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# Home gardens and *Dioscorea* species – A case study from the climatic zones of Sri Lanka

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**Abstract**

Home gardens are considered as vital units for enhancing food security particularly in developing nations of South Asia, such as Sri Lanka. Although the yam crop *Dioscorea* spp. constitute a popular but still minor component in Sri Lankan home gardens, they have the potential of producing large quantities of edible material with minimal inputs. However, their real value in South Asian home gardens is not yet reported. Hence, this study was carried out to get insights into home garden characteristics, gardener demography as well as current management practices within 300 Sri Lankan home garden systems that are located along a climatic gradient. By using interviews and field observations, gardeners, who cultivated in particular *Dioscorea* species, were studied within 10 of the 25 administrative districts distributed in the wet, intermediate and dry climatic zone of Sri Lanka. Furthermore, current management practices of yams cultivation were analyzed on local scale and compared afterwards with management recommendations published in the year 2006 by the Department of Agriculture. *Dioscorea* species were found in a majority of home gardens, especially in wet and intermediate zones of Sri Lanka. *D. alata* was the most prominent species and was managed at a subsistence level and not as per recommendations developed by the Department of Agriculture. Our results revealed that *Dioscorea alata* is an essential component of Sri Lankan home gardens in rural areas and can yield substantial quantities of edible tubers with low input, especially during times of food scarcities, and has therefore the potential to enhance food security and rural development.

*Keywords:* food security, productivity, smallholder farming, South Asia, tropics, yams, *Dioscorea*

## 1 Introduction

Tropical home gardens are considered to be well developed sustainable agricultural systems, which maximize beneficial interactions among crop plants, while minimizing unfavorable interactions (Nair, 1993). In South Asian nations such as India, Bangladesh, Nepal and Sri Lanka, tropical home gardens are considered to be species rich agroforestry systems with a high degree of biodiversity, having the potential of maintaining soil fertility and providing food and can provide an additional income through sales of produce to rural households (Sangakkara, 1989; Nepal, 2002; Ali & Muhammed, 2005; Pandey & Singh, 2009; Kabir & Webb, 2009; Senanayake *et al.*, 2009; Chandrashekara & Babu, 2010). Furthermore, recent studies in India also identified home gardens as potential carbon stocks due to the high populations of plants and their high species diversity (Kumar, 2006; Saha *et al*., 2009).

Root and tuber crops are vital for providing food for over two billion people especially in the rural regions of Africa, Asia and the Caribbean (Lebot, 2009).

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These species, especially the under-researched yams and aroids are well suited to tropical smallholder conditions because of their adaptability to different cropping systems. Hence these crops are an important component of programs seeking to enhance the welfare and food security of smallholder rural populations of the developing nations (CIP, 2000).

The most prominent root and tuber crops grown in the world are potato (*Solanum tuberosum*), cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), yams (*Dioscorea* spp.) and aroids (*Colocasia* spp.) (FAO, 2009). Whereas a large number of studies were carried out on potato, cassava and sweet potato (Scott *et al.*, 2000), especially by the HarvestPlus program in Asia and Africa (Zhao & Shewry, 2011), yams, which have the potential of producing 2.4 Mg dry matter $ha^{-1}$ and 182 MJ of energy $ha^{-1}day^{-1}$ when compared to 1.9 Mg dry matter $ha^{-1}$ and 151 MJ of energy $ha^{-1}day^{-1}$ produced by rice, have received less attention.

Yam tuber (*Dioscorea* spp., Dioscoreaceae, Monocotyledons) is a staple food for over a billion people in the tropical nations of Africa, Asia, the Caribbean and the Pacific region (Coursey, 1967; Lebot, 2009). They constitute a reliable source of food in times of scarcity, and some species provide pharmacologically active ingredients important in traditional medicines (Liu *et al.*, 2007; Mignouna *et al.*, 2008; Lebot, 2009). Although the family Dioscoreaceae has over 600 species, the most commonly cultivated species are *Dioscorea alata*, *D. rotundata* and *D. cayenensis*. The two most important are *D. alata* (water yam) which is grown in the humid and sub-humid tropics, especially in Asia and the Caribbean and *D. rotundata* (white guinea yam) in Africa, all of which is principally grown with low inputs in smallholder farming systems (Hildebrand, 2003; Mahalakshmi *et al.*, 2007; Maliki *et al.*, 2012). Furthermore, they are a part and parcel of the culture of many West African and Pacific nations (Orkwor *et al.*, 1998).

Tropical tuber crops are important smallholder crops in Sri Lanka (Department of Agriculture, 2006), and in the tropical Asian region (Ray & Sivakumar, 2009). In Sri Lanka, prominence is given to cassava and sweet potato, due to their greater acceptability, and even *Colocasia* spp., due to its greater adaptability. In contrast, *Dioscorea* spp. (especially *D. alata*) is also grown widely in home gardens, for its usefulness in times of food insecurity and ease of management as reported by the Department of Agriculture of Sri Lanka (Department of Agriculture, 2006) and identified in a recent survey in Sri Lanka (Jayamali, 2010), unlike in some parts of Africa, where it is a major commodity (Lebot, 2009; Iwuchukwu & Onwubuya, 2012). Thus the Department of Agriculture of Sri Lanka (2006) has recommended guidelines for its cultivation. The survey by Jayamali (2010) also illustrated the presence of one or more species of *Dioscorea*, principally as a home garden crop, which provided a source of energy to the family diet or income through sales.

Based on mean annual rainfall, Sri Lanka has three climatic zones: wet (> 2500 mm mean annual rainfall), intermediate (1750–2500 mm mean annual rainfall) and dry zone (< 1750 mm mean annual rainfall) (Punyawardena *et al.*, 2003). The nation is also further subdivided into 25 administrative districts, each having its own unit to promote agriculture, especially crop production. However, the Department of Agriculture recommends the cultivation of *Dioscorea* species in all three climatic zones, due to the high adaptability of this crop, the availability of suitable species and low management requirements when compared to other crops such as vegetables and cereals, or even root crops such as sweet potato. However there is no comparative report for Sri Lanka on home gardeners growing these species in different climatic zones and the practices they adopt to cultivate *Dioscorea*. Hence, this study was carried out to get insights into home garden characteristics, gardener demography as well as current management practices within 300 home garden systems in Sri Lanka that are located along a climatic gradient. By using interviews and field observations, gardeners, who cultivated in particular *Dioscorea* species, were studied within 10 of the 25 administrative districts distributed in all three climatic zones (wet, intermediate and dry zone) in 2011. Furthermore, current management practices of yams cultivation were analyzed on local scale and compared afterwards with management recommendations published in the year 2006 by the Department of Agriculture that functions under the Ministry of Agriculture of Government of Sri Lanka. In a last step, we tried to determine the importance of *Dioscorea* crop cultivation in home gardens, as this species is considered as a potential food security crop, especially for rural people in Asia (Ray & Sivakumar, 2009).

## 2 Materials and methods

This study considered three different climatic zones defined on the basis of mean annual rainfall (dry zone, intermediate zone and wet zone) and was conducted from February to June 2011, in 10 of the 25 admin-

istrative districts of Sri Lanka. We selected the districts Hambantota, Moneragala, Trincomalee and Polonnaruwa in the dry zone, where Hambantota and Moneragala were identified as the poorest regions of Sri Lanka (Department of Census and Statistics, 2009) as well as Matale, Badulla and Kurunegala in the intermediate zone and Kandy, Galle and Matara being the districts in the wet zone (Figure 1). From all locations, 30 research sites each were selected on a random basis to represent every district, encompassing a total of 300 home gardener families that were surveyed once.

Interviews, field visits and a questionnaire was used to determine important home garden characteristics such as garden size and *Dioscorea* species diversity as well as gardeners demographic features such as education level and farming experiences. The specific role of *Dioscorea* species in home garden cultivating in Sri Lanka was determined by collecting data on *Dioscorea* yield along the climatic gradient and by comparing needed labor investment. The survey data were analyzed on a qualitative basis using open coding and the statistical packages SPSS and SAS (Version 6.0). For ease of data presentation, the age classes of the respondents were defined on the basis of a ten year interval.

## 3 Results

### *3.1 Home garden characteristics*

Home garden characteristics such as garden size and yam species diversity did not differ significantly within a given climatic zone (Fishers exact test, $P = 0.05$), but show great variance along the climatic gradient. On average, home gardens that were located within the wet zone were relatively small in comparison to gardens within the two other climatic zones. Here most gardeners (67 %) cultivated an area between 25 and 500 $m^2$. Further 24 % of the gardeners cultivated an area between 501 and 1000 $m^2$, and the percentages of larger size gardens (1001–2000 $m^2$) were significantly lower

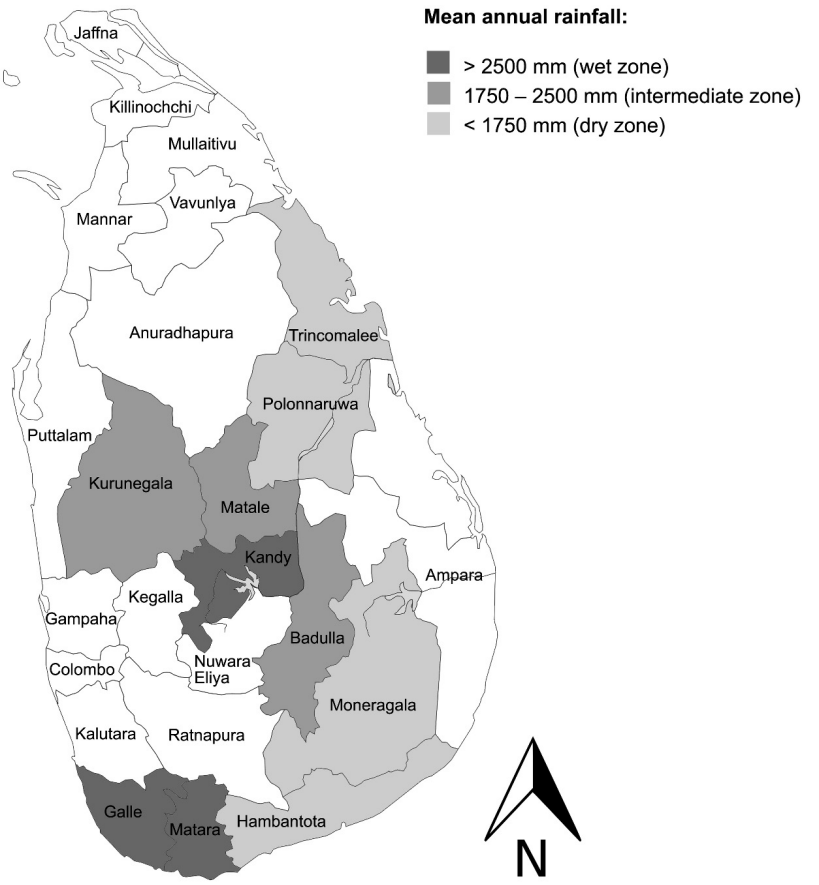


**Fig. 1:** *Selected administrative districts of Sri Lanka, with information on mean annual rainfall for home garden survey. In total 30 research sites per district were selected randomly resulting in a total of 300 home gardener families.*

(9 %). In contrast, in the intermediate zone, the numbers of home gardens having a size between 25–500 $m^2$, 501–1000 $m^2$, 1001–1500 $m^2$ and 1501–2000 $m^2$ were similar. Most home gardens of districts with dry climatic conditions, were of moderate size (501–1000 $m^2$), or of very large size, having more than 4000 $m^2$.

The majority of interviewed gardeners (88 %) cultivated yams within their home gardens, and in the Trincomalee district (dry zone), which had been affected by the separatist war (1983–2009), even all farmers declared to grow yams in their gardens. However, only 60 % of the gardeners in Hambantota that was also located within the dry zone planted yams. The survey results also revealed that the average number of yam farmers was equal among the three climatic zones.

With respect to the cultivation of *Dioscorea* species, research sites showed a high variance in the number of home gardens. Particularly within the dry zone, only an average of 18 % of the farmers cultivated *Dioscorea* species. But, although the numbers of home gardens with *Dioscorea* were lower than those with *Colocasia*, this species was very prominent in the home gardens of the wet zone and particularly of the intermediate climatic zone (Table 1). In the wet zone, the number of home gardens that included *Dioscorea* species was lowest in Galle (only 20 % of home gardeners). In all other districts, *Dioscorea* was the more common species (exceeding 85 % of home gardens), especially in Kurunegala (96 %) as well as in Kandy and in Badulla (90 %).

The three most common *Dioscorea* species grown in Sri Lankan home gardens were *D. alata*, *D. bulbifera* and *D. esculenta*. *D. alata* was the most common species cultivated in all districts among all three climatic zones (Table 2). However, the number of cultivated *D. alata* plants was lowest within the drier areas, where no home garden had more than five plants. The highest number of *D. alata* plants was found in home gardens in the Matara district that is located within the wet zone.

In contrast to *D. alata*, the numbers of *D. bulbifera* and *D. esculenta* were very low (Table 2). With exception of the Galle district (wet zone), *D. bulbifera* was not cultivated by home gardeners in Sri Lanka among all climatic zones. Also *D. esculenta* was cultivated only within two districts of the wet and intermediate zone, and here only with low plant densities.

### *3.2 Home gardener demography*

The age of the 300 interviewed home gardeners ranged from 21–77 years and age class analyses revealed differences in the demographic structure, where gardeners societies within intermediate and dry zone comprehends, for the predominant part, farmers in the age between 31 and 50 years (Figure 2). In contrast, gardener societies of districts within the wet zone, showed

**Table 1:** *Numbers of home gardeners in Sri Lanka cultivating tropical tubers along a climatic gradient, with specific focus on gardeners cultivating Dioscorea species* ($n_{total}$ *= 300 home gardens).*

| *Climatic zone and District* | *Respondants* | | | |
|---|---|---|---|---|
| | *Home gardens with tropical tubers, including Dioscorea sp. and Colocasia sp.* | | *Home gardens with Dioscorea sp.* | |
| | *Number* | *Percentage* * | *Number* | *Percentage* * |
| *Wet zone* | | | | |
| Kandy | 27 | 90.0 | 21 | 70.7 |
| Galle | 24 | 80.0 | 06 | 20.0 |
| Matara | 26 | 86.6 | 19 | 63.4 |
| *Intermediate zone* | | | | |
| Badulla | 27 | 90.0 | 23 | 76.7 |
| Kurunegala | 29 | 96.6 | 26 | 86.6 |
| Matale | 25 | 83.3 | 15 | 50.0 |
| *Dry zone* | | | | |
| Hambantota | 18 | 60.0 | 04 | 13.3 |
| Moneragala | 28 | 93.3 | 03 | 10.0 |
| Polonnaruwa | 28 | 93.3 | 03 | 10.0 |
| Trincomalee | 30 | 100 | 12 | 40.0 |

* Percentage refers to number of gardeners within one district.

**Table 2:** *Abundance of cultivated Dioscorea plants within home gardens in Sri Lanka along a climatic gradient.*

| *Climatic zone and District* | *Dioscorea species* | *Number of farmers cultivating Dioscorea plants* * | | | |
|---|---|---|---|---|---|
| | | *1–5 plants per home garden* | *6–10 plants per home garden* | *11–15 plants per home garden* | *More than 15 plants per home garden* |
| *Wet zone* | | | | | |
| Kandy | *D. alata* | 16 (53.3) | 05 (1.6) | – | – |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | – | – | – | – |
| Galle | *D. alata* | 5 (16.6) | – | 1 (3.3) | – |
| | *D. bulbifera* | 1 (3.3) | 1 (3.3) | – | – |
| | *D. esculenta* | – | – | – | – |
| Matara | *D. alata* | 12 (40.0) | 4 (13.3) | 3 (10.0) | 1 (3.3) |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | 7 (23.3) | 1 (3.3) | – | – |
| *Intermediate zone* | | | | | |
| Badulla | *D. alata* | 21 (70.0) | 2 (6.6) | – | – |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | – | – | – | – |
| Kurunegala | *D. alata* | 24 (80.0) | 1 (3.3) | 1 (3.3) | – |
| | *D. bulbifera* | – | – | – | |
| | *D. esculenta* | – | – | – | – |
| Matale | *D. alata* | 5 (16.6) | 2 (6.6) | 1 (3.3) | 1 (3.3) |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | 5 (16.6) | 1 (3.3) | – | – |
| *Dry zone* | | | | | |
| Hambantota | *D. alata* | 4 (13.3) | – | – | – |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | – | – | – | – |
| Moneragala | *D. alata* | 2 (6.6) | – | – | 1 (3.3) |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | – | – | – | – |
| Polonnaruwa | *D. alata* | 3 (10.0) | – | – | – |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | – | – | – | – |
| Trincomalee | *D. alata* | 9 (30.0) | 2 (6.6) | 1 (3.3) | – |
| | *D. bulbifera* | – | – | – | – |
| | *D. esculenta* | – | – | – | – |

* Percentages of farmers cultivating *Dioscorea* sp. is given in parentheses.

a nearly even distribution on all age classes with an emphasis on the age class 51–60 years.

Most of the interviewed households (76 %) consisted of four members, two males and two females who worked regularly within the home gardens. The survey results also revealed that 10 % of the gardeners had no formal education, while the majority (46 %) had five years of schooling and 36 % had attended school for 10 years. The other 8 % had some professional training in addition to their formal schooling. There were no graduates among the home gardener population. The highest numbers of non-educated home gardeners (19 %) were found to live within the districts of the dry zone. Hence, the numbers of home gardeners who did not attend school were significantly lower in the wet and intermediate zones (3–4 %).

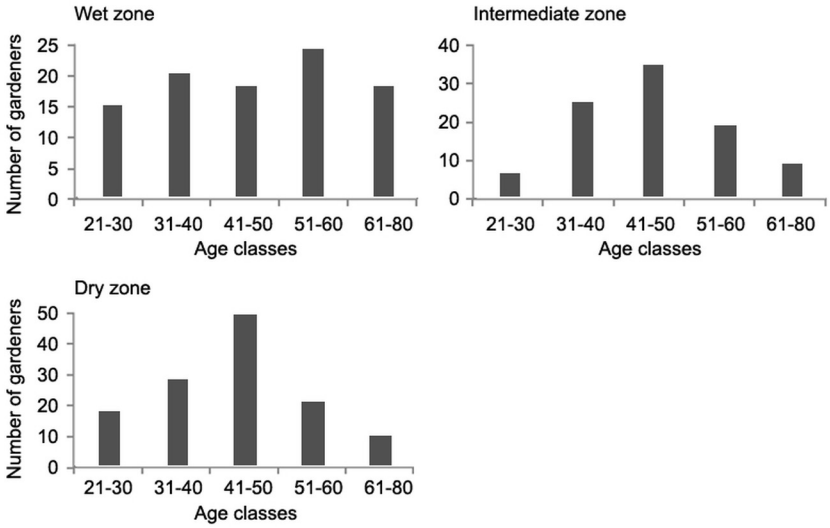


**Fig. 2:** *Distribution of farmer age classes among three climatic zones in Sri Lankan home garden systems.*

With respect to the gardeners farming experiences, the survey could show that 57 % had less than 5 years of experience in managing their own gardens, while 14 % had over 15 years of experiences. The percentage of home gardeners having more than 5 years experiences in home garden management was highest in the dry zone. The most important parameter ascertained in this study was that all respondents among the climatic zones stated that the home garden was indispensable. It provided food for the family, especially vegetables, which are costly in the market, and there was at certain times, products available for sharing with neighbors and in some instances, brought an income to the household.

### *3.3 Common cultivation practices of Dioscorea sp. in home gardens in Sri Lanka*

All home gardeners planted *D. alata* in small pits made in their allotments at random spacings, as these plants were intercropped with other vegetable crops. Thus the recommended spacing of 1×1 m that was made by the Department of Agriculture (2006) was not followed by the gardeners. Only one home gardener in Trincomalee (dry zone) planted *D. alata* in beds. With exception of one gardener in the Matale district, also *D. bulbifera* and *D. esculenta* plants were planted by using the common method of pits, instead of using beds. The used planting method varied between small tubers, setts from the head pieces of harvested tubers or bulbs. Irrespective of the districts or climatic zones, most home gardeners used setts for planting *D. alata*. All of the *D. bulbifera* was planted using bulbs, while setts and small tubers were used to plant *D. esculenta*. Over 95 % of home gardeners used planting material for *D. alata* from their own gardens, while the balance obtained setts from neighboring farms and friends. Only one home gardener, who started cultivating *D. alata* in 2008 in Trincomalee (dry zone) obtained setts from the Department of Agriculture. Bulbs were used to plant *D. bulbifera* and one home gardener who cultivated *D. esculenta* obtained the planting material from the Department of Agriculture.

Due to the prevailing climatic conditions in Sri Lanka, where there are two seasons based on rainfalls received during the Northeast (October–January) and Southwest (April–July) monsoons, which represent the major and minor seasons (Punyawardena *et al.*, 2003), most home gardeners tend to plant the setts at the first intermonsoonal rains in March (Figure 3). However the planting time varies from late November to early April, irrespective of the region.

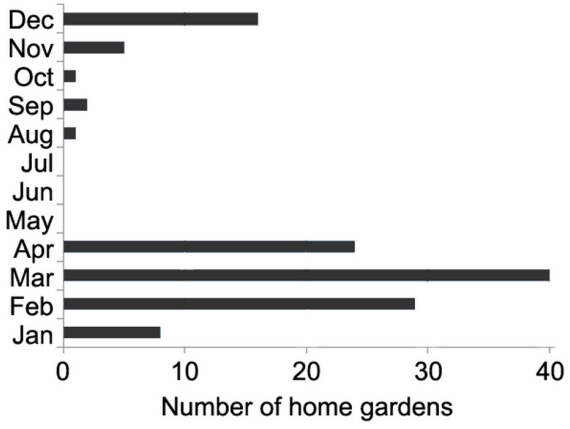


**Fig. 3:** *Time of planting Dioscorea species in Sri Lankan home gardens.*

The majority of home gardeners (60 %) that cultivated *D. alata* as main yam crop applied some form of manure or fertilizers, irrespective of the climatic zone. Among those who applied some form of nutrients, most gardeners (73 %) applied self-made compost, while the others used both composts and mineral nutrients. Although the Department of Agriculture (2006) recommended the application of 150 kg of urea (46 % N), 195 kg Triple Super phosphate (45 % $P_2O_5$) and 180 kg Muriate of Potash (60 % $K_2O$) per hectare, none of the surveyed home gardeners used the recommended quantities. They added mineral fertilizers only as a basal dressing that was left over from either rice or vegetable production. However, 95 % of home gardeners added approximately 1 kg of wood ash to the planting hole.

In the surveyed home gardens, as there were no extensive cultivations, 66 % of the home gardeners trained the vines to trees and there was no significant pattern between districts or climatic zones. However 21 % of the gardeners did not provide any support, while 12 % had single stakes. Only one home gardener in the wet zone provided V type of staking. Thus the usefulness of supporting the vine through either staking or facilitating the growth onto adjacent trees was evident, and home gardeners stated the benefits of this practice.

As recommended by the Department of Agriculture (2006), with the exception of one gardener in Kandy (wet zone), all home gardeners in districts of the wet and intermediate zones weeded regularly around their *Dioscorea* plants. In dry zones, only 86 % of home gardeners removed regularly weeds around *Dioscorea* plants. The occurrence of pest animals, such as field rats, was restricted to three home gardeners living in wet and intermediate zones. Harvesting time of *Dioscorea* species did not vary among the studied districts or among the three climatic zones. Around 70 % of the home gardeners harvested their crop in December and January, to correspond to nine months after planting. However, times of food scarcity led to a harvest at early stages. Home gardeners harvested after falling of the leaves and the wilting of the vine. There were also no differences between the three species of *Dioscorea* cultivated in terms of the time of harvest.

The yields of the three species of *Dioscorea* ranged from 1–15 kg per vine, and did not differ among the districts or along the climatic gradient. The yield was highest for *D. alata* while *D. esculenta* and *D. bulbifera* only produced a modest return. The highest yields of 12–15 kg per vine were found for *D. alata* plants that were cultivated especially in the intermediate and wet zones, where gardeners applied manures and mineral fertilizers. The average yield of *D. alata* within the dry zone was between 2–5 kg per vine.

Unlike in Africa, home gardeners in Sri Lanka did not store their *Dioscorea* crop and the yams were consumed as a curry with rice as an accompaniment, or was boiled and eaten as the principal source of carbohydrates instead of rice or wheat flour. Any excess was shared with neighbors or sold in village fairs. The highest consumption of tubers with a mean of 10 kg per family during the harvest, occurred within the district of the dry zone, where other food was scarce due to the poverty status of families and harsh climatic conditions. Most home gardener families in the wet and intermediate zones consumed 1–3 kg *Dioscorea* yams per family during the harvest period. The most important observation was that all households surveyed consumed *Dioscorea* yams even if it was not grown in the home garden. In the dry zone, which receives the lowest rainfall, all the yams produced in the respective gardens was consumed and some home gardeners even bought yams (*D. alata*) from village fairs for household consumption.

*Dioscorea* cultivation in Sri Lanka seems to be a low labor input crop, with minor differences in effort along the climatic gradient (Table 3). Home gardens in the intermediate zone used the most labor as *Dioscorea* was cultivated to greatest extent in all three districts. This was followed by labor use patterns in the wet zone. In contrast in the dry zones, less labor was used as the numbers of plants were also lower (Tables 3 and 2 respectively). Thus a positive correlation could be shown for numbers of plants cultivated and the needed labor for cultivation ($r = 0.74$, $P \leq 0.05$). The most amount of labor was invested in land preparation, irrespective of the zone, while harvest did not use much labor, as this was done irregularly by either males or females at times of requirements for food or sale. The farm gate price of *Dioscorea* yams did not vary significantly among districts or climatic zones and was sold for an average price of 0.45 USD per kilogram (=60 Sri Lanka Rupees).

## 4 Discussion

### *4.1 Home garden characteristics and home gardener demography*

Home gardens were the smallest in the wet zone, followed by the intermediate zone, and the most extensive in the dry zone. This is due to the population pressure in the wet zone, which is the most populated region of Sri Lanka (Department of Census and Statistics, 2009). Thus the land is fragmented and people do not have extensive areas for home gardening due to urbanization

**Table 3:** *Labor usage for women and man in days per month for cultivating Dioscorea plants until harvest in Sri Lankan home gardens.*

| *Climatic Zone and District* | *Labour use per home garden (days per month)* | |
|---|---|---|
| | *Male* | *Female* |
| *Wet zone* | | |
| Kandy | 15 | 19 |
| Galle | 8 | 6 |
| Matara | 18 | 13 |
| *Intermediate zone* | | |
| Badulla | 24 | 23 |
| Kurunegala | 21 | 22 |
| Matale | 17 | 15 |
| *Dry zone* | | |
| Hambantota | 2 | 5 |
| Moneragala | 4 | 1 |
| Polonnaruwa | 4 | 3 |
| Trincomalee | 11 | 10 |

pressures and division on the basis of inheritance within families as this could already be shown for other regions of South Asia (e.g. Nagendran *et al.*, 2012). The division of home gardens of the intermediate climatic zone into garden size categories revealed a uniform distribution of the numbers of home gardens which can be a result of home garden locations in both urban and rural regions. The moderate extents in the dry zone, which even had a few very large home gardens is indicative for the availability of land due to lower population pressures in these dry climatic zones.

Highest numbers of older home gardeners were in the wet zone, as home gardens in these regions have lasted a few generations (Wickramasinghe, 1995). Furthermore, all home garden families in the three zones have two males and two females and none were graduates, as seen in similar studies in South Asia (Rahut & Scharf, 2012). However, the great number of home gardeners in the wet and intermediate zones, who received higher education than gardeners in districts with drier climate, is a result of a better local infrastructure and the overall development of primary education in Sri Lanka (Tan, 2002). The greater experience of the home gardeners of the dry zone can be explained by the commencement of farming activity at an earlier age, to the detriment of the education.

Home gardens were considered as a vital unit of the family life by all respondents. Earlier studies in Sri Lanka (e.g. Wickramasinghe, 1995) had concentered on their importance only in the wet zone and this study which covered all three climatic zones clearly confirmed their value, a feature not identified earlier. Their value was enhanced during periods of food scarcity, thus highlighting their role in helping home gardeners overcome hunger and contributing to family food security and also that of neighbors through sharing and sales.

### *4.2 Yams in home gardens*

The overall presence of some form of tuber crops (*Dioscorea* or *Colocasia*) highlighted their importance in rural home gardens among all climatic zones. However, its cultivation density, particularly within the dry climatic zone, was surprisingly variable and thus needs further clarification. It is assumed that the more sandy soils in the district of Trincomalee and the overall low management effort supported the high planting frequency within home gardens of Trincomalee. However, as the yam crop requires at least a specific soil moisture value (Lebot, 2009), the lowest number of home gardens cultivating either *Dioscorea* or *Colocasia* was found within the very dry region of Hambantota. The high prominence of both species within the intermediate zone is due to the adequate rainfall in this climatic zone and the warmer temperatures (Punyawardena *et al.*, 2003) which are ideal climates for both species (Lebot, 2009). However, we always found one specific farm in all climatic zones (i.e. Matara in the wet zone, Matale in the intermediate zone and Moneragala in the dry zone) that had more than 15 plants of *D. alata* in their home gardens. These gardeners were commercial cultivators, who planted this crop for specialized markets, which again illustrates the high adaptability of this species to various climatic zones.

### *4.3 Dioscorea and its management in home gardens*

The prominence of *Dioscorea* species in the home gardens of the wet and intermediate zones in contrast to that of the dry zone, especially Trincomalee was interesting. This implies that home gardeners in dry regions preferred *Colocasia*, a species with a shorter growth duration and lower yield potential but does not require staking, when compared to *Dioscorea* (Onwueme, 1978). The lower number of *Dioscorea* plants in the dry zone is again a causal effect of the drier climate for this nine month crop. The larger numbers of *Dioscorea* plants in home gardens of the wet and intermediate zones also indicated the preference of this species by the home gardeners, which was also confirmed during the interviews, as it could provide a high tuber yield, especially at times of food scarcity. Furthermore, as a result

of the warmer climate, the most prominent species was *D. alata*, while *D. bulbifera* that is used primarily for medicinal purposes in Asia (Liu *et al.*, 2009) was principally in the wet zone and none in the intermediate and dry zones. This clearly identified *Dioscorea alata* as the major species of *Dioscorea* grown in Sri Lankan home gardens, which could be also attributed to the greater demand for this species, and its higher productivity in comparison to *D. esculenta* and *D. bulbifera*, a phenomenon that was not reported earlier. It also confirms the importance and popularity of *D. alata* as an important smallholder crop among all three climatic zones of Sri Lanka, wherefore significant efforts were made by the Department of Agriculture to promote the cultivation of *D. alata* in Sri Lanka on a broad scale.

*Dioscorea* is propagated using setts, bulbs and small tubers (Onwueme, 1978), although the Department of Agriculture (2006) recommended setts from the head region of the tubers, each weighing approximately 250 g, preferably planted on well prepared beds or in pits. However the home gardeners used their own planting material, and planted them in pits. This again proved that although the Department of Agriculture offers planting material, especially of the recommended *D. alata* varieties, home gardeners cultivating *Dioscorea* used their own planting material as they found this method to be the most reliable.

For planting, home gardeners tended to either use the rain of the major season, residual soil moisture or intermonsoonal rain – and as recommended by the Department of Agriculture (2006), they plant within the period of late February through March until early April. Although crop management in *Dioscorea* involves fertilizer application, staking and the management of weeds, pests and diseases, home gardeners who grew *Dioscorea* spp. did not consider the use of mineral fertilizers as an essential component of management, as they were confident of acceptable yields with their instinctive management of applying manures and fertilizers. The application of ash to the plants was considered to be essential to enhance tuber growth and protect the setts from diseases. It was also interesting to note that over 99 % of home gardeners stated the absence of pests or diseases in their *Dioscorea* plants, thus confirming the usefulness of this species as an ideal home garden crop. The practice of staking was not commonly adopted as this crop was a part of a mixed community of plants and the home gardeners took advantage of using adjacent trees to support their vines. Furthermore, due to the overall small number of home garden vines but also due to very dry climatic conditions, home gardeners of districts within the dry zone had less problems with weeds, wherefore the management practices of regular weeding was more adopted by farmers within intermediate and wet zones.

The ability of *D. alata* to produce high yields in Sri Lankan home garden systems which are considered to be more fertile than agricultural fields in Sri Lanka (Egodawatta *et al.*, 2012) could be highlighted by this study. By upscaling our results and with respect to have only a little or no addition of mineral fertilizers to yam fields, farmers in Sri Lanka could reach 20–30 Mg of edible material per hectare, if the crop is planted at a spacing of 1×1 m, and the Department of Agriculture (2006) declared even yields of 32–35 Mg per hectare. This clearly presents the potential of this species, which does not need significant management when compared to cereals such as rice and maize and that can be cultivated within a low input system, to provide edible food.

The fact that *D. alata* was a part of the food habits of the smallholder home gardeners, especially in the drier regions, where food was scarce and food security was a greater problem confirmed its usefulness in the tropics and its valuable contribution to food security of rural households. It is a low labor input crop and even if the yams are not consumed within the family, home gardeners could derive a good income (much more than from perishable vegetables), if this species was cultivated and the tubers could be harvested at staggered intervals and if required be stored as in Africa (Lebot, 2009). The fact that it fetches a reasonable price even at the farm gate also indicates its usefulness as a possible income crop for the smallholder home gardeners.

## 5 Conclusions

In comparison to Africa, *Dioscorea* yam in Sri Lankan home gardens constitutes only a minor crop. However, this study clearly highlighted the importance of home gardens and the role of *Dioscorea* spp. among three different climatic zones of Sri Lanka, and that *D. alata* was the most popular yam species as in most Asian nations. They have the potential of producing significant edible material with little inputs, when compared to staple cereals such as rice and maize. On the basis of these results, it can be stated that the promotion of this crop on a more extensive scale in home gardens and even in larger fields would provide edible carbohydrates to the people with lower inputs than traditional staple crops, to bring about greater food availability and thus food security to Sri Lankan peoples and similar developing nations of tropical South Asia.

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