Morphological Characterization of *Sesbania* Accessions using Multivariate Analysis

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Forty accessions of *Sesbania* belonging to 13 species tracing their origin to India, Brazil, Australia and Philippines, were evaluated for 15 agro-morphological characters in Randomized Block Design with three replications. Accessions showed significant genetic variability for all the 15 characters. Euclidean distance (D^2) between all possible pairs (780 pair comparisons) of accessions were calculated and used in unweighted pair group method with arithmetic average cluster analysis. The accessions were delineated into 7 clusters. The highest inter-cluster distance (33.44) was present between cluster 1 and 7 followed by distance of cluster 7 with cluster 2 and 3. Cluster 7 contained only one accession of *bispinosa* species and was isolated from other clusters. Majority of *S. rostata* species were grouped together in one cluster. Other clusters were heterogeneous. The composition of clusters indicated that geographic diversity is not the sole factor for determining the genetic diversity. The botanical origin of the species needs to be established. The study suggested that grouping of *Sesbania* accessions would facilitate in maintaining and utilizing the germplasm resources. Some potential pairs of accessions are suggested for their utilization in hybridization programme.

Key words: *Sesbania*, Characterization, Cluster analysis, Euclidean distance, Multivariate analysis

The genus *Sesbania*, one of the important genera of legumes, is ecofriendly and has a great potential for sustaining of agriculture. It is an organic biofertilizer due to its heavy root nodulation and helps to improve soil physical structure, texture and prevents leaching and loss of nutrients. *Sesbania* species have many other uses like ruminant fodder, fire wood and medicines (Veasey *et al.*, 1999). Considering the immense importance of the *Sesbania* species, there is renewed interest in utilization and genetic improvement of this genus. Germplasm characterization of *Sesbania* will be of great help in maintaining and utilizing germplasm resources and initiating a sound breeding programme of this important genus. However, very limited information is available on this aspect of *Sesbania* germplasm. Therefore, this study is aimed to present characterization of a set of 40 diverse accessions of *Sesbania* using 15 agro-morphological traits in field testing.

Materials and Methods

Forty land races of *Sesbania* comprising 16 indigenous and 24 exotic belonging to 13 species represented a wide spectrum of variability. These accessions had their origin from Australia, Brazil, India and Philippines. The material was planted in Randomized Block Design in three replications at the experimental area of Department of Pant Breeding, CCS HAU, Hisar. Each plot was of 3 m length with row to row spacing of 45 cm and plant to plant spacing of 15 cm. Five plants were randomly selected from each accession in each replication for recording the observation on 15 agro-morphological traits viz., plant height at 20 days after sowing (20 DAS), plant height at 60 DAS, green biomass at 60 DAS, number of root nodules at 60 DAS, fresh weight of root nodules at 60 DAS, number of leaves per plant at 50% flowering, number of leaflets at 50% flowering, leaf length at 50% flowering, plant height at maturity, number of pods per plant, pod length, number of seeds per pod, dry biomass of plant, 100-seed weight and seed yield per plant. Euclidean distances (D_i^2) between all possible pairs of accessions were calculated based on 15 characters (Mahalanobis, 1948) and used in unweighted pair group method with arithmetic average (UPGMA) cluster analysis (Romesburg, 1984).

Results and Discussion

Significant differences were observed for the characters among accessions (Table 1). This indicated a substantial genotypic variability to further pursue the cluster analysis. Cluster analysis of the 40 accessions of *Sesbania* was performed using D^2 statistics based on Euclidean distances. The analysis delineated the accessions into 7 clusters (Fig. 1 and Table 2). The composition and geographic origin of the accessions in different clusters are depicted in Table 1. The clusters appeared to be homogeneous within themselves but differed from each other. Cluster 1 contained 9 accessions. All these accessions were exotics except one indigenous accession

Table 1. ANOVA for 15 quantitative traits in 40 *Sesbania* accessions

Mean square for	Source of variation		
	Replication (2)	Treatment (39)	Error (78)
Plant height at 20 DAS (cm)	78.59	52.64*	28.61
Plant height at 60 DAS (cm)	2696.56	2245.48*	254.63
Green mass at 60 DAS (g)	38.50	6852.38*	161.85
No. of root nodules	45.30	2393.97**	17.28
Weight of root nodules (g)	0.83	0.88**	0.08
No. of leaves at 50% flowering	82.95	6408.92**	61.24
No. of leaflets per leaf	7.37	162.43**	26.33
Leaf length at 50% flowering (cm)	42.96	165.31**	6.06
Plant height at maturity (cm)	1010.06	9807.62**	2041.76
No. of pods	426.53	11909.89**	1551.74
Pod length (cm)	6.48	24.00**	3.68
No. of seeds per pod	22.01	47.39**	11.25
Dry weight at 60 DAS (g)	87.26	55.90**	12.96
100-seed weight (g)	0.05	0.71**	0.16
Seed yield per plant(g)	51.74	1430.33**	58.71

*Significant at 5 per cent level.
**Significant at 1 per cent level.

Table 2. Cluster composition based on clustering on morphological characters and geographic origin of *Sesbania* accessions (T)

Cluster	Acc. (No.)	Coded Acc.	Species	Accession	Origin/source
1	9	T4	*S. rostrata*	EC 223312	IRRI, Philippines
		T6	*S. rostrata*	EC 218472	IRRI, Philippines
		T5	*S. rostrata*	EC 178342	IRRI, Philippines
		T8	*S. sesban*	EC 213473	IRRI, Philippines
		T2	*S. rostrata*	EC 331973	IRRI, Philippines
		T3	*S. rostrata*	IC 277784	PAU, Ludhiana
		T14	*S. sesban*	EC 509439	Brazil
		T15	*S. exasperata*	EC 599434	Brazil
		T16	*S. virgata*	EC 509442	Brazil
2	7	T10	*S. aculeata*	IC 277777	PAU, Ludhiana
		T12	*S. aculeata*	IC 277782	PAU, Ludhiana
		T7	*S. rostrata*	EC 213472-A	IRRI, Philippines
		T36	*S. aculeata*	IC Pant-3	Uttaranchal
		T37	*S. aculeata*	NBPGR-3	Najafgarh, New Delhi
		T32	*S. macrantha*	EC 493701	Australia
		T35	*S. aculeata*	IC Pant-1	Uttaranchal
3	9	T29	*S. simpliciuscula*	EC 493667	Australia
		T31	*S. cannabina*	EC 493700	Australia
		T33	*S. macrantha*	EC 493702	Australia
		T34	*S. speciosa*	EC 493706	Australia
		T38	*S. aculeata*	PDCSR-2	Modipuram (UP)
		T39	*S. aculeata*	NIC 4149	India
		T40	*S. aculeata*	NIC 4223	India
		T18	*S. aculeata*	SES H-1	Haryana
		T1	*S. rostrata*	EC 331970	IRRI, Philippines
4	3	T23	*S. exaltala*	EC 493664	Australia
		T26	*S. leptocarpa*	EC 493676	Australia
		T28	*S. exasperata*	EC 493688	Australia
5	4	T9	*S. aculeata*	IC 277791	Modipuram (UP)
		T22	*S. simplicuscula*	EC 493666	Australia
		T11	*S. aculeata*	IC 277786	PAU, Ludhiana
		T25	*S. exasperata*	EC 493687	Australia
6	7	T13	*S. aculeata*	IC 277776	PAU, Ludhiana
		T20	*S. aculeata*	IC 277789	PAU, Ludhiana
		T17	*S. aculeata*	Ses H-9	Haryana
		T19	*S. aculeata*	Ses H-6	Haryana
		T21	*S. simpliciuscula*	EC 493668	Australia
		T27	*S. campylocarpa*	EC 493695	Australia
		T30	*S. exaltala*	EC 493662	Australia
7	1	T24	*S. bispinosa*	EC 493681	Australia

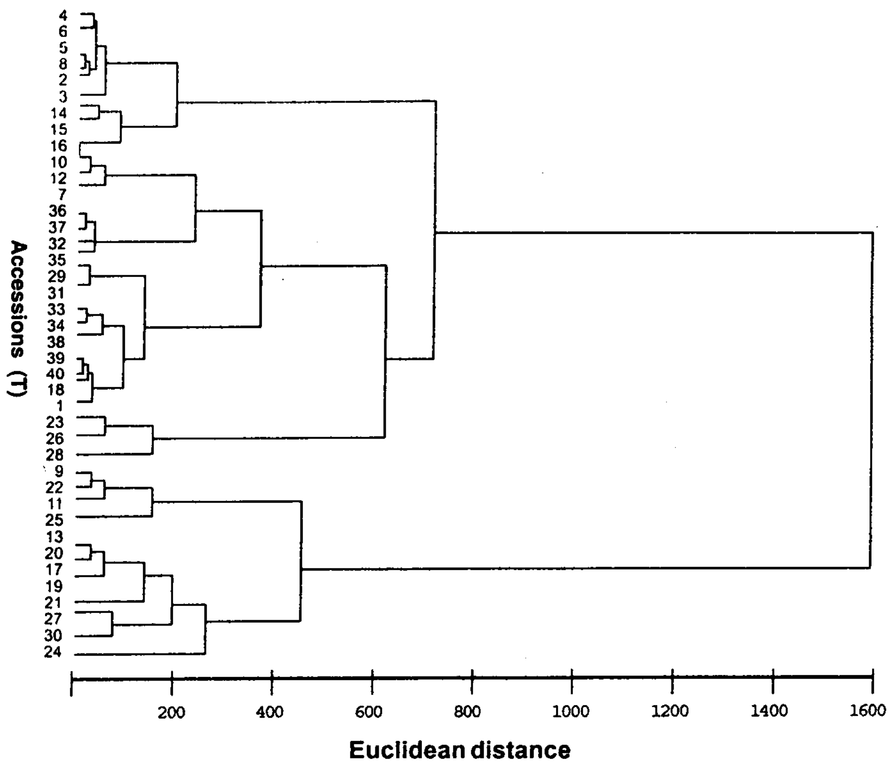

Fig. 1: Dendrogram from cluster analysis with 15 quantitative characters

from Punjab. This cluster contained majority of accessions from Philippines (5 accessions) and three accessions from Brazil. Five accessions of this cluster belonged to *rostrata* species, two belonged to *sesban* and remaining two belonged to *exasperata* and *virgata* species each. Cluster 2 consists of 7 accessions. Majority of them were indigenous. This cluster had two exotic accessions, one each from Philippines and Australia. Cluster 3 had nine accessions: 4 from Australia, one from Philippines and 4 from India. Three accessions, all belonging to Australia were grouped together in cluster 4. Each of these accessions belonged to three different species (*exalata*, *leptocarpa* and *exasperata*). Cluster 5 had 4 accessions, two each from India and Australia. Seven accessions comprising 4 from India and 3 from Australia, were grouped together in cluster 6. These accessions belonged to 4 different species. Cluster 7 was very unique containing only one accession belonging to bispinosa species from Australia.

Intra- and inter-cluster distances are shown in the Table 3. Cluster 4 appears to be more heterogeneous as it had maximum intracluster distance (14.75). The minimum intracluster distance was found among accessions belonging to cluster 3. The highest intercluster distance (33.44) was present between cluster 1 and 7. This was followed by the distances of cluster 7 from cluster 2 and cluster 3. In general, cluster 5 also exhibited substantial intercluster distances from other clusters.

The mean values of clusters for different agro-morphological characters are given in Table 4. The salient features of the clusters for different characters are summarized hereafter.

Cluster 1

Cluster 1 comprised accessions with low mean values for green mass at 60 DAS, number of root nodules, weight of root nodules, number of leaves at 50 per cent flowering, number of leaflets per leaf, pod length and seed yield. It had medium mean values for plant height at maturity, number of pods per plant, number of seeds and 100-seed weight.

Cluster 2

It is characterized by accessions with higher plant height at 60 DAS, higher green mass, high number and weight of root nodules, high number of leaflets, high mean value of plant height at maturity, high number of pods, more number of seeds per pod, low plant dry weight, bold seeded accessions and medium mean value of seed yield.

Table 3. Euclidean intra and inter cluster distances

	Cluster–1	Cluster–2	Cluster–3	Cluster–4	Cluster–5	Cluster–6	Cluster–7
Cluster–1	10.03	16.50	14.28	20.33	25.48	20.24	33.44
Cluster–2		11.19	12.90	22.71	17.13	15.84	27.91
Cluster–3			09.19	16.64	19.80	14.89	26.16
Cluster–4				14.75	25.58	19.07	24.58
Cluster–5					12.32	17.37	21.68
Cluster–6						11.69	18.81
Cluster–7							00.00

Table 4. Mean values of clusters for 15 quantitative traits in 40 *Sesbania* accessions

Cluster	Plant height at 20 DAS (cm)	Plant height at 60 DAS (cm)	Green mass at 60 DAS (g)	No. of root nodules	Weight of root nodules (g)	No. of leaves at 50% flowering	No. of leaflets/ leaf at 50% flowering	Leaf length at flowering (cm)	Plant height at flowering (cm)	No. of pods/ plant	Pod length maturity (cm)	No. of seeds/ plant	Dry weight at 60 DAS (g)	100-seed weight (g)	Seed yield/ plant (g)
1	02.59	139.47	69.90	17.94	0.88	55.67	24.03	22.05	475.24	84.49	18.81	29.57	18.42	2.03	24.68
2	23.26	176.82	135.91	53.07	1.50	42.51	37.98	28.82	528.16	104.25	22.73	34.32	17.90	2.41	45.80
3	22.77	177.79	155.07	29.82	1.14	83.87	35.80	28.83	496.21	86.91	20.08	30.64	23.07	2.15	27.10
4	23.53	163.48	136.19	25.26	0.72	171.87	32.29	19.53	414.53	78.81	19.82	27.53	20.59	1.37	25.42
5	22.57	156.62	124.62	98.67	1.55	78.18	38.36	30.16	475.46	104.56	21.81	30.82	20.63	1.96	31.42
6	21.01	161.95	139.35	56.55	1.50	117.53	36.74	35.56	528.52	176.46	23.44	34.49	22.99	2.47	71.11
7	21.33	155.60	195.13	90.17	2.97	207.17	42.03	40.60	513.67	115.67	22.41	32.10	22.53	1.90	59.17

Cluster 3

Majority of accessions of this cluster were tall at 60 DAS with higher green mass, more number of leaves and leaflets, more plant height at maturity, moderately high number of seeds, more dry weight of plant and accession with low seed yield.

Cluster 4

Cluster 4 consisted of mainly accessions with tall plants at 60 DAS, high green mass, low values for number and weight of root nodules, high number of leaves, medium plant height maturity, low number of pods per plant, small pod length, less number of seeds per pod, small seeded plants and low seed yield.

Cluster 5

The accessions belonging to this cluster were characterized with medium plant height at 60 DAS, medium mean value of green mass, high values for number and weight of root nodules, moderately high number of leaflets, medium plant height at maturity, moderately high number of pods, medium pod length, medium number of seeds and medium mean value for 100-seed weight and seed yield.

Cluster 6

Accessions of this cluster had high average value of plant height and green mass at 60 DAS, medium mean value for number and weight of root nodules, tall plants at maturity, high number of pods per plant, more pod length, more number of seeds, bold seeded plants with high seed yield.

Cluster 7

This cluster consisted of only one accession belonging to the species *bispinosa* from Australia. This accession is characterized with highest mean values for green mass, number and weight of root nodules, number of leaves and leaflets, tall plants at maturity, moderately high number of pods, larger pod size and moderately high seed weight.

In the present study, majority of the *S. rostrata* species were grouped together in cluster 1. All these accessions were from Philippines. Two remaining accessions of *S. rostrata* were grouped in two different clusters i.e. cluster 2 and cluster 3 each. The separation of accessions of the same species into different clusters has also been reported in *Sesbania* by Veasey *et al.* (2001, 2002). On the other hand accessions from Brazil belonging to three different species were grouped together in cluster 1. The other clusters were also heterogeneous having different species together. This warranted further detailed investigation on species relationship in *Sesbania*. Species nomenclature in *Sesbania* has been questioned by Backer and Van den Brink (1963), Markila (1980) and Evans and Rotar (1987). The accessions from Australia tended to be together but split into three different groups. Thus, the complex composition of clusters indicates that the geographic diversity is important but not the sole factor determining the genetic diversity. Factors other than geographic diversity might also be responsible for different grouping of accessions. This is in agreement with the findings of Gupta and Singh (1970) and Malhotra *et al.* (1974). A plausible explanation is given by Clausen and Hiesey (1958) who demonstrated that even a single component of environment such as the temperature could cause difference between and within the race. Similarly, Murthy and Arunachalam (1966) were of the opinion that the genetic drift and selection in different environments may also cause greater diversity than geographic origin influenced the clustering pattern.

In addition, the reproductive biology of the species may also affect grouping of accession. In *Sesbania* species *sesban* and *virgata* have been reported to be partial allogamous (Heering, 1994; Veasey *et al.*, 2002; Girma *et al.*, 2002). Besides, grouping of subjects (accessions) into clusters may be rather sensitive to the particular choice of variables (characters) used in clustering. A different choice of variables, apparently equally reasonable, may give different clusters (Manly, 1998). The characters related to floral morphology and other taxonomic characters are more relevant to the botanical origin of the species.

The inter-cluster distances and the mean performance of accessions suggested that improvement in yield may be achieved by use of T3 accession from cluster 1 and T24 from cluster 7 as parents in the crossing programme. Similarly, accession T37 (NBPGR-3) belonging to cluster 2 with high green mass should be crossed with accession T24 for genetic improvement of green mass for manuring. The other potential pairs of parents are: T3 from cluster 1 with T11 from cluster 5, and T23 from cluster 4 with T11 from cluster 5. These pairs of parents have high mean values for green biomass with high genetic divergence between them.

It is evident from the study that measurement of divergence between accessions and grouping them according to similarity will facilitate the selection of potential parents for hybridization. This information supplemented with passport data would be useful to *Sesbania* breeders for proper maintenance and exploitation of the germplasm in crop improvement programme.

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