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Evaluation of Variability in Proximate Compositions Among Accessions of Sword Bean (*Canavalia gladiata* Jacq. DC) and Jack Bean (*Canavalia ensiformis* L. DC)

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Abstract

Exploitation of available germplasms particularly in the developing countries is still limited despite the availability of rich gene pools. *Canavalia* species are underutilized legumes of wide importance for humans and livestock feed. Field and laboratory studies were carried out on evaluation of variability in proximate compositions within and between fifteen genotypes of *Canivalia* species collected from Genetic Resources Centre, International Institute of Tropical Agriculture (IITA), Ibadan. The study was a randomized complete block design replicated three thrice. Harvested mature seeds were analysed for proximate composition. The results revealed that moisture content ranged from 26.97 to 30.05, crude protein 15.45-21.85%, lipid 7.05-29.70%, ash 10.18-17.43%, sugar 0.75-1.37%, starch 7.40-0.26% and energy levels 1016.56-1825.82 kJ 100 g^{-1} DM. Significant ($p<0.05$) variability was observed in sugar, lipid and energy contents among the accessions based on analysis of variance (ANOVA). The first principal component analysis (PCA) had the highest contribution of 31.4% to the total variation. Based on proximate composition, the 15 accessions clustered into six main groups. Lipid varied widely and significantly ($p<0.05$) correlated to energy. Aggregation of accessions within the same species into a cluster revealed high similarity within a biological and taxonomic unit. The similarities among these 15 accessions could allow for inter specific hybridization.

Keywords: biological and taxonomic unit, *Canavalia*, clusters analysis, hybridization, proximate composition, variability

Introduction

Number of plants that feed the world is becoming smaller as the genetic diversity of many crop species are reducing too. These trends are coming at a time when human population is expanding rapidly and all available options will be needed to meet world food demand (Smith, 1998).

The natural gene pool for most crop species still remains very rich but their exploitation is limited (Vance *et al.*, 2000). A revitalized investigation of all plant resources available worldwide is most needed. Collection and the assemblage of crop accessions for *in-situ* conservation are primary for genetic improvement in order to preserve the plant diversities from extinction is needful. Many plant genetic resources may have been adversely affected due to neglect and under-utilization. For instance, the most commonly cultivated legumes among peasant farmers in humid tropics are Soy bean (*Glycine max),* cowpea *(Vigna unguiculata),* groundnut (*Arachis hypogaea*) and lima bean *(Phaseolus lunatus*). However, there are many other pulses that could help meet human and livestock dietary needs; most of which are cultivated only in localized areas and are less used (Nwokolo, 1987, Vance *et al.,* 2000). Some of these underexploited legumes include African yam bean (*Sphenostylis stenocarpa*), Bambara groundnut (*Vigna subterranea*), Pigeon pea (*Cajanus cajan*), Green gram (*Phaseolus aureus*), Winged bean (*Psophocarpus tetragonolobus*), Sword bean (*Canavalia gladiata*) Jack bean (*Canavalia ensiformis*), Lablab beans (*Dolichos lablab* L.) (Adewale, 2010; Sørensen *et al.,* 1997).

Canavalia species ranks well among the neglected crop species (Dada *et al.,* 2012; Ekanayake *et al.,* 2000). The nutritional, pharmaceutical usefulness of this legume both to man and his livestock are outstanding; the seeds are used as food for man while foliage is important as meal for animals (Graham and Vance, 2003). The immature pod of most legumes is rich in protein, minerals and vitamins while the seeds are the most nutritious part (Nwokolo, 1987). The fruits of *Canavalia* spp. have been reported as potential sources of nutritional (Ekanayake *et al.,* 2000), nutraceutical, (Nwokolo, 1987) and pharmaceutical benefits for humans and livestock, (Grubben and Denton, 2004). Both species of Sword bean (*Canavalia gladiata*) Jack bean (*Canavalia ensiformis*) are used in Nigeria as ornamental plants and in some places are believed to be "snake repellents". Sword bean contains gibberellin A-15, a growth-promoting hormone (Tokoya and Takama, 1981)

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and its leaf meal has been shown to be a good source of pigment for egg yolks but information on its nutritive value is quite sketchy (Vadivel and Janardhanan, 2001). Generally information on nutritive value of *Canavalia* species is scanty. This study was carried out to unravel the nutritive compositions as well as variation in proximate constituents of seven accessions of *Canavalia gladiata* and eight accessions of *Canavalia ensiformis*.

Materials and methods

Seeds of fifteen ascensions of *Canavalia* species comprising of eight accessions of sword bean (*C. ensiformis*) and seven accessions of jack bean (*C. gladiata*) were obtained from the Genetic Resources Centre, International Institute of Tropical Agriculture (IITA), Ibadan. The experiment was laid out in a randomized complete block design (RCBD) with three replicates in a field at IITA, Ibadan (Lat. 7°30', Long. 3°54') during the early planting season (July to December) of 2009. Planting was done at the spacing of 1 m × 1m. Two seeds were planted per hill; which was later thinned to one after seedling emergence. Field management was carried out as required.

Data collection and analysis

At maturity, matured pods were air dried and further oven dried at 70°C to constant weight. Samples were collected from oven dried seeds for proximate analysis. Twenty dried seeds each of the fifteen accessions of *Canavalia* species were ground to powder in order to determine their nutritional composition. Ground samples were taken for proximate analysis.

Analyses of proximate composition and gross energy

The proximate constituents of the oven-dried materials were determined by the methods of Association of Official Analytical Chemist (AOAC, 1998). All analyses were carried out in duplicate. Crude protein was determined by Kjeldahl method using Kjeltec^{TM} model 2300 as described in Foss Analytical Manual (2003). Gross energy of the dry material was determined against thermocouple grade benzoic acid using a Gallenkamp ballistic bomb calorimeter (Model CBB - 330- 0104L).

Statistical analysis

The means of the proximate compositions in each replicate were generated and subjected to ANOVA using PROC GLM procedure of Statistical Analysis Software (SAS, 2002). The means of the accessions for the various traits were separated by the least significant difference (LSD) at $p< 0.05$. Correlation analysis was carried out to determine the relationship among the proximate compositions of the two species. The 15 × 7 data matrix was then subjected to PCA, clustering and Fastclus analysis using SAS (version 9.1).

Results

Proximate composition of 15 accessions of *Canavalia* spp is presented in Tab. 1. Results revealed significant dif-

Tab. 1. Assessment of fifteen accessions of Canavalia spp. by seven quantitative proximate descriptors

Accessions	Proximate compositions (%) 100g^{-1} dry matter						Energy (kJ)
	Moisture content	Sugar	Starch	Lipid	Ash	Crude protein	
TCe1	28.80	0.85	26.95	7.05	10.23	18.11	1016.56
TCe7	27.68	0.76	26.53	12.03	17.43	19.67	1221.59
TCe4	27.95	0.80	27.52	24.50	10.90	18.02	1676.71
TCg1A	27.92	1.15	24.65	11.32	11.00	19.60	1162.22
TCg1B	28.43	1.10	28.22	16.53	10.78	20.40	1430.24
TCg1C	28.48	0.77	34.20	13.10	10.18	19.15	1380.88
TCg2	28.10	0.75	26.67	14.07	12.60	21.85	1336.32
TCe2A	30.05	1.02	26.03	14.37	11.93	19.38	1295.77
TCe2B	29.10	1.20	25.20	8.38	10.67	19.00	1051.68
TCe3	26.97	1.37	25.85	7.50	11.62	18.35	1020.51
TCg3A	27.98	1.33	28.98	15.65	11.85	18.23	1340.43
Tcg3B	28.58	1.23	26.60	15.98	12.42	19.98	1375.72
TCg4A	28.68	1.08	25.32	11.02	10.33	17.42	1125.67
TCg4B	28.37	1.32	28.11	9.15	10.85	15.45	1069.49
TCe5	29.73	1.23	25.75	29.70	11.80	17.07	1825.82
Mean	28.45	1.06	26.97	14.06	11.64	18.76	1288.64
CV(%)	2.74	20.95	8.33	44.09	15.27	8.15	18.29
LSD (0.05)	1.27	0.07	0.77	0.46	0.10	1.32	28.03

Means with similar letters are not significantly different at p <0.05 (LSD)
CV = coefficient of variation

ferences among the 15 accessions of *Canavalia spp.* with regard to proximate compositions. TCe1 had the least fat content (7.05%) and energy (1016 kJ) as against the highest value for the same traits (29.70% and 1825.82 kJ) in TCe5 accession. Sugar content was least in TCg2 (0.75%) but not significantly different from TCe7 and TCg1C. The accession with the highest sugar content was TCe3. The moisture content in the studied *Canavalia* genotypes was significantly different, where TCe2A had highest (30.05%) moisture content and TCe7 had the highest (17.43%) ash content. Although, TCg1C had the highest (34.20%) starch content but had the least (10.18%) ash content. The 15 accessions varied slightly but significant in their protein content with a CV of 8.15%. Nevethless,TCg2 had the highest crude protein (21.85%). Among the seven proximate variables tested in the 15 accessions moisture content had the least variation (CV = 2.74%) among the samples, while lipid (fat) had the highest variation (CV = 44.08%).

The eigen values of the PC for seven proximate variables is presented in Tab. 2. The first five PC - axes explained the total variation within the 15 accessions. The first three axes had eigen values ≥ 1.0 and explained 75% of the total variation within the studied accessions. The first PC-axis made the highest contribution (31.4%) to explaining the total variation in the proximate compositions.

The seven variables had significant contribution to the variances within each PC-axis. Energy, fat, moisture content and sugar were the four variables which significantly contributed to the quantity of variance in the PC1 axis. In PC2, moisture content, sugar, ash and protein were most significant; while sugar, starch and ash were significant for PC3. Sugar, starch, lipid and protein were the four significant variables, in PC4. In the last PC-axis, moisture content, sugar, ash and protein were significant in their impact in determining the variance within the PC-axis, Sugar consistently featured in the five PC-axes.

The clustering of proximate compositions of the 15 accessions of *Canavalia* spp is presented in Fig. 1. The classi-

Tab. 2. Eigenvectors and variance proportion of seven proximate variables in five PC-axes

Proximate composition	Eigenvectors				
	PC1	PC2	PC3	PC4	PC5
Moisture content	0.29	0.34	0.04	0.79	- 0.33
Sugar	- 0.24	- 0.55	0.28	- 0.23	0.31
Starch	0.18	0.20	-0.74	- 0.26	- 0.12
Fat	0.63	- 0.16	0.19	- 0.20	0.12
Ash	0.05	0.44	0.55	- 0.17	- 0.57
Protein	0.08	0.56	0.13	0.39	0.64
Energy	0.65	- 0.06	0.08	0.19	0.16
Eigen value	2.20	1.77	1.26	0.85	0.57
% variance	31.41	25.26	18.01	12.21	08.21
Cumulative (%) variance	31.41	56.67	74.68	86.88	95.09

Significant at eigenvectors ≥ 0.20

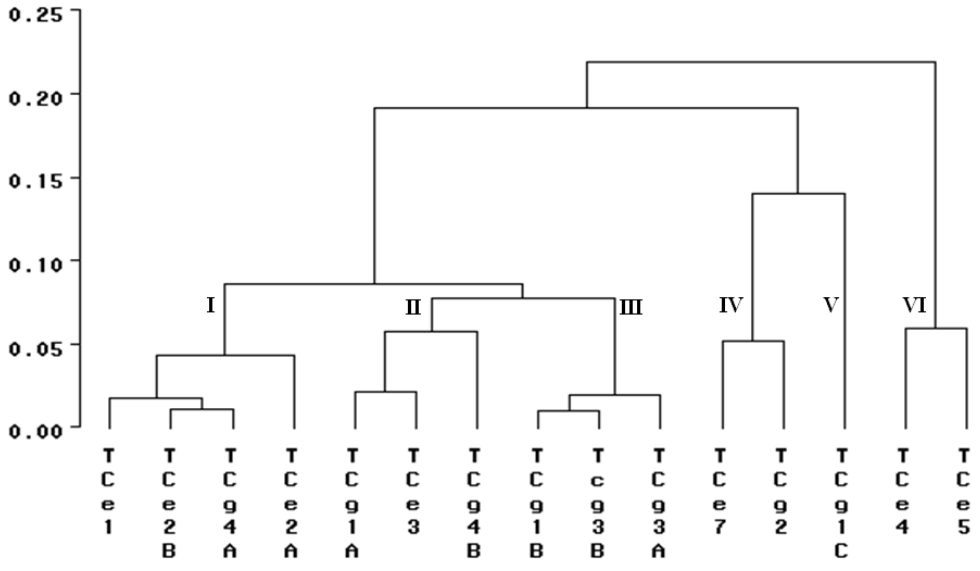

Fig. 1. The dendrogram representation of 15 accessions of *Canavalia spp* using the proximate variables

fication was based on similarities among the 15 accessions for the seven proximate variables. The 15 accessions were unique; differing from each other based on the proximate descriptors. No pairing of accessions occurred at a similarity distance of zero. Six main clustering patterns were possible as shown in Fig. 1. The cluster with the highest membership was I; clusters III and IV had three members each, clusters IV and VI had two accessions each while cluster V had a single accession. Only accessions within *gladiata* species featured in clusters III and V, while accessions within the *ensiformis* species featured only in cluster VI. In clusters I, II and IV accessions within the two species (*ensiformis* and *gladiata*) freely clustered together based on some proximate similarities (Fig. 1).

The similarity distances within which the fifteen accessions joined or tied are presented in Tab. 3. Based on the proximate variables considered in this study, TCg1B and TCg3B were the closest; they tied at the similarity distance of 0.01 (Tab. 4). The next accessions with closest pairing were TCe2B (*C. ensiformis*) and TCg4A (*C. gladiata*) at the similarity distance of 0.0101. The 15 accessions of *Canavalia* spp clustered within similarity distance of 0.01 - 0.22 (Fig. 1 and Tab. 3).

The intra-cluster variability of the fifteen accessions within the five clusters are presented in Tab. 4. Moisture content was highest in cluster I but lowest in II. Sugar content was highest in II but lowest in IV and V. Least starch content was obtained in cluster I with a mean of 7.76. TCg1C (cluster V) had the highest starch content of 10.25. The least fat and energy obtained in this study was in cluster II while highest was observed in cluster VI. However, ash and protein content was highest in cluster IV.

Tab. 5 presented the Pearson correlations among the seven the proximate variables. The was no significant relationship among most of the seven proximate factors. Nonetheless, there was a significant relationship between fat and ash components of the 15 *Canavalia* accessions.

Tab. 3. The Cluster history of the fifteen accessions of *Canavalia spp* determined by the proximate variables

Clusters	Accessions/ Cluster pairs		Frequencies	Cluster distance
14	TCg1B	Tcg3B	2	0.01
13	TCe2B	TCg4A	2	0.0101
12	TCe1	CL13	3	0.0168
11	CL14	TCg3A	3	0.0188
10	TCg1A	TCe3	2	0.0209
9	CL12	TCe2A	4	0.0428
8	TCe7	TCg2	2	0.0511
7	CL10	TCg4B	3	0.0576
6	TCe4	TCe5	2	0.0587
5	CL7	CL11	6	0.077
4	CL9	CL5	10	0.0859
3	CL8	TCg1C	3	0.1399
2	CL4	CL3	13	0.1912
1	CL2	CL6	15	0.2194

Discussion

All the 15 studied accessions belonging to two species of *Canavalia* differed significantly from one another for all the proximate variables. The range of values for most traits was narrow with the various accessions having superior performance for each variable. The 15 genotypes varied widely in fat content. This study agrees with the con-

Tab. 5. Pearson correlation of coefficients among the proximate variables

	MC	Sugar	Starch	Fat	Ash	Protein
Sugar	0.002					
Starch	0.062	0.392				
Fat	0.312	0.057	0.032			
Ash	0.239	0.248	0.198	0.061		
Protein	0.122	0.435	0.016	0.051	0.313	
Energy	0.283	0.165	0.192	0.981***	0.062	0.061

*** Significant

Tab. 4. Intra-cluster variability of the 15 accessions of *Canavalia spp*. based on some quantitative proximate descriptors

Proximate variables	Clusters					
	I	II	III	IV	V	VI
Moisture content	8.75(2.17)	8.32(2.55)	8.50(1.09)	8.36(1.03)	8.54	8.65(4.39)
Sugar	0.31 (13.49)	0.38(8.42)	0.37(9.38)	0.23(0.08)	0.23	0.31(30.12)
Starch	7.76(3.11)	7.86(6.70)	8.18(3.12)	7.97(0.36)	10.25	7.99(4.73)
Fat	3.06(31.62)	2.80(20.15)	4.82(2.72)	3.91(11.09)	3.93	8.12(13.56)
Ash	3.24(7.22)	3.35(3.64)	3.51(7.13)	4.50(22.77)	3.05	3.41(5.56)
Protein	5.54(4.79)	5.34(11.96)	5.86(5.86)	6.22(7.46)	5.75	5.26(3.85)
Energy	336.73(11.08)	325.22(6.62)	414.67(3.26)	383.55(6.38)	414.4	525.37(6.01)
	Accessions within the same clusters					
	TCe1, TCe2B, TCg4A and TCe2A	TCg1A, TCe3 and TCg4B	TCg1B, TCg3B and TCg3A	TCe7 and TCg2	TCg1C	TCe4 and TCe5

* Coefficient of Variation in parenthesis

clusion of Doss *et al.* (2011), that *Canavalia* species has compositional variability of proximate contents. The high coefficient of variability in lipid, sugar and energy is an indication of availability of opportunity for further selection of these traits for improvement of this species. This is inline with the submission of Nassir and Adewusi (2012), Asch *et al.* (2005) and Price *et al.* (2002). Exploitation of the proximate constituents of *Canavalia* species with respect to crude protein, carbohydrates, and ash contents becomes necessary since the percentage composition of these compounds are comparable to other legumes whose nutritional demands are highly competitive between humans and livestock. This is in consonance with the view of Adebowale *et al.* (2005), Pugalenthi *et al.* (2004), Siddhuraju and Bressani (2002) and Becker (2001).

This depicts a very high similarity between accessions within the same species. There seems to be a very high level of similarities between *C. ensifromis* and *C. gladiata*. The clusters generated using proximate data revealed accessions from the two species uniting in groups based on some similarities. TCe2B (*C. ensiformis*) and TCg4A (*C. gladiata*) were the closest accessions within the two species in the genus *Canavalia*. This is a type of inter-specific similarity within a genus. On the other hand some accessions among the 15 clustered in the same group. The aggregation of accessions within the same species into a cluster further revealed that there are high similarities within a biological and taxonomic unit. Intra and inter-specific hybridization may not be a big problem in any proposed breeding program for the improvement within each species or the genus. This is in line with observations of Nassir *et al.* (2008) and Vadivel and Janardhanan (2001).

The variability which existed within each clusters suggests the possibility of making selection for introgression of superior accessions with outstanding performance for various quantitative traits. Amongst the proximate variables, percentage fat content highly correlated with the energy constituent. Selection for any of these traits means a simultaneous selection of the other (Nassir *et al.,* 2008). This study provides a template for further improvement through hybridization that could lead to production of elite hybrids. Similar view had been reported by Bandyopadhyay and Santra (2009).

Ash, moisture content, fat and energy were highest in *C. ensiformis* while starch and protein constituents were highest in the *C. gladiata*. The accessions from *Canivalia* species are good sources of quality nutrients for both humans and livestock according to Bamikole *et al.* (2000). Selection of accession with desirable proximate characters is highly recommended for legume breeding programme (Dada *et al*., 2012).

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