Inter-relationships in Morphotypes of Greater Yam (*Dioscorea alata* L.)

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The germplasm holding in greater yam (*Dioscorea alata* L.) consisting of 182 accessions belonging to 19 morphotypes collected from different agro-ecological situations of peninsular India were subjected to a detailed investigation on characterization of both above ground and below ground vegetative parts with respect to 49 qualitative and 22 quantitative traits. Seventy-six descriptor states were analyzed for pair-wise similarity coefficients by un-weighted pair-group method analysis (UPGMA) and also for single and complete linkage. The study revealed existence of 9 major arbitrary clusters indicating close resemblances between many of the morphotypes. Clustering pattern did not show any strict relationship between geographical distribution and morphotypes as the accessions from different geographic regions and of different morphotypes were grouped in most of the clusters. Based on these observations, an attempt is being made here to interpret the extent of similarity within and between the earlier described morphotypes.

Key Words: Clustering, *Dioscorea alata*, Morphotypes.

Greater yam (*Dioscorea alata* L.) belonging to the family Dioscoreaceae is an ancient crop with considerable importance under the subsistence farming system in the tropics. Earlier reports indicated the occurrence of considerable variability in the crop using both morphological and biometrical techniques (Burkill, 1917; Gooding, 1960; Rhodes and Martin, 1972; Muralidharan and Velayudhan, 1985; Velayudhan *et al.*, 1991). Studies on genetic relationship between greater yam cultivars revealed a narrow genetic base as demonstrated by isozyme patterns (Lebot *et al.*, 1998). This study also revealed the occurrence of identical zymotypes in different geographical areas and different zymotypes in same geographic zone. Velayudhan *et al.* (1991) have reported a classification of this plant in which the germplasm has been grouped into 19 morphotypes on the basis of subjective morphology. Even though these morphotypes differed in many qualitative and quantitative characteristics, a critical observation on them showed some differences within certain morphotypes and similarities between different morphotypes. Hence, in order to revalidate the morphotypes in *Dioscorea alata* and to study the interrelationship between various accessions, these were subjected to detailed morphological studies.

Materials and Methods

Germplasm of 182 accessions of *D. alata,* belonging to 19 morphotypes (M1 to M19) (Velayudhan *et al.*, 1991), collected from different localities of peninsular India were selected. These were grown at the experimental farm of NBPGR Regional Station, Thrissur, at 10.5° N latitude and 76.5° E longitude in two main cropping seasons between 1999-2001. The experimental plants were raised in augmented design with three controls following the recommended package of practices (Anon, 1996).

Observation on 49 qualitative and 22 quantitative traits was made on 3 plants per accession. Data on above ground vegetative characters such as leaves, bulbils and flowers were recorded at the maximum growth period during September to October and that on below ground tubers at the time of harvest during January.

The qualitative characters contained 76 different descriptor states and each state was scored as present (1) or absent (0) across all the accessions. The two-way data matrix of accessions x traits was used to calculate pair-wise similarity coefficients following Jaccard (1908). Similarity coefficients were subjected to unweighted pair-group method analysis (UPGMA) to generate a dendrogram using average linkage procedure. In addition to this, the same was subjected to single-linkage and complete-linkage method of analysis and consensus of these two were worked out to find ball-clusters in the germplasm. The entire analysis was carried out using the computer programme, NTSYS-PC, Version 1.80 (Exeter Software, New York). Based on this grouping, the range of various quantitative traits was also worked out. The re-evaluation of the diversity patterns was done using these 76 different descriptor states.

Results and Discussion

In the present study of the morphotypes and collections of 182 accessions, 9 major groups having 30 different ball clusters were identified. The ball clusters were identified by single link and complete link methods and their

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consensus. The resulting dendrogram obtained for different clusters are summarized in Figures 1-5 and this depicts the detailed clustering for all the 182 accessions.

The similarity coefficients ranged from 0.046512 to 1.000 for all accessions. The minimum morphologic similarity was between IC 87393 and EC 391129 and the greatest similarity between IC 87401 and IC 136849. A detailed account of this grouping is summarized below.

Cluster 1

Morphotype 1 ('Chorakachil') of earlier classification is a complex group having close linkage of more than 80% with some accessions in M2 (IC 87331), M3 (IC 87353, IC 87354, IC 87359), M4 (IC 87338) and M9 (IC 87361). Two accessions (IC 136853 and IC 266651), earlier grouped in M1, showed clustering with M12 ('Kulambukachil'), but as a distinct ball cluster. In this cluster, 7 different ball clusters were found, each with two accessions having more than 80% similarity. Hence a total of 31 accessions clustered together with more than 60% linkage. In this cluster, all the accessions earlier grouped as M1, clustered together except IC 136853 and IC 266651 but with close similarity to some accessions grouped in M2, M3, M4 and M9. The characteristics of the plants grouped in this cluster include the presence of erect, non-spiny greenish purple stem; oblong/digitate bulbils with brown outer skin, purple inner skin and light yellow flesh. Flowering was observed in October. An average of 5-8 tubers were produced per plant with smooth outer skin, purple cortex and white flesh. Crop duration is about 151 days. Tuber starch is grainy with very good taste. The typical types on the basis of the characters of this cluster for easy scoring are IC 44207 and IC 44208 of the morphotype M1.

Cluster 2

In this cluster, morphotype 6 ('Thonielayankachil') in earlier grouping was the major representative showing close resemblance with M3 (IC 87352 and IC 87412), M5 (IC 87358) and M6 (IC 87372) with 15 accessions. This

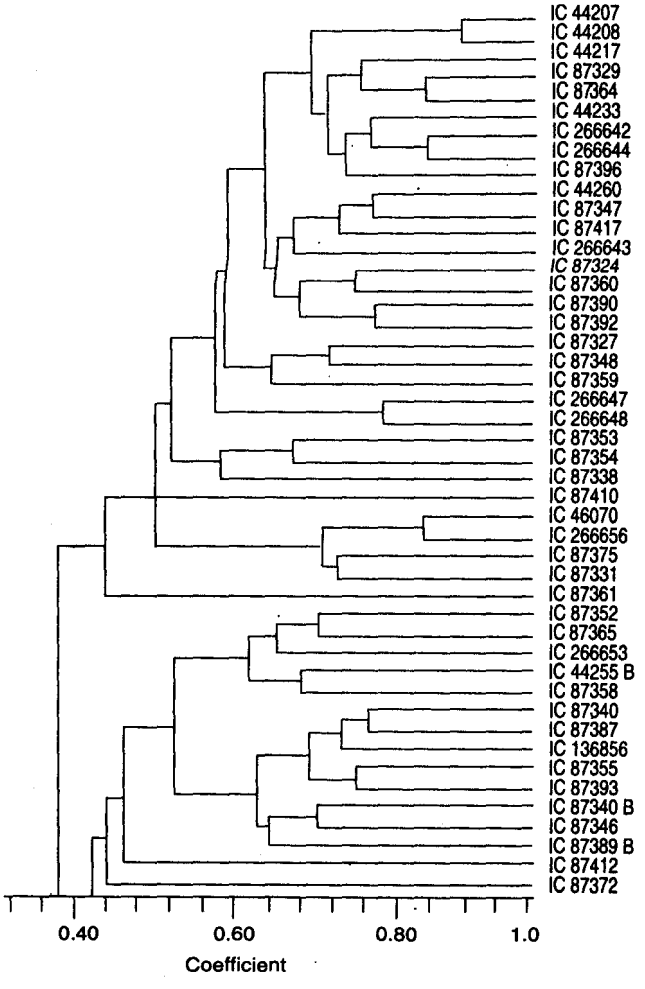

Fig. 1: Accessions grouped under Cluster 1 and 2

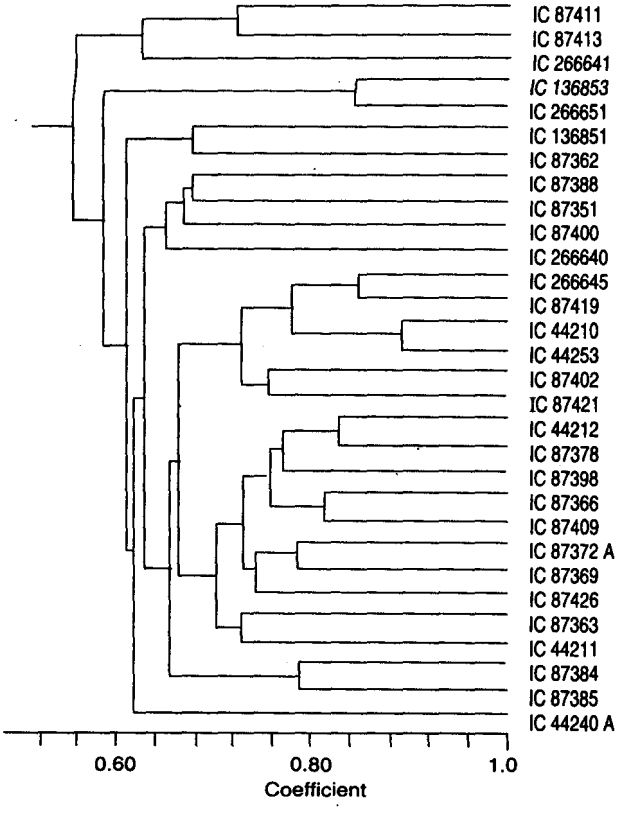

Fig. 2: Accessions forming Cluster 3

Dendrogram based on morphological traits

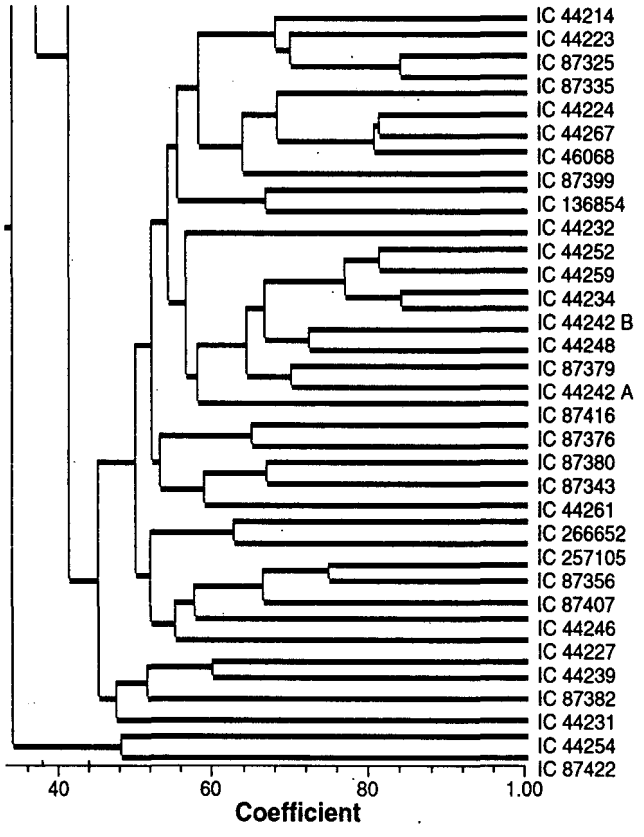

Fig. 3. Accessions forming Cluster 4

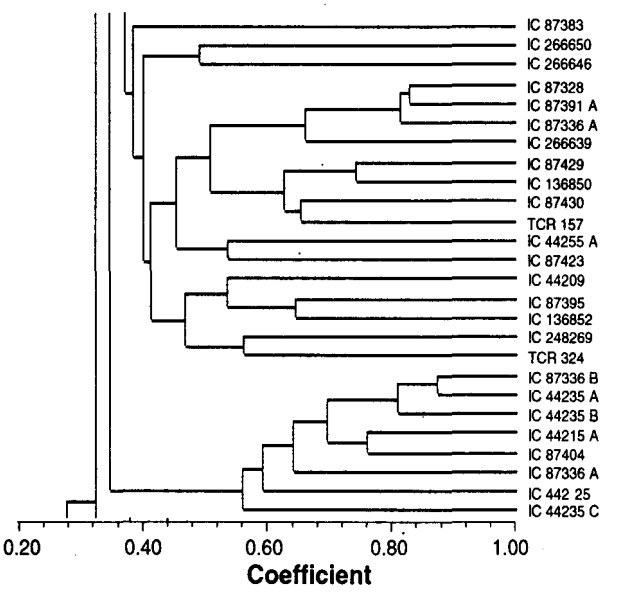

Fig. 4. Accessions forming Cluster 5 and 6

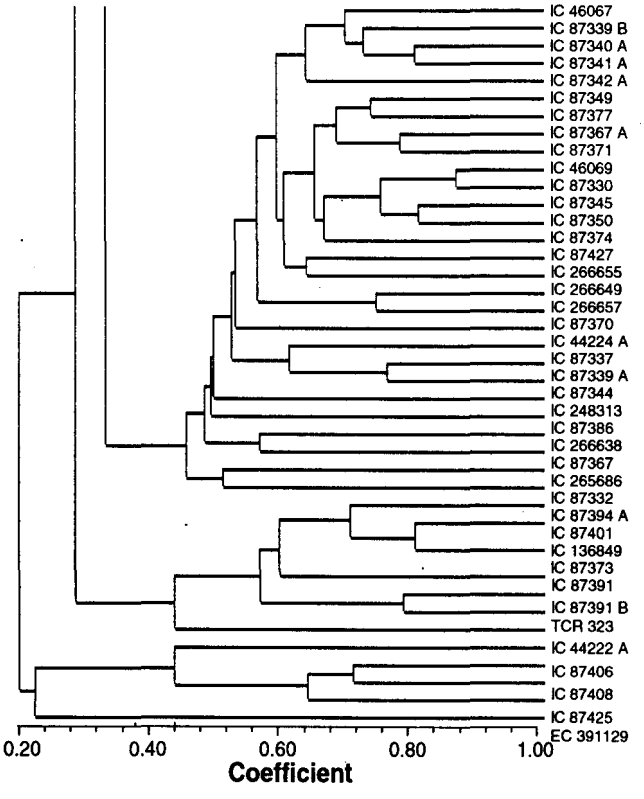

Fig. 5. Accessions forming Cluster 7, 8 and 9

cluster showed the presence of two ball clusters one with 5 accessions, one each from M3 (IC 87352) and M5 (IC 87358) and three from M6 (IC 44255 B, IC 87365 and IC 266653) and the other with 8 accessions, all from M6 (IC 87340, IC 87340 B, IC 87346, IC 87355, IC 87387, IC 87389 B, IC 87393 and IC 136856). The prostrate, non-spiny purple stem characterizes this cluster with medium sized digitate/oblong bulbils having gray outer skin, purple inner skin and yellow flesh colour. Non-flowering is reported in these plants. 2-3 irregular tubers per plant having warty skin, dark purple cortex colour, white flesh with purple centre and orange yellow outer part. Highly grainy starch without much taste is the major character. Distinctive types of this cluster are IC 87340 and IC 87387 of M6. The highest values for bulbil thickness (2.34-6.83 cm) and individual tuber weight (0.88-2.52 kg) were recorded in this cluster (Table 1).

Cluster 3

Majority of the representatives in this cluster were from M12 ('Kulambukachil') with 30 different accessions. Many accessions in M12 of this cluster showed close linkage with accessions in M1 (IC 136853, IC 266651), M8 (IC 87413), M11 (IC 44212, IC 136851, IC 266641), M13 (IC 87351, IC 44240 A), M6 (IC 266640, IC 266645) and M7 (IC 44210, IC 44253, IC 87411). There were 5 ball clusters, 4 with two accessions each and other one with 4 accessions, viz., M6 (IC 266645), M12 (IC 87419) and M7 (IC 44210, IC 44253). The characteristic features that

Table 1. Variability in quantitative traits of different clusters

S.No.	Traits	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster8	Cluster 9
1	Leaf length (cm)	14.17-21.23	11.67-23.83	12.07-21.4	14.43-22.37	10.6-21.67	9.77-19.0	13.37-17.5	13.53-19.53	16.27 – 19.5
2	Leaf breadth (cm)	8.43 – 13.3	9.53 – 15.17	7.13 – 14.93	10.17 – 16.27	7.33 – 16.5	6.87 – 12.9	11.23 – 16.93	9.13 – 14.63	12 – 14.97
3	Petiole length (cm)	6.5 – 10.87	8.57 – 14.83	7.03 – 13.17	8.17 – 15.4	6.67 – 15.73	5.43 – 12.13	9.8 – 20	8.6 – 13.17	10.5 – 13.07
4	Basal wing length (cm)	4.13– 7.23	5.23– 8.47	3.17– 7.8	5.3 – 9.57	3.9 – 9.07	3.5 – 6.87	5.1– 8.3	5.0 – 7.67	6.57 – 8
5	Basal wing distance (cm)	1.63 – 6.13	0.87 – 4.00	0.27 – 3.07	0.33 – 2.73	0.4 – 3.7	0.43 – 1.83	0.43 – 2.13	0.7 – 2.63	0.4 – 4.83
6	Sinus depth (cm)	2.03 – 4.23	2.4 – 5.93	2.87 – 6.67	3 – 6.23	1 – 5.77	1.87 – 4.23	3.07 – 6.67	2.37 – 6.13	1.27 – 4.17
7	Initiation of bulbils (days)	0 – 154	101 – 148	79 – 159	91 – 151	0 – 116	0 – 121	0 – 135	0 – 114	–
8	Flower initiation (days)	0 – 159	0 – 159	0 – 160	0 – 154	0 – 169	0 – 147	0 – 159	0 – 147	–
9	Bulbil length (cm)	0 – 4.92	2.82 – 7.47	2.82 – 10.31	1.44 – 9.94	0 – 11.95	0 – 8.63	0 – 11.08	0 – 4.58	–
10	Bulbil thickness (cm)	0 – 5.89	2.34 – 6.83	1.45 – 5.9	1.68 – 6.03	0 – 6.77	0 – 2.96	0 – 4.47	0 – 2.49	–
11	Individual Bulb weight (g)	0 – 61.33	5.33 – 95.33	3.83 – 100.5	2.83 – 124	0 – 85.5	0 – 27.67	0 – 56.33	0 – 15.33	–
12	No. of bulbils	0 – 164	25 – 353	8.0 – 590	5.0 – 805	0 – 460	0 – 65	0 – 555	0 – 95	–
13	Bulbils /Plant	0 – 33.33	8.33 – 117.66	2.66 – 196.66	1.6 – 268.33	0 – 186.66	0 – 21.66	0 – 185	0 – 31.66	–
14	Bulbil Yield (Kg)	0 – 0.924	0.064 – 2.382	0.018 – 3.497	0. 011 – 3.593	0 – 3.685	0 – 0.394	0 – 3.793	0 – 0.258	–
15	Bulb. Harvest (days)	0 – 186	171 – 181	167 – 186	0 – 185	0 – 186	0 – 184	0 – 177	0 – 180	–
16	Individual Tuber wt. (Kg)	0.360 – 1.34	0.88 – 2.52	0.410 – 2.42	0.30 – 1.92	0.37 – 2.05	0.7 – 2.12	0.63 – 2.63	0.78 – 2.10	0.58 – 2.27
17	Tuber length (cm)	11.33 – 24	16.33 – 31.33	10.33 – 27	11 – 23.67	12 – 38.33	16.33 – 34	21.33 – 45	17.67 – 22.5	12 – 22.67
18	Tuber perimeter (cm)	25. 33 – 49.33	31.67 – 55.67	29 – 49.67	25.33 – 54.67	26.67 – 55.67	22.67 – 46.5	23.33 – 55.67	39 – 54.33	33.33 – 48.67
19	No. of Tuber Bran.	2 – 6.67	3.5 – 10	0 – 6.33	0 – 5	0 – 5.33	1 – 8	0 – 6.0	2.33 – 5.5	2 – 4
20	Neck length (cm)	0 – 9	2.67 – 10	0 – 7.5	0 – 6	0 – 5.33	2 – 5.5	0 – 6.0	0 – 6	2 – 3
21	Yield/ Plant (Kg)	0.58 – 2.25	0.25 – 3.7	0.63 – 2.53	0.33 – 2.78	0.42 – 2.83	1.23 – 3.33	1 – 4.4	1.17 – 2.5	1.07 – 2.9
22	Total Yield (Kg)	1.75 – 6.75	3.5 – 11.1	1.9 – 7.6	1 – 8.35	1.25 – 8.5	3.7 – 10	3 – 13.5	3.5 – 7.5	3.2 – 8.7

distinguish the plants belonging to this cluster are purple coloured, non-spiny, erect stem. Bulbil initiation in 146 days in October having brown outer skin, greenish purple inner skin and white flesh. Flowering in November. Two tubers per plant are recorded with highly warty brown skin and light purple cortex with white flesh is a common feature in this cluster. The starch is grainy and flowering is recorded in 159 days. IC 44212 and IC 87378 of M12 were the representative types.

Cluster 4

This cluster proved to be a distinct one with most of the accessions from M13 ('Thalavannankachil') of earlier grouping. Of the 39 accessions in this cluster, 36 were of earlier M13 and others are from M6 (IC 266654), M11 (IC 44254) and M15 (IC 87422). This cluster showed the presence of 4 distinct ball clusters each with two, three and four (2 clusters) accessions. This group included plants with prostrate, non-spiny, purple stem. Bulbils were

initiated in 108 days and are large, oblong, with brown outer skin, purple inner skin and purplish white flesh. Flowering is recorded in October. The plants bear 1-3 spherical tubers with dark brown skin, dark pruple cortex and purplish cream flwsh were having grainy starch with good flesh taste. The types identified are IC 44248 and 87379 of M13.

Cluster 5

This group was also found to be a complex one with all the accessions from earlier M18 ('Karimpachamullankachil') and a few from M16 (IC 87429, IC 87430), M17 (IC 136850), M15 (IC 44255 A, IC 87423), M10 (IC 44209, IC 87395, IC 136852, IC 266650) and one ungrouped accession (IC 248269). This showed 3 distinct ball clusters, one with accessions from M18 (IC 266689, IC 87328, IC 87336 A, 87391 A), second one with M16 (IC87429) and M17 (IC 136850) and the third with two accessions from M10 (IC 87395, IC 136852). This cluster has types with erect spiny purple stem and bulbil initiation in 91-94 days. The bulbils are large, digitate with brown outer skin, light green inner skin and yellow flesh. Flowering was absent. 1-2 digitate tubers with warty brown outer skin, light yellow cortex and white/ cream tuber flesh is a characteristic feature of this cluster. Flesh is slightly grainy and starchy with not much taste. IC 87328 and IC 87391 A of M18 are the typical types of this cluster.

Cluster 6

This group was a distinct ball cluster with 8 accessions of which 5 are from M11 ('Kaiyyankachil'), 2 from M12 (IC 44235 C, IC 87336 A) and the other from M7 (IC 87336 B). Plants are prostrate, non-spiny, with purple stem and purple wings. Bulbils as well as flowering are absent. Six cylindrical highly warty tubers with brown outer skin, light purple cortex and white flesh is produced per plant. Crop duration is about 146 days. Starch is grainy with good taste. Representative types of this cluster include IC 87336 B of M7 and IC 44235 A of M11

Cluster 7

Of the 28 collections in this cluster, most of them (23) are from M16 (Vattayilakachil) of earlier classification. These accessions were found grouped with one accession from M4 (IC 87367), one from M13 (IC 44224 A) and three accessions from ungrouped category. This group showed the presence of 5 distinct clusters, 4 of them with 2 accessions each and the other with 4 accessions. Early stem prostrate, non-spiny and purple. Bulbil initiation was recorded in 133 days and the bulbils are oblong, medium sized with outer brown skin, light green inner skin and yellow flesh. 4-5 cylindrical, highly warty brown skinned tubers having light yellow cortex and very light yellow tuber flesh which is grainy is a common feature in this cluster. Crop duration is about 141 days. Tuber yield in this cluster is the highest, which ranges from 3.0 to 13.5 kg/plant (Table 1). Representative types identified are IC 46069 and IC 87330 of M16.

Cluster 8

This cluster was found to be a group of two different morphotypes, M2 (Parakkachil–5 accessions) and M19 (Thalikayilakachil-2 accessions), but each of these morphotypes appeared as distinct ball clusters. Moreover, one ungrouped accession (IC 259824) was also found clustered in this forming 8 accessions in this cluster. As these morphotypes occur as distinct ball clusters in this group, they can be treated as separate entities. Here the green early stem is erect and spiny with dark purple wings. Bulbil formation and flowering are absent. Single digitate tuber per plant with smooth dark brown outer skin, purple cortex and very light yellow flesh is the characteristic tuber type of this cluster. The tuber flesh is grainy with very good taste. Crop duration is about 141 days. Tuber perimeter is the highest in this group ranging from 39.0 to 54.33 cm (Table 1). Typical type identified is IC 87391 of M19.

Cluster 9

This is a distinct group of 4 accessions in earlier M14 (Aanikachil) and an ungrouped exotic accession (EC 391129). Moreover 3 accessions in M14 (IC 87406, IC 87408, IC 87425) appeared as a ball cluster. Erect green stem with purple wings and light green petiole top and bottom is a general feature in this group. Bulbils and flowers are absent. 1-2 oblong tubers having highly warty dark brown outer skin, light yellow cortex and white flesh were produced per plant. Crop duration is about 146 days. Grainy flesh with very good taste is the distinctive feature of this cluster. Characteristic types identified are IC 87406 and IC 87408 of M14.

As the qualitative characters grouped the germplasm into 9 different clusters, the quantitative traits also showed distinct variation between the clusters.

A critical observation of these clusters showed that only 10 morphotypes retained the integrity as morphologic groups, even though most of them showed relationships with accessions from other morphotypes. As far as the morphotypic diversity and geographical distribution are

concerned, the clustering pattern did not show any strict relation as the accessions from different geographic regions are grouped in all the clusters.

According to this, the status of the morphotypes 3,4,5,7,8,9,10,15 and 17 as separate entities are not concrete and are grouped in the 9 basic clusters in which many accessions retained the integrity with earlier morphotypic grouping. Hence, cluster-1 with majority of accessions from earlier M1, cluster-2 with M6, cluster-3 with M12, cluster-4 with M13, cluster-5 with M18, cluster-6 with M11, cluster-7 with M16, cluster-8 with M2 and cluster-9 with M14 can be grouped as distinct morphologic entities. Even though the accessions earlier grouped as morphotypes differ in certain morphometric parameters, the distinctiveness of such traits may not be sufficient to group them as distinct morphotypes. In effect, it can be concluded that the germplasm holds distinct variability with respect to vegetative and tuber characteristics and there exists 9 different morphologic groups in the germplasm.

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