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RESEARCH NOTES

Morphological Characterization of Meghalayan *Dioscorea* spp. (yam), North East India

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ABSTRACT

The species of *Dioscorea* (yam) are regarded as a staple food crop for millions of people in the tropical and subtropical regions of the world. It is regarded as an important food crop next to cereals and grains due to high yield storage of carbohydrates. Economically, only few species are recognized for cultivation from agricultural point of view, in spite of its large species diversity. The species of *Dioscorea* also represents great morphological variability in nature. However, very little research has been done on it. Hence, in the present study, an attempt was made to establish genetic variability and relationships among 50 accessions of *Dioscorea spp*. growing naturally in Meghalaya. Principal Component Analysis (PCA) for the first nine components indicates 91.5% observed variability. Morphological characters or traits with discriminating values were stem color, leaf type, number of leaflet in compound leaf, leaf color, leaf shape, inner petal shape, staminode absent or present, length and width of mature leaf. Agglomerative Hierarchical Cluster Analysis clearly separated the 50 accessions based on their close association.

Keywords: Agglomerative hierarchical cluster analysis, Morphological traits, Principal Component Analysis.

INTRODUCTION

The genus *Dioscorea* L., commonly known as yam, is the largest genus in the family Dioscoreaceae, including about 602 species (Coursey, 1967) distributed mainly in tropical and subtropical region of the world. Apart from its large morphological diversity, only few species are recognized for cultivation worldwide. Yams (*Dioscorea spp*.) are regarded as food security crops, especially in West Africa where large commercial scale production is practiced (Mwirigi *et al.,* 2009; FAO, 2013). Species of *Dioscorea* are important both taxonomically and economically. Several species of *Dioscorea* are staple food for many tribal people of Northeast India, especially in Meghalaya. Many species are also used as medicine in this area. In terms of utilization of food, *D.bulbifera* L. and *D. pentaphylla* L. are the most popular yams found to be consumed by the people of Meghalaya (Sheikh *et al*., 2009). Small scale cultivation of the edible species is in practice in this area. Despite the importance of yams, large scale production or commercialization of the edible species and its wild relatives are not in practice due to lack of knowledge regarding the existing level of diversity among various species or varieties within the species. Proper systematic evaluation, quantification, and characterization are necessary for efficient utilization of large genetic diversity. Hence, morphological characterization is highly recommended for

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systematic evaluation of the species. Several efforts on morphological variability studies on *Dioscorea* mainly *D.alata* L. have been made by various researchers (Sastrapadja, 1982; Velayudhan *et al*., 1989; Lebot *et al.,* 1998; Hasan *et al*., 2008; Anokye *et al*., 2014). Mwirigi *et al*. (2009) studied the variability of Kenyan yams and concluded four main groups of the species where one group had only one cultivar that had not been documented previously. Apart from this, Mahalakshmi *et al.* (2007) studied the development of a West African yam (*Dioscorea* spp.) core collection for yam cropping and improvement. Norman *et al*. (2011) studied on the diversity of yam (*Dioscorea* spp.) genotypes from Sierra Leone. According to Anonymous (1952) about 50 species of *Dioscorea* are distributed in India and approximately 28 species (Sharma and Hore, 1995) are distributed in North East India. In Meghalaya, nearly 16 species have been reported (Sheikh *et al*., 2009) out of which only few species have been targeted for economic and medicinal purposes due to lack of taxonomic knowledge. The main objective of the present study was to conduct preliminary morphological investigation for proper identification of different yam species in Meghalaya and to determine relationships between the various yam accessions to facilitate further studies in yam improvement by establishing yam germplasm conservation in Meghalaya.

MATERIALS AND METHODS

Plant Materials

A total of 10 species (*D.bulbifera* L., *D.pentaphylla* L., *D.pubera* Bl., *D. Kamoonensis* Knuth, *D. bellophylla* (Prains) Haines, *D. melanophyma* Prain and Burkill, *D.glabra* Roxb., *D. hispida* Dennstaedt, *D.hamiltonii* Hook. *f*., *D. lepcharum* Prain *et* Burk) with 5 accession of each species (Table 1) were collected from wild habitat of Meghalaya (Figure 1), one of the 8 states of Northeastern region of India lying between 25º 5´ N and 26º 10´ N latitude and 89º 47´ E and 92º 47´ E longitude with an area of 22,429 Km^2. Morphological study were conducted on fully mature male plant of the respective species which was abundantly distributed in wild habitat. All accessions were maintained as a living collection in the experimental garden at North Eastern Hill University (NEHU), Shillong.

Morphological Data Recording and Statistical Analysis

Forty-eight morphological variables (36 quantitative characters and 12 qualitative) were recorded as described (Table 2). The characters used and the methods of data recording were according to International Plant Genetic Resources Institute's (IPGRI) descriptors for yam (*Dioscorea* sp.) with few modification (IPGRI, 1997). The morphological data were recorded either directly from the measurement, using a 1-9 scale or as a binary recording (1= Present and 0= Absent). All the data were standardized and subjected to PCA and cluster analysis. Principal Component Analysis (PCA) and cluster analysis was performed using XLSTAT ver. 2014 statistical software.

RESULTS

Principal Component Analysis

The aim of Principal Component Analysis is determining the number of main factors for reducing the number of effective parameters to discriminate genotypes. In addition, associations between traits emphasized by this method may correspond to genetic linkage between loci controlling traits or a pleiotropic effect (Iezzoni and Pritts, 1991; Rakonjac *et al*., 2010). Table 3 shows the correlation between the original

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Table 1. Fifty accessions of 10 species of *Dioscorea* from the study area.

No.	Species	Accession [a]	District	Collection area
1	*D. bulbifera*	DBU 1	East Khasi hills	Sohra
		DBU2	East Khasi hills	Upper Shillong
		DBU3	South Garo hills	Bagmara
		DBU4	Ri-bhoi	Krydemkulai
		DBU5	West Garo hills	Nokrek
2	*D. hispida*	DHI1	West Garo hills	Nokrek
		DHI2	West Garo hills	Sasatgiri
		DHI3	Jaintia hills	Dawki
		DHI4	Ri-bhoi	Krydemkulai
		DHI5	Jaintia hills	Jarain
3	*D. melanophyma*	DMI	East Khasi hills	Upper Shillong
		DM2	East Khasi hills	Cherrapunji
		DM3	East Khasi hills	Mawphlong
		DM4	Jaintia hills	Garumpani
		DM5	Jaintia hills	Jarain
4	*D. glabra*	DG1	Jaintia hills	Pyrunsla
		DG2	East Khasi hills	Barapani
		DG3	East Khasi hills	Umsning
		DG4	West Garo hills	Rongchugiri
		DG5	Ri-bhoi	Krydemkulai
5	*D.pentaphylla*	DPE1	East Khasi hills	Upper shillong
		DPE2	South Garo hills	Balphakram
		DPE3	West Khasi hills	Nongstoin
		DPE4	Ri-bhoi	Quinine
		DPE5	Ri-bhoi	Umling
6	*D. hamiltonii*	DH1	East Khasi hills	Barapani
		DH2	Ri-bhoi	Krydemkulai
		DH3	Jaintia hills	Jarain
		DH4	East Khasi hills	Upper shilling
		DH5	West garo hills	Phulbari
7	*D.pubera*	DP1	Ri-bhoi	Umling
		DP2	West Khasi hills	Nongstoin
		DP3	Ri-bhoi	Nongpoh
		DP4	East Khasi hills	Barapani
		DP5	East Khasi hills	Sohra
8	*D. belophylla*	DB1	Ri-bhoi	Krydemkulai
		DB2	Ri-bhoi	Krydemkulai
		DB3	Ri-bhoi	Quinine
		DB4	East Khasi hills	Barapani
		DB5	East Khasi hills	Umsning
9	*D.kamoonensis*	DK1	Jaintia hills	Dawki
		DK2	Jaintia hills	Pyrunsla
		DK3	Jaintia hills	Jarain
		DK4	East Khasi hills	Cherrapunji
		DK5	East Khasi hills	Upper shillong
10	*D. lepcharum*	DL1	West Khasi hills	Nongstoin
		DL2	West Garo hills	Nokrek
		DL3	West Garo hills	Phulbari
		DL4	Ri-bhoi	Krydemkulai
		DL5	Ri-bhoi	Quinine

[a] DBU-*D. bulbifera*; DHI- *D.hispida*; DM-*D.melanophyma*; DG-*D.glabra*; DPE-*D.pentaphylla*; DH-*D.hamiltonii*; DP- *D.pubera*; DB- *D.belophylla*; DK-*D.kamoonensis*; DL- *D.lepcharum.*

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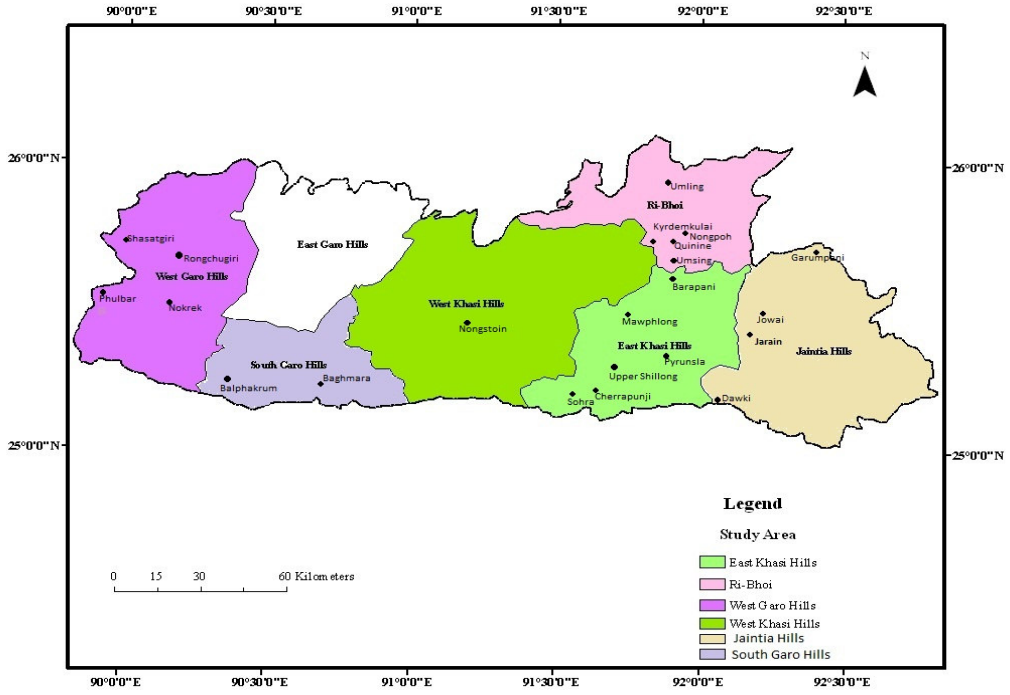

Figure 1. Location map of the study area.

Table 2. Thirty-six qualitative and twelve quantitative traits studied in *Dioscorea* species (IPGRI, 1997).

Code	Traits acronym	Characters/Descriptors	Score code-descriptor code
		Qualitative characters	
		stem	
1	STD	Twinning direction	1-Clockwise (Left); 2-anticlockwise (Right)
2	STR/A	Stem ridged/angled	1-Ridged; 2-angled
3	STH	Stem height	1-< 2m; 2-< 2-10 cm; 3->10 cm
4	STC	Stem color	1-Green; 2-purplish green; 3-brownish green 4-Dark brown; 5-purple; 99-others
5	STA/U	Stem armed/unarmed	1-Armed; 2-unarmed
6	STG/P	Stem glabrous/pubescent	1-Glabrous; 2-pubescent
		Leaves	
7	POL	Position of leaves	1-Alternate; 2-opposite; 3-alternate at base/opposite above; 99-others
8	LT	Leaf type	1-Simple; 2-compound
9	NoL	Number of leaflets in compound leaf	0-Absent; 1-mainly 3; 2-mainly5; 3-more than5
10	LC	Leaf color	1-Yellowish; 2-pale green; 3-dark green; 4-purplish green; 99-others
11	LD	Leaf lobation	1-Shallowly lobed; 2-deeply lobed.
12	LS	Leaf shape	1-Ovate; 2-cordate; 3-ellliptic oblong;4-oblanceolate; 5-cordate long; 6-narrowly elliptic 7-Lanceolate; 99-others
13	DL	Distance between lobes	1-No measurable distance; 5-intermediate; 9-very distant
14	LAS	Leaf apex shape	1-Obtuse; 2-acute; 3-emarginate; 99-others

*cm= centimeter; mm= millimeter.

Table2 continued…

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Continued of Table2

Code	Traits acronym	Characters/Descriptors	Score code-descriptor code
15	LG/P	Leaf glabrous/pubescent	1-Glabrous; 2-pubescent
16	PC	Petiole color	1-Brownish green; 2-purplish green; 3-Dark brown; 7-green; 99-others
17	PL/LF	Petiole length in correlation to leaf length	3-Short; 5-median; 7-long
18	PG/P	Petiole glabrous/pubescent	1-Glabrous;2-pubescent
		Flowering	
19	INFS	Inflorescence smell	0-Absent;1-present
20	NoINF/INT	Number of inflorescence per internode	1-One or two; 2-many
21	INFG/P	Inflorescence glabrous/pubescent	1-Glabrous;2-pubescent
22	FLBS	Floral bract shape	
23	OTS	Outer tepal shape	1-Ovate acuminate; 2-orbicular; 3-ovate; 99-others
24	ITS	Inner tepal shape	1-Ovate; 2-obovate; 3-lanceolate; 4-suborbicular;99-others
25	TG/P	Tepal glabrous/pubescent	1-Linear oblong; 2-oblong obovate; 3-ovate; 99-others
26	IT> OT/OT> IT	Inner tepal> outer tepal/outer tepal> inner tepal	
27	STA	No of stamen	1-Glabrous; 2-pubescent
28	STAMA/P	No of staminode	1-Inner tepal> outer tepal; 2-Outer tepal> inner tepal
		Aerial tubers	
29	BA/P	Absence/Presence of aerial tubers	
		Aerial tuber shape	1-3 stamens; 2-6 stamens
30	BS	Bulbil Surface texture	0-Absent; 1-3 staminode present
31	BST	Bulbil abundant/less	
32	B ab/P	**Underground tuber**	0-Absent; 1-present
33	TUS	Tuber shape	1-Round; 2-oval; 3-irregular; 4-ellongated
			1-Mmooth; 2-wrinkled; 3-rough
34	RTTU	Number of roots on the tuber surface	1-Abundant; 2-less
35	TUSC	Skin color of tuber	1-Round; 2-oval; 3-oval-oblong;4-cylindrical; 5-flattened; 6-irregular; 99-other
36	TUFC	Tuber flesh color	3-Few; 7-many
			1-Off-white; 2-black; 3-brown; 4-dark brown; 99-others
		Quantitative characters	
37	LML	Length of a mature leaf	1-White; 2-off-white; 3-yellow; 4-orange; 5-light purple; 6-purple; 99-others
38	WML	Width of mature leaf	
39	PL	Petiole length	
40	SL	Spike length	
41	FLBL	Floral bract length	1-(10-15) cm; 2-(16-20) cm; 3-(21-25) cm;4-(26-30) cm;5->30 cm
42	FLBW	Floral bract width	1-(1-10) cm; 2-(11-20) cm; 3-(21-30) cm;4>30 cm
43	OTL	Outer tepal length	1-(1-6) cm; 2-(7-12) cm; 3-(13-19) cm; 4>20 cm
44	OTW	Outer tepal width	1-(1-5) cm; 2-(6-10) cm; 3-(11-15) cm; 4->16 cm
45	ITL	Inner tepal length	1-(0.5-1.5) mm; 2-(1.6-2.5) mm; 3->2.6 mm
46	ITW	Inner tepal width	1-(0.1-0.5) mm; 2-(0.6-0.9) mm; 3->0.9 mm
47	AL	Anther length	1-(0.5-1) mm; 2-(1.5-2) mm; 3->2 mm
48	FL	Filament length	1-(0.5-1) mm; 2-(1.5-2) mm; 3->2 mm
			1-(0.5-1) mm;2-(1-1.5) mm; 3->1.5 mm
			1-(0.1-0.5) mm; 2-(0.6-1)mm; 3->1 mm
			1-(0.1-0.5) mm; 2-(0.6-1) mm; 3->1 mm
			1-(0.1-0.5) mm; 2->0.5 mm

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Table 3. Eigen values and cumulative variance for nine major factors obtained from PCA and significant parameters within each component for *Dioscorea* species.[a]

Traits	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
STD	**-0.812**	0.290	-0.355	0.150	-0.172	0.237	0.092	0.016	0.041
SR/A	-0.368	-0.098	0.304	-0.405	0.109	**0.476**	0.009	0.323	0.277
STH	0.137	**0.488**	0.168	-0.341	-0.239	-0.085	0.299	-0.364	-0.383
STC	**0.701**	-0.078	-0.109	-0.064	0.396	**0.516**	-0.058	0.133	0.030
STA/U	**-0.466**	-0.118	0.302	0.176	**0.639**	0.107	**0.440**	-0.124	0.016
STG/P	0.218	**0.798**	-0.348	-0.098	0.251	-0.115	0.106	0.105	0.035
POL	**-0.742**	0.252	**-0.445**	0.085	0.012	-0.044	0.207	0.168	0.104
LT	**0.932**	-0.316	-0.119	-0.013	0.051	-0.010	0.093	-0.035	-0.001
NoL	**0.692**	**-0.524**	-0.223	-0.063	0.224	-0.026	-0.096	-0.329	0.129
LC	**0.517**	-0.102	-0.003	0.038	-0.018	-0.340	-0.201	0.205	-0.086
LB	**-0.813**	0.240	0.361	-0.107	0.033	-0.182	-0.162	0.078	-0.006
LS	**0.931**	-0.314	-0.120	-0.017	0.057	0.004	0.099	-0.037	-0.006
DL	**-0.782**	0.270	-0.033	0.104	-0.215	0.195	0.074	-0.282	-0.245
LAS	0.148	-0.026	**-0.693**	0.185	-0.180	0.297	0.307	-0.003	0.213
LG/P	-0.257	**0.508**	-0.408	0.265	**0.533**	-0.112	-0.046	0.118	-0.037
PC	0.055	-0.317	**-0.426**	-0.216	-0.063	**0.594**	-0.189	0.245	-0.275
PL/LF	0.269	**0.605**	0.193	-0.077	0.340	-0.159	-0.154	0.002	-0.058
PG/P	0.067	0.242	-0.105	**0.666**	**0.442**	-0.024	0.232	0.361	-0.104
INFS	0.094	0.318	**0.570**	**-0.646**	-0.004	0.262	-0.058	0.197	0.130
NoINF/INT	-0.160	0.146	0.367	0.002	-0.389	0.352	-0.335	0.034	**-0.422**
INFG/P	0.359	**0.865**	-0.240	-0.064	0.214	0.036	-0.026	-0.003	-0.011
FLBS	0.302	-0.120	**-0.461**	0.206	**-0.590**	-0.338	0.342	0.010	-0.183
OTS	-0.147	0.093	-0.019	0.249	**-0.479**	0.003	-0.328	-0.042	**0.423**
ITS	**0.674**	0.075	-0.315	**-0.486**	-0.213	-0.067	-0.187	0.160	-0.253
TG/P	-0.359	-0.113	**0.691**	0.276	-0.405	0.301	0.058	0.037	-0.107
IT> OT/OT< IT	**0.607**	**0.549**	-0.024	**-0.445**	-0.259	-0.033	0.205	0.013	0.093
STA	**-0.599**	**0.697**	0.112	-0.278	-0.224	-0.011	0.035	0.046	0.062
STAMA/P	**0.599**	**-0.697**	-0.112	0.278	0.224	0.011	-0.035	-0.046	-0.062
BA/P	-0.198	**-0.806**	0.242	-0.197	0.259	0.013	0.294	0.019	-0.195
BS	**-0.497**	**-0.478**	-0.040	-0.367	0.185	0.195	0.369	0.366	0.123
BST	-0.351	**-0.582**	0.154	**-0.503**	0.229	-0.047	-0.059	0.406	-0.132
BAB/L	-0.415	**-0.618**	0.043	**-0.567**	0.226	-0.039	0.021	-0.198	-0.123
TUS	-0.311	-0.220	**-0.460**	0.077	**-0.442**	-0.414	-0.189	0.336	0.179
RTTU	0.303	-0.384	**0.657**	0.266	0.381	-0.196	0.068	-0.159	0.176
TUSC	-0.128	**0.604**	-0.296	0.360	**0.544**	0.081	-0.240	-0.016	-0.107
TUFC	-0.144	**0.597**	-0.278	0.384	**0.545**	0.071	-0.234	-0.032	-0.101
LML	**0.590**	**0.606**	0.302	-0.293	-0.049	-0.166	0.144	0.128	0.055
WML	**0.514**	**0.534**	0.278	**-0.520**	-0.169	-0.174	0.078	0.038	0.067
PL	0.100	**0.574**	0.243	**-0.470**	0.172	-0.030	**0.458**	-0.020	0.118
SL	-0.167	0.032	**0.774**	-0.231	0.200	-0.387	-0.285	0.039	-0.004
FLBL	**0.637**	0.050	0.269	0.376	-0.095	0.063	**0.484**	0.336	-0.047
FLBW	**0.639**	0.344	0.322	0.164	-0.195	0.234	-0.013	0.400	-0.128
OTL	-0.286	0.087	**0.552**	**0.461**	0.065	**-0.468**	0.009	0.253	-0.179
OTW	0.095	-0.103	0.182	**0.743**	**-0.523**	0.016	0.060	0.159	0.091
ITL	0.133	-0.207	**0.787**	0.413	0.024	-0.249	-0.014	0.098	0.058
ITW	0.235	0.260	**0.480**	**0.562**	-0.102	0.396	0.256	0.009	-0.096
AL	**-0.547**	-0.090	-0.295	-0.165	-0.102	-0.359	**0.584**	-0.035	-0.118
FL	-0.119	-0.320	**-0.595**	-0.233	0.131	-0.396	-0.076	**0.434**	-0.166
Eigenvalue	10.736	8.492	6.611	5.402	4.217	2.909	2.430	1.885	1.264
Variability (%)	22.366	17.692	13.772	11.255	8.785	6.061	5.062	3.928	2.634
Cumulative %	22.366	40.058	53.830	65.085	73.870	79.931	84.993	88.920	91.555

[a] Values in bold indicate the most relevant characters (> 0.42) that contributes to the variation of the components.

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variables and the first nine principal components. For each factor, a principal component loading of more than 0.42 was considered as being significant. Result from the PCA indicates that 91.5% of the observed variability was explained by the first nine components. The first four components explained about 65.08% of the total observed variability. PC1 represented mainly from STC, LT, NoL, LC, LS, ITS, IT> OT/OT< IT, STAMA/P, LML, WML, FLBL and FLBW accounted for 22.36% of the variance.PC2 represented STG/P, LG/P, PL/LF, INFG/P, IT> OT/OT< IT, STA, LML, LMW and PL accounted for 17.69% of the variance. PC3 and PC4 account for 13 and 11.2% of variance. The remaining components explained less variability. On the other hand, variables such as OTS and TUS in the present study seemed to be less important when applying this analysis. Correlation among the variables associated with the first and second principal components are shown in Figure 2.

Cluster Analysis

Agglomerative Hierarchical analysis based on similarity and dissimilarity was assessed among 50 accessions. Dendogram obtained from un-weighted pair-group average method (similarity) produced four main clusters (Figure 3). Cluster (A) is represented by *D.pubera* characterized by the presences of pubescence in stem, leaf, inflorescences, floral bract and flowers. Cluster (B) with species of *D.kamoonensis, D.melanophyma, D.pentaphylla, D.hispida* which are characterized by the presences of compound leaf, number of leaflets, stem color are grouped together. Cluster (C) with species of *D.glabra* and *D.belophylla* which are characterized by stem surface, leaf type, stem color, petiole color. Cluster (D) characterized by the presence of similar leaf and stem parameters such as leaf color, leaf glabrous, number of leaflets, stem unarmed and glabrous which is represented by species of *D.hamiltonii, D.bulbifera* and *D.lepcharum.* Whereas dendogram obtain

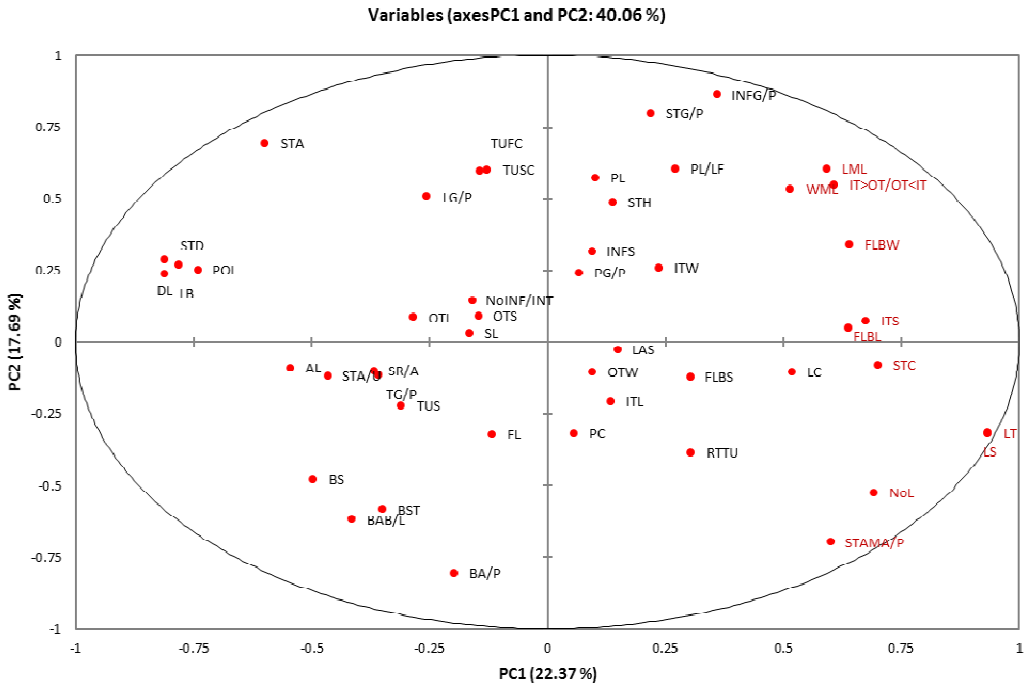

Figure 2. Correlation among variables associated with first and second principal components.

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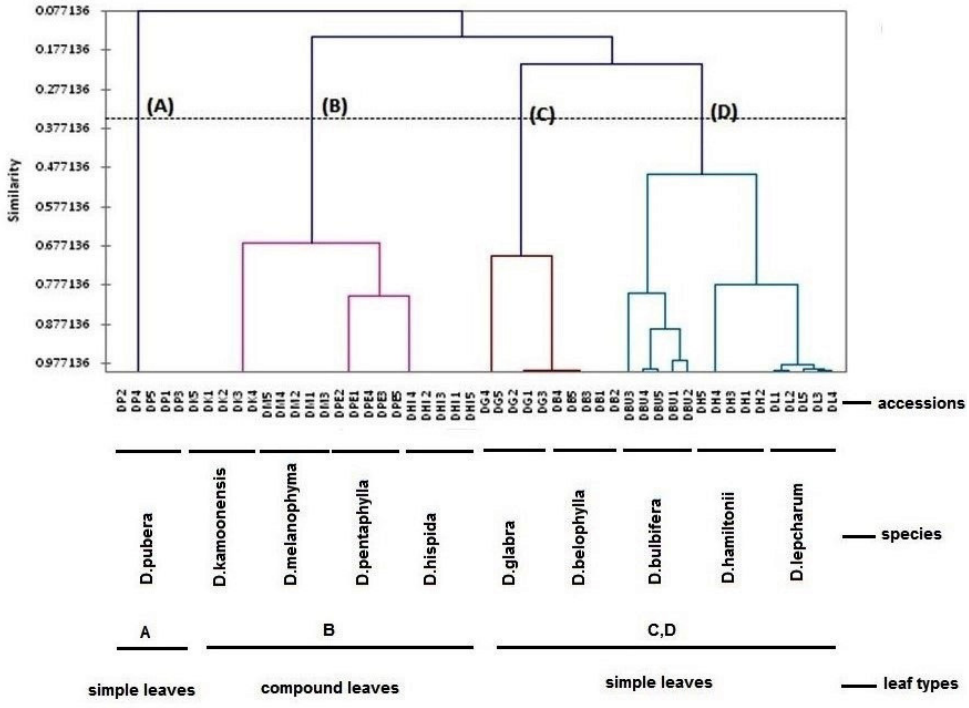

Figure 3. Dendrogram (Un-weighted pair group average method) based on similarity of 10 species of *Dioscorea* with 50 accessions.

from Ward's Method (dissimilarity) produces three main clusters (Figure 4). Cluster (A) includes *D.pentaphylla, D.kamoonensis, D.melanophyma, D.hispida* species which are characterized by the presence of compound leaf, number of leaflets, stem color. Cluster (B) includes species of *D.glabra* and *D.belophylla* which are characterized by rough stem surface, leaf type, stem color, petiole color. Cluster (C) with species of *D.pubera, D.hamiltonii, D.bulbifera* and *D.lepcharum* characterized by the presences of leaf type, absence of leaflets, presence of 6 stamens, and absence of staminode.

The similarity and dissimilarity pattern of clustering was analyzed in order to assess the species grouping together in clusters based on the similarities or dissimilarities of characters taken into consideration. In both of the dendograms, it was observed that clustering pattern was similar, except for *D.pubera* that was shown as an individual grouping in un-weighted pair-group average method of clustering. Species with compound leaves were separated from species with simple leaves in different clusters in both of the dendrograms. The 50 accessions used in the present study were morphologically variable and, therefore, clustered in groups based on their close relationships.

DISCUSSION

The descriptors used for assessing the variability among the Meghalayan yam were efficient in discriminating the 50 accessions based on their close relationships or association. Generally, all 48 traits contributed towards phenotypic variability, which indicated high degree of morphological polymorphism within the accessions of *Dioscorea* species studied. Substantial morphological variation within

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and between the various accessions may be attributed to cross-pollination and sexual recombination followed by selection by isolated human communities in diverse environments (Martin, 1976). The phenotypic variation among the Meghalayan yam accessions has found characters or traits that can be used as markers for identifying and classifying the species. The traits that best discriminate between the 50 yam accessions were stem color, leaf type, number of leaflet in compound leaf, leaf color, leaf shape, inner petal shape, staminode absence or presence, length and width of mature leaf. Several researchers have reported on the morphological traits used for discriminating within or between the species of *Dioscorea* and using those morphological markers for identifying and characterizing different yam species. Bourret (1973) studied the morphological variation of *D.alata* existing in New Caledonia and attempted to classify more than 100 cultivars in 4 major groups based on 20 characters including size and vigor of the plant, size and shape of the leaves, stem and wing characteristics, presence and absence of bulbils, shape and color of tubers. Velayudhan *et al*. (1989) conducted a similar study on 140 local cultivars from India using 22 morphological agronomic characters descriptors and identified 15 groups. Hasan *et al*. (2008) used 47 morphological traits to assess 70 accessions of *D.alata* collected throughout Malaysia. Characters that contributed most towards morphological variability were shape, size, and flesh color of underground tubers, shape and color of aerial tuber, position, shape, size, and vein color of leaves and petiole color. Mwirigi *et al*. (2009) studied morphological variability between 43 Kenyan yam species using 17 morphological variables, out of which the characters that contributed towards morphological variability were twining direction, stem color, spine shape, leaf types and presence or absence of flowering for above-ground plant parts; and tuber flesh color, skin color, shape of the tuber, hardness of the tuber when cooked, and presence or absence of roots on the tuber surface for the parts below ground. Bressan *et al*. (2011) studied the morphological variation and isozyme diversity in *D.alata* landraces from Vale do Ribeira, Brazil and concluded that results obtained from both of the markers revealed the importance in maintaining high diversity for *D.alata*. Out of the 24 morphological traits, the traits that contributed most to the species variability were related to shape, size and flesh color of underground tuber, shape and color of aerial tuber, position, shape, size and vein color of leaves, petiole color, shoot growth rate and number of days for shoots to germinate. Islam *et al*. (2011) conducted morphological characterization study on 60 yam germplasm accessions of Bangladesh, out of which 59 accessions were *D.alata* and 1 accession of *D.bulbifera* based on stem twining direction, presence of winged, ridges, or spines on stem, leaf shape, shape and size of aerial tubers. Anokye *et al*. (2014) used 107 morphological characters to assess 49 accessions of *D. alata* from Ghana. Characters that contributed towards differentiation of the accessions were tuber skin and flesh color, leaf margin color, leaf shape, petiole wing color, spine shape on stem and branching of stem above the ground. Morphological characters or traits such as leaf color, stem color and leaf shape were common variables reported by various researchers, and also in the present study. Hence, these variables could be introduced as useful morphological markers for identifying and characterizing yam species.

Morphological characterization provides an inexpensive means of quickly evaluating the species. So, it should be considered as the first step for evaluating species rather than going in depth with molecular or biochemical characterization. However, phenotypic evaluation is mostly influenced by environment and may not distinguish between closely related accessions. Therefore, complementary studies, for example using genetic characterization, are needed for accurately identifying and classifying the species.

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ویژگی های مورفولوژیکی سیب زمینی شیرین (*Dioscorea* spp) منطقه Meghalaya در شمال شرقی هندوستان

ن. شیخ، . ی. کومار

چکیده

گیاهان گونه *Dioscorea* (سیب زمینی شیرین) به عنوان غذای اصلی میلیون ها انسان در مناطق استوایی و نیمه استوایی جهان قلمداد می شود.عملکرد این گونه گیاهی مقدار زیادی کربوهیدرات در ذخیره دارد و بنا بر این بعد از غلات غذای مهمی محسوب می شود. با اینکه تنوع زیادی در این گیاه وجود دارد، از نظر اقتصادی، تعداد محدودی گونه این گیاه برای کاشت در کشاورزی شناسایی شده اند. گونه *Dioscorea* تنوع مورفولوژیکی زیادی در طبیعت نشان میدهد. با این همه، پژوهش های بسیار محدودی روی آن انجام شده است. از این رو، در پژوهش حاضر تلاش شد تا تغییرات ژنتیکی و روابط میان ۵۰ نمونه (ثبت شده) گونه *Dioscorea* که به طور طبیعی در منطقه Meghalaya یافت و کشت می شوند، معین شود. نتیجه تجزیه مولفه های اصلی (*PCA*) برای ۹ جزء اصلی ۹۱/۵٪ تغییرات را نشان می دهد. ویژگی ها مورفولوژیکی یا صفات ارزشمند برای تشخیص و تمایز(discriminating values) عبارت بود از رنگ ساقه، نوع برگ، تعداد برگچه ها در برگ مرکب، شکل برگ، شکل گلبرگ داخلی، حضور یا فقدان شبه پرچم (staminode)، و طول وعرض برگ کامل. بالاخره اینکه، تجزیه خوشه ای سلسله مراتبی صعودی(Agglomerative Hierarchical Cluster Analysis) ۵۰ نمونه مزبور را برمبنای نزدیکی رابطه آن ها جدا سازی کرد.

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