FINAL REPORT

ON

COLLECTION, CLASSIFICATION AND EVALUATION OF DIOSCOREA YAMS

Prof. H. P. M. Gunasena

Dean and Professor of Crop Science

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Faculty of Agriculture

University of Peradeniya

Peradeniya

Sri Lanka.

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EXECUTIVE SUMMARY

1. In all 356 accessions of mainly cultivated species and varieties of the genus Dioscorea were examined in this study. Of these 342 accessions were collected from Colombo, Galle, Gampaha, Jaffna, Kalutara, Kandy, Kurunegala, Matale and Puttalam districts of Sri Lanka, 13 accessions of Dioscorea alata were obtained from Puerto Rico and 1 accession of Dioscorea rotundata was received from Nigeria. Sri Lanka accessions had in all 31 different local names in Sinhala and Tamil.

2. These accessions which consisted of underground tubers of mainly edible Dioscorea were grown at the University Experimental Farm at Dodangolla under comparable climatic and soil conditions.

3. The collection and cultivation of Dioscorea species and cultivars were commenced in 1982. The comparative study of morphological and other features were begun in January 1984. The accessions were studied for their tuber form, size, colour of flesh and skin. They were grouped into related species and forms and replanted in the field in April 1984 and harvested after about 9 months.

4. Herbarium specimens, illustrations and photographs were made of some selected accessions to show range in variation within species and varieties.

5. Comparative morphological studies of the tuber morphology and above grounds parts such as stem, leaf, flower and aerial bulbils were carried out. Replicate samples of leaves of comparable age

were used for making measurements of length and breadth of lamina, length of petiole, length, breadth and weight of tubers.

6. Samples obtained from 42 selected accessions were used for studies of foliar anatomical and epidermal features such as epidermal cell size, guard cell size, stomatal distribution, stomatal arrangement and stomatal frequency, height of epidermal and palisade layers and extent of spongy chlorenchyma tissue.

7. Ecophysiological parameters such as 'density thickness', 'degree of succulence', and 'potential tissue hydration' were also determined using the same 42 accessions.

8. Fresh and dried leaf samples of 15 accessions were extracted with methanol and the concentrated methanolic extracts were surveyed by 2 directional paper chromatography. The ultra violet active compounds and $AlCl_3$ positive compounds were located and the data were analysed to evaluate inter and intra specific variations of phenolic constituents of leaves of 4 different species and some of their varieties.

The salient findings are as follows:

9. Based on the morphological characters, 356 accessions of Dioscorea were found to represent 5 different species. They are D. alata, D. bulbifera, D. esculenta, D. pentaphylla and D. rotundata. Of these D. rotundata recently introduced from Nigeria has not been hitherto cultivated in Sri Lanka. D. pentaphylla is a wild species found in Sri Lanka and other tropical countries. The three commonly cultivated species in Sri Lanka are D. alata, D. bulbifera and D. esculenta.

10. Within species, varieties having similar morphology represent varietal groups. They have different names from different localities. In D. alata 12 such "varietal" groups were recognized. In D. bulbifera 2 varietal groups and in D. esculenta also 2 varietal groups were recongnized.

11. D. alata is the most commonly cultivated species in Sri Lanka. There were 279 accessions and this species has considerable variations in tuber and leaf morphology. This study recognizes that there are at least 12 different forms of D. alata cultivated in Sri Lanka. These are referred to by 32 different names of which 25 are local Sinhala or Tamil names. Names such as King Yam and Jaffna Purple have been used in some Agricultural Research Stations in Sri Lanka. The young sprouts in all the different forms of D. alata are purplish in colour (sprouts of forms and varieties of other 4 species are greenish in colour). The aerial stems twins to the right in D. alata. The stems are usually quadrangular and sometimes 5 angled. Wings are present. At the junction of stem and petiole wings expand to form auricles. Hairs and spines are not found. Spines were present in one accession only, (Kondol ala, accession number 159). Leaf arrangement is opposite. The leaves are simple and variable ovate in shape, apex acuminate and base of leaves are usually cordate. There are 7 arcuate primary veins of which 3 reach the apex of the leaf. Secondary and tertiary veins are reticulate. One or two large tubers are formed per vine.

Tubers are usually large and appear spherical, lobed digitate or cylindrical in shape. Colour of flesh varies, ranging from white (Hingurala), yellow (Kahata ala), orange (Tambala), pale purple (Raja ala) to deep purple (Leydanta). Surface below the brown corky protective layer "skin" also shows distinct colour variations in different cultivars. Flesh and area just below skin on exposure to air change colour (darkens) except in Hingurala which does not discolour on exposure to air. Aerial tubers are found in 9 varieties only. They are Angili ala (100%), Hingurala (32%), Kahata ala (34%), Kahata angala (33%), Kombu valli-2 (100%), Urumparai (100%), Kiri ala (33%), Kondol ala (100%) and Jaffna Purple (67%). Aerial tubers are usually small but bear some resemblance to underground tubers. Flowers when present are dioecious and were observed in 7 varieties, namely, Angili ala (♂ 100%), Hingurala (♂ 27%) and (♀ 5%), Ini ala (♀ 25%), Kahata ala (♂ 3%) and (♀ 9%), Kiri Kondol (♀ 12%), Kombu valli-1 (♀ 100%) and Kombu valli-2 (♀ 75%) and Rata ala (♀ 7%).

12. D. bulbifera had 28 accessions. This species has 2 distinct varietal groups in Sri Lanka. One variety with edible aerial tubers called Mothaka valli is mainly cultivated in the Jaffna District. The other variety is found growing wild in the wetter parts of the low country and mid country. Accessions supplied as Rasavalli (yellow flesh) and Jaffna collection (with accession numbers 179, 180, 181, 182) are forms of Mothaka valli. They were wrong local names by the suppliers. The aerial stems twine to the left and it is cylindrical. Branching and leaf development somewhat is late. The base of the petiole expands

to form auricles. Wings, spines and hairs are absent. Leaves are alternately arranged. Leaf is simple, broadly ovate, apex acuminate and base cordate. There are 9 arcuate primary veins of which 3 reach the apex. Secondary and tertiary veins are reticulate (dicot feature).

Tubers are of medium size, usually 1 or 2 per vine, spherical or ellipsoidal in shape. Flesh colour is yellow but may have purple blotches in some varieties. Surface below "skin" is green or yellow in colour. The tuber colour changes when damaged or exposed to air. A large number aerial tubers or bulbils are produced on the vine, aerial tubers are the main edible part. Flowers function as male flowers Mothaka valli (♂87.5%), Rasa valli (yellow flesh) (♂100%), Jaffna collection (accession numbers 179 - 182) (♂75%) and Udala (♂87.5%). Udala (accession number 333) is different from the other Udala forms having warty aerial bulbils and the tuber is densely covered with adventitious roots.

13. D. esculenta had 44 accessions and is represented in Sri Lanka by 4 different forms. They are D. esculenta var. Java ala, D. esculenta var. Siru valli, D. esculenta var. Kukulala, and D. esculenta var. Katu ala. Of these D. esculenta forma Java ala represents D. esculenta var. fasiculata while the other 3 forms are varieties belonging to the cultivar D. esculenta var. spinosa. This species is cultivated on a moderate scale in Sri Lanka. All these varieties usually sprout late and have a dormancy period. The aerial stems twins to the left and are cylindrical. Plants are spiny and pubescent. Wings and

auricles absent. Prominent spines are found at the base of the petiole. Leaf arrangement is alternate. Leaf is simple, broadly ovate, apex acuminate and base cordate. There are 7 to 9 arcuate primary veins of which 3 reach the apex. Reticulate venation found between the primary veins.

Tubers are smaller, more or less ovoid in shape and many tubers are produced per plant. They are borne in clusters at the end of stolons. Tubers are densely covered with adventitious roots. Flesh of tuber is yellowish white and the area below skin is pale yellow or greenish yellow and it changes colour on exposure to air. No aerial tubers were found in this species. Male flowers were observed only in D. esculenta var. fasiculate forma Java ala (♂77%).

14. D. pentaphylla is a wild species, rarely cultivated in Sri Lanka. Our living collection at Dodangolla had only one accession. This yam sprouted late. The aerial stem twines to the left and is cylindrical. The plant is spiny and pubescent. Wings and auricles are absent. Leaves are alternately arranged. Leaf is compound palmate or trifoliate. Leaflets elliptical, apex acuminate, base obtuse with palmate venation. Tubers are produced singly and they are small, elongate and branched. Flesh of tuber is yellowish white and area below skin is pale yellow and it changes colour on exposure to air. Aerial tubers are absent and flowers are produced in the wild state.

15. D. rotundata has hitherto not been cultivated in Sri Lanka and it is a cultivated variety introduced from Nigeria in 1983. There was only one accession of this variety. It sprouted early

when compared with the other 4 species. The aerial stem twines to the right and it is cylindrical. Wings, auricles and hairs are absent. Spines are found on mature stems and on petioles only. Leaf arrangement is opposite. Leaf is simple, narrowly ovate, apex acuminate and base cordate. There are 7 arcuate primary veins of which 3 reach the apex. Reticulate venation is found between the primary veins. A single tuber was formed which was cylindrical in shape. Tuber flesh colour is white and surface below skin is yellowish white and it darkens on exposure to air. Aerial tubers and flowers are absent.

16. Keys for the identification of the species grown in Sri Lanka and separate supplimentary keys for the identification of the distinct cultivars or forms of the three (3) species, namely: D. alata, D. bulbifera and D. esculenta have been prepared using the morphological characters of tubers, stems, leaves and flowers.

17. Besides morphological characters, anatomical characters such as the appearance of the mid rib region as seen in section and transverse section of the leaf lamina were found to be useful in distinguishing the 3 major cultivated species of Dioscorea. Forms of D. alata has a characteristics projection downwards in the mid rib region, whereas in D. esculenta and D. bulbifera mid rib region is more or less rounded and in D. rotundata it is flattened with 2 projections to the sides at lower end and in D. pentaphylla it is flattened with no projections.

18. Transverse section of leaf lamina show marked differences in the upper epidermal cells of the three cultivated species. In D. alata the upper epidermal cells are large and cuboidal, in D. bulbifera these cells are small and rectangular and in D. esculenta they are intermediate in size and rectangular. There are 2 palisade layers of which the lower layer is shorter than the upper layer.

19. Leaf epidermal features showed that D. bulbifera is amphistomatous and the other species are hypostomatous. In all the species stomata are anomocytic in arrangement with polygonal anticlinal epidermal walls. Stomatal distribution is irregular and the axes of stomata are randomly orientated. Guard cells are bean shaped in surface view.

The epidermal features are not very helpful in distinguishing the different varieties and forms of a species. All 3 species of Dioscores exhibit some xeromorphic features as regards the leaf anatomy; viz. 2 layered palisade, hypostomatous distribution of guard cells.

20. Three leaf indexes were used as ecophysiological parameters. "Degree of succulence" and "potential tissue hydration" showed significant differences between the 3 cultivated species of Dioscorea.

21. Ecophysiological and anatomical features suggest that D. esculenta can withstand moderate water stress when compared with D. alata and D. bulbifera.

22. In the 15 accessions examined for phenolic constituents, compound number 1 was found in all the samples, and it may be regarded as a generic marker. There are no compounds which could be used for species characterization. Pattern of distribution of the phenolic constituents was not useful in identifying varieties within a species.

23. In all 24 characters were tested, of which 15 characters showed significant differences between the 3 cultivated species.

(a) Morphological characters

Five morphological characters showed significant differences. D. alata had the highest values in all the morphological characters except for lamina breadth which was found to be high in D. bulbifera. D. esculenta had the lowest values for all the morphological characters analysed.

Highest lamina length was found in D. alata (10.94 cm) intermediate value in D. bulbifera (9.35 cm) and lowest value in D. esculenta (5.41 cm). Lamina breadth had the highest value in D. bulbifera (7.96 cm), intermediate value for D. alata (7.05 cm), and lowest value for D. esculenta (5.29 cm). Very long leaf petioles were found in D. alata (6.50 cm), intermediate values in D. bulbifera (5.81 cm), and somewhat short values in D. esculenta (4.28 cm).

Maximum tuber length was recorded in D. alata (22.88 cm) intermediate range in D. bulbifera (15.59 cm), and the lowest in D. esculenta (12.81 cm). The highest value for maximum tuber breadth was found in D. alata (17.55 cm), intermediate value in D. bulbifera

(15.74 cm) and the lowest value in D. esculenta (5.32 cm).

All the 6 morphological characters seem to be significant between the 2 species D. alata and D. esculenta. D. alata and D. bulbifera can be distinguished qualitatively in the field or in herbarium specimens. But in these 2 species the quantitative parameters examined do not show statistically significant differences. There is significant difference in lamina length, lamina breadth, and maximum tuber length between the two species D. esculenta and D. bulbifera.

(b) Anatomical characters

Seven anatomical characters, namely, number of epidermal cells, stomatal index, lamina thickness, height of upper epidermal cells, height of upper tier palisade cells and total height of palisade cells showed high significant difference among the 3 cultivated species. Number of epidermal cells had the highest values of 45.35 in D. bulbifera while D. alata had a value of 30.70 and the lowest value of 20.97 was found in D. esculenta. Stomatal index was found to be the highest in D. esculenta with a value of 26.03%, while D. alata had a value of 22.23% and D. bulbifera had the lowest value of 16.71%.

Lamina thickness had the highest value of 275.28 μ in D. esculenta while D. alata had a value of 226.22 μ and D. bulbifera had the lowest value of 191.84 μ. Height of upper epidermal cells showed the highest value in D. alata of 60.10 μ while D. esculenta had a value of 45.35 μ and D. bulbifera had the lowest value of

24.79 μ. Total height of palisade cells was also highest in D. esculenta having value of 130.32 μ while D. alata had value of 80.14 μ and D. bulbifera had the lowest value of 76.31 μ.

Between the two species D. alata and D. esculenta number of epidermal cells, stomatal index, lamina thickness, height of upper epidermal cells, height of palisade cells showed significant differences.

The species D. alata and D. bulbifera showed significant differences for the same characters mentioned above except for the height of palisade cells.

The pair of species D. esculenta and D. bulbifera showed significant differrnces in all the 7 characters.

(c) Ecophysiological characters

Of the ecophysiological parameters "potential tissue hydration" showed significant between the 3 cultivated species. D. alata had the highest value of 434.49%, D. esculenta had the intermediate value of 387.82% and lowest value of 360.76% was found in D. bulbifera.

"Degree of succulence" showed high significant variance among 3 species. Highest value of 0.0202 gm/cm^2 was obtained for D. alata. Intermediate value of 0.0197 gm/cm^2 was found in D. esculenta and the lowest value of 0.0158 gm/cm^2 was in D. bulbifera.

There was no difference significantly among the 3 species for "density thickness". Between the 2 species D. alata and D. esculenta there is no significant difference for these leaf indexes. Between

the 2 groups D. alata and D. bulbifera both in the significant leaf indexes showed significant difference. Between D. esculenta and D. bulbifera only degree of succulence was significant.

(d) Vegetative propagation

Use of mini-setts and vine cuttings for rapid propagation were studied. Mini setts weighing 15g could be used to produce seed tubers of desirable size ie. 250 - 500 g for field planting.

Partially woody vine cuttings having about 4 nodes have produced more uniform planting material and results clearly show their potential for rapid propagation.

(e) Mineral nutrient composition.

The mineral nutrient of 69 local and one introduced accession from Puerto-Rico were analysed. The wide variation in the composition of the nutrients among different groups, and accessions within groups were noted.

INTRODUCTION

Economic importance of root and tuber crops

In tropical countries besides cereals, root and tuber crops form an important group of staple foods. Dioscorea is one of the tuber crops in which the carbohydrate content is high.

The economic importance of these root and tuber crops lies in (a) their utility as a source of carbohydrate in human diet, (b) industrial potential as a source of starch, (c) potential as a source of animal feed and (d) as a source of pharmaceutical products. These crops require less space and management than cereal crops and are capable of giving higher yields with very little attention. Although they are mainly consumed locally some tuber crops can be exported. Root and tuber crops are becoming increasinly important as a source of carbohydrate food item, with population expansion and with the limitation in land suitable for cultivation of cereals.

Yams provide staple food stuff for millions of people in tropical and even some subtropical countries and also an important secondary food for many people. Apart from the yams that are cultivated as food crops, wild yams form a reliable standby to human population in time of famine and scarcity. Some of the yams have recently become economically important as a source of steriods for pharmaceutical use (Coursey, 1967).

In Sri Lanka greater emphasis has been placed on Manioc and Sweet potato and to a lesser extent on Dioscoreas and Aroids. But with the increase in demand for carbohydrate food stuffs dioscoreas

have become an important food item. Pests and diseases have not been a serious problem so far and these tuber crops have a high potential in developing countries.

Growing areas and world production

Tuber crops are grown in many parts of the tropics. But in West Africa, East Africa, South America, India and South East Asia, one or more of these tuber crops feature as major food items in the diet of people. Areas and production of all root and tuber crops in the world is given in Table 1a.

The genus Dioscorea is a large one and its species are found in most parts of the world. Although they are tropical plants a number of species are found in temperate parts of the world, while some are even found growing in alpine habitats. Yams are of appreciable economic value among the tropical species. D. opposita and D. japonica grow in the temperate regions of China and Japan. But they appear to be of tropical origin. They occur in both old and new worlds in wild state, while in the Australian continent, there are a few indigenous species. Within the tropics Dioscorea are found almost everywhere where the rainfall is sufficient for their growth (Coursey, 1967).

The largest acreage and the greatest amount of yam production is in West Africa. This region accounts for over 95% of total world acreage and production of yams (Onwneme, 1978). Areas and production of yams are given in Table 1b.

Table 1a. Area harvested, yield and production of total root and tuber crops in the world

	Area harvested 1000 ha			Yield Kg/ha			Production 1000 Mt		
	1981	1982	1983	1981	1982	1983	1981	1982	1983
World	47610	48140	47523	11616	11573	11714	553989	557144	556676
Asia	16717	16844	16743	12871	13059	13705	215167	219963	229462
Europe	5494	5373	5296	20375	18611	17994	111945	100011	95303
Africa	13282	13727	13440	6569	6640	6402	87259	91151	86044
USSR	6854	6858	6886	10525	11401	12053	72139	78185	83000
South America	3816	3880	3694	11160	10845	10492	42591	42078	38754
North Central America	1189	1196	1199	18657	19170	17846	22177	22934	21396
Ocenia	256	260	264	10583	10759	10286	2712	2793	2716
Sri Lanka	78	82	85F	9611	9833	9496	751	802	810F
Nigeria	3051F	3152F	3003F	10087	10260	9483	30775F	32338	28477
Puerto Rico	7F	6F	6F	5886	5813	5648	38	38	35

F - FAO Estimate
Ha - Hectare

Kg - Kilogram
Mt - Metric ton

Source: FAO Production Year Book, 1983; vol. 37, pp. 121-123

Table 1b. Area harvested, yield and production of yams in the world

	Area harvested 1000 ha			Yield Kg/ha			Production 1000 Mt		
	1981	1982	1983	1981	1982	1983	1981	1982	1983
World	2464	2523	2471	9751	9962	9428	24030	25138	23299
Africa	2338	2397	2344	9825	10047	9489	22970	24081	22238
South America	41	41	41	9389	9427	9440	384	385	386
North Central America	55	54	55	5752	5499	5492	318	296	303
Ocenia	14	15	15	14166	13797	13823	204	208	210
Asia	16	16	16	9694	10135	9877	152	165	160
Europe				10000	10556	10192	3	3	3
Nigeria	1500F	1550F	1500F	11667	11935	11083	17500F	18500*	16625*
Puerto Rico	2F	2F	2F	6550	6495	6048	15	15	15

F - FAO Estimate
* - Unofficial figure

Ha - Hectare
Kg - Kilogram

Mt - Metric ton

Source: FAO Production Year Book, 1983; vol. 37, pp. 130

Local Production

The great diversity of local tuber crops make it possible to find varieties for every ecological region and they can be grown all the year around. In Sri Lanka the production figures are given in Table 2.

Dioscorea yams take nine months to mature and are grown both in the wet zone and in the dry zone mostly in home gardens and in wild state in Sri Lanka. It can be grown successfully, upto an elevation of 1000 meters above mean sea level and in varied soil types provided the soil is well drained.

It is mostly grown in the mid and low country wet zone region. In the Jaffna district yams are grown under irrigation. In Sri Lanka yams are not favoured for large scale cultivation, because of their long age. Moreover, the climbing habit makes it necessary to have stakes. The tubers are usually harvested in December and January and cannot be planted till March-April because they undergo a period of dormancy.

Nutritive value

In Dioscorea the tuber is the economically utilized part of the yam plant. The chemical composition of the tuber varies with species and cultivars. It may also vary depending on the environmental conditions under which the tuber is produced. The dry matter of the tuber is one third of its weight and the rest is water. There is a gradient of increase in percentage of moisture (and a decrease in percentage of dry matter) from head to tail (Onwneme, 1978).

Table 2. Area harvested, yield and production of root and tuber crops in Sri Lanka

	Area harvested ha			Yield Mt/ha			Production Mt		
	1981	1982	1983	1981	1982	1983	1981	1982	1983
Other yams (Dioscorea and Aroids)	4693	4259	4402	8.86	17.27	8.44	41591	73543	37168
Sweet potato	8872	9560	7982	8.60	9.61	9.15	76330	91861	73013
Manioc	36790	50993	37855	11.22	9.85	16.37	413100	502500	619700
Potato	4648	5501	6634	13.64	11.76	12.43	63400	64700	82500

Ha - Hectare
Mt - Metric ton

Source: Department of Agriculture, Peradeniya, Sri Lanka

Summary of proximate analysis of yam tubers are given in Table 3.

Carbohydrates are the major dry matter components of yams. Most of this carbohydrate is starch, and is mainly Amylopectin, and exist as starch grains. Sugars are present in minute quantities. Sugar content of tubers increase during or just before sprouting. The protein content of yam is low ranging from 1-2% of fresh weight: and is low in sulphur containing amino acids. Mucilage which exudes when the yam tuber surface is cut or damaged are mostly glycoproteins.

Vitamins and minerals (ash) are minor components of yam tubers. Significant amount of Vitamin C are present. Traces of Vitamin A and B are present. The mineral fraction contains calcium, iron and phosphorus among components.

Some yams contain traces of polyphenolic compounds and they cause the cut surface to turn brown. Certain yam species contain alkaloids (e.g. Diosgenin). The former is used as a poison and the latter is extracted for pharmaceutical use.

Wild yam species are usually bitter in taste, and also have an astringent effect when eaten, which may be due to alkaloidal and phenolic substance. It is believed that oxalates and oxalic acid may also be responsible for the acrid taste of some wild tubers.

Other uses of Dioscorea yams

The genus Dioscorea contains about six hundred species (Purseglove, 1975). But the economically important species and the

Table 3. Summary of proximate analysis of yam tubers

Species	Moisture %	Carbohydrate %	Crude fat %	Crude protein %	Crude fibre %	Ash %
D. alata	65-73	22-29	0.03-0.27	1.12-2.78	0.65-1.40	0.67-2.06
D. cayenensis	83	15	0.05	1.02	0.04	0.53
D. rotundata	58-73	23	0.12	1.09-1.99	0.35-0.79	0.68-2.56
D. opposita	70-80	16-29	0.06-1.10	1.11-3.10	0.33-1.00	0.69-1.10
D. esculenta	67-81	17-25	0.04-0.29	1.29-1.87	0.18-1.51	0.50-1.24
D. bulbifera	63-67	27-33	0.04	1.12-1.50	0.70-0.73	1.08-1.51
D. dumetorum	79	17	0.28	2.78	0.30	0.72
D. hispida	78	18	0.16	1.81	0.93	0.69
D. trifida	-	38	0.44	2.54	-	-

Source: Yams - D. G. Coursey, 1967

edible species of yams are represented mainly by ten species. They are D. rotundata, D. alata, D. cayenensis, D. esculenta, D. dumetorum, D. bulbifera, D. trifida, D. opposita, D. japonica and D. hispida. Numerous other species of Dioscorea are only eaten occasionally or are not used for food at all.

The toxicity of wild species of yams is due to alkaloids Dioscorine or dihydrodioscorine. These substances are soluble in water and hence can be detoxicated easily by soaking in water, or salt water to remove the alkaloid.

There are various other uses of yams:

i) From D. mexicana, D. composita and D. floribunda, pharmaceutical Diosgenin (Steroidal sapogenin) is extracted on a commercial scale. Some Dioscorea species are also used in traditional medicine.

ii) Due to toxicity some wild species of yams are used as poisons for hunting; e.g. D. hispida, D. dumetorum, D. dregeana and some varieties of D. bulbifera. Various yams of section Lasiophyton are used in the preparation of arrow poisons. Tubers of D. piscatorum are used to prepare an insecticidal powder.

iii) Some contain considerable amount of tanning and have limited use for the preservation of fishing lines and nets; e.g. D. cirrhosa.

iv) Dried stems have been used as cordage.

v) Occasionally grown as ornamental plants, vines covering a trellis or lattice screen; e.g. D. alata, D. opposita, D. elephantipes is grown as indoor plants.

Species and some varieties found in Sri Lanka

In Sri Lanka three species of yams (Dioscorea) are cultivated. They are D. alata, D. bulbifera and D. esculenta. The following varieties Angili ala, Hingurala, Kiri kondol, Raja ala, Kukulala, Mothaka valli and Siru valli are cultivated. Of these Angili ala, Hingurala, Kiri kondol, and Raja ala belong to D. alata while Mothaka valli is a variety of D. bulbifera commonly cultivated in the Jaffna district. Siru valli and Java ala are edible varieties of D. esculenta.

The following are the wild species that have been recorded for Sri Lanka. They are D. intermedia Thw., D. obcuneata Hook t., D. opposita L., D. pentaphylla L., D. spicata Roth and D. trimenii.

Objectives of the study

(a) To collect and evaluate different morphological features of the above ground parts and the below ground parts of accessions obtained from various agro-ecological zones of Sri Lanka with a view to characterizing the available germplasm of edible Dioscorea species in Sri Lanka.

(b) To carry out comparative studies on the epidermal features, foliar anatomy, ecophysiological parameters and phenolic constituents of some of the accessions grown under comparable soil and climatic conditions at the University Experimental Station, Dodangolla, with the aim of finding the salient differences among the edible Dioscoreas cultivated in Sri Lanka.

(d) To evaluate the above data and construct keys for the identification and characterization of species and varieties of edible Dioscorea presently available in Sri Lanka.

MATERIALS AND METHODS

Collection and conservation of plant material

In all 356 yam samples were collected. Of these 342 accessions were collected from Colombo, Galle, Gampaha, Jaffna, Kalutara, Kandy, Kurunegala, Matale, Matara and Puttalam districts of Sri Lanka. Thirteen accessions were obtained from Puerto Rico and 1 accession was received from Nigeria (Table 4). They were received as underground tubers. For each accession the local name was recorded from the source of collection or supplier and an accession number was given.

These were propagated and maintained at the University Experimental Station, Dodangolla, Kundasale, situated in the mid country intermediate zone at an elevation of 367 m above mean sea level (MSL). The evaluation of the yam species was carried out during the year 1984, which were planted in April 1984, and harvested in early January 1985. The average rainfall, temperature and relative humidity during these experimental period was 20.12 cm, 27°C and 68.6% respectively, pH of the soil was 5.3. The soil type was clay loamy and it belongs to the reddish brown latosol soil group.

All the 356 accessions were planted after grouping the varieties and giving field numbers. Each planting hole was 60 x 60 x 60 cm^3, spaced 1 m x 1 m, filled with a mixture of two baskets dried cowdung and soil. Planting holes were staked to give support to the vine. The morphological characters were studied in detail in all

the 356 accessions which included 46 varieties or forms. A typical accession of each of these varieties was studied in detail for anatomical eco-physiological and phytochemical characters.

Illustrations, photographs and herbarium specimens were also made of the different cultivars and species of the plant material collected.

Systematic description of the morphology

Qualitative characters such as dormancy, colour of the sprout, tender vine, mature vine and wing, direction of twining, branching, leaf formation, presence or absence of spines, hairs and auricles, leaf arrangement, structure, venation, shape, colour of lamina, vines and petiole were studied. Tuber flesh colour, the colour immediately below cork layer and changes in colour after cutting and exposing to air were examined. Flowers, where available were studied.

Quantitative characters such as lamina length, breadth, length of petiole, number of veins (main and secondary), number of spines on stem and petiole, weight of underground tuber and aerieal tuber, maximum length and breadth of underground tuber, inflorescence number per leaf axil, inforescence length, and flower number were measured and counted.

Colours compared with the ISCC, NBS (Inter Society Colour Council, National Bureau of Standards, USA) colour name charts illustrated with centroid colours.

Flowers were dissected under the microscope and the number of petals, sepals, ovary, style, stigma and stamens were observed. Total number of flowering plants, number of male/female plants, percentage of male/female plants were calculated.

Study of foliar anatomical and epidermal features

'.1 Permanent microtome sections

These were prepared from the leaf lamina. Sections were taken from the mature leaves including the midrib. The following procedure was adapted.

(1) Fixing
(2) Dehydration
(3) Infiltration
(4) Embedding
(5) Sectioning
(6) Dewaxing
(7) Staining

Lamina thickness, height of upper epidermis, palisade cells (upper and lower) spongy cells and lower epidermis were measured at a magnification of 12.5 x 10 using Leitz Filar micrometer. Drawings were made of midrib region and portion of lamina, under a Camera Lucida at a magnification of 10 x 10 and 10 x 20 respectively.

.2 Leaf epidermal features

Comparative studies of the leaf epidermal features such as the number of epidermal cells and stomata (complete), length and breadth of ten epidermal cells, length of ten guard cells, breadth of ten pairs of guard cells were measured at a magnification of 12.5 x 45 using Leitz Filar micrometer, and stomatal index was

calculated as follows (Meidner and Mansfield, 1968).

$$\text{Stomatal Index} = \frac{\text{No. of stomata per unit are}}{\text{No. of stomata per unit area} + \text{No. of epidermal cells per unit area}} \times 100$$

Drawings were made of epidermal features using Camera Lucida at a magnification of 10 x 40.

For the above study leaves from the 10th and 11th nodes below the growing tips of branches were collected in polythene bags at about 9.00 a.m. and brought to the laboratory. Epidermal peels were prepared to study the leaf epidermal characters. The epidermal peels were removed and put in 0.5% Toludine Blue, and then washed with water, and mounted on the slide in a drop of 50% glycerine.

Methods of characterizing some leaf indexes

Leaves from the 10th to 12th nodes below the growing points of branches were collected in polythene bags between 9.00 - 9.30 a.m. and brought to the laboratory. The leaf discs were cut with a cutter of known area (1.77 cm^2). Three sets each containing 30 discs were made from each variety. Leaves were cut from any place in the lamina leaving the mid rib.

The leaf discs were immediately put in distilled water for three hours, (time calculated in a preliminary test), then blotted using absorbent papers and rapidly weighted to obtain turgid weight. Discs were then over dried, weighed again for dry weight determinations.

Leaf indexes namely, 'degree of succlence','density thickness' and 'potential leaf tissue hydration' were calculated as outlined by Elias (1979). Calculations were made as follows:

(a) Density thickness = $\frac{\text{Oven dry weight of discs}}{\text{Area of discs}}$ gm/cm^2

(i.e. Dry matter content per unit area)

(b) Degree of succulence = $\frac{\text{Turgid fresh weight - Oven dry weight}}{\text{Area of discs}}$ gm/cm^2

(i.e. Water content per unit area)

(c) Potential leaf tissue hydration

$$= \frac{\text{Turgid fresh weight - Oven dry weight}}{\text{Oven dry weight}} \times 100\%$$

(i.e. Water content per dry matter) = % 100

Extraction and chromatographic separation of flavanoid constituents

(a) Mature green leaves were collected, cut into small pieces and sundried. One gram of the dried leaf material was first extracted with 50 ml cold Methanol (85%) overnight. Filtered the extract into a flask and re-extracted the marc with 25 ml hot Methanol (85%) and filtered. Combined the extracts (cold and hot) and evaporated to dryness in a hot water bath.

The above sample was dissolved in 5 ml Methanol and 0.1 ml was used for two directional paper chromatographic separation.

Two dimensional paper chromatography was carried out using Whatman No.1 paper 0.1 ml of the extract was applied at the corner of 28.5 x 28.5 cm^2 chromatography paper, using a micropipette and a hair drier.

The paper was first developed using Butanol - acetic acid - water (4:1:1), when the solvent had run to the edge of the paper it was taken out and dried. Then the paper was developed in the second direction using 2% acetic acid. Two chromatograms were run for each accession. The chromatograms were first viewed under ultra violet light and the active spots were marked.

One of the chromatograms was sprayed with $AlCl_3$ (2% in Ethanol), air dried, and the colour spots were recorded. The second chromatogram was sprayed with sulphanilic acid spray reagent; (prepared by dissolving 4.5 gm of sulphanilic acid in 12 N Hcl with warming and the solution made up to 500 ml with water, 10 ml of two solution was mixed with 10 ml of 4.5% aqueous $NaNo_2$ solution and kept at $0^{\circ}C$ for 15 mins.). After 15 mins. an equal volume (i.e. 20 ml) of freshly prepared 10% Na_2Co_3 solution was added to this mixture, and used for spraying immediately. The colour and position of the flavonoid spots were noted.

(b) Mature green leaves were collected in polythene bags and brought to the laboratory, and cut into small pieces .5 gm of this fresh leaf tissue in 50 ml Methanol (85%) was boiled for 15 mins. and filtered. This marc was macerated using a grinder and boiled with 25 ml Methanol (85%) for 15 mins. and filtered. Combined the extracts and evaporate to dryness in a hot water bath. The above sample was dissolved in 5 ml Methanol, and 0.1 ml of this was used for 2 directional paper chromatographic separation, as was done for dried leaf material.

One of the chrometograms was sprayed with $AlCl_3$ (2% in Ethanol). The second chromatogram was sprayed with sulphanilic acid spray reagent. The colour and position of the flavanoid spots were noted.

Statistical analysis

Measurements of the morphological, anatomical and eco-physiological characters were made on samples obtained from a fully grown vine of each of the varieties. The measurements taken were:

1) Morphological characters
   - (i) Lamina length (cm)
   - (ii) Lamina breadth (cm)
   - (iii) Leaf petiole length (cm)
   - (iv) Maximum tuber length (cm)
   - (v) Maximum tuber breadth (cm)
   - (vi) Underground tuber weight (kg)
   - (vii) Total tuber weight (kg)

2) Anatomical characters
   - (i) Number of epidermal cells (12.5 x 45)
   - (ii) Number of guard cells (12.5 x 45)
   - (iii) Stomatal index (%)
   - (iv) Length of epidermal cells (μ)
   - (v) Breadth of epidermal cells (μ)
   - (vi) Length of guard cells (μ)
   - (vii) Breadth of a pair of guard cells (μ)
   - (viii) Lamina thickness (μ)

(ix) Height of upper epidermal cells (μ)

(x) Height of upper tier palisade cells (μ)

(xi) Height of lower tier palisade cells (μ)

(xii) Total height of palisade cells (μ)

(xiii) Height of spongy cells (μ)

(xiv) Height of lower epidermal cells (μ)

3) Eco-physiological characters

(i) Density thickness (gm/cm^2)

(ii) Degree of succulence (gm/cm^2)

(iii) Potential leaf tissue hydration (%)

The varieties were grouped into 5 different species on the basis of their morphological characters. The analysis of variance was carried out to compare the 3 cultivated species. Since Dioscorea rotundata and Dioscorea pentaphylla had only one accession each they were not included in the statistical analysis.

The varieties which showed similarities in their morphological features only were grouped together within the species and there were 10 such groups among the 3 species studied.

Here too the analysis of variance was carried out to compare the different groups.

Varieties for the analysis of 3 cultivated species

Variety	Groups (species)		
	1. (D. alata)	2. (D. esculenta)	3. (D. bulbifera)
	Angili ala	1. Java-ala	1. Jaffna collection (179-182)

Variety	1. (D. alata)	2. (D. esculenta)	3. (D. bulbifer)
2	Hingurala	2. Katu-ala	2. Mothaka valli
3	Hiritala	3. Kukulala	3. Rasa valli (yellow flesh)
4	Rata Hingurala		
5	Kahata ala		
6	Kahata Kondol		
7	Kahata angala		
8	Raja Hingurala		
9	Kombu valli (2)		
10	Wal ala		
11	Urumpirai		
12	Kiri kondol		
13	Kiri udala		
14	Puerto Rico yams		
17	Jaffna purple		
18	Jaffna collection (176-178, 475-477)		
19	King yam		
20	Raja ala		
21	Rasa valli		
22	Raja valli		
23	Suduraja ala		
24	Ini ala		
25	Kandala		
26	Rata ala		
27	Tambala		

Variety	1. (D. alata)
28	Jamburala
29	Ratu ala
30	Ratangala
31	Leydanta
32	Dandila
33	Kombu valli (1)

Varieties for the analysis of different groups within the 3 species

	Varieties		Varieties
Group 1 -	1. Hingurala	Group 6 -	1. Tambala
	2. Hiritala		2. Jamburala
	3. Rata Hingurala		
Group 2 -	1. Kahata ala	Group 7 -	1. Ratu ala
	2. Kahata kondol		2. Ratangala
	3. Kahata angala		
	4. Raja Hingurala		
	5. Kombu valli (2)		
Group 3 -	1. Kiri kondol	Group 8 -	1. Leydanta
	2. Kiri udala		2. Dandila
	3. Kiri ala		3. Kombu valli (1)
	4. Kondol ala		
	5. Puerto Rico yams		

	Varieties		Varieties
Group 4 -	1. Jaffna purple	Group 9 -	1. Katu ala
	2. Jaffna collection (176-178, 475-477)		2. Kukul ala
	3. King yam		3. Siru valli
	4. Raja ala		
	5. Rasa valli		
	6. Raja valli		
Group 5 -	1. Ini ala	Group 10 -	1. Jaffna collection (179-182)
	2. Kandala		2. Mothaka valli
	3. Rata ala		3. Rasa valli (yellow flesh)

Table 4. Details of the yams collected

Variety	Accession number	Place of collection	District
1. Angili ala	260	Yatiyana	Gampaha
	324	Gonagama	Kurunegala
2. Boke	70	Nigeria	
3. Dandila	430	Pitigala	Galle
4. Hingurala	51-57, 96, 97, 124, 125, 127, 161, 162	Nakkawatta	Kurunegala
	58-65	Muddaragama	Gampaha
	98-100, 126	Palliyapitiya	Gampaha
	128	Kurunegala	Kurunegala
	255	Balagalla	Gampaha
	306, 307	Daraluwa	Kurunegala
	338, 344, 351	Puttalam	Puttalam
	429	Pinkanda	Galle
	441	Madapata	Colombo

Variety	Accession number	Place of collection	District
	450	Kottawa	Colombo
	469, 473	Kalutara	Kalutara
5. Hiritala	263	Miriswatta	Gampaha
	431	Mawadawila	Galle
	438	Matale	Matale
	464	Kalutara	Kalutara
6. Ini ala	121-123	Kurunegala	Kurunegala
	231	Giragama	Gampaha
	249	Kimbulapitiya	Gampaha
	444	Kesbewa	Colombo
	453	Labugama	Colombo
	197	Akurana	Kandy
7. Jaffna purple	66, 68, 69	Palliyapitiya	Gampaha
8. Jaffna collection	176-182, 475-477	Jaffna	Jaffna
9. Jamburala	251	Kadawata	Gampaha
	460	Kalutara	Kalutara
10. Java-ala	71-78, 80	Dunagaha	Gampaha
	240, 241	Kalumada	Gampaha
	258	Doranegoda	Gampaha
	166	Kottawa	Colombo
	443	Puwakpitiya	Colombo
	304	Madapokuna	Kurunegala
	437	Wellawatta	Galle
11. Kahata ala	16-21, 43, 132-138	Palliyapitiya	Gampaha
	22-24	Muddaragama	Gampaha
	189	Eriyagama	Kandy
	195, 196, 209, 210	Murutalawa	Kandy
	236, 275	Divulapitiya	Gampaha
	261	Werallagama	Gampaha

Variety	Accession number	Place of collection	District
	297	Kadahapola	Kurunegala
	329	Labuyaya	Kurunegala
	345, 346	Puttalam	Puttalam
	439	Malepitiya	Matale
	474	Matale	Matale
	446	Kosgama	Colombo
	449	Diyagama	Colombo
	459, 468	Kalutara	Kalutara
12. Kahata kondol	434	Pitikanda	Galle
13. Kahata angala	204	Kadugannawa	Kandy
	298, 299	Kudagalgomuwa	Kurunegala
14. Kandala	313	Maspota	Kurunegala
	314	Polpitigama	Kurunegala
	433	Kahaduwa	Galle
15. Katu ala	163, 164	Palliyapitiya	Gampaha
16. Katu kukulala	193	Hinigama	Kandy
17. Katuwala ala	317	Makandura	Kurunegala
	341	Puttalam	Puttalam
18. King yam	383, 384, 424, 426	Chunnakam	Jaffna
	385, 398, 401, 404 420, 423, 425, 428	Punnalaikad-duwan	Jaffna
	399, 400	Evenai	Jaffna
	406, 409	Innuvil	Jaffna
	407	Maruthanamadam	Jaffna
	410, 412	Urumpirai	Jaffna
	414	Thinnaveli	Jaffna
	415-418, 427	Puttur	Jaffna
	419	Nilavaral	Jaffna

Variety	Accession number	Place of collection	District
19. Kiri ala	207	Kandy	Kandy
	254	Kal-Eliya	Gampaha
	448	Arangola	Colombo
20. Kiri kondol	89-94	Muddaragama	Gampaha
	435	Pitigala	Galle
	440	Kosgahalanda	Matale
21. Kiri udala	466	Kalutara	Kalutara
22. Kondol ala	212	Gampola	Kandy
23. Kombu walli	44-50	Jaffna	Jaffna
24. Kukulala	81, 83, 85	Palliyapitiya	Gampaha
	86-88	Muddaragama	Gampaha
	242, 243	Andiyambalama	Gampaha
	244	Walpita	Gampaha
	264	Pethiyagoda	Gampaha
	300, 312	Yakdessagala	Kurunegala
	301	Gonagama	Kurunegala
	436	Wellawatta	Galle
	442	Piliyandala	Colombo
	452	Bope	Colombo
	463, 470	Kalutara	Kalutara
25. Leydanta	95, 168, 169	Kottawa	Colombo
	465	Kalutara	Kalutara
26. Mothakavalli	101-103, 105, 106, 109, 110	Jaffna	Jaffna
	457, 458	Tellippalai	Jaffna
27. Panuala katuala	154	Jaffna	Jaffna
28. Puerto Rico yams	214, 215, 217, 218, 220, 221, 223, 229	Central America	

Variety	Accession number	Place of collection	District
29. Raja hingurala	165	Kottawa	Colombo
30. Rata hingurala	445	Uruwela	Colombo
31. Rata ala	25-28	Walpola	Gampaha
	29	Palliyapitiya	Gampaha
	238, 239, 278	Hapugahegama	Gampaha
	293	Bihalpola	Kurunegala
	294	Dambadeniya	Kurunegala
	295	Thorakotuwa	Kurunegala
	322	Tisnampola	Kurunegala
	477	Malabe	Colombo
	454	Labugama	Colombo
32. Ratangala	347	Puttalam	Puttalam
33. Ratu ala	191, 193	Kobbekaduwa	Kandy
	203	Sinhayapitiya	Kandy
	271	Kuburegama	Gampaha
34. Raja ala	1, 3	Divulapitiya	Gampaha
	205	Hapugahegama	Gampaha
	265	Nalla	Gampaha
	272	Kalumada	Gampaha
	273, 274	Waradale	Gampaha
	276	Walpita	Gampaha
	2, 6, 8, 9, 10	Alabadagama	Kurunegala
	4, 5, 7, 11-15, 158, 159	Horambawa	Kurunegala
	290	Padeniya	Kurunegala
	291	Apaladeniya	Kurunegala
	292	Mutiyangane	Kurunegala
	332, 333	Halmillawewa	Kurunegala
	334	Barigoda	Kurunegala
	331, 335, 337	Tambare	Kurunegala

Variety	Accession number	Place of collection	District
	205, 208	Kadugannawa	Kandy
	343	Puttalam	Puttalam
	451	Boralesgamuwa	Colombo
	461, 467, 471	Kalutara	Kalutara
35. Raja-valli	455, 456	Punnalaikkadu-wan	Jaffna
36. Rasa-valli	38-42, 116-120, 139, 140, 147-150	Jaffna	Jaffna
37. Rasa-valli (yellow flesh)	141-143	Jaffna	Jaffna
38. Siru-valli	111-115	Jaffna	Jaffna
39. Suduraja ala	200	Sinhayapitiya	Kandy
40. Thudala	462	Kalutara	Kalutara
41. Tambala	30-33, 35-37, 128-131	Kurunegala	Kurunegala
42. Udala	432	Kahaduwa	Galle
	472	Kalutara	Kalutara
	280, 283-288	Hapugahegama	Gampaha
	309	Maspota	Kurunegala
43. Urumpirai	144, 145	Jaffna	Jaffna
44. Uyala wild	234	Rathdoluwa	Gampaha
45. Wal ala	190	Aladeniya	Kandy

RESULTS AND DISCUSSION

General

Studies on the morphological features, anatomical and eco-physiological characteristics and chromatographic survey of phenolic constituents were carried out of the yams collected at Dodangolla (Table 4).

1 Morphological characteristics

The accessions were described and measured. The above ground characteristics such as stem, foliar, floral and aerial tuber/bulbil, were studied in detail. Below ground characteristics such as tubers and roots were also studied for their morphological descriptions and measurements were also taken from the tubers.

The 356 accessions were grouped under the same local name and described as a variety. A small number of accessions did not germinate; e.g. Uyala wild (accession 234), Thudala (accession 462), Panu-ala Katuala (accession 154) and few others. Some accessions seem to be wrong and they are entirely different from the other accessions coming under the same local name. The accessions coming under the same local name were described together.

2 General morphology of the accessions

Stem: Weak stemmed climbers, direction of twining being a species specific character. Presence of wings, hairs, spines and auricles were also of taxonomic importance.

Leaf: Leaf arrangement, structure, presence or absence of hairs, spines, shape and colour helped in the species differentiation. The leaves had broad lamina with 7-9 arcuate primary nerves or veins of which three rach the apex of the leaf, except in D. pentaphylla variety Katuwala ala which had a trifoliate leaf. There was reticulate nervation between the primary veins.

Flowers: They were not found in all the accessions and was not a significant character. Some accessions had entirely male flowers, some accessions had entirely female flowers, and some had flowers which were staminodes (functionally male flowers).

Aerial tubers/bulbils: Aerial tubers were also found in some accessions only. They were of different shapes and colour and resembled the underground tuber.

Underground tubers and roots: All were tuberous, annuals and were of different shapes and colour, and covered with adventitious roots to a greater or lesser degree. In some accessions spines were also found in roots that were near the surface of the ground.

3 Morphological characters useful in differentiating the three commonly cultivated species in Sri Lanka

Based on the morphological characters the yam collection can be grouped into 5 different species, namely: Dioscorea alata, Dioscorea bulbifera, Dioscorea esculenta, Dioscorea pentaphylla and Dioscorea rotundata. The last two species had only one accession each. Therefore, most of the yams cultivated in Sri Lanka belong to the former three species.

(1) Dioscorea alata

Most of the cultivated varieties and forms of yams belong to this species. On the basis of names there are 32 forms in this collection. These yams sprout early when compared with other species except in D. rotundata. The sprout has a purplish red tinge. Branching and leaf formation early. Stem twines to the right, quadrangular or stellate in cross section. Wings present, at the junction of stem and petiole wings widen to form auricles, spines are present in one accession only (Kondol ala, accession 212). All the other accession are spineless. Hairs absent.

Leaf is simple, with opposite arrangement, ovate in shape, apex acuminate, base cordate. There are 7 arcuate primary veins of which 3 reach the apex of the leaf. Secondary and tertiary veins are reticulate.

Flowers when present are dioecious. Aerial tubers are found in some accessions only, resemble the underground tuber to some extent and not freely available.

Tubers are large, shape and colour are highly variable and usually there are 1 or 2 tubers per vine. Flesh colour is white, yellow, orange yellow, pink, purple or deep purple. Surface below the cork layer is pale yellow, orange yellow, purplish pink with deep purple dots, purplish red or deep purple.

Some of the varieties look similar and they are thought to be the varients or different forms of the same cultivar though they are referred to by different names in different localities. These can

be grouped together. The accessions with different local names could be reduced to 12 groups on the basis of tuber, vine and foliar characteristics.

There were 2 types of Kombu valli, one similar to the Kahata ala - yellow colour group (accessions 44-47), and the other belonging to the Leydanta - deep purple group (accessions 48-50). According to the morphological characteristics Jaffna collection (accessions 176-178, 475-477) is similar to Jaffna purple.

The 12 groups are as follows:

1. Angili ala group - (a) Angili ala
2. Hingurala group - (a) Hingurala
   (b) Hiritala
   (c) Rata Hingurala
3. Ini ala group - (a) Ini ala
   (b) Kandala
   (c) Rata ala
4. Kahata ala group - (a) Kahata ala
   (b) Kahata kondol
   (c) Kahata angala
   (d) Kombu valli (2)
   (e) Raja Hingurala
5. Kiri kondol group - (a) Kiri kondol
   (b) Kiri ala
   (c) Kiri udala
   (d) Kondol ala
   (e) Puerto Rico yams
6. Leydanta group - (a) Leydanta
   (b) Dandila
   (c) Kombu valli (1)

7. Raja ala group	- (a)	Raja ala
	(b)	Raja valli
	(c)	Rasa valli
	(d)	King yam
	(e)	Jaffna purple
	(f)	Jaffna collection (176-178, 476-477)
8. Ratu ala group	- (a)	Ratu ala
	(b)	Ratangala
9. Suduraja ala group	- (a)	Suduraja ala
10. Tambala group	- (a)	Tambala
	(b)	Jamburala
11. Urumpirai group	- (a)	Urumpirai
12. Wal ala group	- (a)	Wal ala

Varieties and forms of Dioscorea alata

1. Angili ala group

(a) Angili ala (accessions 260, 324)

Cultivated variety, with early sprouting (dormancy), which is purplish red in colour. Stem twines to the right, with early branching and leaf formation, tender vine light yellowish green, mature vine olive green, quadrangular or stellate in cross section. Wings present, pink in colour, spines and hairs absent, auricles present.

Leaf is simple, opposite in arrangement, ovate, apex accuminate, base cordate with 7 arcuate primary veins of which 3 reach the apex of the leaf. Reticulate venation is found between the primary veins. Lamina olive green, base of lamina and veins light yellowish green,

having a lamina length of 7.3-13.5 cm, breadth of 4.0-8.0 cm. Petiole is winged, yellowish green with dark red upper and lower ends having a length of 5.0-7.5 cm.

Male flowers present, small, regular, perianth incurved, calyx 3, corolla 3, stamens 6 in 2 whorls, arise in leaf axils or tips of branches, 4-6 inflorescences per leaf axil with an inflorescence length of 1.2-1.8 cm having 11.66-14.75 flowers per inflorescence.

Aerial tubers present, 1-2 per leaf axil, few in number, small, elongated or branched with an average total weight of 60 gms.

Tubers (underground) flat and digitate and digits divided half way, with 2 tubers per plant. Flesh is yellowish white which turns to pale yellow on cutting. Below cork is purplish pink with deep purple dots (where roots originate), which turn to light brown on exposure to air, with an average tuber length of 30 cm. breadth of 30 cm and a weight of 3.12 kg. Few adventitious roots are found on tubers.

2. Hingurala group

(a) Hingurala (accessions 51-65, 96-100, 124-128, 161, 162, 255, 306, 307, 338, 344, 351, 429, 441, 450, 469, 473)

Cultivated variety, with early sprouting having a purplish red tinge. Stem twines to the right, with early branching and leaf formation. Tender vine olive brown in most accessions, some are yellowish green, mature vine yellowish green and olive green; quandrangular or stellate in cross section. Wings present, reduced or narrow in most accessions, red, pink or yellowish green in colour. Auricles present. Spines and hairs absent.

Leaf simple, oppositely arranged narrowly ovate in most accessions or ovate, apex acuminate, base cordate, with 7 arcuate main veins, secondary and tertiary veins; reticulate lamina olive green, base of lamina pink and light green, veins light yellowish green. Leaf has a length of 6.75-13.15 cm, breadth of 3.85-7.15 cm. Petiole is winged with upper and lower ends dark red, with a length of 3.75-7.9 cm.

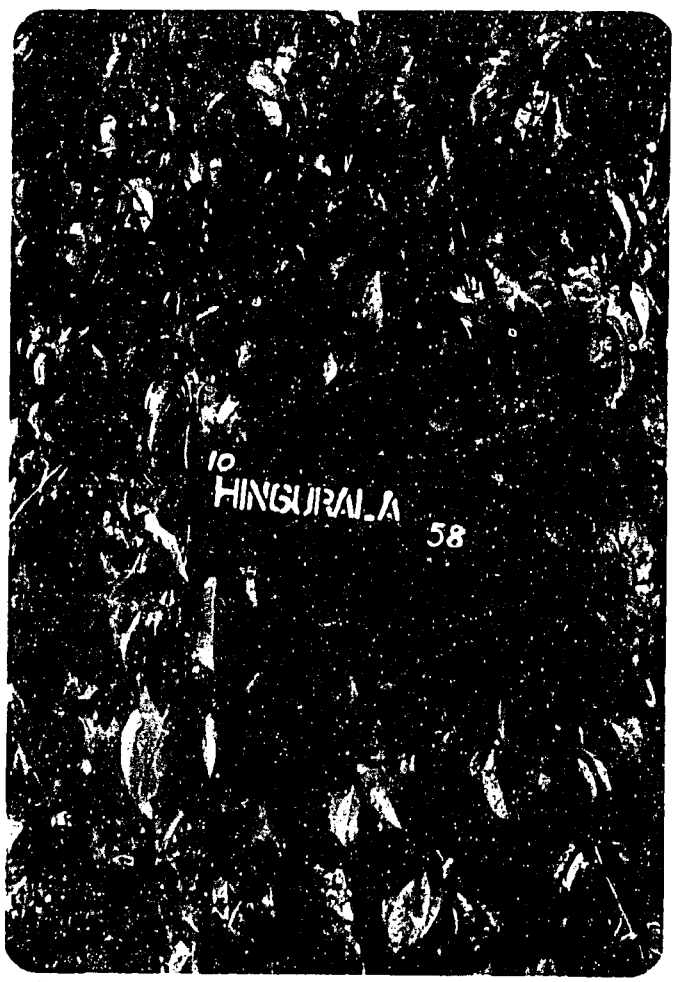


Plate 1. Vines and simple leaves of D. alata variety Hingurala

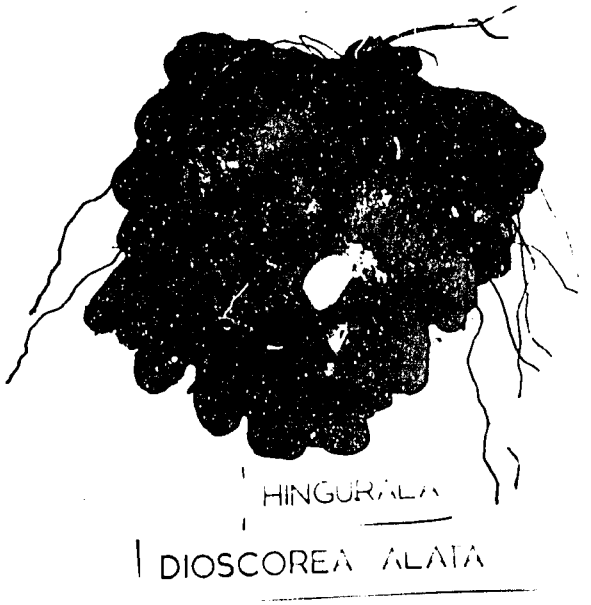


Plate 2. Tubers and roots of D. alata variety Hingurala

Male and female flowers present dioecious, male flowers small, rectangular, perianth incurved, calyx 3, corolla 3, stamens 6 in 2 whorls. Male inflorescence arise in leaf axile or tips of branches with 2-6 inflorescence per leaf axil and 1.1-3.1 cm long inflorescence having 9.46-18.0 number of flowers per inflorescence, with 27.3% male plants. Female flowers are 8-15 cm long, regular, perianth incurved, calyx 3, corolla 3, trilocular inferior ovary having 2 ovules in each locule, having 1 inflorescence per leaf axil, with 5.6-6.8 cm long inflorescence and 10.6-11.6 flowers per inflorescence; 5.4% are female plants.

Aerial tubers present, 1-2 per leaf axil, few, small, elongated or branched with a total weight of 15-425 gm.

Tubers are flat and digitate; with small digits which are deeply

divided; having 2-3 tubers per plant. Flesh is yellowish white which does not change colour in most accessions, and in a few change slightly into yellow or yellowish brown on cutting. Area below cork in purplish pink with deep purple dots, which turn to light brown on exposure to air, having a length of 5.0-39.0 cm, breadth of 7.0-35.0 cm and weight of 30 gm - 5.2 kg. Few adventitious roots are present.

Wrong accessions are 96, 128.

(b) Hiritala (accessions 263, 431, 438, 464)

Cultivated variety which sprouts early having a purplish red sprout. Stem twines to the right, with early branching and leaf formation, tender vine olive brown, mature vine yellowish green, quadrangular or stellate in cross section. Wings present, reduced, red in colour, auricles present. Spines and hairs absent.

Leaf simple, oppositely arranged, narrowly ovate, apex acuminate, base cordate, with 7 arcuate main veins: secondary and tertiary veins reticulate. Lamina olive green, base of lamina light pink, veins light yellowish green, having a length of 8.0-8.3 cm and a breadth of 5.15-5.20 cm.

Flowers and aerial tubers absent. Tubers flat and digitate, with small digits which are deeply divided with 3 tubers per plant. Flesh is yellowish white which does not change colour cutting. Area below cork is purplish pink, with deep purple dots, which turns to light brown on exposure to air. Tuber length is 7.5-16.5 centimeter, breadth of 2.5-11.5 cm, and weight of 40 gm - 1.38 kg. Few adventitious roots present.

(c) Rata hingurala (accession 445)

Cultivated variety with early sprouting, having a purplish red tinge in the sprout. Stem twines to the right. Early branching and leaf formation. Tender vine olive brown, mature vine dark olive green, quadrangular or stellate in cross section. Wings present, reduced and dark purplish red. Spines and hairs absent. Auricles present.

Leaf is simple, arrangement opposite, narrowly ovate, apex acuminate, base cordate with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina light pink and veins light yellowish green having a lamina length of 6.0 - 9.0 cm and a breadth of 3.5-5.5 cm. Petiole is yellowish green, winged with a purplish red upper and lower ends with a length of 2.5-4.0 cm. Flowers and aerial tubers absent.

Tubers is flat and digitate with small digits which are deeply divided, having 3 tubers per plant. Flesh is yellowish white which does not change colour on cutting. Surface below cork is purplish pink with deep purple dots, which turns to greyish purple on exposure to air. Tuber length is 19.0 cm, breadth is 25 cm with a weight of 2.2 kg. Few adventitious roots are present.

3. Ini ala group

(a) Ini ala (accessions 121-123, 197, 231, 249, 444, 453)

Cultivated variety with early sprouting having purplish red sprout. Stem twines to the right, with early branching and leaf formation, tender and mature vine yellowish green, quadrangular or stellate in cross section. Wings and auricles present, pink, red or

Fig. 1. Vine, leaves and flowers of D. alata variety Hingurala

Fig. 2. Tubers and roots of D. alata variety Hingurala

yellowish green. Spines and hairs absent.

Leaf simple, opposite in arrangement, ovate, apex acuminate, base cordate, venation with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina, pink or purplish red, veins light yellowish green, having a length of 9.93-13.05 cm, breadth of 5.4-9.0 cm. Petiole is winged, same colour as stem, with dark red upper and lower ends having a length of 5.94 - 9.90 cm.

Female flowers present, 10-15 cm long, regular, perianth incurved, calyx 3, corolla 3, trilocular inferior ovary with 2 ovules in each locule. Two inflorescences are found in each leaf axil with an inflorescence length of 8.4-13.0 cm and 5.6-8.2 flowers per inflorescence; 25% are female plants.

Aerial tubers present, 1-2 per leaf axil, few, small, elongated or branched, with a total weight of 220 gm.

Tubers are round and lobed with 2-3 tubers per plant. Flesh purple or white, which change to light purple or pale yellow on cutting. Area below cork in most accessions is purplish pink with deep purple dots, some are purplish red, which change the colour into purplish red in most accessions and the few into light orange yellow, having a length of 10.5-52.0 cm, breadth of 13.0-30.0, and a weight of 1.17-4.80 kg. Few adventitious roots are present. Wrong accession no. 122.

(b) Kandala (accessions 313, 314, 433)

Cultivated variety, early sprouting with a purplish red sprout. Stem twines to the right, branching and leaf formation early. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate, venation with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplish red, veins light yellowish green with a lamina length of 9.85-13.05 cm and a breadth of 7.35-9.60 cm. Petiole is yellowish green winged, with a purplish red upper and lower ends having a length of 6.35-9.35 cm. Flowers and aerial tubers absent.

Tubers are round and lobed, 2-3 tubers per plant. Flesh is yellowish white which turns to pale yellow on cutting. Below cork layer is purplish pink with deep purple dots or purplish red, which change into greyisn purple on exposure to air.

Tuber length is 6.0-20.0 cm, breadth is 4.0-30.0 cm and a weight of 70 gm - 4.9 kg. Few adventitious roots are present.

(c) Ratala (accessions 25-29, 238, 239, 278, 293, 295, 322, 445, 447

Cultivated variety with early sprouting having a purplish red sprout. Stem twines to the right, with early branching and leaf formation. Tender and mature vine yellowish green, quadrangular or stellate in cross section. Wings and auricles present, pink or

Plate 3. Female flowers of D. alata variety Ini ala

purplish red in colour. Spines and hairs absent.

Simple leaf with opposite arrangement, ovate, apex acuminate, base cordate with 7 arcuate main veins, secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplish pink, veins light yellowish green with a lamina length of 10.25-14.00 cm, and a breadth of 5.75-9.20 cm. Petiole is yellowish green, winged with purplish red upper and lower ends with a length of 5.15-9.35 cm.

Female flowers present 10-15 cm, long, regular, perianth incurved, calyx 3, corolla 3, triocular, inferior ovary with 2 ovules in each locule. Two inflorescences are present in each leaf axil with an inflorescence length of 28.5-34.0 cm, and each infloresence has flowers in the range of 19.5-25.5 cm, 7.14% are female plants.

Plate 4. Tubers and roots of D. alata variety Ini ala

Aerial tubers present, small, elongate, 1-2 per leaf axil, few in number with a total weight of 75-120 gm.

Tubers are round and lobed with 1-2 tubers per plant. Flesh is white and orange yellow which turns to orange yellow on cutting. Below cork layer is purplish pink with deep purple dots which turns to greyish purple on exposure to air. Tuber length is in the range of 16.0-43.0 cm, breadth if 9.0-30.0 cm and the weight is 2.15-6.0 kg. Few adventitious roots are present. Wrong accession number, 295.

Plate 5. Aerial tubers of D. alata variety Ini ala

4. Kahata ala group

(a) Kahata ala (accessions 16-24, 43, 132-139, 189, 195, 196, 209, 210, 236, 261, 275, 297, 329, 345, 346, 439, 446, 449, 459, 468, 474)

Cultivated variety, early sprouting with a purplish red tinge. Stem twines to the right, branching and leaf formation early, tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink or red. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina pink, red and light green, veins light yellowish green, having a length of 8.3-14.75 cm

Fig. 3. Vine, leaves, flowers and aeril tubers of D. alata variety Ini ala

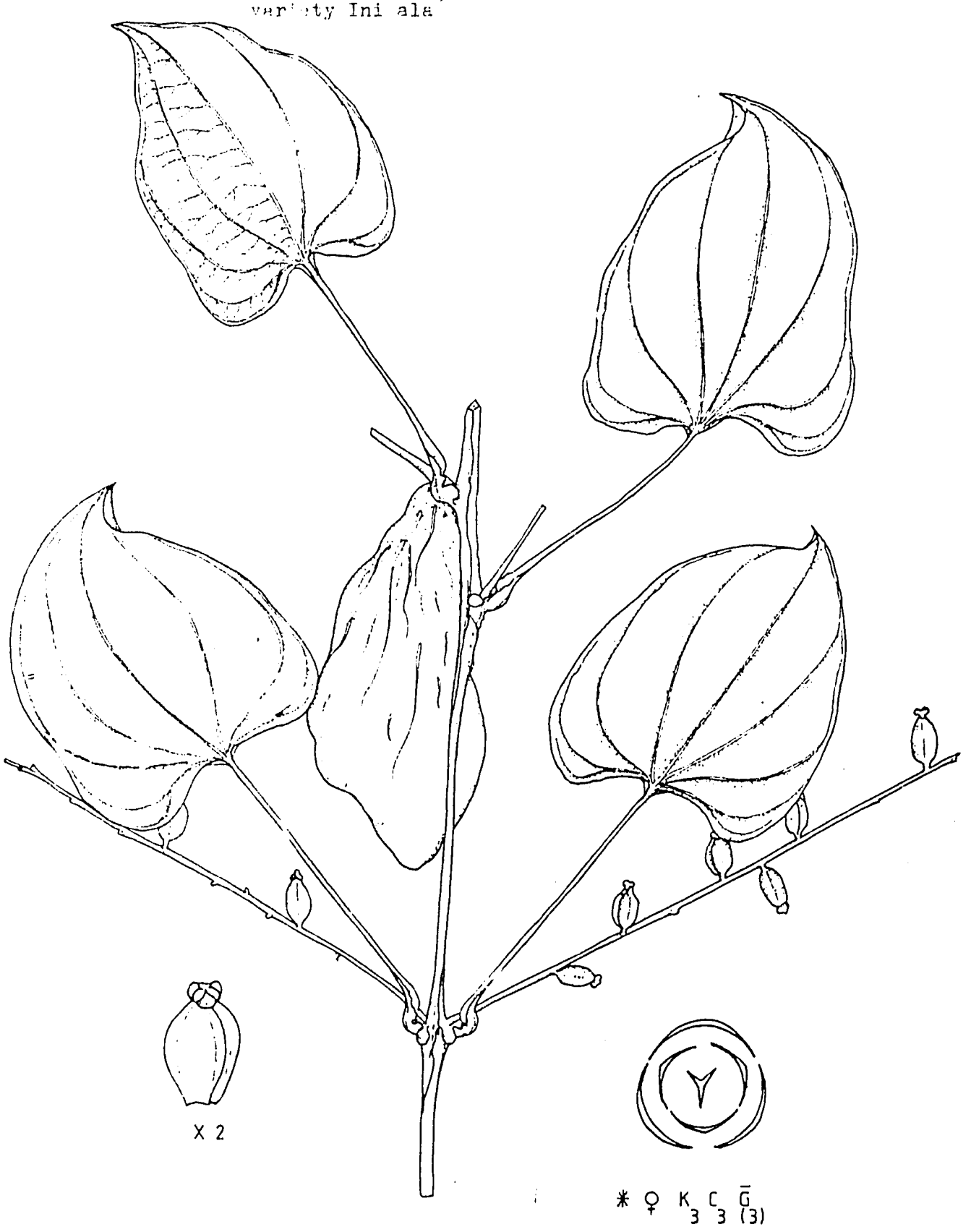


Fig. 4. Tubers and roots of D. alata variety Ini ala

and a breadth of 5.45-10.45 cm. Petiole is yellowish green, winged with dark red upper and lower ends with a length of 5.15-9.80 cm.

Both male and female flowers present, dioecious, male flowers small, regular, perianth incurved, calyx 3, corolla 3, stamens 6 in 2 whorls, 3-5 inflorescences arise in leaf axile or tips of branches, with an inflorescence length of 0.63-1.0 cm, having 6.75-11.25 flowers per inflorescence, 2.86% are male plants. Female flowers are 10-15 cm long, regular, perianth incurved, calyx 3, corolla 3, trilocular inferior ovary, having 2 ovules in each locule, 2 inflorescences arise in each leaf axil, with an inflorescence length of 10.0-22.4 cm and 6.1-11.6 per inflorescence. 8.57% are female plants.

Aerial tubers present, having 1-2 per leaf axil, few, small, elongated with a total weight of 20 gm-590 gm.

Tubers are cylindrical and lobed, having 1-2 tubers per plant. Flesh is yellowish white and pink, which change into light orange yellow or pale yellow. Surface below cork layer is orange yellow, or purplish pink with deep purple dots, which change into orange yellow or purplish red with a tuber length of 8.5-75.0 cm, a breadth of 4.5-30.0 cm and a weight of 20 gm-9.3 kg. Moderate amount of adventitous roots are present. Wrong accession numbers are 22-24, 261.

(b) Kahata kondol (accession 434)

Cultivated variety, with early sprouting, having a purplish red tinge. Stem twines to the right, branching and leaf formation early, tender and mature vines yellowish green, quadrangular or

Plate 6. Male flowers of D. alata variety Kahata ala

stellate in cross section. Wings and auricles present and purplish pink in colour. Spines and hairs absent.

Leaf is simple, arrangement is opposite, ovate, apex acuminate, base cordate, venation with 7 arcuate main veins and secondary and tertiary veins reticulate. Lamina olive green, base of lamina and veins light yellowish green with a lamina length of 8.5-12.5 cm and a breadth of 5.0-9.5 cm. Petiole is yellowish green, winged with upper and lower ends dark red, having a length of 5.0-9.0 cm. Flowers and aerial tubers absent.

Tubers are cylindrical and lobed, with 2-3 tubers per plant. Flesh is yellowish white which turns to pale yellow on cutting. Below cork layer is light orange yellow, which change to orange yellow on exposure to air. Tuber has a length of 38.0 cm, breadth of

Plate 7. Tubers and roots of D. alata variety Kahata ala

15.0 cm and a weight of 3.0 kg. Moderate amount of adventitious roots are present.

(c) Kahata angala (accessions 204, 298, 299)

Cultivated variety, sprouts early with a purplish red tinge in the sprout. Stem twines to the right, branching and leaf formation early. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, which are purplish pink in colour. Spines and hairs absent.

Leaf is simple, arrangement is opposite, ovate, apex acuminate, base cordate with 7 primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplish red, veins light yellowish green, with a lamina length of 10.0-12.35 cm, and a breadth of 5.5-6.88 cm. Petiole is yellowish green, winged, with upper and lower ends dark purplish red, having a length of 5.75-6.80 cm. Flowers absent. 1-2 aerial tubers are found in each leaf axil, few in umber, small, elongated with a total weight of 155 gm.

Tubers are cylindrical and lobed with only one tuber per plant. Flesh is yellowish white and orange yellow which change into orange yellow on cutting. Surface below cork is purplish red which change into grey purplish red on exposure to air, which has a tuber length of 25.0-35.0 cm, a breadth of 14.0-30.0 cm and a weight of 2.1-3.2 kg. Moderate amount of adventitious roots are present. Wrong accession number, 204.

(d) Kombu valli (2) - accessions 48-50

Cultivated variety with early sprouting and purplish red sprout. Stem twines to the right with early branching and leaf formation. Tender and mature vines yellowish green in colour, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate and base cordate, venation with 7 arcuate main veins and there is reticulate venation between the primary veins. Lamina olive green with light purplish pink lamina base and light yellowish green veins,

a lamina length of 10.15-11.80 cm and a breadth of 6.70-8.20 cm. Petiole is yellowish green, winged with upper and lower ends dark purplish green having a length of 8.15-9.50 cm.

Female flowers present 10-15 cm long, regular, perianth incurved, calyx 3, corolla 3, trilocular inferior ovary having 2 ovules in each locule 2 inflorescences are present in each leaf axil, with an inflorescence length of 12.45-15.65 cm, with a flower number of 8.8-11.2 per inflorescence. Aerial tubers present, 1-2 per leaf axil, few, small, elongated with a total weight of 250 gm-1 kg.

Tuber is cylindrical and lobed with 1-2 tubers per plant. Flesh is pale yellow which turns to light orange yellow on cutting. Surface below cork is light orange yellow which change to orange yellow on exposure to air. Tuber length is in the range of 30.0-50.0 cm, breadth is 22.0-40.0 cm and weight is 6.25-7.70 kg. Moderate amount of adventitious roots are present.

(e) Raja hingurala (accession 165)

Cultivated variety. Sprouting is early with a purplish red sprout. Stem twines to the right with early branching and leaf formation. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Winges and auricles present, purplish pink in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina light pink, and veins light yellowish green, having a lamina length of 7.5-13.0 cm and a

breadth of 4.5-9.0 cm. Petiole is yellowish green, winged with purplish red upper and lower ends having a length of 5.0-8.0 cm. Flowers and aerial tuber are absent.

Tuber is cylindrical and lobed having only 1 tuber per plant. Flesh is light yellow which change to orange yellow on cutting. Below cork is pale yellow which changes to orange yellow on exposure to air. Tuber length is of 32.0 cm, breadth is of 13.0 cm and a weight is 5.8 kg. Moderate amount of adventitious roots are present.

5. Kiri kondol group

(a) Kiri kondol (accessions 89-94, 435, 440)

Cultivated variety, with early sprouting, having a purplish red tinge in the sprout. Stem twines to the right, early branching and leaf formation. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate, venation with 7 arcuate main veins, with reticulate venation between the primary veins. Lamina olive green, base of lamina and veins light yellowish green, with a lamina length of 11.25-15.30 cm and a breadth of 6.53-7.80 cm. Petiole is yellowish green, winged with dark red upper and lower ends having a length of 5.10-7.10 cm.

Female flowers present, 10-15 cm long, perianth incurved, regular, calyx 3, corolla 3, trilocular inferior ovary, having 2

ovules in each locule. Flowers are borne on inflorescences having 2 inflorescence per leaf axil, with an inflorescence length of 3.25-7.0 cm and 2.0-5.0 flowers per inflorescence, 12.5% are female plants. Aerial tubers absent.

Tubers are round with 1-2 tubers per plant. Flesh is yellowish white, which turns to pale yellow on cutting. Surface below cork is pale yellow change to orange yellow on exposure to air. Tuber length is in the range of 8.0-24.0 cm, breadth is 8.0-19.0 cm and weight is 530gm-4.85 kg. Few adventitious roots are present.

(b) Kiri ala (accessions 207, 254, 448)

Cultivated variety, with early sprouting, having a purplish red tinge in the sprout. Stem twines to the right, branching and leaf formation is early. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate, with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina and veins light yellowish green. Lamina length is 11.50-16.35 cm, and breadth is 6.20-9.80 cm. Petiole is yellowish green, winged and upper and lower ends purplish red having a length of 5.30-7.40 cm. Flowers absent. Aerial tubers present 1-2 per leaf axil, few, small and round, with a total weight of 45 gm.

Tubers are round having 1-2 tubers per plant. Flesh is yellowish white, which change to pale yellow on cutting. Below cork

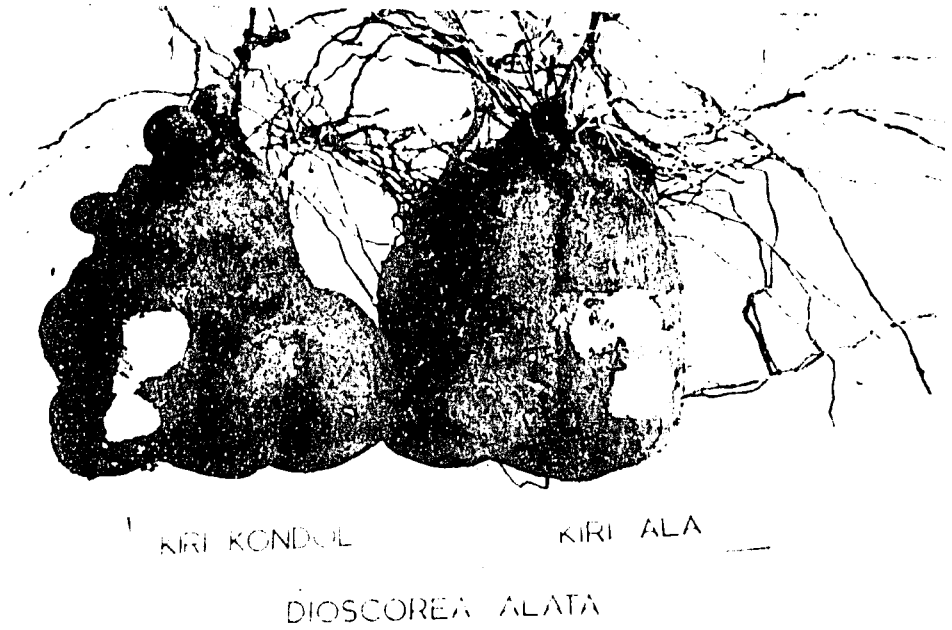


Plate 8. Tubers and roots of D. alata varieties Kiri kondol and Kiri ala

is purplish pink with deep purple dots which change to orange yellow on exposure to air. Tuber length is in the range of 21.0-24.0 cm, breadth is 13.0-16.0 cm and the weight is 2.4-5.0 kg. Few adventitious roots are present.

(c) Kiri adala (accessions 466)

Cultivated variety, early sprouting with a purplish red tinge in the sprout. Stem twines to the right with early branching and leaf formation. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present purplish pink in colour spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate, with 7 arcuate main veins; secondary and tertiary veins

reticulate. Lamina olive green, base of lamina and veins light yellowish green, having a length of 6.5-13.0 cm, and a breadth of 4.0-6.5 cm. Petiole is yellowish green, winged with a length of 4.0-8.0 cm. Flowers and aerial tubers absent.

Tubers are round with 1-2 tubers per plant. Flesh is yellowish white which change to pale yellow on cutting. Below cork is pale yellow which change to orange yellow on exposure to air. Tuber length is 13 cm, breadth 10 cm with a weight of 1.9 kg. Few adventitious roots are present.

(d) Kondol ala (accessions 212)

Cultivated variety, with early sprouting having a purplish red colour sprout. Stem twines to the right, with early branching and leaf formation. Tender and mature vines olive green, quandrangular or stellate in cross section. Wings and auricles present, purplish red in colour. Hairs absent. Spines present, less prominent and found in mature stem only, having 28-38 spines per 30 cm length of stem.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate, venation with 7 arcuate primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina and veins light yellowish green, having a lamina length of 6.5-10.5 cm, and a breadth of 5.0-9.5 cm. Petiole is yellowish green, winged with light purplish pink upper and lower ends having a length of 3.0-6.0 cm. Flowers absent. Aerial tubers present, having 1-2 per leaf axil, few in number, small and round having a total weight of 105 gm.

Tubers is round with 1 tuber per plant. Flesh is yellowish white, which turns to pale yellow on cutting. Surface below cork is pale yellow which turns to orange yellow on exposure to air. Tuber length is of 290.0 cm, breadth is 20 cm, weight is 2.1 kg. Few adventitious roots are present.

(e) Puerto Rico yams (accessions 214, 215, 217, 218, 220, 221, 223-229)

Cultivated variety with early sprouting, having a purplish red tinge in the sprout. Stem twines to the right. Branching and leaf formation is early. Tender and mature vine yellowish green, quadrangular or stellate in cross section. Wings and auricles present, yellowish green in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate, venation with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina is olive green, base of lamina and veins light yellowish green with a lamina length of 10.00-14.60 cm, and a breadth of 5.10-8.75 cm. Petiole is yellowish green, winged with a length of 3.45-7.85 cm. Flowers and aerial tubers absent.

Tubers are more or less round with 1-2 tubers per plant. Flesh is yellowish white, which turns to pale yellow on cutting. Below cork is light orange yellow which turns to orange yellow on exposure to air. Tuber length is in the range of 9.0-34.0 cm, breadth is 12.0-30.0 cm and a weight is 560 gm-8.29 kg. Few adventitious roots are present.

6. Leydanta group

(a) Leydanta (accessions 95, 168, 169, 465)

Cultivated variety with early sprouting, having a purplish red sprout. Stem twines to the right, with early branching and leaf formation. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish red in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina light purplish pink and veins light yellowish green with a lamina length of 11.60-11.75 cm and a breadth of 7.25-7.35 cm. Petiole is yellowish green, winged with upper and lower ends being purplish red, having a length of 7.00-8.30 cm. Flowers and aerial tubers are absent.

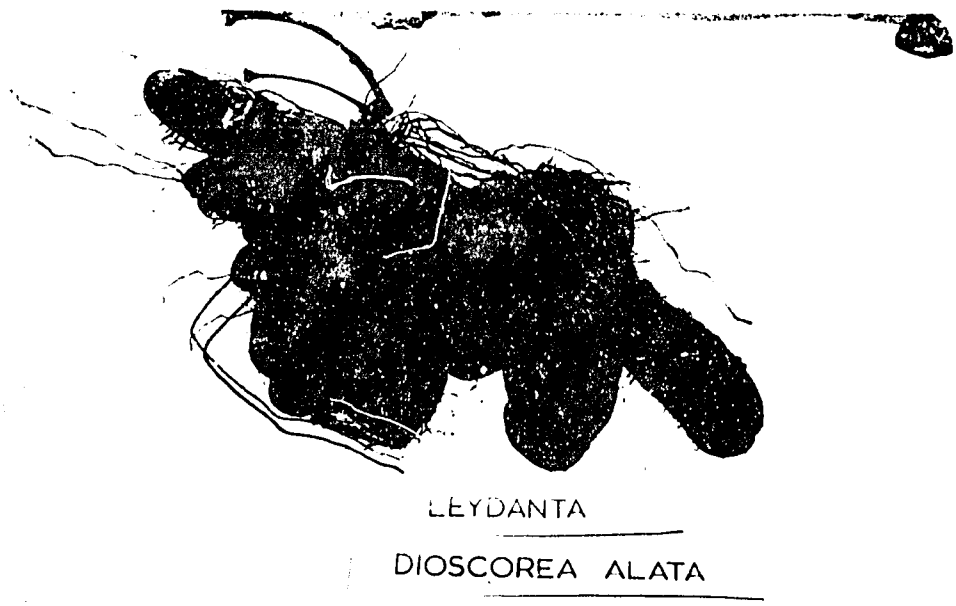


Plate 9. Tubers and roots of D. alata variety Leydanta

Tubers are round lobed with 1-2 tubers per plant. Flesh and surface below cork are deep purple in colour which change to blackish purple on cutting and exposing to air. Tuber length is in range of 19.0-39.0 cm, breadth is 16.0-50.0 cm and the weight is 1.32-4.25 kg. Few adventitious roots are present.

(b) Dandila (accessions 430)

Cultivated variety, which sprouts early, having a purplish red sprout. Stem twines to the right, branching and leaf formation early, tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs absent.

Leaf simple, oppositely arranged, ovate, apex acuminate, base cordate, with 7 arcuate main veins, secondary and tertiary veins reticulate. Lamina olive green, base of lamina, light purplish pink, veins light yellowish green, having a length of 10.0-15.0 cm, breadth of 5.0-9.0 cm. Petiole is winged, yellowish green, with upper and lower ends purplish red having a length of 4.5-8.5 cm.

Flowers and aerial tubers absent.

Tubers are round and lobed having 2 tubers per plant. Flesh and the surface below cork is deep purple which turn to blackish purple on cutting and exposure to air. Tuber length is 12 cm, breadth is 17 cm, with a weight of 700 gm. Few adventitious roots

are found on tubers.

(c) Kombu valli (1) -(accessions 44-47)

Cultivated variety with early sprouting having a purplish red tinge in the sprout. Stem twines to the right with early branching and leaf formation. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement ovate, apex acuminate, base cordate, with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina is light purplish pink and veins light yellowish green, having a lamina length of 9.95-10.60 cm and a breadth of 5.50-7.50 cm. Petiole is yellowish green, winged with upper and lower ends being dark purplish red, having a length of 6.25-7.90 cm.

Female flowers present, 10-15 cm long, regular, perianth incurved, calyx 3, corolla 3, trilocular inferior ovary with 2 ovules in each locule, 2 inflorescences are found in each leaf axil with an average inflorescence length of 13.35-14.65 cm, and flowers are in the range of 7.9-9.8 per inflorescence; 75% are female plants. Aerial tubers are absent.

Tubers round and lobed with 1-2 tubers per plant. Flesh and surface below cork are deep purple in colour which does not change on cutting or exposure to air. Tuber length is of 2.0-4.0 cm and breadth is 2.0-3.0 cm, having a weight of 3.3-6.5 kg. Few adventitious roots are present.

7. Raja ala group

(a) Raja ala (accessions 1-15, 158, 159, 205, 208, 250, 265, 272-276, 290-292, 331-337, 343, 451, 461, 467, 471

Cultivated variety with early sprouting, having a purplish red tinge in the sprouts. Stem twines to the right. Branching and leaf formation early. Tender vines is dark olives green or yellowish green, mature vine is yellowish green; quadrangular or stellate in cross section. Wings and auricles present, pink or purplish red, spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base shallowly cordate with 7 primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplished red. Veins on the upper surface is light purplish pink and veins on the lower surface purplish red. Lamina length is 8.50-13.80 cm and breadth is 6.0-10.25 cm. Petiole is yellowish green, winged with purplish red upper and lower ends, and the length is 5.00-10.35 cm. Flowers absent. Aerial tubers present, 1-2 per leaf axil, few, small, round, with a total weight of 40-60 gm.

Tuber is round with 1-3 tuber per plant. Flesh is purple which change to light purple on cutting. Surface below cork is purplish red which turns to deep purplish red on exposure to air. Tuber length is in the range of 4.0-40.0 cm, breadth is 3.5-32.0 cm with a weight of 70 gm - 5.5 kg. Few adventitious roots are present. Wrong accession number are 205, 208, 273, 290, 291, 332, 250.

(b) Raja valli (accessions 455, 456)

Cultivated variety. Sprouting is early having a purplish red sprout. Stem twines to the right. Branching and leaf formation is early. Tender vine dark olive green, mature vine yellowish green, quadrangular or stellate in cross section. Winges and auricles present, purplish pink in colour. Spines and hairs absent.

Simple leaf with opposite arrangement, ovate, apex acuminate, base shallowly cordate with 7 arcuate main veins and there is reticulate venation between the main veins. Lamina olive green, base of lamina is dark purplish red, veins on the upper surface is light yellowish green and veins on the lower surface, purplish red with a lamina length of 11.0-14.0 cm and a breadth of 8.0-11.0 cm. Petiole is yellowish green, winged with purplish red upper and lower ends having a length of 5.5-9.0 cm. Flowers and aerial tubers absent.

Tubers are round with 1-3 tubers per plant. Flesh is purple which change into light purple on cutting. Below cork layer is purplish red, which turns to deep purplish red on exposure to air. Tuber length is 9.0 cm, breadth is 10.0 cm and the weight is 520 gm. Few adventitious roots are present.

(c) Rasa valli (accessions 38-42, 116-120, 139, 140, 147-150)

Cultivated variety which sprouts early, having a purplish red sprout. Stem twines to the right. Early branching and leaf formation. Tender vine yellowish green or dark olive, mature vine

yellowish green quadrangular or stellate in cross section. Wings and auricles present, purplish pink. Spines and hairs absent.

Leaf is simple, arrangement opposite, ovate, apex acuminate, base shallowly cordate, venation with 7 primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina dark purplish red, veins on the upper surface is light yellowish green, lower surface is purplish red with a lamina length of 9.60-13.70 cm and a breadth of 7.25-8.85 cm. Petiole is yellowish green, winged with a purplish red upper and lower surface having a length of 5.40-7.90 cm. Flowers and aerial tubers are absent.

Tubers are round with 1-3 tuber per plant. Flesh is purple which change to light purple on cutting. Area below cork is purplish red which change into deep purplish red on exposure to air. Tuber length is in the range of 11.0-21.0 cm, breadth is 13.0-29.0 cm with a weight of 850 gm - 385 kg. Few adventitious roots are present. Wrong accession numbers 116, 118.

(d) <u>King yam</u> (accessions 383-404, 406, 407, 409-412, 414-428)

Cultivated variety, which sprouts early, having a purplish red sprout. Stem twines to the right, branching and leaf formation is early. Tender vine dark olive green, mature vine yellowish green, quadrangular or stellate in cross section. Wings and auricles present, pink or purplish red in colour. Spines and hairs absent.

Plate 10. Flowers and roots of D.alata variety Rasa valli

Plate 11. Vines and simple leaves of D.alata variety King yam

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base shallowly cordate with 7 arcuate primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplish red, veins on the upper surface is light purplish pink and on the lower surface is purplish red. Lamina length is of 10.0-15.55 cm. and the breadth is 6.75-12.30 cm. Petiole is yellowish green, winged with dark purplish red upper and lower ends with a length 4.45-10.80 cm. Flowers and aerial tubers are absent.

Tubers are found having 1-2 tubers per plant. Flesh is purple which change to light purple on cutting. Surface below cork is purple red, which change to deep purplish red on exposure to air, with a tuber length of 8.0-24.0 cm, a breadth of 6.0-20.0 cm and a weight of 60 gm - 3.93 kg. Few adventitious roots are present.

(e) Jaffna purple (accessions 66-69)

Cultivated variety, which sprouts early. Sprout with a purplish red tinge. Stem twines to the right, with early branching and leaf formation, tender and mature vine yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish red in colour. Spines and hairs absent.

Leaf simple, arrangement opposite, ovate, apex acuminate, base shallowly cordate, with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplish red, veins on the upper surface are light yellowish green and veins on the lower surface are light purplish pink, leaf length

is 11.73-12.50 cm, breadth is 8.5-9.45 cm. Petiole is yellowish green, winged with dark red upper and lower ends, having a length of 8.0-9.55 cm. Flowers absent.

Aerial tubers present, 1-2 per leaf axil, few in number, small, round, with a total weight of 85-90 gm.

Tubers are round, 1-3 tubers per plant. Flesh is purple which change to light purple when cut. Below cork is purplish red which change into deep purplish red on exposure to air. Tuber has a length of 11.-13.0 cm, breadth of 14.0-21.0 cm and a weight of 1.93-3.40 kg. Few adventitious roots are present.

(f) Jaffna collection (accessions 176-178, 475-477)

Cultivated variety with early sprouting, and purplish red sprout. Stem twines to the right branching and leaf formation early, tender and mature vines yellowish green, quadrangular or stellate stem. Wings and auricles present, purplish red in colour. Spines and hairs absent.

Leaf is simple, arrangement opposite, ovate, apex acuminate, base shallowly cordate with 7 arcuate primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplish red. Veins on the upper surface are light purplish pink, and veins on the lower surface are purplish red in colour. Lamina length is 10.65-14.45 cm and breadth is 8.7-11.15 cm. Petiole is yellowish green, winged, with dark red upper and lower ends, having a length of 6.60-10.15 cm. Flowers and aerial tubers absent.

Tubers are round with 1-3 tubers per plant. Flesh is purple which change into light purple on cutting. Below cork is purplish red which change into deep purplish red on exposure to air, with a tuber length of 8.0-20.0 cm, and a breadth of 10.0-20.0 cm and a weight of 540 gm - 3.54 kg. Few adventitious roots present.

Plate 12. Tubers and roots of D.alata variety Ratu ala

8. Ratu ala group

(a) Ratu ala (accessions 191, 192, 203, 271)

Cultivated variety with early sprouting having a purplish red sprout. Stem twines to the right. Early branching and leaf formation. Tender vine yellowish green or dark olive, mature vine yellowish green, quadrangular or stellate in cross section. Wings

and auricles present, pink or purplish red in colour. Spines and hairs are absent.

Simple leaf with opposite arrangement, ovate, apex acuminate, base cordate with 7 arcuate main veins, secondary and tertiary veins reticulate. Lamina olive green, base of lamina dark purplish pink, veins light yellowish green with a lamina length of 9.45-11.85 centimeter and a breadth of 6.20-9.10 cm. Petiole is yellowish green, winged with purplish red upper and lower ends with a petiole length of 5.45-7.75 cm. Flowers and aerial tubers absent.

Tubers are round and lobed with 1-2 tubers per plant. Flesh is white or white and orange yellow which change to orange yellow on cutting. Below cork layer is purplish red or purplish pink with deep purple dots which turn to grey purplish red on exposure to air. Tuber length is in the range of 7.0-32.0 cm, breadth 6.0-25.0 cm and weight is 150 gm - 4.4 kg. Few adventitious roots are present. Wrong accession numbers are 192, 271.

(b) Ratangala (accession 347)

Cultivated variety. Sprouting is early with a purplish red tinge in the sprout. Stem twines to the right, with early branching and leaf formation. Tender and mature vine yellow green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs absent.

Simple leaf with opposite arrangement, ovate, apex acuminate, base cordate. Venation with 7 arcuate main veins; secondary and

tertiary veins reticulate. Lamina olive green, base of lamina light pink, veins light yellowish green with a lamina length of 8.5-11.0 cm, and a breadth of 5.0-6.5 cm. Petiole is yellowish green, winged with dark purplish red upper and lower ends, having a length of 4.0-5.5 cm. Flowers and aerial tubers absent.

Tubers are round and lobed with 1-2 tubers per plant. Flesh is white and purple which change to orange yellow on cutting. Surface below cork is deep purple which does not change colour on exposure to air. Tuber length is 40 cm, breadth is 12 cm, and the weight is 5.76 kg. Few adventitious roots are present.

9. Suduraja ala group

(a) Suduraja ala (accession 200)

Cultivated variety with early sprouting, having a purplish red tinge in the sprout. Stem twines to the right with early branching and leaf formation. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink. Spines and hairs absent.

Leaf is simple with opposite arrangement, ovate, apex acuminate, base shallowly cordate, venation having 7 primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina deep pink and veins light yellowish green having a lamina length of 12.5-15.0 cm, yellowish green, winged with purplish red upper and lower ends having a length of 4.5-6.5 cm. Flowers and aerial tubers absent.

Tubers are more or less round with 2 tubers per plant. Flesh is yellowish white which does not change colour on cutting. Surface below cork is purplish pink with deep purple dots which turns greyish purple on exposure to air. Tuber length is 17.0 cm, breadth 10 cm, and the weight 870 gm. Few number of adventitious roots are present.

10. Tambala group

(a) Tambala (accessions 30-33, 35-37, 128-131, 248)

Cultivated variety which sprouts early, having a purplish red tinge in the sprout. Stem twines to the right. Branching and leaf formation is early. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate base cordate, venation with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina light pink or red, veins light yellowish green having a lamina length of 9.75-12.30 cm, and a breadth of 5.90-8.0 cm. Petiole is yellowish green, winged with upper and lower ends purplish red having a length of 6.00-7.55 cm. Flowers absent. Aerial tubers present, small, elongated, 1-2 per leaf axil, few in number with a total weight of 25 gm.

Tubers are round and lobed with 1-2 tubers per plant. Flesh is light orange yellow which change to orange yellow on cutting.

Below cork layer is purplish red which change to deep purple on exposure to air. Tuber length is in the range of 15.0-32.0 cm, breadth is 10.0-24.0 cm and the weight is 1.4-6.45 kg. Few adventitious roots are present. Wrong accession numbers 35, 36, 130, 248.

(b) Jamburala (accessions 251, 460)

Cultivated variety, with early sprouting, having a purplish red tinge in the sprout. Stem twines to the right, with early branching and leaf formation. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour spines and hairs absent.

Leaf is simple, opposite in arrangement, ovate, apex acuminate, base cordate, with 7 arcuate main veins; secondary and tertiary veins recticules. Lamina olive green base of lamina dark purplish red, veins light yellowish green, having a length of 8.20-11.0 cm, breadth of 5.9-6.5 cm. Petiole is winged, yellowish green with upper and lower ends dark purplish red having a length of 4.0-5.6 cm.

Flowers and aerial tubers absent. Tubers are round and lobed with 1-2 tubers per plant. Flesh is light orange yellow which turns to orange yellow on cutting. Below cork layer is purplish red, light purple with deep purple dots which turns to deep purple or deep brown on exposure to air. Tubers having a length of 30-43 cm, breadth 18-22 cm, and a weight of 3.26-5.1 kg. Few adventitious roots are present.

11. Urumpirai group

(a) Urumpirai (accession 144, 145)

Cultivated variety. Early sprouting, having a purplish red tinge in the sprout. Stem twines to the right, branching and leaf formation is early. Tender and mature vines yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink, spines and hairs absent.

Simple leaf with opposite arrangement, ovate, apex acuminate, base cordate, venation having 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina purplish red, veins light yellowish green, having a lamina length of 6.5-12.0 cm and a breadth of 3.5-10.0 cm. Petiole is yellowish green, winged with upper and lower ends purplish red with a length of 4.0-7.5 cm. Flowers absent. Aerial tubers present, small, round, 1-2 per leaf axil, few, similar in appearence to underground tuber with a total weight of 1.0 kg.

Tuber is round with 1 tuber per plant. Flesh is pale yellow which change to yellow on cutting. Below cork is light orange yellow which change to brown in colour. Tuber length is in the range of 19.0-30.0 cm, breadth 14.0-16.0 cm and the weight 3.95-5.30 kg. Moderate amount of adventitious roots present.

12. Wal ala group

(a) Wal ala (accession 190)

Wild veriety. Sprouting is early having a purplish red tinge

in the sprout. Stem twines to the right, branching and leaf formation early. Tender and mature vine yellowish green, quadrangular or stellate in cross section. Wings and auricles present, purplish pink in colour. Spines and hairs are absent.

Simple leaf, opposite in arrangement, ovate, apex acuminate, base cordate with 7 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina light pink, and veins light yellowish green having a lamina length of 6.0-7.5 cm and a breadth 3.5-5.0 cm. Petiole is yellowish green, winged with upper and lower ends purplish red with a length of 3.5-5.5 cm. Flowers and aerial tubers absent.

Tuber is cylindrical and lobed with 1 tuber per plant. Flesh is yellow which change to light orange yellow on cutting. Surface below cork is pale yellow which change to brown on exposure to air. Tuber length is 33.0 cm, breadth 12.0 cm and the weight 2.35 kg. Few adventitious roots present.

(?) Dioscorea bulbifera:

There are 4 forms in this species. Tubers sprout early and the sprout has a green colour. Branching and leaf formation is late. Stem twines to the left, circular in cross section. Wings, spines and hairs absent. Base of petiole is enlarged to form two ear like projections (auricles) encircling them.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate, base cordate. Venation with 9 arcuate primary veins of

which 3 reach the apex of the leaf. Secondary and tertiary veins are reticulate.

Flowers present which function as male flowers or staminodes. Aerial tubers or bulbils are produced in large number and resemble the underground tuber to some extent.

Tubers are of medium size and usually 1-2 tubers per plant, spherical or ellipsoidal. Flesh colour is mostly yellow, some have purple blotches. Surface below cork layer is green or yellow in colour.

The varieties can be grouped into 2 groups according to the morphological characteristics:

1. Mothaka valligroup - (a) Mothaka valli
   (b) Rasa valli (yellow flesh)
   (c) Jaffna collection (accessions 179-182)
2. Udala group - (a) Udala

1. Mothaka valli group

(a) Mothaka valli (accessions 101-103, 105, 106, 109, 110, 157, 158)

Cultivated variety with early sprouting and the sprout is green in colour. Stem twines to the left. Branching and leaf formation is late. Tender and mature vines yellowish green, vines are circular in cross section. Wings, spines and hairs are absent. Auricles are present.

Leaf is simple with alternate arrangement, broadly ovate, apex acuminate, base cordate, venation with 9 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green in colour, base of lamina and veins light yellowish green with a lamina length of 7.25-11.20 cm and a breadth of 6.00-10.35 cm. Petiole is yellowish green, 4.10-7.30 cm long with a tinge of greyish purplish red at the lower end.

Functionally male flowers present, small, regular, with a spreading perianth, calyx 3, corolla 3, 6 stamens in 2 whorls, 3 stigma are present. Flowers arise in leaf axils, 1-3 inflorescences per axil with an inflorescence length of 0.6-6.2 cm and 9.86-29.2 flowers per inflorescence. 87.5% are flowering plants.

Large number of aerial tubers or bulbils are present, 1 per leaf axil, small, medium and large size, round and smooth, edible, with a total tuber weight of 285 gm - 3.28 kg.

Tubers are round 1-2 tubers per plant. Flesh is yellowish green which change the colour to yellow on cutting. Surface below cork layer is light green which change into pale yellowish green on exposure to air. Tuber length is of 7.0-20.0 cm, breadth is 8.0-19.0 cm, and weight is 450 gm - 3.6 kg. Moderate amount of adventitious roots are present.

Plate 13. Vines and simple leaves of D.bulbifera variety Mothaka valli

(b) Rasa valli (yellow flesh) (accessions 141-143)

Cultivated variety. Sprouting is early, having a green sprout. Stem twines to the left. Late branching and leaf formation. Tender and mature vines yellowish green, circular in cross section. Auricles present. Spines, hairs and wings absent.

Leaf is simple with alternate arrangement of leaves, broadly

MOTAKA WALLI

DIOSCOREA BULBIFERA

Plate 14. Tubers and roots of D.bulbifera variety Mothaka valli

Plate 15. Male flowers of D.bulbifera variety Mothaka valli

ovate, apex acuminate, base cordate. Venation with 9 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina and veins light yellowish green with a lamina length of 10.30-11.5 cm, and a breadth of 7.80-10.10 cm. Petiole is yellowish green, 5.20-6.55 cm long, with a tinge of grey purplish red at the lower end.

Functionally male flowers present, small, regular with a spreading perianth, calyx 3, corolla 3, 6 stamens in 2 whorls, 3 stigma present, 1-3 inflorescences per leaf axil, having an inflorescence length of 0.9-1.64 cm with 16.4-26.8 flowers per inflorescence. All the plants flowered.

Large number of aerial tubers or bulbils are present, having one bulbil per leaf axil, small, medium and large size, round and smooth edible, with a total tuber weight of 1.12-1.14 kg.

Tubers are round with 1-2 tubers per plant. Flesh is greenish yellow which turns to yellow on cutting. Below cork is pale yellow which has the same colour on exposure to air. Tuber length range from 13.0-21.9, breadth 14.0-19.0 cm, and a weight of 1.18-2.0 kg. Moderate amount of adventitious roots present.

(c) Jaffna collection (accessions 179-182)

Cultivated variety. Sprouting is early. Sprout is greenish in colour. Stem twines to the left. Branching and leaf formation late. Tender and mature vine yellowish green, circular in cross section. Wings, spines and hairs absent. Auricles present.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate, base cordate, venation with 9 arcuate primary veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina and veins light yellowish green with a lamina length of 8.65-11.00 cm, and a breadth of 7.00-11.30 cm. Petiole is yellowish green, 5.0-6.95 cm long having a tinge of grey purplish red at the lower end. Functionally male flowers present, regular, with a spreading perianth. Calyx 3, corolla 3, 6 stamens in 2 whorls, 3 stigma present, 1-3 inflorescence arise in leaf axils with an inflorescence length of 2.28-6.72, having 29.2-44.2 flowers per inflorescence. 75% of the plants flowered. Large number of aerial tubers or bulbils are present, 1 per leaf axil, small medium to large size, round and smooth, edible, having a total weight of 730 gm - 1.73 kg. Tubers are round, 1-2 tubers per plant. Flesh is yellowish green, which change to yellow on cutting. Below cork is light green which change to pale yellowish green on exposure to air. Tubers have a length of 14-23 cm, breadth of 18-21 cm and a weight of 1.75-3.0 kg. Moderate amount of adventitious roots present.

2. Udala group

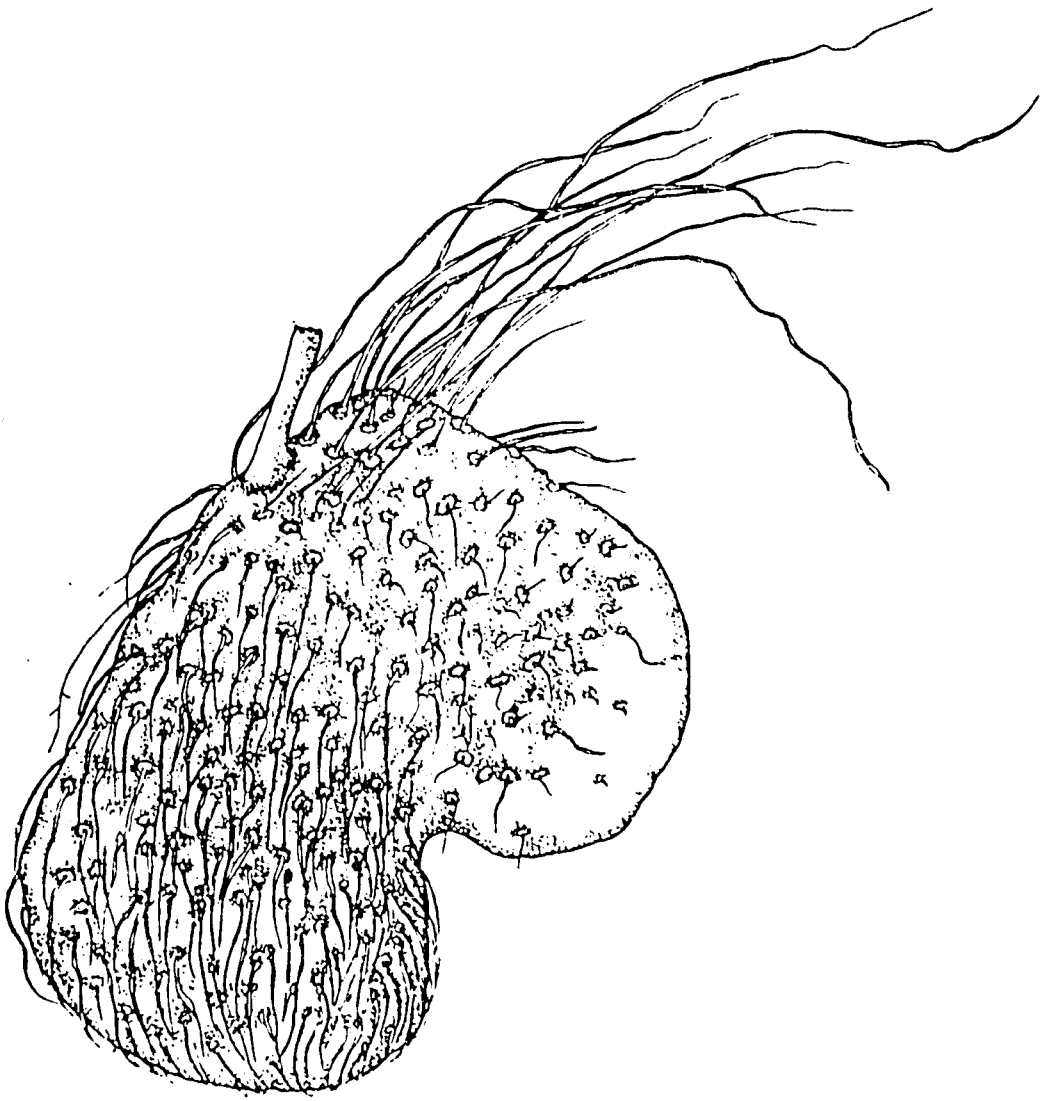
(a) Udala

There are 2 types of Udala, namely, Udala (1) and Udala (2).

Udala (1) (accessions 171, 280, 283-288, 432, 472).

Fig. 5. Vine, leaves, flowers and aerial tuber of D. bulbifera variety Udala

Fig. 6. Tubers and roots of D. bulbifera variety Udala



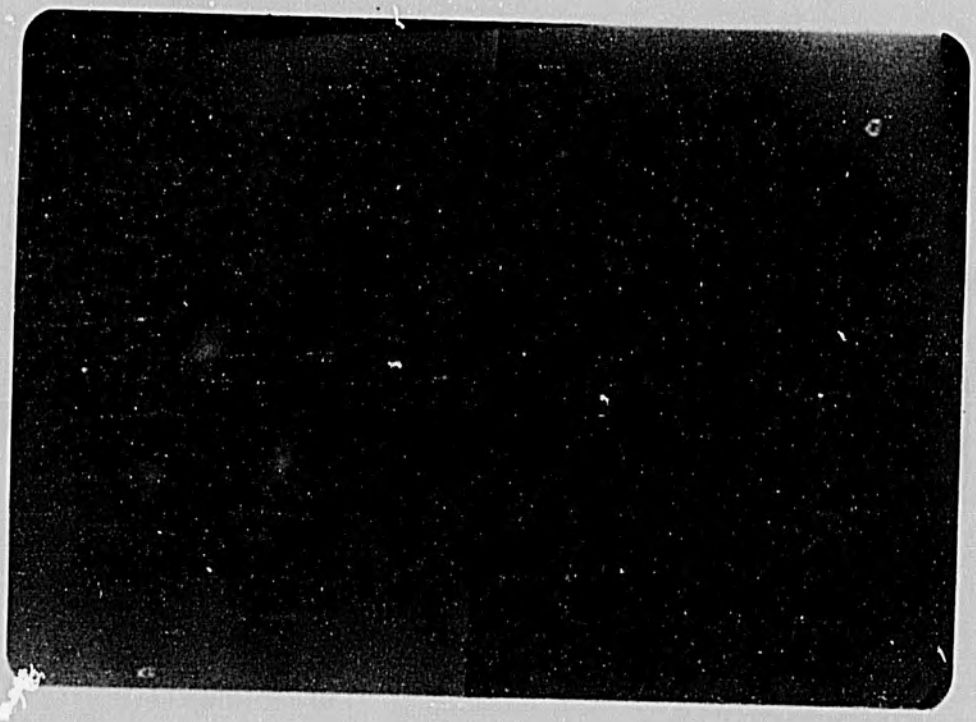


Plate 16. Aerial tubers of D.bulbifera varieties Hothaka valli, Udala (1) and Udala (2)

wild variety. Early sprouting with a green sprout. Stem twines to the left, branching and leaf formation is late. Tender and meture vines yellowish green, circular in cross section. Vines spines and hairs absent. Auricles present.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate, base cordate. Venation with 9 arcuate primary veins with reticulate venation between the primary veins. Lamina olive green, base of lamina and veins light yellowish green with a length of 6.65-11.50 cm, and a breadth of 4.30-10.65 cm. Petiole is yellowish green, 4.30-10.40 cm long with a tinge of grey purplish red at the lower end.

Functionally male flowers, small, regular with a spreading perianth, calyx 3, corolla 3, 6 stamens in 2 whorls, 3 stigma present. 1-3 inflorescence in each leaf axil with an inflorescence length of 1.38-17.57 cm and 10.0-45.5 flowers per inflorescence. 85.7% of the plants flowered.

Aerial tubers or bulbils are present in large number, 1 per leaf axil, small, medium and large size, round with rough surface. Non edible variety with a total weight of 505 gm - 2.14 kg, of aerial tuber per plant. This form seems to be intermediate between Mothaka valli and Udala (2).

Tuber is round with 1-2 tubers per plant. Flesh is greenish yellow with light purple blotches. The flesh colour change to yellow on cutting. Below cork layer is pale yellow which does not change colour on exposure to air. Tuber length is 11.0-45.0 cm, breadth is 11.0-19.0 cm and the weight is 450 gm - 3.10 kg. Moderate amount of adventitious roots present. Wrong accession numbers 432, 285.

Udala (2) (accessions 309)

Wild variety. Sprouting is early and the sprout is green in colour. Stem twines to the left, branching and leaf formation late. Tender vine yellowish green, mature vine reddish brown, circular in cross section. Wings, spines and hairs absent. Auricles present.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate tails, base cordate with 9 arcuate main veins; secondary

and tertiary veins reticulate. Lamina olive green, base of lamina and veins light yellowish green with a lamina length of 4.0-10.5 cm and breadth of 2.0-7.5 cm. Petiole light brown 3.0-5.5 cm long with a greyish purplish red tinge at lower end.

Functionally male flowers present, small, regular with a spreading perianth, calyx 3, corolla 3, 6 stamens in 2 whorls, 3 stigma present. 3-4 inflorescences arise in leaf axil having an inflorescence length of 1.0-15.5 cm and flowers are in the range of 9.33-23.67 per inflorescence.

Aerial tubers or bulbils are present, large number, 1 per leaf axil, small, medium and large size, round or elliptical with a warty surface; warts prominent. Non edible variety. The plant had a total tuber weight of 835 gm per plant.

Tuber is ellipsoidal in shape with 1-2 tubers per plant. Flesh is yellow which turns to orange yellow on cutting. Below cork is light yellow which turns to orange yellow on exposure to air. Tuber length is 9.5 cm, breadth 15.0 cm and weight 1.2 kg. Tubers appear very hairy due to a large number of adventitious roots.

(3) Dioscorea esculenta

There are 4 forms in this species. These yams sprout late when compared with other species. The sprout has a greenish tinge. Branching and leaf formation is early. Stem twines to the left, circular in cross section. Wings and auricles absent, pubescent,

Fig 7.. Vine, leaves and flowers of D.esculenta variety Java ala

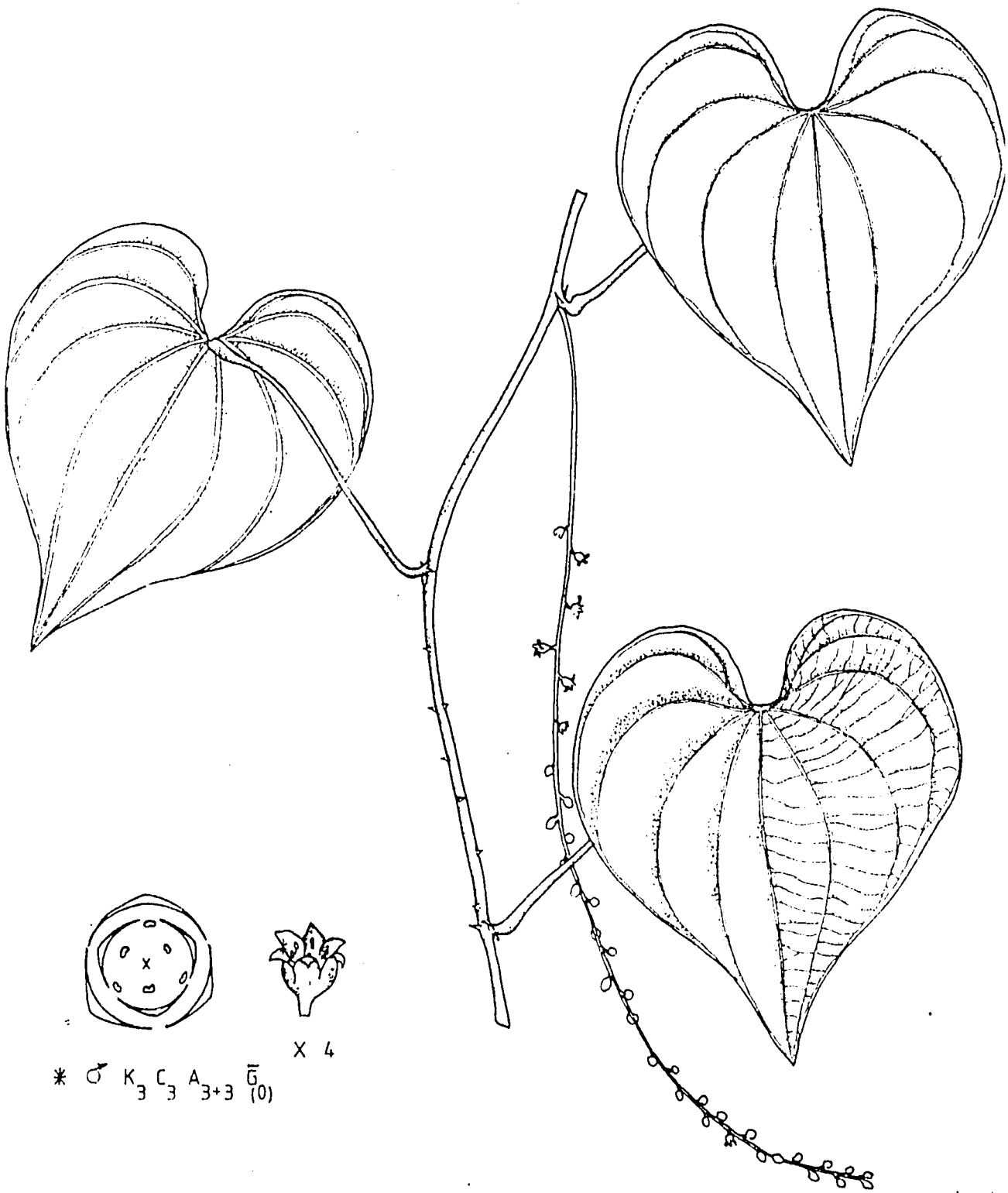
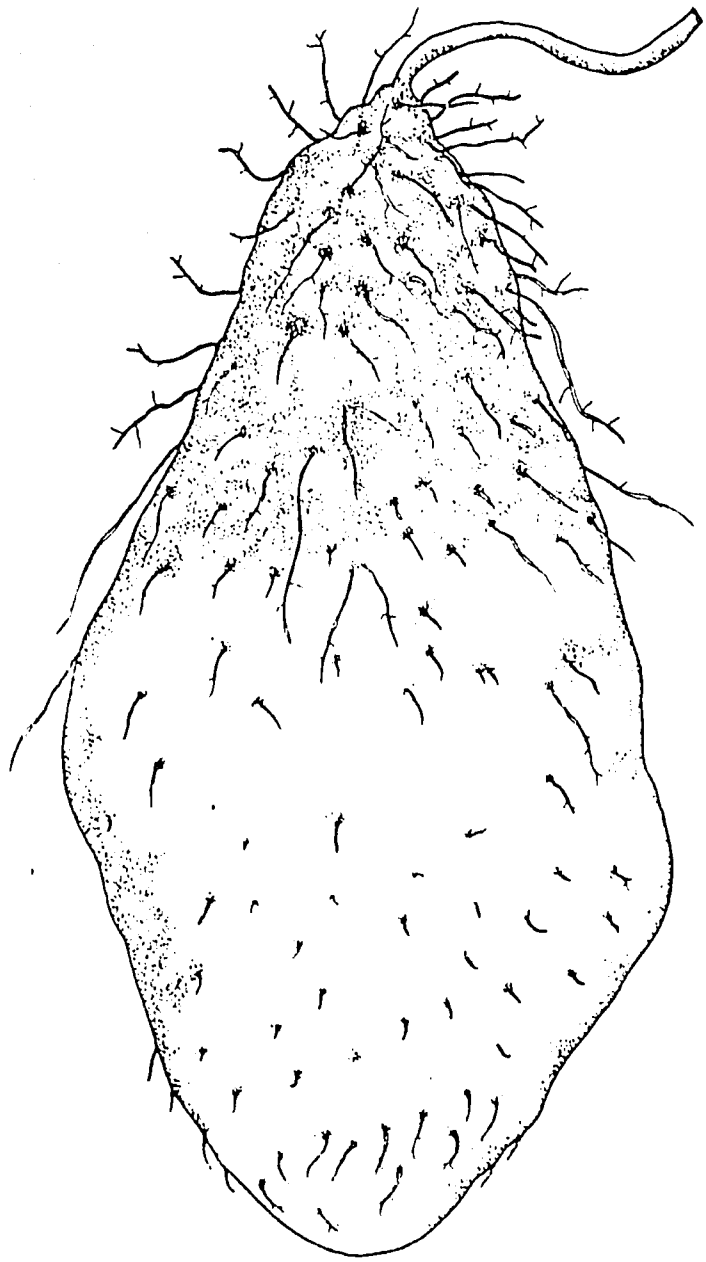


Fig 8. Tubers and roots of D.esculenta variety Java ala



spines present in stem, leaf and roots that are near the surface of the ground.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate, base cordate. Venation with 7-9 arcuate primary veins of which 3 reach the apex of the leaf. Secondary and tertiary veins are reticulate.

Male flowers are present in the variety Java-ala to a considerable degree. Aerial tubers absent.

Tubers are small, ovoid in form, many, 5-6 per plant, borne in clusters at the end of stolons. Tubers appear very hairy due to large number of adventitious roots present. Flesh is yellowish white. Below the surface cork layer is pale yellow or greenish yellow.

According to the morphological characteristics the varieties can be grouped into 2 groups as follows:

1. Java ala group - (a) Java ala
2. Kukulala group - (a) Kukul ala /Katu Kukulala
   (b) Katu ala
   (c) Siru valli

Plate 17. Male flowers of D.esculenta variety Java ala.

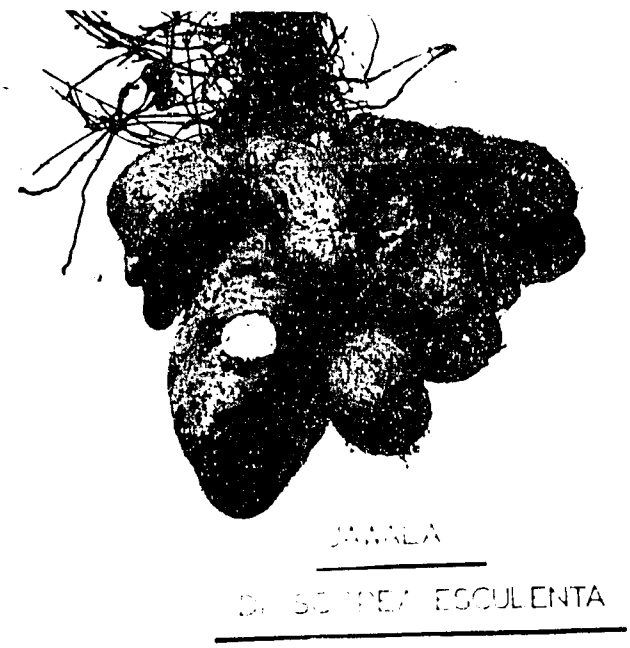


Plate 18. Tubers and roots of D.esculenta variety Java ala.

1. Java ala group

(a) Java ala (accessions 71-78, 80, 166, 240, 241, 258, 304, 437, 443)

Cultivated variety. Late sprouting. Sprout has a greenish tinge. Stem twines to the left, branching and leaf formation is early. Tender vine light olive green, mature vine dark olive green, circular in cross section. Wing and auricles absent. Pubescent, spines present, less prominent. Spines are found in mature stem and petiole only with a range of 4.2-19.0 spines per 30 cm length of stem.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate, base cordate. Venation with 7-9 arcuate main veins; secondary and tertiary veins reticulate. Lamina olive green, base of lamina and veins light yellowish green with a length of 4.70-9.00 cm, breadth of 4.20-7.40 cm. Petiole is yellowish green with a length of 3.60-6.35 cm.

Male flowers present, small, regular, perianth incurved, calyx 3, corolla 3, stamens 6 in 2 whorls. 1 inflorescence arise per leaf axil, with an inflorescence length of 7.2-51.5 cm, and flowers in the range of 3.4-55.4 per inflorescence. 76.92% produce male flowers. Aerial tubers absent.

Tubers are somewhat ovoid in form, borne in clusters, with 5-12 tubers per plant. Flesh yellowish white which change to light brown on cutting. Surface below cork is greenish yellow which turn

to brown on exposure to air. Tuber length is in the range of 13.0-27.0 cm, the breadth is 7.0-17.0 cm and the weight is 7.00 gm - 5.1 kg.

Tubers appear very hairy due to a large number of adventitious roots. Spines present on roots that are near the surface of the ground.

2. Kukulala group

(a) Kukulala/Katukukulala, (accessions 81-88, 193, 242-244, 264, 300, 301, 312, 436, 442, 452, 463, 470

Cultivated variety with late sprouting. Sprout has a greenish tinge. Stem twines to the left. Branching and leaf formation early. Tender vine light olive green, mature vine dark olive green and circular in cross section. Wings and auricles absent. Pubescent, more prominent spines present in all parts of the stem and petiole with a range of 23.4-61.2 spines per 30 cm length. Prominent spines present at the base of petiole.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate, base cordate. Venation with 7-9 arcuate main veins and reticulate venation found in between the primary veins. Lamina olive green, base of lamina and veins light yellowish green. Lamina length is 4.10-9.75 cm and breadth is 4.15-6.80 cm. Petiole is yellowish green with a length of 3.40-6.65 cm. Flowers and aerial tubers absent.

Tubers are ovoid in shape, borne in clusters with 15-60 tubers per plant. Flesh is yellowish white which change to pinkish white on cutting. Surface below cork is pale yellow turns to brown on exposure to air. Tuber length is in the range of 8.0-17.0 cm, breadth is 3.0-6.0 cm and the weight is 450 gm - 3.6 kg.

Tubers appear very hairy and some tubers are less hairy due to the adventitious roots. Spines present on roots that are near the surface of the ground.

Plate 19. Vines and simple leaves of D.esculenta variety Kukulala

(b) Katuala (accessions 163, 164)

Wild variety. Late sprouting with a greenish tinge in the sprout. Stem twines to the left, branching and leaf formation is early. Tender vine is light olive green, mature vine in dark olive green, circular in cross section. Wings and auricles absent. Pubescent, spines present, more prominent and present in all parts of the stem and leaf petiole with a range of 16-35 spines per 30 cm length of stem. Prominent spines present at base of petiole.

Leaf is simple, alternate arrangement, broadly ovate, apex acuminate, base cordate, venation having 7-9 arcuate primary veins with reticulate venation between them. Lamina olive green, base of lamina and veins light yellowish green, with a lamina length of 3.5-5.5 cm and a breadth of 4.0-6.0 cm. Petiole is yellowish green having a length of 3.5-5.0 cm. Flowers and aerial tubers absent.

Tubers are ovoid small and borne in clusters with 15-20 tubers per plant. Flesh is yellowish white, which change to light brown in colour. Below cork layer is pale yellow which change to brown on exposure to air. Average tuber length is 2.5 cm and breadth 1.5 cm and the weight is 220 gm.

Tubers appear less hairy. Spines present on roots that are near the surface of the ground.

(c) Sirn. valli (accessions 11-115)

Cultivated variety, late sprouting with a greenish tinge in the sprout. Stem twines to the left. Branching and leaf formation is early. Tender vine light olive green, mature vine dark olive green, circular in cross section. Wings and auricles absent. Pubescent, more prominent spines present in all parts of the stem and petiole, having 36.2-55.2 spines per 30 cm length of stem. Prominent spines present at the base of petiole.

Leaf is simple, alternate in arrangement, broadly ovate, apex acuminate base cordate. Venation with 7-9 arcuate main veins and in between these veins are reticulate. Lamina olive green, base of lamina and veins light yellowish green with a lamina length of 5.55-6.15 cm and a breadth of 6.00-6.25 cm. Petiole yellowish green with a length of 3.8-4.2 cm. Flowers and aerial tubers absent.

Tubers are somewhat ovoid, borne in clusters with 5-15 tubers per plant. Flesh yellowish white, which turns to pinkish white. Below cork layer is pale yellow which turns to brown on exposure to air. Tuber length is in the range of 9.0-20.0 cm, breadth is 3.0-6.0 cm and the weight 550 gm - 3.35 kg.

Tubers appear very hairy due to a large number of adventitious roots which are found more towards the upper end. Spines present on roots that are near the surface of the ground.

Fig. 9. Vines and compound trifoliate leaves of D.pentaphylla variety Katuwala ala

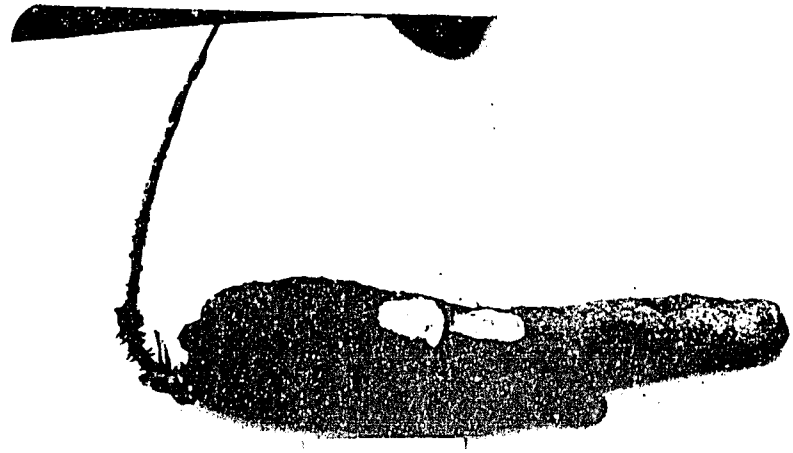
Fig 10. Tubers and roots of D.pentaphylla variety Katuwala ala

Plate 20. Vines and compound trifoliate leaves of D.pentaphylla variety Katuwala ala

Cultivars of Dioscorea alata show a great range of variation in the forms of tubers, colour of the tuber, size and pigmentation of the leaves and stem. There is considerable confusion as regards local names for different cultivars of D.alata. In some instances morphologically distinct cultivars are referred to by the same local name. For example, the accession which was given the name Raja Hingurala, appears to be similar and very closely related to many of

Plate 21. Vines and simple leaves of D.rotundata variety Boke

the Kahata ala accession. Accessions given the name Rasa valli, Raja valli, Raja ala, Jaffna purple and King yam and the following Jaffna collection without local names, have features which are closely similar to one another, in my view should be regarded as one genotype or cultivar. The greatest amount of variation, diversity and confusion exist among the different accession of D.alata.



BOKE

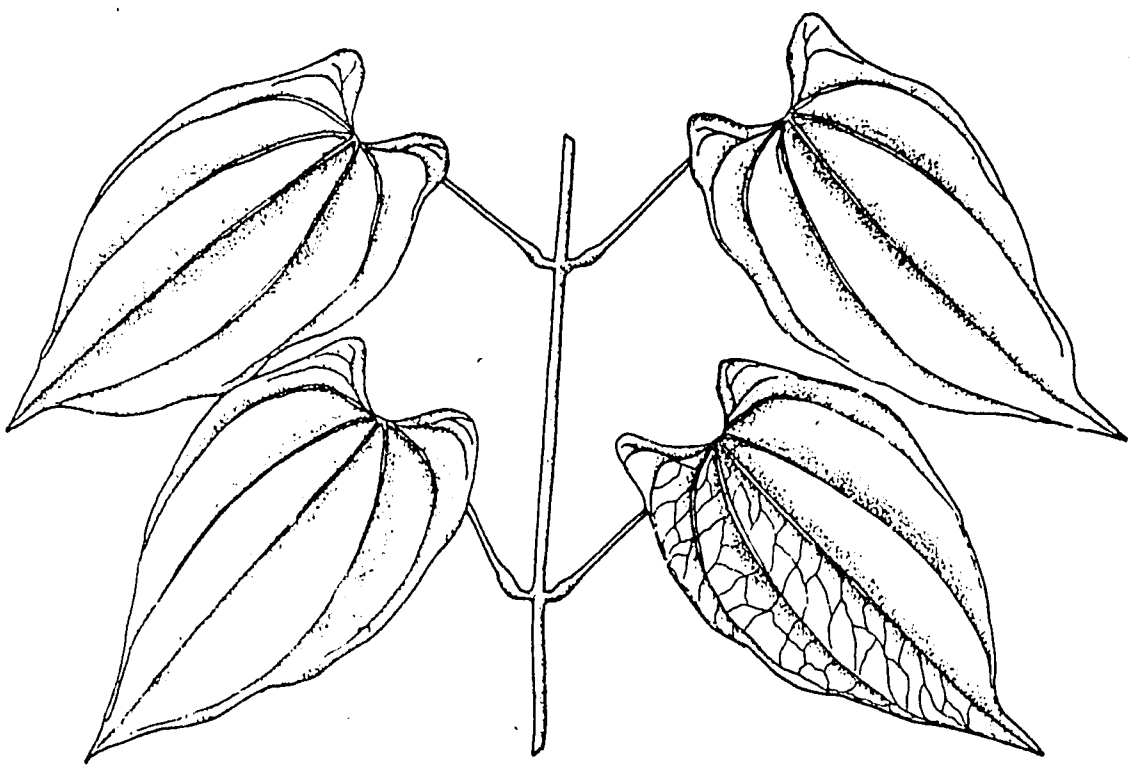
DIOSCOREA ROTUNDATA

Plate 22. Tuber and growing shoots of D.rotundata variety Boke

For the cultivated edible Dioscorea bulbifera accessions 3 different names were given for the material obtained from Jaffna. On comparative studies of the foliar, vine and tuber characteristics, strongly suggest that all 3 accessions belong to 1 genotype. Mothaka vallie, Jaffna collection, Rasa valli (yellow flesh). The wild accessions of D.bulbifera called Udala in Sinhala is, however, different from the cultivated accessions obtained from Jaffna. It could be concluded that there are 2 distinct varieties or forms of Dioscorea bulbifera in Sri Lanka.

Four different local names were given for accessions of Dioscorea esculenta of which Java ala, Kukulala and Katu ala from the wet zone of Sri Lanka and Siru valli from Jaffna appear to be 4

Fig. 11. Vine and simple leaves of D.rotundata variety Boke



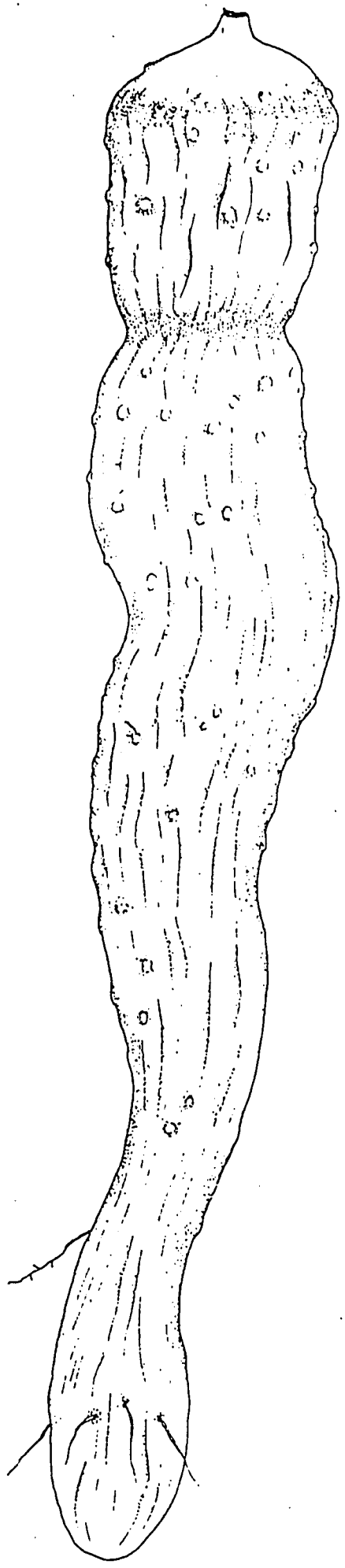


Fig 12. Tuber and roots of D.rotundata variety Boke

distinct forms of D.esculenta. The accessions which were given the name Kukulala has some similarity to the accessions of Katu ala. Java ala which as the name suggests is probably an early introduction from Indonesia (Java), and it has distinctly larger tubers with relatively few spines on the aerial parts of the plant and is a distinct variety of D.esculenta. Variety Siru valli cultivated in Jaffna district has tubers which are larger than Kukulala and smaller than Java ala. Like the other varities of D.esculenta the numerous adventitious roots give it a shaggy of "hairy" tubers. The aerial features of the vines of the cultivars of D.esculenta variety Katu ala, D.esculenta variety Kukulala, and D.esculenta variety Siru valli appear very similar and are somewhat different than that of D.esculenta variety Java ala.

The following accessions appear to have been called by wrong names by the collector or suppliers. Careful examination of tubers and above ground parts suggest that their names should be as follows:

	Name given by the collector	Accession numbers	Name suggested after evaluation at Dodangolla
1.	Hingurala	96	Leydanta
		128	Kahata ala
2.	Ini ala	122	King yam
3.	Kahata ala	22	Hingurala
		23	Raja ala
		24	Raja ala
		261	Raja ala
4.	Kahata angala	204	Leydanta

	Name given by the collector	Accession numbers	Name suggested after evaluation at Dodangolla
5.	Raja ala	205	Ini ala
		208	Hingurala
		273	Hingurala
		276	Rata ala
		290	Rata ala
		292	Rata ala
		332	Rata ala
		250	Kahata ala
		158	Kahata ala
		159	Kahata ala
6.	Rata ala	295	Kahata ala
7.	Raja Hingurala	165	Kahata ala
8.	Ratu ala	192	Raja ala
		271	Leydanta
9.	Rasa valli	116	Ini ala
		118	Leydanta

4.2 Keys

4.2.1 Key (1) to the 5 species of "Dioscorea" cultivated at Dodangolla

A. Stem twines to the right; that is in a clockwise direction.

B. Stems winged and square. Leaves simple and ovate, tuber shape variable.

Yams of South-East Asian origin.

Species-Dioscorea alata

	Var/form	Accession numbers
1.	Angili ala	260, 324
2.	Dandila	430
3.	Hingurala	51-62, 96-100, 124-128, 161, 162, 255, 306, 307, 338, 344, 351, 429, 441, 450, 469, 473

	Var/form	Accession numbers
4.	Hiritala	263, 431, 438, 464
5.	Ini ala	121-123, 197, 231, 249, 444, 453
6.	Jamburala	251, 460
7.	Jaffna purple	66-69
8.	Jaffna collection	176-178, 475-477
9.	Kahata ala	16-24, 43, 132-139, 189, 195, 196, 209, 210, 236, 261, 275, 297, 329, 345, 346, 439, 446, 449, 459, 468, 474
10.	Kahata kondol	434
11.	Kahata angala	204, 298, 299
12.	Kandala	313, 314, 433
13.	King yam	383-404, 406, 407, 409-412, 414-428
14.	Kiri ala	207, 254, 448
15.	Kiri kondol	89-94, 435, 440
16.	Kiri udala	466
17.	Kondol ala	212
18.	Kombu valli	44-50
19.	Leydanta	95, 168, 169, 465
20.	Puerto Rico yams	214, 215, 217, 218, 220, 221, 223-229
21.	Raja Hingurala	165
22.	Rata Hingurala	445
23.	Rata ala	25-29, 238, 239, 278, 293, 295, 322, 455, 447
24.	Ratangala	347
25.	Ratu ala	191, 192, 203, 271
26.	Raja ala	1-15, 158, 159, 205, 208, 250, 265, 272-276, 290-292, 331-337, 343, 451, 461, 467, 471

	Var/form	Accession numbers
27.	Raja valli	455, 456
28.	Rasa valli	38-42, 116-120, 139, 140, 147-150
29.	Suduraja ala	200
30.	Tambala	30-33, 35-37, 128-131, 248
31.	Urumpirai	144, 145
32.	Wal ala	190

BB. Stems wingless and round. Leaves simple, narrowly ovate and dark green, tuber shape cylindrical. Yams of African origin.

Species - Dioscorea rotundata

	Var/form	Accession numbers
1.	Boke	70

AA. Stem twines to the left; that is in an anti-clockwise direction.

B. Leaves simple and broadly ovate.

C. Numerous small tubers produced; bulbils absent.

Species - Dioscorea esculenta

	Var/form	Accession numbers
1.	Java ala	71-78, 80, 166, 240, 241, 258, 304, 437, 443
2.	Katu ala	163, 164
3.	Kukulala/ Katukukulala	81-88, 193, 242-244, 264, 300, 301, 312, 436, 442, 452, 463, 470
4.	Siru valli	111-115

CC. Usually one or two tubers produced, large number of aerial bulbils present.

Species - Dioscorea bulbifera

Var/form	Accession numbers
1. Jaffna collection	179-182

Var/form	Accession numbers
2. Mothaka valli	101-103, 105, 106, 109, 110, 457, 458
3. Rasa valli (yellow flesh)	141-143
4. Udala	171, 280, 283-288, 432, 472, 309

BB. Leaves compound trifoliate or palmate.

Species - Dioscorea pentaphylla

Var/form	Accession numbers
Katuwala ala	317

4.2.1 Key (2) to the 5 species of "Dioscorea" cultivated at Dodangolla

A. Tubers are small, many, borne in clusters at the end of stolons, ovoid, very hairy. Spines present.

Species - Dioscorea esculenta

Var/form	Accession numbers
1. Java ala	71-78, 80, 166, 240, 241, 258, 304, 437, 443
2. Katu ala	163, 164
3. Kukulala/Katukukulala	81-88, 193, 242-244, 264, 300, 301, 312, 436, 442, 452, 463, 470
4. Siru valli	111-115

AA. Tubers are large and usually with one or two tubers. Spines rarely present.

B. Tubers shape variable. Sprout purplish red, stems winged and square.

Species - Discorea alata

Var/form	Accession numbers
1. Angili ala	260, 324

Var/form	Accession numbers
2. Dandila	430
3. Hingurala	51-65, 96-100, 124-128, 161, 162, 255, 306, 307, 338, 344, 351, 429, 441, 450, 469, 473
4. Hiritala	263, 431, 438, 464
5. Ini ala	121-123, 197, 231, 249, 444, 453
6. Jamburala	251, 460
7. Jaffna purple	66-69
8. Jaffna collection	176-178, 475, 477
9. Kahata ala	16-24, 43, 132-139, 189, 195, 196, 209, 210, 236, 261, 275, 297, 329, 345, 346, 439, 446, 449, 459, 468, 474
10. Kahata kondol	434
11. Kahata angala	204, 298, 299
12. Kandala	313, 314, 433
13. King yam	383-404, 406, 407, 407, 409-412, 414-428
14. Kiri ala	207, 254, 448
15. Kiri kondol	89-94, 435, 440
16. Kiri udala	466
17. Kondol ala	212
18. Kombu valli	44-50
19. Leydanta	95, 168, 169, 465
20. Puerto Rico Yams	214, 215, 217, 218, 220, 221, 223-229

Var/form	Accession numbers
21. Raja Hingurala	165
22. Rata Hingurala	445
23. Rata ala	25-28, 238, 239, 278, 293, 295, 322, 445, 447
24. Ratangala	347
25. Rata ala	191, 192, 203, 271
26. Raja ala	1-15, 158, 159, 205, 208, 250, 265, 272-276, 290-292, 331-337, 343, 451, 461, 467, 471
27. Raja valli	455, 456
28. Rasa valli	38-42, 116-120, 139, 140, 147-150
29. Suduraja ala	200
30. Tambala	30-33, 35-37, 128-131, 248
31. Urumpirai	144, 145
32. Wal ala	190

BB. Tuber shape not variable. Sprout green, stems wingless and cylindrical.

CC. Large number of aerial bulbils present.

Species - Dioscorea bulbifera

Var/form	Accession numbers
1. Jaffna collection	179-182
2. Mothaka valli	101-103, 105, 106, 109, 110, 457, 458
3, Rasa valli (yellow flesh)	141-143
4. Udala	171, 280, 283-288, 432, 472, 309

CC. Aerial bulbils absent

D. Leaves simple. Stem twines to the right; that is in a clock-

wise direction. Spines present in mature stem only. Yams of African origin.

Species - Dioscorea rotundata

Var/form	Accession numbers
1. Boke	70

D. Leaves compound trifoliate or palmate. Stem twines to the left; that is in an anti-clockwise direction. Spines present in all parts of the plant. Yams of South-East Asian origin.

Species - Dioscorea pentaphylla

Var/form	Accession numbers
1. Katuwala ala	317

2 Key for the identification of varieties and forms of "Dioscorea alata" found in Sri Lanka

A. Tubers somewhat flat and digitate. Flesh yellowish white. Surface below skin is purplish pink with deep purple dots.

B. Tubers are large and digits divided halfway.

Var/form	Accession numbers
1. Angili ala	260, 324

BB. Tubers small, digits deeply divided.

Var/form	Accession numbers
1. Hingurala	51-65, 96-100, 124-128, 161, 162, 255, 306, 307, 338, 344, 351, 429, 441, 450, 469, 473
2. Hiritala	263, 431, 438, 464
3. Rata Hingurala	445

AA. Tubers cylindrical and lobed.

B. Flesh colour is yellowish white, light yellow, and orange yellow. Cultivated variety. Surface skin is purplish pink with deep purple dots, or light orange yellow or purplish red.

Var/form	Accession numbers
1. Kahata ala	16-24, 43, 132-139, 189, 195, 196, 209, 210, 236, 261, 275, 297, 329, 345, 346, 349, 446, 449, 459, 468, 474
2. Kahata kondol	434
3. Kahata angala	204, 298, 299
4. Kombu valli (2)	48, 49, 50
5. Raja Hingurala	165

BB. Flesh is light orange yellow. Surface below skin is pale yellow. Tuber more hairy. Wild variety.

Var/form	Accession numbers
1. Val ala	190

AAA. Tubers more or less round.

B. Flesh is yellowish white. Surface below skin is purplish pink with deep purple dots or pale yellow or light orange red.

C. Leaf base shallowly cordate (shallow sinuous).

Var/form	Accession numbers
1. Suduraja ala	200

CC. Leaf base cordate (deep sinuous).

Var/form	Accession numbers
1. Kiri ala	207, 254, 448
2. Kiri udala	466
3. Kiri kondol	89-94, 435, 440

4.	Kandol ala	212
5.	Puerto Rico Yams	214, 215, 217, 218, 220, 221, 223-229

BB. Flesh is pale yellow. Surface below skin is light orange yellow. Tubers with more adventitious roots.

Var/form	Accession numbers
1. Urumpirai	144, 145

BBB. Flesh is light purple. Surface below skin is purplish red.

Var/form	Accession numbers
1. Raja ala	1-15, 158, 159, 205, 208, 250, 265, 272-276, 290-292, 331-337, 343, 451, 461, 467, 471
2. Rasa valli	38-42, 116-120, 139, 140, 147-150
3. Raja valli	455, 456
4. King yam	383-404, 406, 407, 409-412, 414-428
5. Jaffna purple	66-69
6. Jaffna collection	176-178, 475-477

AAAA. Tubers round and lobed.

B. Flesh is white or light purple or light orange yellow. Surface below skin is purplish pink with deep purple dots.

Var/form	Accession numbers
1. Ini ala	121-123, 197, 231, 249, 444, 453
2. Kandala	313, 314, 433
3. Rata ala	25-29, 238, 239, 278, 293, 295, 322, 445, 447

BB. Flesh is white and light purple. Surface below skin is purplish red or deep purple.

Var/form	Accession numbers
1. Ratu ala	191, 192, 203, 271
2. Ratangala	347

BBB. Flesh is light orange yellow. Surface below skin is purplish red..

Var/form	Accession numbers
1. Tambala	30-33, 35-37, 128-131, 248
2. Jamburala	251, 460

BBBB. Flesh and surface below cork are deep purple in colour.

Var/form	Accession numbers
1. Leydanta	95, 168, 169, 465
2. Dandila	430
3. Kombu valli (1)	44-47

3 Identification of varieties and forms of "Dioscorea bulbifera" found in Sri Lanka

A. Tubers round. Flesh is greenish yellow. Aerial tubers have a smooth surface. Cultivated and edible variety.

Var/form	Accession numbers
1. Methaka valli	101-103, 105, 106, 109, 110, 457, 458
2. Rasa valli (yellow flesh)	141-143
3. Jaffna collection	179-182

AA. Tubers round or ellipsoidal. Flesh is greenish yellow with light purple blotches. Aerial tubers with slightly wavy or warty surface. Wild and non edible variety.

Var/form	Accession numbers
1. Udala	171, 280, 283-288, 432, 472, 309

4 Characters used in the identification of varieties and cultivars of "Dioscorea esculenta" cultivated in Sri Lanka

A. Spines less prominant and found in mature stem and leaf petiole only.

Var/form	Accession numbers
1. Java ala	71-78, 80, 166, 240, 241, 258, 304, 437, 443

AA. Spines more prominent and found in all parts of the stem and leaf petiole.

Var/form	Accession numbers
1. Katu ala	163, 164
2. Kukulala/ Katukukulala	81-88, 193, 242-244, 264, 300, 301, 312, 436, 442, 452, 463, 470
3. Siru valli	111-115

Foliar anatomical and epidermal features

.1 Mid rib region and transverse section of leaf lamina

Drawings were made of the outline of T.S. mid rib region and T.S. portion of leaf lamina under camera lucida.

1. The outlines of the leaf mid rib region of D. alata has a characteristics projection downwards, where as the other 4 species do not have it. The shapes of the mid rib region of D. esculenta and D. bulbifera are more or less rounded and there is not much difference in shape between the two species. The shape of D. rotundata are flattened with two projections to the sides at the lower end. The shapes of D. pentaphylla is also flattened with no projections. (Appendix Figures, pages 196 - 205, Mid Rib Region).

2. Transverse section of leaf lamina show marked differences in the upper epidermal cells of the different species.

Upper epidermal cells of D. alata are generally larger than those of D. esculenta and D. bulbifera, and the cells are somewhat

cuboidal in a transverse section. Upper epidermal cells of D. bulbifera are relatively small and rectangular when compared to those of D. alata and D. esculenta. Upper epidermal cells of D. esculenta are of intermediate size and more elongated in shapes. (Appendix Figures, pages 206 - 217, Lamina thickness).

There are two palisade layers in all the accessions drawn. The lower palisade layer is generally much smaller than the upper palisade layer. The presence of two palisade layers indicate some degree of adaptation to dry habitat or to regions of very high solar radiation or insolation. All three species of Dioscorea exhibit a certain degree of xeromorphic features as regards the leaf anatomy.

2 Leaf epidermal features

As regards stomatal distribution the majority of species and cultivars examined show the hypo-stomatous condition. Dioscorea bulbifera is amphistomatous while the other species examined are hypostomatous.

Drawings were made of epidermal features using camera lucida. (Appendix Figures, pages 218 - 222 Leaf Epidermal Features).

In all the species stomatal arrangement is anomocytic and the anticlinal epidermal walls are polygonal. Stomatal distribution is irregular and the axes of stomata are randomly orientated. Guard cells are bean shaped in surface view.

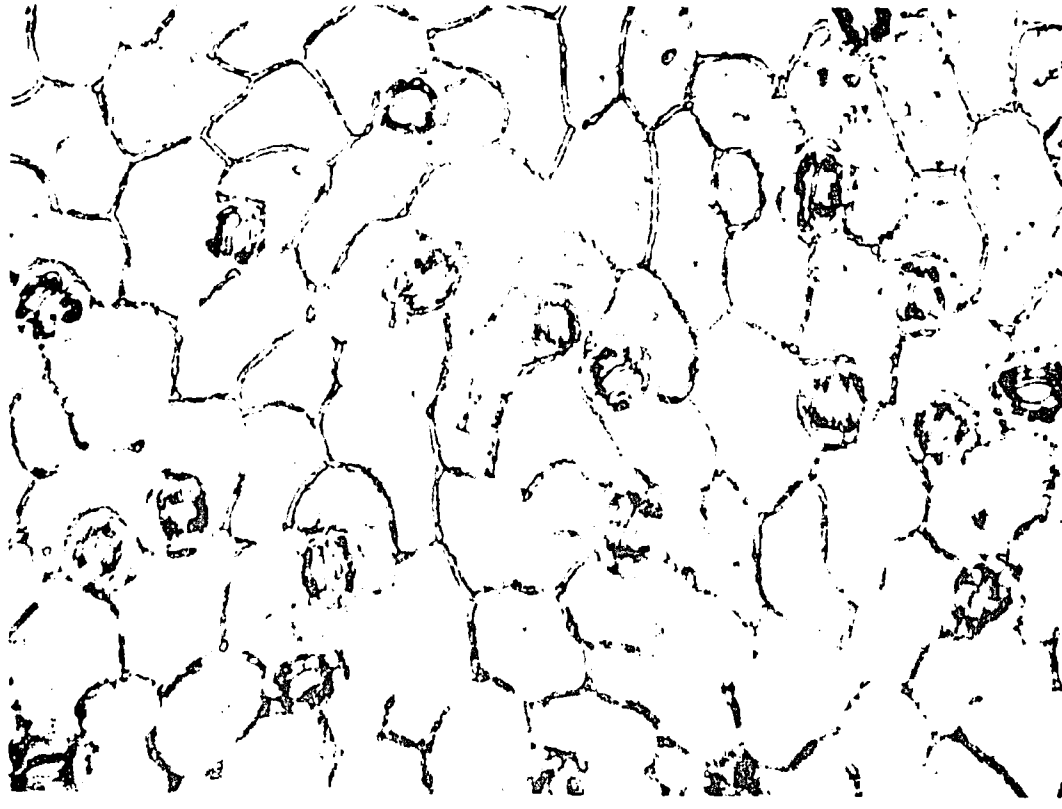


Plate 23. Dioscorea alata, Hingurala; Lower Epidermis (10 x 10)

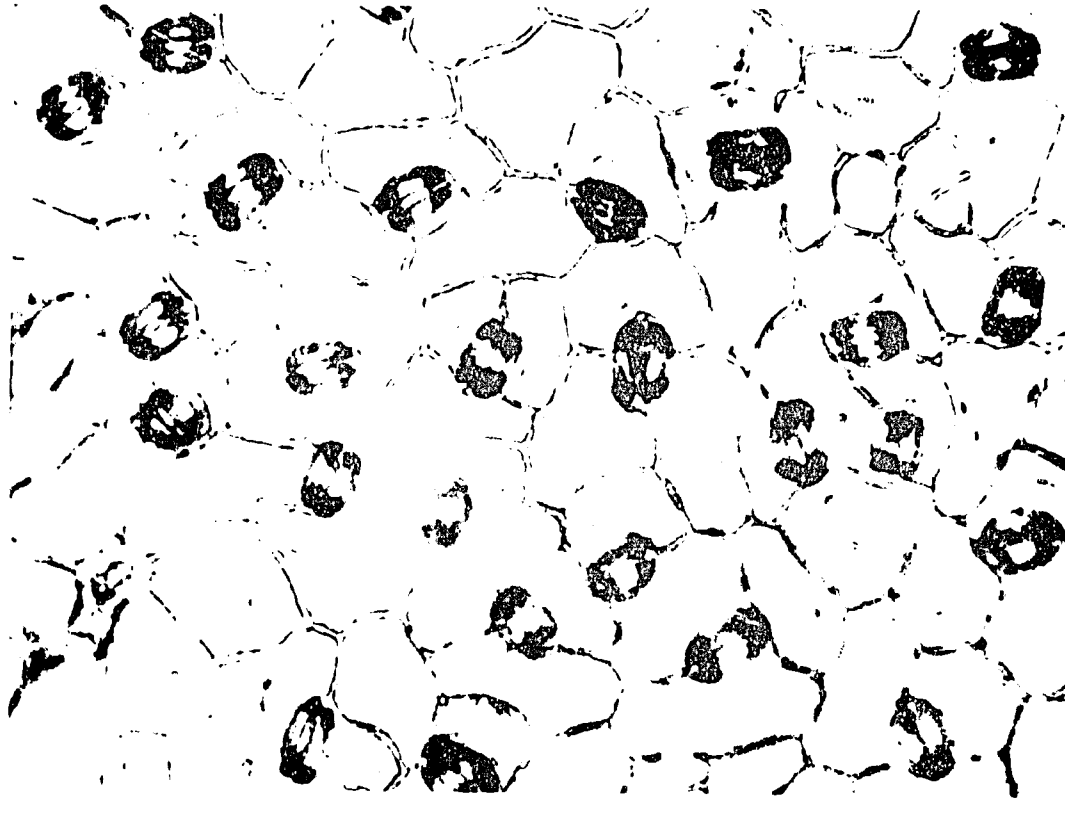


Plate 24. Dioscorea alata, Raja ala; Lower Epidermis (10 x 10)

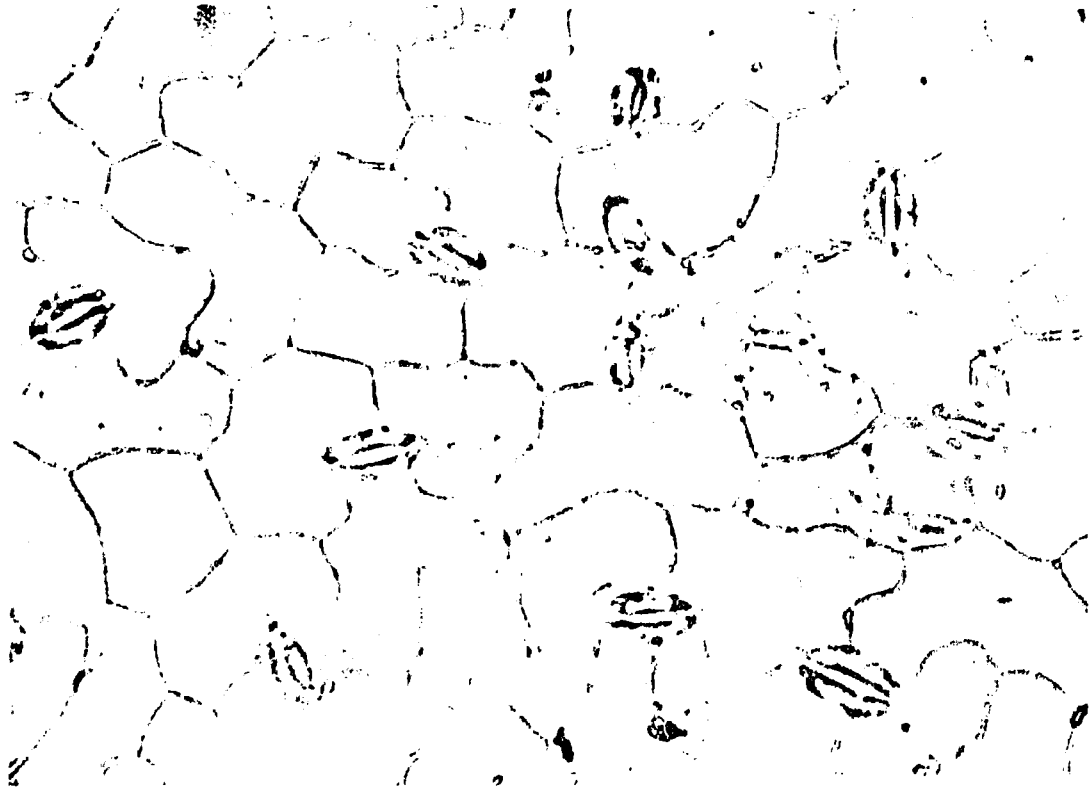


Plate 25. Dioscorea bulbifera, Mothaka valli; Lower Epidermis (10 x 10)

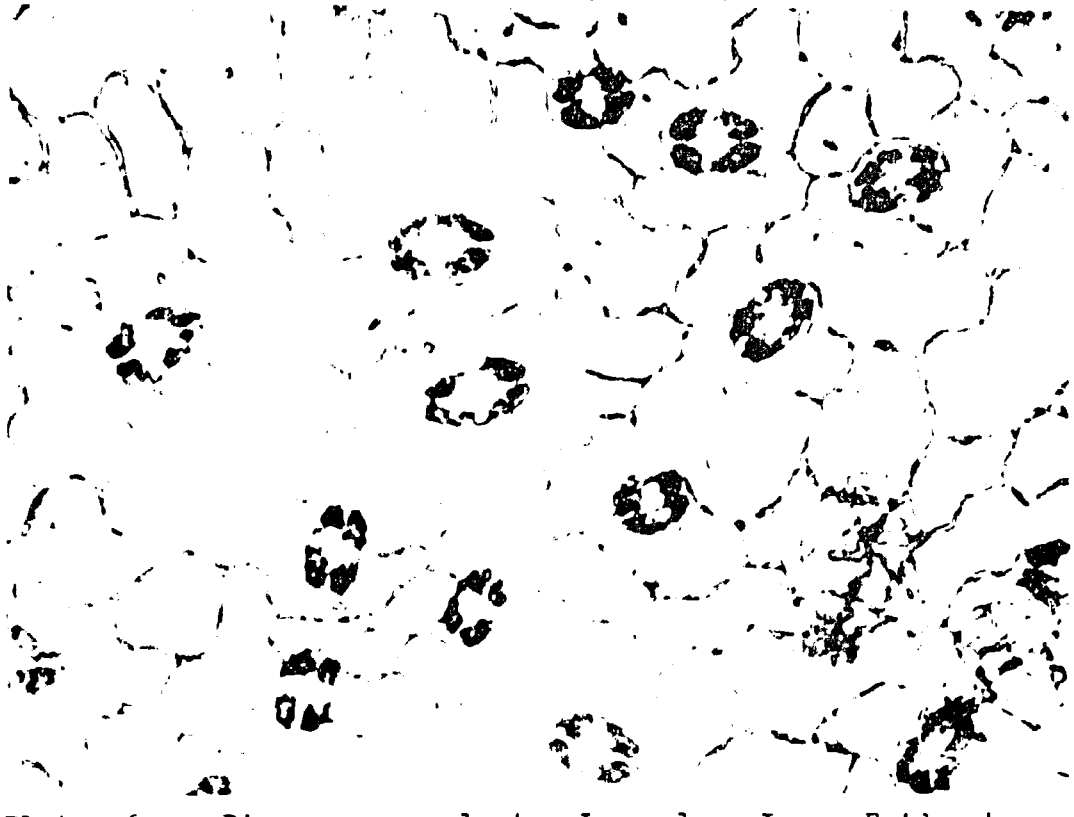


Plate 26. Dioscorea esculenta, Java ala; Lower Epidermis (10 x 10)

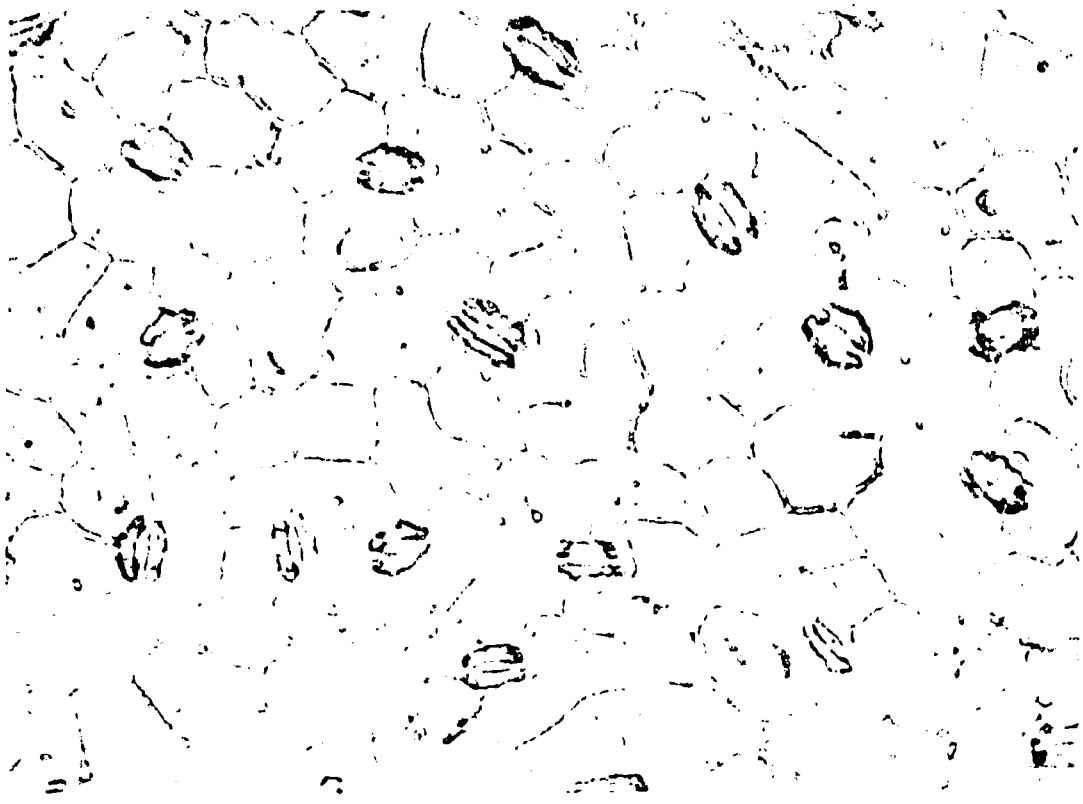


Plate 27. Dioscorea esculenta, Kukulala; Lower Epidermis (10 x 10)

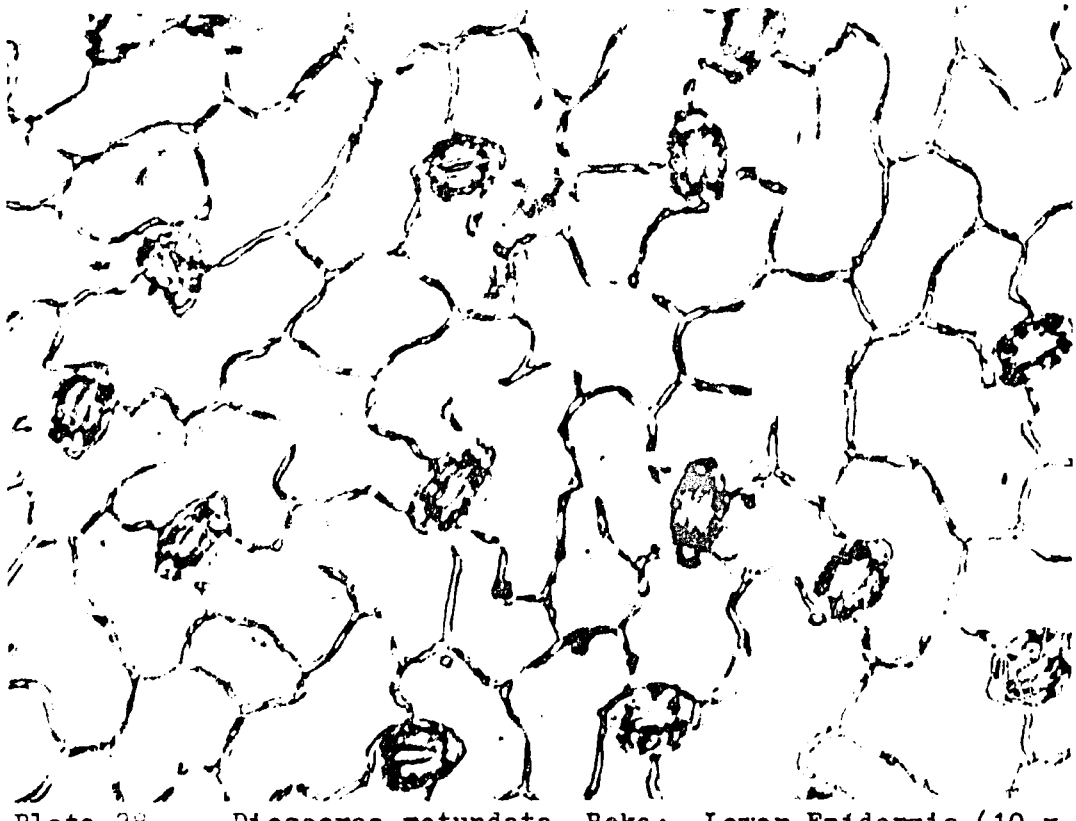


Plate 28. Dioscorea rotundata, Boke; Lower Epidermis (10 x 10)

1. Adaxial surface

The four varieties of Dioscorea bulbifera, namely; Mothaka valli, Jaffna collection, Rasa valli (yellow flesh) and Udala are amphistomatous, but the number of stomata on the adaxial surface is few. The epidermal walls are straight.

The other species examined do not have stomata on the adaxial surface. The epidermal walls are somewhat straight.

2. Abaxial surface

The shapes of the epidermal cells of different cultivars and species are given below.

(a) D. rotundata

1. Boke - Markedly sinuous, elongated

(b) D. pentaphylla

1. Katuwala ala - Somewhat straight, elongate and isodiametric

(c) D. esculenta

1. Kukulala
2. Java ala
3. Siru valli
4. Katu ala

- Somewhat straight isodiametric

(d) D. bulbifera

1. Mothaka valli
2. Jaffna collection
3. Udala

- Sinuous, elongate

(e) D. alata

1. Angili ala
2. Hingurala
3. Hiritala
4. Rata Hingurala
5. Ini ala
6. Kandala
7. Kahata angala
8. Kahata ala
9. Kahata Kondol
10. Kombu valli

\- Somewhat straight and elongate

11. Raja Hingurala - Somewhat straight, usually isodiametric, some cells elongate

12. Kiri ala
13. Kiri Kondol
14. Kiri Udala
15. Kondol ala
16. Puerto Rico Yama

\- Somewhat straight, isodiametric

17. Jaffna purple
18. Jaffna collection
19. King yam
20. Raja ala
21. Rasa valli
22. Raja valli
23. Urumpirai
24. Wal ala
25. Suduraja ala

\- Sinuous, elongate

26. Leydanta	)	
	)	
27. Tambala	)	
	)	
28. Jamburala	)	
	)	- Sinuous, elongate
29. Rata ala	)	
	)	
30. Ratu ala	)	
	)	
31. Ratangala	)	

The epidermal features are not very helpful in varietal identification. Within the species it is difficult to identify varieties by means of their epidermal features. Stomatal arrangement, guard cells form and the shape of the epidermal cells as seen in the surface view is somewhat similar in most of the accessions examined in this study.

The hypostomatous conditions and the presence of more than one tier of palisade cells can be regarded as xeromophic features.

4 Eco-physiological parameters

Leaf indexes, namely; 'Density Thickness' (dry matter content per unit area) 'Degree of Succulence' (water content per unit area), and 'Potential leaf tissue hydration' (water content per unit dry matter), were calculated for 3 different species, namely; D. alata, D. bulbifera and D. esculenta (Table 6).

There was no significant difference between the 3 species in 'Density Thickness'. The highest value for this was found in D. esculenta (0.0051 gm/cm^2) which seems to be positively correlated to lamina thickness.

'Degree of Succulence' and 'Potential leaf tissue hydration' showed significant difference among the 3 species, and these 2 leaf indexes are related to the water content in the leaf.

In D. alata upper epidermal cells are large and more vaculolated, and in D. bulbifera these cells are small when compared. This indicates that the water content per unit area in the leaf is highest in D. alata and hence the degree of succulence is highest in D. alata and lowest in D. bulbifera. The values obtained for potential leaf tissue hydration also substantiates this view.

When we compare lamina thickness, D. esculenta has the highest value and this is also reflected in Density Thickness where high values were recorded for D. esculenta as compared with the other two species. Leaf indexes were non significant between the different forms or groups within all the three species, (Table 7).

Ecophysiological parameters suggest that D. esculenta can withstand moderate water stress when compared to D. alata and D. bulfera.

5 Survey of phenolic constituents of 15 accessions of Dioscorea

Fifteen varieties/forms were selected from the 3 common edible species of Dioscorea, namely; D. alata, D. bulbifera and D. esculenta and with the species D. rotundata variety Boke were tested for flavanoid spots for comparison. Testing was done for the dry leaf as well as for the fresh leaf.

1 Position of the flavanoid spots in the 2-dimensional chromatogram

Two-dimensional chromatogram showing position of flavanoid spots are given in Fig. 13. A total of 14 ultra violet active spots (A.....N) and a total of 9 coloured spots after spraying with aluminium chloride and sulphanilic acid reagent were recorded. The number of ultra violet active spots varied from 1 to 6 and the number of coloured spots after spraying with the above mentioned reagents varied from 1 to 5.

2 Colour of spots under ultra violet light and with different spray reagents

Detection procedure	Appearance
Visible light	None
Ultra violet light	White
Aluminium chloride	Yellow
Sulphanilic acid reagent	Reddish brown

3 Spot numbers and their distribution pattern

The numbers of ultra violet active spots and chemically reactive spots are given in Table 5.

Spots number 1 is common to all the species and is comparatively larger than the other flavanoid spots. It can be used as a generic marker.

Spot number 3 was found in the fresh leaf of 4 varieties of D. esculenta, namely; Java ala, Siru valli, Kukulala and Katu ala. It was also found in the dry leaf of D. esculenta varieties but not

in Java ala. Probably this compound must have been broken down during the drying of the leaf. Fresh leaves of D. alata varieties, namely; King Yam and Ini ala also had same spots, showing that it is not specific to D. esculenta only.

Spot number 8 was found only in the fresh leaf of D. esculenta variety Siru valli which seem to be specific to that variety. Siru valli also had the highest number of flavanoid spots (5).

In D. alata variety Ini ala spot number 9, Hingurala spot number 2, and in D. esculenta variety, Siru valli spot number 7 were detected in the dry leaf but not in the fresh leaf. These compounds may be regarded as being specific to these varieties only.

It should be mentioned that the fresh leaves had the same number or more number of flavanoid spots in all the varieties tested. This shows that some of the phenolic compounds are broken down or destroyed in the drying process.

Within species also there seems to be variability in the flavanoid spots. Also there is variability in the number of ultra violet active spots.

Spot number 1 is a phenolic compound ($AlCl_3$ positive) found in all the 4 species and 14 varieties examined in this study. This phenolic or flavanoid can be used as a generic marker.

There are no species specific phenolic compounds or ultra violet active spots. This preliminary study shows that leaf flavanoids are not useful in species or varietal characterization of the genus Dioscorea.

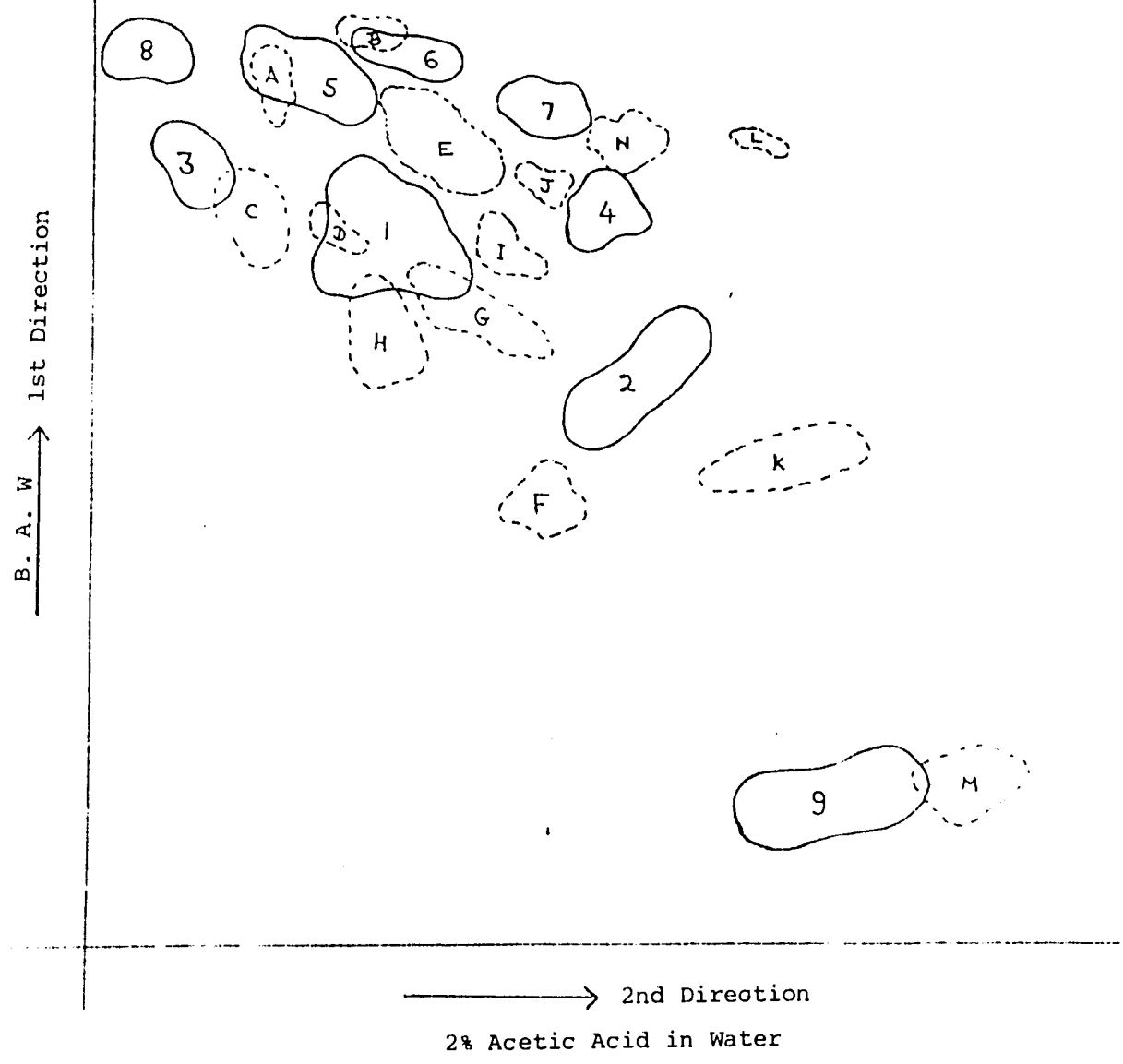
Table 5. Flavanoid Spot numbers in different varieties/forms and their distribution pattern

Varieties / forms	Chromogenic spots										Ultra violet spots															
	Spot numbers									Total No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total No.
	1	2	3	4	5	6	7	8	9																	
D. alata																										
King yam - Dry leaf	+			+						2									+	+						2
Fresh leaf	+		+	+						3	+			+					+	+						4
Raja ala - Dry leaf	+									1	+	+		+			+			+						5
Raja valli - Dry leaf	+									1	+				+		+									3
Rasa valli - Dry leaf	+									1	+	+	+	+	+	+										6
Ini ala - Dry leaf	+								+	2	+							+		+	+	+	+			6
Fresh leaf	+		+							2		+			+					+						3
Hingurala - Dry leaf	+	+								2		+	+		+		+	+								5
Fresh leaf	+			+			+			3	+									+				+		3
Kahata ala - Fresh leaf	+				+	+				3	+	+			+					+						4
D. esculenta																										
Java ala - Dry leaf	+									1	+					+										2
Fresh leaf	+		+	+						3	+								+							2
Siru valli - Dry leaf	+		+				+			3					+									+		2
Fresh leaf	+		+		+	+		+		5	+	+			+											3
Kukulala - Dry leaf	+		+				+			3		+						+			+					3
Fresh leaf	+		+				+			3					+					+						2
Katu ala - Fresh leaf	+		+				+			3		+			+				+							3

(contd.) Table 5.

Varieties / forms	Chromogenic spots									Total No.	Ultra violet spots													Total No.
	Spot numbers																							
	1	2	3	4	5	6	7	8	9		A	B	C	D	E	F	G	H	I	J	K	L	M	N
D. bulbifera																								
Mothaka valli - Dry leaf	+			+						2	+	+							+					+	4
Fresh leaf	+			+			+			3									+						1
Rasa valli (yellow flesh) - Fresh leaf	+			+	+	+				4					+				+						2
Udala - Fresh leaf	+				+		+			3										+		+			2
D. rotundata																								
Boke - Fresh leaf	+									1											+				1

Fig. 13. Two-dimensional chromatogram showing position of flavanoid spots on the chromatogram



Statistical evaluation of morphological, anatomical and ecophysiological parameters

1 Comparison between the three cultivated species of Dioscorea

In all 24 morphological, anatomical and ecophysiological characters were tested; of which 14 characters showed significant differences in means either at 5% or at 1% level between the 3 cultivated species (Table 6).

(1) Morphological characters

Five morphological characters showed significant differences in means between the 3 species. Lamina breadth, and maximum tuber length showed significant differences in means at 5% level. Lamina length, leaf petiole length and maximum tuber breadth showed significant differences in means at 1% level among the 3 cultivated species. There was no significant difference of means in underground tuber weight and total tuber weight.

D. alata had the highest mean values in all the morphological characters except for lamina breadth where *D. bulbifera* showed the highest value. *D. esculenta* had the lowest values for all the morphological characters.

Highest mean lamina length was found in *D. alata* (10.94 cm), intermediate in *D. bulbifera* (9.35 cm) and the lowest value in *D* esculenta (5.41 cm). Mean lamina breadth was highest in *D. bulbifera* (7.96 cm), intermediate value in *D. alata* (7.05 cm) and lowest value in *D. esculenta* (5.29 cm). Mean leaf petiole length was

longest in D. alata (6.50 cm), intermediate in D. bulbifera (5.81 cm) and lowest in D. esculenta (4.28 cm).

Mean maximum tuber length was found to be highest in D. alata (22.88 cm), intermediate in D. bulbifera (15.59 cm), and lowest in D. esculenta (12.81 cm). The highest value for mean maximum tuber breadth was found in D. alata (17.55 cm), where as an intermediate value was found in D. bulbifera (15.74 cm) and the smallest mean breadth was in D. esculenta (5.32 cm). Highest mean underground tuber weight was found in D. alata (2.90 kg) intermediate in D. bulbifera (1.65 kg), and the lowest value in D. esculenta (1.56 kg). Mean value for total tuber weight was found highest in D. alata (2.99 kg), D. bulbifera had an intermediate weight (2.85 kg) and the lowest weight was in D. esculenta (1.56 kg).

For the characters that showed significant mean differences among the species, t-test were performed for pairs of species to see which pairs were significantly different. Analysis of variance between the 2 species, D. alata and D. esculenta, showed that mean lamina breadth and maximum tuber length were significantly different at 5% level. Leaf petiole length was significantly different at 1% level. Lamina length, maximum tuber breadth were significantly different at 0.1% level between these 2 species. Although D. alata and D. bulbifera can be distinguished qualitatively in the field or in herbarium specimens, the quantitative parameters in these two species do not show statistically significant differences.

The 2 species D. esculenta and D. bulbifera showed significant differences at 5% level for lamina length, lamina breadth and maximum

tuber breadth. There were no significant differences between these 2 species for leaf petiole length and maximum tuber length.

(2) Anatomical characters

Among the 14 anatomical characters analysed, 7 characters, namely; number of epidermal cells, stomatal index, lamina thickness, height of upper epidermal cells, height of upper palisade cells, height of lower palisade cells and total height of palisade cells showed significant difference at 1% among the 3 cultivated species.

Mean number of epidermal cells was highest in D. bulbifera (45.35), while intermediate number was found in D. alata (30.70) and lowest was found in D. esculenta (20.97). A high mean stomatal index was found in D. esculenta (26.03%), while D. alata had an intermediate value (22.23%), and the lowest stomatal index was in D. bulbifera (16.71%).

Mean lamina thickness was highest in D. esculenta (275.28 μ), intermediate in D. alata (226.22 μ) and lowest in D. bulbifera (191.84 μ). The highest value for the mean height of upper epidermal cells was found in D. alata (60.10 μ), intermediate value in D. esculenta (45.34 μ), and the lowest value in D. bulbifera (24.79 μ). Mean height of upper palisade cells gave height value in D. esculenta (85.47 μ), intermediate value in D. alata (56.74 μ) and lowest value in D. bulbifera (49.67 μ). Mean height of lower palisade cells was also highest in D. esculenta (44.82 μ), intermediate in D. bulbifera (26.64 μ) and the lowest in D. alata (23.40 μ). Mean highest value for the total height of palisade cells was found in D. esculenta

(130.32 μ), intermediate value for D. alata (80.14 μ) and the lowest value was found in D. bulbifera (76.31 μ).

There was no significant difference among these 3 species for number of guard cells, length of epidermal cells, breadth of epidermal cells, length of a guard cells, breadth of a pair of guard cells, height of spongy cells, and height of lower epidermal cells.

When t-tests for the pairs of species were performed it was seen that the mean number of epidermal cells, and stomatal index were significant at 5% level for the comparison between D. alata and D. esculenta. Lamina thickness was significant at 1% level. The height of upper epidermal cells, height of upper palisade cells, height of lower palisade cells, and the total height of palisade cells were significant at 0.1% level.

For the comparison between the 2 species, D. alata and D. bulbifera, lamina thickness showed significant difference at 5% level. The number of epidermal cells, stomatal index, height of upper epidermal cells showed significant difference at 0.1% level, but other anatomical characters were not significant between these 2 species.

The pair of species D. esculenta and D. bulbifera showed significant difference at 1% level for all the 7 characters that were significant in the F-test of the ANOVA.

(3) Ecophysiological parameters

Of the 3 ecophysiological characters "potential leaf tissue hydration" showed significant difference at 5% level between the

3 cultivated species of Dioscorea. D. alata had the highest mean value of 434.49%, D. esculenta had the intermediate value of 387.82% and the lowest mean value of 360.76% was found in D. bulbifera.

"Degree of succulence" showed significant difference at 1% level among the 3 species having the highest mean value of 0.0202 gm/cm^2 for D. alata, intermediate value of 0.0197 gm/cm^2 for D. esculenta and the lowest value of 0.0158 gm/cm^2 for D. bulbifera.

There was no significant difference among the 3 species for "density thickness". For this leaf index the highest mean value of 0.0051 gm/cm^2 was found in D. esculenta, and intermediate value of 0.0047 gm/cm^2 in D. alata and lowest value of 0.0044 gm/cm^2 in D. bulbifera.

The t-test for the pairs of groups showed that between D. alata and D. esculenta no significant difference for the above 3 leaf indexes. Between the 2 groups D. alata and D. bulbifera "potential tissue hydration" showed significant difference at 5% level, and the "degree of succulence" showed significant difference at 0.1% level. In D. esculenta and D. bulbifera "degree of succulence" was significantly different at 5% level between these 2 species, where as no significant difference was found for "potential tissue hydration".

2 Group comparisons

In the group comparisons maximum tuber breadth showed significant difference at 5% level. Lamina length, lamina breadth, leaf petiole length and maximum tuber length showed significant difference at 1% level among the morphological characters.

Number of epidermal cells, stomatal index, lamina thickness, height of upper epidermal cells and height of lower palisade cells showed significant difference at 1% level. Other anatomical characters and the ecophysiological characters were non significant among the 10 groups compared (Table 7).

.3 95% Confidence Interval for different group mean comparisons

Raja ala group (gp. 4) was taken as a standard group as there are 6 different forms of this variety and it is found in both mid and low country wet zones and in the Jaffna district and is a widely distributed variety. This group was compared with the other 9 groups and the 95% confidence interval for the difference of means between this group and the rest taken individually are shown in Table 8.

(1) Morphological Characters

Mean lamina length was higher in Raja ala group (gp. 4) than the Hingurala, Kukulala and Mothaka valli groups, (gps. 1, 9 & 10). Mean lamina breadth was higher in Raja ala group (gp. 4) than in the groups Hingurala, Kahata ala, Kiri kondol, Tambala, Ratu ala, Leydanta and Kukulala, (1, 2, 3, 6, 7, 8 & 9).

Raja ala group (gp. 4) had a higher mean leaf petiole length than the petiole lengths of Hingurala, Kiri kondol, Ratu ala, Kukulala and Mothaka valli groups, (gps. 1, 3, 7, 9 & 10).

Mean maximum tuber length was much higher in Kahata ala, Tambala and Ratu ala groups, (gps. 2, 6, 7) than the mean maximum tuber length of Raja ala group (gp. 4).

Leydanta group (gp. 8) had a higher mean maximum tuber breadth than Raja ala group (gp. 4), where as this difference was much higher in Raja ala group (gp. 4) when compared to Kukulala group (gp. 9).

(2) Anatomical characters

Mean number of epidermal cells was much higher in Hingurala and Mothaka valli groups (gps. 1 & 10) than in Raja ala group (gp. 4). Higher mean stomatal index was found in the Raja ala group (gp. 4) than the Hingurala and Mothaka valli groups (gps. 1 & 10).

Kahata ala group (gp. 2) had a much higher mean lamina thickness than in the Raja ala group (gp. 4).

Mean height of upper epidermal cells was higher in the Kahata ala group (gp. 2) than in Raja ala group (gp. 4) where as it is much higher in Raja ala group (gp. 4) than in the groups Kukulala and Mothaka valli (gps. 9 & 10).

In the Kukulala group (gp. 9) mean height of lower epidermal cells was higher than the Raja ala group (gp. 4).

For the above mentioned characters Confidence Interval contains zero between the other groups.

Table 6. Means F-test and t-test for the different species

Characters	Species Means			F-test	t-test		
	Group 1 (*D. alata*)	Group 2 (*D. esculenta*)	Group 3 (*D. bulbifera*)		Group 1 vs 2	Group 1 vs 3	Group 2 vs 3
Morphological characters							
1. Lamina length (cm)	10.94	5.41	9.35	* *	* * *	n.s.	*
2. Lamina breadth (cm)	7.05	5.29	7.96	*	*	n.s.	*
3. Leaf petiole length (cm)	6.50	4.28	5.81	* *	* *	n.s.	n.s.
4. Maximum tuber length (cm)	22.88	12.81	15.59	*	*	n.s.	n.s.
5. Maximum tuber breadth (cm)	17.55	5.32	15.74	* *	* * *	n.s.	*
6. Underground tuber weight (kg)	2.90	1.56	1.65	n.s.	-	-	-
7. Total tuber weight (underground + aerial) (kg)	2.99	1.56	2.85	n.s.	-	-	-
Anatomical characters							
8. Number of epidermal cells (12.5 x 45)	30.70	20.97	45.35	* *	*	* * *	* *
9. Number of guard cells (12.5 x 45)	8.60	7.37	9.12	n.s.	-	-	-
10. Stomatal Index (%)	22.23	26.03	16.71	* *	*	* * *	* *
11. Length of epidermal cells (μ)	54.01	59.40	52.77	n.s.	-	-	-
12. Breadth of epidermal cells (μ)	24.29	20.30	25.12	n.s.	-	-	-
13. Length of a guard cell (μ)	26.17	26.46	27.38	n.s.	-	-	-
14. Breadth of a pair of guard cell (μ)	20.43	19.98	20.03	n.s.	-	-	-
15. Lamina thickness (μ)	226.22	275.28	191.84	* *	* *	*	* *

(contd.) Table 6

Characters	Species Means			F-test	t-test		
	Group 1 (*D. alata*)	Group 2 (*D. esculenta*)	Group 3 (*D. bulbifera*)		Group 1 vs 2	Group 1 vs 3	Group 2 vs 3
16. Height of upper epidermal cells (μ)	60.10	45.34	24.79	* *	* * *	* * *	* *
17. Height of upper palisade cells (μ)	56.74	85.47	49.67	* *	* * *	n.s.	* *
18. Height of lower palisade cells (μ)	23.40	44.82	26.64	* *	* * *	n.s.	* *
19. Total height of palisade cells (μ)	80.14	130.32	76.31	* *	* * *	n.s.	* *
20. Height of spongy cells (μ)	62.71	72.67	66.97	n.s.	-	-	-
21. Height of lower epidermal cells (μ)	16.34	15.04	15.26	n.s.	-	-	-
Ecophysiological characters							
22. Density thickness (gm/cm^2)	0.0047	0.0051	0.0044	n.s.	-	-	-
23. Degree of succulence (gm/cm^2)	0.0202	0.0197	0.0158	* *	n.s.	* * *	*
24. Potential leaf tissue hydration (%)	434.49	387.82	360.76	*	n.s.	*	n.s.

n.s. - non significant
* - significant P = 0.05
** - highly significant P = 0.01
*** - very highly significant P = 0.001

Ten groups used in group comparison between the three cultivated species.

Group 1 - Hingurala

Group 2 - Kahata ala

Group 3 - Kiri kondol

Group 4 - Raja ala

Group 5 - Ini ala

Group 6 - Thambala

Group 7 - Ratu ala

Group 8 - Leydanta

Group 9 - Kukulala

Group 10 - Mothaka valli

Table 7. Means and F-test for the different Groups

Character	Group Means										F-test
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	
Morphological characters											
1. Lamina length (cm)	7.99	11.09	11.53	11.93	11.73	10.16	10.34	11.38	4.81	10.00	* *
2. Lamina breadth (cm)	4.88	7.23	6.79	8.73	7.73	6.39	6.46	6.85	4.77	8.73	* *
3. Leaf petiole length (cm)	4.36	7.28	5.61	7.67	7.70	6.60	5.78	6.92	4.32	5.96	* *
4. Maximum tuber length (cm)	17.38	32.70	20.43	13.51	21.83	30.29	28.62	22.83	8.10	15.67	* *
5. Maximum tuber breadth (cm)	17.60	19.94	15.98	14.59	18.10	18.04	14.50	24.25	3.25	16.10	*
Anatomical characters											
6. Number of epidermal cells (12.5x4.5)	46.17	27.74	29.84	27.43	30.60	29.50	27.35	33.35	20.25	43.63	* *
7. Stomatal Index (%)	16.18	23.54	23.20	21.97	24.64	22.95	22.90	23.39	26.38	16.41	* *
8. Lamina thickness (μ)	230.26	256.04	220.96	213.18	232.70	238.28	206.64	204.24	227.73	192.51	* *
9. Height of upper epidermal cells (μ)	58.46	72.22	59.72	55.07	60.06	63.24	49.95	54.20	41.10	24.54	* *
10. Height of upper palisade cells (μ)	48.72	65.79	54.83	55.75	61.17	56.05	51.80	54.39	63.53	50.32	n.s.
11. Height of lower palisade cells (μ)	28.00	26.64	22.42	21.71	24.05	24.60	19.79	22.57	37.11	27.01	* *
12. Total height of palisade cells (μ)	76.71	92.43	77.26	77.45	85.22	80.66	71.59	76.96	100.64	77.33	n.s.

(contd.) Table 7

Character	Group Means										F-test
	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	
Eco-physiological characters											
13. Degree of succulence (gm/cm^2)	0.0187	0.0213	0.0197	0.0197	0.0204	0.0197	0.0208	0.0204	0.0215	0.0157	n.s.
14. Potential leaf tissue hydration (%)	503.62	454.28	443.86	399.42	402.89	388.90	414.38	421.88	357.08	364.59	n.s.

n.s. - non significant

* - significant P = 0.05

** - highly significant P = 0.01

Table 8. 95% Confidence Intervals for different mean comparison

Character	Mean comparison Group 4 vs 1			Mean comparison Group 4 vs 2			Mean comparison Group 4 vs 3		
	Mean difference $\bar{x}4 - \bar{x}1$	Lower boundary	Upper boundary	Mean difference $\bar{x}4 - \bar{x}2$	Lower boundary	Upper boundary	Mean difference $\bar{x}4 - \bar{x}3$	Lower boundary	Upper boundary
1. Lamina length (cm)	3.94	2.21	5.67	0.84	- 0.58	2.26	0.4	- 1.02	1.82
2. Lamina breadth (cm)	3.85	2.59	5.11	1.50	0.47	2.53	1.94	0.91	2.97
3. Leaf petiole length (cm)	3.31	1.94	4.68	0.39	- 0.73	1.51	2.06	0.94	3.18
4. Maximum tuber length (cm)	- 3.87	-14.91	7.17	-19.19	-28.24	-10.14	- 6.92	-15.97	2.13
5. Maximum tuber breadth (cm)	- 3.01	-12.12	6.1	- 5.35	-12.81	2.11	- 1.39	- 8.85	6.07
6. Number of epidermal cells (12.5 x 45)	-18.74	-28.75	- 8.73	- 0.31	- 8.53	7.9	- 2.41	-10.62	5.80
7. Stomatal Index (%)	5.79	1.75	9.83	- 1.57	- 4.88	1.74	- 1.23	- 4.54	2.08
8. Lamina thickness (μ)	-17.08	-41.84	7.68	-42.86	-63.14	-22.58	- 7.78	-28.06	12.50
9. Height of upper epidermal cells (μ)	- 3.39	-10.28	3.50	-17.15	-22.80	-11.50	- 4.65	-10.30	1.00
10. Height of lower palisade cells (μ)	- 6.29	-12.63	0.05	- 4.93	-10.13	0.27	- 0.71	- 5.91	4.49

(contd.) Table 8

Character	Mean comparison Group 4 vs 5			Mean comparison Group 4 vs 6			Mean comparison Group 4 vs 7		
	Mean difference $\bar{x}4 - \bar{x}5$	Lower boundary	Upper boundary	Mean difference $\bar{x}4 - \bar{x}6$	Lower boundary	Upper boundary	Mean difference $\bar{x}4 - \bar{x}7$	Lower boundary	Upper boundary
1. Lamina length (cm)	0.2	- 1.53	1.93	1.77	- 0.30	3.84	1.59	- 0.48	3.66
2. Lamina breadth (cm)	1.0	- 0.26	2.26	2.34	0.83	3.85	2.27	0.76	3.78
3. Leaf petiole length (cm)	- 0.03	- 1.40	1.34	1.07	- 0.56	2.70	1.89	0.26	3.52
4. Maximum tuber length (cm)	- 8.32	-19.36	2.72	-16.78	-29.97	- 3.59	-15.11	-28.30	- 1.92
5. Maxium tuber breadth (cm)	- 3.51	-12.62	5.6	- 3.45	-14.34	7.44	0.09	-10.80	10.98
6. Number of epidermal cells (12.5 x 45)	- 3.17	-13.18	6.84	- 2.07	-14.04	9.90	0.08	-11.89	12.05
7. Stomatal Index (%)	- 2.67	- 6.71	1.37	- 0.98	- 5.81	3.85	- 0.93	- 5.76	3.90
8. Lamina thickness (μ)	-19.52	-44.28	5.24	-25.10	-54.68	4.48	6.54	-23.04	36.12
9. Height of upper epidermal cells (μ)	- 4.99	-11.88	1.90	- 8.17	-16.41	0.07	5.12	- 3.12	13.36
10. Height of lower palisade cells (μ)	- 2.34	- 8.68	4.0	- 2.89	-10.47	4.69	1.92	- 5.66	9.50

(contd.) Table 8

Character	Mean comparison Group 4 vs 8			Mean comparison Group 4 vs 9			Mean comparison Group 4 vs 10		
	Mean difference $\bar{x}4 - \bar{x}8$	Lower boundary	Upper boundary	Mean difference $\bar{x}4 - \bar{x}9$	Lower boundary	Upper boundary	Mean difference $\bar{x}4 - \bar{x}10$	Lower boundary	Upper boundary
1. Lamina length (cm)	0.55	- 1.18	2.28	5.05	7.12	9.19	1.93	0.20	3.66
2. Lamina breadth (cm)	1.88	0.62	3.14	3.96	2.45	5.47	0	- 1.26	1.26
3. Leaf petiole length (cm)	0.75	- 0.62	2.12	3.35	1.72	4.98	1.71	0.34	3.08
4. Maximum tuber length (cm)	- 9.32	-20.36	1.72	5.41	- 7.78	18.60	- 2.16	-13.20	8.88
5. Maximum tuber breadth (cm)	- 9.66	-18.77	- 0.55	11.34	0.45	22.23	- 1.51	-10.62	7.60
6. Number of epidermal cells (12.5 x 45)	- 5.92	-17.89	6.05	7.18	- 4.79	19.15	-16.20	-26.21	- 6.19
7. Stomatal Index (%)	- 1.42	- 6.25	3.41	- 4.41	- 9.24	0.42	5.56	1.52	9.60
8. Lamina thickness (μ)	8.94	-20.64	38.52	-14.55	-44.13	15.03	20.67	- 4.09	45.43
9. Height of upper epidermal cells (μ)	0.87	- 7.37	9.11	13.97	5.73	22.21	30.53	23.64	37.42
10. Height of lower palisade cells (μ)	- 0.86	- 8.44	6.72	-15.40	-22.98	- 7.82	- 5.30	-11.64	1.04

Studies on Rapid Vegetative Propagation Techniques

The supply of planting material in yam cultivation is a major problem. Mini-sett technique and rooted vine cutting are used for rapid propagation, to produce seed tubers in other yam growing countries. There is no information on these two methods for yam cultivars of Sri Lanka. Therefore, to evaluate the possibility of using these two methods, and to study their field performance, following experiments were designed and conducted in the University Experimental Station, Dodangolla, Kundasale.

1. Mini-sett technique
2. Rooted vine cuttings

1. Experiment I. - Mini-sett technique

Usually seed yams, either whole tubers or pieces 250 - 500 g. are used to produce ware yams. In the mini-sett technique tuber pieces weighing 25 - 125g were used to produce 250 - 500 g seed tubers from local yam cultivars, under field conditions during 1986.

The treatments included 10 cultivars and five seed sizes weighing 25, 50, 75, 100 and 125 g.

Cultivars used belong to D. alata, namely: Ini ala, Nigerian, Raja ala, Thambala, Kahata ala, Rata ala, Le-dantha, Angili ala, Hingurala and Kombuwalli.

Tuber pieces were obtained from non-dorment tubers after removing from head and tail of the tubers. After ashing and drying cut surfaces, tuber setts were sprouted in sand beds. They were transplanted in experimental plots of size 2.5 m X 1.5 m at a spacing of 0.5 m X 0. m.

Final tuber yields are given in Table 1. Effects of both cultivars and weight groups, and the interactions between cultivars and weight groups were very highly significant. Tuber yields were within the range 356g and 1183g with a mean yield of 751.53g. Increasing weight of tuber pieces increased the tuber yield by 66% of the mean yield from 25 to 125g. Kahata ala (876.67g) the highest and Hingurala (538.67g) the lowest shows a difference of 45% of the mean tuber yield. The treatment combinations, except, 25g of Raja ala, Angili ala and 25g and 50 g of Ini ala, Hingurala have given higher yields than the expected size of seed tubers 250 to 500g. Therefore, lower weights of tuber pieces, could be used to produce expected size of seed tubers and this possibility was attempted in Experiment 2.

Experiment 2

In Experiment 2. tuber pieces weighing 15, 25 and 35g were used with the ten cultivars. This experiment was conducted during the 1987 growing season.

The final tuber yields are given in Table 2 shows significant differences between cultivars and weights of tuber pieces. There is no significant interactions between cultivars and weights.

Raintall data for 1985, 1986 and 1987 in inches.

Experimental Station, Dodangolla, Kundasale.

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total
1985	4.52	2.30	7.32	2.00	5.88	16.6	7.43	4.48	5.68	12.6	11.2	7.00	87.01
1986	19.28	4.92	5.44	6.68	4.44	3.48	3.88	7.54	4.80	14.3	3.48	2.48	80.72
1987	3.00	-	3.20	7.76	8.36	4.16	-	3.28	7.56	18.9	8.08	7.16	71.46

Yields were within the range of 269g to 627g with a mean yield of 471.38g. Rata ala gave the highest yield (562.61g), 49% of the mean over the lowest 332.96g of Hingurala. Increasing the weight of the tuber pieces from 15g to 35g increased yield by 24% of the mean tuber yield.

Yields of seed tuber were less than in the Experiment I probably due to the severe drought that prevailed during 1987 growing season (see raintall data).

Two thirds of the yields in this experiment (Table 2.) were within the expected range of seed tubers, ie. 250 - 500g.

2. Rooted vine cuttings.

Rooted vine cuttings of Dioscorea could be used to produce seed tubers. Cuttings having 3 - 5 nodes, when supplied with high humidity and shade conditions develop roots and shoots well. This method can also be used to purify the clones infested with root nematodes when rooted in clean sand beds. However, this method takes two growing seasons to produce seed tubers.

Experiment 3.

Same cultivars as in the mini-sett experiments 1 & 2 were used to produce rooted vine cuttings. A completely randomized design with three replicates was used.

Partially woody vine cuttings having four nodes were obtained before tuber initiation and sprouted in sand beds. Beds were covered with polethene mounted on a frame to increase humidity. Rooted cuttings after hardening by gradual removal of shade were transplanted in experimental plots of size 1m X 2m spacing given was 20 cm X 20 cm.

Tuber yields of the experiment were within the range of 49.88g to 20.11g per cutting with a mean of 31.52g. The yield of Kombuwalli is significantly different from other cultivars. The number of tubers per cutting were within the range of 1.4 of Raja ala and 2.16 of Ini ala with a mean of 1.78. Weight of a tuber ranged from 9.34g (Rata ala) and 25.76g (Kombuwalli with a mean of 17.8g. (see table 3).

Experiment 4.

The tubers obtained from Experiment 3 were tested in a field experiment to evaluate their performance in seed tuber production. A randomized complete block design with three blocks was used.

Tubers within the range 15 - 20g were planted in the plots of size 2.5m X 1.0m with a spacing of 0.5m X 0.5m.

Final tuber yields ranged from 123.5 - 960.13g/plant with a mean of 406.59g. They were significantly different. Le-dantha gave the highest yield while Hingurala was the lowest (Table 4).

Dioscorea alata species tested have given satisfactory results in rapid methods of propagation. Mini-setts of 15g have produced seed tubers within the range expected, ie. 250 - 500g. This shows the possibility to produce seed tubers using tuber pieces of 15g or less. The smaller the weight of a Mini-sett, the potential number of seed tubers that could be produced per unit weight of yam is high.

Rooted vine cuttings have produced more uniform planting material though the tubers were small. The size of the tubers may have been more if they were grown in the field. It wasevident that at the end of the second year the mean size of tubers were over 400 g. Results clearly shows the suitability of this method for production seed tubers hence further investigation will be required.

Analysis - Mineral Nutrient Composition of Yam

Very little information is available on the nutritional composition of local yam cultivars. The purpose of this study was to determine the composition of energy, nutrient and minerals in the tubers of local yam cultivars.

Seventy accessions were selected from the available germplasm collection for this study. Mature and dormant tubers were cleaned and peeled to depth about 2 mm. chopped samples were dried and ground. Analysis of protein, lipid, fibre and ash were performed on ground dry samples and the results expressed as % on dry weight basis. Samples were analyzed for K, Ca, Na, Mg and Fe by atomic absorption spectrophotometry. Phosphorus was determined colorimetrically. All analysis were carried out in duplicate.

Dioscorea alata is the largest yam species in Sri Lanka D. esculenta and D. bulbitera are relatively smaller species. Table 5. presents the major nutrients and the composition of five minerals in those major species.

D. alata and D. esculenta species show a high content of crude fat and D. alata has a high content of ash (table 5). Variation is lower in crude protein content except Jaffna Collection which

contains 13.2% crude protein. Crude fat content is highly variable and D. bulbifera shows lower values. Kahata ala and Siruwalli are high in crude protein content which is more than 20 %. They contain the lowest starch while six cultivars has more than 90 % starch. Introduced accession from Puerto-Rico had the lowest ash percentage and the highest Sodium content. Potassium content is much higher than other mineral in all cultivars. Except in some cultivars Calcium content is also high. D esculenta species are rich in Magnesium than the others.

Table 1. Final tuber yields of *D. alata* cultivars g/plant.

	Weight group					
Cultivars	125g	100g	75g	50g	25g	Mean
Kahata ala	1183	1030	943	713	513	876.67 a
Rata ala	1160	1013	863	753	543	866.67 a
Kombuwal i	1080	947	857	717	543	828.67 ab
Thambala	1073	950	900	683	496	820.6 ab
Le-dantha	1095	994	777	596	563	805.33 b
Nigerian	903	816	770	703	540	746.67 c
Raja ala	953	814	714	543	477	700.13 c
Angili ala	916	863	718	516	466	696.4 c
Ini ala	853	784	623	500	417	635.47 d
Hingurala	660	613	590	473	356	538.67 e
Mean	987.87	882.53	775.60	620.00	491.67	
	a	b	c	d	e	
Grand mean			751.53			

Table 2. Final tuber yield of *D. alata* cultivars. g/plant.

	Weight group			
Cultivars	35g	25g	15g	Mean
Rata ala	627	563	498	562.51 a
Nigerian	593	528	484	534.9 ab
Kumbu wa:li	579	510	474	500.96 bc
Le-danth	563	551	442	518.96 bc
Thambala	555	481	410	482.63 cd
Kahata ala	564	484	345	464.3 de
Angili ala	478	458	407	447.63 de
Raja ala	471	445	407	440.98 ef
Ini ala	441	408	375	407.97 f
Hingurala	388	342	269	332.96 g
Mean	526.07	477.02	411.05	
	a	b	c	
Grand mean		471.38		

Table 3. Tuber yield and number / vine cutting and mean tuber weight.

Cultivar	Tuber yield per cutting (g)	No. of tubers per cutting	Weight / tuber (g)
Kombuwalli	49.88	1.93	25.76
Thambala	34.59	1.60	21.62
Kahata ala	33.93	1.60	17.95
Lee-dantha	33.03	1.73	20.01
Ini ala	32.85	2.16	15.99
Angili ala	32.56	1.80	19.49
Nigerian	31.95	2.00	15.97
Raja ala	26.05	1.40	18.27
Hingurala	20.23	1.53	13.57
Rata ala	20.11	2.13	9.34
Mean	31.52	1.78	17.80
C.V. %	25.82	20.62	10.20

Table 4. Tuber yield / plant (g) from the tubers of vine cuttings. Taken from Experiment 3.

Cultivar	Tuber yield/plant (g)	
Le-dantha	960.13	a
Kahata ala	627.17	b
Thambala	543.80	bc
Rata ala	393.43	cd
Nigerian	350.03	cde
Kombu wa:li	336.70	cdef
Angili a.a	311.10	def
Ini ala	270.00	def
Raja ala	150.03	ef
Hingurala	123.50	f
Mean	406.59	
C.V %	28.83	

Note: Means having the same subscript are not significantly different.

Table 5. Summary of Analysis of Dry matter and minerals of yam tubers.

	C.P.%	C.Fat%	C.Fibre%	Starch %	Ash %	K ppm	Ca ppm	Na ppm	Mg ppm	Fe ppm	P ppm
D. alata	1.58-10.89	0.16-5.60	0.99-24.00	69.00-95.36	1.77-9.43	6910-18445	11-686	100-650	770-1119	51-99	1020-4850
D.esculenta	4.00- 5.12	0.50-3.00	2.00-21.10	71.90-92.82	2.71-3.98	10215-15100	153-244	123-355	973-1057	73-77	2300-3550
D.bulbifera	5.56-13.20	0.80-1.00	2.00- 7.24	78.76-91.54	3.04-3.84	11010-15160	38-469	168-322	535- 824	68-84	2800-3200

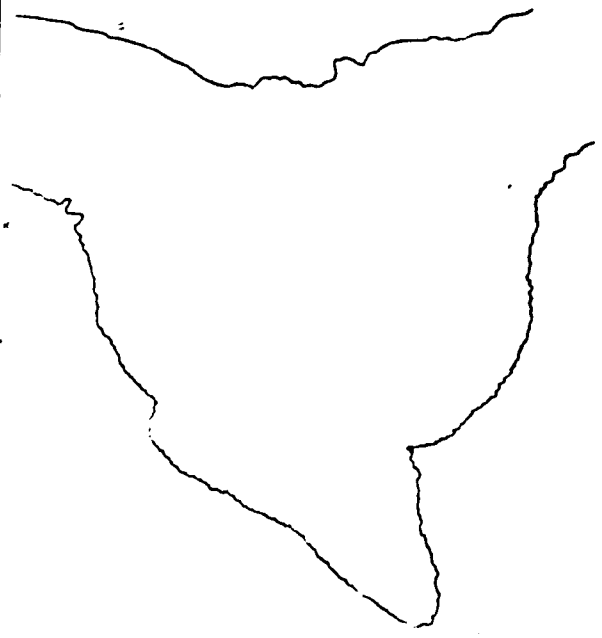
Table 6. Analysis of drymatter and minerals of yam tubers.

	C.P. %	C.Fat %	C.Fibre %	Starch %	Ash %	K ppm	Ca ppm	Na ppm	Mg ppm	Fe ppm	P ppm
D. alata											
Raja ala	5.93	0.435	3.89	89.71	3.59	8747	264	155	589	64	1628
King yam	7.05	0.400	3.54	89.02	3.64	9375	292	246	684	71	2162
Rasawalli	7.37	0.950	8.00	83.68	3.50	18445	122	128	690	72	2850
Hingurala	4.89	1.740	3.50	89.86	3.68	9255	198	187	633	70	1684
Angiliala	7.37	0.390	3.85	88.39	4.27	8040	276	117	527	51	1680
Ini ala	6.53	0.760	7.33	85.37	3.84	15307	251	236	715	77	3310
Kombuwalli	6.02	2.10	7.32	84.56	4.67	8790	401	141	762	65	2030
Kahata ala	6.00	1.000	24.00	69.00	3.28	13850	144	236	598	64	5600
Kahata angala	3.63	2.050	7.20	87.11	4.37	15695	144	185	796	75	2060
Rata ala	6.19	0.610	3.25	89.95	4.01	11749	240	205	711	74	2057
Kiriala	9.49	2.900	5.92	81.68	4.37	11612	205	267	740	80	3220
Le-dantha	8.61	0.820	6.61	83.73	3.97	9490	199	134	668	99	1420
Thambala	5.50	1.000	2.00	91.50	3.22	16115	70	216	601	78	2650
Urumpirei	9.32	0.720	3.45	86.50	4.52	16315	252	249	889	76	2360
Kandala	7.46	0.360	3.55	88.63	4.10	7730	349	321	691	63	1800
Ratuala	6.08	0.540	3.92	89.46	5.79	8540	70	124	511	75	2120
Peurto-Rico *	4.81	1.500	2.00	91.69	2.72	10008	88	504	469	85	2600
D. esculenta											
Kukulala	5.12	0.500	2.00	92.38	3.82	13055	153	200	973	73	3200
Jawala	4.18	1.000	2.00	92.82	3.98	15100	184	122	1012	77	3550
Siruwalli	4.00	3.000	21.10	71.90	2.71	10215	244	355	1057	75	2300
D. bulbitera											
Motakawalli	6.12	1.000	2.50	90.38	3.45	14955	38	322	824	84	2900
Udala	5.56	0.900	2.00	91.54	3.04	15160	56	302	535	70	3200
Jaffna collection	13.20	0.080	7.24	78.76	3.84	11010	469	168	773	68	2840

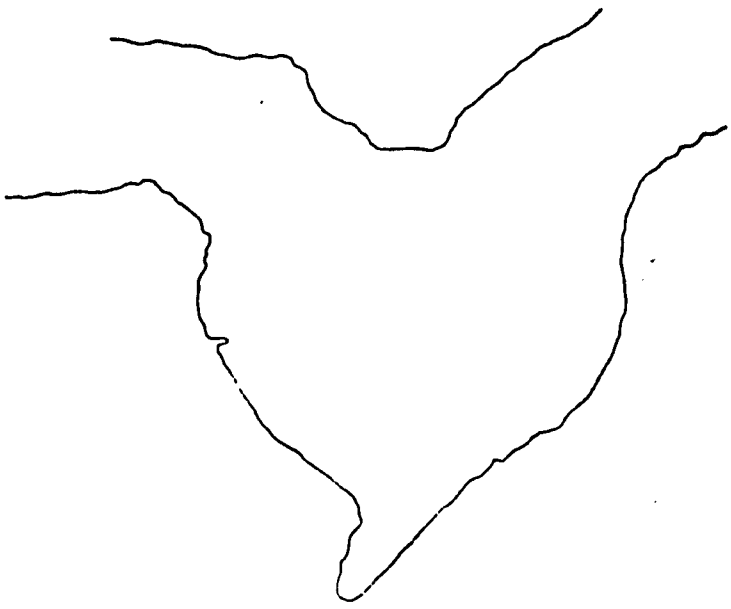
* A foreign accession from Puerto Rico

Appendix 1

Outlines of T.S. Leaf Midrib Region



DIOSCOREA ALATA - ANGILI ALA
MIDRIB REGION (10 X 10)



DIOSCOREA ALATA - HINGURALA
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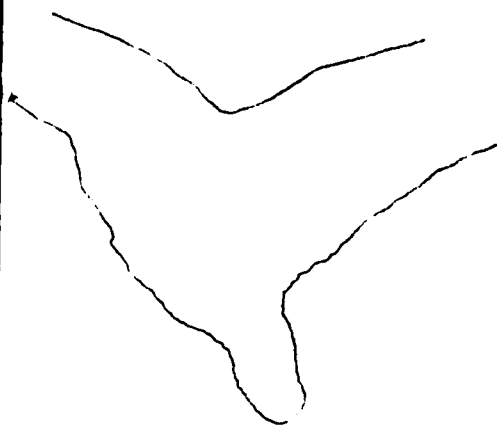

DIOSCOREA ALATA - HINGURALA
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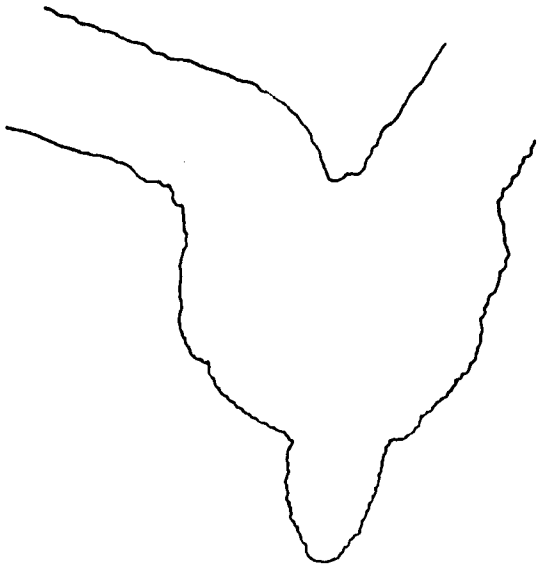
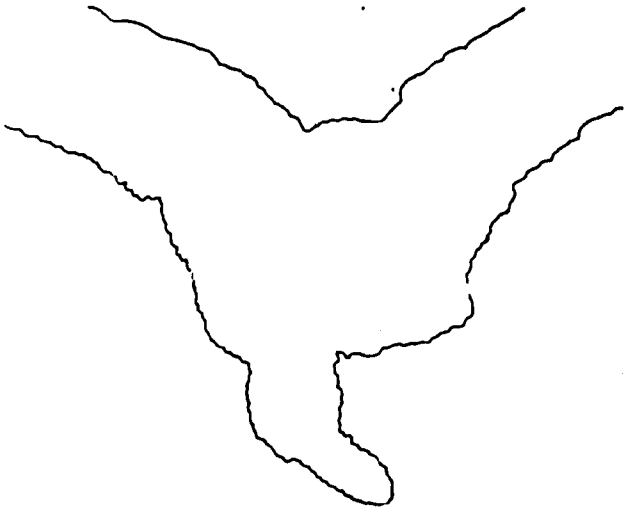


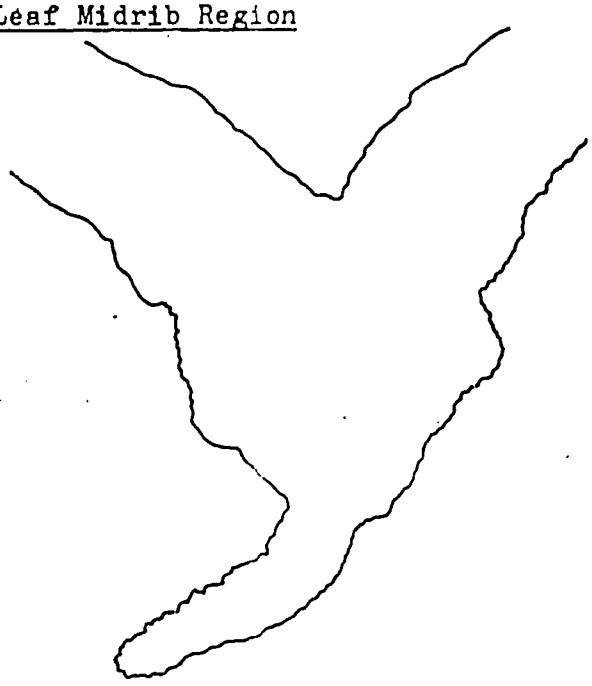
DIOSCOREA ALATA - RATA HINGURALA
MIDRIB REGION (10 X 10)

Appendix 1

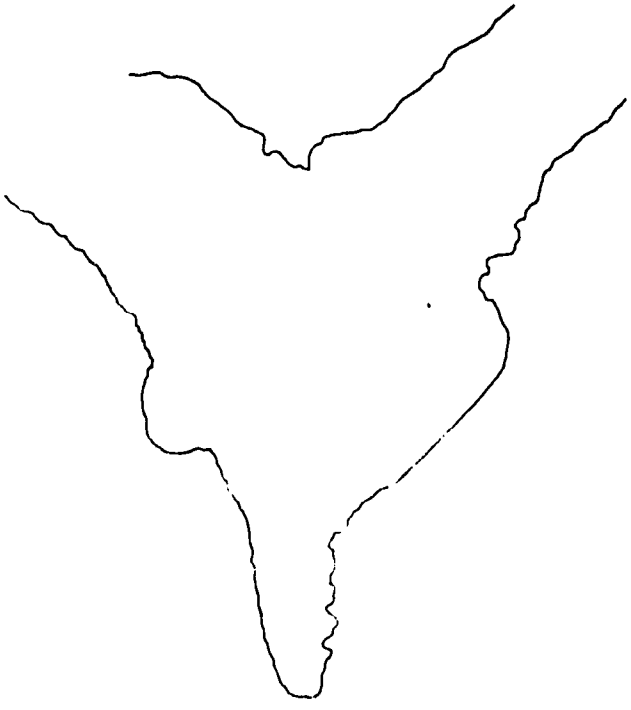
Outlines of T.S. Leaf Midrib Region



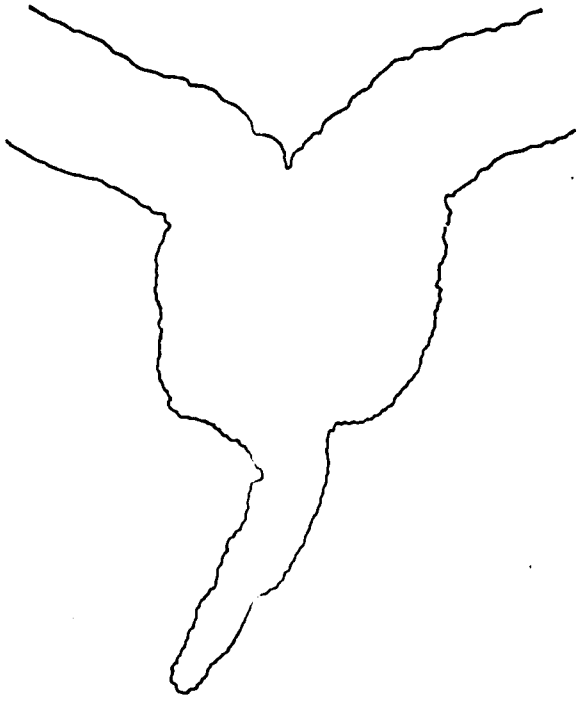
DIOSCOREA ALATA-KAHATA KONDOL
MIDRIB REGION [10 X 10]



DIOSCOREA ALATA-RAJA HINGURALA
MIDRIB REGION [10 X 10]



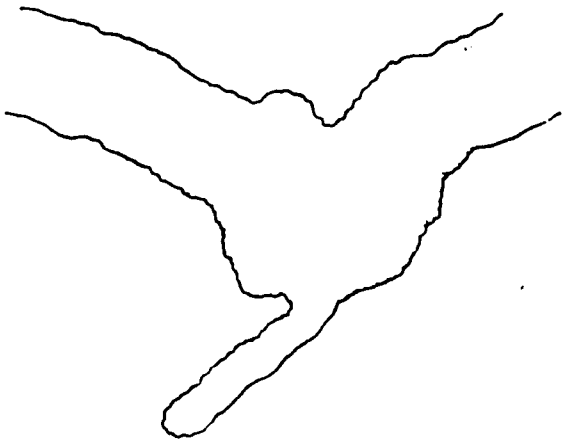
DIOSCOREA ALATA-KAHATA ALA
MIDRIB REGION [10 X 10]



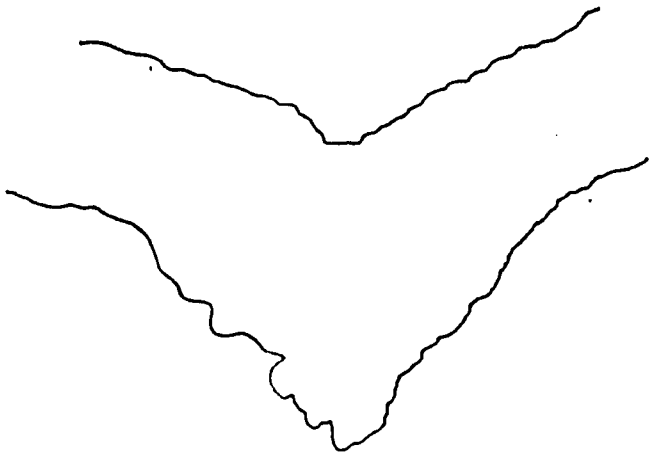
DIOSCOREA ALATA-KAHATA ANGALA
MIDRIB REGION [10 X 10]

Appendix 1

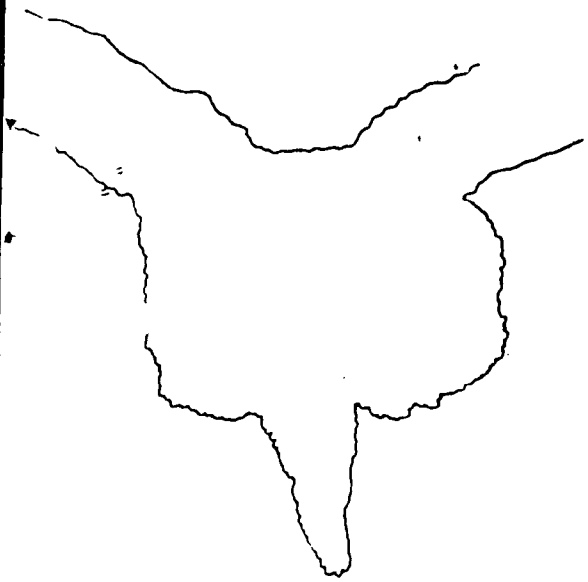
Outlines of T.S. Leaf Midrib Region



DIOSCOREA ALATA - KIRI UDALA
MIDRIB REGION (10 X 10)



DIOSCOREA ALATA - KONDOL ALA
MIDRIB REGION (10 X 10)

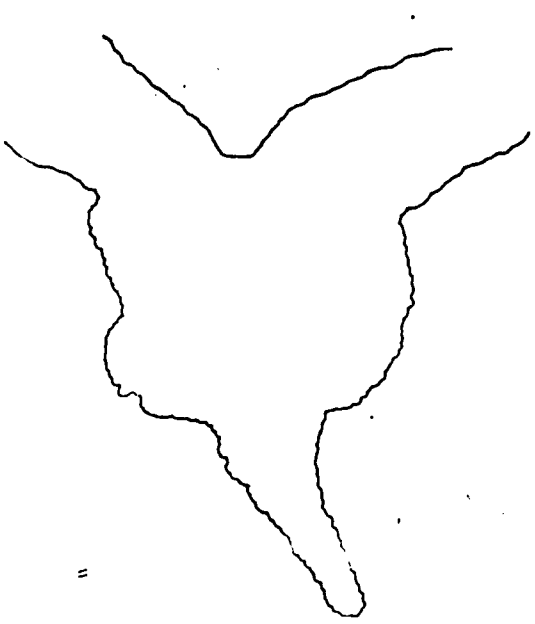


DIOSCOREA ALATA - KIRI ALA
MIDRIB REGION (10 X 10)

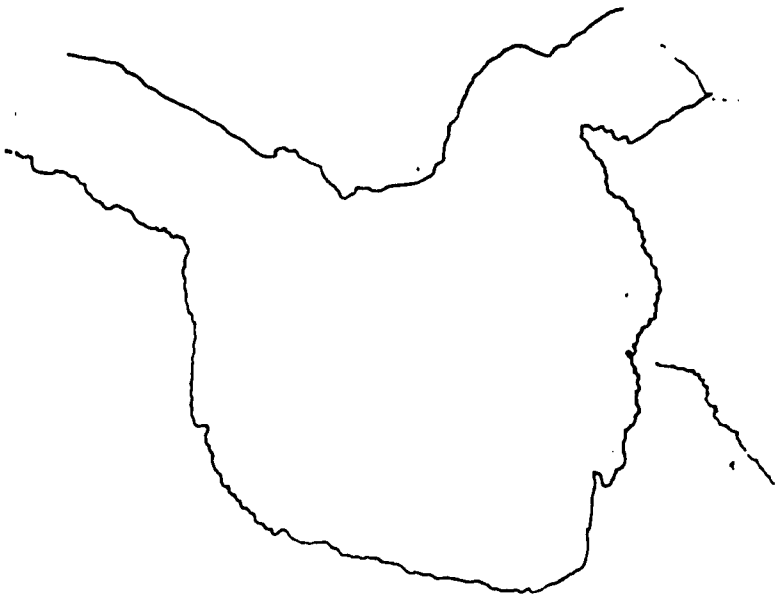
DIOSCOREA ALATA - KIRI KONDOL
MIDRIB REGION (10 X 10)

Appendix 1

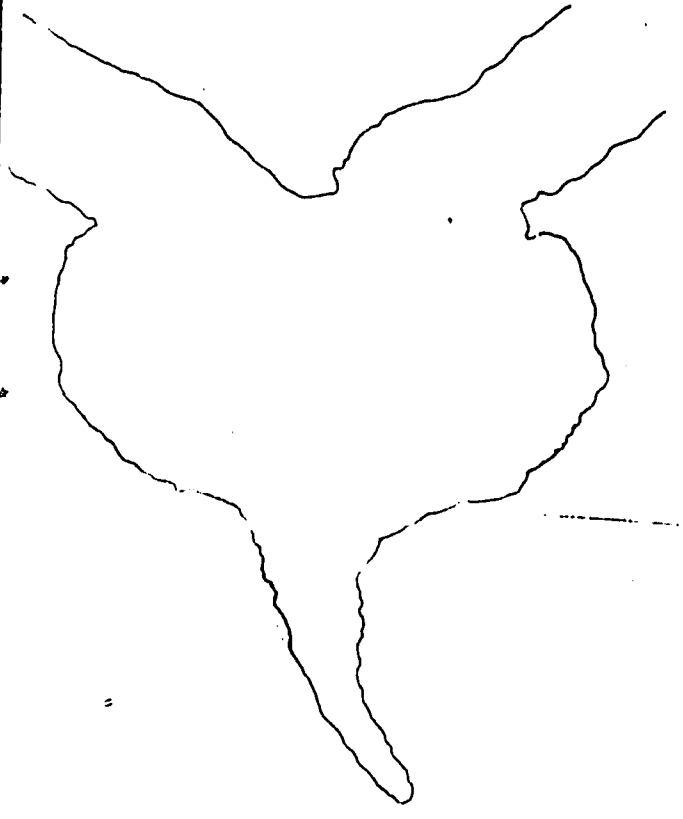
Outlines of T.S. Leaf Midrib Region



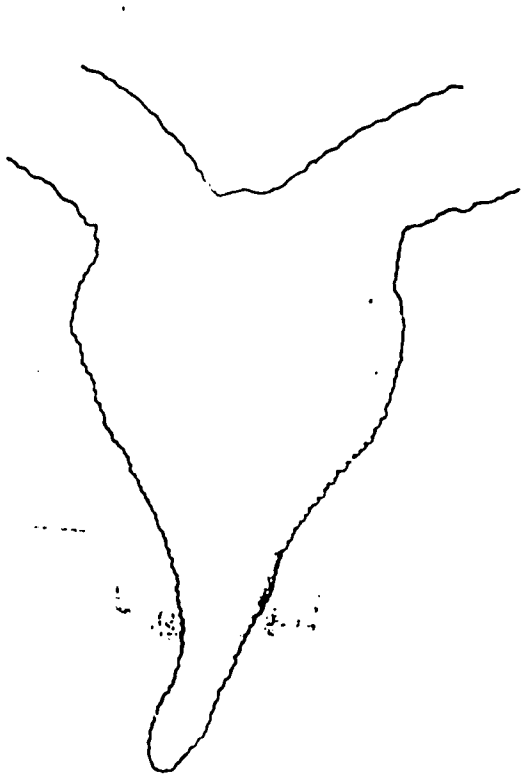
DIOSCOREA ALATA-KING YAM
MIDRIB REGION (10 X 10)



DIOSCOREA ALATA-PALE ALA
MIDRIB REGION (10 X 10)



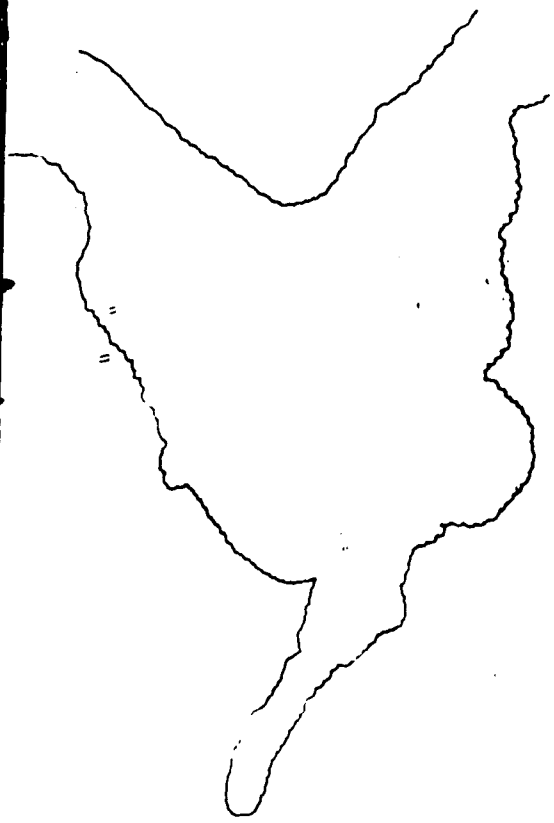
DIOSCOREA ALATA-JAFFNA PURPLE
MIDRIB REGION (10 X 10)



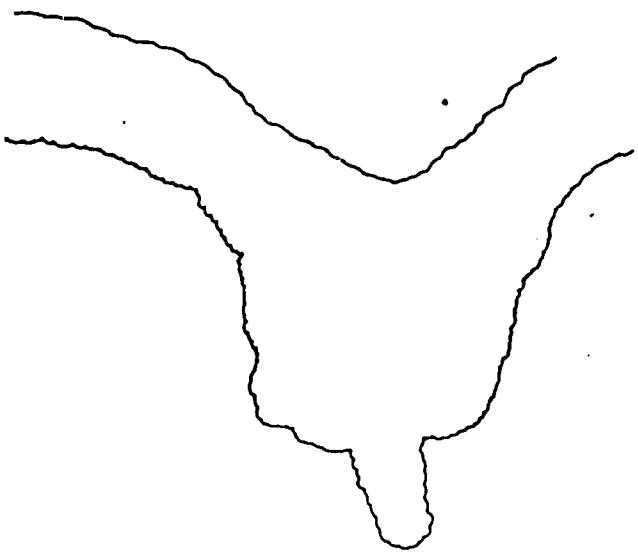
DIOSCOREA ALATA-JAFFNA COLLECTION
MIDRIB REGION (10 X 10)

Appendix 1

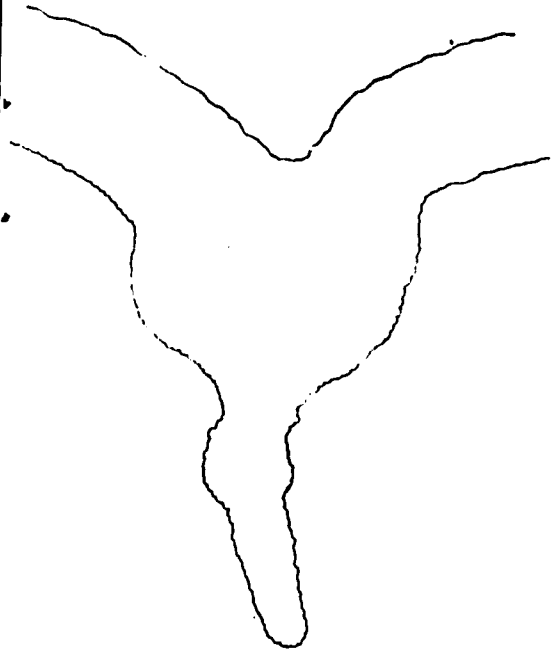
Outlines of T.S. Leaf Midrib Region



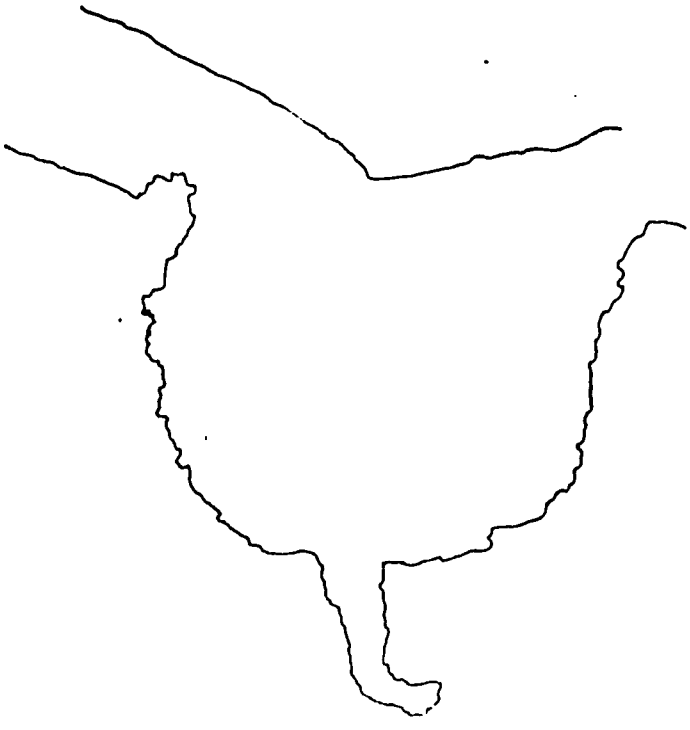
DIOSCOREA ALATA - SUDURAJA ALA
MIDRIB REGION (10 X 10)



DIOSCOREA ALATA - URUMPIRAI
MIDRIB REGION (10 X 10)



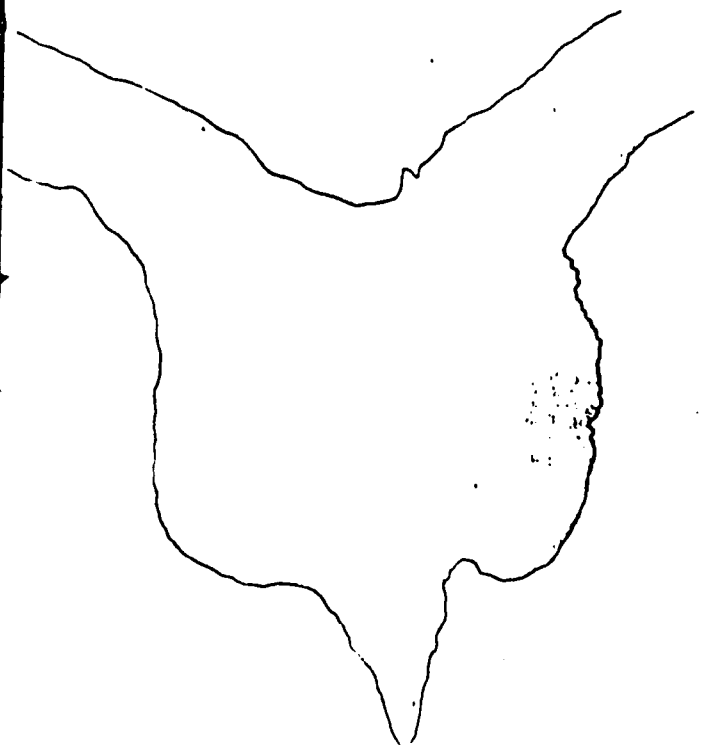
DIOSCOREA ALATA-RAJA WALLI
MIDRIB REGION (10 X 10)



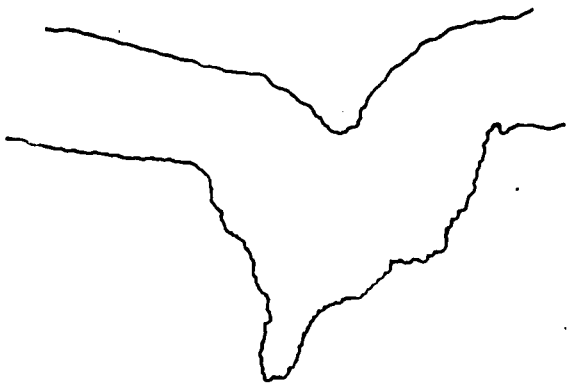
DIOSCOREA ALATA - RASA WALLI
MIDRIB REGION (10 X 10)

Appendix 1

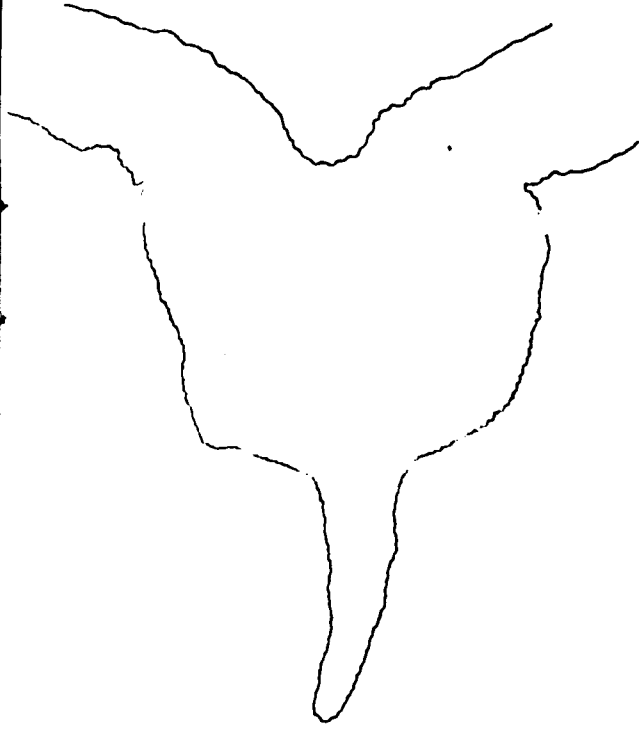
Outlines of T.S. Leaf Midrib Region



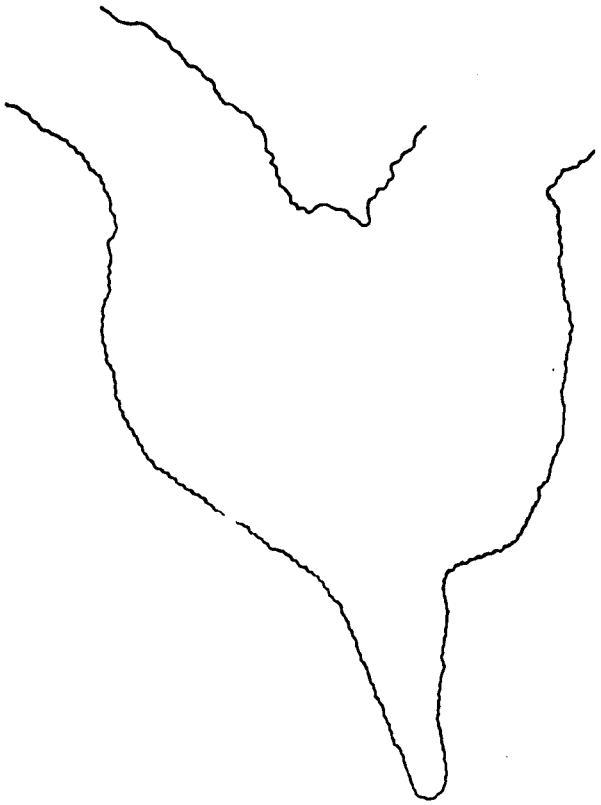
DIOSCOREA ALATA-LEYDANTA
MIDRIB REGION (10 X 10)



DIOSCOREA ALATA-DANDO
MIDRIB REGION (10 X 10)



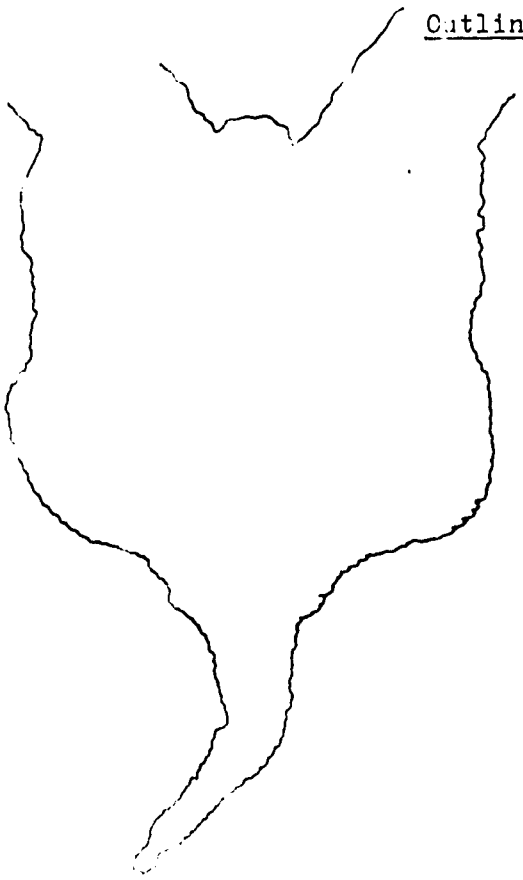
DIOSCOREA ALATA-TAMBALA
MIDRIB REGION (10 X 10)



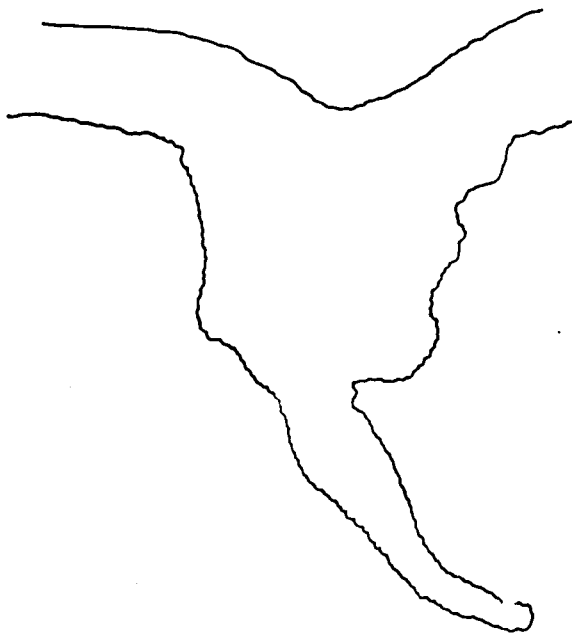
DIOSCOREA ALATA-JAMBURALA
MIDRIB REGION (10 X 10)

Appendix 1

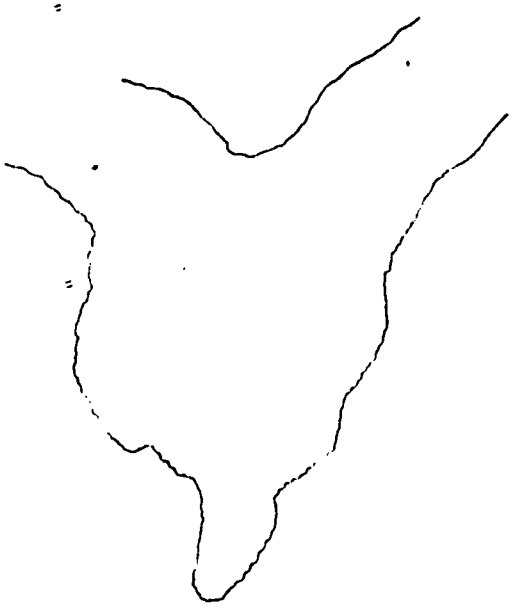
Outlines of T.S. Leaf Midrib Region



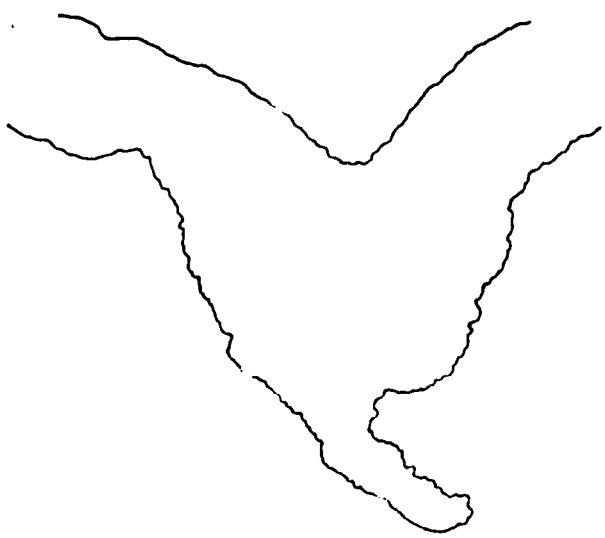
DIOSCOREA ALATA - PUERTO RICO YAM
MIDRIB REGION (10 X 10)



DIOSCOREA ALATA - RATA ALA
MIDRIB REGION (10 X 10)



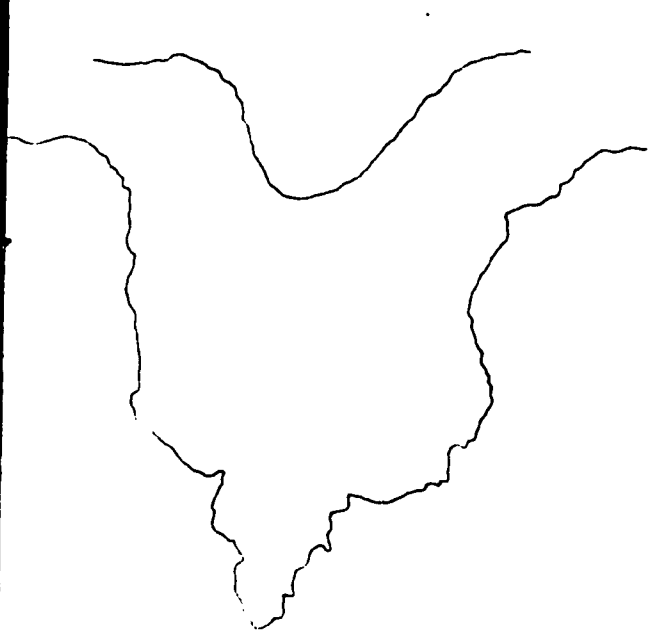
DIOSCOREA ALATA RATANGALA
MIDRIB REGION (10 X 10)



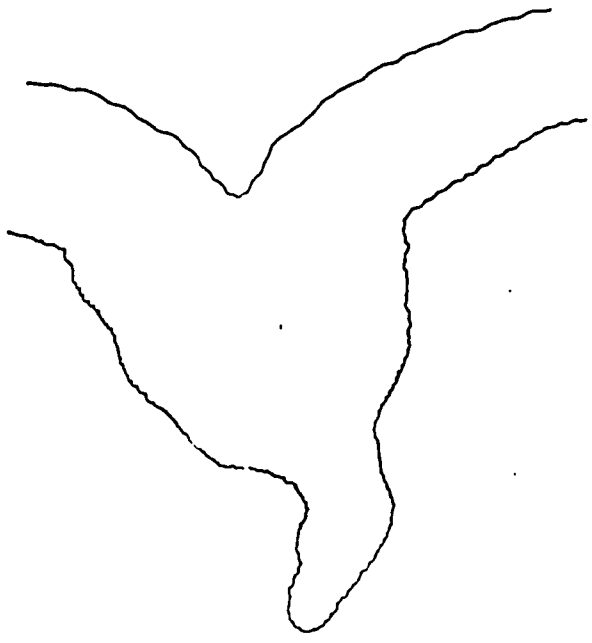
DIOSCOREA ALATA - RATA ALA
MIDRIB REGION (10 X 10)

Appendix 1

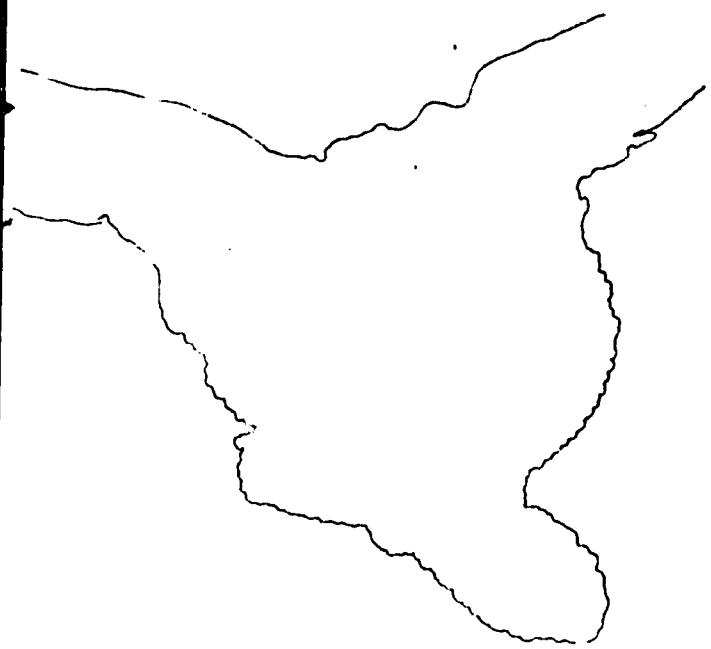
Outlines of T.S. Leaf Midrib Region



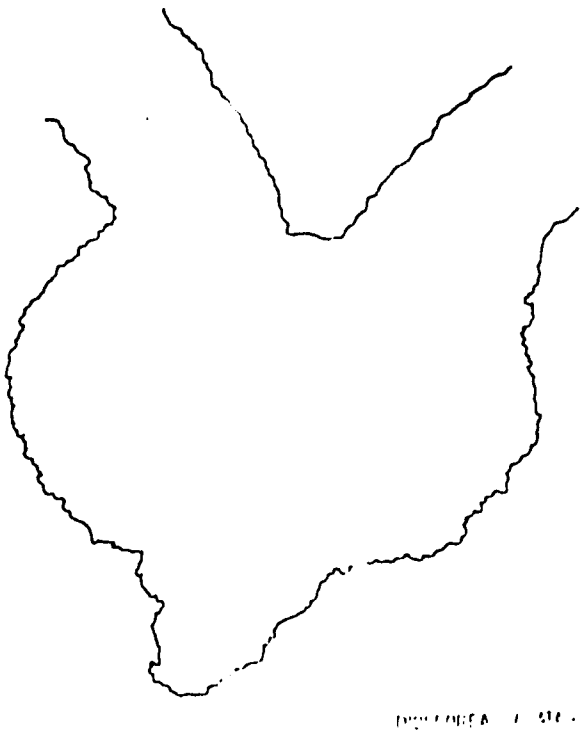
DIOSCOREA ALATA-KEMPU WALLI
MIDRIB REGION [10 X 10]



DIOSCOREA ALATA-WAI ALA
MIDRIB REGION [10 X 10]



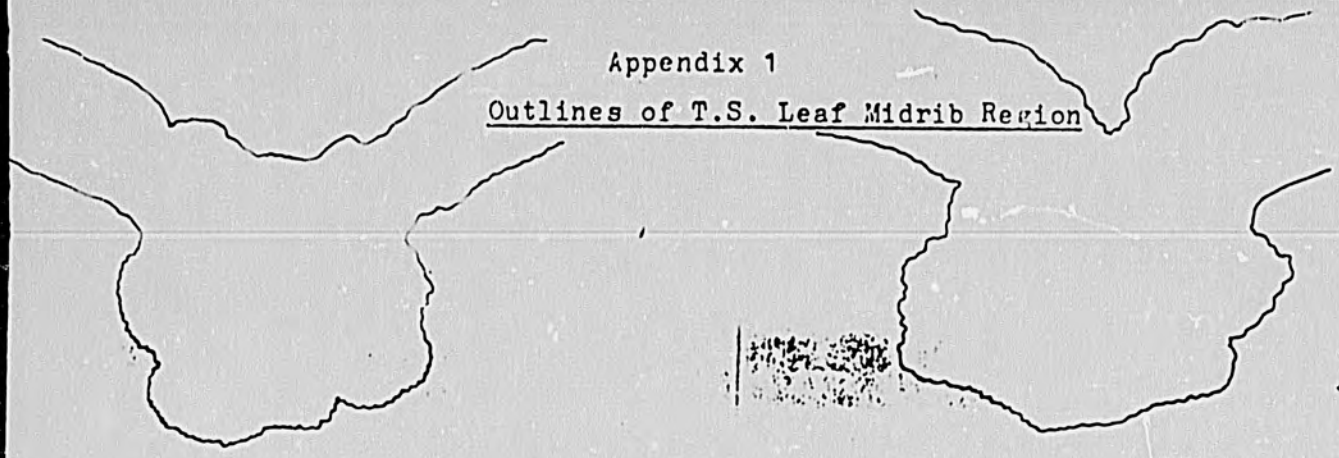
DIOSCOREA ALATA - PU ALA
MIDRIB REGION [10 X 10]



DIOSCOREA ALATA - KANDALA
MIDRIB REGION [10 X 10]

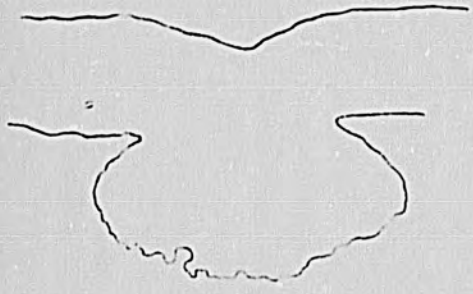
Appendix 1

Outlines of T.S. Leaf Midrib Region

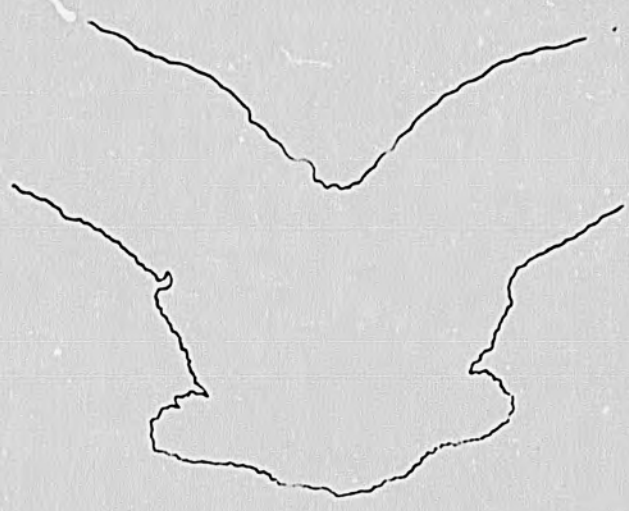


DIOSCOREA BULBIFERA - JAFFNA COLLECTION
MIDRIB REGION (10 X 10)

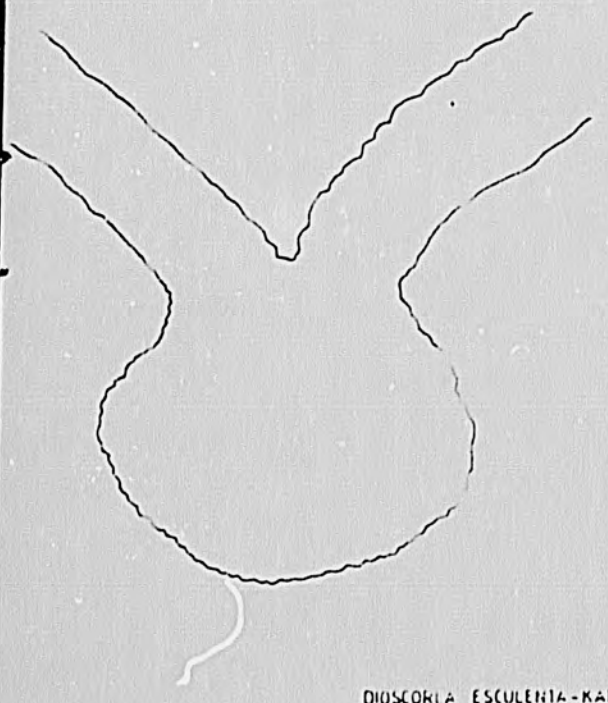
DIOSCOREA ESCULENTA - KUKULALA
MIDRIB REGION (10 X 10)



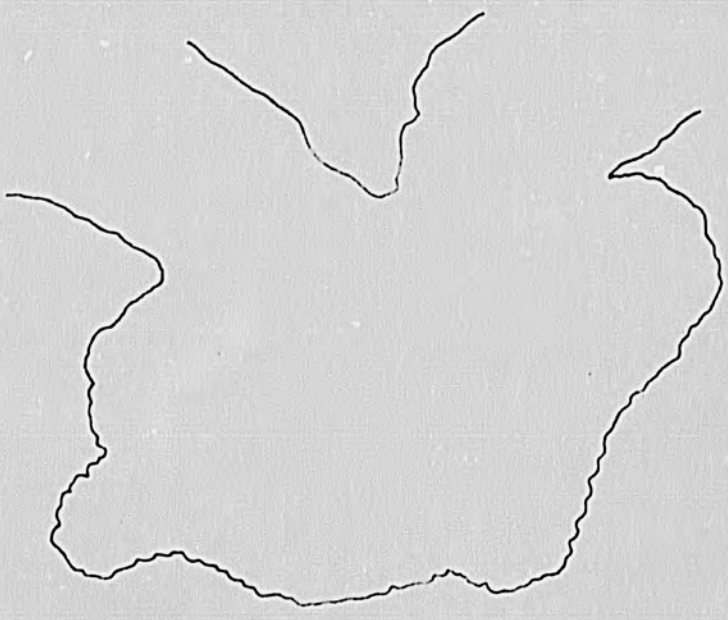
DIOSCOREA PENTAPHYLLA - KATUWALA ALA
MIDRIB REGION (10 X 10)



DIOSCOREA ANGULATA - BOKE
MIDRIB REGION (10 X 10)



DIOSCOREA ESCULENTA - KATU ALA
MIDRIB REGION (10 X 10)

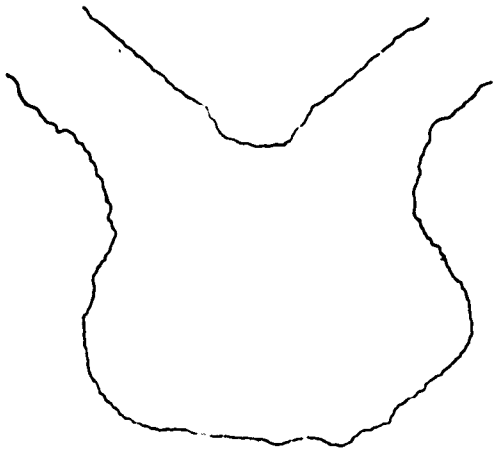


DIOSCOREA ESCULENTA - SIRU WALLI
MIDRIB REGION (10 X 10)

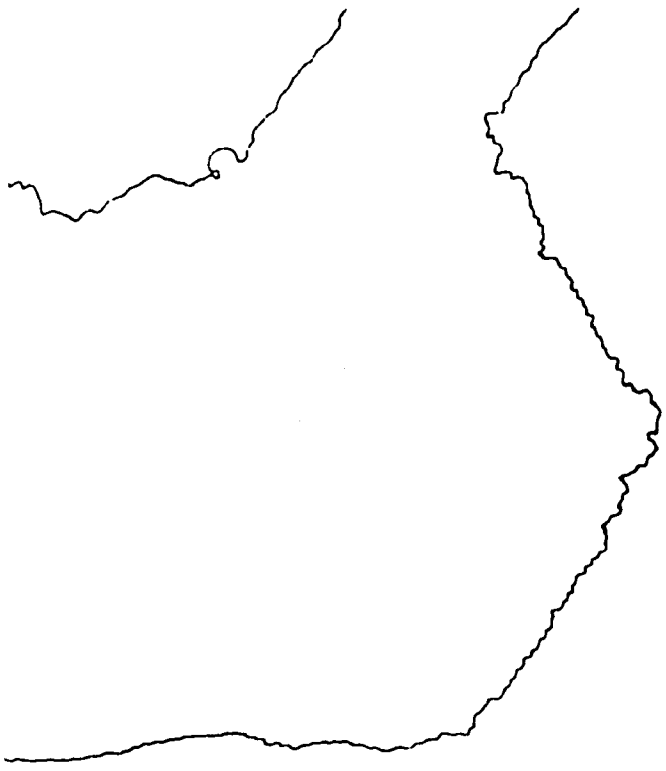
Appendix 1

Outlines of T.S. Leaf Midrib Region

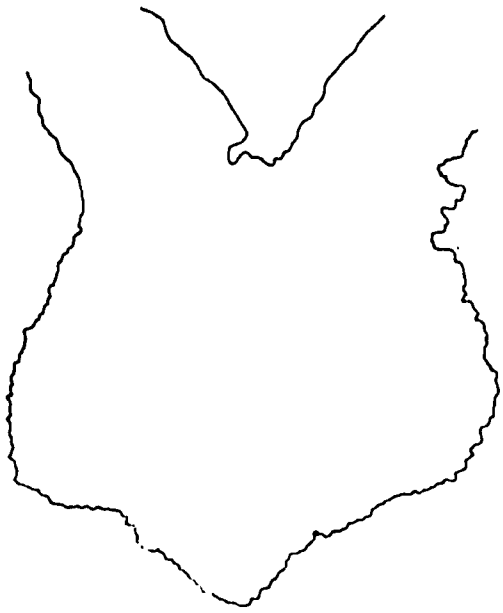
DIOSCOREA ESCULENTA - JANALA
MIDRIB REGION (10 X 10)



DIOSCOREA BULBIFERA - KASA WALI
(YELLOW FLESH)
MIDRIB REGION (10 X 10)

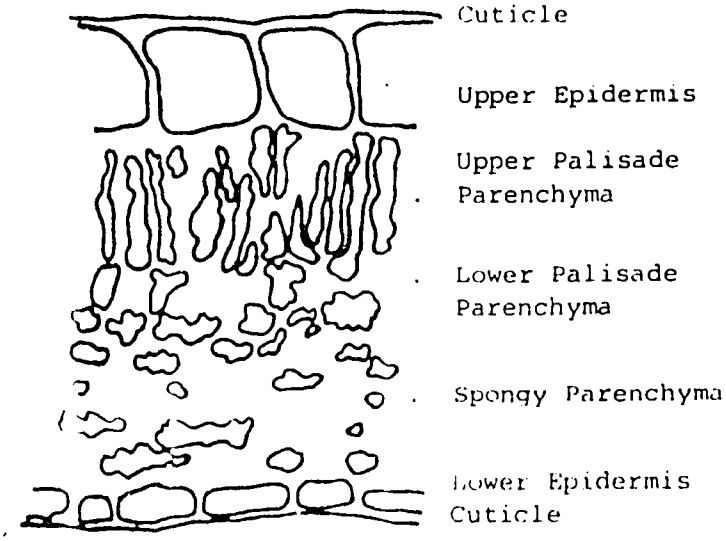


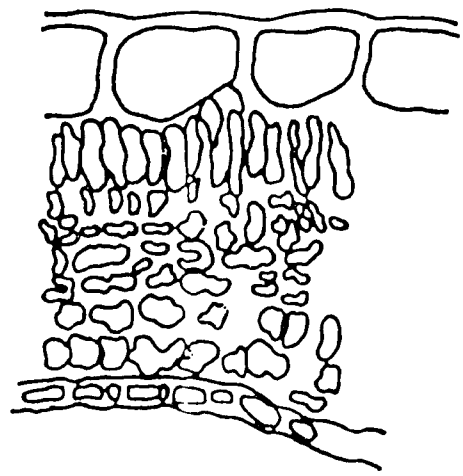
DIOSCOREA BULBIFERA - MOTAKA WALLI
MIDRIB REGION (10 X 10)



DIOSCOREA BULBIFERA - UDALA
MIDRIB REGION (10 X 10)

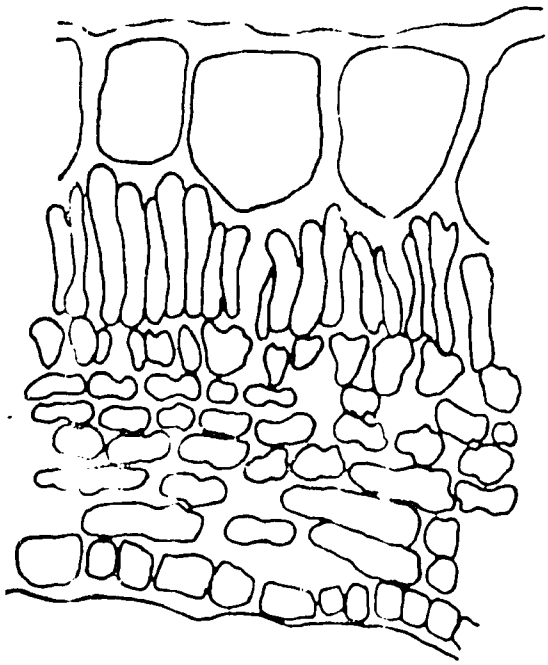
Lamina Thickness

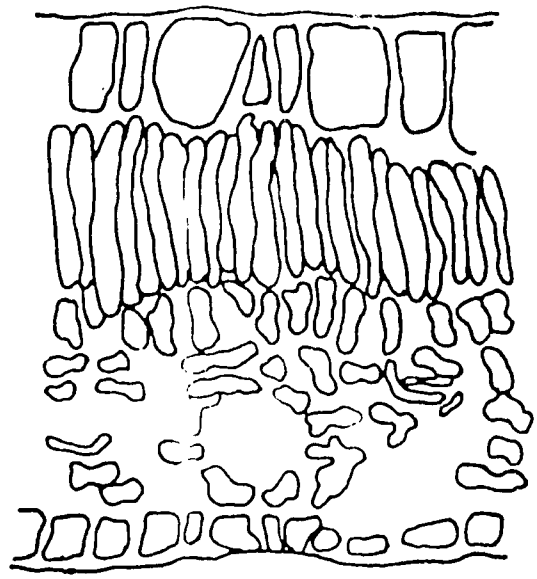




DIOSCOREA ALATA ANGILI ALA
LAMINA THICKNESS (10 X 20)

DIOSCOREA ALATA-HIRITALA
LAMINA THICKNESS (10 X 20)



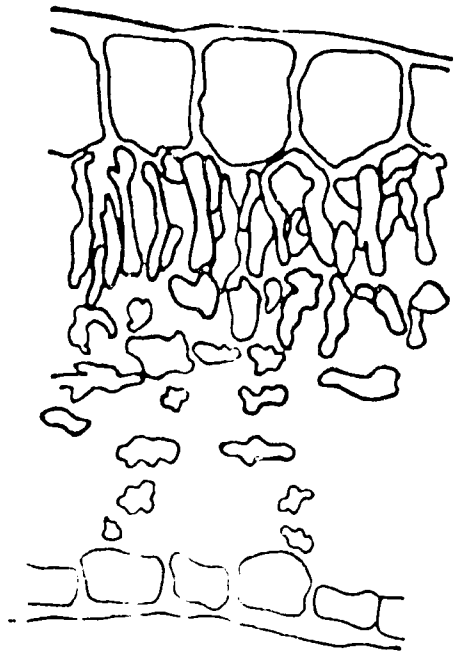


DIOSCOREA ALATA-KAJA HINGURALA
LAMINA THICKNESS 10 X 10)

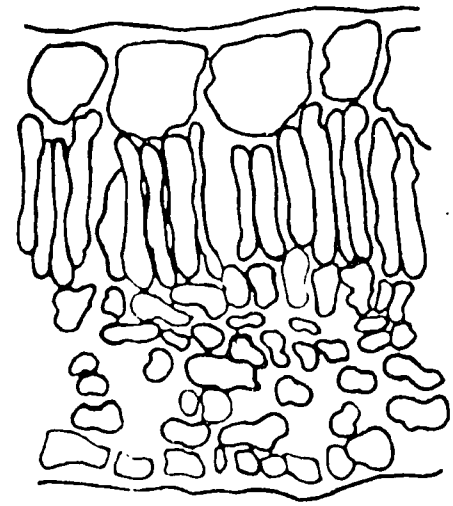
DIOSCOREA ALATA - KANDALA
LAMINA THICKNESS (10 X 10)

Appendix 2

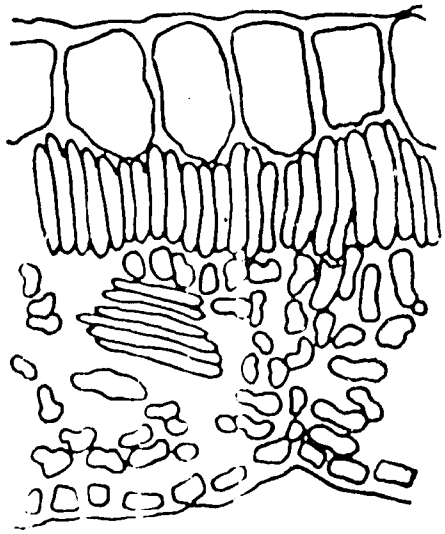
Lamina Thickness



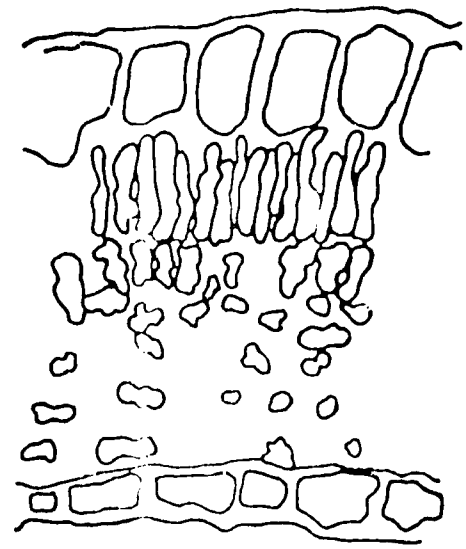
DIOSCOREA ALATA - KIRI KONDOL
LAMINA THICKNESS (10 X 20)



DIOSCOREA ALATA - URUMPIRAI
LAMINA THICKNESS (10 X 20)



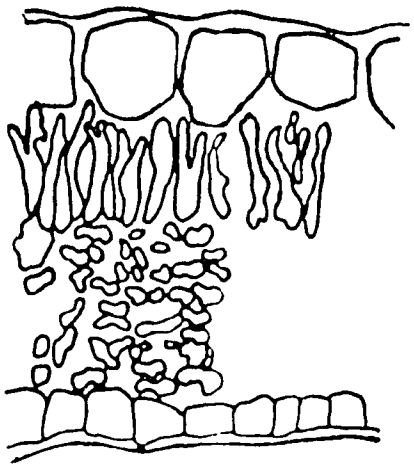
DIOSCOREA ALATA - TAMBALA
LAMINA THICKNESS (10 X 20)



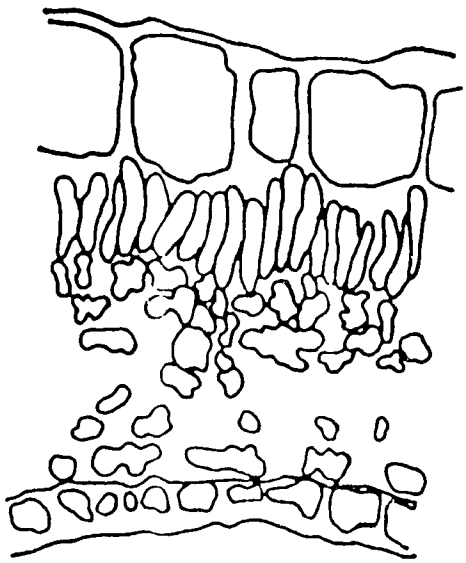
DIOSCOREA ALATA - JAMBURALA
LAMINA THICKNESS (10 X 20)

Appendix 2

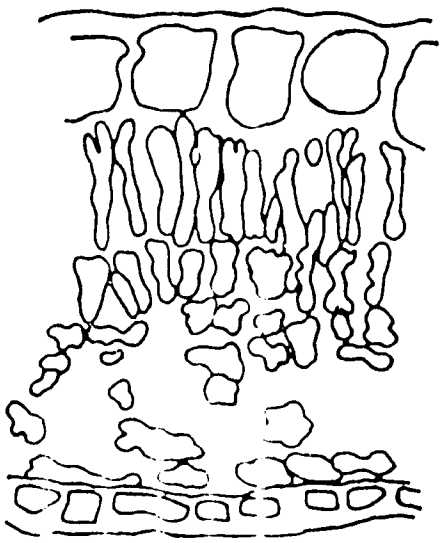
Lamina Thickness



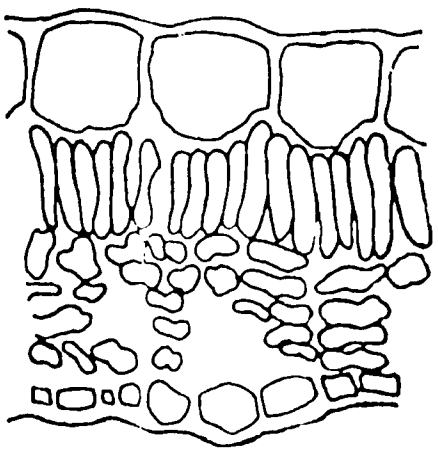
DIOSCOREA ALATA -KIRI ALA
LAMINA THICKNESS [10 X 20]



DIOSCOREA ALATA - PUERTO RICO YAM
LAMINA THICKNESS [10 X 20]



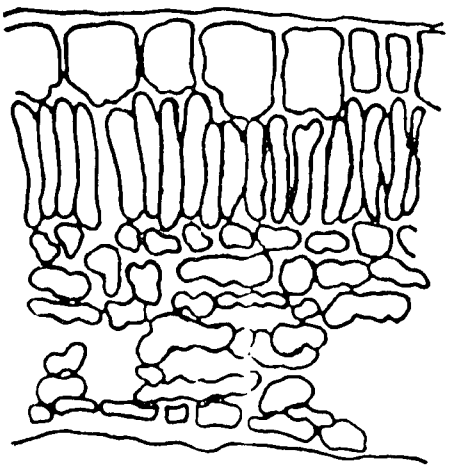
DIOSCOREA ALATA - KONDOL ALA
LAMINA THICKNESS [10 X 20]



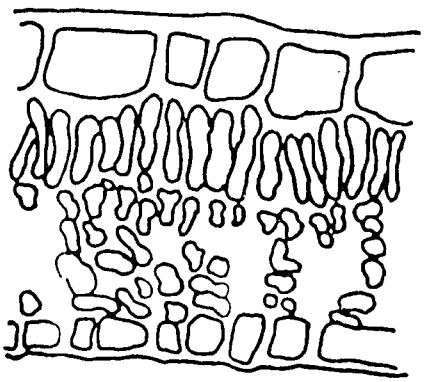
DIOSCOREA ALATA - KIRI UDALA
LAMINA THICKNESS [10 X 20]

Appendix 9

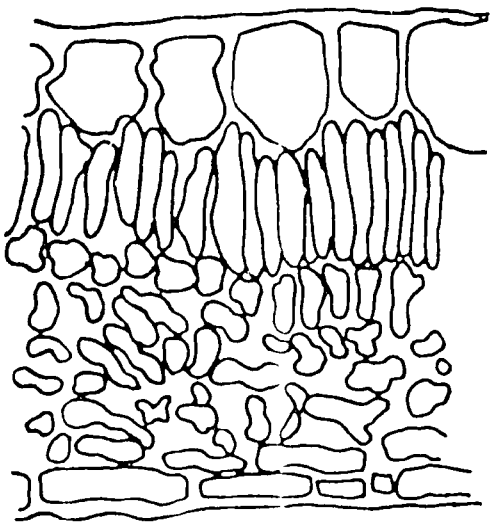
Lamina Thickness



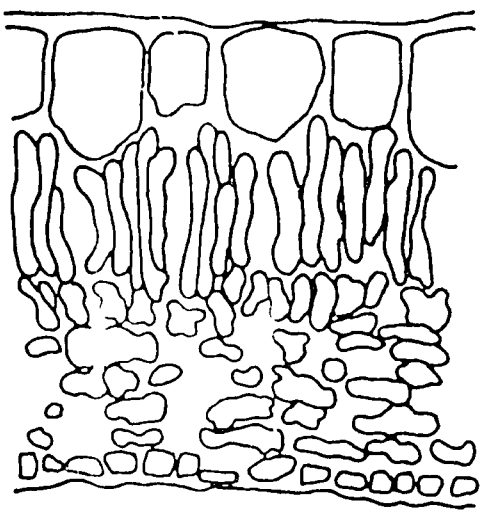
DIOSCOREA ALATA - DANDILA
LAMINA THICKNESS (10 X 20)



DIOSCOREA ALATA - RATU ALA
LAMINA THICKNESS (10 X 20)

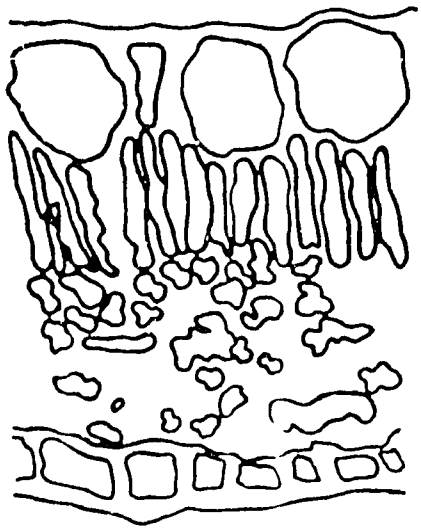


DIOSCOREA ALATA - RATANGALA
LAMINA THICKNESS (10 X 20)

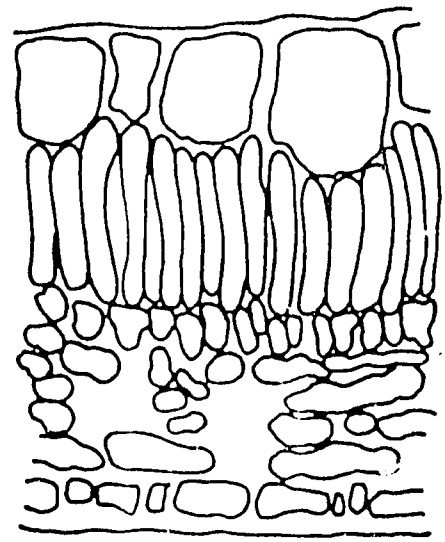


DIOSCOREA ALATA - RATA ALA
LAMINA THICKNESS (10 X 20)

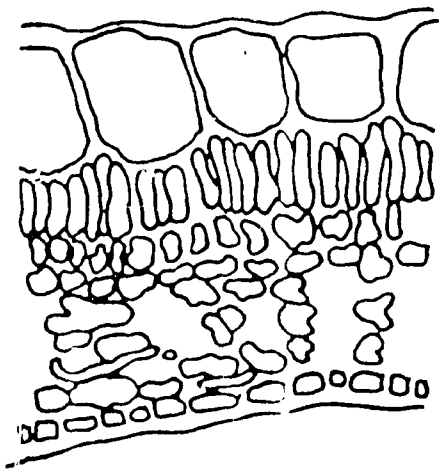
Lamina Thickness



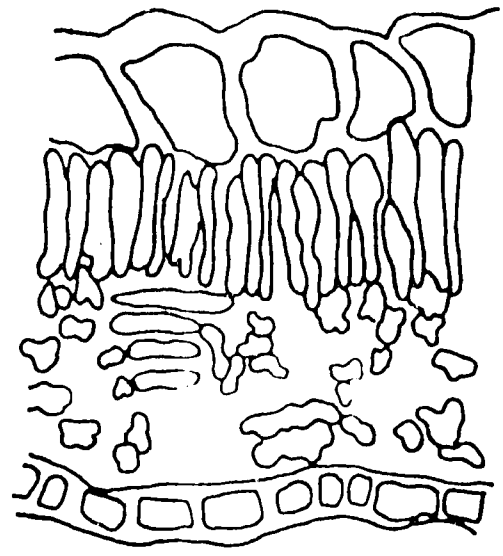
DIOSCOREA ALATA-KOMBU WALLI
LAMINA THICKNESS (10 X 20)



DIOSCOREA ALATA - WAL ALA
LAMINA THICKNESS (10 X 20)

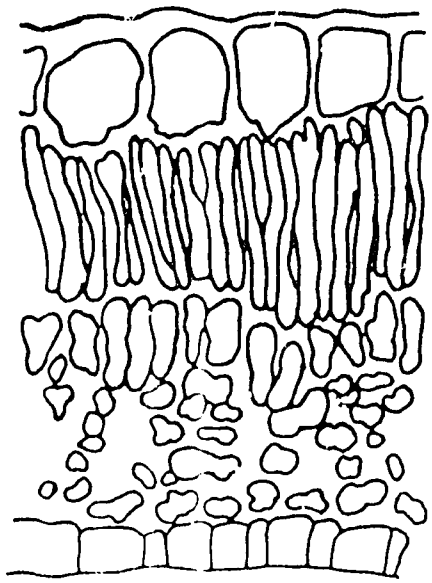


DIOSCOREA ALATA-SUDURAJA ALA
LAMINA THICKNESS 10 X 20)

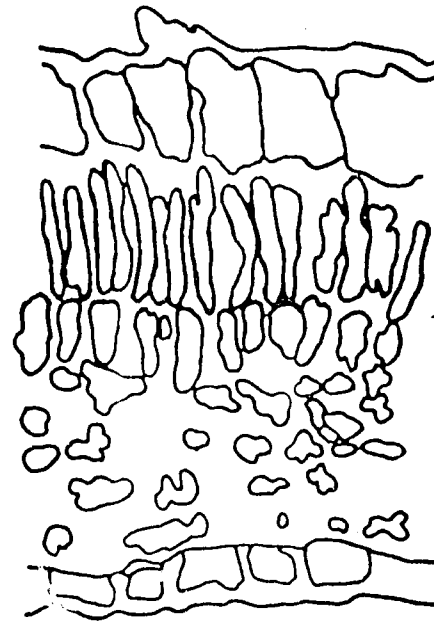


DIOSCOREA ALATA - LEYDANTA
LAMINA THICKNESS (10 X 20)

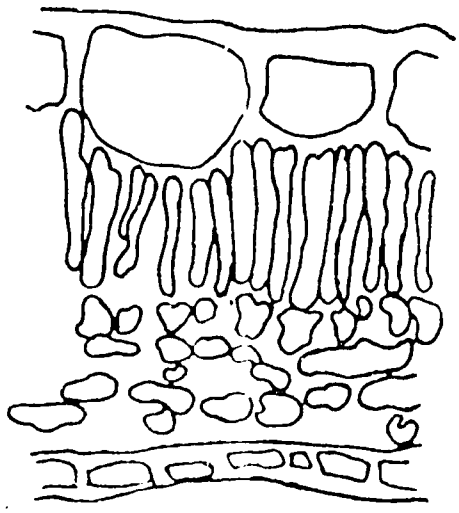
Lamina Thickness



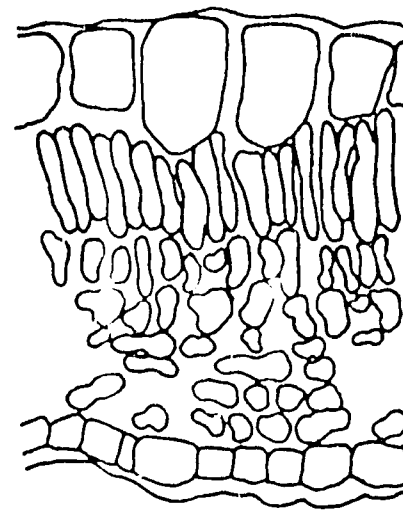
DIOSCOREA ALATA-KAHATA ANGALA
LAMINA THICKNESS [10 X 20]



DIOSCOREA ALATA-KAHATA ALA
LAMINA THICKNESS [10 X 20]

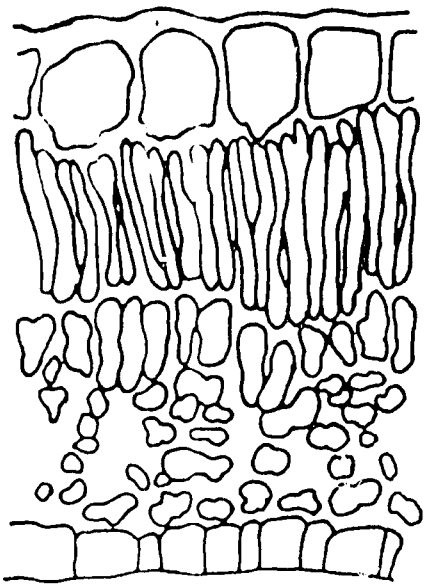


DIOSCOREA ALATA-KAHATA KONDOL
LAMINA THICKNESS [10 X 20]

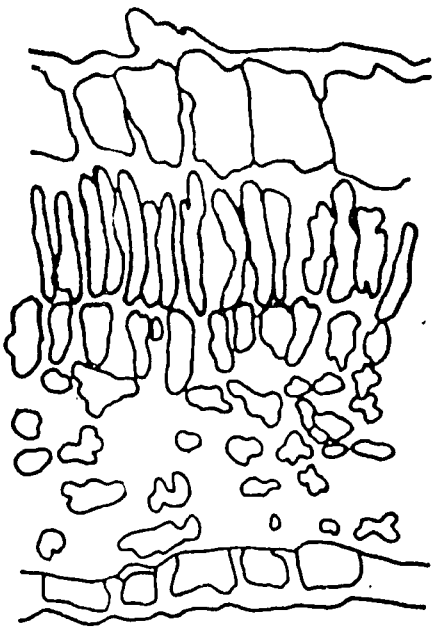


DIOSCOREA ALATA-RATA HINGURALA
LAMINA THICKNESS [10 X 20]

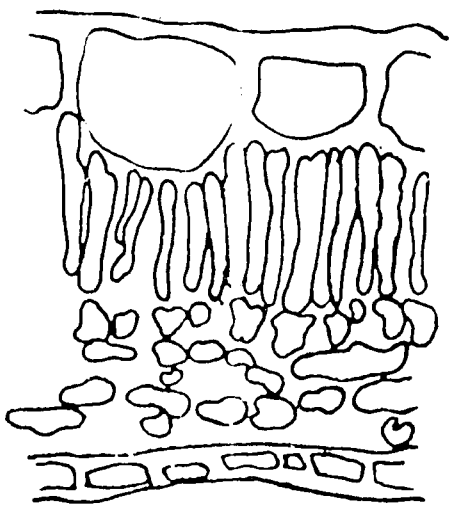
Lamina Thickness



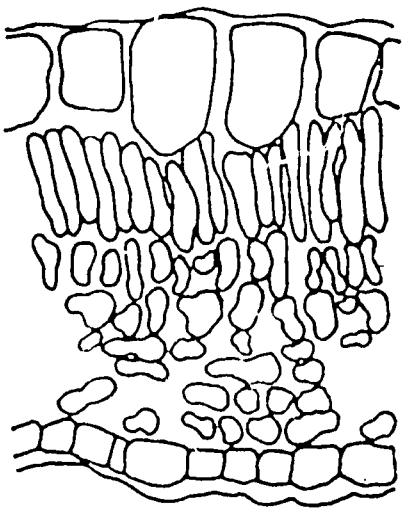
DIOSCOREA ALATA-KAHATA ANGALA
LAMINA THICKNESS [10 X 20]



DIOSCOREA ALATA-KAHATA ALA
LAMINA THICKNESS [10 X 20]



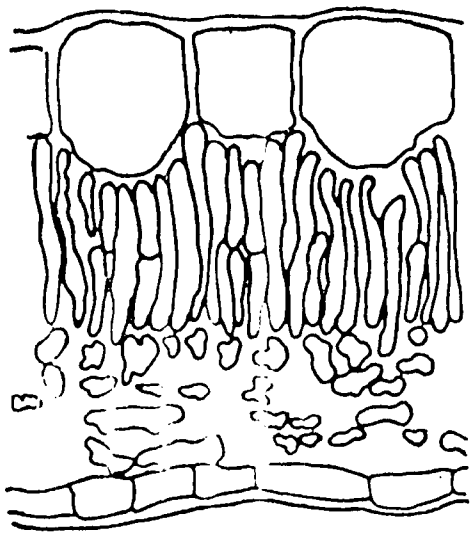
DIOSCOREA ALATA- KAHATA KONDOL
LAMINA THICKNESS [10 X 20]



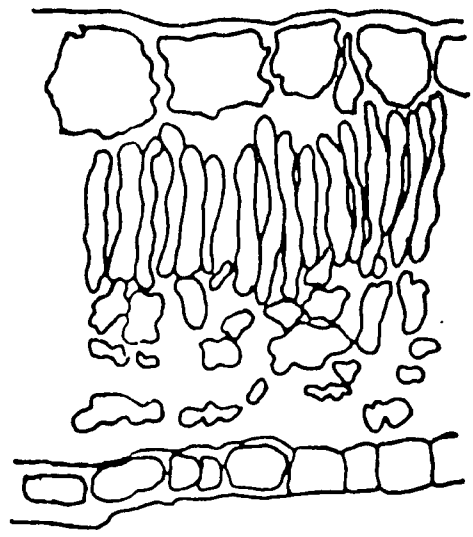
DIOSCOREA ALATA-RATA HINGURALA
LAMINA THICKNESS [10 X 20]

Appendix 2

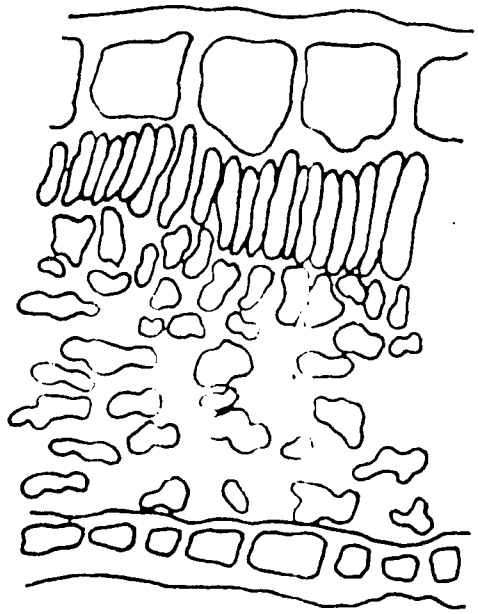
Lamina Thickness



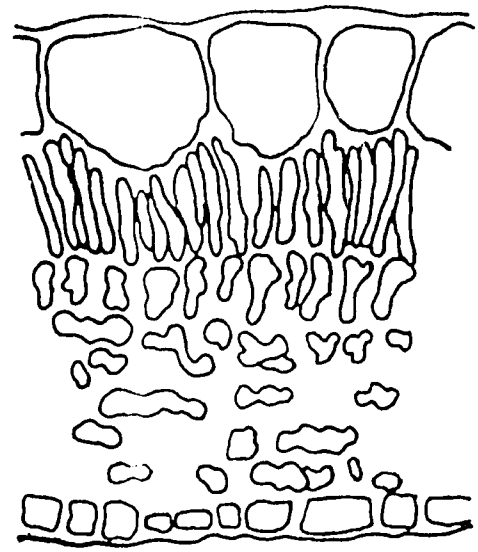
DIOSCOREA ALATA - KING YAM
LAMINA THICKNESS [10 X 20]



DIOSCOREA ALATA-RAJA ALA
LAMINA THICKNESS [10 X 20]

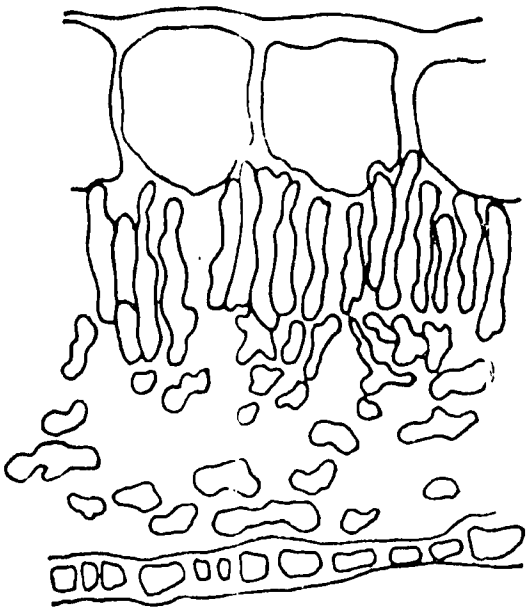


DIOSCOREA ALATA-RASA WALLI
LAMINA THICKNESS [10 X 20]

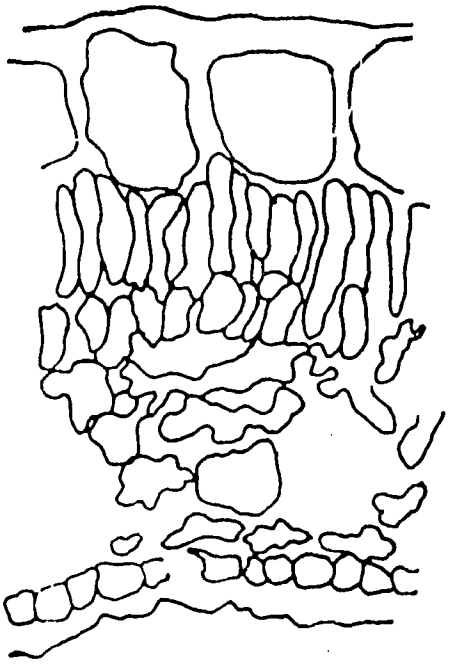


DIOSCOREA ALATA - RAJA WALLI
LAMINA THICKNESS [10 X 20]

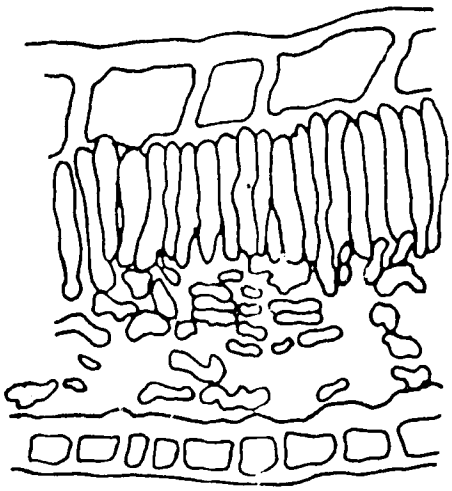
Lamina Thickness



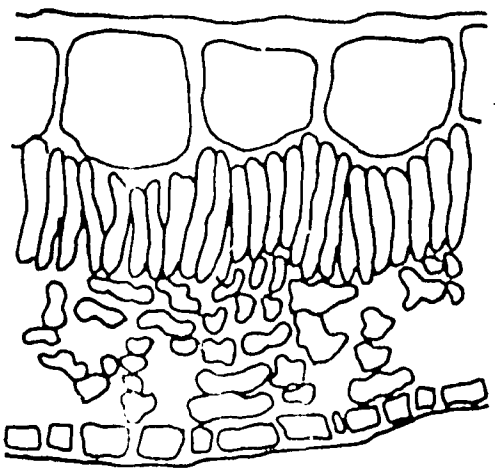
DIOSCOREA ALATA-INI ALA
LAMINA THICKNESS [10 X 10]



DIOSCOREA ALATA - HINGURALA
LAMINA THICKNESS [10 X 10]



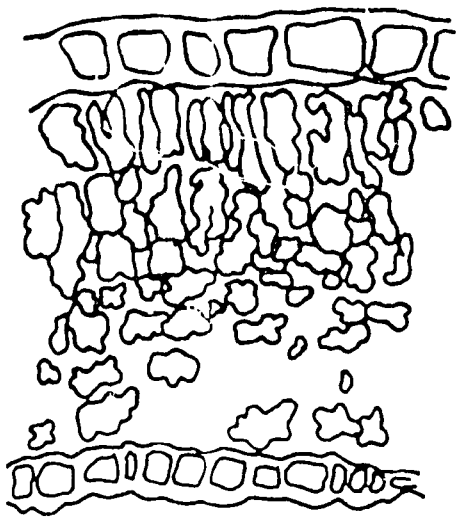
DIOSCOREA ALATA JAFFNA PURPLE
LAMINA THICKNESS [10 X 20]



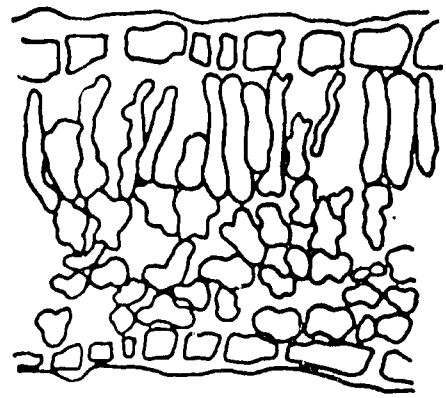
DIOSCOREA ALATA-JAFFNA COLLECTIC
LAMINA THICKNESS [10 X 20]

Appendix 2

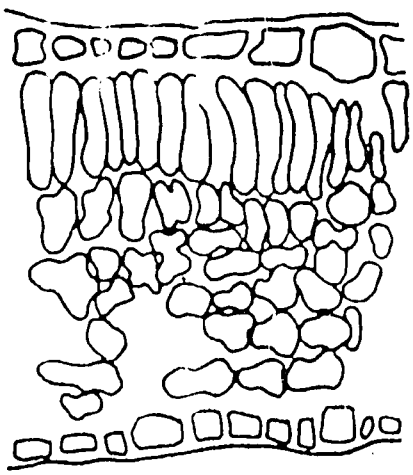
Lamina Thickness



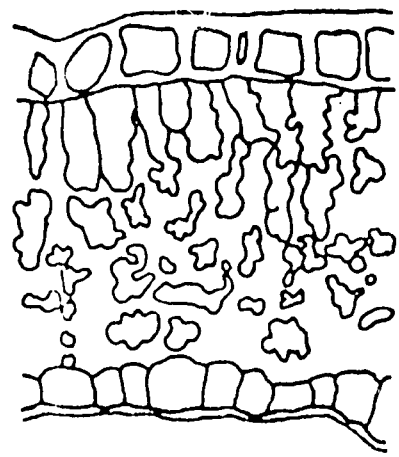
DIOSCOREA BULBIFERA - MOTAKA WALLI
LAMINA THICKNESS (10 X 20)



DIOSCOREA BULBIFERA - RASA WALL
(YELLOW FLESH)
LAMINA THICKNESS (10 X 20)



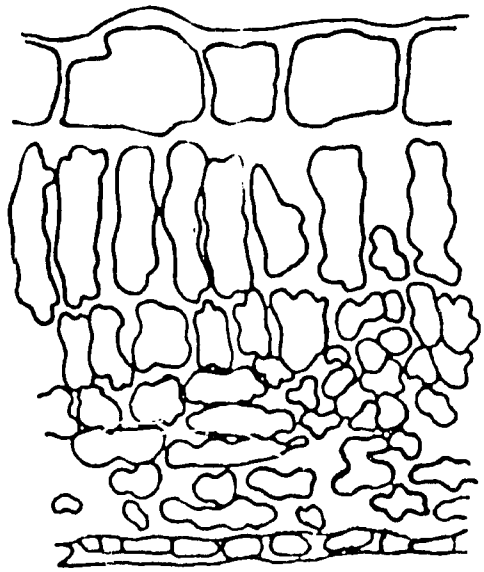
DIOSCOREA BULBIFERA - JAFFNA COLLECTION
LAMINA THICKNESS (10 X 20)



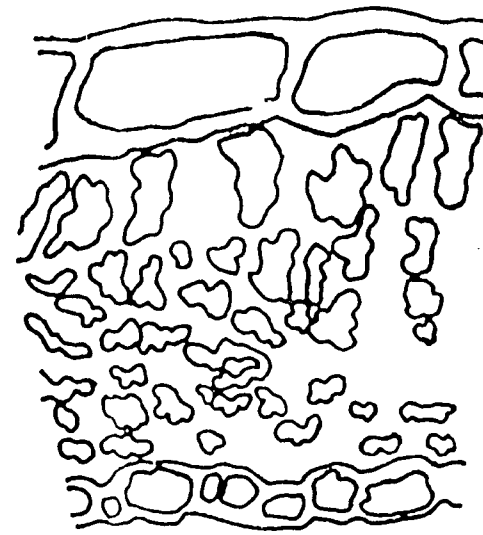
DIOSCOREA BULBIFERA - UDALA
LAMINA THICKNESS (10 X 20)

Appendix 2

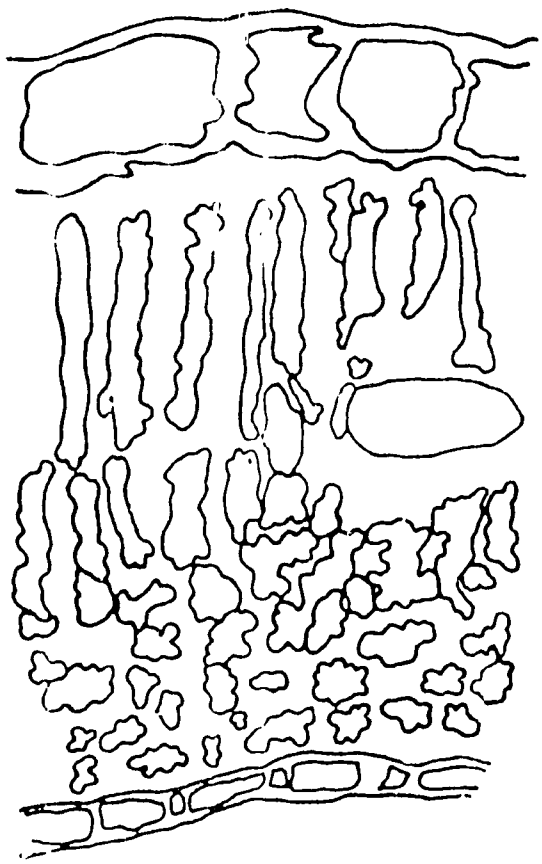
Lamina Thickness



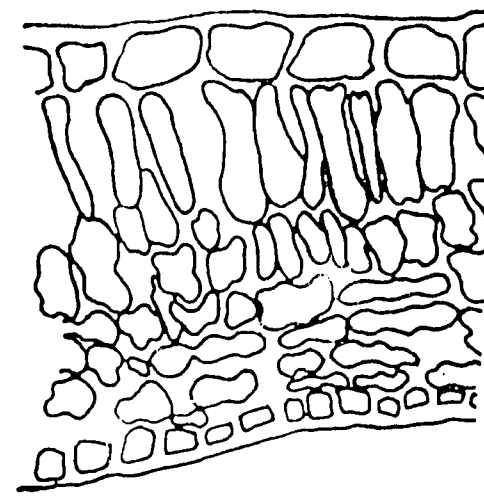
DIOSCOREA ESCULENTA-JAWALA
LAMINA THICKNESS [10 X 20]



DIOSCOREA ESCULENTA-KUKULALA
LAMINA THICKNESS [10 X 20]



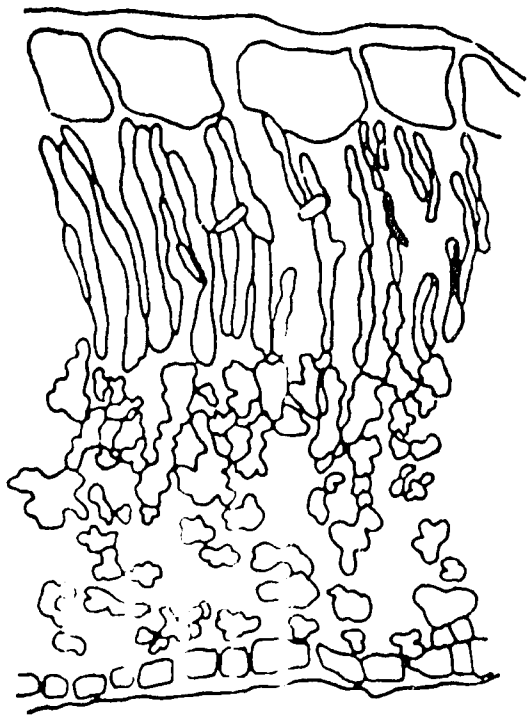
DIOSCOREA ESCULENTA-SIRU WALLI
LAMINA THICKNESS [10 X 20]



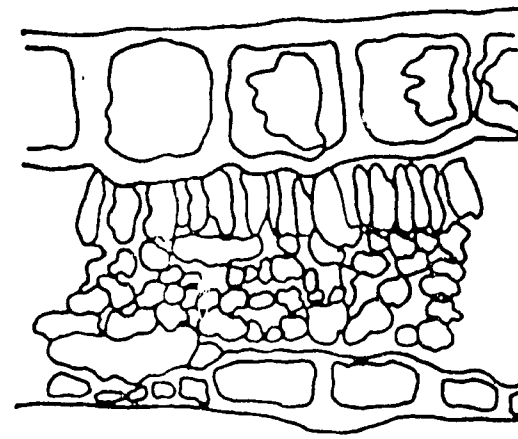
DIOSCOREA ESCULENTA-
KATU ALA
LAMINA THICKNESS[10 X 20]

appendix 2

Lamina Thickness



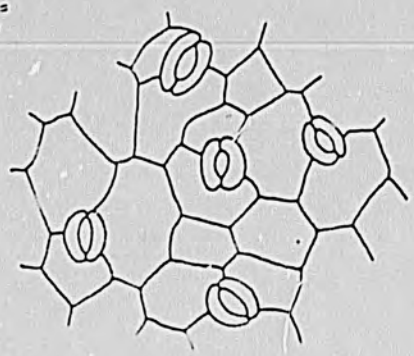
DIOSCOREA ROTUNDATA - BOKE
LAMINA THICKNESS (10 X 20)



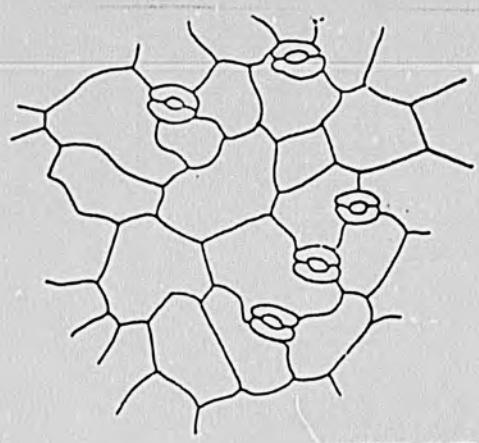
DIOSCOREA PENTAPHYLLA -
KATUWALA ALA
LAMINA THICKNESS (10 X 20)

Appendix 3

Leaf Epidermal Features



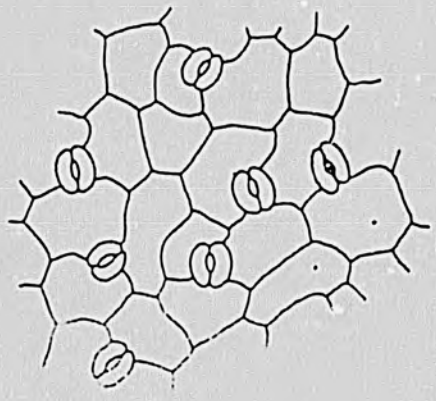
DIOSCOREA ALATA - KONDOL ALA
LOWER EPIDERMIS (10 X 40)



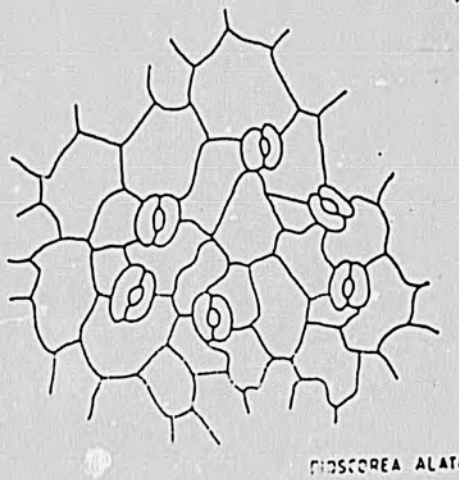
DIOSCOREA ALATA - KIRI KONDOL
LOWER EPIDERMIS. (10 X 40)

Stomata

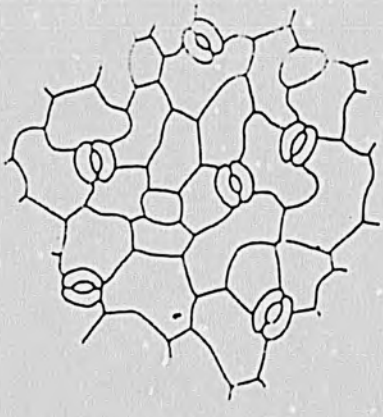
Epidermal Cells



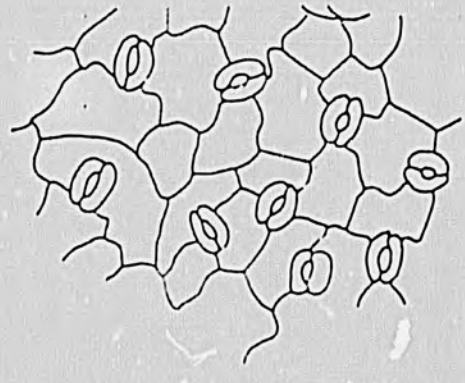
DIOSCOREA ALATA - KIRI UDALA
LOWER EPIDERMIS (10 X 40)



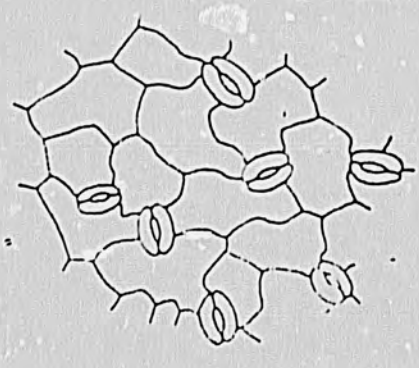
DIOSCOREA ALATA - KIRI [illegible]
LOWER EPIDERMIS (10 X 40)



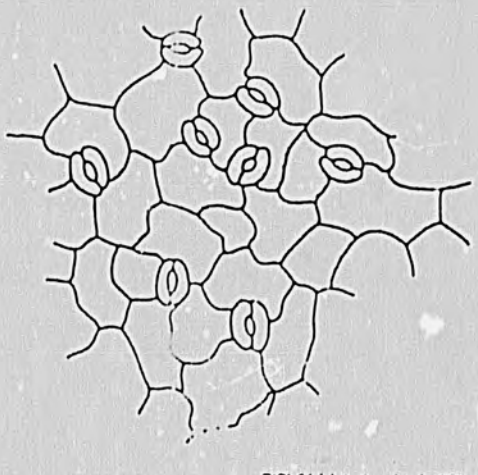
DIOSCOREA ALATA - LEYDANIA
LOWER EPIDERMIS (10 X 40)



DIOSCOREA ALATA - JAMBUIRA
LOWER EPIDERMIS (10 X 40)



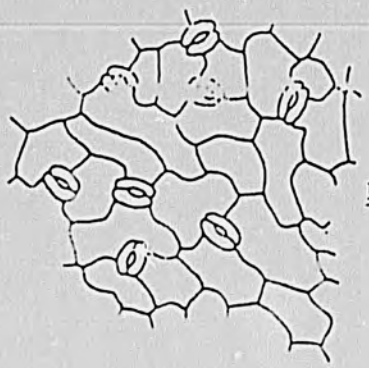
DIOSCOREA ALATA - JAMBALA
LOWER EPIDERMIS (10 X 40)



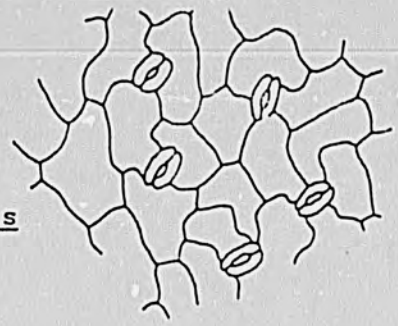
DIOSCOREA ALATA - [illegible] YAMS
LOWER EPIDERMIS (10 X 40)

Appendix 3

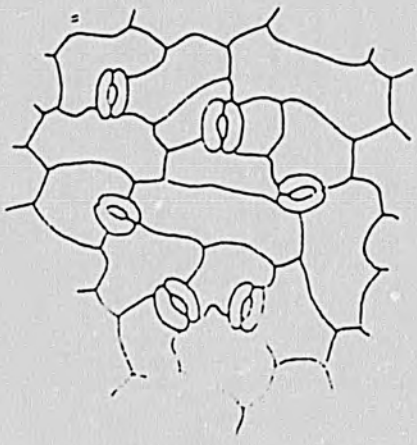
Leaf Enidermal Feetures

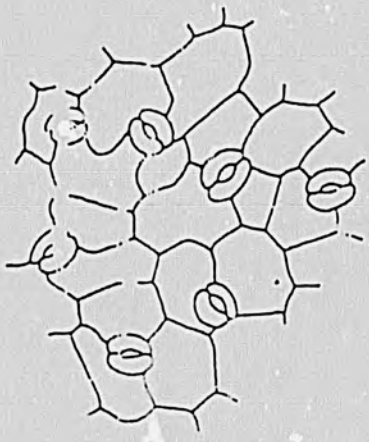


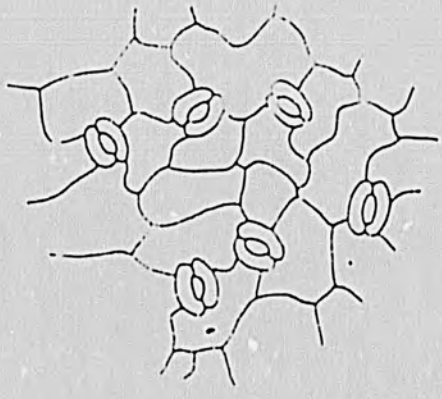
DIOSCOREA ALATA-RATA ALA
LOWER EPIDERMIS (10 X 40)



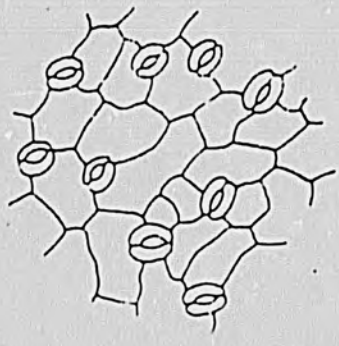
DIOSCOREA ALATA-RATU ALA
LOWER EPIDERMIS (10 X 40)



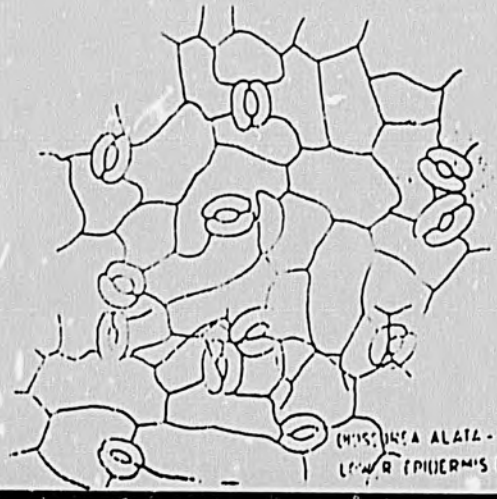




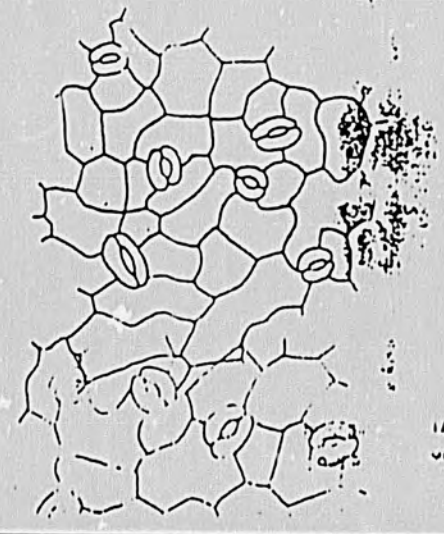
DIOSCOREA ALATA-PILI ALA
LOWER EPIDERMIS (10 X 40)



DIOSCOREA ALATA-MUNDALA
LOWER EPIDERMIS (10 X 40)

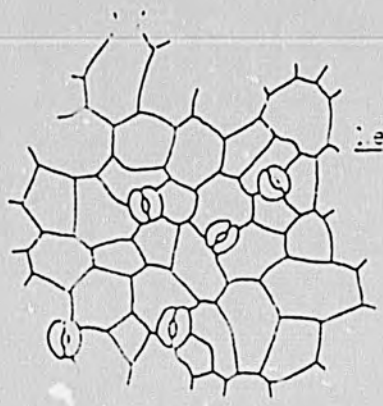


DIOSCOREA ALATA-ANGILI ALA
LOWER EPIDERMIS (10 X 40)

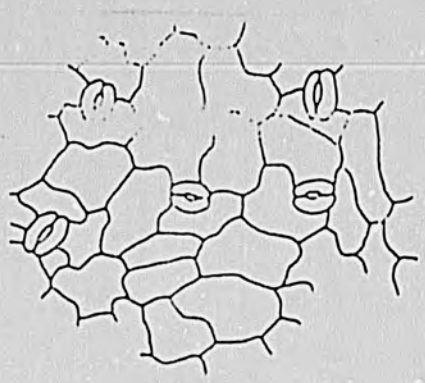


Appendix 3

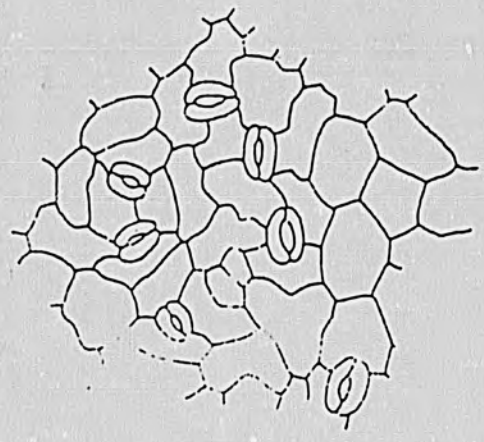
Leaf Epidermal Features



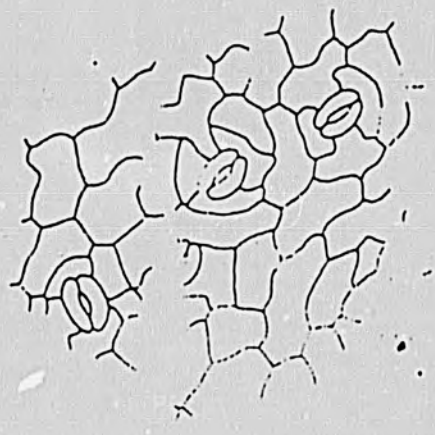
DIOSCOREA ALATA-RAT[illegible] IRALA
LOWER EPIDERMIS [10 X 4[illegible]



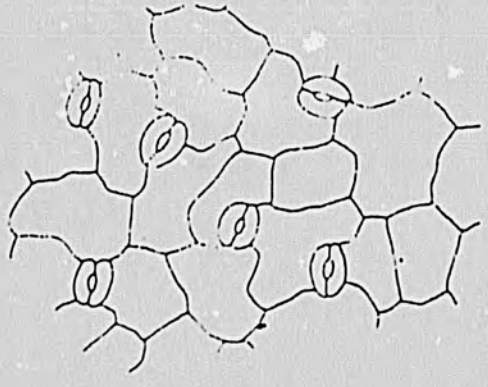
DIOSCOREA BULBIFERA-JAF[illegible]NA COLLECTIO
LOWER EPIDERM[illegible] [10 X 4[illegible]



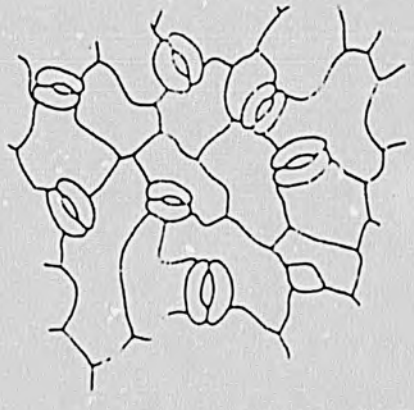
DIOSCOREA BULBIFERA-[illegible]
LOWER EPIDERMIS [10 X 40]



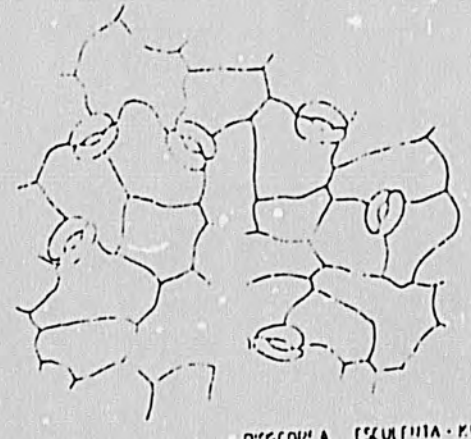
[illegible] [illegible]-MOTAMBA
[illegible] [illegible] [10 X 40]



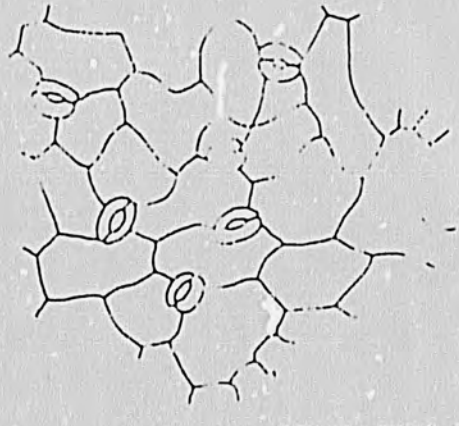
DIOSCOREA ESCULENTA-JAWA A
LOWER EPIDERMIS [10 X 4[illegible]



DIOSCOREA ESCULENTA [illegible]
LOWER EPIDERMIS [10 X [illegible]



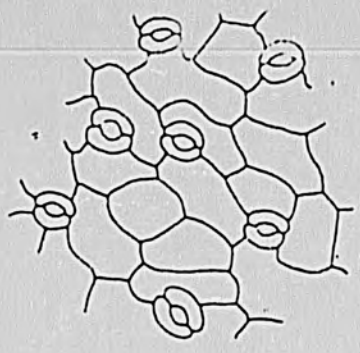
DIOSCOREA ESCULENTA-KURUI A
LOWER EPIDERMIS [10 X 40]



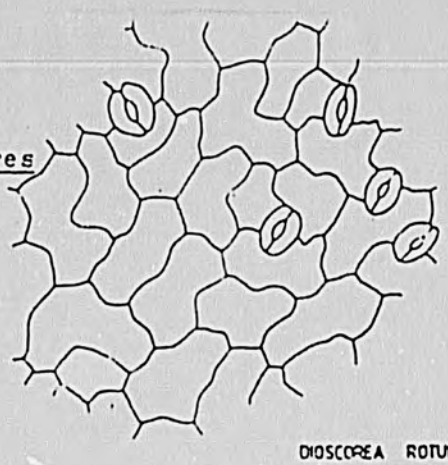
DIOSCOREA ESCUL[illegible]SIH WALU
LOWER EPIDERM[illegible] X 40]

Appendix 3

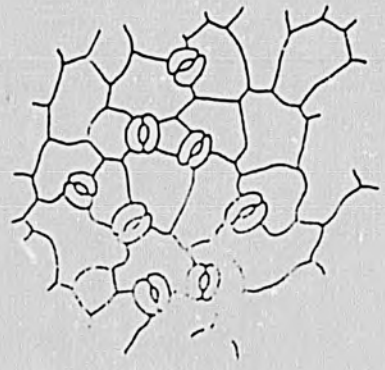
Leaf Epidermal Features



DIOSCOREA ALATA-KAHATA ALA
LOWER EPIDERMIS (10 X 40)



DIOSCOREA ROTUNDATA - BONI
LOWER EPIDERMIS (10 X 40)



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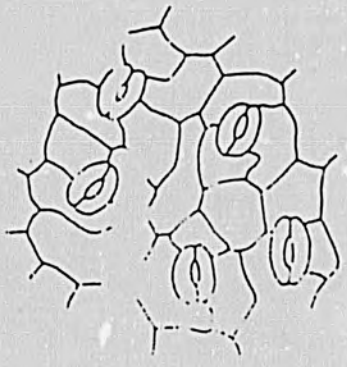
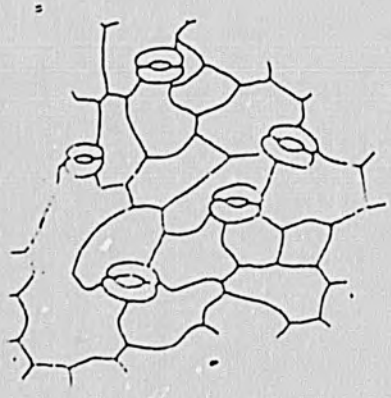


[illegible]
[illegible]



DIOSCOREA ALATA-KAHATA ANGALA
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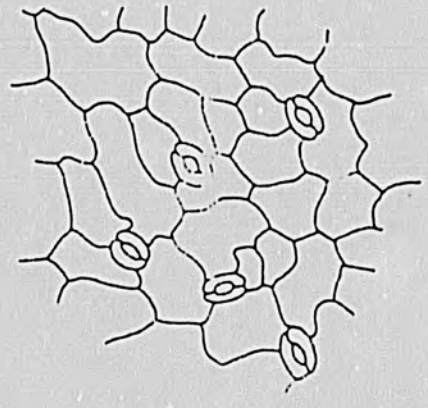
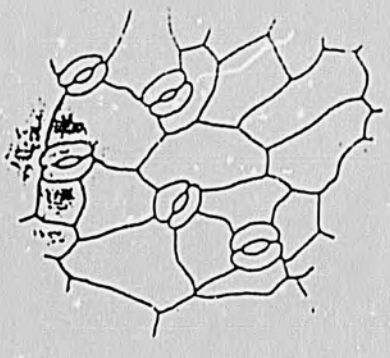
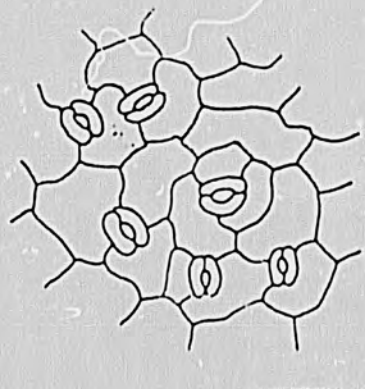


DIOSCOREA ALATA-RATANGALA
LOWER EPIDERMIS (10 X 40)



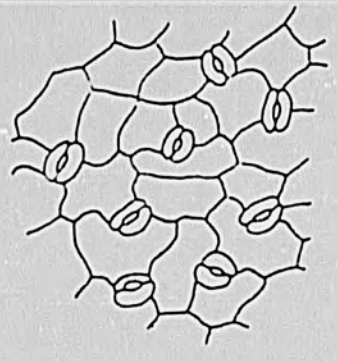
DIOSCOREA ALATA-KAHATA KONDOL
LOWER EPIDERMIS (10 X 40)



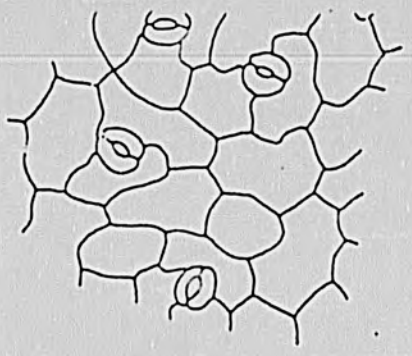
DIOSCOREA ALATA - SUDURAHA ALA
LOWER EPIDERMIS (10 X 40)

Appendix 3

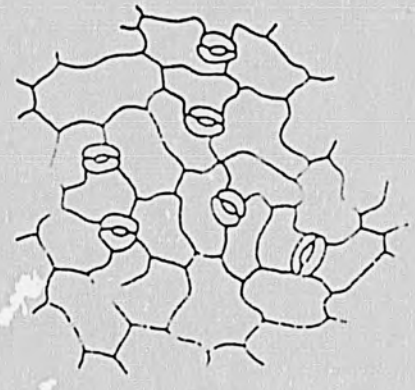
Leaf Epidermal Features



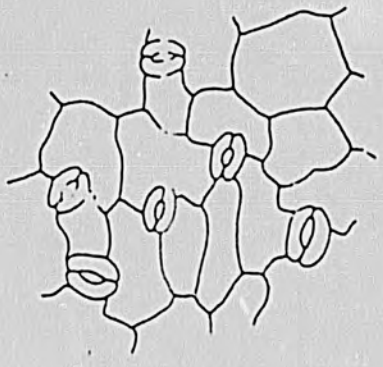
DIOSCOREA ALATA - RASA WALLI
LOWER EPIDERMIS (10 X 40)



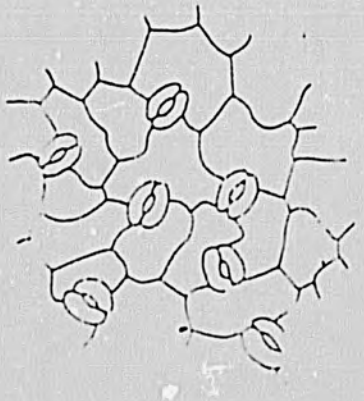
DIOSCOREA ALATA - RAJA WALLI
LOWER EPIDERMIS (10 X 40)



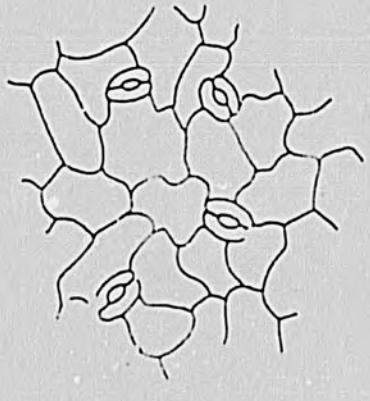
DIOSCOREA ALATA - RAJA ALA
LOWER EPIDERMIS (10 X 40)



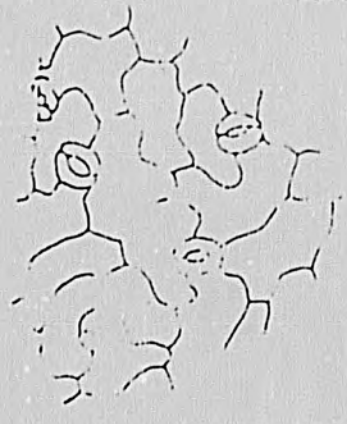
DIOSCOREA ALATA - [illegible] YAM
LOWER EPIDERMIS [illegible] 40)



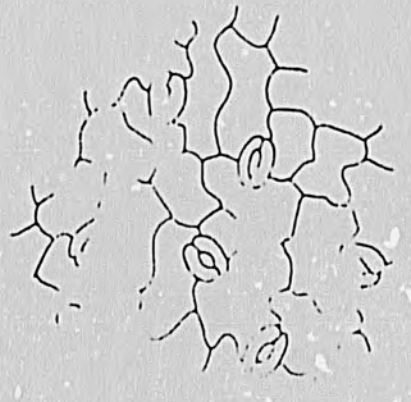
DIOSCOREA ALATA - [illegible]
LOWER EPIDERMIS (10 X 40)



DIOSCOREA ALATA - [illegible]
LOWER EPIDERMIS (10 X 40)



DIOSCOREA ALATA - [illegible]
LOWER EPIDERMIS (10 X 40)



[illegible] ALATA - WAL ALA
LOWER EPIDERMIS (10 X 40)

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