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Raja ala and Kakulu ala: Two New Improved Varieties of Greater Yam

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Abstract

Yams are being cultivated by farmers since ancient times in Sri Lanka. This crop produces high edible energy per hectare, contains more protein than most of the other root and tuber crops and serves as a supplementary food with medicinal properties. Evidence indicated that more than eight edible species of *Dioscorea* are present in Sri Lanka, of which greater yam (*D. alata*) and lesser yam (*D. esculenta*) are widely cultivated. Some of these species, though edible, are not cultivated mainly due to the low productivity and deep penetrating nature of their tubers. However, yams could be popularized, with the identification of high yielding shallow types, which have satisfactory culinary qualities as they need very little attention on agronomic practices. More than 90 accessions of *Dioscorea* germplasm were collected and maintained at the Horticultural Crops Research and Development Institute (HORDI) fields. Characterization using 25 morphological traits was carried out to identify the species of these accessions. Studies showed that due to the vegetative nature of these crops, the same variety had been known by different names at different locations and different clones had been erroneously called by the same name in different locations and had caused duplications. To avoid duplications, characterization of 25 morphological traits and cataloguing of this collection was done along with the evaluation for their yield potential, quality and other desirable agronomic characters. Thus 30 distinct *Dioscorea alata* genotypes were identified. Out of these, selections were made and two improved *D. alata* varieties, Raja ala and Kakulu ala having high yield, good culinary qualities and high marketable value were released in 2007.

Key words: *Dioscorea alata*, characterization, improved varieties, yield, cooking quality

Introduction

The *Dioscorea* is the largest genus of the *Dioscoreaceae* family consisting of over 600 species, tropical or sub tropical, mostly monoecious species, in which the rhizome is modified to produce annual tuber (Cobley, 1976). *Dioscorea alata* (L.) is believed to have originated in Asia and had spread to South-East Asia, Africa and the Pacific Islands (Purseglove, 1972). Out of the eight edible species existing in Sri Lanka, *Dioscorea alata* (greater yam), *Dioscorea esculenta* (lesser yam), *Diocorea bulbifera*, *Dioscorea hispida*, *Dioscorea opposita*, *Dioscorea trifida* and *Dioscorea pentaphylla* are present in natural ecosystems. *Dioscorea rotundata* was introduced from Africa. Out of these species, greater yam (*D. alata*) and lesser yam (*D. esculenta*) are widely cultivated.

Yams are eaten as curry, boiled, steamed, baked, roasted, fried or as puddings. They have medicinal properties and are used both in ayurvedic and western medicine. Earlier it was mostly cultivated in home gardens. Yams have high production potential and are food security crop. They are adapted to marginal environments. Therefore, there is no competition for fertile cultivable land. However, deep, well drained soils are preferred by yams. They thrive well in mixed cropping systems and requires low management, low input and attention. Yams have less

pests and diseases, except for leaf rust disease caused by *Goplana dioscoreae* and anthracnose caused by *Colletotrichum gloeosporioides*. Yams are environment friendly crops with less health hazards. They have increasing export demand also.

Therefore to select, recommend and disseminate the high yielding shallow type yams among the farmers and to study about the *Dioscorea* species present in the country, *Dioscorea* germplasm were collected during late 80's and maintained at the Horticultural Crops Research and Development Institute (HORDI) fields. More than 90 accessions were collected. Morphological characterization using 25 morphological traits was carried out to identify the species of these accessions, whereby, 30 distinct *D. alata* genotypes were identified. The objective of this study was to select greater yam varieties with high yield potential, good culinary qualities and desirable agronomic characters from these 30 genotypes.

Materials and Methods

More than 90 *Dioscorea* germplasm accessions were collected during the late 80's and established at the HORDI, Gannoruwa research fields with the intention of characterizing the germplasm available in the country and to identify the species, to conserve the yam genetic resource, to select good varieties and to encourage production through information generation and transfer. Morphological characterization using 25 traits was carried out to identify the species of these accessions by using International Plant Genetic Resources Institute (IPGRI) descriptors.

The major soil group found in the region was classified as reddish brown latosols (Panabokke, 1967). Every year the yams were planted in April–May with the onset of South-West monsoon and harvested in January-February. Disease free tubers were selected from each accession and cut into proper size (200-250 g) and planted in the nursery. Tuberlets with growing shoots were transplanted at 21 DAP in the main field at the correct season every year. Loose soil with high organic matter is preferred. Planting material with the growing shoot was planted at the centre of the planting hole.

Yam accessions were planted at a spacing of 1m x 1m to study the morphological characters clearly. A support (more than 6 feet high) was provided. Cattle manure was applied @ 10 t ha^{-1}, 3-5 days before planting. Paddy husk was also applied. According to the recommendation of Department of Agriculture, fertilizers were applied to supply N @ 30 kg ha^{-1}, P_2O_5 @ 70 kg ha^{-1} and K_2O @ 35 kg ha^{-1} as basal dressing. At one and a half to two months and three and a half to four months after planting, N @ 30 kg ha^{-1} and K_2O @ 35 kg ha^{-1} each were applied as top dressing. There was no serious pests and diseases, except for leaf rust disease caused by *Goplana dioscoreae* and anthracnose caused by *Colletotrichum gloeosporioides*. Many times the damage caused by leaf rust disease and anthracnose was not very serious and it didn't cause any economic loss. But, when the damage was more, the disease was controlled either by spraying Chlorothalonil 500 g l^{-1} SC or Mancozeb 80% WP or by spraying Cu fungicides to control the spread of the disease. Harvesting was done with the onset of leaf senescence.

Morphological characterization was carried out as per IPGRI descriptors and six stem characters, twelve leaf characters and seven tuber characters were used. The following characters were studied (Table 1).

Table 1. The leaf, stem and tuber characteristics observed

Characteristics
A. Stem
Direction of twining
Presence of wings on stem
Presence of pubescence on stem
Cross section of stem
Presence of spines on stem
Pigmentation of stem at emergence
B. Leaves
Onset of leafing
Arrangement of leaves
Shape of leaves
Colour of leaves
Length/Breadth ratio
Anthocyanin pigmentation on veins, petioles, wings etc.
Presence of wings on petioles
Spines at the base of the petioles
Number of leaf nerves
Number of vascular bundles in petioles
Presence of auricles
Presence of aerial tubers
C. Root and Tuber
Number of tubers/stand
Relationship of tubers

Tuber skin thickness	
Rogosity of tuber surface	
Tendency of flesh to discolour from oxidation	
Grainy appearance of cortex (scelerenchymatous fibre just below the skin)	
Presence of spines on roots	

Thirty distinct *Dioscorea alata* genotypes were identified based on promising characters. With the intention of selecting, improving and releasing, these 30 *D. alata* cultivars were further evaluated in Preliminary Yield Trial (PYT) and Advanced Yield Trial (AYT). The cultivars were planted in randomised block design with three replications. The data were analysed using SAS software programme. The data were analyzed by ANOVA and mean separation were done by Duncan's Multiple Range Test (DMRT) These accessions were improved by clonal selections. According to the results of these trials, seven cultivars with high yield, quality and desirable characteristics were selected and tested in National Co-ordinated Varietal Trial (NCVT) and Varietal Adaptability Trial (VAT). The NCVT was conducted at the Horticultural Crops Research and Development Institute, Gannoruwa, Regional Agricultural Research and Development Centre, Makandura, Adaptive Research Unit, Homagama and Adaptive Research Unit, Wagolla. After this, the selected two cultivars were tested in the farmers' fields in VAT in Kandy, Matale, Kegalle, Kurunegala and Moneragala districts.

Results and Discussion

Yams could be classified based on the characteristics of leaves, stems and tubers. Morphological characterization was carried out using IPGRI descriptors and the morphological characters recorded are given in Table 2.

After characterization, these collections were divided into 39 morphotypic groups, of which 30 morphotypes were distinguished as *D. alata* cultivars.

Such studies have been conducted in other countries also. An assessment of morphological variations among 70 accessions of greater yam (*Dioscorea alata* L.) collected throughout Malaysia, indicated that the characters contributing largely to the species variability were those related to the shape, size and flesh colour of underground tubers; shape and colour of aerial tubers; position, shape, size and vein colour of the leaves; petiole colour; shoot growth rate; and number of days for shoots to germinate (Hasan et al., 2008). Anatomical studies on the roots of 10 *Dioscorea* species showed that these species possessed vital characters that could be used in their description, characterization, recognition, identification and classification. The number of vascular bundles, nature of vessels, form of endodermis and cortex were some of the characters assessed and discussed among the *Dioscorea* species investigated (Edeoga, 2002). Sanchez et al. (2002) reported that *D. alata* species had wide

Table 2. Important morphological traits observed in *D. alata*

Characteristics	*D. alata*
A. Stem	
Direction of twining	Anticlockwise
Presence of wings on stem	Present
Presence of pubescence on stem	Absent
Cross section of stem	Stellate
Presence of spines on stem	Absent
Pigmentation of stem at emergence	Purple
B. Leaves	
Onset of leafing	Late
Arrangement of leaves	Opposite
Shape of leaves	Sagitate
Colour of leaves	Dark green
Length/Breadth ratio	>1
Anthocyanin pigmentation on veins, petioles, wings etc.	Present
Presence of wings on petioles	Present
Spines at the base of the petioles	Absent
Number of leaf nerves	5-7
Number of vascular bundles in petioles	5-6
Presence of auricles	Present
Presence of aerial tubers	Occasionally present
C. Root and Tuber	
Number of tubers/stand	Normally 2 or 3
Relationship of tubers	Completely separate and distinct
Tuber skin thickness	Thick > 1 mm
Rogosity of tuber surface	Rough
Tendency of flesh to discolour from oxidation	More
Grainy appearance of cortex (scelerenchymatous fibre just below the skin)	Much
Presence of spines on roots	Absent

variability within the species. Some 93 accessions were characterized by them using INIVIT Descriptors List. Some tested clones (85%) produced bulbils, few of them flowered and none produced seeds. Studies indicated that there were five duplicate clones. Similar studies by Velayudhan and Liji (2002) indicated that out of the 283 accessions of greater yam (*D. alata*) collected at NBPGR Regional Station Thrissur, 175, were maintained at Vellanikkara, Kerala, India, up to 1993. These collections were divided into 20 morphotypic groups. One of these morphotypes, represented by a single collection, was lost. Collections belonging to the other 19 morphotypes were distinguished and described as 19 cultivars from Peninsular India.

After characterization, further studies were continued only on *D. alata* accessions. The 30 *D. alata* cultivars were evaluated in PYT and AYT. After these, the seven selected cultivars were evaluated in NCVT (Table 3).

The results revealed that the cultivars, Raja ala (33.6 t ha^{-1}) and Kakulu ala (35.9 t ha^{-1}) produced significantly higher yields in all the locations (Fig. 1). The selected two varieties were tested in farmers' fields to evaluate the adaptability (Table 4).

The results clearly showed that the cultivars were highly adaptable to different locations. The major differences between the two new improved varieties, Raja ala and Kakulu ala are provided in Table 5.

Analyses of the tubers for quality characteristics were conducted by the Food Research Unit of the HORDI, Gannoruwa for percentage dry matter, starch and sugars etc. The results are given in Table 6. Lebot et al. (2006) reported that varieties with good eating quality were

Table 3. Yield performance (t ha^{-1}) of *Dioscorea alata* varieties under NCVT programme at different locations (1997-2000)

Varieties	Locations				Mean of varieties
	HORDI	Makandura	Homagama	Wagolla	
Kakulu ala	41.2[a]	29.6[a]	39.5[a]	33.2[a]	35.9
Raja ala	39.2[a]	28.2[a]	36.4[a]	30.5[a]	33.6
Jaffna local	30.1[b]	22.5[b]	29.4[b]	26.6[a]	27.2
Pani ala	24.2[bc]	20.5[bca]	25.1[bc]	18.7[b]	22.1
Kiri ala	21.4[c]	19.6[bc]	20.5[c]	18.2[b]	19.9
Hingurala	20.4[c]	17.2[cd]	19.3[c]	18.0[b]	18.7
Kirikondol	16.5[c]	15.4[d]	18.0[c]	18.3[b]	17.0
Location mean	27.4	21.7	26.7	23.2	
CV (%)	11.4	12.2	13.7	15.3	

Values with the same superscript in a coloumn are not significantly different

Raja ala

Kakulu ala

Fig. 1. Two new improved varieties of *D. alata*

Table 4. Yield performance (t ha^{-1}) of Raja ala and Kakulu ala under VAT programme in farmers' field in yam growing areas (2001-2003)

Location/District	Raja ala	Kakulu ala	Local cultivar	Location mean
Paranapatiya/(Kandy)	28.8	30.1	14.2	24.4
Medagama/(Moneragala)	20.5	23.4	13.4	19.1
Wawela/(Matale)	24.4	26.6	12.4	21.1
Deewela/(Kegalle)	27.5	28.4	18.4	24.8
Rajangana/(Kurunegala)	26.4	30.1	-	28.2
Variety mean	25.5	27.7	11.7	
Varietal Deviation Mean (VDM)	2.2	0.2	12.5	
Varietal Deviation Variance (VDV)	0.77	0.10	7.85	

Table 5. Varietal description of Raja ala and Kakulu ala

Characteristics	Raja ala	Kakulu ala
Leaf		
Shape	Ovate with cordate base and acuminate apex	Narrowly ovate with sagitate base and acuminate apex
Colour	Dark green	Light green
Anthocyanin pigmentation	Present on veins, petioles and wings	Present only on wings at emergence
Tuber		
Number of tubers/stand	1 or 2	2 or 3
Shape	Globular rarely having few lobes	Fan shaped with few branched lobes
Flesh colour	Light purple	White
Flesh discolouration from oxidation	Mild	Moderate
Export potential	Present	Not present
Tuber yield	High yield (32-35 t ha^{-1})	High yield (35-38 t ha^{-1})

Table 6. Quality characters of Raja ala and Kakulu ala

Character	Raja ala	Kakulu ala
Tuber weight (kg)	1-1.5	3.0-5.0
Tuber length (cm)	20.5	32.0
Middle circumference (cm)	32.0	30.5
External colour	Brown (gp 200 B)	Brown (gp 200 B)
Internal colour	Violet (gp 83 - B- C)	Yellow (gp 13 D)
Moisture content (%)	68.2	75.9
Starch content (% wet wt. basis)	23.8	19.7
Fibre (%) (wet wt. basis)	5.1	6.2
Brix	8.0	8.0
Peeling %	8-10	12-15
Taste	Starchy	Moderately starchy and slightly sweet
Palatability	Good with aroma	Good, moderately mucilaginous

characterized with high dry matter, starch and amylose contents.

The variety Raja ala contained high dry matter and starch contents (31.8% and 23.8% respectively). The variety Kakulu ala also contained fairly high dry matter content and starch contents (24.1% and 19.7% respectively). Brix value for both varieties was also good. Therefore both varieties had high yield and good culinary qualities. These varieties were further tested for quality traits with different category of people (farmers and consumers etc.) to assess their preferences (Table 7).

The variety Raja ala scored 29.9 and Kakulu ala scored 24.0 showing high farmer and consumer preferences.

Table 7. Ratings assigned for quality traits of Raja ala and Kakulu ala

Quality traits	Raja ala	Kakulu ala	Local cultivar
Pre cooking			
Shape and size	4.5	3.2	2.5
Mucilaginous	3.8	3.0	2.5
Peeling %	4.0	3.4	2.7
Browning	3.2	3.0	2.5
Post cooking			
Texture and appearance	4.8	4.0	2.8
Moistness	4.8	3.8	3.0
Taste preference	4.8	3.6	2.5
Final score	29.9	24.0	18.5

Ratings vary from 1- unacceptable, to 3 - average and to 5 - excellent. Final score rating may vary from 7 poorest to 35 best possible

Conclusion

Out of the 90 *Dioscorea* accessions collected, 30 were characterized morphologically. *D. alata* accessions were evaluated and two new improved *D. alata* varieties, Raja ala and Kakulu ala with high yield, good culinary qualities and marketable value were selected and were released officially for cultivation in Sri Lanka in 2007.

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