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GENETIC VARIABILITY IN HYACINTH BEAN

[*Lablab purpureus* (L.) Sweet]

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF OLERICULTURE
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2000

DECLARATION

I hereby declare that this thesis entitled **"Genetic variability in hyacinth bean [*Lablab purpureus* (L.) Sweet]"** 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, fellowship or other similar title, of any other University or Society.

Vellanikkara
20-11-2000.

BIJU, M.G.

CERTIFICATE

Certified that this thesis, entitled "**Genetic variability in hyacinth bean [*Lablab purpureus* (L.) Sweet]**" is a record of research work done independently by **Mr.Biju, M.G.,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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CERTIFICATE

We, the undersigned members of the Advisory Committee of **Mr.Biju, M.G.,** a candidate for the degree of **Master of Science in Horticulture** with major in **Olericulture,** agree that the thesis entitled **"Genetic variability in hyacinth bean [*Lablab purpureus* (L.) Sweet]"** may be submitted by Mr.Biju, M.G., in partial fulfilment of the requirements for the degree.

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ACKNOWLEDGEMENT

It is my pleasant privilege to express my deepest sense of gratitude to Dr.K.P.Prasanna, Associate Professor, Cropping System Research Sub-centre, Vadakkenchery and Chairperson of my advisory committee for the valuable guidance rendered by her throughout my work. Her enthusiastic encouragement, constructive criticism and the patience shown by her, had contributed the most in making this small investigation of mine a success.

I would like to place on record my sincere thanks to ***Dr.S.Rajan,*** *Professor and Head (i/c), Department of Olericulture for the timely help rendered during the course of research. His affectionate and timely advice has no doubt, helped me at various stages of my work.*

I owe my heartfelt thanks to ***Dr.Salikutty Joseph,*** *Associate Professor, Department of Olericulture for her constructive criticisms and suggestions, which has helped a lot for improvement of my thesis.*

I am indebted to ***Sri.S.Krishnan,*** *Associate Professor, Department of Agricultural Statistics, for his timely and willing help during the statistical analysis of data and interpretation of results.*

I express my deep sense of gratitude to Dr.Nirmala Devi, S., Dr.Baby Lissy Markose, Dr.Indira, P., Dr.P.G.Sadhan Kumar and Dr.Mini, C of the Department of Olericulture for their friendly help and whole hearted support.

I express my heartfelt gratitude to Dr.V.K.G.Unnithan, Associate Professor, Department of Agricultural Statistics for his valuable suggestions and immense help rendered in the statistical analysis of data.

My thanks are also due to Dr.V.K.Raju, Associate Professor, Department of Processing Technology for extending his help rendered in photographic work.

The warm and willing assistance given by Smt.Joyce during statistical analysis is duly acknowledged.

My sincere thanks are due to Sri.Srinivasan Mrs.Sankunthala and others for helping me in the field work.

Acknowledgement is due to all the members of the Department of Olericulture, for their valuable suggestions and encouragement.

I further express my thanks to Mr.Joy, J.M.J. Computer Centre, Thottapady, for his neat typing of the manuscript.

With immense pleasure, I extend my whole hearted thanks to my dear friends Sanjeev, Ranjith, Priya, Julie, Ashok, Reshmi, Ambili, Laju, Parab, Shirish, Rajiv, Prince, Sajna, Annie, Lavanya, Gouthami, Veena, Shibu, Sanchu, Manjusha, Shiji, Viji, Divya, Beena, Sunil and Muthulakshmi.

The award of KAU Junior Fellowship is greatefully acknowledged.

With gratitude and affection, I recall the boundless affection, warm blessings and incessant encouragement given to me by beloved parents, sister, brother-in-law, Tharun and Kitchu.

Above all, I submit this small venture before GOD ALMIGHTY for blessing me with health, strength and confidence during the critical periods throughout the study.

Biju

BIJU, M.G.

Dedicated to my beloved

Parents

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Introduction

INTRODUCTION

India is the land with different agroclimatic conditions ideally suited for growing a number of vegetable crops. It is the second largest vegetable producer in the world contributing about 12.22 per cent of world's vegetable production. It is unfortunate that the vegetables produced in India is not enough to meet the basic requirements of the huge population of the country. Commercialisation of under exploited vegetables will help in solving this problem to a certain extent. Vegetable legumes are consumed all over the world, especially in the tropical belt. Hyacinth bean (*Dolichos lablab*) (2n=22, 24, 44) is one such important vegetable belonging to the family Leguminosae which is well suited for tropical as well as subtropical conditions (Peter, 1998).

Dolichos lablab commonly known as Indian bean occupies a unique position for its use as vegetable and seed. It also contains moderately well balanced aminoacids. Young pods of hyacinth bean is an excellent table vegetable. Leaves and flowers are cooked and eaten like spinach. Foliage of the crop provides fodder and manure. Green pod contains 86.1 g moisture, 6.7 g carbohydrate, 3.8 g protein, 0.7 g fat, 1.8 g fibre, 0.9 g minerals, 34 mg magnesium, 210 mg calcium, 68 mg phosphorus, 55.4 mg sodium, 1.7 mg iron, 74 mg potassium, 40 mg sulphur, 312 I.U. vitamin A, 0.06 mg riboflavin, 0.1 mg thiamine, 0.7 mg nicotinic acid and 9 mg vitamin C per 100g of pod (Chakravarthy 1986). The crop is highly effective for erosion control and soil protection. Pods and dried seeds of field bean are used as vegetable (Shivashankar *et al.*, 1993). Hyacinth bean is one of the major sources of protein in the dietary in southern India.

Despite its good qualities, its commercial cultivation is limited because of its trailing habit and photosensitive nature. Consumer preference of this vegetable is widely varied for pod size, shape and colour. Very little variability is observed within a variety. This may be because of self-fertilisation and also due to lack of opportunities to outcross, as this crop is usually grown in isolated locations such as backyards. So to meet the varied consumer demand and also crop improvement, creation of variability is necessary.

Varietal improvement with objectives such as improving vegetable as well as seed yield, combining early maturity, better plant types, determinate habit having high harvest index, improved quality and suitability as a vegetable and seed should be given emphasis in order to achieve a major break-though in the genetic improvement of lablab.

The choice of appropriate parents is an important criterian in any hybridization programme to generate variability and in synthesising new genotypes. Information on the nature of gene action governing the yield and yield components and various physiological and biochemical traits in lablab are also essential for identifying the potentially useful parents. For any crop improvement programme, the first and foremost requirement is a proper assessment of the variability present in the genetic stock.

Yield itself being a complex character, is the combined effect of a number of interacting components. The interrelations between yield and the various components and also among the component characters can be measured using correlation coefficients. This is helpful in understanding the traits upon which selection is to be based.

Hyacinth bean available in India represents a wide range of variability. In this crop green pod yield is the most important aspect to be considered in its improvement. Hence the genetic potentialities of yield contributing characters should be properly assessed for improvement in this crop. Breeding methodology for crop improvement consists of (1) Genetically cataloguing the germplasm available in hyacinth bean (2) Studying the variability in yield and identifying the suitable line(s) for further breeding programme.

The success of breeding programme depends upon the quantum of genetic variability for exploitation, the genetic coefficient of variability together with the heritability estimates, genetic advance, genetic divergence and association of different traits among themselves and with yield. The present effort was made to investigate the following objectives.

1. Genetic cataloguing of germplasm based on the descriptor of hyacinth bean.
2. Estimating the phenotypic and genotypic coefficient of variation.
3. Assessing the genetic parameters, viz. heritability, genetic advance and genetic gain.
4. Estimating the direct and indirect effects of yield attributes on yield using path coefficient analysis.
5. Clustering the different accessions and quantify the genetic divergence among themselves.
6. Identifying the elite genotypes on the basis of selection indices.

Review of Literature

2. REVIEW OF LITERATURE

Dolichos bean (*Lablab purpureus*(L).Sweet.) belongs to the family leguminosae, sub family papilionaceae. India has been assigned as the place of origin (Ayyangar and Nambiar 1935). The following synonyms have been recorded for this bean.

1. *Dolichos lablab* (Roxb.)
2. *Dolichos purpureus* L.(Linnaeus, 1763)
3. *Lablab niger*, medik. (Medikus, 1787)
4. *Lablab vulgaris* savi.(Savi, 1824)
5. *Lablab purpureus* (L). sweet.(Sweet 1827)

The plant is commonly referred to as hyacinth bean, dolichos bean, Indian bean, sem and lablab. Linnaeus (1753) placed lablab under the genus dolichos. Dolichos is the Greek word for long pod and lablab is an Egyptian terminology, perhaps going with the dull ratling sound of the seeds inside the dry pods (Ayyangar and Nambiar 1935).

The biometrical aspects of yield components has been attempted by several workers in hyacinth bean. The relevant literature pertaining to such studies in hyacinth bean are reviewed under the following sub heads.

1. Genetic variability
2. Heritability
3. Correlation
4. Path coefficient analysis
5. Genetic divergence
6. Selection index

2.1 Genetic variability.

Several authors reported wide range of variation in the plant and pod characters among the hyacinth bean cultivars (Singh *et al.*, 1985, Rahman. 1988 and Newaz. 1990). The success of any breeding programme for evolving superior cultivars depends upon the nature and magnitude of genetic variability. The study of association of different characters is also essential to ascertain the contribution of the different characters towards the pod production. Many workers studied the extent of variability in this crop by working out the genotypic and phenotypic coefficient of variation.

In hyacinth 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 pod^{-1}, 100 seed weight, protein content and yield.

Arunachalam (1978) reported a high genotypic coefficient of variation (gcv) in the characters like yield plant^{-1}, pod number and plant height.

In hyacinth bean, high genotypic coefficient of variation was observed for all the characters except number of seeds pod^{-1} indicating the predominance of additive gene effects (Singh *et al.*,1979). Baswana *et al.* (1980) reported in *Lablab purpureus*, high gcv for pod weight, width and thickness, yield plant^{-1}, number of flowers inflorescence^{-1} and number of pods clusters^{-1}.

Pandita *et al.* (1980) reported high and significant variation in characters like number of days to flowering, pod size, number of pods plant^{-1} and number of flowers cluster^{-1} in sem.

Muthukrishnan *et al.* (1981) assessed the extent of variability in winged bean and observed that single pod weight expressed the highest phenotypic and genotypic variability followed by pod yield plant^{-1}

Genetic analysis of quantitative characters in field bean was conducted by Rao (1981). The results showed large genotypic coefficient of variation in the characters like pod yield plant^{-1}, inflorescence plant^{-1} and also plant height.

Erskine and Kesavan (1982) observed that over all variability for days from sowing to the opening of first flower, mean pod length and weight of 100 seeds was partitioned between and within races of winged bean

A trial conducted at Hebbal ,Bangalore by Nayar (1982) for evaluation of 81 genotypes in field bean showed that high gcv was exhibited by pods plant^{-1} and seed yield plant^{-1}.

Reddy (1982) observed high genotypic coefficient of variation in characters like total number of pods plant^{-1}, pod yield plant^{-1}, seeds pod^{-1}, pods plant^{-1} and plant height in hyacinth bean.

Singh *et al.* (1982) reported that the coefficient of genetic variation was the lowest (15.10 per cent) for days to first picking and highest for pod width (36.5 per cent) and green pod yield plant^{-1} (30.67). Highest coefficient of genetic variability revealed the possibilities that the desired types can be selected. Contrary to this, chances of improvement were low for days to first picking as genetic coefficient of variability was low.

Das *et al.* (1987) studied 16 genotypes of hyacinth bean and they observed maximum variability in number of pods plant^{-1}. Genotypic coefficient of variation was found high for all characters like pod yield plant^{-1}, number of pods plant^{-1} and breadth of pod.

Borah and Shadeque (1992) studied genetic variability in 12 local cultivars of hyacinth bean. They observed high gcv in inflorescence length, pod weight, vitamin C content, pod breadth, pod yield plant^{-1} and pod length which indicated the existence of variability for selection based on these traits.

Fifteen hyacinth bean genotypes including two exotic types were studied for estimation of genetic variability and correlation by Uddin and Newaz, (1997). Results showed highest gcv in green pod yield and number of green pods plant^{-1}. A moderately high gcv was observed in individual pod weight, number of flowers cluster^{-1}, number of inflorescence plant^{-1} and rate of pod abortion.

2.2 Heritability and genetic advance

A study conducted by Singh *et al.* (1979) using 48 strains of lablab bean showed high value of heritability in all characters. Among these, days to flower and yield plant^{-1} showed very high heritability while number of seeds pod^{-1} showed the lowest.

High heritability and genetic advance for yield plant^{-1}, pod weight, pod width and number of flowers inflorescence^{-1} were reported by Baswana *et al.* (1980) in Indian bean.

Muthukrishnan *et al.* (1981) observed that heritability and genetic advance as percentage of mean were high for pod weight followed by pod length and pod yield plant^{-1} in winged bean.

In dolichos bean Rathnaiah (1982) reported high heritability and genetic advance for the characters namely plant spread, green pod yield, yield unit area^{-1}, number of pods plant^{-1} and number of inflorescence plant^{-1}.

A study on heritability in field bean conducted by Reddy (1982) showed high heritability and genetic advance for seeds plant^{-1}, total pods plant^{-1}, seeds pod^{-1}, plant height, effective spike length, internodal length and flowers spike^{-1}.

Singh *et al.* (1982) reported high heritability and high genetic gain for the characters of pod width and number of pods cluster^{-1} in hyacinth bean.

In winged bean Phlip (1984) estimated high heritability for crude protein and crude fibre content, but genetic advance was low.

Eighteen genotypes of sem was evaluated by Singh *et al.*(1985) and it was shown that pod width and number of pods cluster^{-1} combined relatively high values for expected genetic advance and heritability.

Studies conducted by Singh *et al.* (1986) in 16 genotypes of dolichos bean showed high heritability with greater genetic advance for pod yield plant^{-1}, number of pods plant^{-1} and breadth of pod.

Analysis of variance for 16 vareities of dolichos bean by Das (1987) indicated that 100 seed weight and green pod yield plant^{-1} had high heritabilities of 91.4 per cent and 85.6 per cent respectively.

Studies conducted at Bangladesh in 13 local genotypes of hyacinth bean by Nawaz (1990) showed high heritability as well as high genetic advance for pod yield, number of pods plant^{-1},number of inflorescence cluster^{-1} and pod weight.

Study conducted by Borah and Shadeque (1992) in hyacinth bean showed highest estimates of heritability and genetic advance in characters like pod weight, pod breadth and vitamin C content.

Desai *et al.* (1996)estimated the heritability and genetic advance which revealed that there is ample scope for improvement in number of branches, seeds pod^{-1}, days to flowering, days to maturity, 100 seed weight and yield.

Uddin and Newaz. (1997) found high heritability and genetic advance in characters like pod yield, number of pods plant^{-1} and pod weight in hyacinth bean.

2.3 Correlation

Arunachalam (1978) reported that pod yield was positively correlated with the pod number, plant height, pod length, pod width, seed length and seed width while it was negatively associated with crude fibre and protein in hyacinth bean.

In dolichos bean Singh *et al.* (1979) observed that genotypic correlations were higher than phenotypic correlations. Yield plant^{-1} was positively and significantly associated with fruit length, fruit width and number of seeds pod^{-1}.

Studies conducted in 39 genotypes of Indian bean by Baswana *et al.* (1980) revealed a positive correlation between yield and weight of pod, of which latter was again correlated positively with length of pod, width of pod and seeds pod^{-1}.

Pandita *et al.* (1980) reported that in Indian bean, inflorescence length and pod length were highly and positively correlated with yield whereas days to flowering was negatively correlated with yield.

Rao (1981) reported that inflorescence and pods plant^{-1} showed high positive and significant correlation with pod and seed yield plant^{-1} which in turn showed high positive and significant correlations among themselves.

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 plant^{-1} showed and percent dry weight of green pods also showed significant positive genotypic correlation with yield, but were found to be influenced by the environment (Sathyanarayana and Gangadharappa, 1982).

A study by Singh *et al.* (1982) revealed that the green pod yield plant^{-1} had significant and positive correlation with pod width and 100 seed weight in sem.

Silva and Omran (1987) revealed that shelling percentage was positively and significantly correlated with seed yield in winged bean

Nandi *et al.* (1997) observed that pod weight and pod girth were positively and significantly correlated with green pod yield plant^{-1}. The number of pods plant^{-1} was closely associated with green pod yield plant^{-1}.

Uddin and Newaz (1997) conducted correlation study of hyacinth bean in Bangladesh which showed a positive association of number of flowers in the inflorescence with rate of flower abortion and number of green pods. Green pod yield had strong and significant positive association with pod number, inflorescence plant^{-1} and pod weight.

2.4 Path coefficient analysis

Reports of Agarwal and Kang (1976) in hyacinth bean suggested that the character, pods plant^{-1} could be used to make selection for higher yield.

In lablab bean, Singh *et al.* (1979) reported the highest direct effect for number of seeds pod^{-1}followed by pod width. Indirect effect of fairly high magnitude was also exerted by number of seeds pod^{-1} in relation to other yield components. Days to flowering, hundred seed weight, pod width and protein content were reported to have direct effect on yield in dolichos bean (Pandita *et al.* 1980).

Path coefficient analysis in dolichos bean conducted by Reddy (1982) revealed that pods spike^{-1}, percentage of pod set, productive pods plant^{-1} and seeds plant^{-1} had large positive direct effects on bean yield.

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 first flowering. Pods plant^{-1}, bunches plant^{-1} and percent dry weight of green pods influenced yield indirectly.

Path analysis in field bean by Rathnaiah (1985) indicated that plant spread and number of pods plant^{-1} had the highest positive and direct effects on green pod yield plant^{-1}.

A study conducted by Dahiya *et al.* (1992) in sem suggested that increased yield in sem was brought about by selecting for number of pods plant^{-1}, plant height and pod weight.

Path coefficient analysis by Srinivasan and Das (1996) in *Lablab purpureus* showed highest direct effect of dry weight of leaves on green fodder yield.

Path coefficient analysis in *Dolichos lablab* var. *lignosus* revealed that number of primary branches and seeds pod^{-1} had the highest direct positive effect on yield (Desai *et al.*, 1996).

2.5 Genetic divergence

A knowledge of genetic diversity, its nature and degree is useful in the improvement of any heritable character. Genetic divergence studies were conducted in horse gram (*Dolichos biflorus* L.) by Ramakrishnan *et al.* (1979) using Mahalanobis-D^2 statistics. They studied eight yield components among 11 genetically diverse varieties, representing different areas and found no association between geographical distribution and genetic diversity. According to them, 100 seed weight and dry weight of nodular tissue formed the chief contributions to total divergence.

Baswana *et al.* (1980) reported that the number of pods plant^{-1} contributed the most to divergence, followed by pod weight and yield in his clustering analysis on the basis of Mahalanobis-D^2 statistics in Indian bean.

Studies conducted on genetic divergence and breeding behaviour of field bean by Nayar (1982) revealed considerable variability for all traits. Days to flowering, days to maturity and seed protein content contributed most to divergence.

Marangappanavar (1986) concluded that, inter cluster spatial patterns were not consistent with varietal geographic distribution, following his clustering studies in cowpea.

Mishra *et al.* (1987) grouped 75 genotypes of *Dolichos biflorus* into five clusters, based on yield and 11 yield related characters.

Sharma and Luthra (1987) in their divergence studies in *Dolichos biflorus* using 56 genotypes, concluded that, the composition of clusters formed using D^2 statistics differed between groups, due to environmental variations.

Sickhar *et al.* (1988) suggested that the degree of expression of economic characters was also as important as genetic distance of the parents involved in the crosses.

According to Thiagarajan *et al.* (1988), days to 50 per cent flowering, 100 seed weight and plant height contributed most to genetic divergence in cowpea.

D^2 analysis of divergence in 30 genotypes of *Lablab purpureus* conducted by Kumari and Chandrasekharan (1991) revealed that all the genotypes were genetically divergent for all characteristics studied. Leaf number made the greatest contribution to genetic diversity, followed by dry matter production and plant height. Studies by Singh (1991) in hyacinth bean using Mahalanobis-D^2

statistic analysis revealed that the days to flowering and number of pods per cluster were contributing most to divergence.

Birari and Ghanekar (1992) studied genetic diversity derived from the data on 15 quantitative characters of lablab bean (*Lablab purpureus*). The genotypes were grouped into seven clusters on the basis of D^2 and canonical analysis and the selection was made based on high seed yield plant^{-1} (94.8 g plant^{-1}).

Hazra *et al.* (1993) studied the genetic divergence among cowpea genotypes belonging to three cultigroups unguiculata, biflora and sesquipedalis under two environments. Using D^2 statistics, the genotypes were grouped into four clusters in both the environments. No close correspondence was observed between geographic distribution and genetic divergence.

Sudhakumari and Gopimony (1994) studied genetic divergence in cowpea using Mahalanobis-D^2 technique, and reported that the intercluster distance was more than the intracluster distances suggesting homogeneity within the clusters and heterogeneity between the clusters. Maximum divergence was observed between Clusters V and VII which indicate that parents chosen from these are likely to produce better recombinants with better adaptability in hybridization works.

2.6 Selection Index

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

Sanghi *et al.* (1964) observed that in cluster bean 90 per cent of the variability in yield was accounted by the variables such as clusters plant^{-1}, pods plant^{-1} and bunches plant^{-1}.

Kumar *et al.* (1976) analysed the regression values in cowpea and showed that the clusters plant^{-1}, pods plant^{-1} and hundred seed weight were the important characters in determining the pod yield.

Rathnaiah (1982) worked out selection indices in field bean (*Lablab purpureus* L. sweet) using characters like number of pods plant^{-1}, plant spread, green pod yield plant^{-1}, number of inflorescences plant^{-1} and length of inflorescence and pod.

Singh *et al.* (1982) observed that green pod yield plant^{-1} showed a significant effect on pod weight and 100 seed weight in sem and these characters were ideal for effective selection.

In winged bean Philip (1984) reported that characters such as days to final harvest, number of pods plant^{-1}, and girth of pod were used for selection index analysis.

Das *et al* (1987) reported that characters like pod yield plant^{-1}, number of pods plant^{-1} and breadth of pod were effective for selection in dolichos bean.

Uddin and Newaz (1997) reported in hyacinth bean that for selection programme, characters like number of pods plant^{-1}, inflorescence plant^{-1} and pod weight were effective for improvement of yield.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on "Genetic variability in hyacinth bean ((*Lablab purpureus* (L.) Sweet)" was carried out at the College of Horticulture, Kerala Agricultural University, Vellanikkara during the period from 1999 to 2000.The crop was raised at the Vegetable Research Farm of the Department of Olericulture, which is located at an altitude of 23 m above MSL and between 10^0 82" and between 76^0 16" east longitude.

The project consisted of the following experiments.

3.1 Genetic cataloguing of hyacinth bean.

3.2 Evaluation of variability in hyacinth bean

3.1 Genetic cataloguing of hyacinth bean

Fourty four accessions collected from different parts of the country (Table1) were genetically catalogued based on the descriptor developed for hyacinth bean (Table 2).

3.2 Evaluation of variability in hyacinth bean

3.2.1 Experimental materials

The experimental materials consisted of 44 accessions collected from different parts of India.

3.2.2 Experimental methods

The experiment was laid out in a randomized block design with two replications. Each replication consisted of 44 plots with two pits and within each plot two plants per pit. The crop was raised during August 1999 to March 2000. Pits were dug at a spacing of 2 x 2 meters. Farmyard manure was applied as basal

Table 1. Source of hyacinth bean accessions used in the study

Sl.No	Acc.No	Source	Sl.No	Acc.No	Source
1	DL-3	Pollachi	23	DL-50	Nettissery
2	DL-6	Pollachi	24	DL- 51	Kunnamkulam
3	DL- 7	Coimbatore	25	DL-52	Delhi
4	DL-8	Coimbatore	26	DL-53	Thrissur
5	DL-12	Jabalpur	27	DL-54	Coimbatore
6	DL-13	Jabalpur	28	DL-55	Waynad
7	DL-18	Edappilly	29	DL- 56	Delhi
8	DL- 27	Thriprayar	30	DL-58	Vaniampara
9	DL-28	Coimbatore	31	DL-59	Pooluvanbatti
10	DL- 29	Thriprayar	32	DL-60	Kodungallur
11	DL-30	Kozhikod	33	DL-61	Paravatany
12	DL-37	Kurukanchery	34	DL-62	Delhi
13	DL-38	Thrissur	35	DL-63	Coimbatore
14	DL-39	Thrissur	36	DL-64	Thriprayar
15	DL-40	Palghat	37	DL-65	Shornur
16	DL41	Vadakkenchery	38	DL-66	Delhi
17	DL42	Vadakkenchery	39	DL-67	Puzhakkal
18	DL-43	Thrissur	40	DL-68	Nenmara
19	DL-44	Pattambi	41	DL-69	Coimbatore
20	DL-45	Nenmara	42	DL- 71	Ollur
21	DL-48	Coimbatore	43	DL-72	Chirakkakod
22	DL-49	Muthuvara	44	DL-73	Malappurum

Table 2.Genetic cataloguing of hyacinth bean (Lablab purpureus (L.) Sweet)

1.	Plant characters	
	1. Vegetative	
1.1.	Basic plant vigour	-Highly vigorous/Vigorous/Average vigour
2.	Leaf size	-Large/Medium/Small
3.	Leaf density	-Dense/Medium/Sparse
4.	Leaf shape	-Normal/Moderately dissected/Highly dissected
5.	Utility type	-Vegetable type/Dual (vegetable+seed)/Pulse type
6.	Stem pubescence	-Present/Absent
7.	Raceme position	-Mostly above conopy/Up to 1/3rd of conopy/ Throughout the conopy
	2. Pod characteristics	
2.1.	Pod shape	-Straight/Slightly curved/Highly curved
2.	Pod fibrousness (At green picking stage)	-Very soft/Average/Highly fibrous
3.	Pod attachment to peduncle	- Pendant/30°-60° from erect/Erect
4.	Pod colour	-Green/Light green/Dark green/Maroon/Light maroon
	3. Seed characteristics	
3.1.	Seed size	-Big/Medium/Small
2.	Seed shape	-Round/Oval/Rhomboid/Flat oval/Oblong oval/ Oval round/Oblong
3.	Seed colour	- Light brown/Dark brown/ Dark brown to black/black

@ 20t ha^{-1} and mixed thoroughly with the soil in the pit. Frtilizer was also applied @ 50 Kg N, 100 kg P and 50 Kg K $hectare^{-1}$ (KAU, 1996). Out of this half the quantity of N, whole of phosphorus and potash were applied as basal dose and remaining N applied 20 days after sowing.

Weeding was done at 15 days interval. During the cropping period, plant protection measures were undertaken against the control of bacterial wilt, leaf eating caterpillar and aphids. Irrigation was given at two days interval during the dry periods.

3.2.3 Observations

For taking observations two plants were selected from each genotype per replication. Following parameters were recorded and average was worked out for further analysis.

a) Days to germination

The number of days was counted from date of sowing to the germination of seeds.

b) Days to first flowering

The number of days was counted from sowing to the opening of first flower.

c) Days to 50 per cent flowering

The number of days from sowing to the appearance of flowers in 50 per cent of the plants was recorded

d) Days to first harvest.

The number of days from sowing to the date of first harvest of the fruits at vegetable maturity was noted.

e) Days to final harvest

The number of days from sowing to the date of final harvest of the fruits at vegetable maturity was noted.

f) Duration of crop

The number of days was counted from the date of sowing to the date of final harvest.

g) Number of pods per cluster

The total number of pods in 10 clusters were counted at the full flowering stage of the plant in each replication and average worked out.

h) Pod length

Length of 20 randomly selected pods at vegetable maturity from each observational plant was measured and average recorded in centimeters.

i) Pod girth

The same pods used for length measurements were used for recording pod girth also. The girth of twenty pods were measured and the average recorded in centimeters.

j) Pod weight

The weight of the same pods were taken in an electronic balance and the average was worked out in gram.

k) Pod thickness.

This was measured in centimeters using Vernier calipers at the broadest region of the pod for five randomly selected pods and the mean worked out.

l) Number of seeds per pod.

The number of seeds in 10 pods were counted and recorded the average number of seeds per pod.

m) 100 Seed weight.

One hundred fully matured and dried seeds from each genotype were weighed using an electronic precision balance and the weight recorded in gram.

n) Primary branches per plant

The number of branches originating from the main vine were counted after the plants was pulled out.

o) Vine length.

The plants were pulled out after the final harvest and the length was measured from the collar region to the tip of the main vine.

p) Thickness of main stem

This was measured in centimeters using Vernier calipers at the bottom region of the main stem and recorded in centimeters.

q) Fruit setting percentage

Ten flowers were tagged at random on the plant and the number of fruits set was recorded. The percentage of fruit set was then worked out.

r) Number of pods per plant

The total number of pods produced per plant at the time of harvest were observed.

s) Pod yield per plot (kg)

Pods were harvested separately from each plot periodically and weighed the pods using a top loading balance.

t) Days to vegetable maturity.

The days taken from flower opening to the vegetable maturity of the pod in each plant was recorded.

u) Shelling percentage

After harvest the weight of the shell is taken separately and shelling percentage was calculated by the formula

$$\text{Shelling percentage} = \frac{\text{Weight of seed}}{\text{Weight of dry pod}} \times 100$$

v) Crude fibre

Crude fibre content was estimated by acid-alkali digestion method as suggested by Sadasivam and Manickam,1992.

w) Crude Protein.

To estimate the protein content, nitrogen content was estimated by Microkjeldhal digestion and distillation method as described by Jackson (1973) which was then multiplied with a factor of 6.25 to get the crude protein content.

3.2.4 Statistical analysis.

Data on different characters were subjected to statistical analysis, using spar-1 package . The analysis of variance technique suggested by Fisher (1954) was employed for the estimation of various genetic parameters like analysis of variance, genotypic and phenotypic coefficient of variation, genotypic and phenotypic correlation coefficients and path coefficient analysis for estimation of direct and indirect effects.

3.2.4.1 Phenotypic, genotypic and environmental variance

The variance components were estimated using the formula suggested by Burton (1952).

Phenotypic variance (vp) = Vg + Ve

where,

Vg - genotypic variance
Ve - environmental variance

Genotypic variance (vg) = $(V_T - V_E)/N$

Where

V_T - mean sum of squares due to treatments

V_E - mean sum of squares due to error

N - number of replications

Environmental variance (Ve) = V_E

3.2.4.2 Phenotypic and genotypic coefficient of variation

The phenotypic and genotypic coefficient of variation were calculated by the formula suggested by Burton and Devane (1953).

Phenotypic coefficient of variation (pcv) = $(Vp^{1/2}/\ \bar{X})_X\ 100$

Where,

Vp = phenotypic variance

$\bar{X}$ = Mean of characters under study

Genotypic coefficient of variation (gcv) = $(Vg^{1/2}/\square X)_X\ 100$

Where,

Vg = genotypic variance

$\bar{X}$ = Mean of characters under study

3.2.4.3 Heritability

Heritability in the broad sense was estimated by the formula suggested by Burton and Devane (1953).

$H^2 = (Vg/Vp)\ x\ 100$

Where,

Vg = genotypic variance

Vp = phenotypic variance

The range of heritability was categorized as suggested by Robinson *et al.*(1949) as

0-30 per cent	- low
31-60 per cent	- moderate
61 per cent and above	- high

3.2.4.4 Expected genetic advance

The genetic advance expected for the genotypic variance was calculated using the formula suggested by Lush (1949) and Johnson *et al.* (1955) with value of the constant K as 2.06 as given by Allard (1960).

$$\text{Expected genetic advance } GA = (Vg/Vp^{1/2}) \times 2.06$$

Where

Vg = genotypic variance

Vp= phenotypic variance

3.2.4.5 Genetic gain (genetic advance as percentage of mean)

Genetic advance (GA) calculated by the above method was used for estimation of genetic gain.

$$\text{Genetic gain, } GG = (GA/\bar{X}) \times 100$$

Where,

GA =Genetic advance

$\bar{X}$ = Mean of characters under study

The genetic gain was classified according to Johnson *et al.* (1955) as follows.

1-10 per cent	- low
11-20 per cent	- moderate
21 per cent and above	- high

3.2.4.6 Phenotypic and genotypic correlation coefficients

The phenotypic and genotypic correlation coefficients were worked out to study the extent of association between the characters. The phenotypic and genotypic correlation coefficients among the various characters were worked out in all possible combinations according to the formula suggested by Johnson *et al.* (1955). Phenotypic correlation coefficients between two characters 1 and 2.

$$(rp12) = COVp12/(Vp1.Vp2)^{1/2}.$$

where,

Vp1=phenotypic variance of character 1

Vp2= phenotypic variance of character 2

Genotypic correlation coefficient between two character 1 and 2 was calculated by the formula

$$(rg12)=COVg12/(Vg1.Vg2)^{1/2}$$

where,

Vg1= Genotypic variance of character 1

Vg2= Genotypic variance of character 2

3.2.4.7 Path coefficient analysis

In path coefficient analysis the correlation among cause and effect are partitioned into direct and indirect effects of causal factors on effect factor. The principles and techniques suggested by Wright (1921) and Li (1955) for the analysis using the formula given by Dewey and Lu (1959).

3.2.4.8 Genetic divergence

The genetic divergence among 44 accessions were assessed based on different characters as given by Mahalanobis (1936). Clustering of genotypes using Mahalanobis D^2 value was carried out using the computer oriented iterative algorithm method as suggested by Suresh and Unnithan (1996).

3.2.4.9 Selection index

Discriminate function analysis developed by Fisher (1936) and first applied by Smith (1936) for plant improvement was used for formulating selection index.

Results

4. RESULTS

4.1 Genetic cataloguing in hyacinth bean

Fourty four accessions of hyacinth bean were genetically catalogued based on the descriptor mentioned in Table 2. Morphological characters like vegetative, inflorescence, pod and seed characters (Table 3) were recorded and accessions were catalogued.

Growth habit of all accessions included in the experiment was prostrate type. Leaf shape is normal and leaf size varied from small to large. Leaf density was found to be medium or dense.

Pods at green picking stage was found to be very soft to highly fibrous. Shape of the pod varied from slightly curved and highly curved.

Seed shape varied from flat oval, oval and oblong oval to oblong. Seed colour varied from light brown to black and seed size ranged from small to medium.

4.2 Evaluation of variability in hyacinth bean

4.2.1 Variability

The analysis of variance showed significant difference between accessions for all characters studied except number of seeds pod^{-1}, thickness of pod and number of primary branches. The mean performance of duration and vegetative characters and pod characters of 44 accessions of hyacinth bean were presented in Table 4 and Table 5. The population mean, range, genotypic coefficient of variation and genotypic coefficient of variation are given in the Table 6.

Table 3. Vegetative, inflorescence, pod and seed characters of hyacinth bean

Sl. No.	Acc. Number	Raceme position	Pubescene	Leaf shape	Leaf size	Leaf density	Pod attachment to peduncle	Pod shape	Pod colour	Pod fibrousness	Seed shape	Seed size	Colour of seed	Basic plant vigour	Utility type
1	DL-3	Mostly above conopy	Absent	Normal	Medium	Medium	Erect	H. curved	Dark green	Highly fibrous	Oblong oval	Medium	Light brown	Average vigour	Dual type
2	DL-6	Mostly above conopy	Absent	Normal	Medium	Medium	Erect	S. curved	Light green	Average	Oblong oval	Medium	Light brown	Vigorous	Pulse type
3	DL- 7	Mostly above conopy	Present	Normal	Medium	Dense	Erect	S. curved	Green	Average	Flat oval	Medium	Dark brown	Highly vigourous	Dual type
4	DL-8	Mostly above conopy	Present	Normal	Medium	Medium	Erect	H. curved	Green	Average	Oval	Medium	Black	Average vigour	Pulse type
5	DL-12	Mostly above conopy	Present	Normal	Medium	Medium	Pendant	S. curved	Dark green	Highly fibrous	Flat oval	Medium	Black	Average vigour	Dual type
6	DL-13	Mostly above conopy	Absent	Normal	Medium	Medium	Erect	S. curved	Dark green	Highly fibrous	Flat oval	Medium	Light brown	Vigorous	Pulse type
7	DL-18	Throughout the conopy	Present	Normal	Medium	Dense	30 to 60^0 from erect	S. curved	Dark green	Average	Flat oval	Medium	Black	Vigorous	Dual type
8	DL- 27	Mostly above conopy	Present	Normal	Medium	Medium	Erect	S. curved	Green	Average	Flat oval	Medium	Black	Average vigour	Dual type
9	DL-28	Throughout the conopy	Absent	Normal	Medium	Dense	Erect	Straight	Dark green	Highly fibrous	Oblong	Medium	Light brown	Highly vigourous	Dual type
10	DL- 29	Mostly above conopy	Absent	Normal	Medium	Medium	30 to 60^0 from erect	S. curved	Green	Average	Flat oval	Medium	Light brown	Vigorous	Dual type
11	DL-30	Mostly above conopy	Absent	Normal	Medium	Dense	Erect	S. curved	Light green	Highly fibrous	Oblong oval	Medium	Black	Vigorous	Dual type
12	DL-37	Mostly above conopy	Absent	Normal	Medium	Medium	Pendant	S. curved	Dark green	Average	Oval	Small	Black	Average vigour	Pulse type
13	DL-38	Mostly above conopy	Absent	Normal	Medium	Dense	30 to 60^0 from erect	S. curved	Green	Highly fibrous	Oblong oval	Medium	Dark brown to black	Highly vigourous	Dual type
14	DL-39	Mostly above conopy	Present	Normal	Medium	Medium	30 to 60^0 from erect	S. curved	Dark green	Highly fibrous	Oval	Medium	Light brown	Average vigour	Dual type
15	DL-40	Up to 1/3rd of conopy	Present	Normal	Small	Medium	30 to 60^0 from erect	Straight	Green with maroon tinge	Average	Oblong	Medium	Black	Vigorous	Dual type
16	DL41	Mostly above conopy	Present	Normal	Medium	Medium	30 to 60^0 from erect	S. curved	Dark green	Average	Flat oval	Small	Black	Average vigour	Dual type
17	DL42	Mostly above conopy	Present	Normal	Medium	Medium	Erect	S. curved	Light green	Average	Oval	Medium	Light brown	Vigorous	Dual type
18	DL-43	Mostly above conopy	Absent	Normal	Medium	Dense	Erect	Straight	Dark green	Average	Flat oval	Medium	Light brown	Vigorous	Dual type
19	DL-44	Up to 1/3rd of conopy	Absent	Normal	Medium	Dense	30 to 60^0 from erect	S. curved	Green	Average	Oval	Small	Black	Highly vigourous	Dual type
20	DL-45	Throughout the conopy	Absent	Normal	Medium	Dense	Pendant	Straight	Dark green	Average	Oval	Small	Light brown	Highly vigourous	Dual type
21	DL-48	Throughout the conopy	Absent	Normal	Small	Dense	30 to 60^0 from erect	Straight	Light green	Average	Oval	Small	Light brown	Highly vigourous	Dual type
22	DL-49	Throughout the conopy	Absent	Normal	Medium	Dense	30 to 60^0 from erect	S. curved	Green	Average	Oblong oval	Medium	Dark brown	Vigorous	Dual type

Table 3. Continued

Sl. No.	Acc. No.	Raceme position	Pubescene	Leaf shape	Leaf size	Leaf density	Pod attachment to peduncle	Pod shape	Pod colour	Pod fibrousness	Seed shape	Seed size	Colour of seed	Basic plant vigour	Utility type
23	DL-50	Up to 1/3rd of conopy	Absent	Normal	Medium	Dense	30 to 60⁰ from erect	S. curved	Dark green	Average	Flat oval	Medium	Light brown	Vigorous	Dual type
24	DL- 51	Mostly above conopy	Present	Normal	Medium	Medium	Erect	H. curved	Green	Average	Flat oval	Medium	Black	Average vigour	Dual type
25	DL-52	Throughout the conopy	Absent	Normal	Medium	Dense	Erect	H. curved	Green	Very soft	Oval	Medium	Dark brown	Highly vigourous	Dual type
26	DL-53	Throughout the conopy	Present	Normal	Medium	Dense	Erect	H. curved	Green	Average	Oval	Medium	Black	Highly vigourous	Dual type
27	DL-54	Up to 1/3rd of conopy	Absent	Normal	Medium	Medium	30 to 60⁰ from erect	S. curved	Dark green	Highly fibrous	Oblong oval	Medium	Dark brown	Highly vigourous	Dual type
28	DL-55	Mostly above conopy	Absent	Normal	Small	Dense	Erect	S. curved	Dark green	Average	Flat oval	Medium	Black	Average vigour	Dual type
29	DL- 56	Throughout the conopy	Absent	Normal	Medium	Medium	Pendant	S. curved	Dark green	Very soft	Oval	Big	Dark brown	Average vigour	Dual type
30	DL-58	Mostly above conopy	Absent	Normal	Medium	Medium	Erect	S. curved	Reddish green	Average	Oval	Medium	Black	Average vigour	Pulse type
31	DL-59	Throughout the conopy	Absent	Normal	Medium	Dense	Pendant	S. curved	Light maroon	Very soft	Oblong oval	Medium	Dark brown to black	Vigorous	Dual type
32	DL-60	Up to 1/3rd of conopy	Absent	Normal	Small	Medium	30 to 60⁰ from erect	H. curved	Light green	Very soft	Oval	Medium	Dark brown	Vigorous	Dual type
33	DL-61	Throughout the conopy	Absent	Normal	Small	Medium	Pendant	S. curved	Green	Highly fibrous	Flat oval	Medium	Light brown	Vigorous	Veg.type
34	DL-62	Throughout the conopy	Absent	Normal	Medium	Medium	Erect	S. curved	Green	Very soft	Oval	Medium	Black	Vigorous	Dual type
35	DL-63	Up to 1/3rd of conopy	Absent	Normal	Medium	Medium	30 to 60⁰ from erect	Straight	Green	Very soft	Flat oval	Medium	Dark brown	Vigorous	Veg.type
36	DL-64	Mostly above conopy	Present	Normal	Medium	Medium	Erect	S. curved	Dark green	Average	Oval	Medium	Black	Average vigour	Dual type
37	DL-65	Up to 1/3rd of conopy	Absent	Normal	Small	Medium	30 to 60⁰ from erect	S. curved	Dark green	Average	Flat oval	Medium	Light brown	Vigorous	Dual type
38	DL-66	Up to 1/3rd of conopy	Absent	Normal	Medium	Medium	30 to 60⁰ from erect	H. curved	Dark green	Average	Oblong oval	Big	Light brown	Vigorous	Veg.type
39	DL-67	Up to 1/3rd of conopy	Present	Normal	Medium	Medium	30 to 60⁰ from erect	S. curved	Green	Average	Oval	Medium	Dark brown to black	Vigorous	Dual type
40	DL-68	Mostly above conopy	Present	Normal	Medium	Dense	30 to 60⁰ from erect	S. curved	Green	Highly fibrous	Oval	Medium	Dark brown	Vigorous	Pulse type
41	DL-69	Up to 1/3rd of conopy	Present	Normal	Medium	Dense	Pendant	H. curved	Maroon	Very soft	Oblong oval	Medium	Black	Vigorous	Veg.type
42	DL- 71	Up to 1/3rd of conopy	Absent	Normal	Medium	Medium	30 to 60⁰ from erect	S. curved	Dark green	Average	Oval	Big	Light brown	Vigorous	Veg.type
43	DL-72	Throughout the conopy	Absent	Normal	Medium	Dense	Pendant	S. curved	Green	Average	Flat oval	Medium	Light brown	Average vigour	Dual type
44	DL-73	Up to 1/3rd of conopy	Absent	Normal	Medium	Dense	30 to 60⁰ from erect	S. curved	Light green	Average	Oblong oval	Medium	Black	Vigorous	Veg.type

b) Days to germination

Significant difference was found among different accessions for days taken for germination and it ranged from 3.00 (DL-48 and DL-28) to 7.00 days (Dl-44).

c) Days to first flowering

Analysis of variance for days to first flowering showed that there was a significant difference among genotypes for this character. The value ranged from 54.5 (DL-8) to 110 days (DL-69).

d) Days to 50 per cent flowering

Days to 50 per cent flowering varied from 75 in DL-13 to 151 in DL-69 with a mean of 103.27. The pcv and gcv values were 13.89 and 13.84 respectively.

e) Days to vegetable maturity

Significant difference was observed among the different accessions for days to vegetable maturity and it ranged from 11 days (DL-44 and DL-40) to 24.5 days (DL-56) with an average value of 16.59. The pcv and gcv were 18.90 and 17.81 respectively.

f) Days to first harvest

Significant difference was found among the different accessions for days taken for first harvest and it ranged from 61 (DL-13) to 127.5 (DL-69) days with a mean of 86.14 days. The pcv and gcv estimates were 14.39 and 14.08 respectively.

g) Days to final harvest

The accession DL-6 had maximum days to final harvest (211.5 days) and the accession DL-54 had the minimum days (137.50 days). The pcv was 7.88 and gcv was 7.73. The mean value was 169.16 days.

Table 4. Men performance of duration and vegetative characters in 44 accessions of hyacinth bean

Accession Number	Days to germin-ation	Days to first flowering	Days to 50% flowering	Days to first harvest	Days to final harvest	Duration of crop (Days)	100 seed weight (g)	No of primary branches	Thickness of main stem (cm)	Length of vine (cm)	Days to vegetable maturity
DL-3	4.0	58.00	93.5	76.5	162.0	270.00	33.95	1.25	3.80	315.0	17.00
DL-6	4.0	60.50	104.0	82.5	211.5	290.00	25.26	2.00	4.85	283.0	11.75
DL-7	4.0	59.50	104.0	84.0	162.0	262.50	25.00	3.50	5.75	267.5	19.00
DL-8	3.5	54.50	120.0	79.0	172.5	260.00	29.20	2.50	5.70	278.0	18.00
DL-12	5.5	86.50	119..0	97.5	159.0	252.50	28.42	1.75	6.85	190.0	14.00
DL-13	3.5	47.50	75.0	61.0	169.0	245.00	26.67	3.75	5.10	278.0	14.50
DL-18	5.0	61.00	105.0	90.0	163.5	275.00	25.60	3.00	5.85	254.0	19.25
DL-27	4.0	60.00	104.0	85.0	177.5	272.50	28.30	3.50	6.95	215.0	21.00
DL-28	3.0	61.50	104.5	82.0	171.0	262.50	30.01	1.50	3.25	141.5	18.75
DL-29	5.0	63.00	105.0	90.0	165.0	260.00	30.38	4.25	4.60	360.0	17.75
DL-30	4.5	58.00	95.5	80.0	175.0	260.00	31.41	2.50	7.75	225.0	18.00
DL-37	4.0	64.50	105.0	84.5	166.0	265.00	26.15	2.00	7.20	157.5	17.25
DL-38	4.0	58.00	84.0	78.0	160.0	252.50	29.52	2.00	4.10	256.0	17.00
DL-39	5.5	71.00	110.0	89.0	175.0	279.00	25.90	3.50	4.75	140.5	21.00
DL-40	4.0	57.00	98.5	79.0	170.5	262.50	27.75	3.25	7.05	298.0	11.00
DL41	4.0	63.00	103.0	84.0	170.0	255.00	24.20	2.60	6.65	380.0	13.50
DL42	4.0	60.50	103.0	77.5	171.0	260.00	26.70	2.50	6.30	295.0	17.50
DL-43	4.5	62.50	99.0	87.0	181.0	275.00	30.33	2.00	6.90	162.5	17.00
DL-44	7.0	57.50	78.0	71.0	171.0	260.00	26.05	2.00	6.10	336.0	11.00
DL-45	4.0	62.50	80.0	82.5	143.5	242.00	27.08	3.50	4.15	317.5	19.50
DL-48	3.0	61.50	95.0	83.0	172.5	270.00	34.23	1.50	5.85	257.5	17.75
DL-49	6.5	50.50	95.0	71.0	151.0	242.50	25.35	3.75	5.80	256.0	17.00
DL-50	4.0	63.00	103.0	86.0	167.5	275.00	25.67	2.50	4.80	359.5	17.10
DL-51	4.0	65.00	106.0	85.0	166.0	270.00	23.55	3.75	6.80	237.5	15.00
DL-52	5.0	87.50	120.0	107.5	165.0	275.00	32.81	1.75	5.05	267.5	15.25
DL-53	4.0	67.50	101.5	81.0	162.5	252.50	28.50	2.75	5.45	238.0	13.50
DL-54	5.0	56.00	78.0	76.5	137.5	237.50	27.83	3.00	5.75	212.5	18.50
DL-55	4.0	70.00	110.5	94.0	160.0	280.00	26.06	2.50	5.90	416.0	12.00
DL-56	5.0	90.50	140.5	122.5	166.5	270.00	38.55	3.00	4.90	237.5	24.50
DL-58	5.0	62.00	103.5	82.0	164.0	260.00	31.33	2.50	5.65	293.0	16.50
DL-59	5.0	63.00	103.0	81.5	171.0	262.50	22.77	1.75	4.10	336.0	12.00
DL-60	3.5	59.00	94.5	82.5	171.0	272.50	25.73	3.25	4.70	273.0	14.25
DL-61	5.5	61.00	104.5	82.5	167.5.	257.50	27.50	2.25	7.10	195.0	13.50
DL-62	5.5	59.00	100.0	86.5	171.0	275.00	28.50	1.62	3.50	258.0	19.00
DL-63	6.0	74.00	109.5	94.0	192.0	272.50	33.78	1.50	5.85	257.5	17.50
DL-64	4.0	58.00	103.0	85.5	166.0	270.00	28.50	2.50	4.00	220.0	18.00
DL-65	5.5	62.00	104.0	83.0	172.0	280.00	24.06	2.50	5.80	293.0	12.50
DL-66	5.0	65.50	105.0	82.5	182.0	280.00	26.12	1.50	4.9	300.0	16.00
DL-67	4.0	70.00	104.5	91.0	174.0	270.00	28.08	3.25	5.55	195.0	17.00
DL-68	4.0	90.50	129.0	116.0	161.0	250.00	28.12	1.75	3.25	129.0	15.00
DL-69	5.5	110.00	150.5	127.5	210.0	295.00	33.42	1.75	6.85	321.0	19.00
DL-71	5.0	55.50	95.0	82.5	178.5	271.00	30.65	1.25	6.06	193.5	22.30
DL-72	5.5	65.50	104.5	83.0	166.0	270.00	31.12	3.25	5.35	285.0	18.00
DL-73	4.5	61.00	94	83.5	152.0	240.00	23.42	1.75	5.10	273.0	14.50

h) Duration of crop

Duration of crop varied from 237 days (DL-54)to 295 days(DL-69).

i) Number of pods cluster^{-1}

Different accessions under study showed significant difference between them for number of pods cluster^{-1}. The number of pods cluster^{-1} ranged from 2.75 (DL-63) and to 12.38 (DL-49). The mean pods cluster^{-1} was 6.77. The pcv and gcv estimates were 33.80 and 28.28 respectively.

j) Pod length

Pod length varied from 2.2 cm (DL-63) to 12.38 cm (DL-43) with a mean value of 7.39 cm. The pcv and gcv values were 38.43 and 38.33 respectively. There was significant difference between accessions in pod length.

k) Girth of pod

The girth of pod ranged from 1.87 cm in DL-59 to 6.38 cm in DL-45 with a mean of 3.98 cm. The value of pcv was 24.76 and that of gcv was 24.54.

l) Weight of pod

The different accessions varied significantly for weight of pod. Maximum pod weight was observed for the accession DL-27 (14.62 g) and minimum for DL-37 (1.13 g). The pcv and gcv estimates were found to be high (65.32 and 65.21, respectively).

m) Thickness of pod

Analysis of variance for thickness of pod revealed that there was no significant difference between the different accessions for this character. The lowest value recorded for this character was 0.10 cm for DL-55, DL-54, DL-37, DL-38, DL-3, DL-43, DL-7 and DL-12 and the highest value was 0.45 cm for

DL-68 with a mean value of 0.20 cm. The pcv and gcv were 45.15 and 38.73 respectively.

n) Number of seeds pod^{-1}

Maximum number of seeds pod^{-1} was recorded for the accession DL-54 and minimum for DL-8. The values ranged between 2.72 to 5.68 with a mean value of 3.70. The pcv and gcv estimates were 19.05 and 16.68 respectively. No significant difference was noted between the different accessions.

o) 100 seed weight

The 100 seed weight was maximum for the accession DL-59 (38.55 g) and minimum for DL-56 (22.77 g) with a mean value of 28.26 g. The pcv and gcv values were 12.29 and 11.59 respectively.

p) Number of primary branches

Significant difference was not found among the different accessions for the character. The accession DL-3 and DL-71 had minimum number of primary branches (1.25) and the accession DL-29 had the maximum number (4.25) with a mean of 2.49. The pcv value was 34.48 and gcv was 29.38.

q) Length of vine

Vine length varied from 129 cm (DL-68) to 420 cm (DL-55) with a mean of 261 cm. The pcv and gcv values were 26.81 and 23.52 respectively.

r) Thickness of main stem

Thickness of main stem varied significantly among different accessions studied. The accession DL-30, had maximum value of 7.75 cm and DL-48 recorded minimum value of 3.25 cm with a mean of 5.29 cm. The pcv and gcv estimates were 24.89 and 15.13 respectively.

s) Fruit setting per cent

Analysis of variance for fruit set revealed that there was significant difference between the different accessions under study. Lowest fruit set of 20 per cent was observed in the accession DL-63 and the highest fruit set was observed in DL-29 (47.5%) with a mean value of 31.82 per cent. The pcv and gcv were 21.72 and 19.26 respectively.

t) Number of pods plant^{-1}

The number of pods plant^{-1} ranged from 207.79 in DL-45 to 3961.27 in DL-7. The mean number of pods per plant was 1549.11. The pcv and gcv estimates were found to be 54.32 and 50.65.

u) Pod yield plot^{-1}

The yield of pods varied significantly among different accessions. The accession DL-63 had the lowest yield and DL-6 had the highest yield. Average yield plot^{-1} was 3.66 kg and the value ranged between 1.51 kg and 7.1 kg. The pcv and gcv estimates were 36.50 and 31.53 respectively.

v) Shelling per cent

The shelling per cent was maximum for the accession DL-71 and minimum for DL-38. The values ranged between 53.95 per cent and 86.96 per cent with a mean value 69.82. The pcv and gcv estimates were 14.08 and 13.98 respectively.

w) Crude fibre content of pod

The crude fibre content of pods at edible maturity ranged from 1.15 per cent to 3.42 per cent the mean value being 1.94. The accession DL-65 recorded the lowest fibre content and accession DL-41 had the highest fibre content. The pcv was 26.79 and gcv was 24.65.

Table 5. Mean performance of yield and pod characters of 44 accessions of hyacinth bean

Accession Number	No of pods / cluster	Pod length (cm)	No of seeds / pod	Girth of pod (cm)	Weight of pod (g)	Thickness of pod (cm)	pod setting %	No of pods / plant	Crude fibre % of pod	Crude protein % of pod	Shelling %	Yield / plot(kg)	Yield kg/ha
DL-3	6.12	5.35	3.91	2.35	2.03	0.10	32.50	1862.50	1.65	2.57	87.9	3.72	4650
DL-6	6.25	11.61	3.60	3.74	3.10	0.20	41.0	1575.50	1.30	2.29	57.92	7.10	8875
DL-7	11.0	4.75	3.00	3.74	1.43	0.10	40.0	3961.27	2.35	2.56	68.1	5.62	7025
DL-8	9.38	5.78	2.72	2.87	1.62	0.25	27.50	2000.00	2.10	2.37	81.72	3.20	4000
DL-12	7.62	5.47	3.35	3.84	2.12	0.10	22.50	1191.31	1.65	1.89	78.47	2.54	3175
DL-13	10.0	4.38	3.25	3.73	1.34	0.20	32.50	2935.6	1.85	2.36	72.41	3.88	4850
DL-18	7.75	5.61	3.00	3.45	1.85	0.20	27.50	2337.83	2.44	2.20	81.51	4.32	5400
DL-27	6.50	5.03	3.38	3.98	14.62	0.15	32.50	2590.91	1.53	1.69	85.75	4.27	5337.5
DL-28	8.38	5.18	3.25	4.12	4.01	0.20	27.50	714.41	1.64	2.38	68.28	2.18	2725
DL-29	7.38	4.66	3.05	3.30	4.32	0.20	47.50	1511.62	2.15	2.19	66.29	6.50	8125
DL-30	6.75	7.28	4.25	4.01	2.35	0.25	30.0	1988.36	2.00	1.68	74.04	4.28	5350
DL-37	8.75	5.41	4.22	3.78	1.13	0.10	30.0	2433.62	1.93	2.51	58.94	2.75	3437.5
DL-38	5.50	5.54	3.50	3.83	1.49	0.10	27.50	1715.68	1.66	2.63	86.96	2.62	3250
DL-39	9.50	6.50	3.38	4.18	1.35	0.20	37.50	3555.54	1.90	2.17	57.09	4.80	6000
DL-40	7.50	10.58	5.57	2.47	2.84	0.20	42.50	1963.09	1.74	2.27	68.33	5.57	6962.5
DL41	7.00	7.56	4.00	3.95	1.83	0.15	32.50	2364.86	3.42	2.23	66.42	4.38	5475
DL42	7.00	4.50	3.22	3.71	1.26	0.15	22.50	1440.0	2.58	2.46	77.93	1.80	2250
DL-43	7.88	12.38	4.38	4.73	2.22	0.10	37.50	1470.58	1.56	2.21	85.93	3.25	4062.5
DL-44	7.75	8.16	4.38	3.76	2.24	0.25	30.0	1677.76	2.79	2.01	67.12	3.78	4725
DL-45	3.00	8.0	4.00	6.38	11.50	0.35	22.5	207.79	1.78	1.74	78.1	2.40	3000
DL-48	7.5	10.62	4.50	2.74	3.03	0.35	30.0	587.50	1.90	2.15	60.72	2.18	2725
DL-49	12.38	10.27	3.50	4.52	5.33	0.15	42.5	983.30	1.63	2.02	60.18	4.70	5875
DL-50	3.50	11.31	3.50	4.38	2.23	0.25	25.0	1827.0	2.28	2.10	60.95	3.85	4812.5
DL-51	7.12	4.50	3.12	3.65	2.03	0.25	32.50	2121.94	1.63	2.07	55.85	4.35	5437.5
DL-52	6.0	11.43	4.38	3.32	3.72	0.18	27.50	720.0	1.74	1.51	68.82	2.70	3375
DL-53	6.88	4.75	3.50	3.74	1.76	0.20	30.0	2078.65	1.50	2.41	60.85	3.70	4625
DL-54	6.25	11.27	5.68	4.07	3.34	0.10	32.5	1148.65	1.29	2.79	75.93	3.82	4775
DL-55	7.25	5.85	3.04	2.52	1.42	0.10	30.0	1921.1	1.75	2.36	73.74	3.10	3875
DL-56	2.88	10.81	3.55	5.72	4.91	0.15	45.0	1051.02	2.03	2.03	77.01	5.15	6437.5
DL-58	6.38	5.96	3.22	3.85	1.85	0.20	30.0	1357.0	1.35	1.65	81.39	2.50	3125
DL-59	4.25	9.95	3.75	1.87	3.94	0.20	32.50	1226.18	2.21	2.26	62.25	4.95	6187.5
DL-60	5.62	8.22	3.03	3.57	2.32	0.30	26.25	1146.0	2.15	1.79	55.57	3.25	4062.5
DL-61	9.25	4.38	4.25	3.84	1.94	0.30	30.0	1205.12	1.75	1.98	82.35	2.35	2937.5
DL-62	4.0	5.53	3.80	4.14	3.47	0.13	30.0	992.72	16.25	2.50	75.13	3.42	4275
DL-63	2.75	2.20	4.12	3.88	3.75	0.20	20.0	402.65	2.71	2.25	61.93	1.51	1887.5
DL-64	7.38	5.04	3.12	4.03	1.31	0.15	32.50	2007.53	2.60	2.74	74.96	2.65	3312.5
DL-65	5.38	10.43	4.50	4.13	3.22	0.15	30.25	1721.0	1.15	2.19	68.68	4.85	6062.5
DL-66	4.50	4.62	4.38	4.50	7.53	0.30	45.0	649.13	1.78	2.69	52.12	4.88	6100
DL-67	6.88	9.18	3.25	6.13	2.46	0.15	42.5	1787.19	3.18	2.56	65.07	4.32	5200
DL-68	9.25	12.0	3.12	6.52	3.54	0.45	27.5	663.84	1.28	2.43	68.3	2.35	2937.5
DL-69	4.12	3.75	3.12	5.80	4.43	0.15	25.0	575.04	2.35	2.21	69.99	2.47	3087.5
DL-71	5.62	11.25	3.12	3.84	7.15	0.40	30.0	381.94	1.44	2.20	52.95	2.75	3437.5
DL-72	5.38	10.50	4.38	3.82	2.45	0.30	30.0	1428.56	1.58	2.04	75.84	3.50	4375
DL-73	6.38	7.72	3.38	4.67	4.22	0.15	30.0	679.66	1.78	2.19	62.39	2.88	3600

Table 6. Range, mean, phenotypic coefficient of variation and genotypic coefficient of variation of different characters in hyacinth bean

Sl. No.	Characters	Range	Mean+SE	pcv	gcv
1	Days to50%flowering	75-151	103.273+1.28	13.89	13.84
2	Days to first harvest	60-130	86.136 +2.56	14.39	14.08
3	Days to final harvest	137-213	169.159+2.55	7.88	7.73
4	Number of pods cluster^{-1}	2.25-12.75	6.770+1.25	33.80	28.28
5	Pod length (cm)	2.15-12.5	7.392+0.208	38.43	38.33
6	Girth of pod (cm)	1.85-6.52	3.98+0.340	24.76	24.54
7	Weight of pod (g)	1.12-11.62	3.024+1.16	65.32	65.21
8	Thickness of pod (cm)	.100-.501	0.201+0.130	45.15	38.73
9	Number of seeds pod^{-1}	2.5-5.75	3.699+0.115	19.05	16.68
10	100 seed weight (g)	22.75-38.85	28.26+0.046	12.29	11.59
11	Number of primary branches	1.00-4.5	2.491+0.449	34.48	29.38
12	Length of vine (cm)	125-420	261+1.09	26.81	23.52
13	Thickness of main stem	3-8.2	5.293+33.59	24.89	15.13
14	Fruit setting (%)	20-50	31.818+3.18	21.71	19.26
15	Number of pods plant^{-1}	168.83-4577.46	1549.113+2.03	54.32	50.65
16	Pod yield plot^{-1} (kg)	1.17-7.95	3.662+2.08	36.50	31.53
17	Days to vegetable maturity	10-25	16.593+304.03	18.90	17.81
18	Shelling (%)	51.65-88.64	69.824+0.674	14.08	13.98
19	Crude fibre content of pod	1.14-3.6	1.937+1.21	26.79	24.65
20	Crude protein content of pod	1.33-2.92	2.2169+1.05	15.18	11.90

Plate 1: General view of experimental plot

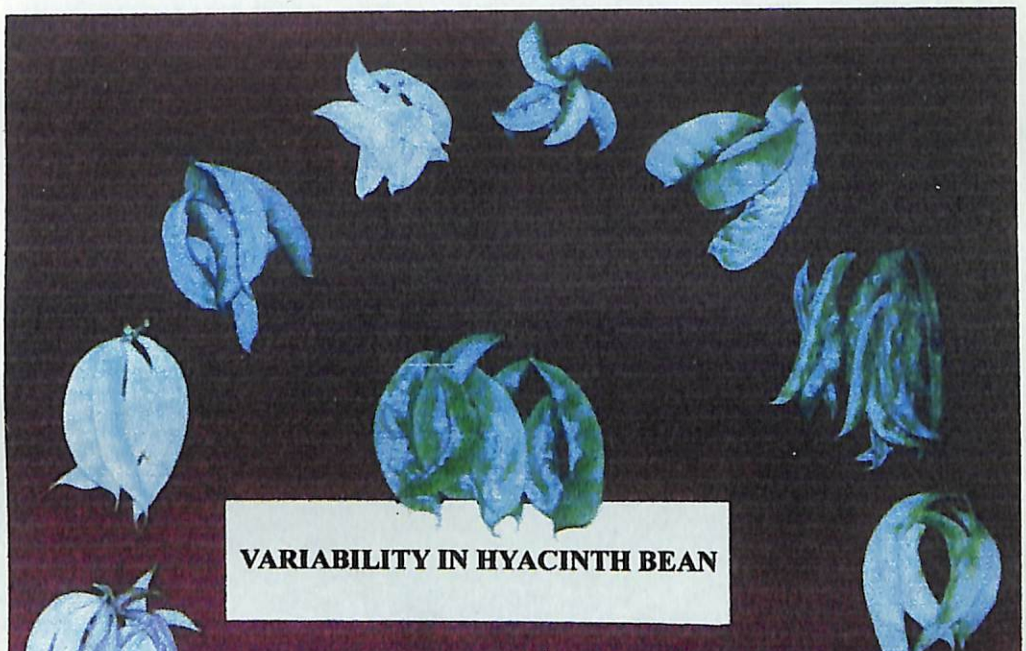
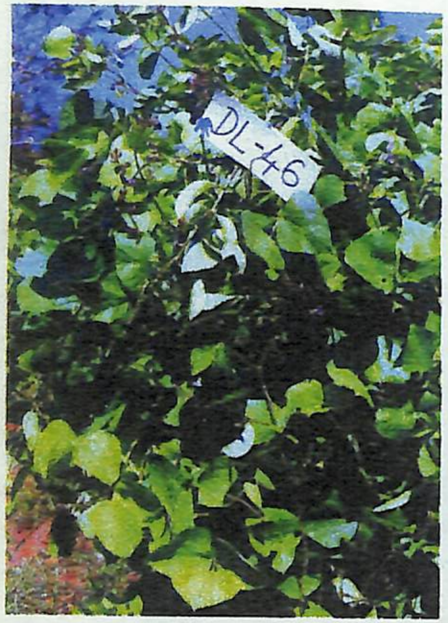


Plate 2: Genetic variability in hyancinth bean

Plate 3: Accession with highest yield (DL – 6)

Plate 4: Accession with maximum number of primary branches, maximum fruit setting percentage and rank second in yield (DL – 29)

Plate 5: Morphological variability in hyacinth bean

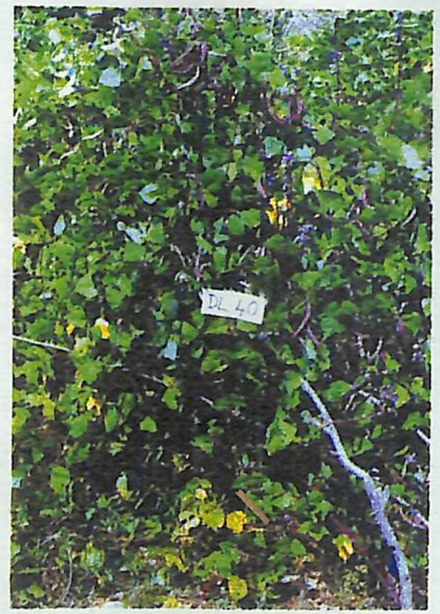


DL – 46

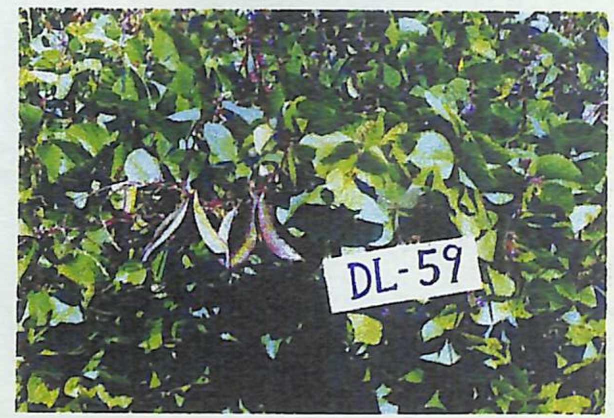
DL - 73

DL - 60

DL – 71

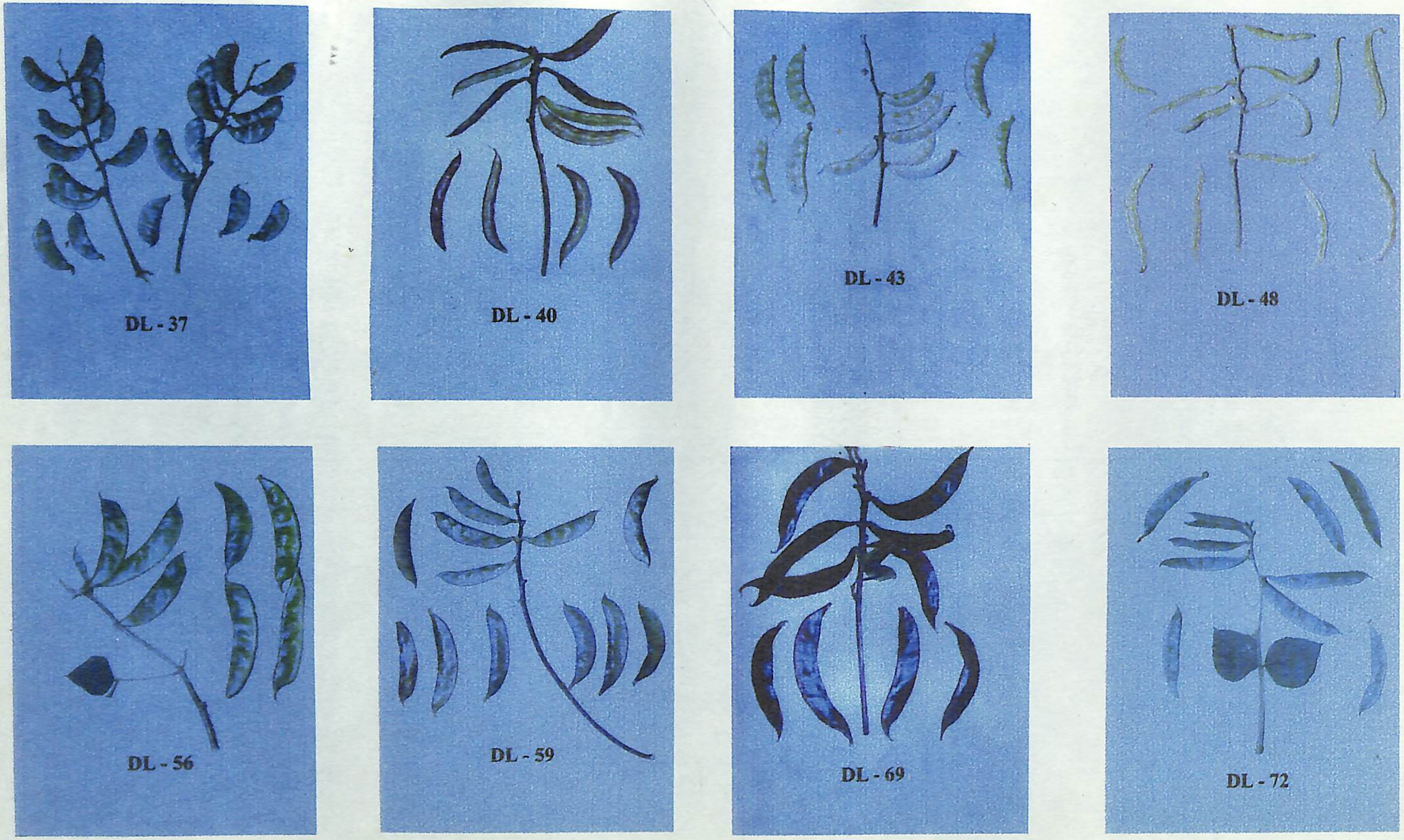


DL – 40



DL - 59

Plate 6: Variability in fruit characters



x) Crude protein content of pod

The crude protein content of pods at vegetable maturity stage was maximum for DL-54 and minimum for DL-52. The value ranged between 1.51 to 2.79 per cent with a mean of 2.22. The pcv and gcv estimates were 15.18 and 11.90 respectively.

4.2.2 Heritability, genetic advance and genetic gain

Heritability, genetic advance and genetic gain values for different characters are presented in Table 7.

Highest heritability was observed for the character weight of pod (99.7%), followed by pod length (99.5%). Other characters with high heritability were days to 50 per cent flowering (99.2%), shelling percentage (98.5%), girth of pod (98.3%), days to final harvest (96.3%), days to first harvest (95.7%), 100 seed weight (88.9%), days to vegetable maturity (88.7%), fruit setting percentage (84.6%), crude fibre content of pod (84.6%), thickness of main stem (78.8%), length of vine (77%), number of seeds pod^{-1} (76.7%), pod yield plot^{-1} (74.6%), thickness of pod (73.6%), number of primary branches (72.6%), number of pods cluster^{-1} (70%), number of pods plant^{-1} (61.5%) and crude protein content of pod (61.5%). Moderate and low heritability values are not there for the characters.

Genetic advance was the highest for number of pods plant^{-1} (1507.09) and the lowest for thickness of pod (0.14).

Highest magnitude of genetic gain was manifested by weight of pod (134.26%) and the lowest by days to final harvest (15.63%). The characters like number of pods plant^{-1} (97.29%), pod length (78.73%), thickness of pod (69.66%), pod yield plot^{-1} (55.98%), number of primary branches (51.39%), girth of pod (50%), number of pods per cluster (48.75%), crude fibre content of pod (46.73%). The characters like Length of vine (42.51%), fruit setting percentage (35.23%), days to vegetable maturity (34.53%), number of seeds pod^{-1} (30.01%), shelling

Table 7. Heritability, Genetic advance and genetic gain for different characters in hyacinth bean

Sl. No.	Characters	Heritability	Genetic advance	Genetic gain
1	Days to 50 % flowering	0.992	29.32	28.39
2	Days to first harvest	0.957	24.44	28.37
3	Days to final harvest	0.963	26.44	15.63
4	Number of pods cluster^{-1}	0.700	3.30	48.74
5	Pod length	0.995	5.82	78.734
6	Girth of pod	0.983	1.99	50
7	Weight of pod	0.997	4.06	134.26
8	Thickness of pod	0.736	0.14	69.66
9	Number of seeds pod^{-1}	0.767	1.11	30.01
10	100seed weight	0.889	6.36	22.51
11	Number of primary branches	0.726	1.28	51.39
12	Length of vine	0.770	110.94	42.51
13	Thickness of main stem	0.788	1.04	18.933
14	Fruit setting (%)	0.846	11.21	35.23
15	Number of pods plant^{-1}	0.615	1507.09	97.29
16	Pod yield plot^{-1}	0.746	2.05	55.98
17	Days to vegetable maturity	0.887	5.73	34.53
18	Shelling (%)	0.985	19.95	28.58
19	Crude fibre content of pod	0.846	0.91	46.73
20	Crude protein content of pod	0.615	0.43	19.22

percentage (28.58%), days to 50 per cent flowering (28.39%), days to first harvest (28.37%) and 100 seed weight (22.51%) also had high genetic gain.

Moderate genetic gain was observed for the characters like crude protein (19.22%), thickness of main stem (18.93%) and days to final harvest (15.63%).

4.2.3 Correlation studies

The estimates of genotypic and phenotypic correlations between different pairs of characters are presented in Table 8 and Table 9. It was observed that yield was significantly and positively correlated with fruit setting percentage (rg = 0.958 and rp = 0.662) and number of pods plant^{-1} (rg = 0.402 and rp = 0.483) both genotypically and phenotypically. Yield per plant was significantly and positively correlated with number of primary branches (rg = 0.554) and negatively correlated with 100 seed weight genotypically (rg =-0.379).

Significant positive genotypic and phenotypic correlation was observed between days to vegetable maturity and 100 seed weight (rg = 0.371 and rp = 0.491) and with girth of pod (rg = 0.530) genotypically. Days to vegetable maturity was also found to be significantly and negatively correlated with length of vine (rg = -0.421).

No significant correlation was observed between shelling percentage and other characters phenotypically. But significant positive genotypic correlation was observed with girth of pod (rg = 0.344) and negatively correlated with thickness of pod (-0.377).

With regard to number of pods plant^{-1}, its correlation with number of pods cluster^{-1} and number of primary branches was significant and positive genotypically (rg = 0.538 and 0.556 respectively) and phenotypically(rp = 0.046 and 0.463 respectively). Number of pods plant^{-1} was positively correlated with fruit setting percentage (rg = 0.319) genotypically. Significant negative association between number of pods plant^{-1} and days to first harvest, 100 seed weight, girth of pod, weight of pod and thickness of pod was recorded phenotypically (rg = -0.313, -0.418, -0.299, -0.693 and –0.438).

Crude protein content of pod was significantly and positively correlated with thickness of pod genotypically (rg = 0.367) and no significant correlation was observed phenotypically. Significant positive genotypic correlation was observed between crude fibre content of pod and length of vine (rg = 0.387).

Significant positive correlation was obtained between fruit setting percentage and number of pods cluster^{-1} and number of primary branches (rg = 0.341 and 0.449 respectively).

Length of vine was significantly and positively associated with number of pods cluster^{-1} and 100 seed weight (rg = 0.366 and 0.367 respectively). Thickness of main stem was found to have no significant correlation with other traits considered.

Number of primary branches was significantly and negatively associated with girth of pod (rg = -0.314). It also showed significant positive correlation with days to final harvest and number of pods cluster^{-1} (rg = 0.333 and 0.345 respectively). Significant positive correlation was observed between thickness of pod and weight of pod (rg = 0.462).

With regard to weight of pod, its correlation with number of pods cluster^{-1} and 100 seed weight was significant and positive (rg = 0.468 and 0.431 respectively). Girth of pod was positively correlated with days to first harvest (rg = 0.465). Pod length was not significantly associated with any other trait considered.

With regard to 100 seed weight, its correlation with days to 50 per cent flowering and days to first harvest was significant and positive (rg = 0.371 and

Table 8. Genotypic correlation coefficients among yield and its components in hyacinth bean

Characters	Days to 50% flowering	Days to first harvest	Days to final harvest	No of pods cluster^{-1}	Pod length	No of seeds/pod	100 seed weight	Girth of pod	Weight of pod	Thickness of pod	No of primary branches	Thickness of main stem	Length of vine	Fruit setting (%)	Crude fibre	Crude protein	No of pods plant^{-1}	Yield plot^{-1}	Shelling (%)
Days to first harvest	0.886**																		
Days to final harvest	0.407**	0.274																	
No of pods cluster^{-1}	0.143	0.3510*	-252																
Pod length	-0.055	0.093	-0.094	-0.097															
No of seeds pod^{-1}	-0.341*	-2.226	-0.122	-0.25	0.417**														
100 seed weight	0.371**	0.468**	0.191	-0.343*	0.017	0.093													
Girth of pod	0.26	0.465**	0.008	-0.179	0.156	-0.139	-0.139	0.123											
Weight of pod	-0.035	0.155	-0.076	0.468**	0.233	0.153	0.431**	0.118											
Thickness of pod	-0.032	0.016	0.094	-0.058	0.269	0.001	0.202	0.062	0.462**										
No of primary branches	-0.182	-0.187	0.333*	0.345*	-0.068	-0.115	0.099	-0.314*	-0.103	-0.08									
Thickness of main stem	0.092	-0.071	0.275	0.35	-0.112	0.363	-0.175	-0.087	-0.366	-0.278	0.203								
Length of vine	-0.135	-0.165	0.029	0.366*	-0.071	0.039	0.367*	-0.166	-0.098	-0.115	0.117	-0.009							
Fruit setting (%)	0.015	-0.064	0.084	0.341*	0.226	0.126	0.017	-0.025	0.076	-0.212	0.449**	-0.083	0.018						
Crude fibre content of pod	0.032	0.029	0.168	-0.047	-0.272	-0.228	0.033	-0.067	-0.205	-0.187	0.153	0.056	0.387*	-0.048					
Crude protein content of pod	-0.128	-0.166	0.004	0.067	-0.205	0.011	-0.045	-0.151	-0.187	0.367*	-0.208	-0.566	-0.088	0.209	0.095				
No of pods plant^{-1}	-0.133	-0.313*	-0.042	0.538**	-0.274	-0.225	-0.418**	-0.299*	-0.693**	-0.438**	0.556**	0.293	0.03	0.319*	0.252	0.232			
Yield plot^{-1}	-0.038	-0.146	0.158	0.103	0.241	0.065	-0.374*	-0.169	-0.013	-0.207	0.554**	-0.017	0.319	0.958**	0.003	0.135	0.402**		
Shelling (%)	-0.012	0.017	-0.244	0.008	-0.162	0.024	-0.011	0.344*	-0.245	-0.377**	0.033	0.072	-0.012	-0.227	-0.086	-0.067	0.1	-0.27	
Days to vegetable maturity	0.216	0.287	-0.025	-0.166	-0.078	-0.239	0.371**	0.530**	0.261	0.035	0.101	-0.21	-0.421**	0.038	0.008	-0.001	-0.068	-0.192	0.175

* Significant at 5% level   ** Significant at 1% level

Table 9. Phenotypic correlation coefficients among yield and its components in hyacinth bean

Characters	Days to 50% flowering	Days to first harvest	Days to final harvest	No of pods cluster^{-1}	Pod length	No of seeds pod^{-1}	100 seed weight	Girth of pod	Weight of pod	Thickness of pod	No of primary branches	Thickness of main stem	Length of vine	Fruit setting (%)	Crude fibre content of pod	Crude protein content of pod	No of pods plant^{-1}	Yield plot^{-1}	Shelling (%)
Days to first harvest	0.8633*																		
Days to final harvest	0.399	0.2507																	
No of pods cluster^{-1}	-0.120	-0.2998	-0.1888																
Pod length	-0.056	0.089	-0.095	-0.079															
No of seeds pod^{-1}	-0.304	-0.166	-0.099	-0.144	-0.362														
100 seed weight	0.351	0.435	0.180	-0.273	-0.016	0.102													
Girth of pod	0.256	0.459	-0.0049	0.143	0.151	-0.118	0.108												
Weight of pod	-0.352	0.150	-0.730	-0.386	0.233	0.128	0.108	0.428											
Thickness of pod	-0.263	0.026	0.051	0.101	0.239	-0.049	0.022	0.173	0.399										
No of primary branches	-0.150	-0.194	-0.291	0.265	-0.048	-0.168	-0.215	-0.079	-0.086	-0.069									
Thickness of main stem	-0.056	-0.026	0.137	0.136	-0.076	0.201	-0.015	-0.099	-0.221	-0.108	0.111								
Length of vine	-0.109	-0.108	0.020	-0.294	-0.061	0.006	0.152	-0.311	0.086	-0.076	-0.079	-0.022							
Fruit setting (%)	-0.004	-0.043	-0.54	0.174	0.208	0.092	-0.45	0.013	0.071	0.125	0.341	0.011	-0.001						
Crude fibre content of pod	0.030	0.019	0.158	-0.029	-0.261	-0.159	-0.061	0.034	0.189	-0.108	0.086	0.138	0.269	-0.016					
Crude protein content of pod	-0.090	0.141	-0.029	0.146	-0.149	0.009	-0.152	-0.031	0.134	0.200	0.153	0.186	-0.076	0.218	0.160				
No of pods plant^{-1}	-0.123	-0.282	-0.031	0.046*	-0.258	-0.152	-0.308	-0.271	-0.643*	0.351	0.463*	0.189	-0.039	0.224	0.208	0.129			
Yield plot^{-1}	-0.036	0.110	0.139	0.110	0.202	0.068	-0.230	-0.135	-0.009	0.135	0.422	0.022	0.184	0.662*-	0.025	0.023	0.483*		
Shelling (%)	-0.011	0.012	-0.238	0.012	0.160	0.021	0.318	-0.011	-0.241	-0.313	0.008	0.028	-0.012	-0.202	-0.075	-0.048	-0.095	-0.229	
Days to vegetable maturity	0.201	0.265	-0.028	-0.141	-0.072	0.232	0.491*	0.343	0.247	0.040	0.113	-0.055	0.343	0.042	0.009	0.002	-0.016	0.082	0.169

* significant at 5% level   ** Significant at 1% level

0.468 respectively) and that with number of pods cluster^{-1}, the correlation was negative and significant (rg = -0.343).

Number of seeds pod^{-1} was significantly and positively correlated with pod length (rg = 0.417) and negatively correlated with days to 50 per cent flowering (rg = -0.341).

Significant correlation between number of pods cluster^{-1} and days to first harvest was observed (rg = 0.351). Significant correlation was not observed between days to final harvest and other characters except for days to 50 per cent flowering (rg = 0.407).

Significant positive genotypic and phenotypic correlation was observed between days to first harvest and days to 50 per cent flowering (rg = 0.886 and rp = 0.863).

Genotypic and phenotypic correlation whenever greater than unity, were not considered at all as it occurred mainly due to inadequacy of the model.

4.2.4 Path coefficient analysis

The direct and indirect contribution of the component characters and yield can be found out by partitioning the correlation between yield and component characters into direct and indirect effects (Table 10). In path coefficient analysis highest positive direct effect on yield was exhibited by fruit setting percentage (1.070) followed by number of pods plant^{-1} (0.244).

Direct effect of days to final harvest on yield was negative (-0.060). But due to its high positive indirect effects through traits like number of pods cluster^{-1} (0.126), fruit setting percentage (0.090), weight of pod (0.007), days to vegetable maturity (0.007), its correlation with yield was found to be positive (0.158).

Table 10. Direct and indirect effect of yield components on fruit yield in hyacinth bean

Characters	Days to final harvest	No of pods cluster^{-1}	Pod length	Weight of pod	Fruit setting (%)	No of pods plant^{-1}	Days to vegetable maturity	Genotypic correlation with yield
Days to final harvest	**-0.060**	0.126	-0.001	0.007	0.090	-0.01	0.007	0.158
No of pods cluster^{-1}	0.015	**-0.049**	-0.001	-0.044	0.365	0.131	0.046	0.103
Pod length	0.006	0.048	**0.012**	-0.022	0.242	-0.067	0.021	0.241
Weight of pod	0.005	0.233	0.003	**-0.094**	0.081	-0.169	-0.072	-0.013
Fruit setting (%)	-0.005	-0.017	0.003	-0.007	**1.070**	0.078	-0.011	0.958
No of pods plant^{-1}	0.003	-0.267	-0.003	0.065	0.342	**0.244**	0.019	0.402
Days to vegetable maturity	0.002	0.082	-0.001	-0.025	0.041	-0.017	**-0.275**	-0.192

Diagonal bold values indicates direct effects

High positive indirect effects of fruit setting percentage (0.365) and number of pods plant^{-1} (0.131) were responsible for positive correlation coefficient between yield and number of pods cluster^{-1} (0.103) eventhough the direct effect of number of pods cluster^{-1} was negative (-0.049).

Pod length had low positive direct effect on yield (0.012). High indirect effects of fruit setting percentage (0.242), number of pods cluster (0.048), days to vegetable maturity (0.021) and days to final harvest (0.006) was observed.

Direct effect of weight of pod on yield was negative (-0.094). Its genotypic correlation with yield was also negative (-0.013) due to high indirect effects of number of pods plant^{-1} (-0.169) and days to vegetable maturity (-0.072).

Fruit setting percentage had high direct effect on yield (1.070) and was positively correlated with yield. Due to its indirect effects on number of pods plant^{-1} (0.078) and pod length (0.003) its correlation with yield was positive and high.

Number of pods plant^{-1} had high positive direct effect on yield (0.244). High negative indirect effect of number of pods cluster^{-1} (-0.267) on fruit yield was also noticed.

Days to vegetable maturity had negative (-0.275) and very low direct effect on yield. Its indirect effects through number of pods cluster^{-1} (0.082), weight of pods (-0.025) and fruit setting percentage (0.041) were prominent.

Residual effect due to unknown factors on yield was –0.1192.

4.2.5 Genetic divergence

Using Mahalanobis D^2 statistics, the 44 accessions of hyacinth bean were grouped into 11 clusters. The clustering pattern and the variable means of clusters are presented in Table 11 and Table 12.

Among the 11 clusters, cluster number I had maximum number of accessions (16). Cluster III and VI had 6 accessions each and clusters IV, IX and X consisted of 3 accessions each, Clusters II and VIII had 2 accessions each and cluster V, VII and XI comprised of a single accession.

Accessions included in cluster I were DL-55, DL-44, DL-68, DL-8, DL-37, DL-52, DL-58, DL-38, DL-43, DL-42, DL-3, DL-27, DL-7, DL-51, DL-53 and DL-64 and it recorded the highest mean value of number of pods plant-1 (2972.50) and lowest value for weight of pod (1.64 g).

Cluster II included DL-63 and DL-69 and recorded the highest days to final harvest (201.00 days). Cluster III which included DL-65, DL-50, DL-48, DL-49 and DL-72 and they had an average fruit yield of 3.24 kg $plot^{-1}$. Cluster IV which included DL-18, DL-54 and DL-56 had an average fruit yield of 4.24 kg $plot^{-1}$.

Cluster V consisted of a single accession DL-40 and recorded lowest value for number of pods $cluster^{-1}$ (3.00), number of pods $plant^{-1}$ (207.79) and days to final harvest (143.50 days). It also recorded the highest mean value for weight of pod (11.56 g).

Accessions DL-60, DL-59, DL-41, DL-30, DL-39 and DL-67 were included in cluster VI, which recorded average fruit yield of 4.13 kg $plot^{-1}$. Cluster VII recorded only one accession DL-66 and had the highest value for fruit setting percentage (45.00).

Accessions included in cluster VIII were DL-6 and DL-61 and they had highest mean value for pod length (11.98 cm) and yield $plot^{-1}$. Cluster IX included DL-12, DL-73 and DL-45 and it recorded lowest mean value for days to vegetable maturity (13.83).

Table 11. Clustering pattern in 44 accessions of hyacinth bean

Cluster number	No. of accessions in each cluster	Accessions
I	16	DL-55, DL-44, DL-68, DL-8, DL-37, DL-52, DL-58, DL-38, DL-43, DL-42, DL-3, DL-27, DL-7, DL-51, DL-53, DL-64
II	2	DL- 63, DL-69
III	6	DL-65, DL-50, DL-28, DL-49, DL-48, DL-72
IV	3	DL-18, DL-54, DL-56
V	1	DL-40
VI	6	DL-60, DL-59, DL-41, DL-30, DL-39, DL-67
VII	1	DL-66
VIII	2	DL-6, DL-61
IX	3	DL-12, DL-73, DL-45
X	3	DL-13, DL-62, DL-29
XI	1	DL-71

Table 12. Means of variables for eleven clusters in hyacinth bean

Cluster No	Days to final harvest	No of pods/ cluster	Pod length	Weight of pod	Fruit setting %	No of pods/plant	Yield/ plot	Days to vegetable maturity
I	165.56	7.74	5.14	1.64	30.00	2972.50	3.34	16.44
II	201.00	3.44	2.96	4.09	22.50	488.85	1.99	18.25
III	167.33	6.17	11.05	3.03	28.38	1157.98	3.24	15.93
IV	156.50	7.21	9.60	4.82	39.17	904.66	4.24	18.67
V	143.50	3.00	8.00	11.56	22.50	207.79	2.40	19.50
VI	172.67	7.25	7.81	2.09	33.13	2086.62	4.13	15.79
VII	182.00	4.50	4.63	7.53	45.00	649.13	4.88	16.00
VIII	159.67	7.06	11.98	2.68	39.25	1523.04	5.18	14.38
IX	169.00	6.00	10.60	3.37	35.83	1445.97	4.78	13.83
X	169.00	6.58	5.13	3.94	35.00	1072.92	4.03	18.50
XI	178.50	5.63	11.25	7.15	30.00	381.94	2.75	23.00
SD	13.25	2.28	2.83	1.96	6.87	839.42	1.34	3.13
CV	1.51	18.51	2.81	3.82	10	19.63	18.39	6.34

Table 13. Inter and Intra cluster D^2 value among eleven clusters of hyacinth bean germplasm

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	**86.92**										
II	1113.32	**151.73**									
III	1069.09	2216.52	**115.14**								
IV	1256.82	1395.91	627.81	**297.57**							
V	9237.77	5712.11	8428.47	5332.68	**0.00**						
VI	320.34	1500.23	427.83	878.90	9243.67	**145.17**					
VII	3325.65	1144.20	3753.06	1783.56	2349.35	3529.14	**0.00**				
VIII	1842.77	3194.46	508.16	1468.89	10924.23	884.05	5067.76	**472.52**			
IX	1060.09	2103.21	218.22	503.62	7886.07	482.05	3268.65	681.59	**299.57**		
X	633.43	401.25	1334.87	657.73	5785.85	839.17	1282.02	2319.70	1143.46	**186.99**	
XI	3088.	2015.57	1631.46	764.12	3154.86	2432.57	1475.62	2613.71	1596.88	1645.91	**0.00**

The value printed in bold indicates intra cluster D^2 values

Accessions DL-13, DL-62 and DL-29 included in cluster X had an average fruit yield of 4.03 kg $plot^{-1}$. DL-71 alone was included in cluster XI and it recorded highest value for days to vegetable maturity (23.00 days).

Inter and Intra D^2 values among the eleven clusters are given in Table 13. Cluster VIII had maximum intra cluster values (472.52) and clusters V, VII and cluster XI the minimum (0.00). The intra cluster distance for other clusters were 86.92 (cluster I), 151.73 (cluster II), 115.14 (cluster III), 297.57 (cluster IV), 145.17 (cluster VI), 299.57 (cluster IX) and 186.99 (cluster X).

The maximum statistical distance was found between cluster V and VIII (10924.23) followed by cluster V and VI (9243.67).The distance between the clusters III and IX displayed the lowest degree of divergence(218.22)

4.2.6 Selection index

A selection index helps to select suitable genotypes from a mass population based on minimum number of reliable and effective characters.

Selection index involving characters yield $plot^{-1}$, number of pods $cluster^{-1}$, fruit setting percentage, number of pods $plant^{-1}$ and days to vegetable maturity was selected for hyacinth bean to identify superior genotypes. It had a gain in efficiency of 1.1109 per cent over direct selection.

Characters to be considered were selected based on their phenotypic correlations, direct and indirect effects on yield, variability and heritability. The discriminant functions for different combinations of selected characters are given in the Table 14. The selection indices are selected based on efficiency over direct selection and number of characters involved. High efficiency with minimum number of characters is preferred. Estimates of selection indices involving eight characters (yield, days to final harvest, number of pods $cluster^{-1}$, pod length, weight of pod, fruit setting percentage, number of pods $plant^{-1}$ and days to

Table 14. Discriminant function for different character combinations

Sl. No.	Combinations	Discriminant function	Gain in efficiency (%)
1	y, x_1, x_2, x_3, x_4, x_5, x_6, x_7	$0.352y + 0.004x_1 + -0.062x_2 + 0.021x_3 + 0.02x_4 + 0.094x_5 + 0.0002x_6 + - 0.07x_7$	1.1129
2	y, x_1, x_2, x_3, x_5, x_6, x_7	$0.368y + 0.004_{x1} + -0.062_{x2} + 0.02_{x3} + 0.094_{x5}+0.00016_{x6}$	1.1127
3	y, x_1, x_2, x_5, x_6, x_7	$0.387y + 0.0032_{x1} + - 0.061_{x2} + 0.094_{x5} + 0.00012_{x6} + - 0.067_{x7}$	1.1116
4	y, x_2, x_5, x_6, x_7	$0.392y + -0.064_{x2} + 0.094_{x5} + 0.00012_{x6} + -0.067_{x7}$	1.1109
5	y, x_2, x_5, x_7	$0.44y + -0.044_{x2} + 0.089_{x5} + 0.064_{x7}$	1.1083
6	y, x_5, x_7	$0.44y + 0.087_{x5} + -0.059_{x7}$	1.1039
7	y, x_5	$0.47y + 0.082_{x5}$	1.0888
8	y (Direct selection)	0.751y	1.0028

y = Fruit yield plot^{-1}
x_1 = Days to final harvest
x_2 = Number of pods cluster^{-1}
x_3 = Pod length
x_4 = Weight of pod
x_5 = Fruit setting%
x_6 = Number of pods plant^{-1}
x_7 = Days to vegetable maturity

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Table 15. Estimation of selection index using characters viz, fruit yield plant^{-1} (y), number of pods plant^{-1} (x_6), fruit setting % (x_5), number of pods cluster^{-1} (x_2) and days to vegetable maturity (x_7)

Sl. No	Acc. No	Selection index	Rank according to Selection index	Rank according to Yield
1.	DL-6	5.639	1	1
2.	DL-29	5.533	2	2
3.	DL-40	5.199	3	4
4.	DL-66	4.859	4	7
5.	DL-56	4.549	5	5
6.	DL-7	4.463	6	3
7.	DL-67	4.326	7	13
8.	DL-59	4.067	8	6
9.	DL-49	4.024	9	10
10.	DL-39	3.818	10	9
11.	DL-65	3.769	11	8
12.	DL-41	3.701	12	11
13.	DL-51	3.554	13	12
14.	DL-43	3.333	14	23
15.	DL-13	3.315	15	15
16.	DL-44	3.269	16	18
17.	DL-27	3.219	17	14
18.	DL-3	3.208	18	19
19.	DL-53	3.175	19	20
20.	DL-30	3.096	20	14
21.	DL-54	3.052	21	17
22.	DL-55	2.998	22	25
23.	DL-72	2.813	23	21
24.	DL-18	2.775	24	13
25.	DL-62	2.753	25	22
26.	DL-50	2.709	26	16
27.	DL-64	2.657	27	29
28.	DL-73	2.649	28	26
29.	DL-60	2.564	29	23
30.	DL-37	2.474	30	27
31.	DL-58	2.449	31	32
32.	DL-61	2.389	32	35
33.	DL-38	2.329	33	30
34.	DL-52	2.324	34	28
35.	DL-8	2.273	35	24
36.	DL-48	2.073	36	36
37.	DL-71	2.043	37	27
38.	DL-68	1.989	38	35
39.	DL-69	1.852	39	33
40.	DL-12	1.827	40	31
41.	DL-28	1.731	41	36
42.	DL-45	1.582	42	34
43.	DL-42	1.373	43	37
44.	DL-63	1.172	44	38

vegetable maturity) seven characters (yield, days to final harvest, number of pods cluster^{-1}, pod length, fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity), six characters (yield, days to final harvest, number of pod, fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity) five characters (yield, number of pods cluster^{-1}, fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity). Four characters (yield, number of pods cluster^{-1}, fruit setting percentage and days to vegetable maturity), three characters (yield, fruit setting percentage and days to vegetable maturity), two characters (yield and fruit setting percentage) with gain in efficiencies of 1.1129 per cent 1.1127 per cent, 1.1116 per cent, 1.1109 per cent, 1.1083 per cent, 1.1039 per cent and 1.0888 per cent over direct selection are given in Table 15. Based on this high efficiency with minimum number of characters that is five characters with efficiency 1.1109 were selected for estimating selection index.

Based on index selected for hyacinth bean, the accession DL-6 was found to be most superior one followed by accessions DL-29, DL-40 and DL-66. Accession DL-6 was the highest yielding accession with an average yield of 7.10 kg plot^{-1}. DL-29 was the accession with a maximum fruit setting percentage (47.5%).

Discussion

5. DISCUSSION

Hyacinth bean is an important legume vegetables with twining, creeping or bushy habits. Very little attention has been paid for the improvement of this crop. For genetic amelioration of crop plants, the assessment of available genetic variability is a pre-requisite. Large genetic variability in the initial material ensures chances of obtaining desired genotypes.

The present study was planned to estimate variability, heritability, genetic gain, correlation and genetic divergence in respect of various components of pod yield, to analyse the association pattern among them. The results are discussed hereunder.

5.1 Genetic cataloguing in hyacinth bean

Wide range of variation was observed while cataloguing the hyacinth bean germplasm. Pod shape ranged from slightly curved to highly curved and straight. Variations in pod shape, leaf density, seed size, seed shape and colour of seed were also observed. This high variability in morphological characters accentuates the report that India is a possible centre of origin of hyacinth bean (Rao, 1977).

5.2 Variability

Information on variability helps the plant breeder for effective selection of characters for crop improvement.

In the present study, significant differences were observed among the genotypes for characters such as days to germination, days to first flowering, duration of crop, days to 50 per cent flowering, days to first harvest, days to final harvest, number of pods cluster^{-1}, pod length, 100 seed weight, girth of pod, weight of pod, thickness of main stem, length of vine, fruit setting percentage, number of pods plant^{-1}, yield plot^{-1}, shelling percentage, days to vegetable maturity, crude fibre content and crude protein content of pods. The existence of considerable variation indicated enough scope for improvement. Variability in many of the economic characters had been observed by many workers like Joshi (1971), Pandey and Dubey (1972), Rao (1977), Thangavelu (1978), Rajashekharaiah (1979), Nayar (1980), Gangadharappa (1981), Jacob (1981) and Reddy (1982).

Weight of pod and number pods plant^{-1} had higher phenotypic coefficient of variation (pcv) and genotypic coefficient of variation (gcv) suggesting the influence of environment and genotype on these characters. For days to 50 per cent flowering, pod length and girth of pod, gcv was very nearer to pcv and hence effect of genotype on phenotypic expression will also be high. Very low coefficient of variation for days to final harvest revealed that there was no significant difference among the accessions for this character.

High environmental effects on phenotype for the characters like number of pods cluster^{-1}, number of primary branches, length of vine and thickness of main stem were evident from their higher pcv as compared to gcv. The highest gcv was found in weight of pod and number of pods plant^{-1}. A moderately high gcv was observed in thickness of pod, number of primary branches, pod yield plant^{-1}, pod length and number of pods cluster^{-1}. This moderate and high genetic variability can be exploited through selection. Nayar (1982) found maximum genetic coefficient of variation in pods inflorescence^{-1}. In addition to this Singh *et al.* (1985) observed the highest coefficient of genetic variation in green pod yield plant^{-1} in hyacinth bean.

A comparison of genotypic coefficient of variation among the different characters revealed its high value for weight of pod, pod length, number of pods plant^{-1} and thickness of pod. It indicated responsiveness of these traits to appropriate selection for evolution of improved genotype. These findings are corroborated by Singh *et al.* (1979) and Rao (1981).

Pod weight ranged from 1.13 g to 14.62 g and its high pcv (65.32) indicated that variation is not only due to genotypic effect but also due to environmental effects. Length of pod and girth of pod has almost similar gcv and pcv suggesting that variations are mostly due to genotype and hence selection will be effective.

Number of seeds pod^{-1}, length of vine, thickness of main stem, fruit setting percentage, days to vegetable maturity and crude fibre content of pod were also found to be influenced by environment as indicated by higher pcv (19.05, 26.81, 24.89, 21.71, 18.90, 26.79 and 15.18 respectively) compared to gcv (16.68, 11.59, 23.52, 15.13, 19.26, 17.81, 24.65 and 11.90 respectively). Maximum range of variation was observed for number of pods plant^{-1} ((207.79-3961.27). The pcv and gcv were of higher magnitude (54.32 and 5065 respectively) for this trait suggesting very high variability and scope for effective selection.

5.3 Heritability

High heritability value indicates that the character is least affected by environment and low heritability value indicates that the character is highly influenced by environment. If the effect of environment is high, genetic improvement through selection will be difficult due to masking effects of environment on genotype. According to Burton (1952) gcv, along with heritability estimates would give a better idea about the efficiency of selection, as the latter measures the proportion of the variability of a character that is transmitted to the progeny.

Results of the present study revealed that among the characters, weight of pod and pod length exhibited high heritability (99.7 and 99.5 respectively) and genetic gain (134.26 and 78.73 respectively) indicating that these characters are least affected by environment. This revealed that variation for the above characters was mainly due to the action of additive genes and these traits can be improved by selection. Hence there is ample scope for effective selection. The heritability estimates though provide the basis for selection on the phenotypic performance, Johnson *et al.* (1955) suggested that the estimates of heritability and expected genetic advance should always be considered jointly. The results of this study may be compared with that of Rahman (1988) who observed a high heritability associated with high genetic gain for individual pod weight and pod yield plant^{-1}.

All the characters studied indicated high heritability values and the weight of pod showed the highest heritability estimate. The genetic gain was the lowest for the character, days to final harvest (15.63). The genetic gain for rest of the characters was fairly high. High heritability estimates with low genetic gain for the characters like days to final harvest and thickness of main stem suggested that non additive type of gene action and genotype x environment (g x e) interaction may have played a significant role in the expression of these traits. This is in confirmation with the findings of Uddin and Newaz (1997).

Effective selection can be made using weight of pod, pod length and number of pods plant^{-1}. These findings are in agreement with that of Singh *et al.* (1982). Moderate genetic gain was observed for the characters like crude protein content of pod, thickness of main stem and days to final harvest suggesting moderate influence of environment and presence of additive and non additive gene action.

5.4 Correlation

A knowledge of the relationship of yield and its component characters is essential for the simultaneous improvement of yield components and in turn yield, to be effective. The correlation studies carried out, exhibited more or less similar trend for phenotypic and genotypic correlations, but in general, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients.

In the present study, yield was found to be significantly and positively correlated with number of pods plant^{-1} and fruit setting percentage phenotypically and genotypically and with number of primary branches genotypically. A strong positive association between number of pods plant^{-1} and green pod yield in hyacinth bean was noted by earlier workers like Joshi (1971), Rao (1977), Arunachalam (1978), Thangavelu (1978), Reddy (1979), Nayar (1980), Gangadharappa (1981), Rao (1981), Rahman (1988) and Uddin and Newaz (1997). Higher phenotypic correlation between number of pods plant^{-1} and yield revealed that its association with yield was not only due to genes, but also due to favourable influence of environment.

Yield was also found to be positively correlated with days to final harvest, pod length, number of seeds pod^{-1} ·length of vine and number of pods cluster^{-1}. However, these correlations were found to be insignificant indicating the independent nature of these characters in relation to yield.

Days to vegetable maturity was found to be positively and significantly correlated with 100 seed weight and girth of pod genotypically and phenotypically, which reveals that when days to vegetable maturity is high, seed weight as well as girth of pod will be increased. Shelling percentage was negatively correlated with thickness of pod and positively correlated with pod girth. It reveals that if thickness of pod increases, the shelling percentage decreases and with the increase of pod girth, the shelling percentage increases.

Number of pods plant^{-1} was found to increased when the characters like fruit setting percentage, number of primary branches and number of pods cluster^{-1} were increased as indicated by significant positive correlation between these characters. This is in confirmation with the findings of Pandita *et al.* (1980) in dolichos bean. Number of pods plant^{-1} was negatively correlated with 100 seed weight, girth of pod, weight of pod, thickness of pod and days to first harvest. It reveals that as the thickness of pod, weight of pod, 100 seed weight and girth of pod increases, the number of pods plant^{-1} decreases.

Significant positive correlation between crude protein content of pod and thickness of pod indicated that as the thickness of pod increases, the protein content of the pod also increases. Fruit setting percentage was found to be positively and significantly correlated with number of primary branches and number of pods cluster^{-1}, which revealed that when number of primary branches increases, fruit setting percentage also increases and there by number of pods cluster^{-1} also increases.

Vine length was found to be significantly and positively correlated with number of pods cluster^{-1} and hundred seed weight. This indicated that when vegetative growth is more, number of pods cluster^{-1} and 100 seed weight will also be more.

Among the yield components, number of primary branches showed a positive and significant relationship with number of pods cluster^{-1}, and days to final harvest and negative correlation with pod girth. It might be this effect, which lead to the significant positive association between number of primary branches and yield (Singh, 1985). Positive correlation between thickness of pod and weight of pod suggested that as thickness of pod increases, the weight of the pod also increases.

Hundred seed weight exhibited significant negative correlation with number of pods cluster^{-1} while it was positively correlated with days to 50 per cent flowering and days to first harvest. As the days to 50 per cent flowering and days to first harvest delays, the transport of assimilates towards the seed and its subsequent storage in the seeds will be more. If the number of pods cluster^{-1} increases, the 100 seed weight decreases.

Number of seeds pod^{-1} showed a significant positive correlation with pod length and it was negatively correlated with days to 50 per cent flowering. As the number of seeds pod^{-1} increased, the pod length also increased, there by causing an increase in seed yield. Number of pods cluster^{-1} showed a significant positive correlation with days to first harvest. This showed that as number of pods cluster^{-1} are more, days to first harvest will also be more.

Days to first harvest and days to 50 per cent flowering showed a significant positive correlation both phenotypically and genotypically. Delay in 50 per cent of the plants to flower will subsequently delay the days to first harvest.

In general, for almost all characters genotypic correlation was found to be higher than phenotypic correlation indicating that environment had smaller effect on these characters.

Thus we can infer that for increasing yield, the characters to be considered are number of primary branches, number of pods cluster^{-1} fruit setting percentage and number of pods plant^{-1}.

5.5 Path coefficient analysis

Path analysis helps to identify whether the association of different characters with yield is due to their direct effects on yield or is a consequence of their indirect effects through other component characters. It is used to predict the effect of selection based on an independent character with reference to its dependent character.

On partitioning the correlation into direct and indirect effects, it was observed that fruit setting percentage, number of pods plant^{-1} and pod length had high positive direct effects on yield and number of pods cluster^{-1}, weight of pod, days to final harvest and days to vegetable maturity exhibited high negative direct effect on yield. It reveals a true relationship between these characters and yield and hence direct selection for these traits will be rewarding for yield improvement.

Days to final harvest exhibited negative direct effect on yield, but its genotypic correlation with yield was positive. This emphasizes the need for selection of days to final harvest through number of pods cluster^{-1} and fruit setting percentage.

Number of pods cluster^{-1} had negative direct effect on yield, while correlation coefficient was positive. This emphasis the need for selection of number of pods cluster^{-1} through fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity. This is in conformation with Rao (1977), Reddy (1979), Gangadharappa (1981), Rathnaiah (1982) and Reddy (1982).

The direct effect of pod length on yield and correlation coefficient was positive and also there was direct effect of number of pods cluster^{-1}, fruit setting percentage and days to vegetable maturity . Hence direct selection via these characters should be considered.

Weight of pod exhibited negative correlation with yield. Fruit setting percentage and number of pods plant^{-1} exhibited high direct effect on yield and their correlation coefficient with yield was also positive. Hence direct selection can be done through these characters.

5.6 Genetic divergence

Genetic divergence studies based on Mahalanobis D^2 statistics permits precise comparison among all possible pairs of population in any group. Genetically divergent parents are essential to generate new variability and desirable combinants. In the present study, the 44 accessions of hyacinth bean were grouped into eleven clusters, indicating considerable genetic diversity prevailing among them. The distribution of accessions into various clusters showed no uniformity. The accessions DL-40, DL-66 and DL-71 were genetically diverse from other accessions and was grouped independently into separate clusters (cluster V, cluster VII and cluster XI). Genotypes belonging to same place were distributed among different clusters, thus ruling out the association between geographical distribution of genotypes and genetic divergence. The clustering pattern revealed that genetic diversity was not related to geographic diversity which supports earlier observations of Marangappanavar (1986).

The maximum genetic distance was found between the cluster V and VIII (10924.23) followed by cluster V and VI (9243.67) (Table 13). The cluster III and IX displayed the lowest degree of divergence suggesting close genetic make up of the strains included amongst them.

A good scope for selection within the clusters was indicated by the magnitude of intra cluster distances of the cluster VIII (472.52), IX (299.57), IV (297.57), X (186.99), II (151.73), VI (145.17), III (115.14) and I (86.92). The entries in the single variety clusters being diversed from others may also prove as the potential parents for breeding programme. They indicated their independent identity and importance due to various unique characters possessed by them. Intra cluster distances being much lesser than inter cluster ones, suggested homogenous and heterogenous nature of the strains within and between the clusters respectively. Since crosses among divergent parents are likely to yield desirable recombinants, a breeding programme should be initiated between the selected genotypes belonging to different clusters considering their cluster means (Table 13). Hayes (1946) suggested that the success of breeding programme depends upon, to a large measure, on the degree of genetic divergence.

The cluster VIII exhibited highest fruit yield plot^{-1} (5.18 kg) followed by VII (4.88 kg) and IX (4.78 kg). Maximum pod weight (11.56 g) was recorded by cluster V, while, minimum (1.64 g) by cluster I. The solitary cluster VII had maximum pod length (11.98 cm) while cluster XI had maximum days for vegetable maturity (23 days). The cluster VI had maximum number of pods plant^{-1} (2086.62) and cluster VII had maximum fruit setting percentage(45 per cent).

5.7 Selection index

Discriminant function analysis developed by Fisher (1936) and Smith (1936) was carried out with a view to evolve a selection index for isolating superior genotypes. Eight models with various character combinations were tried. Maximum efficiency of selection index over direct selection (1.1129%) was noted when eight characters namely fruit yield plot^{-1}, days to final harvest, number of pods cluster^{-1}, pod length, weight of pod, fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity were included. But in case of selection, number of characters should be minimum and hence index involving five characters namely yield plot^{-1}, number of pods cluster^{-1}, fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity with a gain in efficiency of 1.1109 was selected. Ranking based on selection index showed that the accession DL-6 was the most superior one followed by accession DL-29, DL-40 and DL-66. It indicated that superiority of these genotypes were more stable and reliable since the selection index value was calculated considering other yield contributing factors also. Selection through index values in annuals was also reported by Vanaja (1998) and Sreejaya (1999).

Accession DL-6, identified as the most superior one, was found to be the highest yielding accession with an average yield of 5.639 kg plot^{-1}. It took 82.5 days for first harvest and produced an average of 1575.5 pods plant^{-1} followed by DL-29 with an average yield of 5.533 kg plot^{-1}. It took 90 days for first harvest and produced an average of 1511.62 pods plant^{-1}. DL-13 was found to be the earliest flowering accession (47.5 days).

Summary

6. SUMMARY

The present study on "Genetic variability in hyacinth bean (*Lablab purpureus* (L.) Sweet)" was conducted in the Vegetable Research Farm of Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara during 1999-2000.

The experiment was aimed at cataloguing of available germplasm in hyacinth bean; assessment of genetic variability and divergence; assessment of association of different traits with yield including the direct and indirect effects of traits on yield and formulation of a selection index to identify the superior genotypes.

The experimental material consisted of 44 accessions of hyacinth bean collected from different parts of the country. The experiment was laid out in randomised block design with two replications. The spacing adopted was 2x2m. Observations on different quantitative and qualitative characters were recorded in each replication. The data obtained were subjected to suitable statistical analysis, so as to estimate the variability of genotypes. The salient findings are summarised below.

1. Fourty four accessions of hyacinth bean collected from different parts of India were genetically catalogued based on the descriptor listed for hyacinth bean. Wide variation in fruit size and other vegetative, fruit and seed characters were noted.

2. Most of the accessions showed significant differences for characters studied viz. days to 50 per cent flowering, length of vine, number of pods plant^{-1}, number of pods cluster^{-1}, length of pod, girth of pod, length of vine, fruit setting percentage and yield plot^{-1}.

3. Accession DL-6 had maximum yield of 7.10 kg plot^{-1} followed by the accessions DL-29 with an average yield of 6.50 kg plot^{-1} and maximum fruit setting percentage of 47.5. The number of pods plant^{-1} was maximum in the accession DL-7 (3961.27).The accessions DL-44 and DL-40 recorded minimum days to vegetable maturity (11 days each). Accession DL-44 recorded the maximum number of pods cluster^{-1}.

4. Highest gcv and pcv were observed for weight of pod followed by number of pods plant^{-1}, thickness of pod and pod yield plot^{-1}.

5. High heritability and genetic gain were noted for weight of pod and pod length. Moderate genetic gain was observed for the characters crude protein, thickness of main stem and days to final harvest.

6. Correlation studies revealed that yield was significantly and positively correlated with fruit setting percentage and number of pods plant^{-1} both genotypically and phenotypically. Hence these characters can be improved through straight selection.

7. Results of path coefficient analysis brought out that the highest positive direct effect on yield was exhibited by fruit setting percentage followed by number of pods plant^{-1} and pod length. Number of pods cluster^{-1}, weight of pod, days to final harvest and days to vegetable maturity exhibited high negative direct effect on yield.

8. The 44 genotypes were grouped into eleven clusters based on genetic distance. There was no parallelism between geographical distribution and genetic diversity. Intra cluster distances were much lesser than inter cluster one, suggesting homogenous and heterogenous nature of the strains within and between the clusters respectively. Therefore, it is possible to exploit heterosis in hyacinth bean. The entries in the single variety clusters being diversed from others may prove to be highly potential parents for breeding programme.

9. A selection model was formulated consisting of the characters, pod yield plot^{-1}, number of pods cluster^{-1}, fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity with 1.1109 per cent gain in efficiency over direct selection.

10. Comparison of different genotypes based on selection index revealed the superiority of the genotype DL-6, followed by DL-29, DL-40 and DL-66.

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*Originals not seen

Appendices

APPENDIX – I

Weather data of Vellanikkara (1999 August to 2000 April)

Element	Year:1999					Year:2000			
	August	September	October	November	December	January	February	March	April
Maximum Temperature	29.8	31.6	30.5	31.4	30.7	32.9	33.3	35.6	34
Minimum Temperature	22.9	23.4	23.2	22.7	22.7	23.2	22.8	23.9	24.6
Rainfall	260.1	28.4	506.2	9.1	0.0	0.0	4.6	0.0	67.9
Rainy days	12	3	15	9.1	0.0	0.0	1	0	3
RH-1(%)	94	89	94	81	72	76	85	87	89
RH-2(%)	73	63	75	57	48	43	52	46	59
Sunshine hours	5.5	7.1	4.8	8.2	0.8	9.2	8.6	9.7	7.2

Source: collected from the Agro met observatory Dept. of Agriculture Meteorology

APPENDIX – II

Analysis of variance for different characters in hyacinth bean accessions

Source of variation	Df	Days to germinat-ion	Days to first flower-ing	Days to 50% flowering	Days to first harvest	Days to final harvest	Duration of crop	No of pods cluster^{-1}	Pod length	No of seeds pod^{-1}	100 seed weight	Girth of pod	Weight of pod
Replication	1	0.409	0.011	0.06	14.75	1.50	10.23	1.19	0.46	0.33	1.35	0.012	0.001
Genotype	43	1.549**	273.48**	410.15**	300.72**	348.7**	329.98**	8.9**	16.09**	0.877	22.79**	1.92*	7.79**
Error	43	0.20	2.24	1.64	6.57	6.54	6.25	1.57	0.043	0.115	1.34	0.017	0.013
CD (0.05)		1.211	2.24	3.6323	7.2453	7.2357	6.77	3.5438	6.5884	NS	3.2766	0.3681	0.3268

Source of variation	Df	Thickness of pod	No of primary branches	Thickness of main stem	Length of vine	Fruit setting (%)	Crude fibre content of pod	Crude protein content of pod	No of pods plant^{-1}	Yield plot^{-1}	Shellig (%)	Days to vegetable maturity
Replication	1	0.002	0.09	4.02	816	7.10	4.89	17.43	410080	3.18	5.15	5.90
Genotype	43	0.014	1.27	2.56**	8665**	85.27**	49.71**	18.27**	1323655**	3.12**	191.9**	18.56**
Error	43	0.002	0.20	1.18	1128	10.13	4.14	436	92438	0.45	1.479	1.10
CD (0.05)		NS	NS	3.0699	94.997	9.0014	5.757	5.9076	859.8	1.9050	3.440	2.975

* Significant at 5% level ** significant at 1% level

GENETIC VARIABILITY IN HYACINTH BEAN

[*Lablab purpureus* (L.) Sweet]

By

BIJU, M. G.

ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF OLERICULTURE
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2000

ABSTRACT

The present study on "Genetic variability in hyacinth bean [*Lablab purpureus* (L.) Sweet]" was carried out in the College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during the period 1999-2000. The major objectives of the study were to gentically catalogue the available germplasm and to study the genetic variability, heritability, genetic gain, divergence and correlation of different traits with yield. Fourty four accessions collected from different parts of the country were grown in randomised block design with two replications.

The 44 accessions were catalogued based on the descriptor for hyacinth bean. Significant differences for the characters days to germination, days to first flowering, days to 50 per cent flowering, days to first harvest, days to final harvest, duration of crop, number of pods cluster^{-1}, pod length, 100 seed weight, girth of pod, weight of pod, thickness of main stem, length of vine, fruit setting percentage, number of pods plant^{-1}, yield plot^{-1}, shelling percentage, days to vegetable maturity, crude fibre and crude protein content of pod were noticed among the accessions. The accession DL-6 was found to be highest yielding and DL-8 was found to be the earliest flowering.

The highest genotypic coefficient of variation and phenotypic coefficient of variation was observed for weight of pod followed by number of pods plant^{-1}, number of pods cluster^{-1}, fruit setting percentage, number of pods plant^{-1} and days to vegetable maturity. Accession DL-6 was identified as the most superior one followed by accessions DL-29, DL-40 and DL-66.

APPENDIX – II

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Error	43	0.20	2.24	1.64	6.57	6.54	6.25	1.57	0.043	0.115	1.34	0.017	0.013
CD (0.05)		1.211	2.24	3.6323	7.2453	7.2357	6.77	3.5438	6.5884	NS	3.2766	0.3681	0.3268

Source of variation	Df	Thickness of pod	No of primary branches	Thickness of main stem	Length of vine	Fruit setting (%)	Crude fibre content of pod	Crude protein content of pod	No of pods plant^{-1}	Yield plot^{-1}	Shellig (%)	Days to vegetable maturity
Replication	1	0.002	0.09	4.02	816	7.10	4.89	17.43	410080	3.18	5.15	5.90
Genotype	43	0.014	1.27	2.56**	8665**	85.27**	49.71**	18.27**	1323655**	3.12**	191.9**	18.56**
Error	43	0.002	0.20	1.18	1128	10.13	4.14	436	92438	0.45	1.479	1.10
CD (0.05)		NS	NS	3.0699	94.997	9.0014	5.757	5.9076	859.8	1.9050	3.440	2.975

* Significant at 5% level ** significant at 1% level