GENETIC VARIABILITY AND CORRELATION STUDIES IN WINGED BEAN [*Psophocarpus tetragonolobus* (L) DC]

By
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THESIS
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DECLARATION

I hereby declare that this thesis entitled "Genetic variability and correlation studies in Winged Bean (Psophocarpus tetragonolobus (L) DC)" 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.

Vellanikkara,

31st December, 1984.

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CERTIFICATE

Certified that this thesis entitled "Genetic variability and correlation studies in Winged Bean (*Psophocarpus tetragonolobus* (L) DC)" is a record of research work done independently by Miss. ANCY PHILIP . under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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ANCY PHILIP

CONTENTS

LIST OF TABLES

INTRODUCTION

INTRODUCTION

Among the tropical legumes winged bean has gained much attention in recent years though the crop has been in cultivation in India since long. Masefield (1973) was the first to note the potentialities of this crop. World wide interest, especially as a protein rich and oil yielding crop was generated by the report of the National Academy of Sciences in 1975. The home of winged bean, according to Burkill (1935) is either in Madagascar or Mauritius. However, NAS (1975) has mentioned Papua New Guinea as the primary centre of origin of winged bean, based on the extent of variability present and on knowledge of cultivation of the crop since time immemorial.

Winged bean offers an exceptional promise and shows a great potential for overcoming the protein malnutrition problem throughout the humid tropics. In addition to high protein, its seeds contain sizeable amount of oil, dry matter, potassium, calcium, sodium and phosphorus. Also the tubers have 56 per cent carbohydrate in them. But till to date the crop by and large remains as a secondary backyard crop.

In spite of its importance, the availability of high yielding and superior quality varieties are lacking which in fact necessitates a need-based crop improvement programme. To initiate systematic breeding programme for its improvement, information on genetic variability and correlation among yield and its component characters are of paramount importance. Further, the information on the nature and cause of association among different characters and construction of the selection indices facilitate effective selection. Hence, the present study was aimed with the following objectives:-

(i) To identify the genotypes which are superior for yield and other characters by the analysis of variance technique.

(ii) To find out the extent of genetic variability available for different characters by estimating phenotypic, genotypic and environmental coefficients of variation.

(iii) To study the association between yield and its components and also among themselves by estimating phenotypic, genotypic and environmental correlation coefficients.

(iv) To determine the direct and indirect effects of each component on yield by utilising the path coefficient analysis.

(v) To formulate a reliable selection index by the discriminant function analysis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The biometrical aspects of yield and yield components has been attempted by several workers in pulses. The relevant literature pertaining to such studies in winged bean and the related pulses which are used as vegetable are reviewed under the following titles.

1. Genetic variability
2. Heritability and genetic advance
3. Correlation among polygenic characters
4. Path coefficient analysis
5. Discriminant function analysis

1. Genetic variability

Genetic variability is the basic requirement of any crop improvement programme. Selection of superior varieties would be effective only when major part of the variability of the trait is genetic. Many workers studied the extent of variability in these crops by working out the genotypic and phenotypic coefficient of variation.

Sanghi *et al*. (1964) estimated genotypic and phenotypic variability in cluster bean and observed high values of genetic coefficient of variation for plant height, number of branches and hundred seed weight.

In dolichos bean, Joshi (1971) reported a wide range of phenotypic variability in yield and yield components. Pandey and Dubey (1972) revealed significant differences among the number of seeds per pod, hundred seed weight, protein content and yield.

Seth et al. (1972) reported significant variation among the varieties of french bean for days to flower, primary branch number, average pod weight, pod number per plant and green pod yield per plant. A high genotypic coefficient of variation was observed for primary branch number, average pod length and green pod yield per plant.

High values of variance components and coefficient of variation were associated with clusters per plant, pod length, pod width and yield per plant in cluster bean (Tripathi and Lal, 1975).

Investigations on genetic variability for yield and quantitative characters in pole french bean by Pande et al. (1975) revealed that plant height, days to flower, primary branches, pod length and pods per plant accounted for about 74 per cent of variability in yield.

In dolichos bean, high genetic coefficient of variability was observed for all the characters except number of seeds per pod indicating the predominance of additive gene effects (Singh et al., 1979).

Ramachandran et al. (1980) reported maximum value of genotypic coefficient of variation in yield per plot followed by pods per plant and internodal length in cowpea varieties studied. The lowest value of genotypic coefficient of variation was observed in pod length. The data revealed that major part of the total variation in yield per plot, pods per plant and internodal length were due to genetic causes.

Muthukrishnan et al. (1981) made investigations to assess the extent of variability in winged bean and observed that single pod weight (g) expressed the highest phenotypic and genotypic variability followed by pod yield (g) per plant. Chundawat et al. (1981) observed wide range of phenotypic variation for most of the plant characters in a collection of winged bean introductions. Erskine and Kesavan (1982) observed highly significant differences for green pod yield in winged bean. No significant difference was obtained for number of pode per plant. There was striking variation among pod characters which varied from 9.6 to 18.6 cm in length. Chandel et al. (1981) observed indeterminate types to semispreading types with shorter internodal patterns among winged bean collections from different regions. Much variation was reported in leaf shape, which vary from deltoid, ovate to lanceolate and pod colour from pale green, green, dark green and purplish.

2. Heritability and genetic advance

Burton (1952) suggested that the genotypic coefficient of variation together with heritability estimates would give the best picture of the extent of advance to be expected by selection.

High heritability combined with high genetic advance was reported by Sanghi et al. (1964) in cluster bean, for characters such as plant height, branches per plant, pod length, number of seeds per pod, hundred seed weight and reaction to blight, where as yield and number of pods per plant showed low heritability.

Sohoo et al. (1971) obtained high values of heritability and expected genetic advance in branches per plant, pods per plant and plant height in cluster bean.

In french bean Seth et al. (1972) reported that number of primary branches and average pod length had high heritability, while the heritability estimate was low for average pod yield. High expected genetic advance was found for primary branch numbers, average pod weight and green pod yield per plant.

Pande et al. (1975) reported that the genetic gain expected in french bean was sizeable for plant height, secondary branches and pod yield.

In cluster bean, Tripathi and Lal (1975) observed that clusters per plant, pod length, pod width and yield per plant were highly heritable. The heritability ranging from 48.9 per cent for number of seeds per pod to 98.3 per cent for pod length. Pod length, pod width and yield per plant also had high estimates of genetic advance.

Rajendran et al. (1978) observed that in winged bean, heritability and genetic advance for different characters varied considerably. High heritability for pod length was associated with fairly high genetic gain indicating the presence of additive gene effect.

In lab lab bean, Singh et al. (1979) obtained high genetic coefficient of variability coupled with high heritability and genetic advance for all characters except number of seeds per pod, indicating the predominance of additive gene effects.

The heritability estimate was highest for days to flower followed by days to first harvest and the genetic advance estimated as per cent of mean was maximum for seeds per pod followed by yield per plot and pods per plant in cowpea varieties (Ramachandran et al., 1980).

In a set of winged bean varieties studied by Muthukrishnan et al. (1981), it was observed that heritability genetic advance and genetic advance as percentage of mean were high for pod weight, followed by pod length and pod yield (number) per plant. Chundawat et al. (1981) also reported high genetic coefficient of variation and high expected genetic advance for pods per plant, weight per pod and green pod yield per plant.

Very high heritability was reported for all the characters in cowpea varieties studied by Radhakrishnan and Jebraj (1982). Number of pods and clusters per plant recorded high genetic gain, while days to maturity and plant height registered low genetic gain.

In long bean, Yap (1983) reported that additive gene action was more important than non additive for most of the agronomic traits. Heritability for pod length was high and that for pod yield and seed protein content was low.

3. Correlation among polygenic characters

In a programme of breeding for improving the yield potential of a crop, information on the inter-relationship of yield with other traits is of immense help. This will facilitate selection of suitable high yielding plants through other related components.

In peas, Kohil (1971) reported that plant height, pod length, number of seeds and weight of green seeds per plant were highly and positively correlated with the yield of green pods. Srivastava et al. (1972) revealed significant and positive genotypic correlations between yield and days to flowering, pod length and pod width and pod length and seed number per pod.

The correlation coefficients worked out in french bean by Pande et al. (1975) have revealed that the pod yield was strongly and positively correlated with plant height, primary branches, pod weight, pod length and pods per plant and it was negatively correlated with days to flower.

Kumar et al. (1976) found that pod yield in cowpea was positively associated with branches per plant, pods per plant, pod length, thickness of pod, days to flowering and days taken to maturity.

In winged bean, Sathyanarayana et al. (1978) found positive correlation between green pod yield and number of pods per plant.

In dolichos bean, Singh et al. (1979) observed that genotypic correlations were higher than phenotypic correlations. Yield per plant was positively and significantly associated with fruit length, fruit width and number of seeds per pod. Pandey et al. (1980) observed that yield was very highly and positively correlated with leaflet area, days to flowering, hundred seed weight, pod width and protein content.

Investigations in winged bean by Muthukrishnan et al. (1981) revealed that pod yield was positively correlated with number of fruits and single fruit weight. The single fruit weight was positively correlated with the length of fruit. Chundawat et al. (1981) reported that pod yield was significantly and positively correlated with weight per pod, pod width and pods per plant.

The green pod yield in dolichos bean was significantly and positively correlated with weight of pods, breadth of pod and length of pod. Length of bunch, pods per plant and per cent dry weight of green pods also showed significant positive phenotypic correlation with yield, but were found to be influenced by the environment (Sathyanarayana and Gangadharappa, 1982).

4. Path coefficient analysis

Yield is the endproduct and is the resultant of many complex components, which singly or jointly influence the yield. Selection of these components has been considered more useful as compared to selection of yield *per se* as suggested by several workers. Wright (1921) developed the most potent technique, the path coefficient analysis to understand the extent and nature of direct and indirect effects of the component characters.

Path coefficient analysis employed in cowpea, by Singh and Mehndiratta (1970) have revealed that pods per plant, seeds per pod and hundred seed weight were the most important yield components in cowpea, since they showed significant direct effects on yield.

Path coefficient analysis of yield attributes and pod yield studied by Shettar *et al*. (1975) in snap beans revealed that more weightage has to be given to the number of pods per plant in selection programme since its direct influence on pod yield is very high and its influence on pod yield through pod length is negligible though negative. Direct influence of pod length on pod yield is moderate while indirect influence through pod number is not significant.

In lab lab bean, Singh et al. (1979) reported highest direct path for number of seeds per pod followed by pod width. Indirect effect of fairly high magnitude were also exerted by number of seeds per pod in relation to other yield components. Leaflet area, days to flowering, hundred seed weight, pod width and protein content were reported to have direct effect on yield in dolichos bean by Pandey et al. (1980).

Prakash and Ram (1981) observed that in french bean, the number of green pods per plant contributed its major effect as direct effect and only a negligible effect indirectly. Pod weight had a negligible direct effect on green pod yield, but contributed substantially indirectly through pod length.

Path coefficient analysis conducted by Chundawat et al. (1981) revealed that, in winged bean seed size had the highest direct effect followed by weight per pod, pod width and pods per plant. These traits should therefore be considered for improving the green pod yield in winged bean.

Sathyanarayana and Gangadharappa (1982) employed path coefficient analysis in dolichos bean and concluded that weight of pod exerted high direct effect on green pod yield, followed by length of inflorescence and days to flower. Pods per plant, bunches per plant and per cent dry weight of green pods influenced yield indirectly.

5. Discriminant function analysis

To make effective selection for higher yield, it is necessary to determine the relative efficiency of selection through discriminant function over straight selection.

Sanghi *et al*. (1964) observed that in cluster bean 90 per cent of the variability in yield was accounted for by the variables such as clusters per plant, pods per plant and branches per plant.

Kumar *et al*. (1976) analysed the regression values in cowpea and showed that the clusters per plant, pods per plant and hundred seed weight were the important characters in determining the pod yield.

Prakash and Ram (1981) were of opinion that in french bean green pod number could be considered as an important primary yield component and selection should be primarily for this trait in a breeding programme for higher green pod yield.

MATERIALS AND METHODS

MATERIALS AND METHODS

The investigations were carried out at College of Horticulture, Kerala Agricultural University, Vellanikkara during 1983-84 (July-May). This Station is located at an altitude of 22.25 meters above MSL and situated between 10° 32" N latitude and 76° 10" E longitude.

A. Materials

Thirty two winged bean accessions utilized for the present investigation were selected from the germplasm collection of the Department of Olericulture, College of Horticulture, Vellanikkara. The source and morphological description of the accessions are presented in Table 1.

B. Methods

The experiment was laid out in a randomised block design with three replications. Package of practices recommendations under Kerala conditions is not available for this crop and hence general cultural practices were adopted as described below.

The area was cleared and made in to suitable blocks. Organic manure was uniformly applied basally at the rate of 5 tonnes per hectare. Ridges were taken keeping a spacing of 75 cm between ridges. The seeds

Table 1. Source and morphological description of 32 winged bean accessions

Accession number	Source	Length of internode	Leaf size	Petiole size	Flower colour	Peduncle size	Pod size	Pod shape	Nature of wings	Seed colour	Seed shape	Seed size
1	2	3	4	5	6	7	8	9	10	11	12	13
P.T.1	Ceylon	Medium	Large	Medium	Blue	Large	Medium	Straight	Green	Brown	Round	Medium
P.T.2	Ceylon	Medium	Large	Small	Blue	Medium	Medium	Slightly curved	Green	Brown	Round	Medium
P.T.3	Ceylon	Medium	Medium	Medium	Blue	Medium	Medium	Straight	Green	Brown	Round	Small
P.T.4	Ceylon	Large	Medium	Large	Blue	Medium	Medium	Slightly curved	Green	Brown	Round	Small
P.T.5	Ceylon	Medium	Medium	Medium	Blue	Medium	Medium	Straight	Green	Brown	Rectangular	Medium
P.T.6	Ceylon	Medium	Medium	Medium	Blue	Small	Large	Slightly curved	Green	Brown	Rectangular	Small
P.T.7	Ceylon	Medium	Medium	Large	Blue	Large	Medium	Straight	Green	Brown	Rectangular	Medium
P.T.8	Ceylon	Short	Medium	Small	Blue	Large	Medium	Straight	Green	Light brown	Round	Medium
P.T.9	Ceylon	Large	Medium	Medium	Blue	Small	Medium	Slightly curved	Green	Brown	Round	Medium
P.T.10	Ceylon	Short	Medium	Medium	Blue	Large	Medium	Slightly curved	Green	Light brown	Round	Medium
P.T.11	Ghana	Medium	Large	Medium	White	Medium	Small	Straight	Green	Cream	Round	Small
P.T.12	Ghana	Medium	Medium	Large	Blue	Medium	Medium	Straight	Green	Light brown	Round	Medium
P.T.13	Ghana	Medium	Large	Medium	Light purple	Large	Medium	Straight	Green with brown splashes	Black with brown patches	Flat	Large

Table 1 continued

1	2	3	4	5	6	7	8	9	10	11	12	13
P.T.14	Ghana	Short	Medium	Large	Blue	Medium	Medium	Straight	Green	Brown	Round	Medium
P.T.15	Ghana	Large	Medium	Medium	Blue	Medium	Medium	Straight	Green	Brown	Round	Medium
P.T.16	Ghana	Medium	Medium	Medium	Blue	Medium	Medium	Slightly curved	Green	Brown	Round	Medium
P.T.17	Ghana	Medium	Medium	Large	Blue	Small	Medium	Slightly curved	Green	Dark brown	Round	Medium
P.T.18	Ghana	Large	Large	Large	Blue	Medium	Medium	Straight	Green	Dark brown	Round	Medium
P.T.19	Ghana	Short	Medium	Medium	Blue	Medium	Medium	Straight	Green	Dark brown	Round	Medium
P.T.20	Ghana	Short	Large	Small	Blue	Small	Long	Slightly curved	Green	Light brown	Round	Medium
P.T.21	Ghana	Large	Medium	Small	Blue	Small	Medium	Slightly curved	Green	Dark brown	Round	Medium
P.T.22	Ghana	Medium	Medium	Medium	Blue	Medium	Medium	Straight	Green	Brown	Rectangular	Large
P.T.23	Ghana	Large	Medium	Medium	Blue	Small	Small	Straight	Green	Brown	Round	Medium
P.T.24	Bangalore	Short	Medium	Large	Blue	Medium	Medium	Slightly curved	Green	Light brown	Round	Large
P.T.25	Bangalore	Short	Medium	Medium	Blue	Small	Medium	Straight	Green	Brown	Round	Medium
P.T.26	Bangalore	Medium	Medium	Medium	Blue	Large	Medium	Straight	Green	Light brown	Round	Medium
P.T.27	Bangalore	Medium	Medium	Large	Blue	Medium	Medium	Straight	Green	Light brown	Round	Medium
P.T.28	Bangalore	Medium	Medium	Large	Blue	Large	Medium	Straight	Green	Light brown	Round	Medium
P.T.29	Bangalore	Large	Large	Medium	Blue	Medium	Medium	Slightly curved	Green	Light brown	Round	Medium
P.T.30	Bangalore	Short	Medium	Large	Blue	Large	Medium	Slightly curved	Green	Light brown	Round	Medium
P.T.31	Pattambi	Large	Medium	Medium	Blue	Large	Medium	Straight	Green	Brown	Round	Medium
P.T.32	NBPGR	Medium	Large	Medium	Blue	Large	Small	Straight	Green	Dark brown	Rectangular	Large

were sown at a spacing of 50 cm. Two seeds were sown per hill and later thinned to one after the development of the first trifoliate leaf. There were 6 plants/ accession/replication.

Foliar application of one per cent solution containing nitrogen, phosphorus and potassium at the ratio 9:45:15 was given at 2 leaf stage. This was followed by soil application with 10:10:10 mixture containing nitrogen, phosphorus and potassium, applied at the rate of 10 g per plant. The soil application was continued till second harvest at 15 days interval.

The vines were allowed to trail over trellies consisting of vertical poles of 2 meters height. Separate trelly was made for each accession in a replication.

During the cropping period plant protection measures were undertaken against the control of Fusarium wilt and leaf eating caterpillars. Irrigation was given on alternate days during the dry season.

C. Observations

The entire population was considered for taking observations and the average of each accession in each replication was taken for further analysis. For qualitative analysis representative samples were taken from each accession from each replication. Observations on the following characters were made.

1. Duration of the crop
1.1. Days to germination
1.2. Days to first flower
1.3. Days to fifty per cent flower
1.4. Days to first harvest
1.5. Days to final harvest

2. Pod characters
2.1. Number of pods per plant
2.2. Mean length of pod (cm)
2.3. Mean girth of pod (cm) (including the wings)
2.4. Mean weight of single pod (g)
2.5. Mean number of seeds per pod
2.6. Hundred seed weight (g)
2.7. Shelling percentage

3. Vegetative characters
3.1. Number of lateral branches
3.2. Thickness of stem at the collar region (cm)

4. Tuber characters
4.1. Number of root tubers
4.2. Weight of root tubers (g)

5. Crude protein

The nitrogen content of dried samples of leaves, pods, flowers, seeds and tubers were estimated using the Microkjeldahl Method (A.O.A.C., 1960). The nitrogen content was multiplied by 6.25 to obtain the protein content and expressed as per cent dry weight.

6. Crude fibre

Flowers were tagged on the date of pod set and the pods were harvested at 10, 12 and 15 days after the pod set. Crude fibre content of the dried samples were determined employing the A.O.A.C. (1960) method.

D. <u>Statistical analysis</u>

The details of the statistical analysis followed are given below.

1. <u>Analysis of variance</u>

Analysis of variance and covariance were performed as described by Ostle (1966). The model utilized in the analysis is

$$Y_{ij} = \mu + b_i + t_j + e_{ij}$$

$$i = 1 \ldots\ldots 3$$

$$j = 1 \ldots\ldots 32$$

Where, Y_{ij} = Performance of the j^{th} accession in i^{th} block

μ = General mean

b_i = True effect of the i^{th} block

t_j = True effect of the j^{th} accession and

e_{ij} = Error component of the ij^{th} observation

2. Estimation of variability, heritability and genetic advance and genetic gain

2.1. Variability

Variability existing in the various characters under observation was estimated (Burton, 1952). The formulae used in the estimation of genotypic, phenotypic and environmental variances are as follows:

2.1.1. Genotypic variance (Gv) $= \frac{TM-EM}{\text{Number of replication}}$

Where, TM is the treatment mean square and

EM is the error mean square in the analysis of variance.

Genotypic standard deviation (σg) $= \sqrt{Gv}$

Genotypic coefficient of variation (gcv) $= \frac{\sigma g}{Mean} \times 100$

2.1.2. Phenotypic variance (Pv) $= GV + EM$

Phenotypic standard deviation (σp) $= \sqrt{PV}$

Phenotypic coefficient of variation (pcv) $= \frac{\sigma p}{Mean} \times 100$

2.1.3. Environmental variance (EV) $= EM$

Environmental coefficient of variation $= \frac{\sigma e}{Mean} \times 100$

2.2. Heritability

Heritability is the potentiality of an individual to inherit a particular character to its offspring. In broad sense, it is equivalent to the total genotypic variance divided by the total phenotypic variance. The heritability in broad sense was estimated as suggested by Burton and Devane (1953).

$$h^2(b) = \frac{\text{Genotypic variance}}{\text{Phenotypic variance}}$$

2.3. Genetic advance (GA)

At a certain level of selection pressure, the shift of a population towards the superior side of genetic advance. The expected genetic advance of the available germplasm at 5 per cent intensity of selection was calculated as suggested by Lush (1949) using the constant 'i' as 2.06 as given by Allard (1960).

$GA = i \times h^2 \times \sigma p$ where σp refers to phenotypic standard deviation and 'i' to intensity of selection.

2.4. Genetic gain

The method described by Johnson et al. (1955 a) was used

$$\text{Genetic gain} = \frac{GA}{\bar{x}} \times 100$$

$\bar{x}$ = Mean of the character under study

3. Estimation of correlations

The genotypic and phenotypic covariances were worked out in the same way as the variances were calculated. Mean product of the expectation of covariance analysis is similar to the mean square expectation for analysis of variance. Correlation between yield and its components were calculated at genotypic and phenotypic levels by substituting the genotypic and phenotypic covariances and variances in the formulae suggested by Searle (1961).

a. Genotypic correlation between characters x and y

$$r_{xy}(g) = \frac{Cov_{xy}(g)}{(GV(x).\ GV(g))^{\frac{1}{2}}}$$

$$Cov_{xy}(g) = \frac{TSP - ESP}{\text{Number of replication}}$$

Where, TSP is the mean treatment sum of products and ESP is the mean error sum of products between characters x and y in the analysis of covariance. GV(x) and GV(y) are the genotypic variances for characters x and y.

b. Phenotypic correlation between characters x and y

$$r_{xy}(p) = \frac{Cov_{xy}(p)}{(PV(x).\ PV(y))^{\frac{1}{2}}}$$

$$Cov_{xy}(p) = Cov_{xy}(g) + ESP$$

PV(x) and PV(y) are phenotypic variances for characters x and y.

c. Environmental correlation between characters x and y.

$$r_{xy}(e) = \frac{ESP(xy)}{\left(EM(x) \cdot EM(y)\right)^{\frac{1}{2}}}$$

EM(x) and EM(y) are the error mean squares for characters x and y.

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

In the path coefficient analysis the correlations among cause and effect are partitioned into direct and indirect effects of causal factors on an effect factor. The characters having significant positive correlation with yield at one per cent level were selected and accordingly days to final harvest, number of pods per plant. Length of pod, girth of pod and seeds per pod were considered for the path coefficient analysis.

The estimates of direct and indirect effects in such a closed system of variables were calculated by the path coefficient analysis as suggested by Dewey and Lu (1959). The following set of simultaneous equations were formed and solved for estimating the various direct and indirect effects.

$$r_{1y} = p_{1y} + r_{12}p_{2y} + r_{13}p_{3y} + r_{14}p_{4y} + \cdots + r_{1k}p_{ky}$$

$$r_{2y} = p_{2y} + r_{21}p_{1y} + r_{23}p_{3y} + r_{24}p_{4y} + \cdots + r_{2k}p_{ky}$$

$$r_{3y} = p_{3y} + r_{31}p_{1y} + r_{32}p_{2y} + r_{34}p_{4y} + \cdots + r_{3k}p_{ky}$$

$$r_{4y} = p_{4y} + r_{41}p_{1y} + r_{42}p_{2y} + r_{43}p_{3y} + \cdots + r_{4k}p_{ky}$$

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$$r_{ky} = p_{ky} + r_{k1}p_{1y} + r_{k2}p_{2y} + r_{k3}p_{3y} + \cdots + r_{k(k-1)}p_{(k-1)y}$$

Where, r_{1y} to r_{ky} denote coefficient of correlation between independent characters 1 to k and dependent characters y. r_{12} to $r_{k(k-1)}$ denote coefficient of correlation between all possible combinations of independent characters, and p_{1y} to p_{ky} denote direct effects of characters 1 to k on character y.

The above equation can be written in a matrix form as presented below.

$$
\underset{A}{\begin{pmatrix} r_{1y} \\ r_{2y} \\ r_{3y} \\ r_{4y} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ r_{ky} \end{pmatrix}} = \underset{B}{\begin{pmatrix} 1 & r_{12} & r_{13} & r_{14} & \cdots & r_{1k} \\ & 1 & r_{23} & r_{24} & \cdots & r_{2k} \\ & & 1 & r_{34} & \cdots & r_{3k} \\ & & & 1 & \cdots & r_{4k} \\ & & & & & \\ & & & & & 1 \end{pmatrix}} \underset{C}{\begin{pmatrix} p_{1y} \\ p_{2y} \\ p_{3y} \\ p_{4y} \\ \\ \\ \\ \\ p_{ky} \end{pmatrix}}
$$

The genotypic path coefficients were obtained by replacing the corresponding elements in A and B matrices by genotypic correlation coefficients.

Residual factor (p_{xy}) which measures the contribution of the characters which are not considered in the causal scheme was obtained as follows.

Residual factor (x), $p_{xy} = (1-R^2)^{\frac{1}{2}}$

Where $R^2 = \sum_{i=1}^{K} p_{iy}^2 + 2 \sum_{i<j=1}^{K} p_{iy}\, p_{jy}\, r_{ij}$

5. <u>Estimation of selection indices</u>

A series of selection indices were obtained by discriminant function analysis using different combination of component characters. The component characters were days to final harvest, number of pods per plant and girth of pod. These characters were selected based on the relative magnitude of positive direct effects on pod yield per plant.

The statistical methods suggested by Robinson *et al.* (1951) was used for constructing selection indices and computing genetic advanse. The following set of simultaneous equations were selved to obtain weights in the selection index based on yield and the independent component characters.

$$a_k + b_1 t_{11} + b_2 t_{12} + b_3 t_{13} + \cdots\cdots + b_k t_{1k} + b_y t_{1y} = g_{1y}$$
$$a_2 + b_1 t_{21} + b_2 t_{22} + b_3 t_{23} + \cdots\cdots + b_k t_{2k} + b_y t_{2y} = g_{2y}$$
$$a_3 + b_1 t_{31} + b_2 t_{32} + b_3 t_{33} + \cdots\cdots + b_k t_{3k} + b_y t_{3y} = g_{3y}$$
$$\vdots \qquad\qquad \vdots$$
$$a_k b_1 t_{k1} + b_2 t_{k2} + b_3 t_{k3} + \cdots\cdots + b_k t_{kk} + b_y t_{ky} = g_{ky}$$

Where, t_{kk} and t_{km} represent phenotypic variance and covariance respectively and b_k is the unknown weight g_{ky} and g_{kk} are genotypic covariance and variance respectively.

Genetic advance by discriminant function

$$GA(D) = i(\textstyle\sum b_k g_{ky})^{\frac{1}{2}}$$

Where, 'i' stands for intensity of selection when top 5 per cent of the population is selected (2.06). Genetic advance by straight selection for yield

$$GA(S) = \frac{i.\ g_{yy}}{(t_{yy})^{\frac{1}{2}}}$$

The relative efficiency of selection through discriminant function over straight selection was calculated as suggested by Paroda and Joshi (1970).

$$\text{Relative efficiency over straight selection} = \frac{GA(D)-GA(S)}{GA(S)} \times 100$$

RESULTS

RESULTS

The results obtained in the present investigations are presented under the following titles.

1. General analysis of variance
2. Estimation of variability
3. Heritability and genetic advance
4. Correlation studies
5. Path coefficient analysis
6. Discriminant function analysis

1. General analysis of variance

The partitioning of total variability into its components in a randomised block design revealed significant differences among the accessions for all the characters recorded in this study, exception being for thickness of stem at the collar region (Table 2). Most of the characters included in this study exhibited wide range of variation. Inherent and statistically significant differences among the accessions were observed.

2. Estimation of variability

The extent of variability present in 32 winged bean accessions was measured in terms of range, standard error mean and phenotypic and genotypic coefficient of variation (Tables 3 and 4). Mean performance of the 32

Table 2. General analysis of variance for different characters in 32 winged bean accessions

Source of variation	df	Mean squares								
		Days to germination	Days to first flower	Days to 50% flower	Days to first harvest	Days to final harvest	Number of pods per plant	Length of pod (cm)	Girth of pod (cm)	Average pod weight (g)
1	2	3	4	5	6	7	8	9	10	11
Replication	2	3.51	6.00	295.04	1.08	32.07	247.71	0.51	1.07	0.37
Genotype	31	3.34*	150.34**	391.48**	214.05**	1182.98**	941.37**	4.39**	1.16**	4.98*
Error	62	1.92	26.62	128.05	31.55	216.32	206.25	1.95	0.45	2.18

Table 2 (Continued)

Source of variation	df	Mean squares									
		Seeds per pod	100 seed weight	Number of bran-ches	Thick-ness of stem (cm)	Shelling percen-tage	Number of tubers	Weight of tubers	Yield of pods	Protein content of pods	Fibre content 12 DAF
		12	13	14	15	16	17	18	19	20	21
Replication	2	1.32	3.51	0.84	1.01	45.82	2.92	0.01	0.02	1.73	1.67
Genotype	31	4.68**	63.59**	0.67*	1.35 NS	74.82**	4.98**	0.01**	0.16**	29.88**	11.40**
Error	62	1.36	14.61	0.40	1.14	28.47	2.17	0.004	0.037	1.09	0.51

Table 2 (Continued)

Source of variation	df	Mean squares: Fibre content 15 DAF	Fibre content 18 DAF	Protein content of leaf	Protein content of flower	Protein content of seed	Protein content of tuber
		22	23	24	25	26	27
Replication	1	3.59	2.84	2.34	1.34	0.19	3.75
Genotype	31	20.97**	5.62**	42.73**	14.28**	19.52**	15.92**
Error	31	2.18	0.90	2.33	1.29	0.60	0.98

* P = 0.05

** P = 0.01

NS - Non significant

DAF - Days after fruit set

accessions with respect to different characters studied are presented in Appendix 1.

2.1. Duration of the crop

The mean number of days taken for the seeds to germinate ranged from 5.25 days in P.T.22 to 10.08 days in P.T.6, with a general mean of 8.06 days. On an average the varieties took 70.42 days from sowing to flower, of which P.T.9 (55.67 days) was the earliest flowering and P.T.7 (87.67 days) was the late flowering accession. The mean number of days taken for harvesting of pods was 89.41 days. On an average the harvesting of the pods were continued upto 201.64 days from the date of sowing. The range for this character was from 149.67 days for P.T.8 to 227.67 days for P.T.4.

The phenotypic coefficient of variation was slightly higher than the genotypic coefficient of variation. The environmental coefficient of variation was greater than the genotypic coefficient of variation (17.19 and 8.5) for days to germination which showed that major part of the variability is accounted for by the environment. The genotypic coefficient of variation was highest for days to first flower (9.12) followed by days to final harvest (8.90) and days to first harvest (8.72). Number of days taken for fifty per cent flowering showed the highest phenotypic coefficient of variation (12.0), followed by

Table 3. Range, mean and standard error for different characters

Sl. No.	Characters	Range	Mean	Standard error
1	2	3	4	5
1.	Days to germination	5.25 - 10.08	8.06	0.80
2.	Days to first flower	55.67 - 87.67	70.42	2.98
3.	Days to 50 per cent flower	89.67 - 149.00	117.67	1.73
4.	Days to first harvest	70.33 - 107.00	89.41	3.24
5.	Days to final harvest	149.67 - 227.67	201.64	8.49
6.	Number of pods per plant	34.00 - 98.47	70.00	8.29
7.	Length of pod (cm)	16.73 - 21.31	18.72	10.81
8.	Girth of pod (cm)	7.92 - 11.53	9.68	0.38
9.	Average pod weight (g)	10.38 - 15.28	12.72	0.85
10.	Number of seeds per pod	9.67 - 15.27	12.92	0.67
11.	100-seed weight (g)	24.00 - 47.00	38.10	2.21
12.	Number of branches	2.17 - 4.17	2.86	0.37
13.	Thickness of stem (cm)	3.5 - 5.92	4.69	0.62
14.	Shelling percentage	34.21 - 59.11	49.31	3.08
15.	Number of tubers	2.17 - 8.19	4.33	0.85
16.	Weight of tubers (kg)	0.06 - 0.31	0.13	0.04
17.	Yield of pods (kg)	0.49 - 1.29	0.88	0.11
18.	Crude protein content of pods	23.94 - 38.50	31.28	0.60
19.	Crude protein content of leaves	28.01 - 46.19	37.41	0.41
20.	Crude protein content of flowers	22.31 - 33.31	27.25	0.71
21.	Crude protein content of seeds	34.56 - 49.88	41.35	0.85
22.	Crude protein content of tuber	19.25 - 29.31	25.89	0.55
23.	Crude fibre content 10 D.A.F.	9.00 - 17.75	13.55	0.88
24.	Crude fibre content 12 D.A.F.	13.00 - 22.50	17.13	0.45
25.	Crude fibre content 15 D.A.F.	17.25 - 31.38	23.19	0.57

D.A.F. = Days after fruit set

Table 4. Phenotypic, genotypic and environmental variances and coefficient of variation for different characters

Sl. No.	Characters	Phenotypic variance	Genotypic variance	Environ-mental variance	Phenotypic coefficient of varia-tion (p.c.v.)	Genotypic coefficient of varia-tion (g.c.v)	Environ-mental coefficient of variation (e.c.v)
1	2	3	4	5	6	7	8
1.	Days to germination	2.39	0.47	1.92	19.19	8.50	17.19
2.	Days to first flower	67.86	41.24	26.62	11.69	9.12	7.33
3.	Days to 50% flower	215.86	87.81	128.05	12.00	8.00	10.00
4.	Days to first harvest	92.38	60.83	31.55	10.75	8.72	6.28
5.	Days to final harvest	538.54	322.22	216.32	11.51	8.90	7.12
6.	Number of pods per plant	451.28	245.05	206.25	30.34	22.36	20.52
7.	Length of pod (cm)	2.77	0.81	1.95	8.88	4.81	7.46
8.	Girth of pod (cm)	0.69	0.24	0.45	8.57	5.03	6.93
9.	Average pod weight (g)	2.81	0.63	2.18	13.19	6.26	11.61
10.	Seeds per pod	2.47	1.11	1.36	12.16	8.15	9.03
11.	100 seed weight (g)	30.94	16.33	14.61	14.59	10.60	10.03
12.	Number of branches	0.49	0.09	0.40	24.44	10.48	22.08
13.	Thickness of stem (cm)	1.21	0.07	1.14	23.47	6.40	22.78

1	2	3	4	5	6	7	8
14.	Shelling percentage	43.92	15.45	28.47	13.44	7.97	10.82
15.	Number of tubers	3.11	0.93	2.17	40.69	22.35	34.01
16.	Weight of tubers (kg)	0.006	0.002	0.004	58.68	33.88	47.91
17.	Yield of pods (kg)	0.08	0.04	0.04	31.92	23.14	21.98
18.	Crude protein content of pods	10.69	9.59	1.09	10.45	10.09	3.34
19.	Crude protein content of leaves	15.79	13.47	2.33	10.62	9.81	4.08
20.	Crude protein content of flowers	7.79	6.49	1.29	10.24	9.35	4.00
21.	Crude protein content of seeds	6.90	6.30	0.60	6.35	6.07	1.87
22.	Crude protein content of tubers	5.96	4.98	0.98	9.43	8.62	3.82
23.	Crude fibre content of pods 10 D.A.F.	2.47	1.57	0.90	11.61	9.26	7.00
24.	Crude fibre content of pods 12 D.A.F.	6.47	5.96	0.51	14.86	14.26	4.17
25.	Crude fibre content of pods 15 D.A.F.	8.44	6.26	2.18	12.54	10.79	6.37

D.A.F. = Days after fruit set

days to first flower (11.69) and final harvest (11.51).

2.2. Pod characters

The green pod yield was maximum in P.T.21 (1.29 kg), followed by P.T. 17 (1.21 kg) and P.T. 14 (1.12 kg) and the minimum yield was obtained from P.T. 11 (0.49 kg). The mean yield for the 32 accessions was 0.88 kg. The number of pods per plant showed a wide range of variation from 34.00 to 98.47. The number of pods produced was maximum in P.T.6 (98.47), P.T.9 (97.47), P.T.16 (93.24) and P.T.25 (91.87), while the minimum (34) was obtained from P.T.11.

The length, girth and average pod weight showed a narrow range of variation. The mean number of seeds per pod ranged from 9.67 to 15.27 with an overall mean of 12.92. Weight of hundred seeds and shelling percentage showed a range of variation from 24.0 g to 47.0 g and 34.21 per cent to 59.11 per cent with an overall means of 38.10 g and 49.31 per cent respectively.

The green pod yield exhibited the highest phenotypic and genotypic coefficient of variation of 31.92 and 23.14 per cent respectively. This was followed by the number of pods per plant (30.34 and 23.36 per cent respectively). The coefficient of variation was low for length of pod (p.c.v. 8.88 per cent and g.c.v. = 4.81 per cent), girth of pod (p.c.v. = 8.57 per cent and g.c.v. = 5.03 per cent), and average pod weight (p.c.v. = 13.19 per cent, g.c.v. = 6.26 per cent). Weight of hundred seeds exhibited moderate phenotypic (14.59 per cent) and genotypic (10.60 per cent) coefficient of variation. The environmental coefficient of variation was greater than the genotypic coefficient of variation for shelling percentage (p.c.v. = 13.44 per cent g.c.v. = 7.97 per cent and e.c.v. = 10.82 per cent).

2.3. Vegetative characters

The vegetative characters studied are, number of branches and thickness of stem at the collar region. The range of variation for these characters were 2.17 to 4.17 and 3.5 to 5.92 cm with overall mean of 2.86 and 4.69 cm respectively.

The environmental coefficient of variation was greater than the genotypic coefficient of variation for both these characters. The phenotypic, genotypic and environmental coefficient of variations for number of branches were 24.44 per cent, 10.48 per cent and 22.08 per cent respectively. The phenotypic coefficient of variation for thickness of stem at the collar region was 23.47 per cent with corresponding genotypic and environmental coefficient of variations 6.4 per cent and 22.78 per cent respectively.

2.4. Tuber characters

The number and weight of root tubers were recorded which ranged from 2.17 to 8.19 and 0.06 to 0.51 kg respectively. The tuber yield was maximum in the accession P.T. 31 and minimum in P.T.9. The phenotypic, genotypic and environmental coefficient of variations for weight of tubers were 58.68, 33.88 and 47.91 per cent respectively. The environmental coefficient of variation was greater than the genotypic coefficient of variation for number of tubers also (p.c.v. = 40.69 per cent, g.c.v. = 22.35 per cent and e.c.v. = 34.01 per cent).

2.5. Crude protein

The mean crude protein content was maximum in seeds (41.35 per cent), followed by the leaves (37.41 per cent), pods (31.28 per cent), flowers (27.25 per cent) and root tubers (25.89 per cent). The crude protein content in pods was maximum in the accession P.T.4 (38.50 per cent), followed by P.T.30 (38.28 per cent). The accession P.T.11 recorded the lowest protein content 23.94 per cent.

The phenotypic and genotypic coefficients of variations were almost of the same magnitude as the environmental coefficient of variation was low. The crude protein content of pods showed the highest genotypic coefficient of variation (10.09 per cent), with corresponding phenotypic and environmental coefficient of variations 10.45 per cent and 3.34 per cent respectively.

2.6. Crude fibre

The crude fibre content of the developing pods were determined at 10, 12 and 15 days after fruit set. It ranged from 9.0 per cent to 17.75 per cent, 13.0 to 22.5 per cent, and 17.25 to 31.38 per cent respectively for the number of days. The mean fibre content of pods increased from 13.55 to 23.19 per cent within 10 to 15 days after pod set. The phenotypic and genotypic coefficient of variations were of the same magnitude as the environmental coefficient of variation was low.

3. Heritability and genetic advance

The estimates of heritability, genetic advance and genetic gain with respect to different characters were studied (Table 5).

3.1. Duration of the crop

High heritability estimates were obtained for the characters studied such as days to first flower (0.61), days to first harvest (0.66), days to final harvest (0.59) and days to fifty per cent flowering (0.41). The estimates of genetic advance was highest for days to final harvest (28.60), followed by days to first harvest (13.04). The genetic gain for these characters were 14.19 and 14.58 per cent respectively.

Table 5. Heritability, genetic advance and genetic gain for different characters

Sl. No.	Characters	Herita-bility	Genetic advance	Genetic gain
1	2	3	4	5
1.	Days to germination	0.19	0.63	7.82
2.	Days to first flower	0.61	10.31	14.64
3.	Days to 50 per cent flower	0.41	12.34	10.00
4.	Days to first harvest	0.66	13.04	14.58
5.	Days to final harvest	0.59	28.60	14.19
6.	Number of pods per plant	0.54	23.76	33.94
7.	Length of pod (cm)	0.29	1.01	5.37
8.	Girth of pod (cm)	0.35	0.59	14.04
9.	Average pod weight (g)	0.23	0.78	6.08
10.	Number of seeds per pod	0.45	1.45	11.24
11.	100 seed weight (g)	0.53	6.06	15.91
12.	Number of branches	0.18	0.27	9.25
13.	Thickness of stem (cm)	0.58	0.13	2.79
14.	Shelling percentage	0.35	4.80	9.74
15.	Number of tubers	0.30	1.09	25.28
16.	Weight of tubers	0.33	0.05	40.29
17.	Yield of pods (kg)	0.53	0.30	34.56
18.	Crude protein content of pods	0.89	6.05	19.34
19.	Crude protein content of leages	0.85	5.72	15.29
20.	Crude protein content of flowers	0.83	4.79	17.59
21.	Crude protein content of seeds	0.91	4.73	11.46
22.	Crude protein content of tubers	0.84	5.29	20.41
23.	Crude fibre content of pods 10 D.A.F.	0.64	4.46	32.95
24.	Crude fibre content of pods 12 D.A.F.	0.92	4.83	28.20
25.	Crude fibre content of pods 15 D.A.F.	0.74	5.41	23.32

D.A.F. = Days after fruit set

3.2. Pod characters

The number of pods per plant exhibited the highest estimates of genetic advance (23.76) resulting from high values of heritability (0.54) and the genetic gain was 33.94 per cent. Length, girth and average pod weight have moderate values of genetic advance (1.01, 0.59 and 0.78 respectively) resulting from moderate values of heritability estimates (0.29, 0.35 and 0.23 respectively). The genetic gain that can be expected by selection for these characters were 5.37, 14.04 and 6.08 per cent. The expected genetic advance for yield of green pods was (0.30) though the heritability estimated was 0.53. The estimates of genetic gain revealed that by selecting five per cent superior plants from the available germplasm it was possible to get 34.56 per cent improvement for pod yield.

3.3. Vegetative characters

The expected genetic advance was low (0.27) for number of branches resulting from low values of heritability (0.18). Though the heritability estimated was high for stem thickness (0.59), the expected genetic advance (0.13) and genetic gain (2.79 per cent) were low.

3.4. Tuber characters

The number and weight of tubers exhibited moderate values of heritability (0.30 and 0.33) and genetic advance (1.09 and 0.05). The genetic gain that can be expected for these characters were 25.28 per cent and 40.29 per cent respectively.

3.5. Crude protein

High values of expected genetic advance was observed for crude protein content resulting from high values of heritability. The heritability, expected genetic advance and genetic gain for protein content of pods were 0.89, 6.05 and 19.34 per cent respectively.

3.6. Crude fibre

The heritability estimated was highest (0.92) for the crude fibre content of pods harvested 12 days after fruit set. The expected genetic advance and genetic gain were 4.83 and 28.20 per cent respectively.

4. Correlation studies

The phenotypic, genotypic and environmental correlation coefficients were worked out and the results are presented in Tables 6, 7 and 8. The genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients for most of the characters.

4.1. Correlation among yield and its components

Number of pods per plant exhibited the highest,

Table 6. Phenotypic correlations (r_p) among yield and its components

Characters	Days to first harvest	Days to final harvest	Pods per plant	Length of pod	Girth of pod	Average pod weight	Seeds per pod	Thickness of stem	Weight of root tubers	Crude protein	Crude fibre	Yield of pods
1	2	3	4	5	6	7	8	9	10	11	12	13
Days to first flower	0.71**	0.34*	0.02	0.25*	0.15	0.16	0.05	0.11	0.38**	-0.09	-0.04	0.04
Days to first harvest	-	0.43	0.05	0.01	-0.002	0.14	0.05	-0.04	0.46	-0.004	-0.01	0.12
Days to final harvest		-	0.26*	-0.12	-0.11	0.13	-0.24*	0.30**	0.06	-0.004	-0.02	0.33**
Pods per plant			-	0.18	0.07	-0.19	-0.22*	0.02	-0.32**	0.35**	0.07	0.92**
Length of pod				-	0.25*	0.26*	0.08	0.39**	0.14	-0.08	0.40**	0.27*
Girth of pod					-	0.22*	-0.26*	-0.11	-0.003	-0.10	0.13	0.23*
Average pod weight						-	-0.71**	0.09	0.17	0.22*	0.11	0.16
Seeds per pod							-	-0.53**	-0.43**	-0.13	-0.06	-0.15
Thickness of stem								-	0.35**	-0.11	0.09	-0.03
Weight of root tubers									-	-0.11	-0.04	0.19
Crude protein										-	-0.25*	0.31**
Crude fibre											-	0.12

* P = 0.05 ** P = 0.01

Table 7. Genotypic correlations (r_g) among yield and its components

Characters	Days to first harvest	Days to final harvest	Pods per plant	Length of pod	Girth of pod	Average pod weight	Seeds per pod	Thickness of stem	Weight of root tubers	Crude protein	Crude fibre	Yield of pods
1	2	3	4	5	6	7	8	9	10	11	12	13
Days to first flower	0.65**	0.48**	0.11	0.06	0.37**	0.43**	0.10	0.55**	0.42**	0.09	-0.09	0.17
Days to first harvest	-	0.44**	0.12	0.25*	-0.06	0.18	-0.08	0.34**	0.26*	0.07	0.01	0.19
Days to final harvest		-	0.39**	0.24*	0.08	0.10	0.37**	0.93**	0.03	0.03	-0.03	0.47**
Pods per plant			-	0.36**	0.33**	-0.29**	-0.39**	0.39**	-0.19	0.43**	0.07	0.93**
Length of pod				-	0.18	0.15	-0.03	-0.92	0.25*	-0.13	0.82**	0.44**
Girth of pod					-	0.16	-0.68**	-0.16	-0.15	-0.11	0.19	0.41**
Average pod weight						-	0.12	0.67**	0.28**	0.06	0.23*	-0.03
Seeds per pod							-	-0.07	0.35**	-0.25*	-0.15	-0.35**
Thickness of stem								-	0.85**	-0.11	0.12	0.09
Weight of root tubers									-	0.09	-0.02	0.08
Crude protein										-	-0.34**	0.30**
Crude fibre											-	0.07

* P = 0.05   ** P = 0.01

Table 8. Environmental correlation (r_e) among yield and its components

Characters	Days to first harvest	Days to final harvest	No.of pods per plant	Length of pods	Girth of pod	Average pod weight	Seeds per pod	Thickness of stem	Weight of tubers	Crude protein	Crude fibre	Yield of pods
1	2	3	4	5	6	7	8	9	10	11	12	13
Days to first flower	0.81**	0.14	-0.09	0.18	-0.04	0.01	0.003	0.01	0.10	-0.11	0.18	-0.12
Days to first harvest	-	0.38**	-0.05	0.15	0.07	0.14	0.21*	-0.19	0.72**	-0.32**	-0.11	0.02
Days to final harvest		-	0.09	0.42**	0.29**	0.17	0.10	0.23*	0.14	-0.15	-0.01	0.15
No. of pods per plant			-	0.06	-0.14	-0.15	-0.06	-0.07	-0.43**	0.18	0.13	0.91**
Length of pod				-	0.29**	0.29**	-0.11	-0.33**	0.09	0.04	0.11	0.16
Girth of pod					-	0.36	0.012	-0.07	-0.13	-0.05	0.09	0.08
Average pod weight						-	-0.11	0.02	0.12	-0.86**	0.02	0.28**
Seeds per pod							-	-0.72**	-0.15	0.15	-0.19	0.04
Thickness of stem								-	0.59**	-0.28**	0.25*	-0.003
Weight of tubers									-	-0.61**	-0.11	-0.46**
Crude protein										-	0.66**	0.46**
Crude fibre												0.39**

* P = 0.05   ** P = 0.01

positive and significant association with pod yield (r_p = 0.92, r_g = 0.93, r_e = 0.91), followed by days to final harvest (r_p = 0.33, r_g= 0.47 and r_e = 0.15). The characters such as length of pod (r_p = 0.27, r_g = 0.44), girth of pod (r_p = 0.23, r_g = 0.41) and crude protein content of pods (r_p = 0.31, r_g = 0.30) showed significant positive correlations with green pod yield. The correlation coefficient between seeds per pod and yield was found to be negative (r_g = -0.35). Weight of single pod exhibited a negative correlation with pod yield though not significant. But the environmental correlation between single pod weight and pod yield was positive and significant.

4.2. Intercorrelation among yield components.

Highly significant positive correlation was observed between days to final harvest and days to first flower (r_p = 0.34, r_g = 0.48), days to first harvest (r_p = 0.43, r_g = 0.44) and pods per plant (r_p = 0.26 and r_g = 0.39). Pods per plant showed significant positive correlation with length of pod (r_g = 0.36), girth of pod (r_g = 0.33), thickness of stem (r_g = 0.39) and crude protein content of pods (r_g = 0.43). Average pod weight and number of seeds per pod exhibited significant negative correlation with number of pods per plant (r_g = -0.29 and -0.39 respectively). The weight of root tubers also showed negative correlation with pods per plant though non-significant. The weight of root tuber was positively correlated with thickness of stem (r_p = 0.35, r_g = 0.85 and r_e = 0.59) and also between days to first flower (r_g = 0.42), days to first harvest (r_g = 0.26), average pod weight (r_g = 0.28) and seeds per pod (r_g = 0.34).

The genotypic correlation coefficient between length and girth of pod and length and average pod weight were not significant.

The crude fibre content of pods was positively correlated with length of pod (r_g = 0.82), average pod weight (r_g = 0.23) and was negatively correlated with protein content (r_g = -0.34).

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

The genotypic correlations among yield and its component characters were partitioned into different components to find out the direct and indirect contribution of each character on pod yield (Table 9, Fig.1). The characters such as days to final harvest, pods per plant, length of pod, girth of pod and seeds per pod which showed significant genotypic correlation with pod yield alone were selected for path coefficient analysis.

The path coefficient analysis revealed that number of pods per plant exerted the maximum positive direct effect on pod yield (0.81), followed by days to final

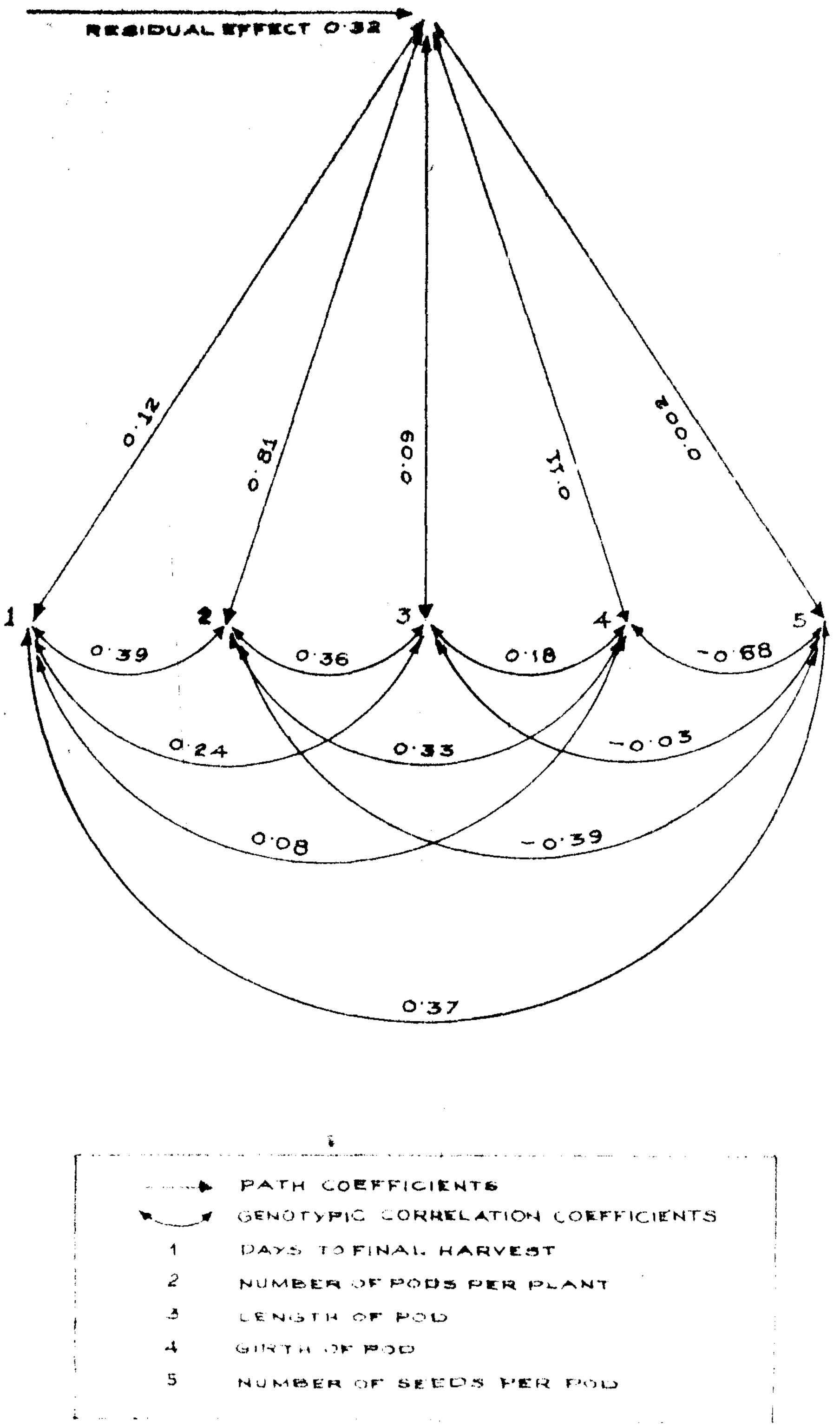
Table 9. Path coefficient analysis showing direct and indirect effects of yield components on pod yield

Characters	Days to final harvest	Pods per plant	Length of pod	Girth of pod	Seeds per pod	Genotypic correlation with yield per plant
1	2	3	4	5	6	7
Days to final harvest	0.12*	0.32	0.02	0.01	0.0006	0.47
Pods per plant	0.05	0.81*	0.04	0.04	-0.0006	0.93
Length of pod	0.03	0.29	0.09*	0.02	-0.0005	0.44
Girth of pod	0.01	0.27	0.02	0.11*	-0.0012	0.41
Seeds per pod	0.05	-0.32	-0.003	-0.08	0.002*	-0.35

*Direct effects

Residual effect = 0.32

FIG.1 PATH DIAGRAM.



harvest (0.12) and girth of pod (0.11). The indirect effect of number of pods per plant through days to final harvest, length of pod and girth of pod were negligibly low though positive.

The number of seeds per pod exerted a positive direct effect on pod yield (0.002). The negative correlation between seeds per pod and pod yield per plant (r_g = -0.35) resulted from the high negative indirect effect through pods per plant (-0.32). The significant positive correlation between days to final harvest on pod yield resulted from the high positive indirect effect through number of pods per plant (0.32). Though the direct effect of length of pod on pod yield was negligible its indirect effect through pods per plant was positive and significant (0.29). The girth of pod also exerted a high positive indirect effect (0.27) through number of pods per plant on pod yield.

The five component characters alone and in combination contributed 90 per cent of the variability in pod yield per plant (R^2 = 0.90). The residual component (0.32) obtained in path analysis was of intermediate magnitude.

6. <u>Discriminant function analysis</u>

Genetic advance through discriminant function analysis was estimated considering yield and its three components namely days to final harvest, number of pods per plant and girth of pod (Table 10). Genetic advance through selection for the three characters was observed superior by 2.965 per cent over straight selection for yield. The genetic advance through discriminant function analysis by taking days to final harvest and number of pods per plant was 1.656 per cent less than the genetic advance that would have been obtained if selection was made based on yield per se. When selection was made based on number of pods per plant the genetic advance obtained was 5.466 per cent lesser than that would have been obtained if selection was made based on yield per se alone.

Hence, the characters such as days to final harvest (X_1), number of pods per plant (X_2) and girth of pod (X_3) were used for formulating the selection index by the multiple regression analysis. The function constructed is as follows:

$$Y = -0.4688+0.00204x_1+0.0058x_2+0.055x_3$$

The accessions were ranked based on the index score. The genotype P.T.6 was found to be superior followed by P.T.25, P.T.27, P.T.9 and P.T.16. The score was minimum for the genotypes P.T.1, P.T.11, P.T.28 and P.T.20.

Table 10. Selection indices and relative efficiency of selection through discriminant function over straight selection

Discriminant function equations	Genetic advance through straight selection	Genetic advance through discriminant function	Relative efficiency
1	2	3	4
Straight selection for fruit yield per plant	0.3024	0.3024	0.000
$Y = -0.4683+0.00204\ x_1+0.0058\ x_2+0.0546\ x_3$	0.3024	0.3114	2.965
$Y = 0.0959+0.0018\ x_1+0.00603\ x_2$	0.3024	0.2970	-1.656
$Y = -0.4882+0.00346\ x_1+0.0688\ x_3$	0.3024	0.1920	-36.446
$Y = -0.0329+0.00642\ x_2+0.0474\ x_3$	0.3024	0.2970	-1.764
$Y = 0.2317+0.00319\ x_1$	0.3024	1.5268	-49.510
$Y = 0.4178+0.00653\ x_2$	0.3024	0.2860	-5.466
$Y = 0.3112+0.0582\ x_3$	0.3024	0.0994	-67.118

DISCUSSION

DISCUSSION

Winged bean is one of the most promising under-exploited tropical legumes. Owing to its potentiality, winged bean has received attention from scientists including breeders. For the systematic improvement of a particular crop species, however, the breeder has to estimate the extent of variability present in the available germplasm. Variability in a population is measured by estimates like phenotypic coefficient of variation and genotypic coefficient of variation.

The present investigation dealt with gathering genetic information _a priori_ to crop improvement in winged bean accessions. The accessions were found to be significantly different for yield and its component characters such as days to germination, days to first flower, days to fifty per cent flower, days to first harvest, days to final harvest, number of pods per plant, length of pod, girth of pod, average pod weight, number of seeds per pod, shelling percentage, hundred seed weight, number of branches, number and weight of root tubers, crude protein and crude fibre content (Table 2). The genetic variability estimated indicated that the differences were due to genetic reasons.

In the 32 accessions studied, green pod yield ranged from 0.49 kg in P.T.11 to 1.29 kg in P.T.21. The number of pods per plant ranged from 34.0 in P.T.11 to 98.47 in P.T.6. This indicated the availability of enough variability in the population under study. The investigations by Pande et al. (1975) in french bean, Ramachandran et al. (1980) and Radhakrishnan and Jebraj (1982) in cowpea, Chundawat et al. (1981) and Shanmugavelu et al. (1981) in winged bean have shown that a wide range of variation was present for most of the characters considered in these crops.

Among legumes, winged bean offers an exceptional promise and shows a great potential for overcoming the protein malnutrition problem throughout the humid tropics. The present investigation revealed considerable variability in the 32 winged bean accessions with respect to protein content. The crude protein content of leaves, pods, flowers, seeds and root tubers were analysed. The mean crude protein content was found to be maximum in seeds (41.35 per cent) followed by leaves (37.41 per cent), pods (31.28 per cent), flowers (27.25 per cent) and root tubers (25.89 per cent). These findings are almost in agreement with those reported by Yap et al. (1981) in winged bean.

The crude fibre content of pods were analysed at 10, 12 and 15 days after pod set. The crude fibre content of pods increased rapidly after 10 days of pod set and became too hard and fibrous to be palatable by about 15 days (13.55 per cent to 23.19 per cent). Chai et al. (1981) obtained similar results in winged bean.

High genotypic coefficient of variation was obtained for weight of tubers (33.88), followed by yield of pods (23.14) and number of pods per plant (22.36). The environmental coefficient of variation (47.91) was higher than the genotypic coefficient of variation (33.88) for weight of root tubers, which indicated that environment accounted for major part of the variability. Ramachandran et al. (1980) in cowpea also observed highest genotypic coefficient of variation for pod yield and number of pods per plant. Among the characters studied, length of pod, girth of pod, average pod weight and thickness of stem showed minimum variability as evidenced from low values of genotypic coefficient of variation. This indicated a limited scope for the improvement of these characters.

Heritability in conjunction with genetic advance would provide better information on the criteria for selection (Johnson et al., 1955 b). The genetic advance was observed to be highest for days to final harvest (28.60) resulting from high values of heritability (0.59), followed by number of pods per plant (23.76) with heritability estimate (0.54). High heritability together with high genetic advance indicate the predominance of additive gene effect. Thus days to final harvest and number of pods per plant were the characters forming reliable index for selection. Sohoo <u>et al</u>. (1971) observed high values of heritability and genetic advance for pods per plant in cluster bean. High heritability and low genetic advance exhibited by crude protein and crude fibre content may be attributed to the action of non-additive genes including dominance and epistasis. Hence straight selection has limited scope for improving these traits.

The selection of plants based on yield indicated a genetic gain of (34.56 per cent) and number of pods per plant (33.94 per cent) in the next cycle of selection when the intensity of selection was 5 per cent. For a rational approach towards the improvement of yield selection has to be made for the components of yield. Association of plant characters and yield, thus assumes special importance as the basis for selecting desired strains. A knowledge of such relationship is essential if selection for the simultaneous improvement of yield components and in turn, yield to be effective. In the present investigation number of pods per plant, days to final harvest, length of pod and girth of pod showed significant and positive correlation with pod yield (Table 7). Sathyanarayana et al. (1978) observed positive correlation between pod yield and pod number in winged bean. The direct effect of number of pods per plant on pod yield was maximum (0.81). Hence, number of pods per plant can be considered as the most important component character of yield. Investigations by Shettar et al. (1975) in snapbean, Nandpuri et al. (1976) in tomato, Rao et al. (1977) in bhindi and Prakash and Ram (1981) in french bean have observed that more weightage has to be given for number of fruits per plant, since its direct influence on yield is very high.

Negative but non-significant correlation was observed between average pod weight and yield of pods. This is quite contrary to the observations made by Chundawat et al. (1981) and Muthukrishnan et al. (1981) in winged bean where they observed positive correlation between average pod weight and pod yield. The negative correlation exhibited by average pod weight on pod yield in the present study may be due to the significant and strong negative correlation between average pod weight and number of pods per plant. Nandpuri et al. (1976) in tomato and Chadha and Sidhu (1983) in brinjal reported similar findings.

The significant and positive correlation between days to final harvest, length of pod and girth of pod on pod yield resulted from high indirect effect (0.32, 0.29 and 0.27 respectively) through pods per plant.

Number of pods per plant showed positive and significant correlation with length and girth of pod, but the indirect effect of pods per plant on yield through length and girth of pod was negligible. The negative correlation between seeds per pod and pod yield per plant (r_g = -0.35) resulted from the high negative indirect effect (-0.32) through number of pods per plant. Its direct effect on pod yield was positive.

Significant and positive genotypic correlation was observed between weight of root tubers and thickness of stem. The weight of root tubers showed positive but non-significant correlation with yield of green pods at genotypic and phenotypic levels, but the environmental correlation was negative and significant. This shows that the environmental factors favourable for tuber yield will be unfavourable for green pod yield.

Weber and Moorthy (1952) in their work in soybean had established that the knowledge of correlations between morphological and chemical characters would be useful in visual selection for chemical characters. In the present study, it was observed that the correlation coefficient among crude protein content and pod yield and number of pods per plant were positive and significant. Pandey et al. (1980) reported positive correlation between pod yield and protein content in dolichos bean. The correlation between crude protein and crude fibre was negative and significant (r_g = -0.34). Thus it is possible to select high yielding and protein rich genotype with less fibre content.

The residual component obtained in path analysis was of intermediate magnitude, indicating that a limited amount of variability in pod yield was attributable to factors other than those considered in this study.

Studies conducted by Agarwal (1978) in okra and Mehra (1978) in chilli indicated the importance of actually calculating the value of the expected genetic advance through selection of component characters and through direct selection. In the present investigation genetic advance through selection for the three characters, days to final harvest, number of pods per plant and girth of pod was observed to be superior by 2.95 per cent over straight selection. Ram et al. (1976) in redgram, Singh et al. (1979) in tomato and Malik et al. (1982) in greengram, Bavaji and Murthy (1982) in chilli proved the efficiency of selection through discriminant function over straight selection.

To sum up, the 32 winged bean accessions exhibited considerable variability with respect to many of the polygenic characters studied. Number of pods per plant and days to final harvest were observed as the most important component characters deciding total pod yield. The present study could identify the lines P.T.6 introduced from Ceylon and P.T.25 introduced from Bangalore as superior ones based on the selection index score. These types were having moderate crude protein content. However, accessions P.T.4 and P.T. 36 were superior in crude protein content having 38.50 per cent and 38.28 per cent respectively.

SUMMARY

SUMMARY

Studies were undertaken with thirty two winged bean accessions during July to May (1983-84) at College of Horticulture, Kerala Agricultural University, Vellanikkara. These accessions were grown in a randomised block design with three replications. The experiment was designed to estimate the extent of variability with respect to growth, yield and chemical constituents, to determine the extent of association between yield and its components and also to assess the direct and indirect effects of the component characters on yield by path coefficient analysis. The efficiency of selection through discriminant function over straight selection was also ascertained.

2. The 32 accessions showed significant differences for all the characters studied exception being for thickness of stem at the collar region.

Most of the characters recorded in this study exhibited wide range of variation. The pod yield per plant ranged from 0.49 kg in P.T.11 to 1.29 kg in P.T. 21. The mean number of pods per plant ranged from 34.0 to 98.47. The phenotypic and genotypic coefficients of variation was maximum for weight of root tubers, resulting from high values of environmental coefficient

of variation. Green pod yield per plant and number of pods per plant exhibited high values of phenotypic and genotypic coefficient of variation.

4. The content of crude protein was maximum in seeds (41.35 per cent) followed by the leaves (37.41 per cent), pods (31.28 per cent), flowers (27.45 per cent) and root tubers (25.89 per cent). Crude protein content in pods was observed to be maximum in P.T.4 (38.50 per cent) and P.T.30 (38.28 per cent).

5. Studies on crude fibre content of pods indicated that it increased rapidly within 10 to 15 days after pod set. The pods were best to be harvested by 10 to 12 days after pod set for green pod consumption.

6. Heritability estimated was found to be highest for the content of crude protein and crude fibre but the genetic advance was low. The genetic advance was maximum for days to final harvest and number of pods per plant. The estimates of genetic gain revealed that by selecting five per cent superior plants from the available germplasm it was possible to get 34.56 per cent and 33.94 per cent improvement for pod yield and number of pods per plant respectively.

7. Correlation between yield and its components and intercorrelation among the various components were worked out at the phenotypic, genotypic and environmental

levels. The genotypic correlation coefficients, however, were slightly higher than the phenotypic correlations in many cases.

8. Yield of pods per plant was highly and positively associated with days to final harvest, number of pods per plant, length of pod and girth of pod. Seeds per pod exhibited significant negative correlation with pod yield. Average pod weight exhibited a negative correlation with pod yield though not significant. The negative correlation of average pod weight and seeds per pod on yield may be due to their strong negative correlation with number of pods per plant. Protein content of pods was positively and significantly correlated with pod yield. The content of crude fibre exhibited positive and significant correlation with length of pod and negative correlation with crude protein content.

9. The path coefficient analysis employed in the present investigation revealed that number of pods per plant exerted high direct effect, followed by days to final harvest and girth of pod. Seeds per pod exerted a positive direct effect on pod yield, the negative correlation with pod yield may be due to its negative indirect effect through number of pods per plant, length of pod and girth of pod. The indirect effect of days to final harvest, length of pod and girth of pod on pod

yield through number of pods per plant was greater than their direct effect.

10. A discriminant function analysis was carried out to estimate the efficiency of selection through discriminant function over straight selection for pod yield per plant. Genetic advance through selection for the three characters, number of pods per plant, days to final harvest and girth of pod were found to be superior by 2.95 per cent over straight selection.

11. A selection index was formulated and based on the index score the accessions were ranked. Accessions P.T.6, P.T.25 and P.T. 27 were found to be the best performing ones. The score was minimum for the accessions P.T.1, P.T.11 and P.T.28.

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APPENDIX

APPENDIX I

Performance of 32 winged bean accessions with respect to different characters (Mean).

Accessions	Days to germina-tion	Days to first flower	Days to 50% flower	Days to first harvest	Days to final harvest
1	2	3	4	5	6
P.T.1	7.83	73.90	130.00	91.89	219.67
P.T.2	8.25	80.00	120.00	102.60	194.67
P.T.3	8.11	69.33	123.00	90.00	211.67
P.T.4	8.33	74.00	123.00	90.00	227.67
P.T.5	9.33	76.17	117.30	93.00	170.00
P.T.6	10.08	71.43	116.00	88.00	223.00
P.T.7	8.97	87.67	149.00	107.00	217.67
P.T.8	6.33	58.00	110.30	72.67	149.67
P.T.9	7.00	55.67	97.00	76.33	202.67
P.T.10	7.33	73.33	129.67	89.67	185.33
P.T.11	8.25	71.33	104.67	85.00	195.33
P.T.12	6.78	58.00	93.67	70.33	186.67
P.T.13	7.33	72.33	122.33	96.33	211.00
P.T.14	8.42	72.33	119.67	92.67	214.33
P.T.15	7.75	67.60	118.00	84.33	187.67
P.T.16	9.75	73.33	128.00	101.00	208.33
P.T.17	8.83	75.00	119.33	94.67	224.33
P.T.18	9.25	67.60	128.60	91.67	218.33
P.T.19	8.75	69.77	110.30	90.33	216.67
P.T.20	7.67	61.67	103.67	80.67	202.33
P.T.21	8.67	66.67	126.00	83.67	186.00
P.T.22	5.25	78.67	113.33	103.33	192.00
P.T.23	8.08	65.30	120.33	83.33	213.33
P.T.24	8.83	62.67	89.67	77.33	188.00
P.T.25	7.42	69.93	116.33	93.33	220.67
P.T.26	9.25	69.23	112.00	91.67	209.33
P.T.27	8.33	76.67	116.33	97.00	216.33
P.T.28	7.00	59.67	119.33	84.67	149.67
P.T.29	7.33	80.00	123.33	91.00	221.67
P.T.30	7.42	72.50	118.67	92.33	203.00
P.T.31	9.10	74.33	130.67	90.00	187.00
P.T.32	8.67	69.00	115.00	85.00	200.33
C.D. (5%)	2.26	[illegible]	18.47	9.17	24.01

Accessions	Number of pods/ plant	Length of pod (cm)	Girth of pod (cm)	Average pod weight(g)	Seeds per pod
	7	8	9	10	11
P.T.1	91.65	17.69	9.54	13.04	13.17
P.T.2	89.07	19.55	9.50	12.62	12.53
P.T.3	60.00	16.04	9.77	13.88	11.87
P.T.4	74.20	17.08	10.24	12.66	13.50
P.T.5	69.49	20.09	9.85	14.13	12.85
P.T.6	98.47	19.55	11.53	11.82	9.67
P.T.7	67.77	17.90	8.88	12.92	13.24
P.T.8	64.73	18.69	9.75	11.63	13.07
P.T.9	97.47	18.81	9.96	10.38	13.00
P.T.10	70.73	18.84	10.14	12.10	13.23
P.T.11	34.00	18.75	8.83	13.04	14.10
P.T.12	61.40	18.41	9.65	12.73	12.37
P.T.13	41.47	17.99	9.33	11.86	10.30
P.T.14	77.43	20.77	9.59	13.58	13.13
P.T.15	68.00	16.81	9.49	11.66	1[illegible].25
P.T.16	93.25	21.31	10.01	12.16	11.80
P.T.17	90.43	19.36	9.39	13.43	12.17
P.T.18	75.60	20.13	10.21	12.86	11.87
P.T.19	74.13	18.26	10.24	14.63	11.73
P.T.20	49.43	19.07	8.85	13.31	16.10
P.T.21	89.83	20.45	10.23	14.48	13.53
P.T.22	35.30	18.66	9.97	13.57	14.42
P.T.23	83.68	16.73	9.95	10.90	12.33
P.T.24	45.87	17.96	9.64	15.28	13.00
P.T.25	91.87	17.73	7.92	11.95	13.40
P.T.26	59.03	18.56	10.09	13.18	12.43
P.T.27	69.23	20.43	9.94	13.68	15.27
P.T.28	59.93	19.07	8.78	11.01	14.00
P.T.29	70.30	19.27	9.53	12.92	13.10
P.T.30	73.47	18.51	9.38	10.92	12.57
P.T.31	62.16	18.61	9.53	13.10	12.11
P.T.32	50.53	17.96	9.80	11.49	13.23
C.D. (5%)	23.44	2.28	1.09	2.41	1.90

Appendix I (Continued)

Accessions	100-seed weight (g)	Number of branches	Thickness of stem (cm)	Shelling percen-	Number of tubers
	12	13	14	15	16
P.T.1	36.67	3.67	4.94	48.59	4.29
P.T.2	43.67	3.00	5.78	51.85	3.50
P.T.3	36.33	3.33	4.95	50.19	3.60
P.T.4	24.00	2.83	4.25	52.00	4.75
P.T.5	32.33	2.83	4.50	34.21	6.09
P.T.6	38.67	3.50	9.17	47.09	2.92
P.T.7	42.33	3.17	4.17	52.26	2.56
P.T.8	45.67	2.50	3.81	52.52	5.65
P.T.9	36.67	2.50	4.75	48.72	3.25
P.T.10	40.00	2.17	4.67	53.92	5.54
P.T.11	36.33	2.83	5.92	43.56	2.75
P.T.12	36.00	2.17	5.08	48.52	3.83
P.T.13	47.00	3.50	5.92	53.29	5.00
P.T.14	42.33	2.67	4.37	53.80	3.53
P.T.15	36.33	2.67	4.12	57.01	4.38
P.T.16	36.00	4.17	5.17	48.05	6.27
P.T.17	43.33	3.00	5.03	45.99	5.49
P.T.18	39.67	2.50	3.92	51.96	3.67
P.T.19	36.00	2.72	5.27	42.77	2.17
P.T.20	35.33	3.00	4.47	48.25	4.50
P.T.21	36.00	2.66	3.67	56.04	5.58
P.T.22	41.67	2.83	3.72	48.91	5.57
P.T.23	37.33	3.17	5.50	44.07	3.61
P.T.24	45.00	2.00	3.50	52.09	5.00
P.T.25	41.67	3.03	5.68	59.11	3.15
P.T.26	41.00	3.22	4.97	43.36	2.89
P.T.27	37.67	2.20	4.58	52.53	4.72
P.T.28	37.67	2.83	3.58	49.91	3.97
P.T.29	32.00	2.33	4.50	44.48	4.42
P.T.30	37.67	2.83	4.83	45.50	4.02
P.T.31	37.67	3.17	4.67	44.26	8.19
P.T.32	32.67	2.77	4.50	52.58	3.67
C.D.(5%)	6.24	1.03	1.74	8.71	2.41

Accessions	Weight of tubers (kg)	Yield of pods (kg)	Content of crude fibre (Per cent)		
			10 D.A.F.	12 D.A.F.	15 D.A.F
	17	18	19	20	21
P.T.1	0.12	1.19	17.75	19.50	25.25
P.T.2	0.11	1.09	13.50	16.13	23.60
P.T.3	0.14	0.84	11.75	17.00	23.48
P.T.4	0.13	0.94	11.38	13.00	22.13
P.T.5	0.21	0.96	13.40	16.25	20.63
P.T.6	0.12	1.17	14.00	16.75	31.38
P.T.7	0.15	0.88	14.40	17.75	23.13
P.T.8	0.13	0.76	13.34	19.00	22.75
P.T.9	0.06	1.01	14.83	17.50	19.98
P.T.10	0.11	0.73	12.17	16.50	26.96
P.T.11	0.07	0.49	13.00	20.00	27.13
P.T.12	0.08	0.76	14.30	16.88	20.33
P.T.13	0.17	0.49	13.50	17.63	24.38
P.T.14	0.09	1.12	13.45	19.25	21.50
P.T.15	0.16	0.78	11.84	18.00	25.63
P.T.16	0.15	1.12	14.65	21.78	25.83
P.T.17	0.14	1.21	13.49	13.75	18.85
P.T.18	0.11	0.98	15.25	22.50	27.18
P.T.19	0.10	1.09	14.67	20.25	21.88
P.T.20	0.28	0.66	12.69	16.25	19.25
P.T.21	0.13	1.29	15.85	16.75	21.65
P.T.22	0.18	0.49	10.38	13.23	17.25
P.T.23	0.10	0.97	14.17	15.58	24.00
P.T.24	0.13	0.51	13.65	16.25	22.00
P.T.25	0.08	1.08	12.95	14.50	18.50
P.T.26	0.08	0.78	13.84	19.63	19.50
P.T.27	0.17	0.94	14.00	20.13	25.63
P.T.28	0.07	0.67	13.50	16.75	25.38
P.T.29	0.11	0.91	9.00	14.00	21.25
P.T.30	0.12	0.81	13.84	14.13	21.25
P.T.31	0.31	0.75	16.50	18.25	28.23
P.T.32	0.12	0.54	12.50	13.38	26.25
C.D. (5%)	0.11	0.31	1.93	1.16	3.02

Accessions	Content of crude protein (Per cent)				
	Pod	Leaf	Flower	Seed	Tuber
	22	23	24	25	26
P.T.1	30.19	35.09	26.69	40.69	26.56
P.T.2	35.44	46.19	22.31	40.25	25.81
P.T.3	31.06	39.81	30.41	40.25	26.25
P.T.4	38.50	46.84	26.69	34.56	22.53
P.T.5	33.25	39.81	30.19	49.88	24.94
P.T.6	31.06	37.63	28.44	43.31	24.94
P.T.7	32.38	32.81	28.86	44.63	28.44
P.T.8	34.56	41.78	28.44	43.63	21.88
P.T.9	32.81	33.25	23.63	36.75	27.56
P.T.10	31.50	38.94	31.06	38.94	27.56
P.T.11	23.94	30.19	23.00	44.63	28.88
P.T.12	31.50	31.06	26.79	43.75	23.63
P.T.13	31.06	40.69	27.56	39.81	24.94
P.T.14	32.38	45.28	33.69	45.50	25.81
P.T.15	33.25	38.06	28.88	44.19	21.45
P.T.16	31.06	41.13	27.13	38.94	28.44
P.T.17	23.69	43.97	26.25	30.34	29.31
P.T.18	28.00	33.78	27.13	40.69	27.56
P.T.19	31.94	38.50	24.94	41.13	31.06
P.T.20	25.81	33.25	25.81	37.19	25.16
P.T.21	31.06	38.94	28.00	38.94	28.44
P.T.22	26.69	37.63	24.26	40.26	27.13
P.T.23	27.78	34.56	23.63	38.50	26.25
P.T.24	34.56	33.69	27.56	43.75	25.81
P.T.25	31.94	37.63	29.31	37.63	24.06
P.T.26	29.31	35.00	24.94	46.38	22.31
P.T.27	30.19	38.06	26.69	41.56	19.25
P.T.28	28.87	31.06	23.63	42.88	29.31
P.T.29	30.19	36.31	25.81	42.44	20.56
P.T.30	38.28	38.94	24.94	40.25	26.25
P.T.31	28.88	28.00	27.13	42.00	27.13
P.T.32	29.75	38.94	33.31	42.00	29.31
C.D. (5%)	1.70	3.12	1.85	1.58	2.02

GENETIC VARIABILITY AND CORRELATION STUDIES IN WINGED BEAN [*Psophocarpus tetragonolobus* (L) DC]

By

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ABSTRACT OF A THESIS
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ABSTRACT

Winged bean accessions introduced from diverse sources were grown in a randomised block design with three replications during July to May (1983-84) at College of Horticulture, Kerala Agricultural University, Vellanikkara. The extent of genetic variability, heritability and genetic advance, association among polygenic characters and its partition into direct and indirect effects were estimated. A discriminant function analysis was also carried out to find out the efficiency of selection through discriminant function over straight selection or vice-versa.

The accessions exhibited significant differences with respect to all the characters studied exception being for thickness of stem at the collar region. The green pod yield and number of pods per plant exhibited high values of genotypic and phenotypic coefficient of variation. High heritability value in conjunction with high genetic advance was observed for days to final harvest and number of pods per plant. The content of crude protein was found to be maximum in seeds, followed by leaves, pods, flowers and tubers. The accessions P.T.4 (38.50 per cent) and P.T.30 (38.28 per cent) recorded the maximum protein content in green pod.

Green pod yield per plant was highly and positively correlated with number of pods per plant, days to final harvest, length of pod and girth of pod. Average pod weight and number of seeds per pod exhibited a negative correlation with pod yield. The negative correlation of these traits on pod yield may be due to their strong negative correlation with number of pods per plant. Genotypic correlation coefficients were partitioned into direct and indirect effects. Number of pods per plant, days to final harvest and girth of pod were the three important components making major contribution to yield. A selection index was formulated and the genotypes were ranked based on the index score. The genotypes P.T.6 and P.T.25 were found to be best performing ones.