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Evaluation of Morphological and Yield Component Traits in Luffa (*Luffa acutangula*) Local Accessions During off Season

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ABSTRACT

In Sri Lanka, continuous vegetable cultivation is important to avoid the price fluctuation during lean production period. However, lack of appropriate varieties limit the cultivation of Luffa (*Luffa acutangula*) during the off season. Hence a study was initiated with the objective to identify suitable parental lines for the development of high yielding desirable Luffa varieties. Ten local germ plasam were evaluated for morphological and yield traits in a replicated trial at the Horticultural Crop Research and Development Institute. There was no significant difference observed in growth parameters, but differ in flowering. However, wide variation was recorded in stomata density, hair length and hair density. Accession 012241 showed early flowering. Only four accessions, 012227, 012571, 012870 and 012241 produced yield during off seasonal cultivation. Low stomata density in upper surface, lengthy hairs and high hair density are the special characteristics recorded in these accessions. Two distinct clusters were grouped based on morphological characters and no duplication was found in accessions. Among the four promising accessions, 012241 belongs to cluster A while other three grouped into cluster B. Distinct accessions either belongs to different clusters or same cluster normally used for breeding purposes. The promising accessions identified in this study could be used as parental lines in the hybridization programme in future.

KEYWORDS: Cluster analysis, Cucurbitaceae, *Luffa acutangula*, Morphology, Yield

INTRODUCTION

Luffa acutangula (Luffa) belongs to the family Cucurbitaceae. It is a low country warm season, cold sensitive crop which originated in India. Three subspecies are documented. *Luffa acutangula* var. Acutangula is the domesticated one while other two var. Amara and var. *forskalii* (Harms) are wild varieties (Heiser and Schilling, 1988).

Luffa acutangula is recognized by shallowly five-lobed leaves with heart-shaped at the base (Godofredo and Stuart, 2015). Female flowers are pedicelled and occurring singly in the axils of the leaves. Flowers are yellow in colour, 2 cm long and borne in axillary raceme. Fruit is oblong-oblanceolate, 20 to 25 cm long, and characterized by 10 prominent, longitudinal sharp angles (Godofredo and Stuart, 2015).

There are numerous medicinal and other uses of the plant (Burkill, 1985; Burkill, 1935). Pods of Luffa are edible as cooked or fried curries and used as soups and sauces. In China *L. acutangula* has also been used as a pesticide (Yang and Walters, 1992).

In Sri Lanka, Luffa can be grown successfully in low country dry zone, wet zone, mid country and intermediate zones. Areas up to 500 m from mean sea level are most organic matter is favorable for cultivation. Excessive water can result in poor growth and root diseases. Temperature range between 25-30 °C is preferred for reasonable seed germination and early growth in Luffa (DOA, 2006). Long days and high temperatures are favored for the development of more female flowers.

In Sri Lanka, *Yala* and *Maha* are the two major cultivating seasons, where the climatic conditions favor for crop growth and production. However, vegetables are cultivated in lesser extent in between these two major seasons. In general, off seasonal products fetches higher price due to less supply and high consumer demand. At present, off seasonal cultivation become popular among farmers due to higher income, however, the production limits by the unfavorable climatic conditions.

Increase in temperature during off season affect a wide range of physiological and phenological processes of the crop which associate with many biotic and abiotic stresses. Therefore, farmers tend to use heavy agrochemicals and other inputs to get good yield. This creates a high demand to the vegetables in the market which results in high price increase especially in the months of April and June. Use of appropriate varieties is one of the strategies to increase the income of farmers during off seasonal cultivation. The Department of Agriculture (DOA) has released three high yielding open pollinated (OP) varieties, LA 33, Asiri and Gannoruwa Ari, for the commercial cultivation (DOA, 2006). Currently there is a high demand for dark green pods in the market.

The locally released varieties produce light green pods, hence they do not fulfill the market requirement. Farmers tend to cultivate exotic hybrid Luffa varieties due to their high yielding ability and pod characteristics despite of its susceptibility to major pest and diseases under local climatic conditions. Furthermore, all the cultivated local and imported varieties are affected by climate changes resulting poor yield and quality in addition to higher pest and disease incidences. In order to address this issue, there is an urgent need to develop high yielding varieties with desirable pod quality and resistance or tolerance to major pests and diseases.

Luffa accessions available in farmer's fields may have useful characters such as high yielding and disease resistance. Hence a study was carried out to evaluate locally available germ plasm collected from Plant Genetic Resources Centre (PGRC) for morphological and yield traits aiming to identify suitable parental lines for the development of high yielding desirable OP and hybrid varieties for commercial cultivation.

MATERIALS AND METHODS

Location

The experiment was carried out at the research field of Horticultural Crop Research and Development Institute (HORDI), Gannoruwa, Peradeniya during January to May 2016. The HORDI is situated in the mid country wet zone of Sri Lanka and 490 m above from mean sea level. It belongs to the agro ecological region of WM_2. Annual rainfall of this region is 1800 mm–2200 mm and average minimum and maximum temperature are 21.1 °C and 30 °C respectively with 70% relative humidity.

Experimental Design

The study was carried out in randomized complete block design (RCBD) with three replicates. Ten local Luffa accessions, 012227, 012571, 012408, 013331, 013332, 012283, 012496 and 012870, 012241 and 012874 were evaluated in this study.

Data Recording

Growth parameters such as plant height, chlorophyll content, number of leaves, stem girth and internode length, were measured weekly. Leaf area was calculated at flowering stage. Chlorophyll content was measured by using chlorophyll meter (Minolta SPAD-502). Qualitative and quantitative leaf morphological characters were recorded from mature fully opened fourth, fifth and sixth leaves on vine.

Qualitative Morphological Characters

Qualitative morphological characters such as shape of leaves and leaf apex, type of the leaf margin, colour of leaves, leaf petiole, and petals and presence of leaf lobes were recorded at flowering stage. Colour was determined by using Royal Horticultural Society (RHS) colour chart.

Quantitative Morphological Characters

Quantitative characters such as length and girth of petiole, width of main lobe, number of petiole ridges, leaf length to width ratio, number of primary and secondary veins, number of leaf lobes, angle (left) between midrib and primary vein, angle (right) between midrib and primary vein, angle (left) between midrib and secondary vein, angle (right) between midrib and secondary vein, length of left from prominent vein, width of leaf apex, length to width ratio of staminate flowers and length of ovary were recorded by visual observations. Length and density of hairs, stomata density of lower and upper surfaces of leaf were measured at flowering stage by compound microscope (Optika; 100x), and OPTIKA lsVIEW software.

Phenological Characters

Days to 50% flowering of staminate and pistillate flowers were recorded.

Data Analysis

Data were analysed using Minitab 17 and cluster analysis was performed by Past 2.17 statistical software. Mean comparison was performed using DMRT. Tukey test was used to study the significant difference among variables at 5% probability level.

RESULTS AND DISCUSSION

Cluster Analysis

The hierarchical clustering dendogram illustrates the relationship among 10 local Luffa accessions and separated them into different clusters with average distance dissimilarities, ranging between 0.0 and 300 (Figure 1). At 85 level of similarity, almost all varieties were distinct from each other. There was no overlapping between any accessions, which indicates that there were no duplications among accessions. All accessions were grouped into two distinct clusters as A and B. Cluster A was represented by 3 local accessions, 012241, 012283 and 012408. Cluster B was represented by 7 local accessions 013332, 012874, 012870, 012227, 012571, 013331, and 012496.Breeding within two accessions which belong to two distinct clusters is useful to get vigorous hybrids. Accessions 012241, 012283, and 012408 can be breed with accessions 013331,

013332, 012874, 012870 and 012496, 012227, 012571, to get vigorous plants. Two distinct accessions which belong to the same cluster can be also used for breeding purpose.

In off season, the conditions are not favourable for plant growth. Therefore the plant should be vigorous, physically tolerant and withstand with those climatic changes to give a considerable yield. Plant characteristics such as stomatal density, hair density and hair length might influence the growth and yield performance of plants.

Days to 50% flowering was varying among accessions though they did not significantly differ in growth parameters (Table 1). There was a significant difference observed in stomatal density in both upper and lower leaf surfaces among tested accessions. Similar finding was observed in hair length in upper surface. However, hair length in lower surface and hair density in both lower and upper surfaces did not significantly vary among accessions.

Normally stomatal density of lower surface is greater than stomatal density of upper surface of leaf (Table 2). Higher upper stomatal density (402.0) was observed in accession number 012241. Stomata are small apertures on the leaf surface that regulate loss of water via transpiration and CO_2 uptake during photosynthesis (Al Afas *et al.*, 2006; Bussis *et al.*, 2006).

However, these openings are also used by pathogens as entry points. Pathogens causing downey mildew and powdery mildew can enter the plant through these openings Plant pathogenic bacteria fungi and nematodes often enter through open stomatal pores when the leaf surface is covered in a film of moisture (Guest and Brown, 1997).

There is a risk of abiotic stress due to high temperatures and low water availability during off seasonal cultivation. High stomata density provides more pores for transpiration. But accession 012241 performed well in terms of growth and yield during off season and this could be attributed to comparatively high hair length and density. The yield performance of selected accessions indicated that comparatively low stomatal density, higher hair length and hair density influence the yield performance of luffa during off season.

Bristly leaves had lower transpiration rates than smooth leaves (Ehleringer, 1982). Wet air strata can be retained between hairs and it reduces leaf temperature and water loss in arid conditions. The hairs of abaxial leaf surface can constitute a hydrophobic barrier capable to reduce the contact area among water droplets and leaf lamina, with the reduction of wettability of epidermal tissues. The presence of very dense leaf hairs leads to a reduction of water retention capacity of the leaf surface, which is decisive during the infection process (Paolocci *et al.*, 2014). Leaf hairs perform two distinct functions in plants. They provide a structural defense against herbivores (Levin, 1973) and insulation against the environment (Esau, 1965; Ehleringer *et al.*, 1976; Rodriguez *et al.*, 1984, Southwood, 1986). These plants comparatively tolerant to the pest and disease incidences. The accessions performed well in this study might possess these characters to withstand the adverse climatic conditions.

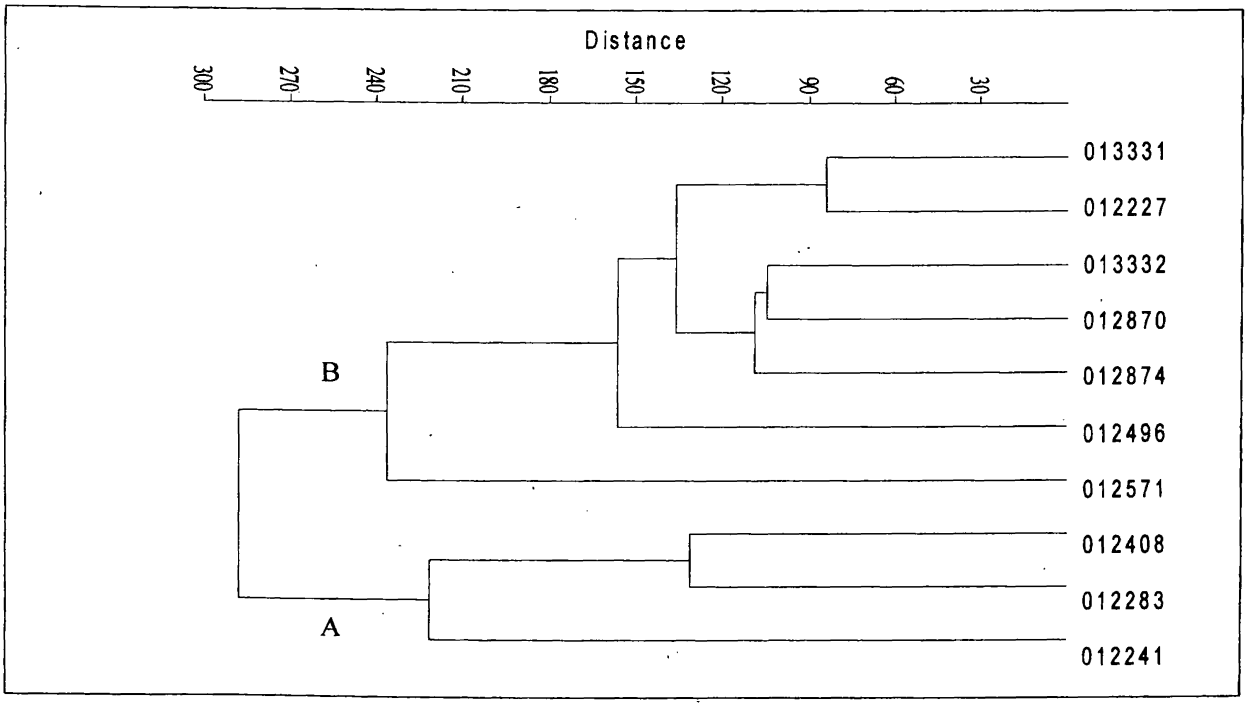

Figure 1. Dendogram constructed based on morphological characters of Luffa local accessions

Table1. Mean values of growth parameters

Accession	Growth parameters (at flowering stage)							
	Internodal distance(cm)	Number of leaves	Girth of stem (cm)	Plant height (cm)	Leaf area (cm^2)	DF (50%) staminate	DF (50%) pistilate	CC ($\mu mol/cm^2$)
012227	11.622^{a}	20.560^{a}	1.6189^{a}	167.67^{a}	296.30^{a}	43.67^{bcd}	49.83^{ab}	61.03^{a}
012571	10.789^{a}	19.000^{a}	1.7100^{a}	159.22^{a}	258.50^{a}	46.50^{abc}	50.00^{ab}	59.70^{a}
012408	11.444^{a}	18.556^{a}	1.7489^{a}	175.44^{a}	261.10^{a}	39.17^{bcd}	47.00^{b}	60.37^{a}
013331	10.500^{a}	20.667^{a}	1.7144^{a}	166.44^{a}	242.90^{a}	45.60^{abc}	49.67^{ab}	59.67^{a}
013332	9.967^{a}	18.333^{a}	1.6744^{a}	151.00^{a}	213.40^{a}	42.17^{bcd}	47.17^{ab}	61.85^{a}
012283	10.978^{a}	18.667^{a}	1.7156^{a}	167.11^{a}	265.50^{a}	54.17^{a}	56.83^{a}	59.82^{a}
012496	9.190^{a}	16.556^{a}	1.3489^{a}	139.50^{a}	233.40^{a}	48.00^{ab}	48.00^{ab}	54.40^{a}
012870	11.267^{a}	21.667^{a}	1.6789^{a}	165.11^{a}	206.40^{a}	39.83^{bcd}	43.33^{b}	63.79^{a}
012241	12.770^{a}	18.778^{a}	1.5800^{a}	160.11^{a}	216.30^{a}	36.00^{d}	41.00^{b}	60.71^{a}
012874	11.100^{a}	14.222^{a}	1.5456^{a}	128.22^{a}	227.80^{a}	37.33^{cd}	46.83^{b}	58.71^{a}

Means in a column with the same letters are not significantly different at the 0.05 level; CC- chlorophyll content; DF- Days to 50% flowering

Table 2. Mean values of stomatal and hair characters

Accessions	Character					
	Stomatal density (Upper Surface) /mm^2	Stomatal density (Lower Surface) /mm^2	Hair length (Upper Surface) (μm)	Hair length (Lower Surface) (μm)	Hair density (Upper Surface) /mm^2	Hair density (Lower Surface) /mm^2
012227	141.2^{b}	429.2^{bc}	92.51^{bc}	94.5^{a}	12.99^{a}	19.1^{a}
012571	112.5^{f}	186.9^{e}	113.5^{abc}	121.6^{a}	6.31^{a}	6.695^{a}
012408	355^{a}	534.3^{a}	78.2^{bc}	184.9^{a}	9.34^{a}	14.35^{a}
013331	209.0^{def}	349.3^{cd}	68.43^{bc}	77.1^{a}	7.72^{a}	12.16^{a}
013332	155.825^{f}	331.6^{cd}	119.60^{ab}	162.1^{a}	9.74^{a}	14.445^{a}
012283	447.8^{b}	474.0^{ab}	163.2^{a}	193.6^{a}	8.99^{a}	13.02^{a}
012496	241.65^{de}	285.9^{de}	64.59^{bc}	71.9^{a}	5.455^{a}	6.33^{a}
012870	168.8^{c}	280.19^{de}	122.1^{ab}	158.9^{a}	13.34^{a}	14.96^{a}
012241	402.0^{cd}	451.3^{ab}	121.17^{ab}	159.9^{a}	9.91^{a}	11.565^{a}
012874	165.0^{c}	392.16^{bc}	53.96^{c}	93.0^{a}	6.88^{a}	8.64^{a}

Means in a column with the same letters are not significantly different at the 0.05 level

CONCLUSIONS

Based on the results there was no duplication in the tested accessions. Distinct accessions belong to different clusters or distinct accessions belong to same cluster can be used for breeding purposes. Although all accessions produced flowers, all of them did not have the ability to withstand the stress conditions and produce yield. Only four, accessions 012227, 012571, 012870 and 012241 produce yield. These plants have drought and pest and disease tolerant ability due to special morphological characters such as hair length and density and stomatal characters. Hence these four accessions can be used as parental lines to develop varieties for off seasonal cultivations.

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