

Importance of Selected Tuber Crops for Cultivation in Sri Lanka – A Systematic Review

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IMPORTANCE OF SELECTED TUBER CROPS FOR CULTIVATION IN SRI LANKA – A SYSTEMATIC REVIEW

Abstract: Food security is a major concern in today's context which encompasses availability, affordability, and nutritional quality of food for the population. In Sri Lanka, around 55 traditional and indigenous yams and tuber crop species were identified, and they grow in almost everywhere in the country. Tubers are in a wider range of cultivars, and it is characterized by increased adoptability to different agroecological zones. Convenience propagation methods, wider adoptability, rich in carbohydrates, and less vulnerability to pests and diseases are vital features in promoting tuber crops to supplement main courses in human diet. This research attempt to review of nutritional and agricultural value of five selected tuber crop species as follows: Elephant foot yam (*Amorphophallus paenoiifolius*), three Rajala species (*Dioscorea alata*, *Dioscorea bulbifera*, *Dioscorea sativa*), and Arrowroot (*Maranta arundinacea*). Data was gathered from relevant textbooks and electronic databases include PubMed, Scopus, Google Scholar, and Journals following the PRISMA model. Traditional root and tuber crops are identified as a rich source of carbohydrates, energy, minerals, vitamins, pharmacological properties, bioactive compounds, and with relatively convenient in cultivation in a wider spectrum of agroecological zones. It is easy to cultivate, and they can grow even in unfavorable harsh climate conditions. It is required relatively less agricultural input and can gain more income and output. Inclusiveness of the selected crops into main meals would increase the diversity of the food intake and helps food security. Make aware of those yams among public is also beneficial as they have good amount of carbohydrate, fibers and many pharmacological properties which relieves diseases as well.

Keywords: Food, Tuber, Sri Lanka, Nutritional, Agricultural

Introduction

Food security is a major concern in today's context which encompasses availability, affordability, and nutritional quality of food for the population. In Sri Lanka, around 55 traditional and indigenous yams and tuber crop species were identified, and they grow in almost everywhere in the country. This research attempt to review of nutritional and agricultural value of five selected tuber crop species as follows: Elephant foot yam (*Amorphophallus paenoiifolius*), three Rajala species (*Dioscorea alata*, *Dioscorea bulbifera*, *Dioscorea sativa*), and Arrowroot (*Maranta arundinacea*) (FAO, 1990).

Agriculture and climate change

Sri Lanka's climate is considered tropical monsoonal with great rainfall variation seasonally and across the three principle climatic zones: the Wet Zone (WZ) in the southwestern region; the Dry Zone (DZ), covering the northern and eastern parts of the country; and the Intermediate Zone (IZ), skirting the central hills (see Annex I). The DZ and IZ, where the majority of Sri Lanka's agro-ecological regions (AERs) are concentrated, are particularly vulnerable to rainfall seasonality and variability (Bandara, Wijewardhana and Liyanage., 2010).

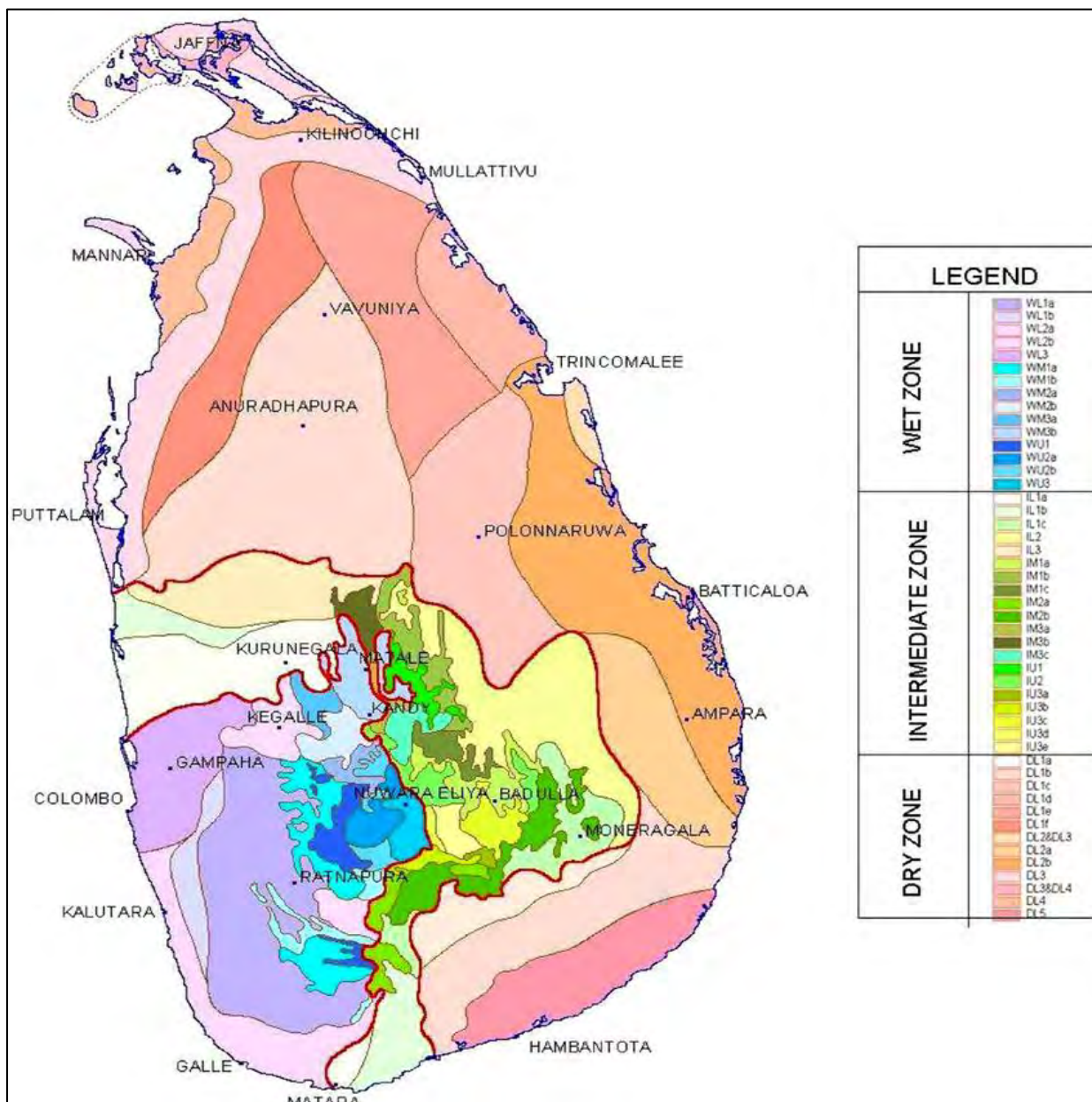


Figure 1. Agricultural zones in Sri Lanka (Bandara, Wijewardhana and Liyanage., 2010).

Bioactivities of Phytochemicals in Roots and Tubers

Table 1 Bioactivities of Phytochemicals in Roots and Tubers

Action	Description
Antioxidant Activity	<ul style="list-style-type: none"> Methanolic extract of potatoes - high phenolic content and strong antioxidant activity as determined by 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity (Hesam, Balali, and Tehrani., 2012).

	<ul style="list-style-type: none"> • Lipid oxidation inhibition (Chimkode, Patil and Jalalpure., 2009). • Wound healing effect (sweet potato roots) (Panda and Sonkamble., 2011).
Antiulcerative Activities	<ul style="list-style-type: none"> • Antiulcerative activity of sweet potato roots (studied in a rat model) (Panda and Sonkamble., 2012). • Treated for gastric ulcers induced by excessive alcohol intake (Kim <i>et al.</i>, 2008).
Anticancer Activities	<ul style="list-style-type: none"> • Inhibition of carcinogenesis - red pigmented cultivar of potatoes compared to a white Russet Burbank cultivar in breast cancer induced rats (Thompson <i>et al.</i>, 2009). • Aqueous extract of yam (<i>Dioscorea alata</i>) - inhibited the H₂O₂-CuSO₄ induced damage of calf thymus DNA. • Protected human lymphoblastoid cells from CuSO₄ induced DNA damage. • Management of copper-mediated oxidative disorders and diabetes (Wang <i>et al.</i>, 2011).
Immunomodulatory Activities	<ul style="list-style-type: none"> • Improved regeneration of bone marrow cells <i>in vivo</i> • Recovery of damaged cell populations (P.F. Su <i>et al.</i>, 2011).
Antimicrobial Activity	<ul style="list-style-type: none"> • Methanolic extracts of <i>Dioscorea</i> yams (<i>Dioscorea dumetorum</i> and <i>Dioscorea hirtiflora</i>) had antioxidant and antimicrobial activities (Sonibare and Abegunde., 2012).
Hypoglycemic Activities	<ul style="list-style-type: none"> • Reduced plasma glucose levels (Ludvik <i>et al.</i>, 2002). • <i>Dioscorea alata</i> showed an antidiabetic activity against alloxan-induced diabetic rats (Maithili <i>et al.</i>, 2011).
Hypocholesterolemic Activity	<ul style="list-style-type: none"> • Yam (<i>Dioscorea</i>) - antioxidative and hypolipidemic effects <i>in vivo</i> (Son <i>et al.</i>, 2007).
Hormonal Activities	<ul style="list-style-type: none"> • Yam (<i>Dioscorea</i>) had effect of reduce the risk of cancer and cardiovascular diseases in postmenopausal women) (W.-H. Wu <i>et al.</i>, 2005). • After subjects had been on a yam diet for 30 days, levels of serum estrogen and sex hormone binding globulin (SHBG) increased significantly. • Remodeling and osteoporosis during the menopause (Chen <i>et al.</i>, 2008).
Antiobesity	<ul style="list-style-type: none"> • Purple sweet potato - prevention of obesity (Hwang <i>et al.</i>, 2011).

Study design

Primary data were collected by using published journal articles with detailed information. Scientific

articles were collected by using google scholar, PubMed and Research Gate following the PRISMA model. Secondary data were collected using authentic text book in Ayurveda medicine.

Results and Discussion

Elephant foot yam (*Amorphophallus paeoniifolius*)

It is one of the most profitable tuber crops cultivated plant and these tubers are taken as vegetables after through cooking and chips are made of these starch rich tubers. Elephant foot yam mainly cultivated in India, Southeast Asia, Philippines, and Sri Lanka.

Scientific classification

- Kingdom : Plantae
- Clade : Tracheophytes
- Clade : Angiosperms
- Clade : Monocots
- Order : Alismatales
- Family : Araceae
- Genus : *Amorphophallus*
- Species : *A. paeoniifolius*
- Binomial name: *Amorphophallus paeoniifolius* (*Amorphophallus paeoniifolius*, 2023).

Table 2 Importance of elephant yam

Related Disease	Importance
elephant yam for diabetes	stimulate the secretion of insulin (flavonoids) (Ravi., 2009)
elephant yam to relieve pain.	analgesic activity inhibit the synthesis of prostaglandins, which are responsible for inflammation. reduce the side effects of conventional analgesics as an add-on drug 2009) (Dey <i>et al.</i> , 2016)
elephant yam in gastrointestinal diseases	traditional medicine for gastrointestinal disorders like piles, abdominal pain and constipation. increases motility in the stomach (gastrokinetic action) (Nedunchezhiyan, Saurabh and Ranasingh., 2006).
elephant yam as an antifungal and	antifungal and antibacterial properties.

antibacterial agent	It was showed significant antibacterial activity against some gram-negative and gram-positive bacteria (Dey <i>et al.</i> , 2012).
elephant yam as an anthelmintic	destroy parasitic worms. Anthelmintic activity of elephant yam against earthworms showed that it may paralyze and kill the earthworm (SVA., 2022).
elephant yam for weight management	Elephant yams for weight loss. Elephant yam used as a part of several healthy recipes. Roasting elephant yam may be preferred over boiling it to preserve the nutrients. Elephant yam may have an excellent nutritional value, making it a healthy food choice (Medindia, 2022).
elephant yam for ulcerative colitis	effective against ulcerative colitis. elephant yam might exhibit anti-colic effects (Dey <i>et al.</i> , 2017)
elephant yam for liver diseases	It may prevent liver damage. hepatoprotective properties elephant yam might bring down the increased enzyme level, increase the protein level and improve the texture of the damaged liver cells (Dey <i>et al.</i> , 2017).



Figure 2. *Amorphophallus paeoniifolius* plant (*Amorphophallus paeoniifolius*, 2023).

Requirements	
Climatic requirements/ Areas suitable for cultivation	This crop can be cultivated up to 900 m elevation. Optimum temperature is 25-30 0C. Temperature less than 20 0C is not suitable. Long day (12 ½hrs) - vine growth short days (10-11 hours) - tuber formation.
Soil	Loamy soil associated with high organic matter content good drainage is preferred.
Seed/ Cutting requirement	10, 000 seed yam cuttings about 250 g weight is needed for 1ha.
Nursery Management	About 250 g weight cuttings are prepared and treated with Fungicide or ash. Plant in a sand bed covered with straw and supply water after remove the dormancy shoots are coming out from cuttings.
Land preparation	Plough the land. Holes - msal'x1'x1' feet and fill with organic matter and plant the cuttings.
Planting	Treated yam cuttings can be directly plant in the field or plant them in a nursery before field planting. Necessity to supply sticks about 7 feet for healthier growing.
Spacing	For species of big yams – 1m x1m. For species of small yams – 1mx 0.5 m
Fertilizer	Combinate organic fertilizer about10 t/ha organic fertilizer regarding to the DOA recommendation.
Water supply	For well growth, essential to have good irrigation. Specially in the 1 st three months
Weed Control	It is significant to control weeds, as this crop takes long period for harvest.

Table 4 Elephant foot yam nutritional component (*Dioscorea alata*, 2023)

Nutritional Component	Amount
Water	69.6 g
Energy	118 kcal
Protein	1.53 g
Total lipid (fat)	0.17 g
Carbohydrate	27.9 g
Ash	0.882 g
Fibre	4.1 g
sugar	0.5 g
Calcium	17 mg
Iron	0.54 mg
Magnesium	21 mg
Phosphorus	55 mg
Potassium	816 mg

Dioscorea spp.

There are 650 species presented in the world and nine species were recognized in Sri Lanka. Maximum prevalent species is *Dioscorea alata*. It is widespread with different names like water yam and white yam (*Dioscorea alata*, 2023). This research attempt to review 3 varieties including *Dioscorea alata*, *Dioscorea bulbifera*, *Dioscorea sativa*.

Table 5 *Dioscorea spp.* cultivation guide (*Dioscorea alata*, 2023)

Requirements	
Climatic requirements/ Areas suitable for cultivation	up to 900 m elevation Optimum temperature is 25-30 0C Temperature less than 20 0C is not suitable. Long day (12 ½hrs) - for vine growth short days (10-11 hours) - for tuber formation.
Soil	Loamy soil associated with high organic matter content. good drainage is preferred.
Seed/ Cutting requirement	10, 000 seed yam cuttings about 250 g weight is needed for 1ha.

Nursery Management	About 250 g weight cuttings are prepared and treated with Fungicide or ash. Plant in a sand bed covered with straw and supply water after remove the dormancy shoots are coming out from cuttings.
Land preparation	Plough the land. Holes - 1'x1'x1' feet and fill with organic matter and plant the cuttings.
Planting	Treated yam cuttings can be directly plant in the field or plant them in a nursery before field planting.
Spacing	For spp with big yams. – 1m x1m. For species with small yams. – 1mx 0.5 m
Water supply	Specially need good irrigation in the 1 st three months
Weed Control	Before adding the top dress 1 weeding is important.
Harvesting	Vines become yellowing at harvesting maturity. 8–9-month period.

Dioscorea alata

Scientific classification

- Kingdom : Plantae
- Clade : Tracheophytes
- Clade : Angiosperms
- Clade : Monocots
- Order : Dioscoreales
- Family : Dioscoreaceae
- Genus : Dioscorea
- Species : *D. alata*
- Binomial name : *Dioscorea alata* L. (*Dioscorea alata*, 2023).



Figure 3. *Dioscorea alata* plant (*Dioscorea alata*, 2023).

Dioscorea bulbifera

Scientific classification

- Kingdom : Plantae
- Clade : Tracheophytes
- Clade : Angiosperms
- Clade : Monocots
- Order : Dioscoreales
- Family : Dioscoreaceae
- Genus : Dioscorea
- Species : *D. bulbifera*
- Binomial name : *Dioscorea bulbifera* (*Dioscorea bulbifera*, 2023)



Figure 4. *Dioscorea bulbifera* plant (*Dioscorea bulbifera*, 2023).

Dioscorea sativa

Scientific classification

- Kingdom : Plantae
- Clade : Tracheophytes
- Clade : Angiosperms
- Clade : Monocots
- Order : Dioscoreales
- Family : Dioscoreaceae
- Genus : Dioscorea
- Species : *D. villosa*
- Binomial name : *Dioscorea villosa* L.
- Synonyms : *Merione villosa* (L.) Salisb.

Dioscorea sativa L.

Dioscorea quaternata Walter

Dioscorea quinata Walter

Dioscorea cliffortiana Lam.

Dioscorea paniculata Michx.

Dioscorea waltheri Desf. (*Dioscorea villosa*, 2023).

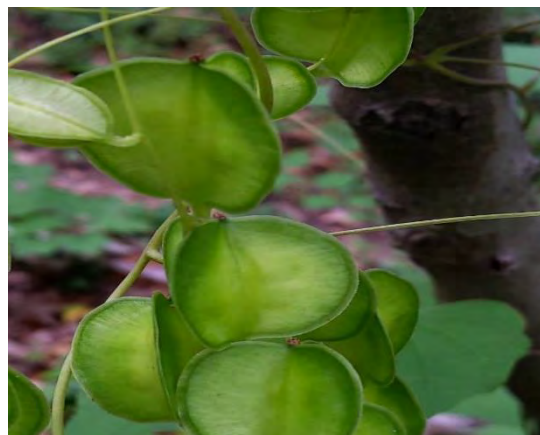


Figure 5. *Dioscorea sativa* plan (*Dioscorea villosa*, 2023).

Arrowroot tubers

Arrowroot tubers are one of the plants that are included in tropical plants, mostly in South America, Brazil, Ecuador, Costa Rica, Mexico, and Venezuela, then spread to India, Sri Lanka, the Philippines, and Indonesia, now widely planted in the Philippines and India (Asha *et al.*, 2015).

Scientific classification

- Kingdom : Plantae
- Clade : Tracheophytes
- Clade : Angiosperms
- Clade : Monocots
- Clade : Commelinids
- Order : Zingiberales
- Family : Marantaceae
- Genus : Maranta
- Species : *M. arundinacea*
- Binomial name : *Maranta arundinacea* L (*Maranta arundinacea*, 2023).



Figure 6. *Maranta arundinacea* plant (*Maranta arundinacea*, 2023).

Table 6 *Maranta arundinacea* cultivation guide

Requirements

Propagation method

using tubers cuttings

It is the most efficient method to increase tuber production and starch quality

Used 3 rhizome segments (Wawo and sukamto, 2011).

growth of Arrowroot under *P. falcataria* stands resulted in the highest plant, stem, diameter, and leaf number (Anonim, 2009).

arrowroot seed growing in 50% light intensity and two times application of the goat manure resulted in the best arrowroot growth (98.6 cm plant height, 100 leaf sheets, and 8 clumps) (Shintu, Radhakrishnan and Mohanan., 2016)

Research in Bogor had found that arrowroot tubers planted under shading would result in higher plant and tuber fresh weight compared to those planted without shading. According to the literature (Wawo and sukamto, 2011).

plant spacing (30 x 40 cm)

Table 7 Composition of Maranta arundinacea (Arrowroot, 2023).

Calories	78 grams
Carbs	16 grams
Fiber	2 grams
Protein	5 grams
Fat	0 grams
Folate	102% of the Daily Value (DV)
Phosphorus	17% of the DV
Iron	15% of the DV
Potassium	11% of the DV

Conclusion

Tubers are in a wider range of cultivars, and it is characterized by increased adoptability to different agroecological zones. Convenience propagation methods, wider adoptability, rich in carbohydrates, and less vulnerability to pests and diseases are vital features in promoting tuber crops to supplement main courses in human diet. Traditional root and tuber crops are identified as a rich source of carbohydrates, energy, minerals, vitamins, pharmacological properties, bioactive compounds, and with relatively convenient in cultivation in a wider spectrum of agroecological zones. It is easy to cultivate, and they can grow even in unfavorable harsh climate conditions. It is required relatively less agricultural input and can gain more income and output. Inclusiveness of the selected crops into main meals would increase the diversity of the food intake and helps food security. Make aware of those yams among public is also beneficial as they have good amount of carbohydrate, fibers and many pharmacological properties which relieves diseases as well.

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