

RESEARCH ARTICLE

Species diversity of local root and tuber crops in agricultural habitats in Uva region

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ABSTRACT

Local roots and tuber crops are important and popular food crops, which are high in carbohydrates, minerals (zinc, iron) and essential vitamins. They also have adaptability on different climatic conditions in addition to contributing to increase agricultural production. Root and tuber crops are versatile staples to address food and nutrition security and produce more food per unit area of land. Also, they are cheap but nutritionally rich compared to many of the other staple crops. Therefore, local roots and tuber crops are vital for sustainable food production in Sri Lanka and are certainly an alternative for achieving food security of the country. Therefore, local roots and tuber crops are an alternative for achieving food security of the country. Today, these crops are facing a threat of extinction in Sri Lanka due to the ignorance of cultivation and consumption. On-farm germplasm conservation process as an in-situ conservation of crop genetic diversity towards improving total agro-ecosystem conservation and small farmers' livelihood through the use of local crop resources can provide a better solution to the food security problem and provide economic benefits for the farmers. The study was aimed to identify the distribution and species diversity of local roots and tuber crops in agricultural habitats in Uva region together with farmers' awareness and constraints on on-farm germplasm conservation. A questionnaire based survey was carried out with Geographic Information System (GIS) application. Many types of local roots and tuber crops are grown in Uva region. Majority of the farmers who are engaged in organic agriculture and home gardening cultivate local roots and tuber crops in the region. Uva region is rich with 29 species of roots and tuber crops. Importantly their distribution follows the agro-ecological zones that provide favourable conditions such as soils, rainfall, elevations and drainage for their growth and development. Cultivation of local roots and tuber crops faced constraints mainly due to pest and climatic problems, lack of planting materials, lack of market places, and lack of knowledge and awareness on on-farm germplasm conservation.

Keywords: Local roots and tuber crops, on-farm germplasm conservation, Uva region

INTRODUCTION

Root and tuber crops are good source of carbohydrates, some minerals and essential vitamins (Aliou, 1998). Some of these possess special characteristics such as medicinal value and special food qualities. They still constitute important and major, components in traditional diets as the rural population is still having traditional eating habits. Diversification of eating habits with the choice of food available will lead to increase the production of root and tuber crops as

carbohydrate supplement in the diet. However, supply is often unsatisfied because of the inherent limitations of the traditional production systems, which impose serious constraints in marketing and processing of root and tuber crops.

Local root and tuber crops are certainly an alternative for achieving food security of the country. The very popular these traditional food crops, which are underground bulky perishables and vegetatively propagated, can be used as main meal, side dish and as well as in preparing snacks and crackers. The factors such as high adaptability for the different climates in wide range, availability of at least one or more variety throughout the year, easy management, minimum pest attacks, less input and attention required and ability to cultivate in marginal lands confirm the greater potential of cultivating local root and tuber crops towards the food security.

The major and more commonly consumed local root and tuber crops in Sri Lanka are Cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), yams (*Dioscorea* spp.) and edible aroids (*Colocasia esculenta* and *Xanthosoma* spp.). These are perennial herbaceous vines are cultivated for the consumption of their starchy tubers in Africa, Asia, Latin America, the Caribbean and Oceania (Aliou, 1998). The tuber crops like sweet potato are short cycle crops (3 to 4 months), and thus well suited to the two cropping seasons in a year particularly under rain-fed systems. Yam and cassava like root crops, though longer in their cropping cycle (about 9 months), are vital in the annual cycle of food availability due to their broader agro-ecological adaptation, diverse maturity period and in-ground storage capability, which permit flexibility in harvesting period for a sustainable food availability throughout the year (Sanginga and Mbabu, 2015). There are 10 species of *Dioscorea* available and popular in Sri Lanka and nine species are edible among them (Wanasundara and Ravindran 1994). These yams are mainly consumed by the gatherers and rarely found in village markets.

Today, local root and tuber crops consumption and cultivation however have been ignored and these crops are facing a threat of extinction in Sri Lanka. Also, the continuous growth of human population and thus the per capita consumption have resulted an unsustainable exploitation of earth's biological diversity, which is impaired by climate change and other environmental impacts. The effective conservation of biodiversity is essential for human survival on the earth and for the maintenance of ecosystem processes. Also, biodiversity continues to decline due to various reasons including human involvement as well as natural disasters. Successful conservation approaches need to be reinforced to protect the biodiversity especially in agro systems to secure the food supply in future (Javis and Hodgkin, 1998). Identification of local germplasm for roots and tuber crops in agricultural habitats in Uva region is timely required for moving towards sustainable agriculture and food security in the region as well as in the country. In biodiversity conservation, priority areas should represent the biodiversity region where they are situated. To achieve this, biodiversity should be measured (Margules *et al.*, 2002).

Therefore, the present study was conducted to identify the species diversity and the distribution of local root and tuber crops grown in agricultural habitats in Uva region and also the farmers' awareness and constraints on-farm germplasm conservation of local root and tuber crops.

METHODOLOGY

Data were collected from 250 farm families who deal with home gardening and organic agriculture. They were selected by snowball sampling method from the areas such as Dehigolla, Arawatta, Madaoya, Meegahakiwula, Sirimalgoda, Passara, Badalkumbura, Therela, Obbegoda, Weherayaya, Handapanagala, Uva-Paranagama and Morayaya. The base was to represent all Agro Ecological Zones of Uva region. The survey was carried out based on interview method and field observations using a structured questionnaire. The questionnaire was focused on the information on local root and tuber crops in farmers' fields, types and extent, purpose of cultivation, constraints for the cultivation, reasons for not cultivating, knowledge of the community about the bio diversity conservation and on-farm germplasm conservation.

Geographic Information System (GIS) was applied to identify and analyse the distribution of local root and tuber crops in agricultural habitats in Uva region by using Arc view GIS software version 3.2a. The locations were manually geocoded to transfer into GIS environment and projected to UTM (Universal Transverse Mercator) system. The geocoded locations were overlaid with soil and climate layers in observing the distributions with particular aspects. The germplasm collected was authenticated by using the live herbarium available at Plant Genetic Resources Centre, Gannoruwa and through personnel communications.

RESULTS AND DISCUSSION

Farmers' involvement in cultivation

The cultivation of local roots and tuber crops in Uva region was significant ($P < 0.05$). All the farmers in Uva-Paranagama, Weherayaya, Sirimalgoda, Morayaya, Madaoya and Meegahakiwula areas in Uva region were engaging in cultivating many different types of local root and tuber crops.

Figure 1 shows the percentages of farmers engaged in cultivating local root and tuber crops. According to the findings, 91% in Arawatta, 88% in Badalkumbura, 80% in Obbegoda and Therela, 79% in Dehigolla, 68% in Passara, and 67% in Handapanagala farmers were involving in cultivation of local root and tuber crops. There were 91% of farmers who engage especially in organic agriculture cultivating local roots and tuber crops in Uva region. Among them, 54% of the farmers were cultivating one to five different types of local root and tuber crops, 45% of the farmers six to ten varieties and around 1% of the farmers more than 10 species, as shown in Figure 2.

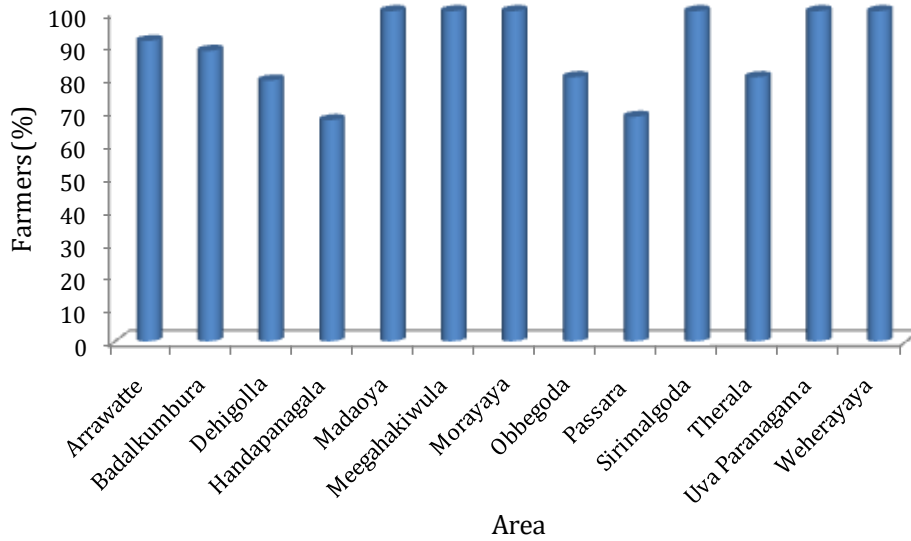


Figure 1: Farmers engaged in cultivation of local root and tuber crops.

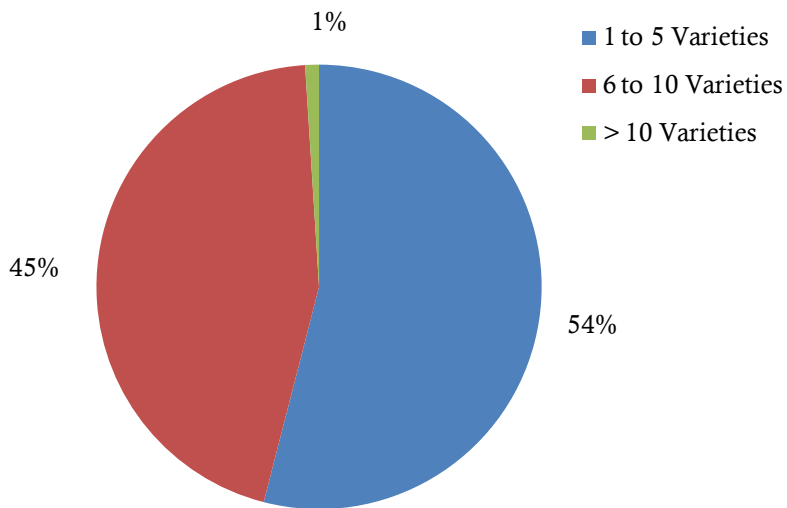


Figure 2: Number of varieties of local roots and tuber crops cultivated by farmers in Uva region.

Species richness

The present study could identify 29 species of local root and tuber crops (Plate 1 (a, b), 2 (a, b), 3 (a, b) and 4 (a, b) among the farmers in Uva region and they were Manioc, Sweet potato, Raja-ala, Kahata-ala, Hingurala, Wal-ala, Katuala, Rasawelli, Udala, Hirithala, Kukulala, Kodol, Maw ala, Gahala, Habarala, Dheseala, Kokisala, Kaluhabarala, Wel ala kola, Buthsarana, Artichoke, Arrowroot, Kidaran, Kiriala, Innala, Sewelala, Dandila, Dehiala and Hondala. This indicates the species richness at present and how it has reduced compared to the earlier recorded number, which was more than 45 different types of local root and tuber crops found in Uva region (Badulla Women Development Centre, 2004).

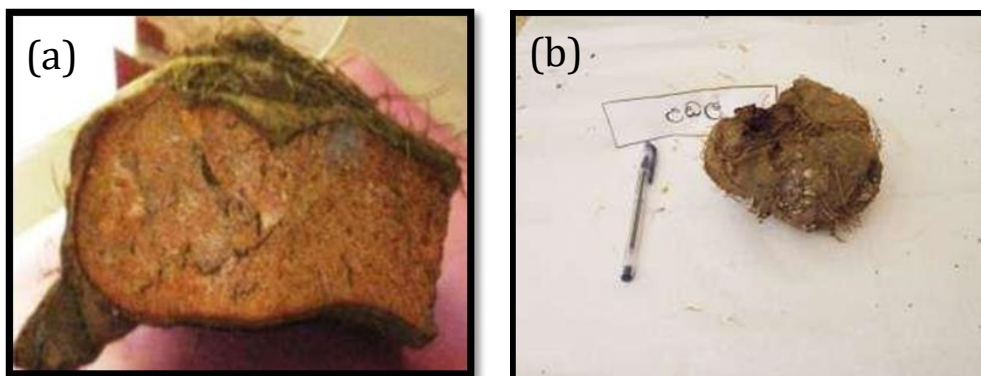


Plate 1: (a) Katuala collected from Kandaketya and (b) Udala collected from Sirimalgoda

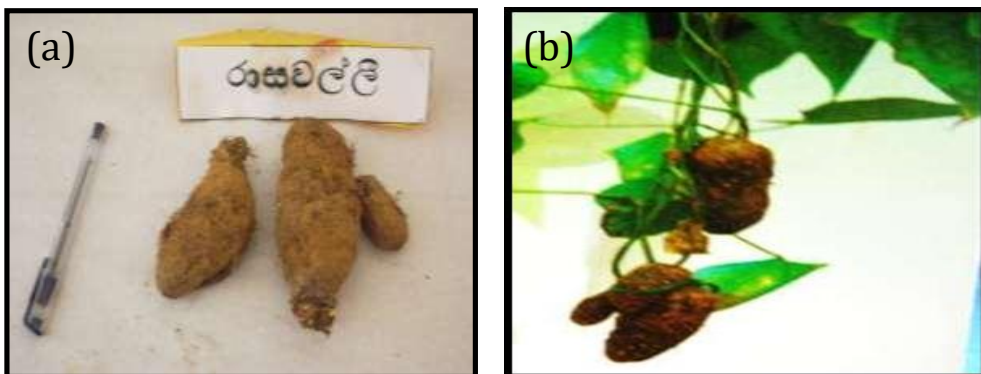


Plate 2: (a) Rasawalli collected from Sirimalgoda and (b) Kodol collected from Dehigolla.

Species distribution

Different types of local root and tuber crops were found in different areas in Uva region (Map 1, Table 1). The highest species richness, *i.e.* 20 different types was found in Sirimalgoda and Badulla area. They were manioc, sweet potato, Raja-

ala, Rasawalli (Plate 2a), Wel-ala, Katuala (Plate 1a), Udala (Plate 1b), Kukulala, Maw ala, Kokisala, Wel ala kola, Buthsarana, Artichoke, Arrowroot (Plate 4a), Kidaran, Kiriala, Innala, Sewelala, Dandila and Dehiala. The next highest species availability was observed in Uva-Paranagama area.

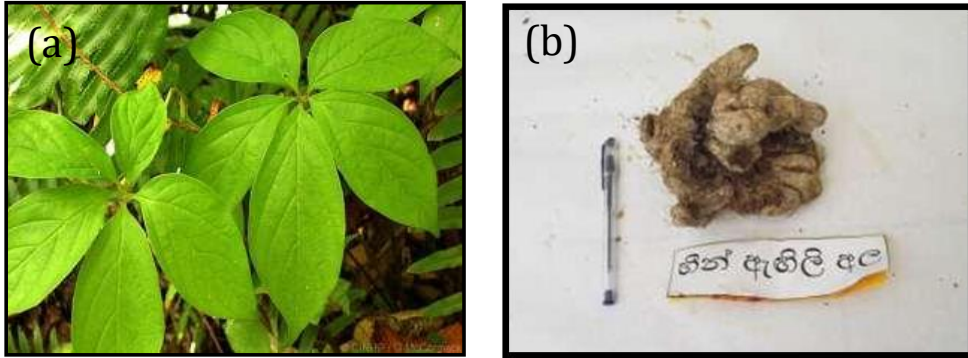


Plate 3: (a) Kahataala collected from Arawatte and (b) Heen angiliala collected from Uva Paranagama

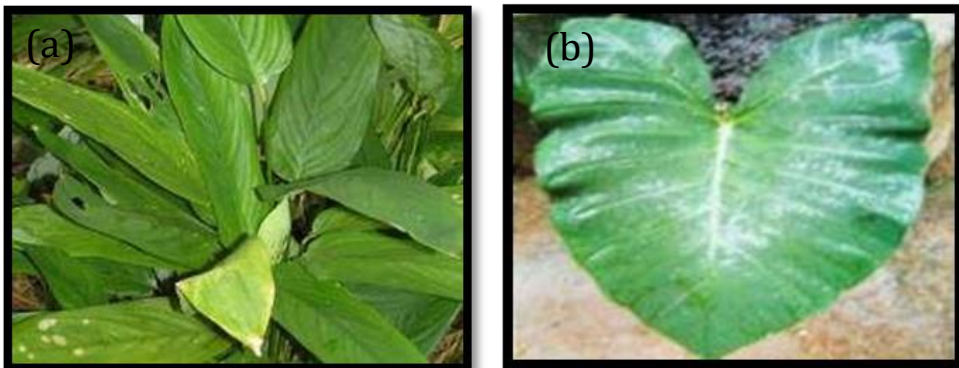
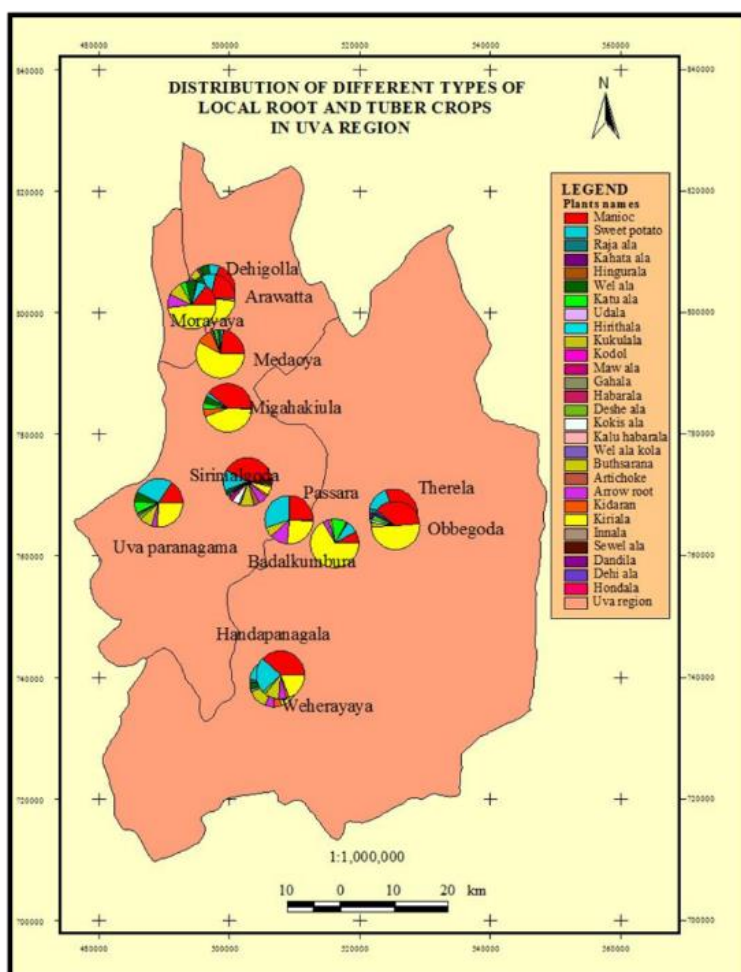


Plate 4: (a) Arrowroot and (b) Coco yam collected from Badulla.

There were about 13 species available: Manioc, Sweet potato, Raja-ala, Hingurala/Heenangili ala (Plate 3b), Wel-ala, Katuala, Udala, Kodol, Gahala, Dheseala, Buthsarana, Arrowroot and Kiriala. Although, there were 13 species available, they were different from the species available in Sirimalgoda. The 11 species available in Morayaya were Manioc, Sweet potato, Raja-ala, Wel-ala, Katuala, Udala, Hirithala, Buthsarana, Arrowroot and Kiriala. The 11 species Manioc, Sweet potato, Hingurala, Wel-ala, Katuala (Plate 1a), Habarala, Kaluhabarala, Kidaran, Kiriala, Innala and Hondala were available in Meegahakiwula and Kandaketiya area. The other 11 different species were available in Badalkumbura namely Manioc, Sweet potato, Raja-ala, Kahata ala, Katuala, Dheseala, Wel ala kola, Buthsarana, Arrowroot, Kiriala and Innala. Ten species were available in Madaoya, Dehigolla and Weherayaya areas. In both Madaoya and Dehigolla areas the species Manioc, Sweet potato, Wel-ala, Katuala, Kodol (Plate 2b), Buthsarana, Arrowroot, Kidaran and Kiriala were

found. Udala was available in Madaoya and Innala was available in Dehigolla except the other species mentioned above.



Map 1: Distribution of different types of local root and tuber crops in agricultural habitats in Uva region.

The ten species namely Manioc, Sweet potato, Raja-ala, Wel-ala, Kukulala, Gahala, Buthsarana, Arrowroot, Kidaran and Kiriala were available in Weherayaya area. Manioc, Sweet potato, Kahata ala (Plate 3a), Wel-ala, Kodol, Buthsarana, Arrowroot, Kidaran, Kiriala and Innala are the ten species were available in Arawatta area and nine species were available in the Therea area: Manioc, Sweet potato, Raja-ala, Kahata-ala, Wel-ala, Katuala, Kaluhabarala, Buthsarana and Kiriala. The lower number of local root and tuber crops in different types *i.e.* eight different species, was available in Handapanagala area. They were Manioc, Sweet potato, Kodol, Dheseala, Buthsarana, Arrowroot, Kidaran and Kiriala. The lowest number of local root and tuber crop species was found in Obbegode area and they were Manioc, Raja-ala, Kahata ala, Katu ala,

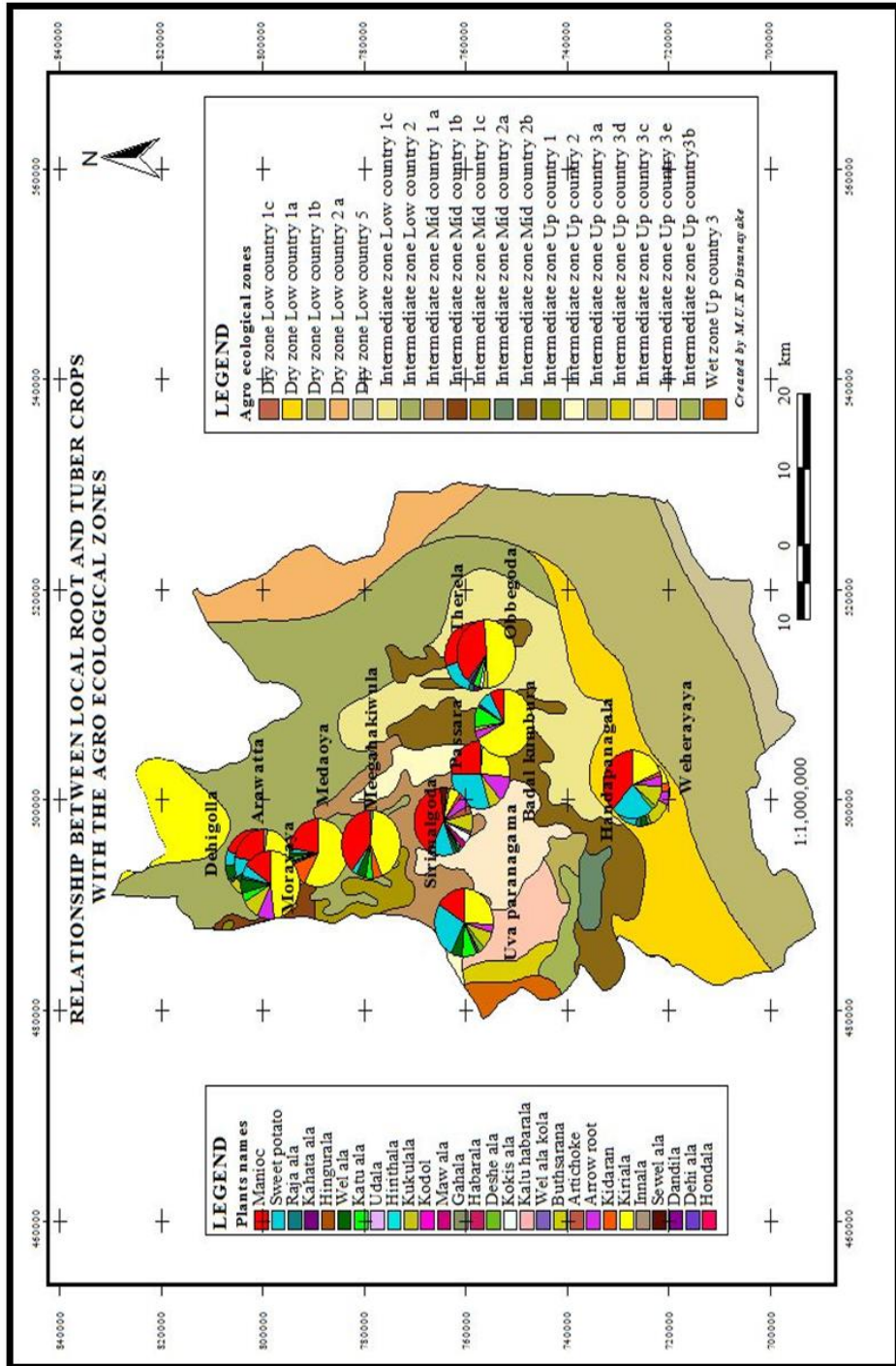
Kokis ala, Buthsarana and Kiriala. All these details are provided in Table1 for the clarity.

Table 1: Different types of root and tuber crops in different areas in Uva region.

Area	Number	Available root and tuber crops
		Types
Arrawatte	10	Manioc, Sweet potato, Katuala, Wel ala, Kodol, Buthsarana, Arrowroot, Kidaran, Kiriala, Innala
Badalkumbura	11	Manioc, Sweet potato, Raja ala, Kahata ala, Katuala, Deheseala, Wel ala kola, Buthsarana, Arrowroot, Kiriala, Innala
Dehigolla	10	Manioc, Sweet potato, Wel ala, Katuala, Kodol, Buthsarana, Arrowroot, Kidaran, Kiriala, Innala
Handapanagala	08	Manioc, Sweet potato, Kodol, Deheseala, Buthsarana, Arrowroot, Kidaran, Kiriala
Madaoya	10	Manioc, Sweet potato, Wel ala, Katuala, Kodol, Buthsarana, Arrowroot, Kidaran, Kiriala, Udala
Meegahakiwula	11	Manioc, Sweet potato, Hingulala, Wel ala, Katuala, Habarala, Kalu habarala, Kidaran, Kiriala, Innala, Hondala
Morayaya	11	Manioc, Sweet potato, Raja ala, Wel ala, Katuala, Udala, Hirithala, Buthsarana, Arrowroot, Kiriala
Obbegoda	07	Manioc, Raja ala, Kahata ala, Katuala, Kokis ala, Buthsarana, Kiriala
Passara	08	Manioc, Sweet potato, Kodol, Deheseala, Buthsarana, Arrowroot, Kidaran, Kiriala
Sirimalgoda	20	Manioc, Sweet potato, Raja ala, Rasawalli, Wel ala, Katuala, Udala, Kukulala, Maw ala, Kokis ala, Wel ala kola, Buthsarana, Arichoke, Arrowroot, Kidaran, Kiriala, Innala, Sewelala, Dandila, Dehiala,
Therala	09	Manioc, Sweet potato, Raja ala, Kahata ala, Wel ala, Katuala, Kalu habarala, Buthsarana, Kiriala
Uva Paranagama	13	Manioc, Sweet potato, Raja ala, Hingurala / Heenangili ala, Wel ala, Katuala, Udala, Kodol, Gahala, Dehesea ala, Buthsarana, Arrowroot, Kiriala
Weherayaya	10	Manioc, Sweet potato, Raja ala, Wel ala, Kukulala, Gahala, Buthsarana, Arrowroot, Kidaran, Kiriala

Relationship between distribution of local roots and tuber crops and Agro Ecological Zones in Uva region

Cocoyam (*Xanthosoma* spp) and Manioc were the species highly grown in Uva region. Buthsarana, which belongs to the Family Cannanceae, has been distributed all over the Uva region. Wel ala, Kahata ala and Katuala are the highly distributed species of *Dioscorea*. Distribution of the other *Dioscorea* species was low in Uva region (Map 2).



Map 2: Distribution of local roots and tuber crops in different Agro Ecological Zones of Uva region in Sri Lanka.

Madaoya, Arawatta and Dehigolla belong to the Low Country Intermediate Zone (IL2) where rainfall is not expected from May to July (*Yala* season). High rainfall is normally experienced in December and January (*Maha* season). An average rainfall can be expected in other months. People in these areas are suffering from water scarcity severely from May to July. The soil types in IL2 zone are Reddish Brown Earth, Immature Brown Loam and Low Humic Gley soil. Farmers in Madaoya, Arawatta and Dehigolla cultivate Manioc, Cocoyam, Katuala, Wel ala and Kidaran. These types give higher yield over the root and tuber crops grown at low water condition as these types are highly adaptable to dry conditions with low fertility soils.

However, species diversity of the on-farm conserved local root and tuber crops were low and restricted only to about five species. Morayaya species diversity was higher compared to the other areas. There were around eleven species in Morayaya. Although, this area belongs to the same Agro Ecological Zone as Madaoya, Arawatta and Dehigolla, water availability is higher in Morayaya area because Yoda ela canal system provides adequate water for this village throughout the year for farming. Therefore, high water availability increased the number of different varieties available in this area.

In the Mid Country Intermediate Zone (IM1), 75% expectancy of annual rainfall is at around 55" and is expected from September to February. Rest of the year is under dry condition (Ministry of Forestry and Environment, 1999). Meegahakiwula belongs to the Mid Country Intermediate Zone 1c (IM1c) whereas Sirimalgoda belongs to the Mid Country Intermediate Zone 1a (IM1a). Both areas consist of Reddish Brown Earth (RBE) and Immature Brown Loam (IBL) soil types. The species diversity of the local root and tuber crops in Sirimalgoda area was higher than that of the Meegahakiwula area. There were about 20 species in Sirimalgoda. *Dioscorea*, *Alocasia* and *Colacasia* species diversity was comparatively higher in this area. The elevation of Sirimalgoda and Meegahakiwula area is around 1000 and 300 m, respectively. The higher elevation in Sirimalgoda area may have caused to have higher number of species diversity as the higher elevations are favorable for the growth of *Dioscorea* species. The findings revealed that Sirimalgoda area was more favorable for the cultivation of yams.

Badalkumbura belongs to the Mid Country Intermediate Zone 2b (IM2b) with an annual rainfall around 45" at 75% expectancy. This rainfall is expected in March, May and from October to November. Rest of the year is in dry conditions (Ministry of Forestry and Environment, 1999). This area consists of same soil conditions as did in Sirimalgoda and Meegahakiwula areas but the annual rainfall is relatively lower than that of those areas. As a result, the species diversity is also lower compared to Sirimalgoda and Meegahakiwula.

Uva-Paranagama belongs to the Up Country Intermediate Zone 3e. Rainfall is distributed throughout the year and the expectancy of rainfall is around 45". This

area is steepy, dissected, hilly and rolling and also consists of Red Yellow Podzolic (RYP) soil (Ministry of Forestry and Environment, 1999). Species diversity of local root and tuber crops are high in this area. There were more than 13 species in Uva-Paranagama. Cultivation of Wal ala and Katu ala of *Dioscorea* species was higher than the other areas. Elevation of this area is recorded as the highest in Uva region. Therefore, these conditions may have created more favorable condition for the growth of the local root and tuber crops.

Therela and Obbegoda belong to the Low Country Intermediate Zone 1c (IL1c). Annual rainfall is around 45" at 75% expectancy and it is expected from October to January. These areas are planes having a variety of soil types. Mostly, Manioc and Cocoyam are cultivated. As this area experiences severe water scarcity most of the people have ignored to protect the species diversity in their fields and pay more attention on the other crops, which could be easily grown with low water conditions.

Manioc and Cocoyam were grown well in almost all the Agro Ecological Zones of Uva region whereas Arrow root and Artichoke like species could be observed in the areas with wet climatic conditions. Species diversity of the yam has increased with the elevation and other favorable conditions such as rainfall and well drainage condition. It is revealed that there is a relationship between species diversity of local root and tuber crops and Agro Ecological Zones in distribution of different types with higher diversity of species.

In the given Agro Ecological Zones, there are different types of soils. High species richness was found in Sirimalgoda, Uva-Paranagama, Weherayaya, Morayaya, Meegahakiwula areas than the other areas in Uva region. Cultivation of yams is also higher in Uva-Paranagama, Weherayaya, and Morayaya areas. Both Sirimalgoda and the Uva-Paranagama areas have RYP soils while Meegahakiwula area has RBE and IBL. The soil types of the Moraya and Weheraya areas are RBE and Low Humic Gley soils. These local root and tuber crops are well grown in those soil groups. Also, these local root and tuber crops are widely adaptable to these soil types given the fact that they can be grown well in a wide range of soil groups.

The elevation and drainage are also considerable factors to determine the Agro Ecological Zones. Higher elevation and well drainage are favorable factors for the growth of most of the local root and tuber crops (Department of Agriculture, 2006). Manioc can grow well from sea level to 1800 m above mean sea level. Sweet potato is grown over a considerable range of latitude and elevation up to 2500 m. Conversely, yams have a relatively narrow range of production, being mainly confined to the tropical region throughout the world from sea level to 1400 m above mean sea level. Most of the cultivated edible aroids are grown at elevations up to 1600 m (Natural Resources Management and Environment Department, 2012). Uva region is situated in higher elevation. Therefore, it is favorable for the cultivation of local root and tuber crops. Sirimalgoda area

(1000 m) and the Uva-Paranagama (1004 m) areas have higher elevation and well drainage compared to the other areas. Also, higher species diversity of local root and tuber crops can be observed there. Cultivation of *Dioscorea* species such as Wel ala and Katuala was also high in these areas.

Constraints identified in relation to species diversity and distribution

Constraints in cultivation of local root and tuber crops are highly significant in Uva region. Pest problems, climatic problems, lack of planting materials and lack of market places are the major constraints in cultivation of local root and tuber crops. However, pest and bad weather conditions are the most prominent constraints in cultivation of local root and tuber crops in Uva region. 42% of the farmers in Uva region suffer due to pest attacks and 25% of the farmers are interrupted by the bad weather. Pest attacks have increased with the deforestation of the area. Wild bores, macaques, bandicoots, elephants are the major pests that attack these crops. The highest percentage of the pest attacks (82%) was recorded in Badalkumbura area. The pest attacks in Therala, Passara, Meegahakiwula, Dehigolla, Madaoaya, Arawatta, Sirimalgoda and Morayaya ranged from 8 to 75% as shown in Figure 3. Wild boar attack is the most prominent pest attack in Uva region.

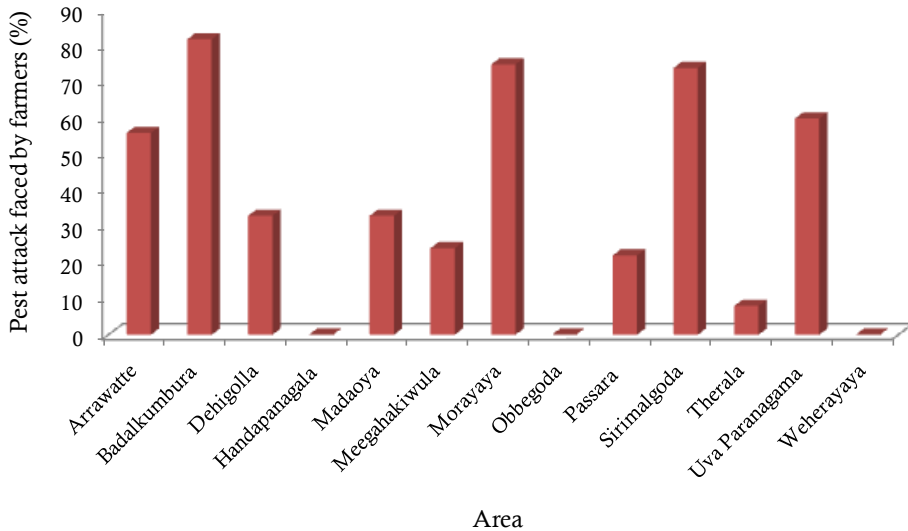


Figure 2: Pest attack faced by farmers (%).

Uva region highly suffers from water scarcity due to low annual rainfall, which is considered as the most occurring weather problem in the region. The highest weather problem was recorded to be 68% in Obbegoda area. The weather problem recorded in Uva-Paranagama, Arawata, Passara, Morayaya, Dehigolla, Weherayaya, Handapanagala and Therala ranged from 20 to 63%.

Lack of planting materials is another reason to neglecting the cultivation of local root and tuber crops in most of the areas in Uva. Most of the types belonging to the local root and tuber crops are not available in adjacent natural habitats of home gardens. They are also highly vegetatively propagated. Most of the home-gardeners obtain planting material from their own gardens, neighboring farms and from their friends (Sangakkara and Frossard, 2014). Therefore, it is very difficult to find quality planting materials for cultivation. In Obbegoda, Passara, Therela and Dehigolla areas, this constraint was recorded up to 30%, while in Sirimalogoda, Handapanagala, Morayaya and Weherayaya it was around 25%.

Difficulty in finding a market and also selling their products are other constraints for ignoring cultivation of root and tuber crops in Uva. This has been an issue especially in Meegahakiwula, Dehigolla, Passara, Badalkumbura, Uva-Paranagama, Madaoya and Arawatta ranged from 9 to 43%. Although, these areas are suitable for growing local root and tuber crops the farmers of the area are reluctant to cultivate local roots and tuber crops. When overlapping the map of the main cities in Uva region and the cultivation of different types of local root and tuber crops it was identified that the number of plants and the species diversity has been increased in areas closer to the major urban areas such as Badulla, Meegahakiwula, Welimada and Mahiyanganaya. This may be because of availability of the market places. As a result, farmers in these areas seem making an effort in cultivating local roots and tuber crops and on-farm conservation. Further, these results reveal that some of these areas like Arawatta, Madaoya, Uva-Paranagama are not much closer to major urban cities and therefore, they have got an issue of lack of market places ignoring the cultivation. The other reason for the less interest in cultivation of local root and tuber crops is that the most of the farmers cannot get good price for their harvest though they are very near to the main cities. Also, there are no defined and proper market chain and places for the local root and tuber crops. As a result of this, most of the farmers discourage to cultivate Manioc, Cocoyam like common and demanding local roots and tuber crops.

The other important constraint is that 94 and 96% of the farmers in Uva region are not aware about the concept of the bio-diversity conservation and the on-farm germplasm conservation, respectively. However, there are 29 species of local roots and tuber crops conserved on-farm among the traditional farmers and have contributed on on-farm germplasm conservation without their theoretical knowledge and awareness on the germplasm conservation.

CONCLUSIONS

Majority of the farmers, who engage in organic agriculture and home gardening cultivate local roots and tuber crops in the Uva region. Species richness in the Uva region is reckoned with 29 species of local roots and tuber crops; Manioc, Sweet potato, Raja-ala, Kahata-ala, Hingurala, Wal-ala, Katuala, Rasawelli, Udala, Hirithala, Kukulala, Kodol, Maw ala, Gahala, Habarala, Dheseala, Kokisala, Kaluhabarala, Wel ala kola, Buthsarana, Artichoke, Arrowroot,

Kidaran, Kiriala, Innala, Sewelala, Dandila, Dehiala and Hondala. The diversity and distribution of local roots and tuber crops in Uva region are in parallel with the Agro Climatic Zones where the most of the conducive conditions such as soil types, rainfall, elevation and drainage are met. Further, the species diversity in agricultural habitats in Uva region highly depends on the farmers' preferences on cultivation of root and tuber crops, which is based on the awareness about different species, their market demand and ease marketing facilities as well as the availability of quality planting materials. The constraints affecting on ignorance of cultivation of local roots and tuber crops are pest attacks, climate issues, lack of planting materials, lack of market places and lack of knowledge and awareness on germplasm conservation.

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