SELECTION INDEX IN HORSE GRAM

(Dolichos biflorus L.)

BY

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THESIS

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1980

DECLARATION

I hereby declare that this thesis entitled "Selection index in horse gram (*Dolichos biflorus* L.) 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.

Vellayani,
30-7-1980.

SURAIYA, D.

CERTIFICATE

Certified that this thesis, entitled "Selection index in horse gram (Dolichos biflorus L.)" is a record of research work done independently by Smt. SURAIYA, D. 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

Pulses, constitute an important group among the various food crops of the tropics. They are indispensable for supplementing the protein content of diets, since they contain about 22 to 28 per cent protein, which is nearly three times as much as in cereals. India grows a variety of pulse crops, but the unfortunate situation is that with the large acreage of about 22 to 24 million hectares, the production is only 9 to 12 million tonnes. The area and production of pulses in Kerala are only 36.53 thousand hectares and 16.27 thousand tonnes respectively. Day by day the demand for food is increasing and this emphasises the necessity for increasing the production of pulses.

Horse gram (Dolichos biflorus L.) is one of the extensively cultivated pulse crops of South India. Owing to an appreciable amount of hardiness and adaptability, it stands out as an exception from other pulse groups. It fares well over a wide range of soils and is capable of withstanding prolonged drought. Though it is an important pulse crop of Southern India its value as a source of edible protein has not been duly recognized and only little attention has been given to its improvement by research workers.

Genetic variability is necessary in any crop improvement programme and information on its extend is therefore basic. The prime aim of breeding in crops is for evolving high yielding varieties and the main job of the breeder is to identify the superior and the more desirable type in a community exhibiting variability. So selection for yield is the chief consideration in any crop breeding programme. However, yield itself is a very complex character depending upon numerous genetic factors interacting with environment. So any direct method of selection based only on yield becomes a difficult proposition due to its inter-relationships with the yield attributes. Efficiency of selection under such circumstances can be improved by determining the associations existing between yield and other plant characters, which would serve as simple guides for spotting out high yielders.

The recent advances in biometrics have made it possible to approach along three different and interrelated biometric methods.

The first, following identification of the components, involves the analysis of their interrelations. Correlation coefficients are estimated as a routine in this regard. Again, an understanding of the attributes of the components such as heritability and genetic advance which help in the confirmation of the relative importance of the components is essential.

Secondly, formulation of suitable selection indices using Fisher's concept of discriminant function, which is a tool in the hands of a breeder, enables him to assess the net value of a particular plant or line. It consists of weighting certain characters associated with yield, which might be more heritable than yield itself. Due to its feature of giving appropriate weight to each of the characters contributing to yield, the breeder has a more realistic value to base his selection upon.

The third aspect is the analysis of path coefficients, which are standardised partial regression coefficients and as such measure the direct influence of one variable upon another and permits the separation of correlation coefficients into components of direct and indirect effects. It is an effective method for accelerating selection in breeding programmes.

Since, there is not much information on the application of suitable selection indices in horse gram (Dolichos biflorus L.) an attempt has been made in the present investigation to study the above aspects in a divergent collection of fifteen varieties of Dolichos biflorus L.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

As has already been pointed out in the introduction, three lines of biometrical study have been conducted, during the course of the present investigation in horse gram.

The first, relates to the understanding of the correlated components of yield of seeds and their relative importance on the basis of statistically computed parameters - Heritability and genetic advance.

The second, involves the use of suitable selection indices, which helps to assess the improvement or efficiency in selection for yield in crop plants and serves as a method or basis for selecting superior genotypes. The technique of computation of selection index which gives due weightage to the phenotypic traits in terms of genotypic values is termed 'Discriminant function technique'.

The last, involves the assessment of the magnitude of the relative direct and indirect influence of the variables, and also that of the residual factor, on yield of seeds. Here the theory of causation and effect is made applicable and the path coefficient analysis method was resorted to.

A review of investigations which were related to and presumed to be useful in carrying out the experiment is presented and this confines only to reports made in pulses.

(1) Correlation of variables, heritability and genetic advance

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

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

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

Johnson et al. (1955) introduced a methodology for partitioning the total variance into that due to genotype, phenotype and error, in the analysis of variance.

Genetic parameters like heritability and genetic advance have been often found to be of great use for assessing the relative importance of these inherited and correlated variables. Hanson et al. (1956) proposed the mathematical relationship of various estimates on computation of heritability. This attribute is generally expressed as the percentage, and in the broad sense it refers to the proposition of variances due to genotype over the variance due to the phenotype.

Oyono (1968) reported that heritability was very low for total seed yield in field beans.

Singh et al. (1968) based on their correlation studies in mung bean reported negative association of yield with number of leaves, days to flowering, number of primary branches and total weight of 10 pods.

Gupta and Singh (1969) while studying 36 varieties of green gram, recorded that yield per plant had high genetic variability and medium heritability, but low expected genetic advance.

Kambal (1969) recorded strong and positive association of yield with number of pods per plant and negative association of seed weight with number of pods per plant and number of seeds per pod in field beans.

Sandhu and Chandra (1969) made heritability studies in bengal gram, and found high heritability values for primary and secondary branches.

Singh and Mehndiratta (1969) found that grain yield was significantly correlated with number of branches, number of pods, number of seeds per pod and 100 grain weight in cowpea. They have also recorded high genetic advance and heritability for 100 grain weight.

Singh and Singh (1969) reported a close resemblance between phenotypic and genotypic correlations, although genotypic correlations were slightly higher than phenotypic correlations in field pea. They also recorded that grain yield was significantly associated with number of branches per plant, number of seeds per pod, number of pods per plant and 100 seed weight.

Singh and Malhotra (1970) while studying 75 strains of mung bean, recorded a significant association of yield with number of branches, number of pods, length of pod, number of seeds per pod and seed size. They also observed that genotypic correlations were higher than phenotypic and environmental correlations.

Verma and Dubey (1970) observed positive association of yield with number of seeds per pod, length of pod, 100 seed weight and number of pods per plant in black gram. Further, they observed that pods per plant, length of pod and 100 seed weight contributed much towards yield.

Joshi (1971) obtained high and positive correlation between yield and number of pods, number of seeds per pod and number of branches in Indian beans. He also observed a high genotypic correlation coefficient.

Sangha et al. (1971) observed that weight of green pods per plant and number of pods per plant contribute much to grain yield in peas.

Gupta et al. (1972) with their correlation studies in gram involving 46 varieties, recorded significant and positive phenotypic correlation of yield with days to 50% flowering, number of pods per plant and number of seeds per pod. They also observed high heritability values for number of seeds per pod and 100-seed weight.

Joshi (1972) reported positive correlations of yield with number of seeds per pod, number of branches and 100-seed weight. He, also recorded high heritability and genetic advance for number of pods per plant.

Maw and Menon (1972) studied yield components in 37 varieties of soybean and reported strong correlation of yield with number of pods, number of seeds, height of plants, days to 50% flowering and maturity. They have also reported that genotypic correlation coefficients were mostly higher than the phenotypic correlation coefficients.

Srivastava et al. (1972) observed high heritability for days to flowering, length of pod and width of pod in green gram. They have also observed high genetic advance for number of seeds per pod.

Sangha and Singh (1973) with their correlation studies in peas reported that number of grains per pod, number of pods and 100 grain weight were the most important characters contributing to yield.

Singh (1973) observed high heritability for 100 seed weight and low heritability for number of secondary branches in bengal gram.

Singh and Malhotra (1973) recorded significant and positive association of yield with number of clusters per plant, pods per plant and secondary branches in pigeon pea.

Tomar *et al.* (1973) while studying 4 yield components in 22 genetic stocks of mung bean recorded positive correlation of yield with number of pods per plant, length of pod, 100 seed weight and number of seeds per pod.

Veeraswamy *et al.* (1973) observed high heritability for days to flower, height of plant, number of clusters and number of branches in green gram. They have also observed high genetic advance for number of clusters, number of branches per plant, height of plant and number of pods. Length of pod and number of seeds per pod showed moderate to high heritability and low genetic advance.

Chaudhary and Singh (1974) observed negative correlation of yield with seed size in soy beans.

Giriraj and Vijayakumar (1974) recorded strong association of yield with days to flower, height of plant, number of pods per plant and number of seeds per pod in mung bean.

Koranne and Singh (1974) reported high heritability for flowers per peduncle, pods per peduncle, pods per plant, length of pod and 100 seed weight, while very low heritability for yield in pea.

Malhotra *et al.* (1974) studied the yield components in 60 strains of green gram and reported strong correlation of yield with number of branches, number of pods, number of clusters, number of seeds per pod and days to flowering. These characters were significantly associated together. They have also reported that number of clusters, number of pods and seeds per pod were the most important yield components accounting for 96% of variability in yield.

Khan and Choudhary (1975) reported positive correlations between yield and height of plant, number of primary, secondary and tertiary branches and number of pods per plant and negative correlation between yield and seeds per pod and seed size in gram.

Rent and Patil (1975) recorded high heritability and genetic advance for height of plant, number of seeds per plant and seed weight per plant in soy bean.

Soundrapandian *et al.* (1975) observed high genotypic and phenotypic variances for number of pods per plant and height of plant in black gram. They have also observed high heritability for length of pod and height of plant.

Sreekantaradhya *et al.* (1975) while studying 40 varieties of horse gram recognised high heritability and genetic advance for number of nodes, number of branches, number of pods, height of plant and yield of seed.

Agarwal and Kang (1976) observed high genetic advance for pods per plant, 100 grain weight and grain yield per plant in horse gram. They have also observed significant correlations between yield and pods per plant, 100 grain weight, length of pod, height of plant and number of branches.

Goud *et al.* (1977) recorded positive correlation of yield with height of plant, length of pods, seeds per pod and 1000 seed weight in black gram. They have also recorded highest genetic variability for seed yield and lowest for length of pod.

Katiyar et al. (1977) recorded positive correlation of yield with height of plant, number of branches per plant, number of pods per plant and days to maturity in chickpea.

Lakshmi and Goud (1977) recorded high coefficient of genetic variation for height of plant, seed yield, number of pods, length of pod and 100 seed weight in cow pea. Further they observed high heritability for number of seeds, height of plant, length of pod and 100 seed weight.

Narasimhaiah et al. (1977) recorded high genetic advance for yield of pods, number of pods per plant and yield of seed in chickpea. Further, they observed high and positive correlation between yield and number of branches, number of pods and number of seeds per plant and seed weight, while days to flowering and maturity showed negative correlation with yield.

Oraon et al. (1977) observed positive correlations of grain yield with number of pods per plant and number of seeds per pod in chick pea. They further noticed that genotypic correlations were slightly higher than phenotypic correlations.

Patil and Phadnis (1977) with their variability studies in gram recorded high genetic variation for pods per plant, pod weight per plant and 100-seed weight.

Sharma and Tiwari (1977) reported high genotypic correlation of yield with number of nodes bearing pods in french beans.

Shivashankar et al. (1977) while studying 100 varieties of horse gram, recorded that primary branches, secondary branches, days to 50% flowering, number of nodes per plant and 100-seed weight were highly heritable, while height of plant, number of seeds per pod, number of pods per plant and yield showed low heritability. Further, they observed positive correlations of yield with height of plant, number of pods per plant, number of seeds per pod and number of nodes per plant.

Singh and Shrivastava (1977) observed high genetic coefficient of variability for number of secondary branches per plant in pigeon pea.

Narasinghani et al. (1978) while studying 65 diverse genotypes of pea recorded that the seed yield per plant was positively associated with number of days to flower, maturity period, height of plant, number of branches, number of pods per plant and number of seeds per pod.

2. Discriminant function

Discriminant function technique was developed by Fisher (1936) and Smith (1936) where in, it was shown that selection for yield could be made more efficient, if the basis of component traits that go to make up the crop yield and the relationship between those characters and yield were studied. This formed the basis for the formulation of selection index.

Wu (1966) while studying discriminant function in eleven characters of nine varieties of soybean, concluded that height of plant was the best and number of branches, the worst character for discrimination between any two varieties.

Mital and Thomas (1969) recorded that number of branches and total number of pods when taken together, would form the best index in guar.

Singh and Mehndiratta (1970) studied yield components in 40 strains of cowpea and observed that discriminant function on 2 yield components viz., grains per pod and 100-seed weight and 3 yield components viz., grains per pod, 100-seed weight and pods per plant, were superior in selection for yield.

Singh and Singh (1972) based on results from discriminant function studies in 40 varieties of field pea recorded that selection based on combination of certain characters would be more effective than that based on a single character.

Malhotra (1973) while attempting discriminant function technique in soybean suggested that a function based on pods per plant, primary branches and seeds per pod was best for the selection of high yielding lines.

Malhotra and Singh (1974) recorded that selection for yield in green gram based on number of clusters, number of pods and number of seeds per pod was 30% superior.

Banerjee *et al.* (1976) during their discriminant function studies with 16 varieties of black gram recorded that an index based on combination of yield and days to flowering and another combining yield, days to flowering and number of pods were more efficient.

Gunaseelan and Rao (1976) recorded that the major components that exerted maximum influence on yield in pigeon pea were plant height and number of pods.

Paniagua and Pinchinat (1976) reported that improved seed yield in french beans could be achieved by selection for a high number of pods per plant, seeds per pod and nodes per plant.

Singh *et al.* (1976) studied 36 strains of black gram and reported that use of discriminant function based on a single character was not superior to direct selection for yield. The relative efficiency of selection was highest when discriminant function was based on number of primary branches, number of clusters per plant, number of pods per cluster and grain yield per plant.

Davis and Evans (1977) after studying 112 breeding lines of navy beans, reported that efficiency of selection would not be improved by including information of yield components. But they have concluded that 10 per cent improvement was predicted if information on total number of nodes, number of inflorescences and hypocotyl diameter were included.

Malhotra and Sodhi (1977) made discriminant function techniques in pigeon pea and reported that number of branches, number of pods and number of clusters should be given due weightage for an effective selection.

Sharma and Assava (1977) reported that the most efficient selection criteria in arhar was pods per plant.

Shrivastava et al. (1977) recorded that direct selection for yield in pigeon pea was superior to selection based on any component alone or in combination. Further they recorded that the efficiency of selection was highest when selection was based on combination of yield with number of primary branches and pod bearing length, with number of primary and secondary branches with pod bearing length and the number of pods per plant or with pod bearing length and 100 seed weight.

Singh et al. (1977) while studying 53 lines of mung bean, reported that an index based on number of primary branches per plant, number of clusters per plant, number of pods per plant and number of seeds per pod would be most efficient for yield improvement.

Tikka et al. (1977) reported that selection based on single characters would not be more efficient, than direct selection for seed yield except in the case of number of pods per plant. They have also concluded that the most efficient selection index included height, pods per plant and 100 seed weight.

Tikka and Asawa (1978) while studying selection indices in 17 varieties of cowpea, recorded 100-seed weight as the stable selection component for increased yield.

(3) Path coefficient analysis

The path coefficient analysis devised by Wright (1921) is an effective means of examining the direct and indirect relationships permitting a critical examination of the specific factors that produce a given correlation.

Dewey and Lu (1959) recommended the path coefficient analysis as a potent method for resolving the accurate and dependable criteria in selection procedures in breeding programmes.

Singh and Singh (1969) with their path coefficient studies in 40 field pea varieties, found that number of branches, number of pods per plant, number of seeds per pod and 100-seed weight are the important determinants of grain yield.

Phadnis et al. (1970) studied 45 chickpea varieties and reported that the number of pods per plant, number of seeds per plant and 100-seed weight were the major factors determining yield.

Singh and Malhotra (1970) who conducted path coefficient analysis with 75 strains of mung bean reported pods per plant, seeds per pod and seed size as the yield components. Further, they reported that seed size had negative indirect effect on yield through seeds per pod and pods per plant and vice-versa.

Singh and Mehndiratta (1970) showed that pods per plant, grains per pod and 100 grain weight directly contributed to grain yield in cowpea.

Gupta and Kataria (1971) based on results from path analysis studies in soybean recorded that maximum weightage should be given to days to maturity and leaves per plant for the improvement of soybean by selection.

Lal and Haque (1971) studied 36 varieties of soybean and reported that 100 seed weight and number of pods had high positive direct effect on seed yield. Further, they observed that 100 seed weight had negative indirect effect on seed yield via number of leaves, total leaf area, plant height, number of nodes and number of pods.

Rew and Menon (1972) while studying 37 varieties of soybean, stated that the yield components were number of pods and days to maturity.

Singh and Malhotra (1973) while studying yield components in pigeon pea stated that cluster per plant is the main yield component in pigeon pea.

Chaudhary and Singh (1974) while measuring the direct and indirect effects of yield components in soybean, recorded that number of pods per plant and seed size had high direct effects towards yield.

Giriraj and Vijayakumar (1974) while applying path coefficient analysis in mung bean, observed that length of pod, days of flower and height of plant had positive direct effect on seed yield. Height of plant and days to flower had negative indirect effect through length of pod and 100-seed weight. They concluded that maximum weightage should be given to length of pod, days to flower and height of plant while formulating selection indices for seed yield in mung bean.

Malhotra and Singh (1974) while examining yield components in green gram, reported that pods per plant had the highest direct and indirect effect on seed yield.

Patil and Pokle (1974) reported that weight of pods is the main yield contributing character in soybean, whereas height of plant, number of branches per plant and number of pods per plants increased the yield through pod weight.

Pokle and Mohatkar (1975) found that pod number per plant had a higher direct effect on yield in pigeon pea.

Veeraswamy <u>et al.</u> (1975) while studying path analysis in red gram recorded that the number of branches showed maximum influence both directly and indirectly on seed yield.

Veeraswamy and Ratnaswamy (1975) reported number of pods per plant as the major yield contributing character in soybean, followed by 100-seed weight and number of nodes.

Wakankar and Yadav (1975) while measuring the direct and indirect effects of yield components in arhar, observed that pod number had the highest positive direct effect on seed yield, followed by number of secondary branches and 100-seed weight. They have also concluded that selection for seed yield should be based on high number of pods, secondary branches and a high seed index and a non-spreading habit.

Aggarwal and Kang (1976) while applying path coefficient analysis in horse gram, observed that pods per plant contributed much for seed yield.

Chandel and Joshi (1976) recorded that number of seeds per pod, number of pods per plant and 100-seed weight had positive direct effect on seed yield and the number of days to flower had a negative direct effect on yield in yellow grained peas.

Kumar et al. (1976) with their path coefficient studies in cowpea recorded that number of clusters per pod, number of pods per plant and 100-seed weight had high direct effect on pod yield. They have also suggested these characters as reliable selection indices in cowpea.

Soundarapandian et al. (1976) studied path coefficient analysis in blackgram and reported that height of plant and number of clusters had direct and indirect effect on seed yield.

Srivastava et al. (1976) showed that days to flower and seeds per pod were the major yield components in soy bean.

Kalloo and Dhankar (1977) concluded from path coefficient analysis of 64 varieties of peas, that number of pod clusters, number of pods per plant and number of branches per plant were the major yield components.

Katiyar et al. (1977) recorded that number of branches per plant had higher positive direct effect on grain yield followed by number of pods per plant. The direct effect of height of plant and days to maturity on grain yield was high and negative.

Sharma and Asawa (1977) concluded from path coefficient analysis in arhar that pods per plant is the most efficient selection criterion.

Singh *et al.* (1977) with their path coefficient studies in green gram recorded that number of primary branches, number of clusters per plant, number of pods per cluster and number of pods per plant had significant association with grain yield. Number of seeds per pod showed lack of association with yield. Primary branches and number of clusters per plant exhibited indirect contribution to grain yield. The pods per cluster and pods per plant contributed direct and indirect effect on grain yield. They have also concluded that number of pods per cluster and number of pods per plant are to be considered as major yield components.

Jatasra *et al.* (1978) conducted path analysis in chick pea and recorded that seeds per pod and 100-seed weight should be given due emphasis while selection for high yield.

Narasinghani *et al.* (1978) while studying path analysis in pea indicated that 100-seed weight had positive direct effect on grain yield.

Patirana and Guzhov (1979) while studying 11 varieties of soybean, observed that number of seeds per pod and single seed weight were the major yield components and concluded that selection for these two characters would be an effective method for increasing seed yield.

Sandhu *et al.* (1980) while attempting path analysis in 268 strains of urd bean affirmed strongly that selection criteria should be based on early flowering, lesser plant height, higher fruiting nodes and larger pods.

MATERIALS AND METHODS

MATERIALS AND METHODS

A. Material

Fifteen varieties of horse gram (Dolichos Biflorus L) exhibiting distinct diversity in characters constituted the material for the study. These varieties represented both indigenous and exotic types and were selected and obtained from the germ plasm collection maintained at the Rice Research Station, Pattambi and University of Agricultural Sciences, Hebbal and local collections from Paravur and Balaramapuram.

Table 1 gives particulars of these varieties, which were given identification numbers V_1 ———— V_{15}.

B. Methods

The experiment was conducted under field condition at the College of Agriculture, Vellayani during September-January 1979-80.

Experimental Design and layout

A proper statistical layout was adopted with a view to minimise environmental variations that might bias the results of the studies. The experiment consisting of fifteen treatments was laid out in a Randomised Block Design with 3 replications (vide Fig.1). The size of the plot was 2.1 m x 2.1 m. Each replication (block) consisted of fifteen such plots (treatments) and the total number of plots in all the replications were forty five. The spacing adopted was 30 x 30 cm.

Figure 1

Design	Randomized block design
Number of treatments (Varieties)	15
Number of replications	3
Plot size	2.1 m x 2.1 m
Spacing	30 x 30 cm

FIG.1. LAY OUT PLAN OF THE FIELD EXPERIMENT.

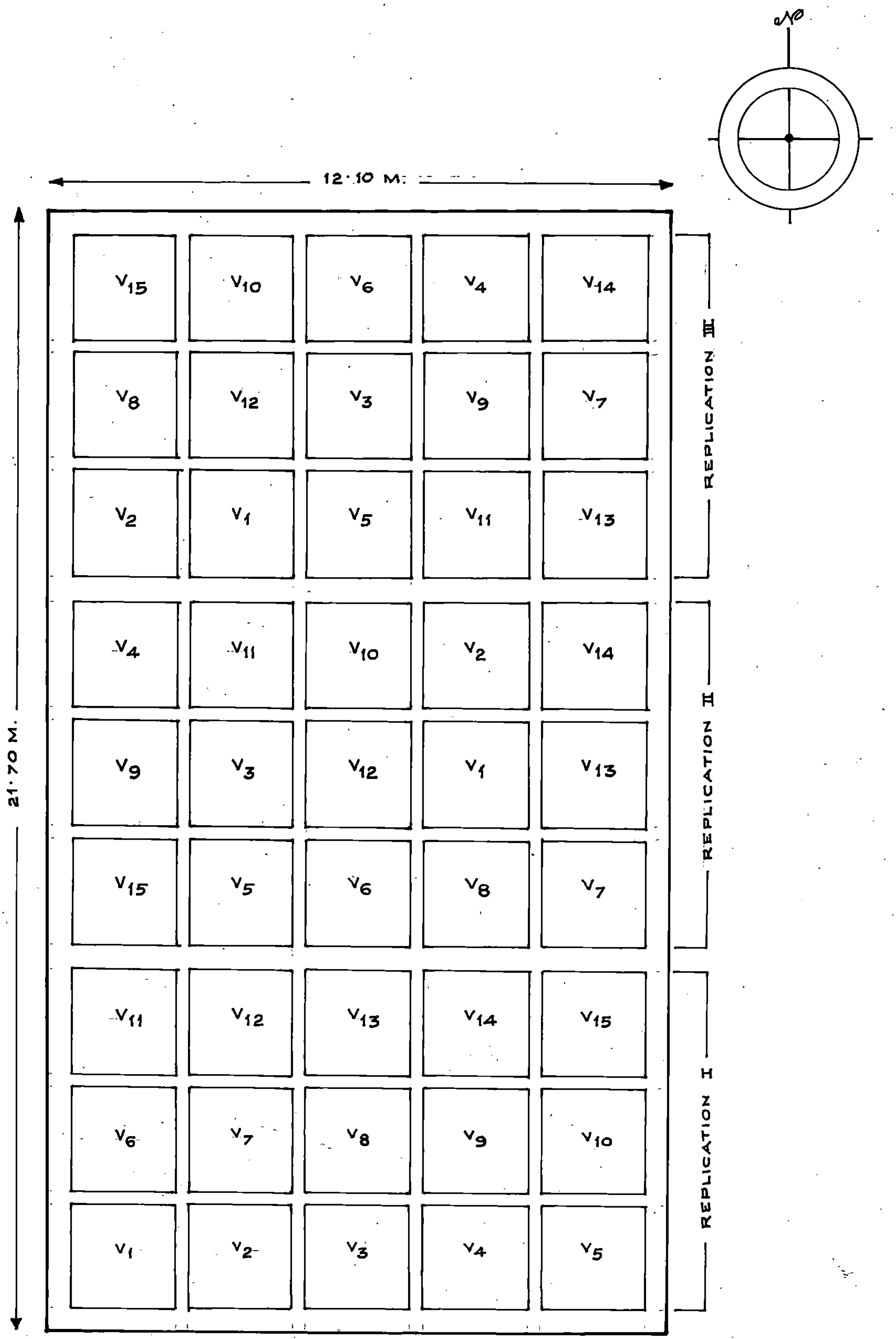


Table 1. Particulars of the fifteen varieties of horse gram (*Dolichos biflorus*. L.) used in the study

Variety	Source	Treatment number
Balaramapuram local	Local collection from Balaramapuram	V_1
Hebbal-2	University of Agricultural Sciences, Hebbal	V_2
HPK-1	,,	V_3
Macharlshore	,,	V_4
Paravur local	Local collection from Paravur	V_5
HPK-6	Rice Research Station, Pattambi	V_6
ENT	University of Agricultural Sciences, Hebbal	V_7
D.C.7460	,,	V_8
PLS-9	Rice Research Station, Pattambi	V_9
Ptb. local	,,	V_{10}
BGM-1	,,	V_{11}
D.C.16679	University of Agricultural Sciences, Hebbal	V_{12}
JND-1	Rice Research Station, Pattambi	V_{13}
HPK-4	,,	V_{14}
HG-93	,,	V_{15}

Sowing and culture

Seeds were dibbled on raised beds in seven rows per plot and with seven plants in each row.

The crop was manured at the rate of 500 kg/ha lime and 39 kg/ha superphosphate as basal dressing. Irrigation was given during early stages and also three insecticide sprayings and two fungicide sprayings were received by the crop during the period of its growth.

Seeds were sown on 30-9-1979 and harvest was completed on 24-1-1980.

Sampling

Leaving a border row on all sides of the plot a total of 10 plants was selected at random and labelled for observations. Thus there were 30 plants (10 plants x 3 replications) from each variety, and the total number of plants subjected to the study comes to 450 (30 plants x 15 varieties).

Characters studied

The 450 plants were studied individually for the following characters.

(1) Seed yield per plant (Y)

Yield of seed from each plant was weighed after normal drying and the weight was expressed in grams.

(2) Number of pods per plant (x_1)

All the pods having seeds were recorded for each plant.

(3) Number of seeds per pod (x_2)

All pods from each plant were shelled and the number of seeds per pod noted.

(4) 100 seed weight (x_3)

Hundred seeds chosen at random from each treatment in the three replications were weighed and expressed in grams.

(5) Length of pods (x_4)

A random sample of 10 pods per plant was collected and the measurement noted in centimeters.

(6) Days to 50 per cent flowering (x_5)

Flowering of 50 per cent plants in the plot was taken, as days to 50 per cent flowering.

(7) Height of plants (x_6)

The height of the plants was measured at maturity and expressed in centimeters.

(8) Number of branches (x_7)

All the productive branches were counted and recorded after full maturity of the plant.

(9) Days to maturity (duration) (x_8)

The number of days taken by the plants for harvest from the date of sowing was noted (All plants constituting the sample in each plot were harvested on the same day).

<u>Statistical procedures</u>

The data collected in respect of the metric traits were tabulated and subjected to statistical analysis.

Analysis of variance was worked out for all the nine characters, to find out whether there were significant differences between the varieties in respect of the characters.

For the estimation of the analysis of variance, the procedures proposed by Panse and Sukhatme (1957) were used.

Analysis of variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Variance ratio (F)
Replications	(r-1)	SS_R	s^2R	$\frac{s^2R}{s^2E}$
Treatments	(v-1)	SS_V	s^2V	$\frac{s^2V}{s^2E}$
Error	(r-1)(v-1)	SS_E	s^2E	

Where r = The number of replications

V = The number of varieties

SS_R = Replication sum of squares

SS_V = Varietal sum of squares

SS_E = Error sum of squares

s^2R = Replication mean square

s^2V = Varietal mean square

s^2E = Error mean square

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

Genotypic, environmental and phenotypic variances, coefficients of variation, covariances and correlation coefficients were computed using the formula given below. Further, heritability and genetic advance due to selection of the best 5 per cent of plants also have been computed.

Genotypic variance (Johnson *et al.*, 1955)

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

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)

Phenotypic coefficient of variation (Burton, 1952)

$$CV_p = \frac{\sqrt{V_p} \times 100}{\text{Mean}}$$

where

CV_p = Phenotypic coefficient of variation

V_p = Phenotypic variance

Genotypic coefficient of variation (Burton, 1952)

$$CV_g = \frac{\sqrt{V_g} \times 100}{\text{Mean}}$$

where

CV_g = Genotypic coefficient of variation

V_g = Genotypic variance

Environmental coefficient variation

$$CV_e = \frac{\sqrt{V_e} \times 100}{\text{Mean}}$$

where

CV_e = Environmental coefficient of variation

V_e = Error (Environmental variance)

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

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

where

h^2 = Heritability expressed in percentage

V_g = Genotypic variance

V_p = Phenotypic variance

Expected genetic advance under selection (Lush, 1949 and Johnson *et al.*, 1955)

$$GA = \frac{i \times h^2 \times \sqrt{V_p}}{Mean.}$$

where

GA = Genetic advance

i = 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).

h^2 = Heritability in broad sense

V_p = Phenotypic variance

Genotypic covariance

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

where

C_oV_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)

C_oV_e = MSPE

where

C_oV_e Error (Environmental covariance)

MSPE = Mean sum of products for error

Phenotypic covariance

$$C_oV_p = C_oV_g + C_oV_e$$

where

C_oV_p	=	Phenotypic covariance
C_oV_g	=	Genotypic covariance
C_oV_e	=	Error (Environmental covariance)

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

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

where

rg	=	Genotypic correlation coefficient
C_oV_g 12	=	Genotypic covariance of variables 1 & 2
V_g1	=	Genotypic variance of variable 1
V_g2	=	Genotypic variance of variable 2

Environmental correlation coefficient

$$re = \frac{C_oV_e\ 12}{\sqrt{V_e1 \times V_e2}}$$

where

re	=	Environmental correlation coefficient
C_oV_e 12	=	Environmental covariance of variables 1 & 2
V_e1	=	Environmental variance of variable 1
V_e2	=	Environmental variance of variable 2

Phenotypic correlation coefficient

$$rp = \frac{C_oV_p\ 12}{\sqrt{V_p1 \times V_p2}}$$

where

rp = Phenotypic correlation coefficient

$C_oV_p\ 12$ = Phenotypic covariance of variable 1 & 2

V_p1 = Phenotypic variance of variable 1

V_p2 = Phenotypic variance of variable 2

The significance of rg is tested using 't' test.

<u>Discriminant function</u>

Application of discriminant function as a basis for making selection on several characters simultaneously is aimed at discriminating the desirable genotypes from undesirable ones on the basis of their phenotypic performance.

The required discriminant function that could serve as the best yard-stick in the selection of plants for yield was evolved by using the estimates of the genotypic components of yield (x_1), and four other characters, namely the number of seeds per pod (x_2), pod length (x_3), plant height (x_4) and number of branches (x_5) which are expected to have associated with yield.

Six models of selection indices were constructed using different combinations with seed yield.

1. Yield and number of seeds per pod
2. Yield and pod length

3. Yield, number of seeds per pod and pod length
4. Yield, number of seeds per pod, pod length and plant height
5. Yield, number of seeds per pod, pod length and number of branches
6. Yield, number of seeds per pod, pod length, plant height and number of branches

It is assumed that the genotype of a given plant for yield can be represented by a function of the type.

Genotype = H = $a_1x_1 + a_2x_2 + a_3x_3$ ——— a_nx_n where a_1, a_2, a_3 a_n are the weights attached to them depending on the relative importance of the characters contributing to yield and x_1 x_2 and x_3 ——— x_n are the genotypic values of the components X_1, X_2 X_3 ——— X_n. The phenotype can be represented by

Phenotype = I = $b_1X_1 + b_2X_2 + b_3X_3$ ——— b_nX_n where b_1, b_2, b_3 ——— b_n are the values of economic weights to be estimated and the problem is to derive those values of b_1, b_2, b_3 ——— b_n.

Phenotype = genotype + environment. So the phenotype is highly correlated with genotype and consequently H & I are also correlated. In the function the weights b_1, b_2, b_3 ——— b_n should be estimated in such a way that the correlation between H & I will be the maximum. Thus selection of phenotypes using I as a discriminant function will ensure a maximum concentration of the desired genes in the plants selected.

Six different selection indices were fitted

$$I_1 = b_1x_1 + b_2x_2$$

$$I_2 = b_1x_1 + b_3x_3$$

$$I_3 = b_1x_1 + b_2x_2 + b_3x_3$$

$$I_4 = b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$$

$$I_5 = b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5$$

$$I_6 = b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6$$

In general, the b values were calculated by solving the normal equations.

$$b_1t_{11} + b_2t_{12} + \text{------------} b_nt_1n = A_1$$

$$b_1t_{12} + b_2t_{22} + \text{------------} b_nt_2n = A_2$$

$$\vdots$$

$$b_nt_1n + b_2t_2n + \text{------------} b_nt_nn = A_n$$

--------(1)

where t = Phenotypic variance and covariance matrix

G = Genotypic variance and covariance matrix

$$A_1 = a_1g_{11} + a_2g_{12} + \text{----------} a_ng_1n$$

$$A_2 = a_1g_{12} + a_2g_{22} + \text{----------} a_ng_2n$$

$$\vdots$$

$$A_n = a_1g_1n + a_2g_2n + \text{----------} a_ng_nn$$

--------(2)

The solution of these equations give the estimate of b values in the following manner.

$b = t^{-1}ga$, where b is the column vector, t^{-1} is the inverse of phenotypic variance and covariance matrix, g is the genotypic variance and covariance matrix and a is the column vector for economic weights.

The values for A_1, A_2 ——————A_n were calculated from the data by substitution of the calculated values of g_{ij} and the assigned values of a_i. The values for a were arbitarily assigned as $a_1 = 1$, $a_2 = 0$, $a_3 = 0$, $a_4 = 0$ and $a_5 = 0$ since the only economic yield is grain. The values were inserted in equation (1) and solved for the values of b_1, b_2, b_3, b_4 and b_5.

The discriminant function was then set up by the general equation.

$$I = b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5$$

where b_1, b_2, b_3, b_4 and b_5 are the solved economic weights and x_1, x_2, x_3, x_4 and x_5 are the contributing characters.

Path co-efficient analysis

The genotypic correlation coefficients of different morphological characters with seed yield were partitioned into direct and indirect effects.

The estimates of direct and indirect effects were calculated as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

Among the nine characters studied, the variables x_3 (100-seed weight), x_5 (days to 50% flowering) and x_8 (duration) were not included in this part of the analysis, since they do not show positive (x_3) and significant (x_5 and x_8) correlations with seed yield.

Yield (Y), and number of pods per plant (x_1), number of seeds per pod (x_2), pod length (x_4), plant height (x_6) and number of branches (x_7) were considered as the effect and causes respectively.

Path analysis were worked out for seven different combinations, using the above variables with yield.

1. $Y\ (x_2,\ x_4)$
2. $Y\ (x_1,\ x_2,\ x_4)$
3. $Y\ (x_2,\ x_7)$
4. $Y\ (x_2,\ x_4,\ x_7)$
5. $Y\ (x_2,\ x_4,\ x_6)$
6. $Y\ (x_1,\ x_2,\ x_4,\ x_6)$
7. $Y\ (x_2,\ x_4,\ x_6,\ x_7)$

The path coefficients were obtained by the simultaneous solution of the following equations which express the basic relationship between correlations and path coefficients.

$$r_{1y} = P_{1y} + r_{12} P_{2y} + r_{13} P_{3y} + \ldots\ldots\ldots\ldots r_{1k} P_{ky}$$

$$r_{2y} = r_{21} P_{1y} + P_{2y} + r_{23} P_{3y} + \ldots\ldots\ldots r_{2k} P_{ky}$$

$$r_{3y} = r_{31} P_{1y} + r_{32} P_{2y} + P_{3y} + \ldots\ldots\ldots + r_{3k} P_{ky}$$

.

.

$$r_{ky} = r_{k1} P_{1y} + r_{k2} P_{2y} + r_{k3} P_{3y} + \ldots\ldots\ldots\ldots + r_{k-1,\,k} P_{(k-1)\,y} + P_{ky}$$

where r_{1y} to r_{ky} denote coefficients of correlation between causal factors 1 to k and the dependent character Y.

r_{12} to $r_{k-1\,K}$ denote coefficients of correlation among all possible combinations of causal factors and

P_{1y} to P_{ky} denote direct effects of characters 1 to K on the character Y.

The above equation can be written in the matrix form as shown below.

$$\begin{Bmatrix} r_{1y} \\ r_{2y} \\ r_{3y} \\ \vdots \\ r_{KY} \end{Bmatrix} = \begin{Bmatrix} 1 & r_{12} & r_{13} & r_{1k} \\ & 1 & r_{23} & r_{2K} \\ & & 1 & r_{3K} \\ & & & \vdots \\ & & & 1 \end{Bmatrix} \begin{Bmatrix} P_{1y} \\ P_{2Y} \\ P_{3y} \\ \\ P_{KY} \end{Bmatrix}$$

A C B

i.e. $\underset{\sim}{A} = \underset{\sim}{C}\ \underset{\sim}{B}$

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

where $\underset{\sim}{C}^{-1}$ is the inverse of $\underset{\sim}{C}$

let C^{-1} =

$$\begin{Bmatrix} C_{11} & C_{12} & C_{13}\text{———}C_{1K} \\ & C_{22} & C_{23}\text{———}C_{2K} \\ & & C_{33}\text{———}C_{3K} \\ & & \vdots \\ & & C_{KK} \end{Bmatrix}$$

Path coefficients are obtained as

$$P_{1Y} = \sum_{i=1}^{K} c_{1i}\, r_{iy}$$

$$P_{2Y} = \sum_{i=1}^{K} c_{2i}\, r_{iY} \quad \text{etc.}$$

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

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

where $R^2 = \sum_{i=1}^{K} P_{iY}^2 + 2 \sum_{i} \sum_{j} \underset{i<j}{} P_{iY}\, P_{jY}\, r_{ij}$

RESULTS

RESULTS

Observations made on the relative expression of nine selected characters in fifteen varieties of horse gram during the course of the experiment and the analysis of data are presented below along with pertinent tables and diagrams.

The characters studied and symbols used are as follows.

Characters	Symbol
1. Seed yield per plant	y
2. Number of pods per plant	x_1
3. Number of seeds per pod	x_2
4. 100-seed weight	x_3
5. Length of pod	x_4
6. Days to 50% flowering	x_5
7. Height of plant	x_6
8. Number of branches	x_7
9. Days to maturity (Duration)	x_8

The mean values computed for yield and the eight components mentioned above are shown in Table 2. There is significant difference between yield and other characters for all the varieties.

The anova for the nine characters for fifteen varieties of horse gram grown in a randomised block design with 3 replications was analysed and the result is presented in Table 3. All the varieties showed significant differences from each other for all the nine characters.

Table 2. Mean values for yield and eight other characters in fifteen varieties of horse gram

Varieties	Characters								
	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
V_1	6.7800	52.0666	4.4823	3.7000	4.6666	51.6666	104.3000	10.7666	96.6666
V_2	7.1715	47.7666	4.2410	3.5000	3.8666	35.3333	80.1666	11.2333	85.3333
V_3	6.6473	47.0333	3.6606	3.7000	3.9000	27.6666	79.0333	12.4666	68.6666
V_4	8.3350	58.3333	4.2153	3.3000	3.9000	52.6666	118.0000	11.0666	103.3333
V_5	8.9771	57.4333	5.0333	3.0000	3.1000	49.6666	111.6333	12.6333	94.3333
V_6	6.6771	49.6666	4.1923	3.5350	3.9000	25.3333	72.5666	9.9666	68.3333
V_7	7.5050	79.4666	3.5693	2.8200	3.7000	40.6666	90.4333	9.5333	89.6666
V_8	7.1280	48.0000	4.4273	3.2950	3.7666	32.3333	89.0666	9.0000	79.3333
V_9	7.2445	49.3000	4.5736	3.5000	3.7666	71.6666	103.1333	11.0333	115.6666
V_{10}	11.2936	60.8000	5.3163	3.3000	3.5666	45.6666	116.7333	13.4333	90.6666
V_{11}	8.1095	63.7666	3.8886	3.4000	3.8000	65.3333	106.6000	11.6666	108.3333
V_{12}	7.7480	59.1333	3.8470	3.2516	3.8000	28.3333	83.9666	8.7000	69.3333
V_{13}	7.7360	58.1333	4.1360	3.4000	4.0666	66.0000	117.3000	11.8666	112.0000
V_{14}	6.4936	49.1333	3.6483	3.3450	3.6000	26.0000	79.5000	8.0666	69.0000
V_{15}	7.1500	46.4666	4.2430	3.5000	3.9666	63.0000	109.8333	11.1000	108.0000

y, x_3 } in grams

x_4, x_6 } in centimetres

x_1, x_2, x_7 } in numbers

x_5, x_8 } in days

Table 3. Anova for yield and its components in horse gram

Source of variation	df	Mean square								
		y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
Block	14	12.7763	369.2940	0.3300	0.0000005	0.0062	1.1559	0.7486	0.6975	1.0883
Treatment	2	4.4414**	266.8700**	0.7327**	0.1463**	0.9251**	757.5174**	771.4800**	7.0216**	655.5079*
Error	28	1.1307	53.4297	0.0516	0.000002	0.0026	0.6317	53.5542	0.5937	0.6365

**Indicates 'F' value significant at 1% level

(The significance for treatment alone is marked)

Correlation of variables, heritability and genetic advance

The variance due to genotype (V_g), environment (V_e) and phenotype (V_p), coefficient of variation due to genotype (g_{cv}), environment (e_{cv}) and phenotype (p_{cv}), heritability in the broad sense (h^2) and genetic advance (GA) for the nine characters were computed and results are presented in Table 4.

Duration (x_8), plant height (x_6) and days to 50 per cent flowering (x_5) show highest genotypic and phenotypic variances while 100-seed weight (x_3) shows the lowest. Days to 50% flowering shows the highest and 100-seed weight shows the lowest genotypic and phenotypic coefficient of variation also. The heritability value is maximum for 100-seed weight and minimum for seed yield (y). The value of genetic advance is also highest for days to 50% flowering and lowest for 100-seed weight.

Estimates of genotypic, environmental and phenotypic [illegible] covariances for the nine characters are presented in Tables 5, 6 and 7.

The association between yield and each one of the components and among the components were investigated and genotypic, environmental and phenotypic correlation coefficients are given in Tables 8, 9 and 10 respectively.

The genotypic relationship between yield and its components are diagramatically represented in Fig.2.

Table 4. Components of variance, phenotypic coefficient of variation, genotypic coefficient of variation, environmental coefficient of variation, heritability and genetic advance for yield and other variables in horse gram.

Variables	Variance			Coefficient of variation			Heritability h^2 (%)	Genetic advance (at 5% intensity of selection
	Genotypic (V_g)	Environmental (V_e)	Phenotypic (V_p)	Genotypic (g_{cv})	Environmental (e_{cv})	Phenotypic (p_{cv})		
y	1.1035	1.1307	2.2342	13.7019	13.8698	19.4965	49.3812	19.8361
x_1	71.1467	53.4297	124.5764	15.1645	13.1414	20.0664	57.1108	23.6072
x_2	0.2270	0.0516	0.2786	11.2602	5.3691	12.4747	81.4756	20.9361
x_3	*0.054783	*0.000002	*0.054785	6.9459	0.0430	6.9460	99.9963	14.3703
x_4	0.3075	0.0026	0.3101	13.5105	1.2542	13.5686	99.1455	27.7109
x_5	252.2952	0.6317	252.9269	35.0722	1.7550	35.1161	99.7502	75.1579
x_6	239.3086	53.5542	292.8628	15.8435	7.4949	17.5269	81.7155	29.5012
x_7	2.1426	0.5957	2.7383	13.5089	7.1113	15.2663	78.3028	24.6229
x_8	284.9571	0.6365	285.5936	18.6641	0.8820	18.6849	99.7777	38.4024

*For the character x_3, the V_g, V_e and V_p were recorded upto the 6th decimal point due to their very low values.

Table 5. Estimates of genotypic variances and covariances for different characters in horse gram (Components of variances in parenthesis)

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	(1.1035)	4.3649	0.3692	-0.1143	0.5090	4.7383	11.4382	1.1493	5.5907
x_1	..	(71.1467)	-0.0794	-1.5922	1.2652	19.5918	47.1054	1.9669	28.7176
x_2	..	..	(0.2270)	-0.0028	0.2232	2.5377	4.1770	0.4385	2.6851
x_3	..	..	..	(0.0547)	-0.0131	0.1739	-0.5262	0.0608	-0.0731
x_4	..	..	..	..	(0.3075)	1.1882	4.4355	0.5889	1.1063
x_5	..	..	..	..	..	(252.2952)	212.3343	11.4553	264.9722
x_6	..	..	..	..	..	..	(239.3086)	13.4855	229.5366
x_7	..	..	..	..	..	..	..	(2.1426)	11.7102
x_8	..	..	..	..	..	..	..	..	(284.9571)

Table 6. Estimates of environmental (error) variances and covariances for different characters in horse gram (Components of variances in parenthesis)

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	(1.1307)	6.7795	0.1175	0.0002	0.0973	0.1737	2.0246	-0.1281	0.0830
x_1	..	(55.4297)	0.1797	0.0020	0.06561	1.1864	4.7006	-0.4571	1.3159
x_2	..	..	(0.0516)	0.00004	0.0029	-0.0051	0.6262	-0.0360	-0.0099
x_3	..	..	..	(0.000002)	-0.00001	0.0002	0.0026	0.0002	0.0002
x_4	..	..	..	..	(0.0026)	0.0120	0.0496	-0.0102	0.0126
x_5	..	..	..	..	..	(0.6317)	-0.1553	-0.1094	0.5753
x_6	..	..	..	..	..	..	(53.5542)	2.4967	-0.3165
x_7	..	..	..	..	..	..	..	(0.5937)	-0.0791
x_8	..	..	..	..	..	..	..	..	(0.6365)

Table 7. Estimates of phenotypic variances and covariances for different characters in horse gram (Components of variance in parenthesis)

	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
y	(2.2342)	11-1635	0.4865	-0.11410	0.5163	4.9120	15.4628	1.02113	5.4757
x_1	..	(124.5764)	0.1002	-1.5901	1.3308	21.4282	51.8060	1.5297	30.0355
x_2	..	..	(0.2785)	-0.0028	0.2261	2.5325	4.8032	0.4025	2.5751
x_3	..	..	..	(0.0547)	-3.0131	0.1741	-0.5835	0.0610	-0.0729
x_4	..	..	..	..	(0.3101)	1.2002	4.4853	0.5786	1.1189
x_5	..	..	..	..	..	(252.9269)	212.1759	11.4458	265.5475
x_6	..	..	..	..	..	..	(292.8628)	15.9852	229.2202
x_7	..	..	..	..	..	..	..	(2.7565)	11.6310
x_8	..	..	..	..	..	..	..	..	(285.5936)

Table 8. Genotypic correlations among yield and eight components in horse gram

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
x_1	--	-0.0198	-0.4065*	0.2704	0.1462	0.3610	0.1593	0.2017
x_2	--	--	-0.0257	0.8448**	0.3353	0.5667**	0.6268**	0.3358
x_3	--	--	--	0.1010	0.0468	-0.1619	0.1775	-0.0165
x_4	--	--	--	--	0.1349	0.5171**	0.7255**	0.1162
x_5	--	--	--	--	--	0.8641**	0.4931*	0.9882**
x_6	--	--	--	--	--	--	0.5956**	0.8789**
x_7	--	--	--	--	--	--	--	0.4739*
x_8	--	--	--	--	--	--	--	--
y	0.4949*	0.7376**	-0.4650*	0.8738**	0.2839	0.7038**	0.7475**	0.3959

**Indicates significance at 1% level probability

*Indicates significance at 5% level probability

Table 9. Environmental correlation among yield and eight components in horse gram

	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
x_1	..	0.1082	0.1917	0.1744	0.3161	0.0879	-0.0776	0.2256
x_2	..	..	0.1410	0.2533	-0.0284	0.3766	-0.2059	-0.0551
x_3	..	..	..	-0.1553	0.2114	0.2534	0.2082	0.2158
x_4	..	..	..	..	0.2948	0.1324	-0.2572	0.3092
x_5	..	..	..	..	..	-0.0267	-0.0317	0.9074
x_6	..	..	..	..	..	..	0.4428	-0.0542
x_7	..	..	..	..	..	..	..	-0.1267
x_8	..	..	..	..	..	..	..	..
y	0.8721	0.4858	0.1471	0.1341	0.2055	0.2602	-0.1564	0.0979

Indicate level of significance.

Table 10. Phenotypic correlations among yield and eight components in horse gram

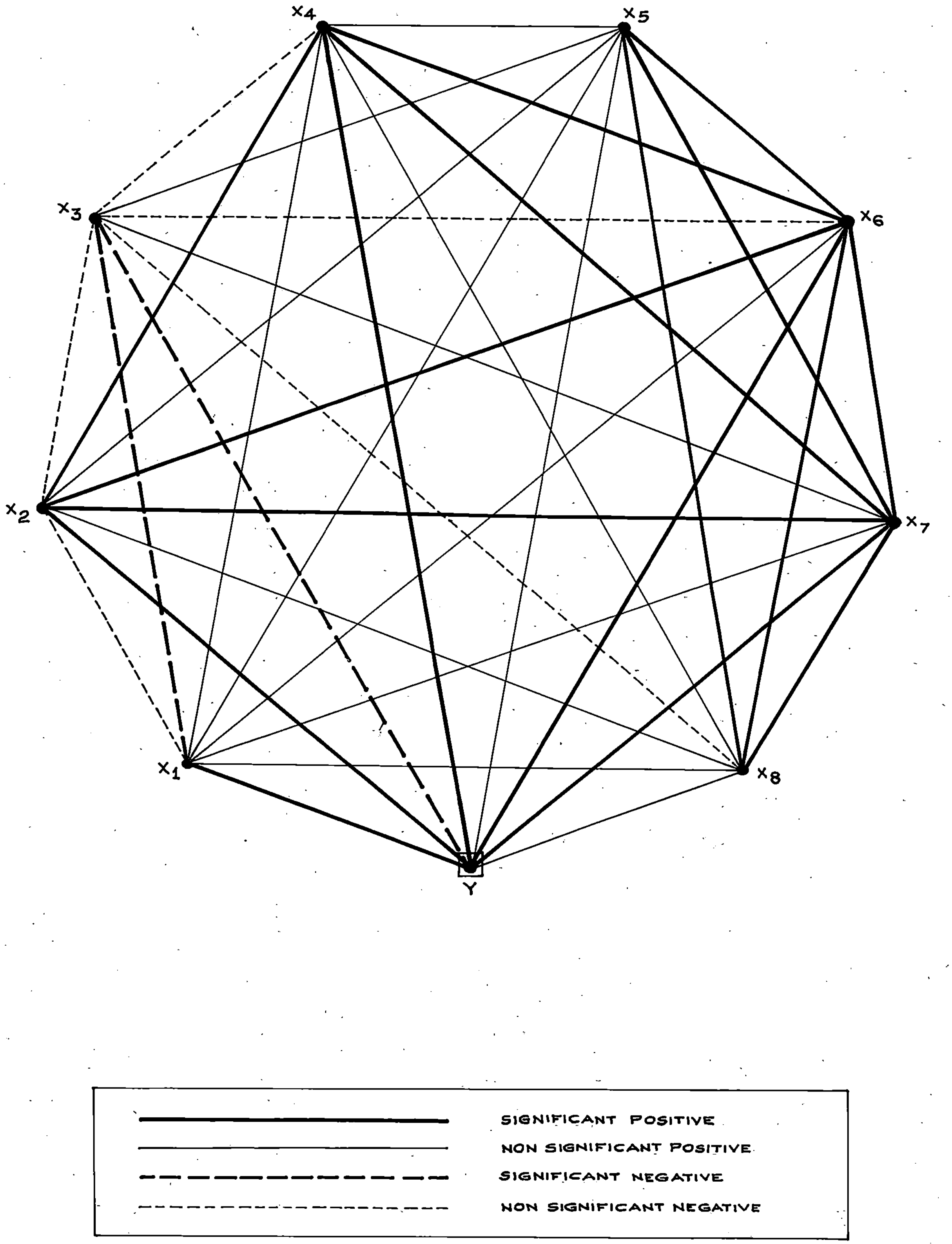
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
x_1	**	0.0170	−0.6087	0.2141	0.1207	0.2712	0.0829	0.1592
x_2	**	**	−0.0229	0.7693	0.3017	0.5317	0.4610	0.2999
x_3	**	**	—	−0.1007	0.0466	−0.1457	0.1576	−0.0184
x_4	**	**	**	**	0.1555	0.4706	0.6281	0.1169
x_5	**	**	**	**	**	0.7796	0.4351	0.9880
x_6	**	**	**	**	**	**	0.5646	0.7926
x_7	**	**	**	**	**	**	**	0.4161
x_8	**	**	**	**	**	**	**	**
	0.6692	0.6167	−0.3262	0.6203	0.2066	0.5263	0.4150	0.2167

Indicate level of significance.

Figure 2.

y	=	Seed yield per plant
x_1	=	Number of pods per plant
x_2	=	Number of seeds per pod
x_3	=	100-seed weight
x_4	=	Length of pod
x_5	=	Days to 50% flowering
x_6	=	Height of plant
x_7	=	Number of branches
x_8	=	Days to maturity (duration)

FIG. 2. CORRELATION DIAGRAM OF YIELD AND EIGHT YIELD COMPONENTS IN HORSE GRAM.



In general, the genotypic correlation coefficients were higher than the phenotypic and environmental correlation coefficients in a number of combinations.

The number of pods per plant (x_1), number of seeds per pod (x_2), pod length (x_4), days to 50% flowering (x_5), plant height (x_6), number of branches (x_7) and days to maturity (x_8) show a positive relationship with yield, while 100-seed weight (x_3) shows a negative trend. Pod length shows the maximum and positive correlation followed in order by number of branches, number of seeds per pod, plant height, number of pods per plant, days to maturity and days to 50% flowering.

Studies on mutual correlations incorporating yield and the eight components (y and x_1——x_8) reveal additional information and the results obtained are also represented diagrammatically in Fig.2.

<u>Discriminant function analysis</u>

Discriminant function technique was adopted in constructing selection indices for seed yield. The characters included in the discriminant function are yield (x_1), number of seeds per pod (x_2), pod length (x_3), plant height (x_4) and number of branches (x_5). Six models of selection indices were constructed using the above characters in different combinations whose discriminant function values are presented in Table 11.

Table 11. Discriminant function for the different combinations.

Sl. No.	Combinations	Discriminant function
1.	x_1, x_2	$0.3313x_1-0.0197x_2$
2.	x_1, x_3	$0.1663x_1-0.0021x_3$
3.	x_1, x_2, x_3	$0.2034x_1-0.0509x_2-0.0015x_3$
4.	x_1, x_2, x_3, x_4	$0.1441x_1-0.0560x_2-0.0017x_3-0.3369x_4$
5.	x_1, x_2, x_3, x_5	$0.1967x_1-0.0523x_2-0.0021x_3+0.0863x_5$
6.	x_1, x_2, x_3, x_4, x_5	$0.1476x_1-0.0553x_2-00.0081x_3-0.3870x_4-0.0990x_5$

Tables 12, 13, 14, 15, 16 and 17 give particulars of the combinations along with the estimates of selection indices and rank correlation coefficients.

When number of seeds per pod taken with yield and pod length taken with yield for the estimation of selection index, the maximum rank correlation coefficient of 1 is obtained (Tables 12 and 13).

Table 12. Estimates of selection index. Characters - yield and number of seeds per pod.

Varie-ties	Selection index	Ranking according to	
		Yield	Selection index
V_1	2.1583	12	12
V_2	2.2925	9	9
V_3	2.1302	14	14
V_4	2.6785	3	3
V_5	2.6751	2	2
V_6	2.1296	13	13
V_7	2.4162	7	7
V_8	2.2744	11	11
V_9	2.3101	8	8
V_{10}	3.6377	1	1
V_{11}	2.6102	4	4
V_{12}	2.4913	5	5
V_{13}	2.4616	6	6
V_{14}	2.0796	15	15
V_{15}	2.2659	10	10

$r = 1$

Table 13. Estimates of selection index. Characters - yield and pod length

Varieties	Selection index	Ranking according to Yield	Ranking according to Selection index
V_1	1.2531	12	12
V_2	1.3275	9	9
V_3	1.2298	14	14
V_4	1.5441	3	3
V_5	1.6612	2	2
V_6	1.2554	13	13
V_7	1.3900	7	7
V_8	1.3196	11	11
V_9	1.3414	8	8
V_{10}	2.0963	1	1
V_{11}	1.5024	4	4
V_{12}	1.4351	5	5
V_{13}	1.4322	6	6
V_{14}	1.2014	15	15
V_{15}	1.3233	10	10
			$r = 1$

When yield, number of seeds per pod and pod length are taken together for constructing selection index a rank correlation coefficient of 0.9657 is obtained (Table 14).

Table 14. Estimates of selection index. Characters - yield, number of seeds per pod and pod length

Varieties	Selection index	Ranking according to Yield	Ranking according to Selection index
V_1	1.1438	12	13
V_2	1.2368	9	8
V_3	1.1597	14	12
V_4	1.4747	3	3
V_5	1.5618	2	2
V_6	1.1387	13	14
V_7	1.3391	7	7
V_8	1.2186	11	11
V_9	1.2349	8	9
V_{10}	2.0214	1	1
V_{11}	1.4457	4	4
V_{12}	1.3742	5	5
V_{13}	1.3567	6	6
V_{14}	1.1292	15	15
V_{15}	1.2322	10	10
			r = 0.9857

Inclusion of yield with number of seeds per pod, pod length and plant height, resulted in a rank correlation coefficient of 0.7642 (Table 15).

Table 15. Estimates of selection index. Characters - yield, number of seeds per pod, pod length and plant height

Varieties	Selection index	Ranking according to Yield	Ranking according to Selection index
V_1	-34.4288	12	8
V_2	-26.2257	9	12
V_3	-25.0865	14	14
V_4	-38.8045	3	1
V_5	-36.6152	2	4
V_6	-23.7334	13	15
V_7	-29.5986	7	9
V_8	-29.2412	11	10
V_9	-34.6463	8	7
V_{10}	-38.0129	1	3
V_{11}	-34.9771	4	6
V_{12}	-27.4005	5	11
V_{13}	-38.6507	6	2
V_{14}	-26.0650	15	13
V_{15}	-36.2252	10	15
			$r = 0.7642$

When yield, number of seeds per pod, pod length and number of branches were considered together, in the formulation of selection index a rank correlation coefficient of 0.6570 is obtained (Table 16).

Table 16. Estimates of selection index. Characters - Yield, number of seeds per pod, pod length and number of branches

Varieties	Selection index	Ranking according to Yield	Ranking according to Selection index
V_1	1.0896	12	15
V_2	1.1807	9	13
V_3	1.1079	14	14
V_4	2.3878	3	4
V_5	2.6072	2	2
V_6	1.9659	13	10
V_7	2.1234	7	8
V_8	1.9572	11	11
V_9	2.1520	8	7
V_{10}	3.1222	1	1
V_{11}	2.4138	4	3
V_{12}	2.0829	5	9
V_{13}	2.3444	6	5
V_{14}	1.7006	15	12
V_{15}	2.1561	10	6
			r = 0.6570

Inclusion of yield, seeds per pod, pod length, plant height and number of branches together, i.e. maximum number for the combination, a decrease in rank correlation coefficient (r = 0.7250) is observed (Table 17).

Table 17. Estimates of selection index. Characters - yield, number of seeds per pod, pod length, plant height and number of branches

Varieties	Selection index	Ranking according to Yield	Ranking according to Selection index
V_1	-39.6185	12	6
V_2	-30.2064	9	12
V_3	-29.8131	14	13
V_4	-43.5805	3	1
V_5	-40.9125	2	4
V_6	-26.3484	13	15
V_7	-33.1496	7	9
V_8	-32.7765	11	10
V_9	-38.7849	8	8
V_{10}	-42.4795	1	3
V_{11}	-39.1239	4	7
V_{12}	-30.7088	5	11
V_{13}	-43.3144	6	2
V_{14}	-29.2159	15	14
V_{15}	-40.5928	10	15
			r = 0.7250

Path coefficient analysis

For assessing the absolute contribution of each component towards yield, path coefficient analysis was also done. The characters included in the analysis are yield (y), number of pods per plant (x_1), number of seeds per pod (x_2), pod length (x_4), plant height (x_6) and number of branches (x_7). Seven different combinations of the six above characters were analysed for path coefficients. The direct and indirect effects of the components belonging to each of the combinations are presented in Tables 18, 19, 20, 21, 22, 23 and 24.

The findings of the analysis are diagramatically presented in Figures 3, 4, 5, 6, 7, 8 and 9 in which the causal scheme with the values for the path coefficients and correlation coefficients are illustrated.

As shown in Table 18 pod length (x_4) has highest and positive direct effect (0.8757) on yield, while number of seeds per pod (x_2) shows negative direct effect (-0.0022).

Table 18. Direct and indirect effects of two yield component characters on seed yield

Characters	Direct effect on seed yield	Indirect effect on seed yield via		Total corre-lation
		Number of seeds per pod	Pod length	
Number of seeds per pod	-0.0022	..	0.7398	0.7376
Pod length	0.8757	-0.0019	..	0.8738

Number of pods per plant (x_1), number of seeds per pod (x_2) and pod length (x_4) caused direct effect on seed yield (Table 19). Among these pod length showed the highest direct effect (0.5121) followed in order by number of pods per plant (0.3626) and number of seeds per pod (0.3121).

Table 19. Direct and indirect effects of three yield component characters on seed yield

Characters	Direct effect on seed yield	Indirect effect on seed yield via			Total corre-lation
		Number of pods per plant	Number of seeds per pod	Pod length	
Number of pods per plant	0.3626	..	-0.0062	0.1385	0.4949
Number of seeds per pod	0.3121	-0.0072	..	0.4327	0.7376
Pod Length	0.5121	0.0980	0.2637	..	0.8738

Figure 3

y = Seed yield per plant

x_2 = Number of seeds per pod

x_4 = Length of pod

Figure 4

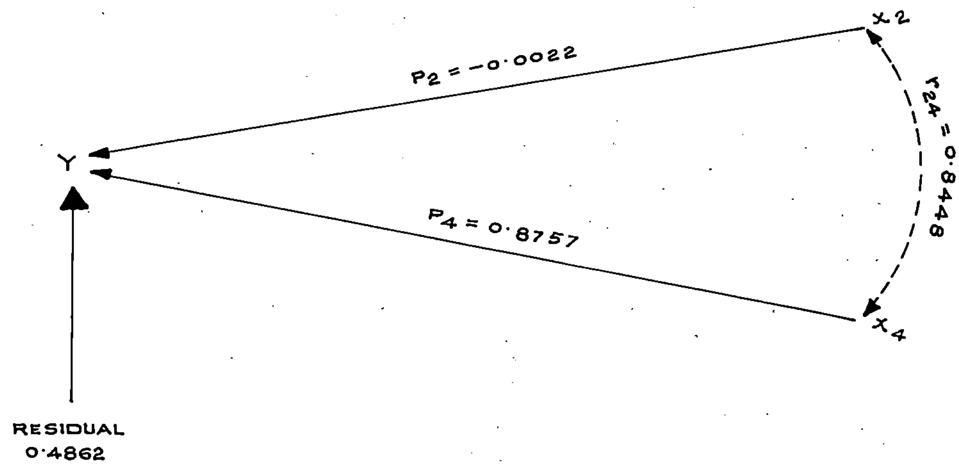
y = Seed yield per plant

x_1 = Number of pods per plant

x_2 = Number of seeds per pod

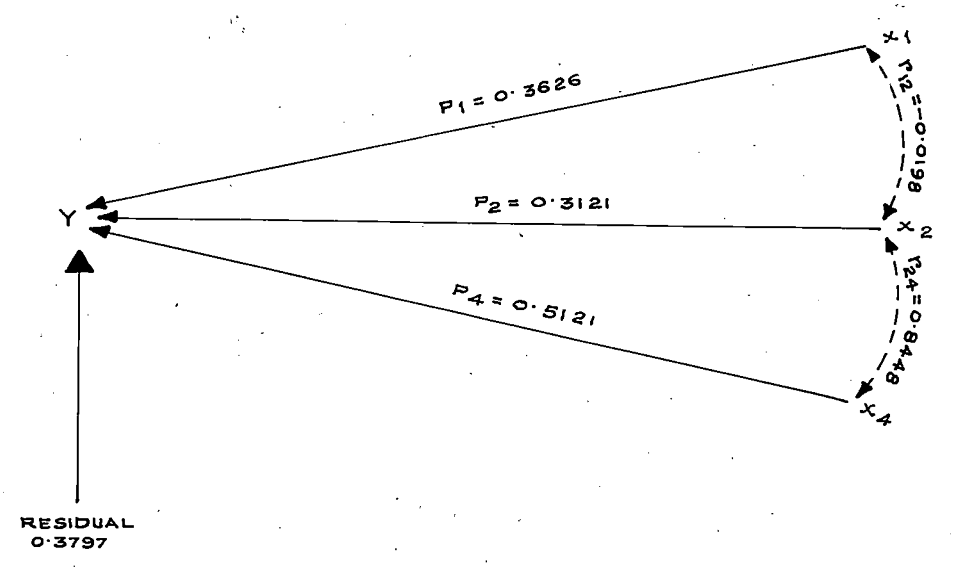
x_4 = Length of pod

FIG.3. PATH DIAGRAM OF YIELD AND TWO YIELD COMPONENTS IN HORSE GRAM.



UNIDIRECTIONAL ARROWS INDICATE THE DIRECT PATH COEFFICIENTS AND THE BI-DIRECTIONAL ARROWS INDICATE THE CORRELATION COEFFICIENTS.

FIG.4. PATH DIAGRAM OF YIELD AND THREE YIELD COMPONENTS IN HORSE GRAM.



UNIDIRECTIONAL ARROWS INDICATE THE DIRECT PATH COEFFICIENTS AND THE BI-DIRECTIONAL ARROWS INDICATE THE CORRELATION COEFFICIENTS.

Number of branches (x_7) has high direct effect (0.4692) than number of seeds per pod (x_4) (0.4426) as seen from Table 20.

Table 20. Direct and indirect effects of two yield component characters on seed yield

Characters	Direct effect on seed yield	Indirect effect on seed yield via		Total corre-lation
		Number of seeds per pod	Number of branches	
Number of seeds per pod	0.4426	..	0.2950	0.7376
Number of branches	0.4692	0.2783	..	0.7475

Table 21 shows that of the three yield components number of seeds per pod (x_2), pod length (x_4) and number of branches (x_7), pod length showed maximum and positive direct effect (0.7127) on yield followed by number of branches (0.2402). Number of seeds per pod showed negative direct effect (-0.0156) on yield.

Table 21. Direct and indirect effects of three yield component characters on seed yield

Characters	Direct effect on seed yield	Indirect effect on seed yield via			Total corre-lation
		Number of seeds per pod	Pod length	Number of branches	
Number of seeds per pod	-0.0156	..	0.6022	0.1510	0.7376
Pod length	0.7127	-0.0151	..	0.1742	0.8736
Number of branches	0.2402	-0.0098	0.5171	..	0.7475

Figure 5

y = Seed yield per plant

x_2 = Number of seeds per pod

x_7 = Number of branches

Figure 6

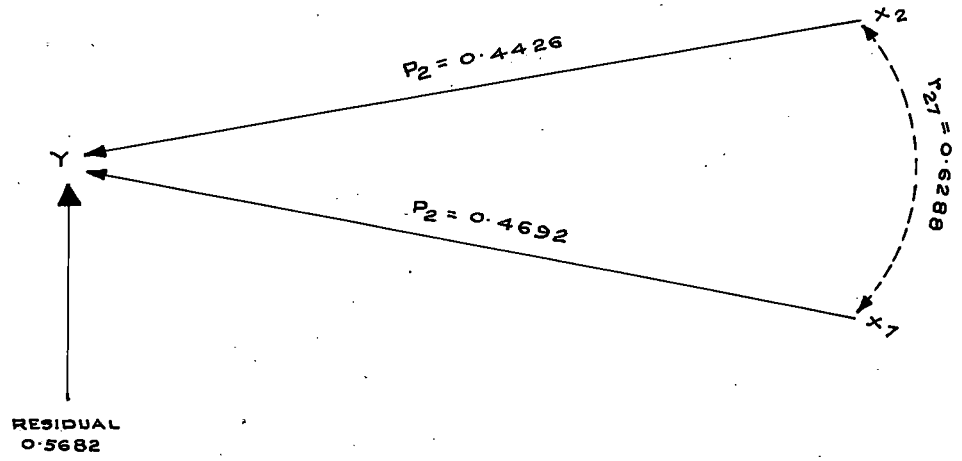
y = Seed yield per plant

x_2 = Number of seeds per pod

x_4 = Length of pod

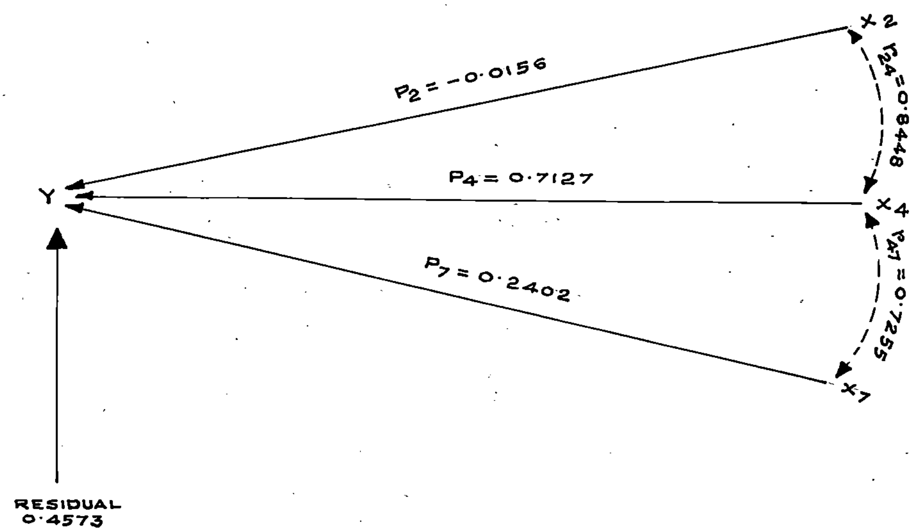
x_7 = Number of branches

FIG. 5. PATH DIAGRAM OF YIELD AND TWO YIELD COMPONENTS IN HORSE GRAM.



UNIDIRECTIONAL ARROWS INDICATE THE DIRECT PATH COEFFICIENTS AND THE BI-DIRECTIONAL ARROWS INDICATE THE CORRELATION COEFFICIENTS.

FIG. 6. PATH DIAGRAM OF YIELD AND THREE YIELD COMPONENTS IN HORSE GRAM.



UNIDIRECTIONAL ARROWS INDICATE THE DIRECT PATH COEFFICIENTS AND THE BI-DIRECTIONAL ARROWS INDICATE THE CORRELATION COEFFICIENTS.

As manifested in Table 22, pod length (x_4) has highest direct effect (0.8257) on yield, followed by plant height (x_3) (0.3749). Number of seeds per pod (x_2) has negative direct effect (-0.1722) on seed yield.

Table 22. Direct and indirect effects of three yield component characters on seed yield

Characters	Direct effect on seed yield	Indirect effect on seed yield via			Total corre-lation
		Number of seeds per pod	Pod length	Plant height	
Number of seeds per pod	-0.1722	..	0.6976	0.2122	0.7376
Pod length	0.8257	-0.1455	..	0.1956	0.8758
Plant height	0.3749	-0.0976	0.4269	..	0.7039

Out of the four yield components (Table 29), pod length (x_4) has highest positive direct effect (0.5975) followed by plant height (x_6) (0.2538) number of pods per plant (x_1) (0.2435) and number of seeds per pod (x_2) (0.0938).

Table 23. Direct and indirect effects of four yield component characters on seed yield

Characters	Direct effect on seed yield	Indirect effect on seed yield via				Total corre-lation
		Number of pods per plant	Number of seeds per pod	Pod length	Plant height	
Number of pods per plant	0.2435	..	-0.0019	0.1616	-0.0917	0.4949
Number of seeds per pod	0.0938	-0.0048	..	0.5048	0.1438	0.7376
Pod length	0.5975	0.0658	0.0792	..	0.1315	0.8738
Plant height	0.2538	0.0879	0.0551	0.3090	..	0.7038

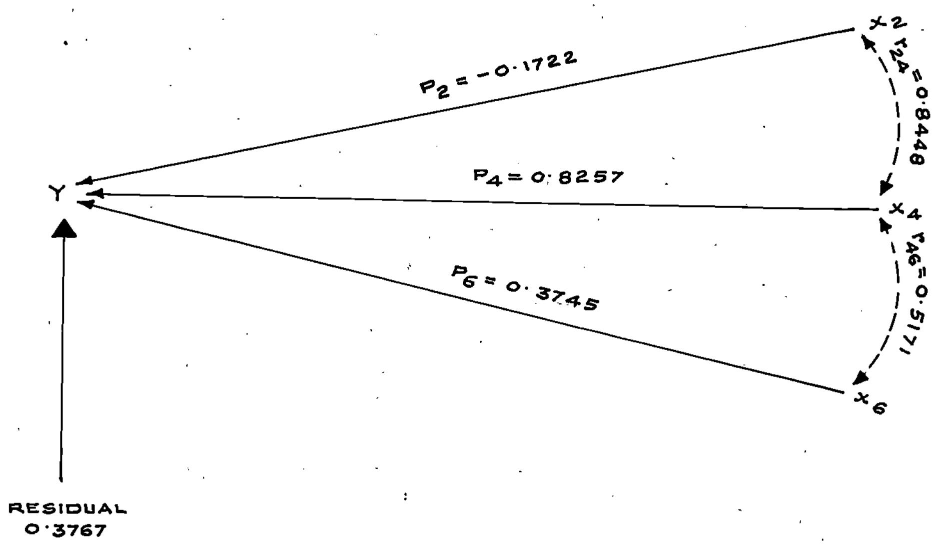
Figure 7

y	=	Seed yield per plant
x_2	=	Number of seeds per pod
x_4	=	Length of pod
x_6	=	Height of plant

Figure 8

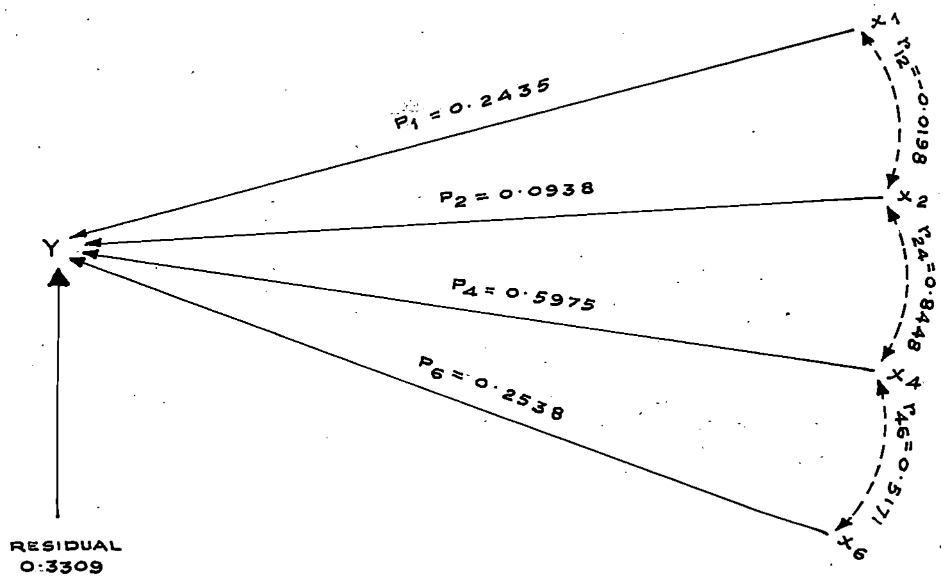
y	=	Seed yield per plant
x_1	=	Number of pods per plant
x_2	=	Number of seeds per pod
x_4	=	Length of pod
x_6	=	Height of plant

FIG. 7. PATH DIAGRAM OF YIELD AND THREE YIELD COMPONENTS IN HORSE GRAM.



UNIDIRECTIONAL ARROWS INDICATE THE DIRECT PATH COEFFICIENTS AND THE BI-DIRECTIONAL ARROWS INDICATE THE CORRELATION COEFFICIENTS.

FIG. 8. PATH DIAGRAM OF YIELD AND FOUR YIELD COMPONENTS IN HORSE GRAM.



UNIDIRECTIONAL ARROWS INDICATE THE DIRECT PATH COEFFICIENTS AND THE BI-DIRECTIONAL ARROWS INDICATE THE CORRELATION COEFFICIENTS.

Figure 9

y = Seed yield per plant

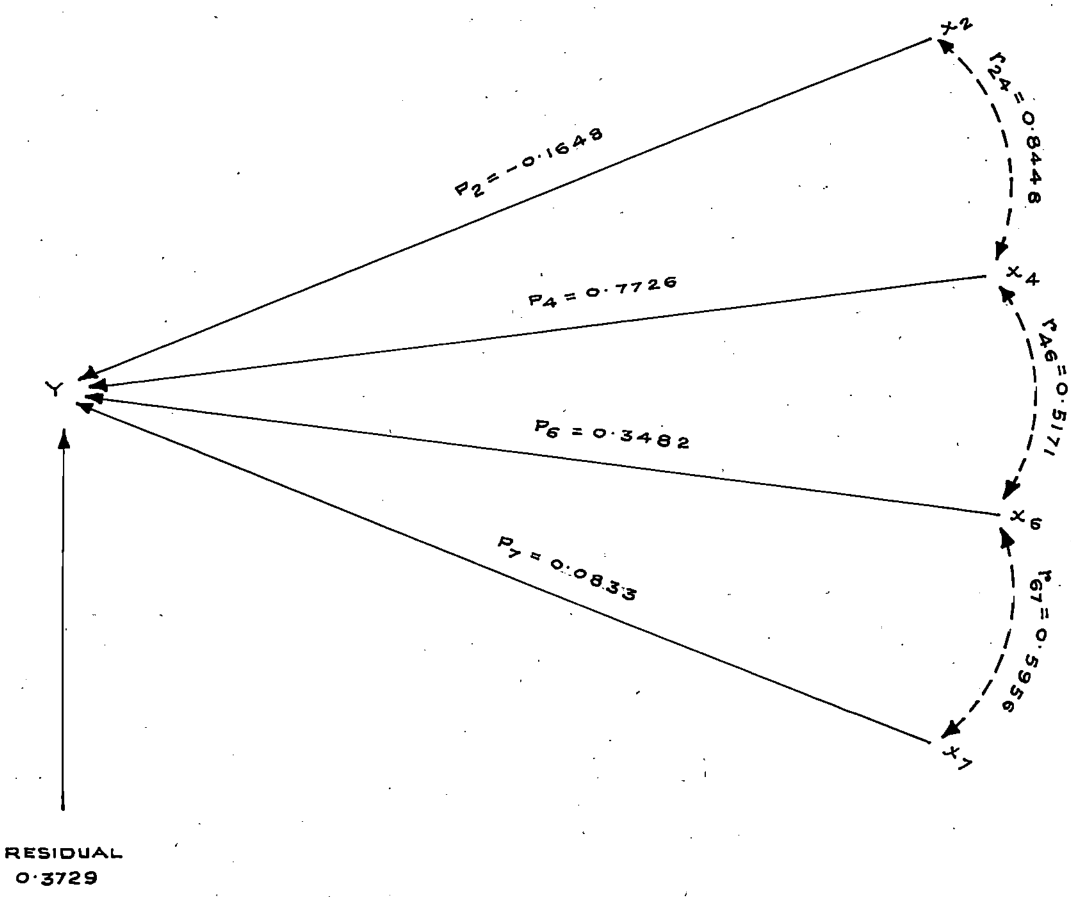
x_2 = Number of seeds per pod

x_4 = Length of pod

x_6 = Height of plant

x_7 = Number of branches

FIG. 9. PATH DIAGRAM OF YIELD AND FOUR YIELD COMPONENTS IN HORSEGRAM.



UNIDIRECTIONAL ARROWS INDICATE THE DIRECT PATH COEFFICIENTS AND THE BI-DIRECTIONAL ARROWS INDICATE THE CORRELATION COEFFICIENTS.

Pod length (x_4) contributed highest positive direct effect of 0.7726 (Table 24) followed by plant height (x_6) (0.3482) and number of branches (x_7) (0.0833). The direct effect of number of seeds per pod (x_2) is negative (-0.1648).

Table 24. Direct and indirect effect of four yield component characters on seed yield

Characters	Direct effect on seed yield	Indirect effect on seed yield via				Total corre-lation
		Number of seeds per pod	Pod length	Plant height	Number of branches	
Number of seeds per pod	-0.1648	..	0.6927	0.1975	0.0924	0.7376
Pod length	0.7726	-0.1392	..	0.1800	0.0604	0.6738
Plant height	0.3482	-0.0955	0.3995	..	0.0496	0.7038
Number of branches	0.0833	-0.1036	0.5604	0.2074	..	0.7475

DISCUSSION

DISCUSSION

Attempts to increase seed yield have been very meagre in horse gram and for such studies information on the inheritance of components related to yield will be very valuable. This involves an understanding of the relevant characters which have direct and indirect effects on seed yield and the expression of these attributes in relation to seed production. The present study has been undertaken to assess the importance of the different quantitative characters which control seed yield as evidenced from an evaluation of fifteen distinctly different varieties of horse gram. The results are discussed here under.

In the light of the analysis of variance (Table 3), it is observed that the varieties differed significantly from each other in respect of the following nine quantitative characters.

(1) Seed yield per plant (y)

(2) Number of pods per plant (x1)

(3) Number of seeds per pod (x2)

(4) 100-seed weight (x3)

(5) Length of pod (x4)

(6) Days to 50% flowering (x5)

(7) Height of plants (x6)

(8) Number of branches (x7)

(9) Days to maturity (duration) (x8).

The mean values for the nine variables in the fifteen varieties were worked out separately and the results are presented in Table 2. The different varieties recorded varying mean values for the characters studied in the specific environmental conditions of Vellayani during the September-January season.

(1) Seed yield per plant (Y). The highest seed yield (11.2956 g) was recorded by the variety Pattambi local (V_{10}) followed by Paravur local (V_5) (8.9771 g).

(2) Number of pods per plant (x1). The maximum number of pods was recorded by the variety S.N.P. (V_7) (79.4666) followed by V_{10} (68.8000).

(3) Number of seeds per pod (x2). The variety V_{10} exhibited the maximum of 5.3163 closely followed by V_5 with 5.0333.

(4) 100-seed weight (x3). 100-seed weight was maximum for varieties Balaramapuram local (V_1) and HPK-1 (V_3) (3.7000 g each).

(5) Length of pod (x4). V_5 exhibited the maximum length of 5.1000 cm followed by V_1 with a length of 4.6666 cm.

(6) Days to 50 per cent flowering (x5). Days to 50 per cent flowering was highest for the variety PRS-9 (V_9) (71.6666) and lowest for HPK-6 (V_6) (25.3333).

(7) Height of plant (x6). Variety Mecharishore (V_4) showed a mean height of 118.0000 cm very closely followed by JHD-1 (V_{13}) with a height of 117.3000 cm.

(8) Number of branches (x7). V_{10} exhibited the maximum number of branches (13.4533) followed by V_5 (12.6333).

(9) Days to maturity (duration) (x8). Duration was highest for V_9 (115.6666) and lowest for V_6 (68.3333).

Considering the mean values for the nine characters shown by the fifteen different varieties, Pattambi local appeared the best with maximum values for seed yield and two yield component characters i.e. number of seeds per pod and number of branches. It is followed by variety Paravur local.

Correlation studies.

The overall variation, in general is recognized as the sum total of variations due to genetic causes, environmental effect and the gene environment interaction.

The genotypic, environmental and phenotypic variances for the nine characters were studied. The genotypic coefficient of variation is highest for days to 50 per cent flowering (35.0722) followed by days to maturity (18.6641) (Table 4). It is lowest for 100-seed weight (6.9459). Environmental coefficient of variation is highest for yield (Y) (13.8698) closely followed by number of pods per plant (x1) (13.1414). It is lowest for 100 seed weight (0.0430). Phenotypic coefficient of variation is highest for days to 50 per cent flowering (35.1161) and lowest for 100-seed weight (6.9460). It is not possible to estimate heritable variation with the help of genetic coefficient of variation alone. Burton (1952) had suggested that genetic coefficient of variation together with heritability estimates would give the best picture of the amount of advance to be expected by selection. The computation of the percentage value for heritability in the broad sense, from the values for the partitioned variance indicate that the value is maximum for 100-seed weight (99.9963) closely followed by days to maturity (99.7777), days to 50 per cent flowering (99.7502) and pod length (x4) (99.1455). Singh and Mehndiratta (1969) in cowpea, Gupta et al. (1972) in gram, Tomar Singh et al. (1973) in bengal gram and Shivashankar et al. (1977) in horse gram recorded high heritability values for 100-seed weight. Srivastava et al. (1972) recorded high heritability for days to flowering and pod length in green gram. Soundrapandian et al. (1975) recorded high heritability for pod length in black gram. The lowest per cent value for heritability is observed for seed yield per plant (Y) (49.3912). Yield which exhibited wide range of variability at the intervarietal level shows the minimum value for heritability and this confirms that this character is highly complex and involves influence of several conditions created by genic and non-genic causes. Similar results have been observed by Oyone (1968) in field beans, Kornano and Singh (1974) in pea and Shivashankar et al. (1977) in horse gram. High heritability estimates indicate the effectiveness of selection based on good phenotypic performance but does not necessarily mean a high genetic gain for a particular trait. Johnson et al. (1955) pointed out that high heritability estimates along with high genetic advance were more useful than the heritability values alone in predicting the resultant effect for selecting the best individual. High heritability and high genetic advance indicate the presence of additive gene effects. Genetic advance has also been estimated for all characters. The value of genetic advance for days to 50 per cent flowering is highest (72.1579) followed by days to maturity (39.4024). It is lowest for 100-seed weight (14.3073). Days to 50 per cent flowering shows higher heritability associated with higher genetic advance.

For a better understanding of the interrelationship of yield and its components, genotypic correlation coefficients have been calculated as well as environmental and phenotypic correlation coefficients and the results are presented in Tables 8, 9 and 10. In general, the genotypic correlations are higher than phenotypic and environmental correlations in a fairly large number of combinations studied. This indicates an inherent association between various characters. Similar results were recorded by Singh and Singh (1969) in field pea, Singh and Malhotra (1970) in mung bean, Joshi (1971) in Indian beans, Kaw and Menon (1972) in soybean and Orson et al. (1977) in chick pea.

It is evident from Table 8 that yield (Y) bears a significantly positive association with number of pods per plant (x1) (0.4949), number of seeds per pod (x2) (0.7376), pod length (x4) (0.8758), plant height (x6) (0.7038) and number of branches (x7) (0.7475). Of this pod length shows the highest correlation with yield. However, the association of yield with 100-seed weight (x3) though significant is negative (-0.4650). The negative association of yield and seed weight is already observed by Chaudhary and Singh (1974) in soybean and Khan and Chaudhary (1975) in gram. Days to 50 per cent flowering (x5) and days to maturity (x8) do not show significant association with yield.

When intercorrelations among the eight characters (x1——x8) are considered number of pods per plant bears significant but negative association with 100-seed weight (-0.4035) and with all other characters it shows no significant correlations.

Number of seeds per pod bears highest and positive association with pod length (0.8448). It also bears significant and positive association with plant height (0.5667) and number of branches (0.6208).

100-seed weight shows no significant association with any of the yield components.

Pod length shows significant and positive association with plant height (0.5171) and number of branches (0.7255).

Days to 50 per cent flowering exhibits positive and significant association with plant height (0.8641), number of branches (0.4931) and days to maturity (0.9882).

Plant height bears positive and significant relationship with number of branches (0.5956) and days to maturity (0.5789).

Number of branches shows significant and positive association with days to maturity (0.4739).

It can be concluded from the correlation studies that the associations of yield with number of seeds per pod, pod length, plant height and number of branches are strongly significant (at 1% level). Of these pod length shows the maximum correlation with yield followed by number of branches, number of seeds per pod and plant height. Intercorrelations among these four characters are also positive and significant. Agarwal and Kang (1976) recorded significant correlation between yield and pod length as well as plant height and number of branches in horse gram. Shivashankar et al. (1977) also recorded positive correlation of yield with plant height and number of seeds per pod in the same crop.

Discriminant function studies.

Discriminant function technique (Fisher, 1936 and Smith, 1936) helps in computing selection indices for seed yield. Six models using various combinations of yield and its components were tried.

When number of seeds per pod (x2) is taken with yield (x1) or pod length (x3) taken with yield (x1) for the computation of selection index, the maximum rank correlation coefficient of 1 is obtained (Tables 12 & 13). This indicates that these two characters when individually taken along with yield would form the best selection index.

It is found that when more number of combinations are included with yield for the computation of selection index, it confuses the issue and so it is not easy to exercise the selection with convenience.

For example, when yield (x1), number of seeds per pod (x2) and pod length (x3) are taken together with yield, a rank correlation coefficient of 0.9357 is obtained (Table 14). But when number of seeds per pod and pod length are individually taken with yield, the maximum rank correlation coefficient of 1 is obtained and this gives the best index rather than the two in combination with yield.

When yield (x1), number of seeds per pod (x2), pod length (x3) and plant height (x4) are taken together a rank correlation coefficient of 0.7642 is noticed (Table 15).

A rank correlation coefficient of 0.8570 is obtained, when yield (x1), number of seeds per pod (x2), pod length (x3) and number of branches (x5) are taken together in the formulation of selection index (Table 16). Here also, like the above table (Table 15) four characters are included, but instead of plant height (x4) here number of branches (x5) is included. So when, number of branches is taken along with the other three components an increase in rank correlation coefficient over the above combination is obtained, indicating that this character has more effect on yield in combination with the other three characters.

When the number of combinations are maximum (Table 17) i.e. five characters, including yield (x1), number of seeds per pod (x2), pod length (x3), plant height (x4) and number of branches (x5), the lowest rank correlation coefficient is noticed (0.7250). When the number of combinations are increased a decrease in 'r' value is noticed. This shows that when number of characters which are considered together increases, the ease and accuracy with which selection may be effected decreases.

The observations can be summarised as follows:-

Sl.No.	Combinations	Rank correlation coefficient
1.	x1, x2	1
2.	x1, x3	1
3.	x1, x2, x3	0.9857
4.	x1, x2, x3, x4	0.7642
5.	x1, x2, x3, x5	0.8570
6.	x1, x2, x3, x4, x5	0.7250

It may be concluded that number of seeds per pod (x2) and pod length (x3) which show the strongest association with yield (x1) are to be given major importance in the selection for yield, since these two characters individually taken along with yield formed the best index. Hazel (1943) suggested that selection based on a suitable index was highly efficient. Goulden (1959) believes that the discriminant function would ensure a maximum concentration of the desired genes in the plants or in the lines selected.

So for making considerable improvement in seed yield in horse gram it is suggested that due importance must be given to number of seeds per pod and length of pod.

Path analysis

The path analysis method (Wright, 1921), further helps us not only in revealing in absolute terms the relationship between yield and its components, but also helps in estimating more or less accurately the direct effect of each of the causes and the indirect effect that each of them contributes through other components in the final causation of the effect.

Direct and indirect effects of number of seeds per pod (x2) and pod length (x4) were computed (Table 18). Of this pod length showed the highest direct effect on seed yield. But its indirect effect through number of seeds per pod is negative and low. The direct effect of number of seeds per pod is also negative, while its indirect effect through pod length is positive. This indicates that pod length which has a high direct effect on yield is the important character to be considered during selection. Also a character like number of seeds per pod which has only a low and negative direct effect but a high positive indirect effect, should not be completely ignored because it also controls the final yield through other character.

In the second combination of number of pods per plant (x1), number of seeds per pod (x2) and pod length (x4), pod length showed the highest and positive direct effect on yield (Table 19). Its indirect effect through number of pods per plant and number of seeds per pod are also positive. Next to pod length, number of pods per plant shows positive direct effect. Here its indirect effect through number of seeds per pod is negative and very low, while its indirect effect through pod length is positive and high. Number of seeds per pod showed the lowest direct effect in this combination and its indirect effect through number of pods per plant is negative and low. But its indirect effect through pod length is positive and high. It can be seen from the table that pod length has high and positive direct effect on seed yield with number of pods per plant as well as with number of seeds per pod. Also these two latter characters show positive and high indirect effect through pod length.

From Table 20 it is evident that when number of seeds per pod (x2) and number of branches (x7) are taken together for path coefficients, number of branches showed higher and positive direct effect on seed yield. Its indirect effect through number of seeds per pod is also positive. Likewise the direct effect of number of seeds per pod and its indirect effect through number of branches are positive.

It can be seen from Table 21 that when number of seeds per pod (x2), pod length (x4) and number of branches (x7) are taken together for the computation of direct and indirect effects, pod length showed the maximum and positive direct effect. Its indirect effect through number of branches is positive, while through number of seeds per pod is negative. Next to pod length, number of branches showed positive direct effect. Its indirect effect through pod length is positive and high but through number of seeds per pod, it is negative and very low. The direct effect of number of seeds per pod is negative here, while its indirect effect through pod length and number of branches is positive, showing that it influences yield indirectly only through other characters.

When number of seeds per pod (x2), pod length (x4) and height of plant (x6) were included in the path coefficient analysis (Table 22), pod length showed the highest and positive direct effect on seed yield, followed by height of plant. The indirect effect of pod length through number of seeds per pod is negative and through height of plant it is positive. The indirect effect of height of plant through pod length is positive and high while its effect through number of seeds per pod is negative. Number of seeds per pod showed negative direct effect on yield, but its indirect effect through pod length and height of plant was positive. These observations confirm that pod length is a stable character that shows a constant positive and high direct effect on seed yield. The character plant height also shows positive direct effect second only to that of pod length.

It is evident from Table 23 that out of the four characters number of pods per plant (x1), number of seeds per pod (x2), pod length (x4) and plant height (x6), pod length showed maximum and positive direct effect. Its indirect effect through number of pods per plant, number of seeds per pod and height of plant is positive. Next to pod length, plant height, number of pods per plant and number of seeds per pod respectively showed positive direct effects. The indirect effect of plant height through number of pods per plant, number of seeds per pod and pod length is positive, of which the effect through pod length is maximum. The indirect effect of number of pods per plant through pod length and plant height is positive, while its effect through number of seeds per pod is negative. The indirect effect of number of seeds per pod through pod length and plant height is positive, while its effect through number of pods per plant is negative. Here also pod length showed maximum effect on seed yield followed by plant height.

When path coefficients were calculated for number of seeds per pod (x2), pod length (x4), plant height (x6) and number of branches (x7) (Table 24), pod length showed maximum and positive direct effect on seed yield, followed by plant height, and number of branches. The direct effect of number of seeds per pod is negative. The indirect effect of pod length through plant height and number of branches is positive, while its effect through number of seeds per pod is negative. The indirect effect of number of seeds per pod through pod length, plant height and number of branches is positive. The indirect effect of number of branches through pod length and plant height is positive but its effect through number of seeds per pod is negative.

The observations can be summarised as follows:-

Sl. No.	Combinations	Character exercising maximum direct effect on yield	Direct effect of the character	Coefficient of determination (%)
1.	x2, x4	x4	0.8757	76.3509
2.	x1, x2, x4	x4	0.5121	85.5827
3.	x2, x7	x7	0.4692	67.7148
4.	x2, x4, x7	x4	0.7127	79.0876
5.	x2, x4, x6	x4	0.8257	85.8097
6.	x1, x2, x4, x6	x4	0.5975	89.0505
7.	x2, x4, x6, x7	x4	0.7726	86.0945

It is interesting to note that the character pod length (x4) when compared with other characters, showed the highest and positive direct effect on seed yield in all the combinations in which it was included. This finding is supported by the correlation studies also, since pod length showed the highest correlation with seed yield. It performed consistently in all the combinations, indicating the stable nature of its effect on seed yield and therefore it can be taken as the most important yield contributing character in horse gram. Similar results were recorded for this character by Giriraj and Vijayakumar (1974) in mung bean and Sandhu et al. (1980) in Urd bean.

The character plant height was included in three combinations and in all three it showed a direct positive effect second only to that of pod length. The indirect effects of the other characters through plant height is also high and positive. Hence this character has a secondary importance as an yield contributing character. Giriraj and Vijayakumar (1974) in mung bean and Soundrapandian et al. (1976) in black gram recorded similar results.

A comparison of the different path analysis models reveals that models containing x2 (number of seeds per pod), x4 (pod length) and x6 (plant height) give high values of coefficient of determination, thereby assuring that a major portion of the variability has been accounted for. Further increase in the number of factors do not give substantial increase in accuracy.

To conclude, the present study clearly brings out the importance of the characters pod length and number of seeds per pod in determining seed yield. Pod length with seed yield and number of seeds per pod with seed yield recorded the best index in discriminant function analysis by showing a rank correlation coefficient of 1. Pod length appears to be the best yield contributing character on the basis of genotypic correlation coefficients and path analysis studies. Path analysis also indicates that the character plant height exercises consistently high influence on yield and is second in importance only to pod length in this respect. Hence it is suggested that the characters pod length, number of seeds per pod and plant height may be taken as the best criteria for selecting a high yielding plant type in horse gram.

SUMMARY

SUMMARY

The present biometric study was carried out in the College of Agriculture, Vellayani during the year 1979-80 with fifteen varieties of horse gram (<u>Dolichos biflorus</u> L.)* to formulate a suitable selection index for yield.

The observation plants were studied individually for the following characters.

(1) Seed yield per plant
(2) Number of pods per plant
(3) Number of seeds per pod
(4) 100-seed weight
(5) Pod length
(6) Days to 50% flowering
(7) Height of plant
(8) Number of branches
(9) Days to maturity (duration).

The data obtained in the study were subjected to statistical analysis viz. estimates of mean for all the different varieties, analysis of variance in respect of the nine selected characters, estimates of components of variances, genotypic, environmental and phenotypic coefficients of variations, heritability, genetic advance and studies of discriminant function and path coefficient analysis.

Considering the mean values shown by the fifteen different varieties, Pattambi local (V_{10}) appeared the best

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*Syn. <u>Vigna</u> <u>unguiculata</u> (L.) Walp.sub.sp. <u>unguiculata</u>

variety with maximum values for seed yield and two yield component characters i.e. number of seeds per pod and number of branches.

For all the nine characters studied, the fifteen varieties exhibited significant differences.

Components of variances, genetic parameters - heritability and genetic advance and correlation coefficients were calculated with a view to assess the relative importance of the different characters in the final expression of yield of seed. Days to 50 per cent flowering showed high heritability and genetic advance suggesting additive gene effects. Pod length exhibited maximum genotypic correlation with seed yield indicating that during selection for better seed yielding types this character should be given maximum importance.

Discriminant function technique was adopted for the construction of suitable selection indices for seed yield using six different combinations of yield components with seed yield. Of these the one based on yield with number of seeds per pod and another based on yield with pod length were found to be equal in effect and more advantageous than all others. Hence these characters in combination with seed yield can form the best index for selection for yield.

The path coefficient analysis was carried out for the calculation of the direct and indirect effects for seven different combinations of yield components and it has been found that pod length exhibited maximum direct effect on seed yield in all the combinations in which it was included.

The indirect effect of all the other characters through pod-length was also high and positive in all the combinations. So pod length can be taken as the most important yield contributing character in horse gram.

The character plant height was included in three combinations and in all three it exercised a consistently high influence, which is second only to pod length in this respect. The indirect effect of the other characters through plant height is also high and positive. Hence this character has a secondary importance as an yield contributing character.

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*Originals not seen

ABSTRACT

A biometric analysis on fifteen varieties of horse gram (Dolichos biflorus L.) was conducted in the College of Agriculture, Vellayani during 1979-80. Plant characters like seed yield per plant, number of pods per plant, number of seeds per pod, 100-seed weight, pod length, number of days for 50 per cent flowering, height of plants, number of branches and duration to maturity were studied. Variety Pattambi local, appeared to be the best, considering seed yield and two yield component characters viz., number of seeds per pod and number of branches.

Days to 50 per cent flowering showed high heritability and genetic advance thus suggesting additive gene effects. Pod length exhibited maximum genotypic correlation with seed yield indicating that this character should be given maximum importance during selection for seed yield.

Discriminant function analysis for the construction of selection indices for seed yield using six different combinations revealed that the index based on yield with number of seeds per pod and another based on yield with pod length were equal in effect and more advantageous than all the others.

It was found by path coefficient analysis that the character pod length exhibited maximum direct effect on seed yield in all the combinations in which it was included

and hence its role as the most important yield contributing character is discussed.

The character plant height showed a direct positive effect second only to that of pod length. So it has a secondary importance as an yield contributing character.