Sri Lanka Journal of Food and Agriculture (2015)
Rajendra Prasad et al. 1(1): 15-23
ISSN 2424-6913

Research Paper

Genetic variability for morphometric traits and insect damage in Dolichos bean (*Lablab purpureus* L. Sweet) germplasm

B.S. Rajendra Prasad[1*], G.A. Mary Reena[2], M. Byre Gowda[2], C.M. Keerthi[3] and T. Onkarappa[2]

Abstract: The variability among 44 accessions of Dolichos bean (*Lablab purpureus* L. Sweet) was assessed for seven quantitative traits, and bruchid and pod borer infestations. The experiment was conducted during the *Kharif* season 2012-2013 at the University of Agricultural Sciences (UAS), Bangalore, India with two check entries (HA 4 and HA 3) in an augmented design using three blocks. A substantial variability among the accessions for quantitative traits, and bruchid and pod borer infestations, except for the number of branches per plant, was documented. The estimates of heritability were high for all the traits studied. The phenotypic and genotypic coefficients of variation, which reflect the average inter-accession differences, were moderate. However, these are useful statistics to understand variability among the accessions. The germplasm was grouped into seven clusters following Wards minimum variance clustering approach with significant deviations among clusters. The intra-cluster distance was lower compared to inter-cluster distance. Some of the accessions were superior to the check HA-4. The results could be used to adopt suitable strategies for breeding Dolichos bean aiming at improved productivity.

Keywords: Dolichos bean, germplasm, variability, wards clustering

Introduction

Dolichos bean (*Lablab purpureus* L. Sweet) (2n = 22), also known as 'hyacinth bean' 'field bean' 'Indian bean', belongs to the family Fabaceae, sub family Faboidae, tribe Phaseoleae and sub-tribe Phaseolineae. It is one of the most ancient crops known for its food and fodder value. Dolichos bean is native to India and presently grown throughout the tropical regions in Asia, Africa and America. The Flora Indica (Roxburgh, 1832) describes seven varieties within *L. purpureus* of which five are cultivated and two are wild. The cultivated varieties are divided into two categories namely, (a) *L. purpureus* var. typicus, a short-lived perennial, usually treated as an annual, twining herb, pods are longer and often grown as a garden crop mainly for green pods, and (b) *L. purpureus* var. lignosus, a longer-lived, semi-erect, bushy perennial but, usually treated as annual. Dolichos bean is predominantly self-pollinated, and is temperature- and photoperiod-sensitive.

[1] Department of Entomology, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India
[2] All India Coordinated Research Project on Pigeon pea, GKVK, Bangalore, Karnataka, India
[3] Department of Plant Breeding and Genetics, University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India
* Corresponding author: rajendrayadav007@gmail.com

In India, Dolichos bean is primarily cultivated in Karnataka and adjoining districts of Tamil Nadu, Andhra Pradesh and Maharashtra (Mahadevu and Byre Gowda, 2005), and used as a vegetable (immature pods and immature grains) and forage (NRC, 2006). In Karnataka, Dolichos bean is grown in an area of 85,000 ha with a production of 18,000 t, contributing to nearly 90 % of both area and production in India. Despite its importance as a multi-purpose crop and ability to withstand drought better than common bean and cowpea (Maass *et al.*, 2010), and adapt to acidic (Mugwira and Haque, 1993) and saline soils (Murphy and Colucci, 1999), Dolichos bean qualifies as an 'underutilized' crop. Breeding programs for Dolichos bean has been limited however, studies done at UAS, Bangalore has resulted in the development and release of high yielding, short duration, photoperiod in-sensitive and determinate growth type cultivars such as HA 3 (Shivashankar *et al.*, 1989) and HA 4 (Girish and Byre Gowda, 2009).

Farmers usually cultivate traditional, photoperiod sensitive, indeterminate cultivars of Dolichos bean. Therefore, productivity of Dolichos bean in farmers field (0.5 t/ha) is low compared to the potential productivity (2.0 t/ha; Shivashankar *et al.*, 1989) of improved cultivars under good management. Low on-farm productivity was attributed to grain yield losses caused by insect pests such as pod borer and aphids, and diseases such as anthracnose and yellow mosaic virus. Augmenting on-farm productivity to potential level requires diversifying the genetic base of Dolichos bean cultivars through enhanced use of the diverse germplasm. Thus, accurate information on the genetic variability and traits of economic importance is a prerequisite for continued genetic improvement. Thus, a study was carried out to assess the variability for morphometric traits of Dolichos bean among the accessions conserved at the University of Agricultural Sciences (UAS), Bangalore, India.

Materials and Methods

Plant material

Study material comprised of 44 accessions and two check entries (HA-4 and HA-3) of Dolichos bean (*Lablab purpureus* L. Sweet) maintained at the All India Coordinated Research Project (AICRP), UAS, Bangalore, India

Experimental site and design

The accessions along with two check entries were sown in an Augmented design (Federer, 1956) in two compact blocks during *Kharif* 2012-2013 at the experimental plots of the Zonal Agricultural Research Station (ZARS), UAS, Bangalore, India. The experimental site was located at an altitude of 930 m amsl, 12° 58' North and 77°35' East latitude and longitude, respectively. Each block consisted of 22 germplasm accessions, two checks (replicated thrice) and two border entries. Each entry was sown in a single row of 3 m length with a row spacing of 0.6 m and 0.2 m between plants within a row. A basal dose of N:P:K mixture 25:50:25 (w/w/w) was applied to the experimental plot. Recommended management practices were followed during the crop growth period to raise a healthy crop.

Collection of data

Data were recorded in five randomly tagged plants on quantitative traits such as days to 50 % flowering, days to maturity, plant height (cm), primary branches per plant, raceme length (cm), pods per plant, green seed yield per plant (g/plant), bruchid seed infestation and pod borer infestation. The data on bruchid seed infestation and pod borer infestation was measured in each accession and check entry following the descriptors developed by research faculty of AICRP on pigeon pea, UAS, Bangalore, India.

Statistical analysis

Quantitative trait means of each of the 44 accessions were adjusted for block effect, which was estimated as differences between trait mean of check entries included in the 'I'th block and trait mean of check entries of all the blocks (Federer, 1956). Adjusted mean values of quantitative traits recorded on five random plants were subjected to statistical analysis. Descriptive statistics (range and variance), and their standardized range and coefficient of variation were estimated (Snedecor and Cochran, 1994) to quantify variability and compare across traits. The 46 Dolichos bean accessions were grouped into 7 clusters using the 'K means' (MacQueen, 1967) model-based approach. The significant difference among clusters for means and variances of nine quantitative traits was examined using t-test and Levene's tests (Levene, 1960), respectively.

Results and Discussion

The analysis of variance revealed highly significant mean squares ($p<0.001$) due to germplasm accessions for all traits except primary branches per plant (Table 1). Mean squares due to check varieties were non-significant ($p>0.05$) for all traits except pod borer infestation, while those due to 'accessions *vs* check varieties' were significant for all traits ($p<0.05$) except plant height, raceme length and primary branches per plant.

Components of variability, heritability and genetic advance

Presence of genetic variability alone is of less significance in crop breeding programmes. Knowledge on relative contribution of the genetic and non-genetic sources on the quantitative trait variability is useful in formulating appropriate selection strategies to breed for improved Dolichos bean cultivars. The estimates of standardized range provide clues about the occurrence of accessions with extreme expression, which varied with the trait. However, standardized range does not reflect the variability in the expression of all the accessions. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation

(PCV), which reflect average inter-accession differences, are more useful statistics to understand variability among the germplasm accessions.

The accessions were highly variable for days to 50 % flowering, raceme length, plant height, primary branches per plant, pods per plant and bruchid seed infestation traits as indicated by the estimates of PCV (>20 %; Table 2). They were moderately variable (10.1 % ≤ PCV ≤ 19.9 %) for days to maturity, green seed yield per plant and pod borer infestation. Relatively narrow difference between PCV and GCV estimates for these traits has amply reflected in the higher broad-sense heritability estimates.

The broad-sense heritability was high (>60 %) for all traits except primary branches per plant (44.2 %). The green seed yield per plant (99.6 %) followed by bruchid seed infestation (99.5 %), pods per plant (99.5 %), primary branches per plant (99.4 %) and pod borer infestation (98.9 %) were more heritable than the rest (Table 2). Dolichos bean is predominantly a self-pollinated crop and hence, the accessions used are a mixture of pure lines whose expression is predominantly determined by additive genetic effects and additive x additive type of epistasis. Consequently, the broad-sense heritability is a reflection of narrow-sense heritability. Thus, selection of desired accessions for any of the traits considered would be effective as all traits were highly heritable.

One of the major application of estimating heritability and the genetic parameters is to compare the expected genetic gains from selection based on alternative selection strategies and different experimental designs (Falconer and Mackay, 1996). The information elicited from such comparisons could be used to design optimal breeding strategies (Milligan *et al.*, 1990). In the present study, the estimates of expected genetic advance over mean (GAM) were higher for pods per plant (77.7), plant height (73.7), raceme length (48.3), days to 50 % flowering (46.8), pod borer infestation (44.3), green seed yield per plant (40.2) and bruchid seed infestation (40.6), while they were lower days to maturity (32.6) and primary branches per plant (21) (Table 2).

The narrow difference between PCV and GCV estimates also suggested the stable expression of accessions for these traits. Their variability could be attributed largely due to genetic causes, a pre-requisite for effectiveness of selection for these traits. The accessions were moderately variable for green seed yield per plant, bruchid seed infestation and pod borer infestation. However, fairly higher estimates of expected genetic advance, which takes into account the variability and heritability, indicated the effectiveness of genotype selection with desired green seed yield per plant, bruchid seed infestation and pod borer infestation.

Organization of variability

The efficiency and pace of Dolichos bean improvement programmes hinges on the precise information on magnitude of fixable (additive and additive based epitasis) component of genetic variability, g × e interaction (both spatial and temporal), DNA marker-assisted chromosomal localization, and mode of action of genes controlling economically-important traits.

Table 1. Analysis of variance of Dolichos bean germplasm accessions for quantitative traits

Sources of variation	d.f.	Mean sum of squares								
		Days to 50 % flowering	Days to maturity	Plant height (cm)	No. of Primary branches/ plant	Raceme length (cm)	Pods/ plant	Green seed yield/ plant (g)	Pod borer infestation (%)	Bruchid seed infestation (%)
Blocks	2	12.5*	32.0	2.0	0.5	10.1	12.5*	12.4*	12.5*	12.5*
Entries (Accessions + Checks)	45	572.5**	416.8**	733.9*	0.9	21.9*	125.1**	183.3**	131.4**	53.8**
Checks	1	6.0	24.0	37.5	0.9	2.2	6.0	7.4	688.8**	2.1
Accessions	43	385.9**	374.1**	761.3*	0.9	22.8*	112.3**	149.3**	115.6**	48.5*
Accessions *vs* Checks	1	9163.3**	2646.0**	254.4	1.3	4.0	792.6**	1821.9**	253.8**	332.5**
Error	2	0.5	2.0	32.0	0.5	1.1	0.5	0.50	0.50	0.5

*p<0.05; **p<0.001

Table 2. Descriptive statistics for morphometric traits and insect damage in Dolichos bean germplasm accessions

Traits	Mean ± SE*	Range			Coefficient of variability		Broad sense	GAM**
		Min.	Max.	Standardized range	PCV (%)	GCV (%)	h^2 (%)	(%)
Days to 50 % flowering	80.8 ± 3.1	40.0	131.5	1.1	22.7	22.7	82.7	46.8
Days to maturity	115.4 ± 2.8	83.0	164.0	0.7	15.9	15.9	99.4	32.6
Plant height (cm)	70.9 ± 4.0	29.0	132.0	1.5	37.5	36.6	95.4	73.7
Primary branches/plant	4.1 ± 0.2	2.1	7.3	1.3	23.1	15.4	44.2	21.0
Raceme length (cm)	18.6 ± 0.7	8.5	30.0	1.2	24.8	24.1	94.6	48.3
Pods/ plant	27.3 ± 1.6	11.0	47.5	1.3	37.9	37.8	99.5	77.7
Green seed yield/ plant (g)	58.9 ± 1.9	36.0	94.2	0.9	19.6	19.54	99.6	40.2
Pod borer infestation (%)	52.3 ± 1.6	29.1	70.8	0.8	19.8	19.75	99.5	40.6
Bruchid seed infestation (%)	31.0 ± 1.0	19.4	44.6	0.8	21.7	21.60	98.9	44.3

*Standard error; **GAM: Genetic advance over men

Identification of accessions contrasting for traits of economic importance is a prerequisite for eliciting such information. Cluster analysis helps in grouping of accessions sharing similar characters in different clusters and to identify genetically diverse and desirable genotypes.

The inter-cluster distance between clusters 3 and 4 (2.19) was higher followed by clusters 3 and 7 (2.04), clusters 2 and 4 (1.96) and clusters 3 and 5 (1.91) suggesting that the genotypes present in cluster 3 were highly diverge than those in the remaining cluster (Table 3). Hence, genotypes present in cluster 3 can be used for breeding programme of Dolichos been to obtain good segregates in segregating generations. The mean differences in quantitative traits between clusters were significant ($p<0.05$) for all the traits except days to 50% flowering, green seed yield per plant and bruchid seed infestation (Table 4).

The trait variances among seven clusters were significant ($p<0.05$) for days to 50 % flowering, days to maturity, plant height, pods per plant and pod borer infestation (Table 5). These results suggested that the K-means clustering approach was efficient to minimise the within-cluster variance and maximise between-cluster variance as a result of inclusion of diverse accessions to different clusters. The estimates of the means of the quantitative traits such as days to 50 % flowering, days to maturity, raceme length, plant height, primary branches per plant, pods per plant, green seed yield per plant, bruchid seed and pod borer infestation were the highest among the accessions included in cluster 4 and 6 and were the least among the accessions included in cluster 2 and 3. It is desirable to choose germplasm accessions from among those included in the clusters 3 and 6 for various applications in Dolichos-bean breeding.

A significant variability among the accessions for quantitative traits was expected as they are landraces, which have evolved over millennia through a combination of natural and human selection on the variation, originated by mutations and distributed by recombination (Allard, 1999). These landraces poses different combination of traits and hence, have better adaptability to different production environment and/or a combination of production environments. Through increased use of landraces, efficiency of breeding Dolichos bean cultivars suitable for diverse production constraints such as terminal drought and insect pest infestation, which are the most frequently occurring abiotic and biotic stresses in regions where Dolichos bean is extensively grown, could be maximized.

Traits-specific accessions

Exploitation of natural genetic variability would help breeders to meet immediate requirement of farmers, consumers and end-users. Continued crop genetic improvement to meet medium and long-term objectives requires variability induced through deliberately planned crosses among genotypes with desired combination of traits. Evaluation of germplasm would provide such information about the accessions/genotypes.

Table 3. Estimates of intra- and inter-cluster distance between accessions of the Dolichos bean

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
Cluster 1	0.82	1.19	1.25	1.47	1.10	1.26	1.35
Cluster 2		0.94	1.16	1.96	1.71	1.38	1.66
Cluster 3			0.78	2.19	1.91	1.89	2.04
Cluster 4				0.89	0.97	1.59	1.23
Cluster 5					0.55	1.46	1.45
Cluster 6						0.80	1.01
Cluster 7							0.77

Table 4. Estimates of quantitative traits (mean) of the Dolichos bean accessions belonging to different clusters

Quantitative trait	Mean of Clusters							'F' Statistic	Probability
	C1*	C2	C3	C4	C5	C6	C7		
	Size of the cluster								
	11	6	5	5	6	4	9		
Days to 50 % flowering	80.0	79.7	84.6	71.4	64.3	102.0	87.4	1.812	0.121
Days to maturity	115.8	112.5	120.4	105.4	96.5	133.8	124.1	2.583	0.033
Plant height (cm)	63.2	52.4	46.4	92.9	98.8	86.6	67.5	4.684	0.001
No. of primary branches/plant	3.6	5.3	3.9	4.3	4.2	4.6	3.9	3.708	0.005
Raceme length (cm)	17.2	14.3	15.1	21.9	22.3	23.2	18.5	4.765	0.001
Pods/ plant	23.7	15.9	17.7	36.1	29.4	32.6	35.9	6.628	0.000
Green seed yield/ plant (g)	63.2	57.3	58.3	55.8	63.2	60.0	53.3	0.672	0.673
Pod borer infestation (%)	53.7	44.4	55.5	56.4	57.9	41.0	52.8	1.971	0.094
Bruchid seed infestation (%)	29.0	23.5	24.2	36.7	32.7	34.5	36.5	6.698	0.000

*Cluster

Table 5. Estimates of variance of quantitative traits of the Dolichos bean accessions belonging to different clusters

Quantitative traits	Variance of clusters							'F' Statistic	P**
	C1*	C2	C3	C4	C5	C6	C7		
	Size of the cluster								
	11	6	5	5	6	4	9		
Days to 50 % flowering	66.0	117.5	411.3	330.3	186.7	1184.7	858.0	2.843	0.022
Days to maturity	79.4	67.9	365.3	361.3	185.5	1163.6	468.4	2.409	0.045
Plant height (cm)	642.5	93.4	125.1	409.6	1135.9	958.7	194.5	2.364	0.048
No. of primary branches/plant	0.3	1.0	1.3	0.7	0.2	0.9	0.8	1.044	0.412
Raceme length (cm)	8.5	11.5	21.7	17.1	19.0	15.8	16.1	0.115	0.994
Pods/plant	18.1	3.1	135.6	104.5	32.5	133.1	102.2	2.451	0.042
Green seed yield/plant (g)	221.3	199.5	113.7	185.5	164.4	36.2	135.3	0.605	0.725
Pod borer infestation (%)	53.2	192.7	56.6	80.9	143.6	39.3	147.6	1.374	0.249
Bruchid seed infestation (%)	7.9	1.9	63.4	39.5	12.7	50.8	46.4	2.029	0.05

*Clusters; **probability

Some accessions used in this study were superior to the check HA-4 for six selected traits such as days to maturity, primary branches plant per plant, pods plant per plant, green seed yield plant per plant, pod borer infestation and bruchid seed infestation. The accessions contrasting for these selected six traits were identified. The accessions GLB 346, GLB 338, GLB 400, GLB 294, GLB 334 and GLB 296 with lesser days to maturity, GLB 55, GLB 187, GLB 426, GLB 46, GLB 422, GLB 424 and GLB 258 with more primary branches per plant, GLB 433, GLB 346, GLB 99, GLB 400, GLB 420, GLB 426 and GLB 306 with more pods per plant, GLB 16, GLB 372, GLB 110, GLB 133, GLB 433, GLB 140, GLB 403, GLB 258 and GLB 346 with higher green seed yield per plant, GLB 223, GLB 63, GLB 426, GLB 187, GLB 425 and GLB 403 with less pod borer infestation and GLB 433, GLB 428, GLB 426, GLB 425, GLB 422, GLB 424 and GLB 420 with less bruchid seed infestation compared to the check variety HA-4, are useful in breeding short duration cultivars with higher productivity. Accessions GLB 426 and GLB 46 that are contrasting for multiple traits *viz.* pods per plant, green seed yield per plant, pod borer infestation and bruchid seed infestation, are useful in developing populations for mapping genes that control these traits simultaneously.

Conclusion

The accessions used in the study are a mixture of pure lines whose expression predominantly determined by additive genetic effects and additive x additive type of epistasis. Thus, the selection of desired accessions for any of the traits considered in the present study would be effective as all the traits were highly heritable. It is desirable to choose accessions from among those included in clusters 3 and 6 for various applications in Dolichos bean breeding.

Acknowledgement

The authors are highly grateful to the Kirkhouse Trust (UK) for providing financial assistance to the project and University of Agricultural Sciences, Bangalore, India for the logistical support.

References

Allard, R.W. (1999): Principles of Plant Breeding. 2nd Ed. John Wiley and Sons, INC, Newyork, USA, pp. 81.

Falconer, D.S. and Mackay, T.F.C. (1996): Introduction to Quantitative Genetics. 4th Ed. Addison Wesley Longman Ltd, England. pp. 356-357.

Federer, W.T. (1956): Augmented (or hoonuiaku) designs. Hawaii. *Plant Res*. 2: 191–208.

Girish, G. and Byre Gowda, M. (2009): Inheritance of qualitative characters in Dolichos bean *Lablab purpureus* (L.) Sweet. *Environ. Ecol.,* 27: 571–580.

Levene, H. (1960): Contributions to Probability and Statistics, Stanford University Press, CA. pp. 278– 292.

Maass, B.L, Knox, M.R., Venkatesha, S.C., Angessa, T.T., Ramme, S. and Pengelly, B.C. (2010): *Lablab purpureus* – A Crop Lost for Africa?. *Tropical Plant Biol.* 3: 123-135.

MacQueen, J. (1967): Some methods for classification and analysis of multivariate observations. pp. 281–297. Fifth Berkeley Symposium on Mathematics, Statistics and Probability. University of California Press.

Mahadevu, P. and Byre Gowda, M. (2005): Genetic improvement of Dolichos bean (*Lablab purpureus* L.) through the use of exotic and indigenous germplasm. *Indian J. Plant Genet. Resour.* 18: 1-5.

Milligan, S.B., Gravois, K.A., Bischoff, K.P. and Martin, F.A. (1990): Crop effect on broad-sense heritabilities and genetic variances of sugarcane yield components. *Crop Sci.* 30: 344-349.

Mugwira, L.M. and Haque, I. (1993): Screening forage and browse legumes germplasm to nutrient stress: II. Tolerance of *Lablab purpureus* L. to acidity and low phosphorus in two acid soils. *J. Plant Nutrition.* 16: 37-50.

Murphy, A.M. and Colucci, P.E. (1999): A tropical forage solution to poor quality ruminant diets: A review of *Lablab purpureus*. *Livestock Res. Rural Dev.* 11: 96-113.

NRC (National Research Council) (2006): Lablab In: Lost Crops of Africa, Vol II: vegetables, pp. 190-205. NRC, Washington DC, USA.

Roxburgh, W. (1832): Flora Indica, vol. 3. W. Thackery and Co, Calcutta.

Shivashankar, G. and Kulkarni, R.S. (1989): Field bean (*Dolichos lablab* L. var. lignosus prain). *Indian Hort.*: 34: 24-27.

Snedecor, G.W. and Cochran, W.G. (1994): Statistical methods. 8th Ed, Iowa State University Press, Ames, Iowa, USA.