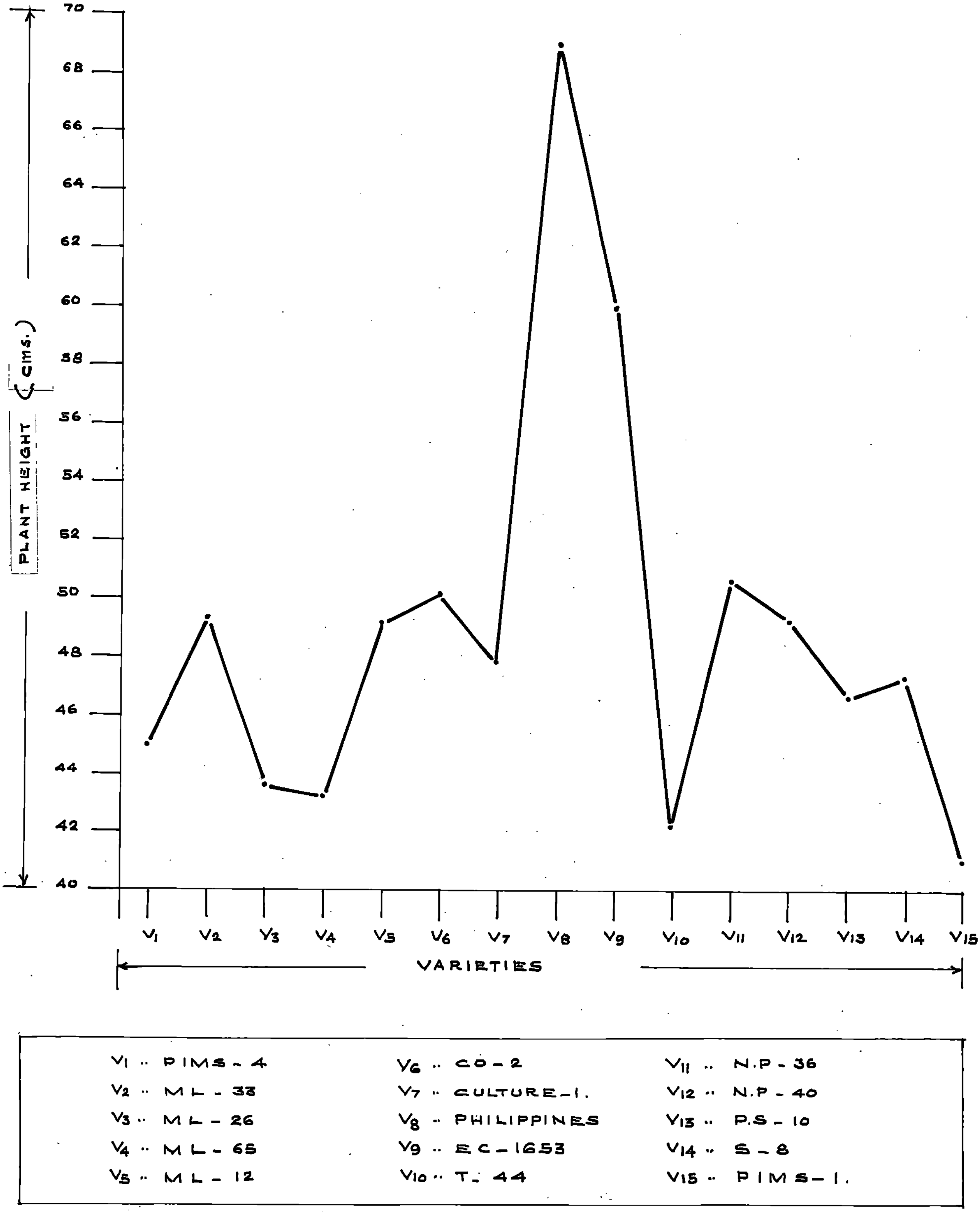
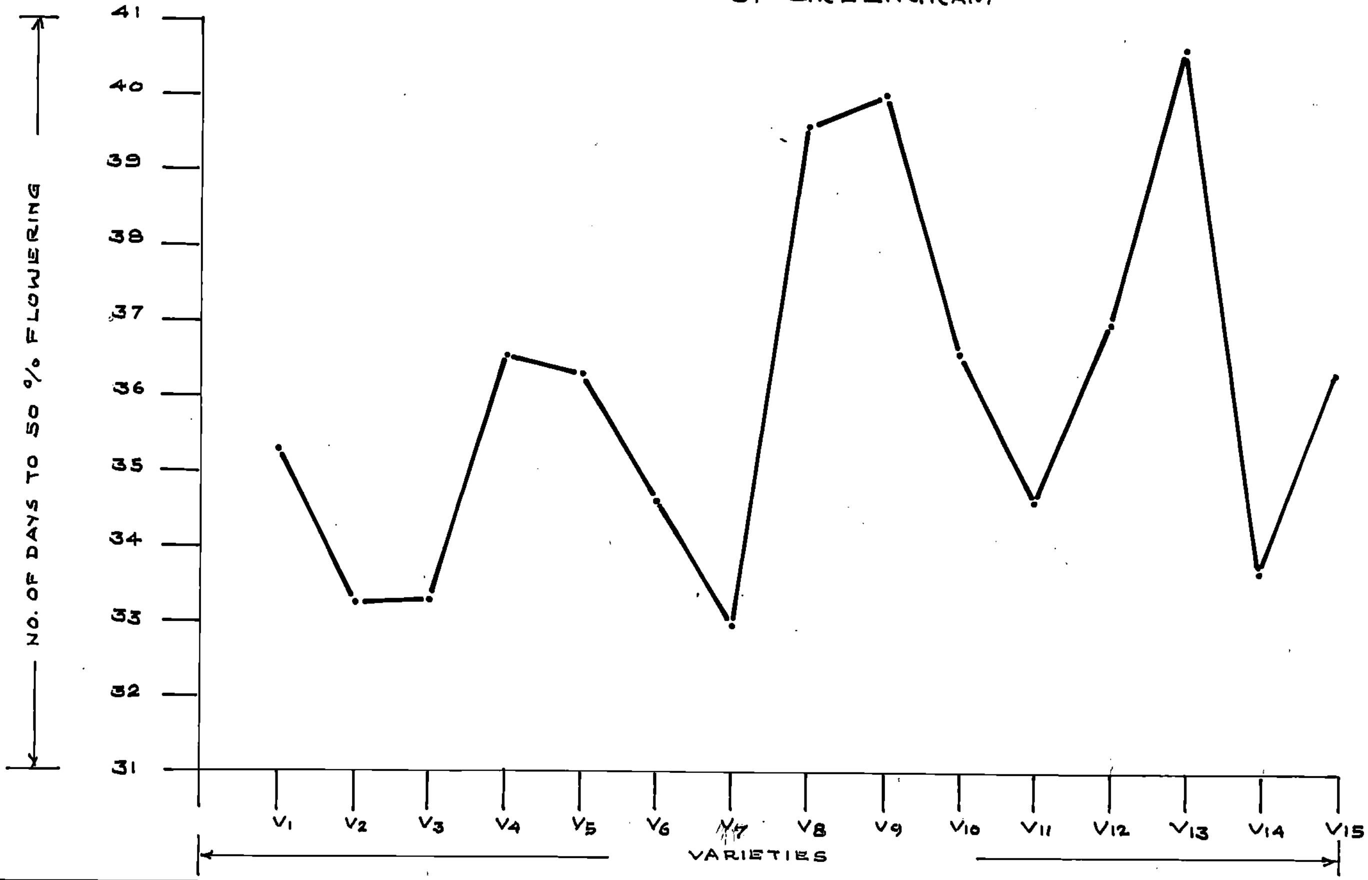


FIG: 8. MEAN VALUES FOR NUMBER OF DAYS TO 50 % FLOWERING IN 15 VARIETIES OF GREENGRAM



V_1 .. PIMS - 4	V_6 .. CO.2	V_{11} .. N.P - 36
V_2 .. ML - 33	V_7 .. CULTURE - 1	V_{12} .. N.P - 40
V_3 .. ML - 26	V_8 .. PHILIPPINES	V_{13} .. P.S - 10
V_4 .. ML - 65	V_9 .. EC - 1683	V_{14} .. S - 8
V_5 .. ML - 12	V_{10} .. T - 44	V_{15} .. PIMS - 1

Table 4

The range and the general mean for ten characters in 15 cultivars of green gram

Character	Range		General mean
	Minimum	Maximum	
1. Yield per plant (gm)	6.717	12.580	9.926
2. Number of seeds per pod	9.730	13.337	10.960
3. Pod length (cm)	6.020	10.253	7.281
4. Number of pods per plant	12.767	30.367	20.058
5. 100 seed weight (gm)	2.790	5.767	3.684
6. Number of clusters per plant	5.400	10.200	6.978
7. Number of branches per plant	0.667	3.033	1.502
8. Plant height (cm)	41.133	69.067	49.018
9. Number of nodes per plant	8.233	14.533	10.969
10. Days to 50% flowering	33.000	40.667	36.089

From the Table 4 it is clear that the magnitude of range between the minimum and maximum values in respect of each character as compared against the mean, varied to different degrees from variable to variable. So the relative magnitude was assessed on the basis of the following relationship.

$$\text{Relative magnitude} = \frac{\text{Range}}{\text{Mean}} \times 100$$

The relative magnitude of variability thus computed is presented in Table 5.

Table 5

Relative magnitude of variability for 10 characters in 15 cultivars of green gram

Character	Relative magnitude of variability(%)
1. Yield per plant	59.06
2. Number of seeds per pod	32.91
3. Pod length	58.15
4. Number of pods per plant	67.74
5. 100 seed weight	80.80
6. Number of clusters per plant	68.78
7. Number of branches per plant	157.52
8. Plant height	56.98
9. Number of nodes per plant	57.43
10. Days to 50% flowering	21.24

This shows that the magnitude of range was maximum for number of branches per plant (157.52%) and minimum for days to 50 per cent flowering (21.24%).

Table 6 contains the estimates of phenotypic variances, genotypic variances and environmental variances.

Table 6

Variances for 10 characters in 15 cultivars of green gram

Character	Pheno-typic variance	Geno-typic variance	Environ-mental variance
1. Yield per plant	4.599	1.311	3.288
2. Number of seeds per pod	1.008	0.803	0.205
3. Pod length	1.341	1.242	0.099
4. Number of pods per plant	28.645	17.483	11.162
5. 100 seed weight	1.212	1.060	0.012
6. Number of clusters per plant	2.735	1.256	1.479
7. Number of branches per plant	0.553	0.184	0.369
8. Plant height	59.509	48.040	11.469
9. Number of nodes per plant	7.873	2.602	5.271
10. Days to 50% flowering	7.337	5.534	1.803

Phenotypic and genotypic coefficients of variation for the different characters in 15 cultivars of green gram are furnished in Table 7 and Fig.9.

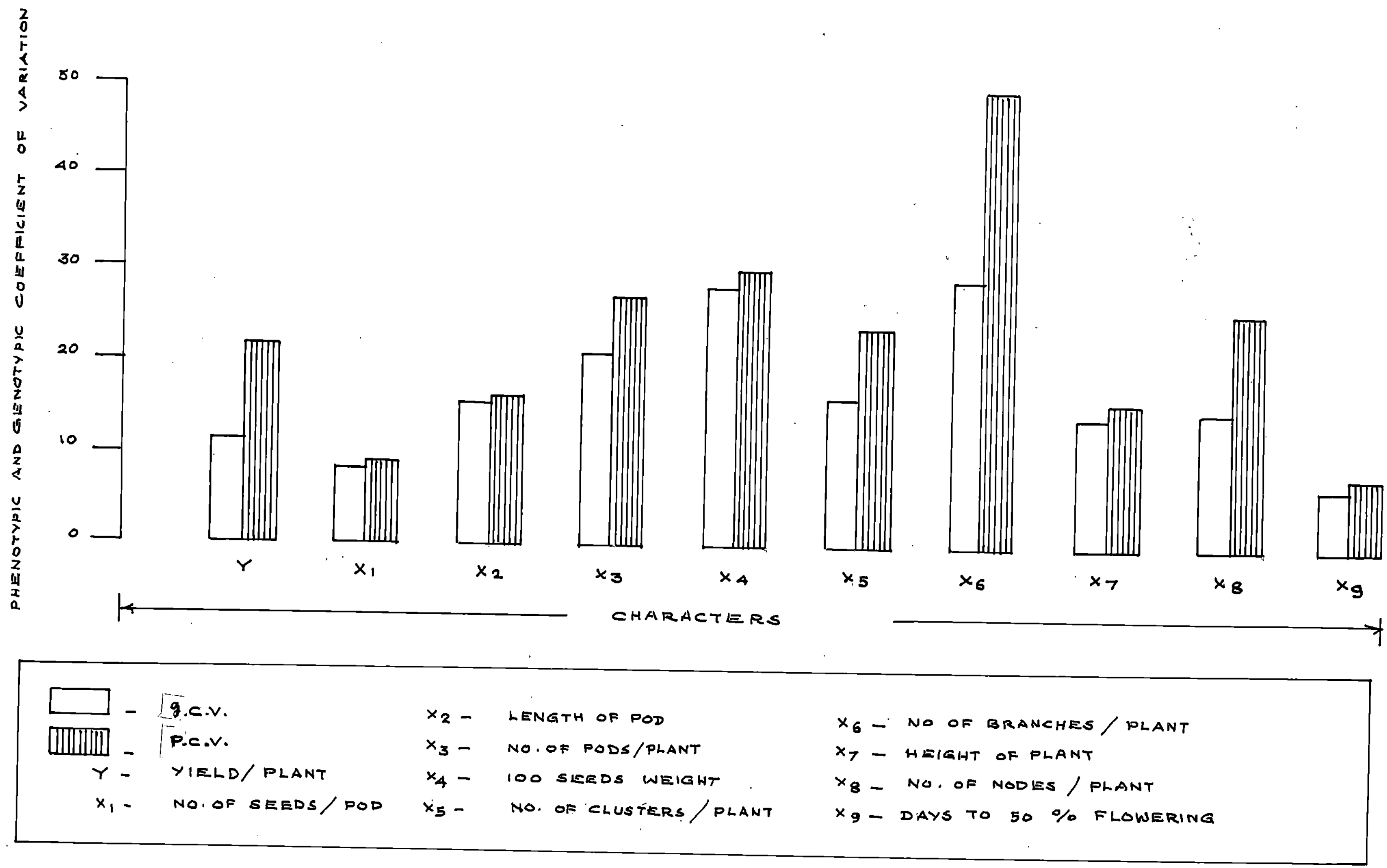
Table 7

Phenotypic and genotypic coefficients of variation for 10 characters in 15 cultivars of green gram

Character	Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)
1. Yield per plant	21.605	11.530
2. Number of seeds per pod	9.160	8.177
3. Pod length	15.906	15.305
4. Number of pods per plant	26.683	20.845
5. 100 seed weight	29.890	27.950
6. Number of clusters per plant	23.714	16.071
7. Number of branches per plant	49.501	28.578
8. Plant height	15.738	14.140
9. Number of nodes per plant	25.580	14.705
10. Days to 50% flowering	7.505	6.517

Genotypic coefficient of variation was the highest for number of branches per plant (28.578) followed by 100 seed weight (27.950). The lowest value was expressed by days to 50% flowering (6.517).

FIG: 9. PHENOTYPIC AND GENOTYPIC COEFFICIENTS OF VARIATION OF TEN CHARACTERS IN GREENGRAM



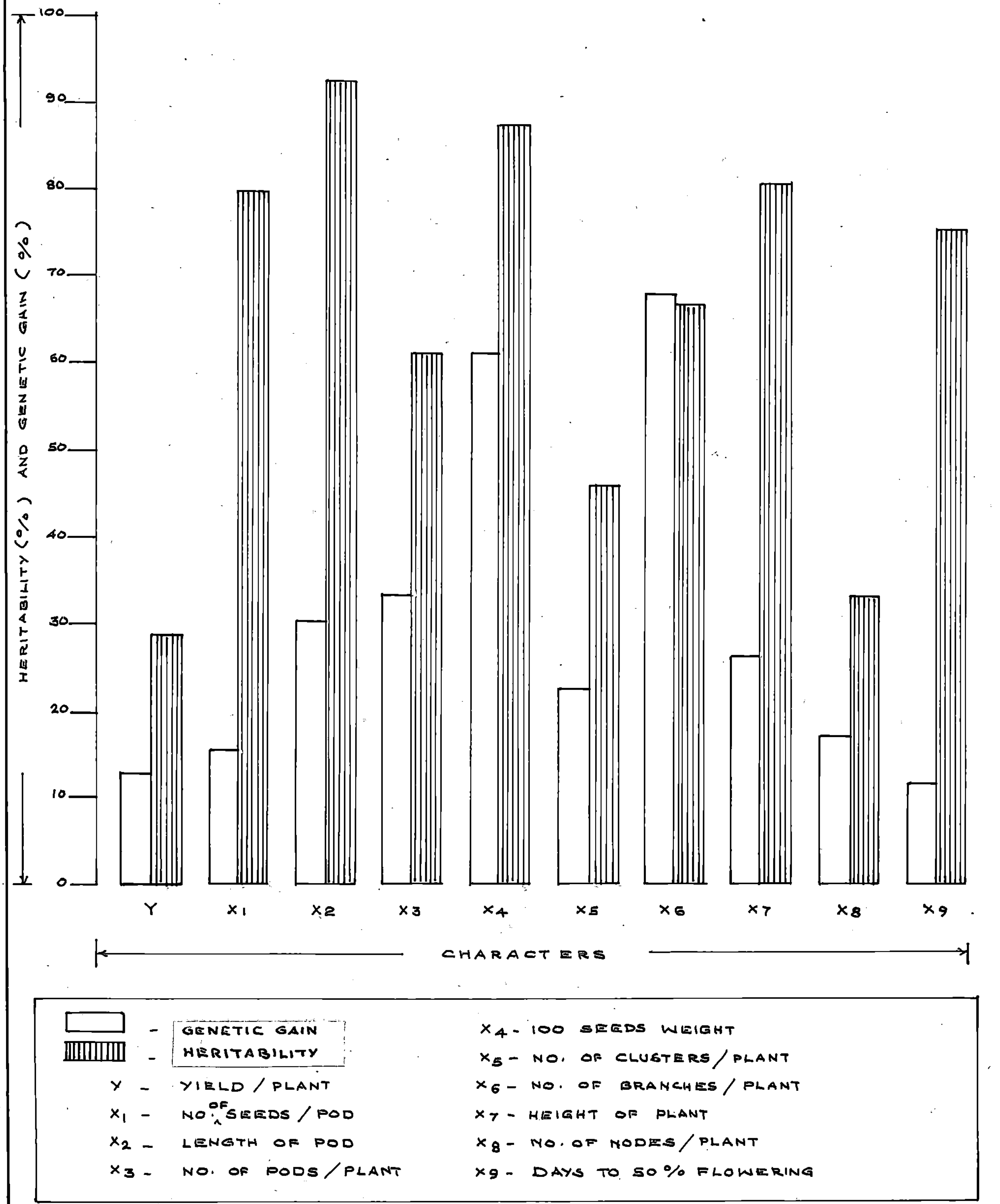
Heritability, genetic advance and genetic gain are presented in Table 8 and Fig.10. From the Table it is evident that the maximum heritability value was recorded by length of pod (92.56%) and minimum by yield per plant (28.5%). Genetic gain was maximum for number of branches per plant (67.98%) and minimum for days to 50 per cent flowering (11.66%).

Table 8

Heritability (h^2), genetic advance (GA) and genetic gain (GG) for 10 characters in 15 cultivars of green gram

Character	Heritability (%)	Genetic advance	Genetic gain (%)
1. Yield per plant	28.50	1.259	12.69
2. Number of seeds per pod	79.69	1.648	15.04
3. Pod length	92.56	2.208	30.33
4. Number of pods per plant	61.03	6.729	33.55
5. 100 seed weight	87.46	2.245	60.90
6. Number of clusters per plant	45.93	1.564	22.44
7. Number of branches per plant	66.67	1.021	67.98
8. Plant height	80.73	12.827	26.17
9. Number of nodes per plant	33.04	1.910	17.41
10. Days to 50% flowering	75.42	4.028	11.66

FIG: 10. HERITABILITY AND GENETIC GAIN FOR TEN CHARACTERS IN GREENGRAM



The covariance analysis was done for all possible combinations of characters. The genotypic covariance components were computed in the same way as the variance components. The correlation coefficients between all possible combinations of the 10 characters were worked out at genotypic level from the genotypic covariances (Table 9). The maximum positive association was found between number of pods per plant and number of clusters per plant (0.8947) followed by length of pod and 100 seed weight (0.6721). The weakest however was between plant height and number of nodes per plant (0.0957). Yield showed significant positive correlations with all characters except days to 50% flowering and number of branches per plant. The genotypic relationship between yield and its components are diagramatically represented in Fig.11.

Path coefficient analysis was undertaken 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 coefficients into direct and indirect effects. The direct and indirect effects of various characters on yield are shown in Table 10. The cause effect relationship brought out by path coefficient analysis is represented in Fig.12.

Table 9. Genotypic correlation coefficients among 10 characters in 15 cultivars of green gram

Character	Yield per plant (y)	No.of seeds per pod (x_1)	Pod length (x_2)	No.of pods per plant (x_3)	100seed weight (x_4)	No.of clusters per plant (x_5)	No.of branches per plant (x_6)	Plant height (x_7)	No.of nodes per plant (x_8)	Days to 50% flowering (x_9)
Yield per plant (y)	1	0.40524*	0.48045*	0.49371**	0.43063*	0.41221*	0.30661	0.38447*	0.50029**	0.34019
No.of seeds per plant(x_1)	..	1	0.71526**	-0.05502	0.44826*	-0.06446	-0.20560	0.45696*	0.24025	0.58013**
Pod length (x_2)	..	..	1	-0.31545	0.87209**	-0.32814	-0.35131	0.64[illegible]**	-0.05219	0.97149**
No.of pods per plant (x_3)	..	..	..	1	-0.42847*	0.89475**	0.74765**	-0.21497	0.67655**	-0.20218
100 seed weight (x_4)	..	..	..	..	1	-0.42639*	-0.38016*	0.63019**	-0.26448	0.46788*
No.of clusters per plant (x_5)	..	..	..	..	..	1	0.81827**	-0.17369	0.78777**	-0.23413
No.of branches per plant (x_6)	..	..	..	..	..	..	1	-0.[illegible]	0.67603**	-0.24084
Plant height(x_7)	..	..	..	..	..	..	..	1 1	0.09573	0.45224*
No.of nodes per plant (x_8)	..	..	..	..	..	..	..	..	1	0.12467
Days to 50 per cent flowering(x_9)	..	..	..	..	..	..	..	..	..	1

* Significant at 5 per cent level

** Significant at 1 per cent level.

Fig. 11

y	=	Yield per plant
x_1	=	Number of seeds per pod
x_2	=	Pod length
x_3	=	Number of pods per plant
x_4	=	100 seed weight
x_5	=	Number of clusters per plant
x_6	=	Number of branches per plant
x_7	=	Plant height
x_8	=	Number of nodes per plant
x_9	=	Days to 50 per cent flowering

FIG: 11. CORRELATION DIAGRAM OF YIELD AND IT'S COMPONENTS IN GREENGRAM

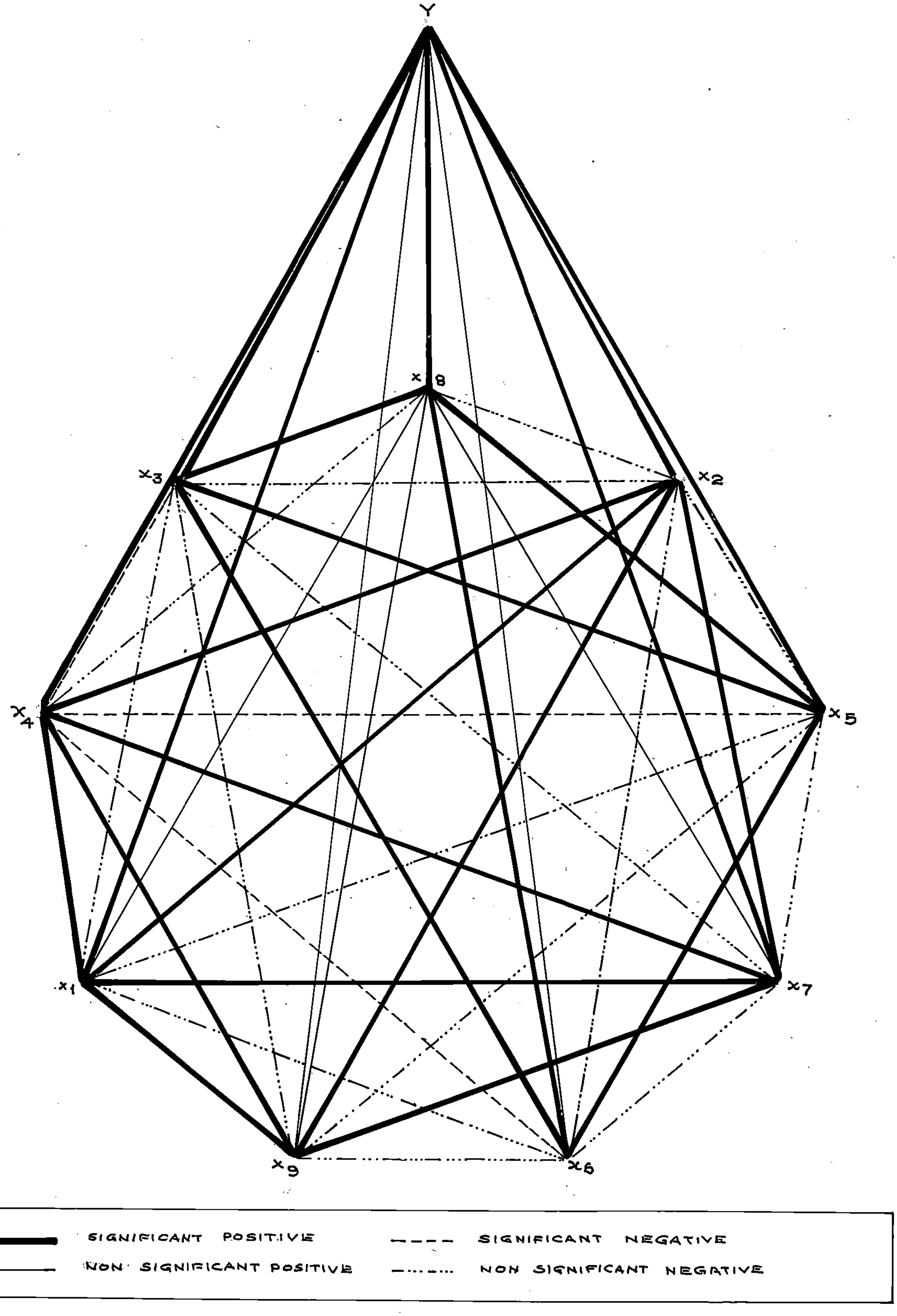


Table 10. Direct and indirect effect of various characters on yield in green gram

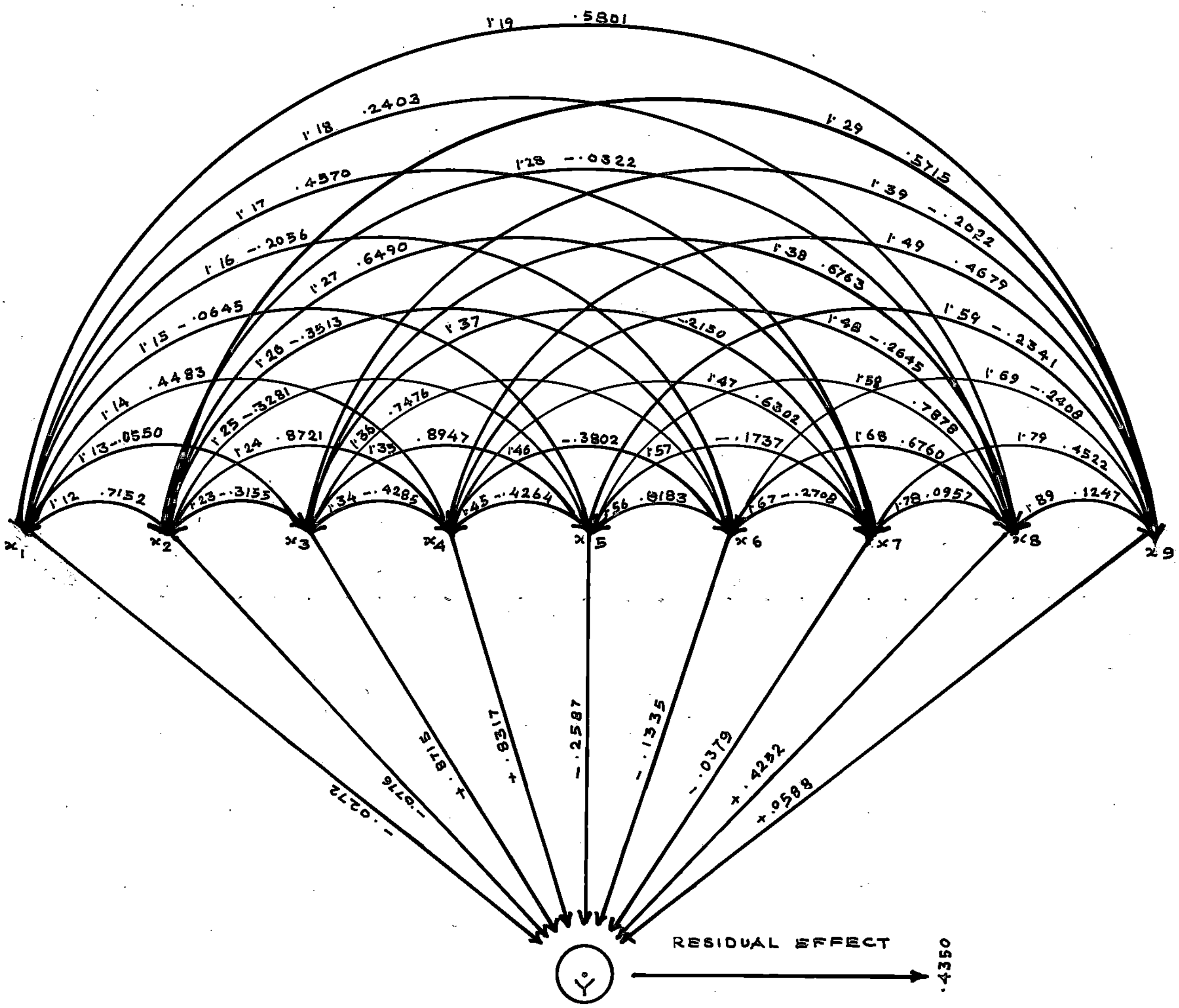
Character	No.of seeds per pod (x_1)	Pod length (x_2)	No.of pods per plant (x_3)	100 seed weight (x_4)	No.of clusters per plant (x_5)	No.of branches per plant (x_6)	Plant height (x_7)	No.of nodes per plant (x_8)	Days to 50% flowering (x_9)	Total corre-lation
No.of seeds per pod (x_1)	-0.02719	-0.05545	-0.04795	0.37280	0.01667	0.02745	-0.01732	0.10215	0.03411	0.40524
Pod length(x_2)	-0.01945	-0.07758	-0.27492	0.72529	0.08488	0.04691	-0.02459	-0.01368	0.03359	0.48045
No.of pods per plant (x_3)	0.02447	0.00149	0.87154	-0.35635	-0.25144	-0.09985	0.00665	0.28756	-0.01188	0.49571
100 seed weight (x_4)	-0.01219	-0.06766	-0.37342	0.83167	0.11029	0.05076	-0.02500	-0.11245	0.02751	0.43063
No.of clusters per plant(x_5)	0.00175	0.02545	0.77979	-0.35461	-0.25867	-0.10926	0.00658	0.33494	-0.01376	0.41221
No.of branches per plant (x_6)	0.00559	0.02725	0.65159	-0.31616	-0.21166	-0.13353	0.01026	0.28743	-0.01416	0.30661
Plant height (x_7)	-0.01242	-0.05034	-0.18735	0.52411	0.04492	0.03616	-0.03790	0.04070	0.02659	0.38477
No.of nodes per plant (x_8)	-0.00653	0.00250	0.58944	-0.21996	-0.20377	-0.09027	-0.00562	0.42518	0.00732	0.50029
Days to 50 per cent flowering (x_9)	-0.01377	-0.04433	-0.17620	0.38912	0.06056	-003216	-0.01715	0.05301	0.05879	0.34017

Residual effect: 0.4350

Fig. 12

Unidirectional arrows indicate the direct path coefficients and bi-directional arrows indicate the correlation coefficients.

FIG: 12. PATH DIAGRAM SHOWING DIRECT EFFECTS AND GENOTYPIC CORRELATIONS IN GREENGRAM



Y - YIELD / PLANT	x_5 - NO. OF CLUSTERS / PLANT
x_1 - NO. OF SEEDS / POD	x_6 - NO OF BRANCHES / PLANT
x_2 - LENGTH OF POD	x_7 - HEIGHT OF PLANT
x_3 - NO. OF PODS / PLANT	x_8 - NO. OF NODES / PLANT
x_4 - 100 SEEDS WEIGHT	x_9 - DAYS TO 50 % FLOWERING

From the Table it is clear that the direct effect on yield was highest for pods per plant (0.87154) followed by 100 seed weight (0.83167) and number of nodes per plant (0.42518). The residual effect works out to be 0.435.

DISCUSSION

DISCUSSION

The prime objective of plant breeding is to pick up desirable genotypes. The genetic improvement of a crop depends on the genetic variability present in it. Proper evaluation of the extent of genetic variation available for yield and yield attributes, their heritability values and genetic advance that could be effected will be of immense help to the breeders.

Yield is a very complex character and is a function of the component characters and environment. In the integrated structure of a plant most of the characters are inter-related and often, a change in one influence the other. In a planned hybridisation programme for evolving a new variety with increased yield, a complete knowledge of the inter-relationships in the quantitative characters of a particular crop is necessary. The present study was hence taken upto estimate some of the basic parameters of quantitative variability in green gram.

Fifteen distinct varieties of green gram constituted the material for the present investigation. Analysis of variance of the data revealed significant differences among the varieties in respect of all the characters.

A. Mean and range

A comparison of the 15 populations for different characters showed that they showed considerable variability for different characters (Table 2). This suggests the possibility of combining yield and other desirable qualities in a cultivar by hybridisation and selection.

Yield per plant (gm.)

Among the different varieties studied, variety Philippines gave the highest yield per plant (12.58 gm.), followed by Co-2 (11.73 gm.). The lowest yielder was ML-33 (6.72 gm.).

Number of seeds per pod

Variety B.G.1653 produced maximum number of seeds per pod (13.33) closely followed by S-8 (11.74). The lowest number of seeds per pod was recorded by Culture-1 (9.73).

Pod length (cm.)

The pods of B.G.1653 were the longest (10.25 cm.). The smallest pods were produced by ML-33 (6.02 cm.).

Number of pods per plant

Maximum number of pods were produced by Co-2 (30.36) and minimum by E.C.1653 (12.76).

100 seed weight

The highest value for 100 seed weight was shown by E.C.1653 (5.76 gm) and the lowest by ML-53 (2.79 gm) and S-8

Number of clusters per plant

Co-2 produced the highest number of clusters (10.2) followed by ML-65 (9.06) and the lowest by E.C.1653 (5.40).

Number of branches per plant

ML-65 produced maximum number of branches (3.033) followed by Co-2 (2.030). The lowest value was recorded by E.C.1653 (0.667).

Plant height (cm)

Among the varieties studied, variety Philippines was the tallest (69.07) and PIMS-1 was the shortest (41.13).

Number of nodes per plant

P.S. 10 had the maximum number of nodes per plant (14.53) and N.P.40 had the minimum (8.23).

Days to 50 per cent flowering

P.S.10(40.67) exhibited maximum number of days to 50 per cent flowering while the minimum was recorded by Culture-1 (33.00).

Genetic improvement of a crop depends on the variability present in the population. Mean and range are the basic estimates of variability. A wide range of variability was noticed for characters like number of branches per plant, number of pods per plant, 100 seed weight and number of clusters per plant. The range of variation for yield was also promising. The range of variability was the lowest for days to 50 per cent flowering. Thus the material studied in green gram points out the possibility of bringing about genetic improvement using traditional breeding methods.

D. Variance and coefficient of variation

These are also measures of variability of a population. Phenotypic variability cannot be utilised for variety 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, days to 50 per cent flowering and plant height. In cowpea, a similar minor difference between phenotypic and genotypic variances for plant height, pod length and 100 seed weight was reported by Lakshmi and Goud (1977). On the other hand, the characters, yield per plant, number of nodes per plant, number of branches and pods per plant and number of clusters per plant showed a wide difference between phenotypic and genotypic variances. Lakshmi and Goud (1977) made similar observations in cowpea.

Only very small differences between phenotypic and genotypic variances were observed in the characters viz., 100 seed weight, pod length, days to 50 per cent flowering and plant height. These indicate that variations observed in those characters were mainly due to genetic causes and that environment had only a negligible influence on them.

Coefficient of variation is another means of expressing the amount of variability. In the present study, the genotypic and phenotypic coefficients of variation were high (above an arbitarily fixed limit of 20 per cent) for number of branches per plant, 100 seed weight and number of pods per plant.

High genotypic coefficient of variation for branches per plant as in the present investigation was observed in green gram by Veeraswamy et al.(1973), in black gram by Sagar et al.(1976) and in peas by Srivastava and Sachan (1974).

A high genotypic coefficient of variation in 100 seed weight as in the present study was noticed in green gram by Singh and Malhotra (1970) and Joshi and Kabaria (1973) and in soybean by Lal and Haque (1972). However, in horse gram only moderate genotypic coefficient of variation was reported by Shivashankar et al.(1977) for this character.

A similar high genotypic coefficient of variation for number of pods per plant was reported in green gram by Gupta and Singh (1969), Singh and Malhotra (1970), Joshi and Kabaria (1973) and Veeraswamy et al.(1973) and in black gram by Soundrapandian (1975). Moderate genotypic coefficient of variation for pods per plant was reported by Shivashankar et al.(1977) in horse gram and low value by Ram et al.(1976) in red gram.

High genotypic coefficients of variation observed for number of branches per plant, 100 seed weight and number of pods per plant suggest that a high degree of genetic variability for these characters, is present in the population and that this can be utilised for crop improvement.

The characters which showed only moderate genotypic coefficients of variation in the present study were (10-20 per cent) pod length, number of nodes per plant, plant height, number of clusters per plant and yield per plant.

The high genotypic coefficient of variation reported by Choudhury et al.(1971) in green gram is quite contrary to the result obtained in the present study for pod length.

Moderate genotypic coefficient of variation for number of nodes per plant as in the present case was obtained in horse gram by Shivashankar et al.(1977). Dut, Lal and Hague (1972) obtained a high genotypic coefficient of variation for number of nodes per plant in soybean.

Results obtained by Chowdhury et al.(1971) and Veeraswamy et al.(1973a) in green gram, Soundrapandian et al.(1975) in black gram, Shivashankar et al.(1977) in horse gram, Lal and Haque (1972) in soybean and Sinha et al.(1977) in cowpea are not in agreement with the moderate genotypic coefficient of variation for plant height in this study.

Moderate genotypic coefficient of variation observed in the present study for clusters per plant is quite contrary to the result reported by Veeraswamy et al.(1973a) in green gram.

A similar moderate genotypic coefficient of variation for yield was noticed in horse gram by Shivashankar et al.(1977). But the results obtained by Gupta and Singh (1969) in green gram and Lal and Haque (1972) in soybean are not in agreement with the present result.

Days to 50 per cent flowering and number of seeds per pod exhibited very low values (less than 10 per cent) of genotypic and phenotypic coefficients of variation.

A similar low genotypic coefficient of variation for days to flowering was reported in green gram by Singh and Malhotra (1970a) and Joshi and Kabaria (1973). But the high genotypic coefficient of variation obtained by Chowdhury et al.(1971) in green gram is quite contrary to the result obtained in this study.

This low genotypic coefficient of variation offers only very little scope to operate selection to these characters.

A high genotypic coefficient of variation is an indication of the fixable amount of variability that is present among the cultivars which can be used with advantage in future improvement programmes.

The present study also showed that number of branches per plant, number of nodes per plant, yield per plant, number of clusters per plant and number of pods per plant were much influenced by environment. This was indicated by their reduced genotypic coefficient of variation compared to phenotypic coefficient of variation.

A wide difference between genotypic and phenotypic coefficients of variation for pods per plant, and yield as in the present study was reported by Lakshmi and Goud (1977) in cowpea and Shivashankar et al.(1977) in horse gram. Similar difference for number of branches per plant was noticed by Sagar et al.(1977) in black gram and Setty et al.(1977) in gram.

In the present investigation, only little difference was observed between phenotypic and genotypic coefficients of variation for 100 seed weight, in plant height, days to 50 per cent flowering, pod length and number of seeds per pod. This implies that the major portion of the observed variability for these characters was due to real genetic differences. Similar observations were made by Lakshmi and Goud (1977) in cowpea for plant height, pod length and 100 seed weight. Sagar et al.(1976) in black gram reported significant difference between phenotypic and genotypic coefficients of variations for number of seeds per pod, pod length and 100 seed weight. Shivashankar et al.(1977) reported in horse gram a reduced genotypic coefficient of variation for plant height and pod length. These observations are not in agreement with the results obtained in the present investigation.

C. Heritability

The estimates of the heritable portion of variation are given by such genetic parameters as heritability, genetic advance and genetic gain. Burton (1952) had suggested that genotypic coefficient of variation together with heritability give the best picture of the amount of progress to be expected by selection.

In the present study, pod length showed maximum heritability (92.6 per cent) and yield per plant the minimum (28.5 per cent). High heritability values (more than 50 per cent Stansfield, 1969), were also shown by 100 seed weight, plant height, number of seeds per pod, days to 50 per cent flowering, number of branches per plant and number of pods per plant.

High heritability values for pod length, as obtained in the present study, has been reported also in green gram by Chowdhury et al.(1971), in black gram by Soundrapandian et al.(1975) and Goud et al.(1977) and in cowpea by Veeraswamy et al.(1973), Tikka et al.(1977) and Lakshmi and Goud (1977).

High heritability for 100 seed weight as noticed in this study had been reported in green gram by Singh and Malhotra (1970a) and Chowdhury et al.(1971), in cowpea by Lakshmi and Goud (1971), in horse gram by Shivashankar et al.(1977) and in gram by Setty et al.(1977).

However, moderate heritability reported by Veeraswamy et al.(1973) in green gram is contrary to the result obtained in this case.

High heritability values for plant height were obtained also in green gram by Chowdhury et al.(1971) and Veeraswamy et al.(1973), in black gram by Soundrapandian (1975) and Goud et al.(1977) and in cowpea by Lakshmi and Goud (1977).

Results obtained in green gram by Joshi and Kabaria (1973), in black gram by Sagar et al.(1976) and Goud et al.(1977) and in cowpea by Tikka et al.(1977) are in agreement with the high heritability value obtained for number of seeds per pod in the present investigation.

A similar high heritability as in this case for days to 50 per cent flowering had been noticed in green gram by Empig et al.(1970), Singh and Malhotra (1970) and Veeraswamy et al.(1973) and in black gram by Sagar et al.(1976).

A high heritability for number of branches per plant as in this study was obtained in green gram by Veeraswamy et al.(1973), in black gram by Sagar et al.(1976), in horse gram by Shivashankar et al.(1977), in red gram by Ram et al.(1976) and in pea by Srivastava and Sachan (1974).

Similarly a high heritability for number of pods per plant as in the present investigation was observed in green gram by Joshi and Kabaria (1973), in black gram by Sagar et al.(1976), in cowpea by Tikka et al.(1977) and in pea by Koranne and Singh (1974). But moderate heritability values were reported by Soundrapandian et al.(1975) in black gram and Lal and Haque (1972) in soybean.

High heritability values for these characters indicate that they are less influenced by environment and could be improved through selection based on phenotypic performance.

Characters like number of clusters per plant, number of nodes per plant and yield per plant had only moderate (20-50 per cent, Stansfield, 1969) heritability estimates in the present experiment.

In black gram, Soundrapandian et al.(1975) reported a similar medium heritability for number of clusters per plant. However, medium heritability values obtained in the present investigation are quite contrary to the high heritability value for number of clusters per plant noticed by Veeraswamy et al.(1973a) and low heritability value reported by Singh and Malhotra (1970a) in green gram.

In case of number of nodes per plant also the result obtained in the present study is not in agreement with the high heritability values reported by Shivashanker et al.(1977) in horse gram, Lal and Haque (1972) in soybean and low heritability estimate reported by Singh and Malhotra (1970a) in green gram.

The heritability for yield in the present study was moderate. In green gram Gupta and Singh (1969) reported a similar moderate heritability for yield. At the same time several others have obtained low heritability values for yield (Empig et al.(1970), Singh and Malhotra (1970a) and Veeraswamy et al.(1973a) in green gram, Goud et al.(1977) in black gram and Shivashanker et al.(1977) in horse gram).

At inter-varietal level, the range of variability for yield, the character which is given top priority, was promising. However, it recorded the minimum value for heritability. This confirms that this character is highly complex in nature and is profoundly influenced by both genic and non-genic factors.

D. Genetic gain

High heritability alone does not provide information about the amount of genetic progress that could result from selection. For this, genetic advance and genetic gain should also be considered along with heritability values. For instance, Johnson et al.(1955) found that heritability estimates along with genetic advance were more useful for selection work than heritability alone in soybean.

The genetic gain observed in the present study pointed out that, by selecting 5 per cent superior individuals, it would be possible to improve the number of branches per plant by 67.98 per cent, 100 seed weight by 60.90 per cent, number of pods per plant 33.55 per cent, pod length by 30.33 per cent, plant height by 26.17 per cent, number of clusters per plant by 22.44 per cent, number of nodes per plant by 17.41 per cent, yield per plant by 12.68 per cent and number of days to flowering by 11.66 per cent.

Genetic gain was maximum for number of branches per plant (67.98 per cent) followed by 100 seed weight (60.90 per cent) and minimum for days to 50 per cent flowering (11.66 per cent).

The characters exhibiting high genetic gain in the present experiment (above an arbiterily fixed limit of 30 per cent) were number of branches per plant, 100 seed weight, number of pods per plant and pod length.

A similar high genetic gain for number of branches per plant was reported in green gram by Veeraswamy et al. (1973), in black gram by Sagar et al.(1976) and in horse gram by Shivashanker et al.(1977).

Results obtained in green gram by Chowdhury et al.(1971) and in gram by Setty et al.(1977) are in agreement with the high genetic gain noticed for 100 seed weight in this experiment. But Veeraswamy e t al.(1973) in cowpea obtained only a low genetic gain for 100 seed weight.

A high genetic gain for number of pods per plant as obtained in the present study has also been noticed in green gram by Gupta and Singh (1969), Singh and Malhotra (1970a) and Veeraswamy et al.(1973a) and in black gram by Sagar et al.(1976).

Results obtained in black gram by Goud et al.(1977) and in cowpea by Veeraswamy et al.(1973c) are in agreement with the high genetic gain for pod length estimated in this study. But a low genetic gain for pod length was reported by Veeraswamy et al.(1973a) in green gram and Lakshmi and Goud (1977) in cowpea.

Moderate genetic gain (between 20 and 30 per cent) was recorded by plant height and number of clusters per plant, in this experiment.

A moderate genetic gain for plant height as in this case was reported in gram by Setty et al.(1977). But high values obtained by Veeraswamy et al.(1973a) in green gram is quite contrary to the present result.

The medium genetic gain obtained for number of clusters per plant in the present investigation is not in agreement with the high values reported by Veeraswamy et al.(1973a) in green gram and Ram et al.(1976) in red gram.

Days to 50 per cent flowering, yield per plant, number of seeds per pod and number of nodes per plant had low genetic gain (less than 10 per cent) in this experiment.

In soybean Kaw and Menon (1973) reported a similar low genetic gain for days to flowering. But Sagar et al.(1976) in black gram obtained a high genetic gain for days to 50 per cent flowering.

In green gram Gupta and Singh (1969) reported a similar low genetic gain for yield as in this experiment. But Singh and Malhotra (1970) in green gram Sagar et al. (1976) in black gram and Veeraswamy et al.(1973) in cowpea and Setty et al.(1977) in gram obtained high genetic gain for yield which is not in agreement with the present results. Yield, though it had only a low genetic gain, should not be over-looked under any circumstance, as it fluctuates with changes in the environmental factors.

Veeraswamy et al.(1973) in green gram and Takshmi and Goud (1977) in cowpea obtained a similar low genetic gain for number of seeds per pod. But a high genetic gain was reported by Goud et al.(1977) in black gram.

Low genetic gain for number of nodes per plant in the present experiment is not in agreement with the results noticed by Singh and Malhotra (1970) and Veeraswamy et al.(1973) in green gram and Lal and Haque (1972) in soybean.

Characters having high genetic gain as well as high heritability in the present experiment were number of branches per plant, 100 seed weight, number of pods per plant and pod length.

In black gram Sagar et al.(1976) observed a similar high genetic gain and heritability for number of branches per plant. However, the results reported by Gupta and Singh (1969) and Singh and Malhotra (1970) in green gram are contrary to the present findings.

In case of 100 seed weight a similar result was noticed in green gram by Singh and Malhotra (1970) and Chowdhury et al.(1971) and in gram by Setty et al.(1977). However, Lakshmi and Goud (1977) reported a high heritability but moderate genetic gain for 100 seed weight in cowpea.

High heritability and genetic gain in the case of pod length as in the present study was noticed in green gram by Gupta and Singh (1969) and Chowdhury et al.(1971), in black gram by Goud et al.(1977) and in cowpea by Veeraswamy et al.(1973). But the result obtained by Lakshmi and Goud (1977) in cowpea is not in agreement with that obtained in the present study.

A similar result for pods per plant as in the present case was observed in black gram by Sagar et al.(1976) and in gram by Joshi (1972) and Setty et al.(1977).

High genetic gain accompanied by high heritability in the case of above characters in the present investigation indicates the possibility of further amelioration of these characters through proper selection procedures. If high heritability is mainly due to additive gene action, then the genetic gain will be high (Panse, 1957).

Days to 50 per cent flowering had high heritability but only low genetic gain. Similar results were obtained in soybean by Kaw and Menon (1973). But the finding of Chowdhury et al.(1971) in green gram is contrary to the present results.

High heritability coupled with low genetic gain for days to 50 per cent flowering shows that selection has only limited scope for improving this trait. With reference to their work on soybean Johnson et al.(1955) had also pointed out that high heritability need not be accompanied by high genetic gain estimates. If high heritability is mainly due to non-additive gene action then the genetic gain will be low (Panse, 1957).

Characters which had high coefficient of variation had high genetic gain also. Number of branches per plant, 100 seed weight and number of pods per plant had high genetic gain and genotypic coefficient of variation. In addition, these characters had high heritability also. These characters also form components of yield. Hence, it would be advantageous for the breeders to formulate selection programme for high yielding strains in green gram on the basis of these characters.

In the case of number of branches, the trait can be modified by mechanical means like clipping, which is now a common practice in bengal gram. This increases the yield also.

B. Correlations

A number of interesting relationships can be observed from the genotypic correlation matrix (Table 7). At genotypic level, a fairly strong and positive correlation was found between yield and other components except number of branches and days to 50 per cent flowering.

A significant association between yield and number of nodes per plant as in the present study was found in soybean by Veeraswamy et al. (1973) and in horse gram by Shivashankar et al. (1977).

A significant positive correlation between pods per plant and yield was also reported in green gram by Singh and Malhotra (1970) and Joshi and Kabaria (1973), in soybean by Veeraswamy (1973) and in horse gram by Shivashankar et al. (1977).

A significant positive correlation between yield and pod length as observed in the present case had been reported in green gram by Singh and Malhotra (1970), in black gram Goud et al. (1977) and in horse gram by Agarwal and Kang (1976).

A similar high positive correlation between yield and 100 seed weight as in the present study was observed in gram by Joshi (1972). But Joshi and Kabaria (1973) and Singh and Malhotra (1970b) in green gram and Shivashankar et al.(1977) in horse gram obtained negative correlation between yield and 100 seed weight.

In green gram Singh and Malhotra (1970b) and Malhotra et al.(1974) and in pigeon pea Singh and Malhotra (1973) and Veeraswamy et al.(1973) noticed a similar significant association between yield and number of clusters per plant as in this case.

Similarly a positive and significant association between yield and seeds per pod was observed in green gram by Singh and Malhotra (1970b), Joshi and Kabaria (1973) and Malhotra et al.(1974) and in peas by Srivastava et al.(1972) as in the present study.

A similar significant association between yield and height of the plant as in the present study was noticed in black gram by Goud et al.(1977), in horse gram by Shivashankar et al.(1977) and in red gram by Veeraswamy et al.(1973).

In the case of days to flowering, Malhotra et al.(1974) in green gram and Veeraswamy et al.(1973) in soybean reported a strong positive correlation with yield. A strong negative correlation was reported by Singh et al.(1968) and Gupta and Singh (1969) in green gram and Shivashankar et al.(1977) in horse gram. But the association between yield and days to 50 per cent flowering was positive and non-significant in the present investigation.

Similarly the significant positive association between yield and number of branches per plant reported by Malhotra et al.(1974) in green gram, Shivashankar et al.(1977) in horse gram, and Veeraswamy et al.(1973) in soybean is not in agreement with the results of the present study where a positive but not significant association was observed.

A significant positive correlation was noticed between seeds per pod and 100 seed weight. However, Joshi and Kabaria (1973) in green gram obtained a negative association between these characters.

A strong and positive association was observed between number of nodes per plant and number of clusters per plant which agrees with the observations of Sengupta and Kataria (1971) in soybean.

Correlation between number of pods per plant and 100 seed weight was significantly negative. Similar results are obtained in green gram by Joshi and Kabaria (1973), in field beans by Kambal (1969) and in soybean by Sengupta and Kataria (1971).

A similar significant positive association between pods per plant and number of clusters per plant as in the present study was observed in green gram by Malhotra et al.(1974), in red gram by Singh and Malhotra (1973) and Veeraswamy et al.(1973).

A significant positive association was observed between number of pods per plant and number of branches, number of clusters and number of nodes per plant.

A negative non-significant association obtained in the present study between branches per plant and pod length is in confirmity with results reported in green gram by Singh et al.(1968).

Seeds per pod and pod length and 100 seed weight and pod length had significant positive correlations similar to the findings in green gram by Giriraj and Kumar (1974) and in pea by Srivastava et al.(1972). Correlation between number of branches per plant and days to 50 per cent flowering showed a weak negative association as noticed in soybean by Sengupta and Kabaria (1971).

For correlation studies it is of prime importance to recognise the nature of population under consideration, since the magnitude of correlation coefficient is influenced by the choice of individuals upon which the observations are made.

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

When the correlation coefficient is partioned into its components, we can identify the factors contributing to the observed correlation.

In the present study, path analysis of the data was done to partition the direct and indirect effects of various characters on yield.

Pods per plant showed significant positive direct effect on yield. Similar results were reported in green gram by Chaudhary and Singh (1974) and Malhotra et al.(1974), in black gram by Banerjee et al.(1976), in red gram by Phadnis et al.(1970) and Ram et al.(1976) and Pokle and Mohatkar (1975) and in soybean by Lal and Haque (1971).

The significant positive direct effect of 100 seed weight on yield as in this study was reported in green gram by Malhotra et al.(1974), in peas by Chandel and Joshi (1976) and in gram by Jatasra et al.(1978).

Sandhu et al.(1980) found that in black gram, the number of fruiting nodes per plant had a significant direct effect on yield. In the present experiment also number of nodes per plant exhibited a positive and significant direct effect on yield.

All other characters except days to 50 per cent flowering showed a negative direct effect on yield. Days to 50 per cent flowering had a positive but insignificant direct effect on yield.

Number of clusters, number of branches and number of nodes per plant exhibited significant positive indirect effect on yield via number of pods per plant. These three characters had significant positive correlations with number of pods per plant. Number of branches per plant in the present experiment exhibited only a weak association with yield but its indirect effect via number of pods per plant was strong and positive.

The indirect effects of pod length and plant height through 100 seed weight on yield are significant and positive. Both these characters had significant positive associations with 100 seed weight and yield.

Number of nodes per plant had the strongest positive correlation with yield but it's direct effect on yield was low when compared with that of number of pods per plant and 100 seed weight.

The indirect effects of plant height via seeds per pod and seeds per pod via plant height were found to be very low, even though there was a significant correlation between these characters. Similarly, the indirect effects of days to flowering through seeds per pod and seeds per pod through days to flowering were insignificant. But, they exhibited a very strong positive correlation between them. Similar is the case with plant height and length of pod.

Number of pods per plant had the highest direct effect on yield. In addition the indirect effects of clusters per plant, branches per plant and nodes per plant through pods per plant were high. Hence it is evident that number of pods per plant is the most important yield contributing factor.

The model used in this analysis accounts for 81 per cent of the variability, leaving only 19 for random variation. This is indicated by the residual factor of 0.435 in the path diagram. This clearly shows that the model used in the path analysis is suitable.

Therefore, it is recommended on the basis of the present investigation carried out in green gram, that for selection of a type with high yield potential, the characters viz. number of pods per plant, 100 seed weight and number of nodes per plant should be given importance.

SUMMARY

SUMMARY

Fifteen diverse varieties of green gram (*Phaseolus aureus* Roxb. Syn *Vigna radiata* (L.) Wilzeck) were tested in a randomised block design and data were collected on grain yield per plant and nine yield contributing characters viz., number of seeds per pod, length of pod, number of pods per plant, 100 seed weight, number of clusters per plant, plant height, number of branches per plant, number of nodes per plant and days to 50 per cent flowering. Observations were recorded on single plant basis.

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 superior genotypes for yield and other characters;
3. to find out the association of different characters with yield and also among themselves and
4. to determine the direct and indirect influences of different component characters on yield using path coefficient analysis.

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.

2. Of the ten characters studied genotypic coefficient of variation was maximum for number of branches per plant and minimum for days to 50 per cent flowering. 100 seed weight and number of pods per plant also exhibited high genotypic coefficients of variation. For characters like days to 50 per cent flowering, plant height, number of seeds per pod, pod length and 100 seed weight, there was only little difference between genotypic and phenotypic coefficients of variation. But for most other characters there was wide difference between phenotypic and genotypic coefficients of variation indicating the larger environmental influence.

3. Heritability was maximum for pod length and minimum for yield per plant. High heritability estimates were observed for pod length, 100 seed weight, plant height, number of seeds per pod, days to 50 per cent flowering, number of branches per plant and number of pods per plant. High heritability

values in the above characters indicate the lesser influence of environment and hence these traits are more dependable for improvement through selection.

4. Genetic advance as a percentage of mean showed that number of branches per plant had the maximum genetic gain followed by 100 seed weight. Days to 50 per cent flowering had the minimum genetic gain. The number of branches per plant, 100 seed weight and number of pods per plant had high heritability and genetic gain indicating the presence of additive gene action. Hence they can be considered as reliable selection criteria for improving yield.

5. At genotypic level, yield per plant showed significant positive correlation with all characters except number of branches per plant and days to 50 per cent flowering. The maximum positive association was found between number of pods per plant and number of clusters per plant.

6. Path coefficient analysis revealed that number of pods per plant 100 seed weight and number of nodes per plant are the 3 factors exerting significant

direct influences on yield. Number of clusters per plant and number of branches per plant exhibited significant positive indirect effects on yield via number of pods per plant. Both these characters had significant positive correlation with number of pods per plant. Number of branches per plant, though had only a weak association with yield, exhibited a strong and positive indirect effect on yield via number of pods per plant. Similarly pod length and plant height exhibited significant positive indirect effects on yield via 100 seed weight. Number of nodes per plant, which had the strongest positive correlation with yield, had only low direct effect on yield when compared to number of pods per plant and 100 seed weight. The model used in the path analysis is suitable as it accounts for about 81 per cent of the variability leaving only 19 per cent for random causes.

Path coefficient analysis thus shows that the 3 characters viz., number of pods per plant, 100 seed weight and number of nodes per plant should be given due weightage by pulse breeders in making selection for high yielding strains in green gram.

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ABSTRACT

Biometric studies on fifteen divergent green gram varieties (*Phaseolus aureus* Roxb. syn. *Vigna radiata* (L.) Wilzeck.) was conducted at the College of Agriculture, Vellayani, during November-January, 1979-'80, to estimate the important genetic parameters like mean, range, genotypic and phenotypic coefficients of variation, heritability, genetic advance and genetic gain and to find out the direct and indirect contributions of various component characters on yield by path coefficient analysis.

There were significant differences among the varieties for all characters studied. Genotypic coefficient of variation was maximum for number of branches per plant followed by 100 seed weight and minimum for days to 50 per cent flowering. High heritability estimates were observed for pod length, 100 seed weight, plant height, number of seeds per pod days to 50 per cent flowering and number of pods per plant. Genetic gain was maximum for number of branches per plant followed by 100 seed weight and minimum for days to 50 per cent flowering. The number of branches per plant 100 seed weight, number of pods per plant and pod length had high heritability and genetic gain indicating the presence

of additive gene action and hence they can be relied upon in selection programmes. At genotypic level, yield showed significant positive correlation with number of nodes per plant, number of pods per plant, pod length, 100 seed weight, number of clusters per plant, number of seeds per pod and plant height.

Path coefficient analysis projected number of pods per plant, 100 seed weight and number of nodes per plant as the traits exerting significant positive direct effect on yield. Hence these 3 characters should be given due consideration in selection programmes.