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Morphological diversity in eggplant (*Solanum melongena* L.), their related species and wild types conserved at the National gene bank in Mauritius.

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Abstract

Mauritius has rich eggplant genetic resources with important implication for research and conservation. Heterogeneity in pedoclimatic condition and farmers selection have resulted in significant accumulation of wide morphological diversity at both inter and intra specific levels in eggplant landraces.

Morphological characterization of 27 *S. melongena*, two *S. macrocarpon*, one *S. nigrum*, three *S. violaceum* and one *S. torvum* accessions was conducted. The aim of the present study was to assess and measure morphological diversity in eggplant genetic resources conserved at the National gene bank in Mauritius in order to promote their conservation, effective management, sustainable use and legal protection. 9 quantitative and 14 qualitative traits were characterized based on (IBPGR 1990) eggplant descriptor list. Significant ($P < 0.01$) correlations were observed between several related traits of high agronomic importance and breeding potentials in selection of genetically divergent parents for hybridization. Yield was positively correlated with leaf area ($r = 0.2$), fruit length and width ($r > 0.5$) and fruit weight ($r = 0.8$) but inversely related with number of fruits per plant ($r =- 0.6$) and plant height ($r = - 0.5$).

The phenogram constructed through UPGMA clustering method showed the phenetic relationship between *S. melongena* accessions, their related species and wild types. It classified the *S. melongena* accessions into Long, Semi long, Round and Oblong cultivar groups based on fruit shape, colour and size. Principal Component Analysis revealed that fruit characters were important marker traits with a large coefficient of variation (> 40 percent) that most effectively discriminated between eggplant accessions and hence useful in establishing a simple but effective eggplant classification system at the gene bank.

Key words: characterization, eggplant (*Solanum melongena* L.), morphological diversity, Mauritius.

Content

List of abbreviations

Agricultural Research and Extension Unit	AREU
Anonymous	Anon
Convention on Biological Diversity	CBD
Food and Agricultural Organisation	FAO
International Board for Plant Genetic Resources Institute	IBPGR
International Treaty on Plant Genetic Resources for Food and Agriculture	ITPGRFA
Ministry of Agriculture	MOA
Plant Genetic Resources Unit	PGRU

Introduction

Eggplant (*Solanum melongena* L.), also known as aubergine, brinjal or Guinea squash is an economically important vegetable crop widely cultivated in the tropics, subtropics and warm temperate regions (Sihachakr et al. 1994). It originated from South East Asia (Lester and Hasan 1991) and belongs to the Solanaceae family. The world production was estimated at 32 million tons in 2007 with China (18 million tons) and India (8.4 million tons) as the greatest producers (FAOSTAT 2007).

Eggplant is a good source of minerals and vitamins (particularly iron) making its total nutritional value comparable with tomato (Kalloo 1993). It is an inexpensive but major food component of the human diet in the developing world most particularly in India and China (Doganlar et al. 2002a). Its close relatives, *Solanum macrocarpon* L. and *Solanum aethiopicum* L., the Gboma and Scarlet African eggplants are the most popular native traditional vegetables in West and Central Africa (Sekara et al. 2007). Besides being used as an important vegetable, eggplant has been extensively exploited in traditional medicine for treatment of many diseases (Khan 1979; Kashyap et al. 2003). Today, eggplant is cultivated worldwide and has a growing reputation (Doganlar et al. 2002a).

Wide morphological diversity exists in eggplant, their related species and wild types observed for plant morphology (Inflorescence, leaf and fruit), physiology and biochemical properties (Daunay et al. 1991; Collonier et al. 2001). Fruit shape, size, colour and taste are the most noticeable characters that vary among individuals (Frary et al. 2007). Eggplant is susceptible to several pests (fruit and shoot borer; *Leucinodes* sp.) and diseases (Fusarium, Verticillium and Bacterial wilt), nematodes (*Meloidogyne* sp.) as well as abiotic stress conditions (Sihachakr et al. 1994; Kashyap et al. 2003). Their wild relatives in contrast offer better resistance to most of these destructive pests and pathogens and are more tolerant to drought and salinity problems (Swarup 1995). Besides, they contain useful genes that can be exploited in genetic improvement of cultivated eggplant varieties.

Mauritius has a rich eggplant genetic diversity of high breeding value and important implication for research and conservation. Also locally known as "Bringelle", eggplant is an economically important and morphologically diverse vegetable crop widely cultivated across the Island with an annual production of 2839 tonnes over an area of 216 ha (Anon 2006a). As a common vegetable in the Mauritian diet, eggplant is widely consumed by the local people in several types of dishes but also appreciated in hotels too. Introduced into the Island during the first human settlement in 17th century and most probably originating from South East Asia and African countries (Rouillard and Gueho 1999), primitive eggplant cultivars have acquired unique horticultural traits and thus evolved into important landraces. Their wild relatives, *Solanum torvum* Sw. (white flowers) and *Solanum violaceum* Ort. (violet flowers) have become naturalised in Mauritius (Anon 2006b). Heterogeneity in pedoclimatic (soil and climate) conditions and farmers selection for adaptation to local tastes and uses across many generations appear to have generated significant level of diversity at both the inter and intra specific levels in eggplant landraces.

Considering the widespread cultivation, nutritional and economic importance of eggplant in Mauritius, annual production has increased from 2097 tonnes in 2003 to 2839 tonnes in 2006 (Anon 2006a). However, agriculture today is heavily dependent on newly introduced modern hybrid cultivars. Furthermore, there is a paradigm shift among local farmers towards high yielding hybrid varieties resulting in genetic erosion and significant loss of important eggplant landraces and their associated traditional knowledge. The survey conducted at farmer's fields revealed that high susceptibility of hybrid varieties to serious pests and diseases most particularly bacterial wilt (*Pseudomonas solanacearum*) is a major constraint faced in commercial eggplant production. Low water availability, salinity problems and heavy fertilisation requirement are the other limiting factors.

Conservation and sustainable use of its crop genetic resources remains a priority consideration in Mauritius to ensure food security, while improving the health and diet of the nation (Anon 2006b). Genetic variability as manifested in morphological and molecular diversity can be effectively used to develop more productive transgenic local eggplant cultivars with improved agronomic traits such as better resistance to pests and diseases, enhanced fruit quality with longer shelf life and better adaptability to changing environmental conditions.

Morphological characterization is essential to describe the distinctive characteristics of cultivars and landraces (UPOV 1991) and therefore considered as the starting point in eggplant plant diversity structure and gene-to-phenotype relationship analysis. It is also useful for characterizing individual accessions and cultivars as a genetic guide in selection of parents for hybridization (Singh et al. 2006) while broadening the genetic base of the cultivated eggplant varieties. Besides, genetic definition of cultivated crop is important for value addition and enhanced marketability.

Research rationale

Knowledge of the local eggplant landraces and traditional varieties, their related species and wild types maintained as *ex-situ* collections at the National gene bank is limited with traits not properly described, evaluated and documented. This constitutes a major research gap since eggplant genetic resources conserved at gene bank are currently underutilized. There is an urgent need for the active reintroduction of eggplant genetic diversity resources into the current production system in order to optimise their use and also protect the existing local cultivars and landraces from extinction.

Enhancement and protection of the local eggplant varieties on the other hand requires analysis of their characteristics, diversity and relationship with similar accessions (Munoz et al. 2008). Beside facilitating the recognition of Farmers Rights under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) for on farm conservation and maintenance of eggplant landraces, morphological characterization of eggplant genetic resources will also enable gene bank curators to identify accessions with desirable traits, monitor their genetic stability and integrity and screen for duplicate accessions to minimize waste of resources and lower management costs.

To this end, a research study on morphological diversity in eggplant accessions, their related species and wild types conserved at the National seed gene bank in Mauritius was established.

The research objectives were:

1. Initiate morphological characterization of eggplant genetic resources conserved at the National gene bank for proper identification, evaluation, monitoring and documentation.
2. Assess and measure morphological diversity to promote conservation, effective management, sustainable use and legal protection of eggplant genetic resources.
3. Identify duplicate accessions present in eggplant collections to minimize waste of resources and lower management costs through establishment of the core collection concept.

Introduction to the species

Eggplant genetic resources have held great interest for many researches, breeders and consumers for a long time. It is therefore useful to present pertinent background information regarding eggplant evolution, history, taxonomy, botany, economic importance and genetic resources in Mauritius in this Masters thesis for a better understanding of the research field of study.

The Solanaceae Family

The Solanaceae is an important family in the plant kingdom of the advanced order Solanales in the division Magnoliophyta, the angiosperms or flowering plant division (Bremer et al. 2003). It includes 91 genera and an estimated number of 2450 species with great variation in habit, morphology and ecology (Mabberley 2008; WEB_1 2007). The family is ranked as third in economic importance and is regarded as a source of many morphologically different domesticated crop species beneficial to human health, diet, beauty and ornamental use (Mueller et al. 2005; Sekara et al. 2007). Tomato, potato, pepper, petunia, datura, tobacco and eggplant are some of the valuable family members (Doganlar et al. 2002b; Knapp et al. 2004).

The Solanaceae family members are well adapted to different agro ecological environments and hence show a good dispersal (Fig. 1) across the globe (Knapp et al. 2004).

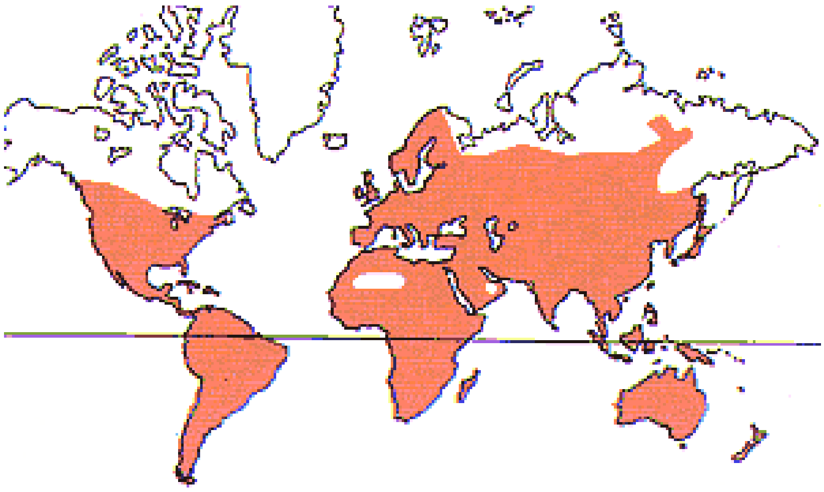


Fig. 1. Dispersion of Solanaceae family members around the world. (Source: WEB_1 2007)

Considering their worldwide distribution, a remarkably high level of morphological diversity is manifested at the species, cultivar and genera levels as reviewed by Knapp et al. (2004).

Eggplant (*Solanum melongena* L.)

The "eggplant complex" as described by Pearce and Lester (1979) includes *S. melongena* the cultivated eggplant, *Solanum insanum* (weedy form of eggplant returned to the wild state) and *Solanum incanum* (a close relative of the wild ancestor of eggplant) (Daunay et al. 1991). However the most frequently used definition of eggplant includes three closely related species: *S. melongena L.*, *S. aethiopicum* L. and *S. macrocarpon L.* (Doganlar et al. 2002 a). *S. melongena* L. commonly referred to as eggplant is the best known species (Daunay et al. 2001) and most widely cultivated throughout the world. The name "eggplant" was probably derived from the egg like shape and white colour fruits of the *S. melongena* species (Kalloo 1993).

Origin and History

Eggplant (*Solanum melongena* L.) has two centres of origin (Nonnecke 1989). India and Indo-china is recognised as the primary centre of eggplant diversity (Fig. 2) with China as the probable secondary centre of variation (Vavilov 1951; Lester and Hasan 1991; Karihaloo and Gottlieb 1995).

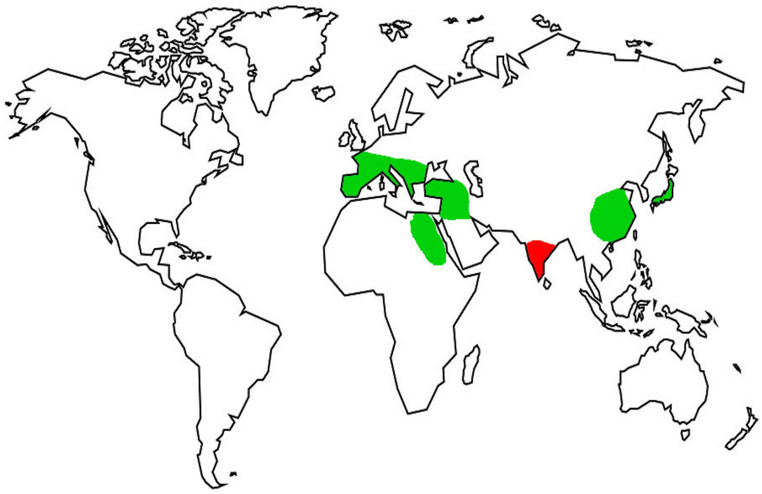


Fig. 2. Primary and secondary diversity centres of eggplant (*Solanum melongena* L.). Red coloured region is the basic primary diversity centre while green coloured regions are secondary diversity centres and major cultivation areas (Source: WEB_2 2007).

Eggplant is known as an ancient crop in Eastern countries, described in India in the 3rd century B.C and cultivated for more than 1500 years in Asia (Kashyap et al. 2003; Swarup 1995; Frary et al. 2007). Large fruited eggplant cultivars were domesticated in India whilst the cultivation of small-fruited eggplant cultivars began in 4th century in China and in 9th century in Africa (Nonnecke 1989; Sekara et al. 2007).

From its Indo-Chinese centre of origin and domestication, eggplant was brought to North Africa and to the Iberian Peninsula by the Arabs before the 10^{th} century. "*Melongena*" was an Arabic name given to one of the eggplant cultivars (Prohens et al. 2005; Sekara et al. 2007). Eggplant was later introduced to the west by the Arabs during 15^{th} century (Kashyap et al. 2003) and its cultivation gradually spread from Mediterranean basin to Africa, Central Europe and then America (Frary et al. 2007).

Eggplant was domesticated in isolation from its putative wild ancestors distributed in Africa and Near East. This probably led to an important founder effect while preventing introgression of genes from the wild types into the domesticated species. The result was a considerable narrow genetic base in cultivated eggplant varieties despite their substantial morphological variation due to the genetic bottleneck suffered during its evolution (Prohens et al. 2005).

Taxonomy

Eggplant and its related species belong to the subgenus *Leptostemonum*, the largest subgenus comprising nearly one third of the species within the genus *Solanum* (Frary et al. 2007). It is a diploid species 2n = 24 with a basic chromosome number of 12 (Doganlar et al. 2002a). The cultivated eggplant (*Solanum melongena* L.) was originally described by Carl Linnaeus in his *Species Plantarum* 1753 (Jarvis 2007; Furini and Wunder 2004). He described the two important *S. incanum* L. and *S. melongena* L. species which are considered as the cornerstones of the "eggplant complex" (Mace et al. 1999).

Historical difficulties and taxonomic confusions as regard to the classification of the genus *Solanum* is due to the fact that more than 3000 binominal names has been used to describe 1000 to 1400 species (Furini and Wunder 2004). This has led to considerable taxonomic confusion surrounding the much crowded and complex genus *Solanum*.

Karihaloo and Gottlieb (1995) referred to a number of wild and weedy taxa occurring in India and bearing close morphological similarities to *S. melongena* which further complicates the eggplant systematic. Lester and Hasan (1990) also reported about the taxonomic confusion between *S. melongena* and its weedy form *S. incanum***.** The high level of morphological plasticity manifested at the genera, species and cultivar levels within the eggplant complex (Furini and Wunder 2004) and the crossability affinities between *S. melongena* and other related *Solanum* species producing fertile F1 hybrids (Daunay et al. 1991) makes classification much more complicated. For this reason, taxonomic classification and eggplant systematic cannot be based solely by considering morphological variability, F1 fertility and crossability parameters (Lester and Hasan 1991; Karihaloo and Gottlieb 1995; Furini and Wunder 2004).

A modified informal group classification of *S. incanum* and *S. melongena* was proposed by Lester and Hasan (1991) is shown in Table 1. Within the "eggplant complex" Group G and H represents the cultivated types of eggplant. Group G is widespread in Southeast Asia and corresponds to primitive cultivars, slightly prickly with small green fruits (3-4 cm in diameter) and white stripes. Group H consists of advanced cultivars with very few tiny prickles bearing large fruits (usually >100 g) highly variable in colour (Prohens et al. 2005).

Table 1. Informal group classification of *Solanum incanum* and *S. melongena* used by Lester and Hasan (1991), modified here

Wild taxa of S. incanum sensu lato, from Africa		
Group A	*S. campylacanthum* Hochst.	Eastern & Southern Africa
Group B	*S. panduriforme* Dunal	Southern Africa
Group C	*S. incanum* L.	Northern Africa, Arabia
Group D	*S. lichtensteinii* Willd.	Southern Africa
Weedy and cultivated taxa of S. melongena, from Asia		
Group E	*S. melongena* (*S. insanum*)	India
Group F	*S. melongena* (*S. cumingii* Dunal)	S.E. Asia
Group G	*S. melongena* (*S. ovigerum* Dunal)	S.E. Asia
Group H	*S. melongena* (*S. melongena*)	worldwide

Source: Mace et al. 1999

S. melongena may have been indirectly derived from its wild *S. incanum* ancestor, domesticated in India and Southeast China. *S. aethiopicum* L. and *S. macrocarpon* L. were domesticated in Africa from their wild relatives *S. anguivi* Lam. and *S. dasyphyllum* Schumach. & Thonn respectively (Lester and Hasan 1991; Sekara et al. 2007).

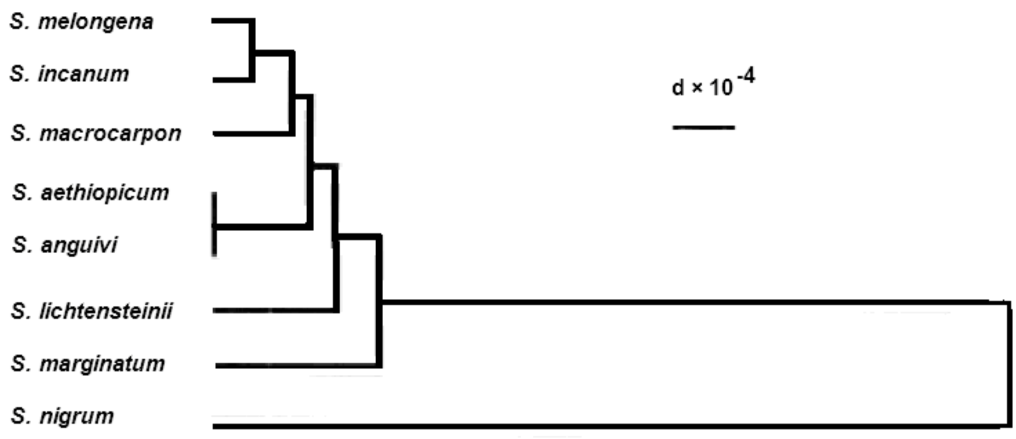


Fig. 3. Dendrogram of Solanum species by UPGMA based on the genetic distance of Nei and Li (Sakata and Lester 1997).

The dendogram (Fig 3) generated by Sakata and Lester (1997), showed the close genetic affinities between *S. incanum, S. melongena* and *S. macrocarpon* in spite of their highly confusing taxonomic relationships. Lester and Hasan (1991) indicated that although *S. incanum* taxa that occur in India can be distinguished from their wild progenitors in Africa and the Middle East, both *S. melongena* and *S. incanum* have been often confused with their distantly related

African eggplant (*S. aethiopicum* L. and *S. macrocarpon* L.) and other wild species such as *S. violaceum* Ort.

Botany

Primitive eggplant cultivars are characterized as tall plants with large spiny leaves, calyx and stems, bearing inflorescence in clusters with andromonoecy and producing small green bitter fruits with thick skin, hard flesh and many seeds (Swarup 1995). Domestication, mutation, human selection, natural inter-crossing, and hybridization have caused dramatic expansion in fruit shape, size and colour while decreasing plant prickliness and fruit bitterness resulting in wide morphological and genetic diversity in eggplant (Frary et al. 2007).

Nonnecke (1989) provided a detailed description of eggplant crop as summarised hereunder. The plant is a shrubby or bushy perennial that grows to a height of 60 to 120 cm with a tough herbaceous or woody spiny stem and erect or spreading determinate growth habit. It is a perennial in warmer regions but cultivated as an annual in temperate regions. Anthocyanins pigmentation, prickles and hairiness on vegetative parts vary quantitatively. The leaves are large, simple, ovate, lobed, hairy on the underside and alternate on the stems. Leaf prickles and hairiness are more pronounced in wild types.

The flowers may be single or multiple with five calyx-lobes and purple-violet corollas. Inflorescences have one to five andromonoecious flowers, although most modern cultivars display solitary hermaphrodite flowers. The basic flower type is 5-merous (5 sepals, 5 petals, 5 stamens) but 6, 7, and 8-merous flowers are common in globose and round fruited cultivars.

The fruit is a pendent fleshy berry and the colour ranges from shiny purple to white, green, yellow and black often with stripes and patches on the skin. Fruit shape varies from long cylindrical to round, oblong and oval shape. Absence or presence and combination and distribution pattern of chlorophylls (a and b) and anthocyanin controls fruit colour diversity in eggplant (Frary et al. 2007). Fruit length may vary from 4 to 45 cm and thickness between 3 and 35 cm in diameter with a weight range scale of 0.5g to 1500 g (Swarup 1995).

Eggplant is normally a self-pollinated crop although crosspollination does occur. Parthenocarpic (seedless) fruit set occurs occasionally (Kalloo 1993). Eggplants are best grown in sandy loam or silt loam soils with a pH of 5.5 to 6.8 at optimum temperature of 21-29 ^{o}C. Seeds are best sown at a temperature of 24-29 ^{o}C (Chen and Li 1996).

Economic Importance

At present eggplant is ranked as third most important crop from Solanaceae family after potato and tomato with a world production of 32 million tonnes.

Greatest producers are China (18 million tons), India (8.4 million tons) followed by Egypt (1 million tons) and Turkey (0.8 million tons). Italy (0.3 million tons) and Spain (0.2 million tons) are important eggplant producers in Europe (FAOSTAT 2007).

Food value

Eggplant is a fairly good source of iron, calcium, phosphorus, potassium and vitamin B group. Its fresh weight is composed of 92.7 percent moisture, 1.4 percent protein, 1.3 percent fibre, 0.3 percent fat, 0.3 percent minerals and the remaining 4 percent consist of various carbohydrates and vitamins (A and C) (Khan 1979; Lawande and Chavan 1998). Apart from its nutritional value, eggplant has also been used in traditional (Khan 1979). For example, tissue extracts have been used for treatment of asthma, bronchitis, cholera and dysuria; fruits and leaves are beneficial in lowering blood cholesterol (Kashyap et al. 2003).

Characterization of eggplant diversity

The ability to characterize morphological diversity is indispensable for effective management and sustainable use of eggplant genetic resources in breeding programmes. Primary characterization involves measuring simple plant characters that can be easily recorded through visual observations at different plant growth stages (leaf area, fruit shape, size and colour, plant prickliness and hairiness). Secondary characterization deals with more complicated morphological traits of agronomic importance such as pest and disease resistance, fruit set, yield potential and biochemical (glycoalkaloid or antioxidant) properties (Ayad et al. 1995).

Morphological crop descriptors allow a quick and easy discrimination between phenotypes. They are generally highly heritable traits that can be easily recorded through visual observations and that are equally expressed in all environments. Morphological descriptors for *S. melongena*, *S. aethiopicum* and *S. macrocarpon* have been developed by IPGRI/FAO, EGGNET and UPOV which provide internationally accepted definitions for these descriptors and include a complete description of important quantitative and qualitative traits illustrated by figures and measured either in metric or arbitrary scale.

Eggplant collections have been evaluated mostly for morphological and agronomic characters (Karihaloo and Gottlieb 1995) revealing wide diversity in plant morphology (plant growth habit, vigour, hairiness, prickliness, fruit shape, size and colour and yield potentials), physiology (flowering behaviour, water use) and biochemical properties (fruit bitterness, glycoalkaloid content)(Daunay et al. 1991; Collonier et al. 2001). Fruit colour, size and shape are the most distinctive characters that vary between the cultivated *Solanum* species and their wild types (Kumar et al. 2008). Chowdhury (1976) classified eggplant into three main groups based on their fruit shapes: round, oval or egg shaped (*S. melongena* var. *esculentum*), long slender shaped (*S. melongena* var. *serpentinum*) and dwarf types (S. *melongena* var. *depressum*) as cited by Martin and Rhodes (1979).

Breeding Objectives

Breeding objectives in eggplant so far have focused mainly on improvement of yield and fruit quality, adaptation to different environment and resistance to severe pests and diseases (Bargato et al. 2007). Although, eggplant has wide variability, they offer partial resistance, often at low levels to most of its pests and pathogens resulting in drastic yield losses (Daunay et al. 1991; Kashyap et al. 2003; Gousset et al. 2004). Their wild relatives in contrast offer better resistance to these pests and diseases. The wild *S. torvum* Sw. species is graft-compatible with *S. melongena* and resistant against Verticillium, Fusarium and bacterial wilt diseases and fruit and shoot borer (*Meloidogyne* spp.) attacks (Swarup 1995; Daunay et al. 1991). *S. violaceum* Ort. species are resistant against *Phomopsis* blight (Daunay et al. 1991).

Attempts at crossing the cultivated eggplant species with their wild relatives have had limited success due to sexual incompatibility (Collonier et al. 2001). Furthermore, conventional breeding methods involve prolonged breeding and hybridization techniques with low success rate (Pessarakli 2004). Kashyap et al. (2003) reviewed the application of plant tissue culture techniques (Soma clonal variation, Somatic hybridization, Somatic embryogenesis and Genetic transformation) for successful introgression of genes from wild species into cultivated varieties. Novel variable traits against biotic and abiotic stresses can now be created and genetically engineered into cultivated species (Kantharajah and Golegaonkar 2004). Seedless eggplant fruits engineered with the chimeric *Def Ha*-iaaM parthenocarpic gene (Donzella et al. 2000) and transgenic *Bacillus thuringiensis* (Bt) eggplant hybrids expressing a natural insecticidal resistance against fruit and shoot borers have been developed (Science Daily 2007).

Fruit shape, size, colour and glossiness and quality (skin thickness, flesh texture, colour and flavour, seediness, transportability and early maturity) are desirable fruit traits targeted in breeding programme. Anthocyanin, total phenols, polyphenol oxidase activity and glycoalkaloid contents influences fruit quality (Swarup 1995). However the unprecedented release of genetically uniform F1 commercial eggplant hybrids is causing erosion of landrace diversity (Sadder et al. 2007).

Eggplant Genetic Resources in Mauritius

Mauritius has a rich agricultural biodiversity encompassing a wide diversity of agricultural crops. However, the number of local crop varieties, landraces and cultivars is still unknown with a significant number of them currently underutilised (Anon 2006b). Crop conservation relies on efficient and well maintained seed and gene bank programme. The urgent need to conserve and maintain its crop genetic diversity has thus prompted the establishment of the National gene bank in 1985.

The unit is mandated for the exploration and collection, long term *ex-situ* conservation, management and sustainable utilization of cultivated crop genetic resources and their wild types. Its main goal is to act as a reservoir of irreplaceable natural gene pool of valuable crop germplasm to provide as wide a genetic base as possible to plant breeders, researches and farming communities for crop improvement programmes. At present a total number of 34 accessions of *S. melongena*, their related species and wild types collected from different regions across the Island since 1985 are being maintained at the seed gene bank. They also include some accessions collected from Rodrigues Island.

The history of eggplant crops in Mauritius dates back to 17th Century. Primitive eggplant species were introduced in the Island by early settlers during the French colonial period most probably from South East Asia and African countries (Rouillard and Gueho 1999). Eggplant genetic resources which have undergone almost four centuries of adaptation in Mauritius have acquired some intrinsic properties that are specific to the island. They have evolved into important landraces with unique traits that are suited to the local agro-climatic conditions prevailing across the Island. Heterogeneity in soil types and climatic conditions with 27 different microclimates identified in the Island (Rughooputh 1997) coupled with farmers selection pressures across many generations for cultivation and taste have resulted in a rich and diverse eggplant genetic resource.

Since plant genetic resources for food and agriculture are the basis of global food security (Rao 2004), increased self sufficiency in vegetable crop production is a major goal defined under the National Sustainable Diversified Agri Food Strategy 2008-2015. Mauritius as a signatory member of the Convention on Biological Diversity (CBD) and International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGFA) has focused on the need to promote conservation and sustainable use of its plant genetic resources (Anon 2006b). Through this study, effective management, conservation and sustainable use of eggplant genetic resources is expected to be enhanced in Mauritius.

Material and Method

Planting Material

A total of 34 accessions were morphologically characterized in the present investigation. They corresponded to 27 *S. melongena* accessions, two *S. macrocarpon* (African Gboma eggplant) and one *S. nigrum* accessions of related species and one *S. torvum* and three *S. violaceum* wild types used as out group (Fig. 4). These accessions (excluding the five farmer's varieties) maintained as *ex-situ* collections at the National seed gene bank were obtained from the Plant Genetic Resources Unit (PGRU) of the Ministry of Agro-Industry and Fisheries, Food Production and Security in Mauritius (Table 2).

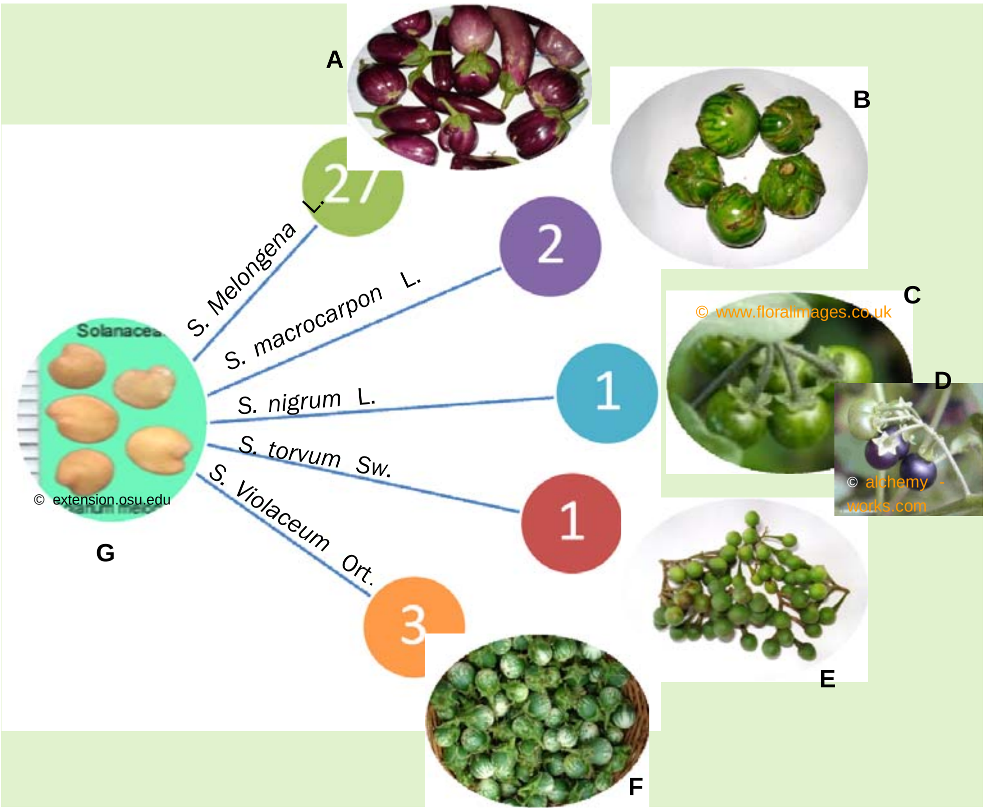


Fig. 4. A total of 34 eggplant accessions obtained from the National gene bank were morphologically characterized. 27 *S. melongena*, two related African eggplant species and four wild type accessions were studied in present investigation.

Among the 34 eggplant accessions, seven accessions were collected from Rodrigues Island located at some 560 km East of Mauritius while the remaining accessions were collected from different agro-ecological regions in Mauritius since 1985 as listed in Table 2.

In addition to morphological characterization of gene bank materials, five farmer's eggplant varieties 'Cipaye long', 'Cipaye Narain', 'Rosita', 'Farcie' and an elongated variety were characterized on farm at Belle Mare located in the Eastern coastal region of the island (Fig. 5). Morphological characters of the five farmer's varieties were compared with their representative samples collected and conserved at the gene bank which were characterized in field experiment at Roches Brunes.

Table 2. List of plant materials (accessions) used in this study together with their passport data

Accession No.(MRU)	Species name	Local name	Area of collection	Date of collection
14	*S. melongena*	'Cipaye long'	Savanne district	1985
17	*S. melongena*	Unknown	Savanne district	1985
18	*S. melongena*	Unknown	Savanne district	1985
19	*S. macrocarpon*	Anguive	Savanne district	1985
21	*S. melongena*	'Cipaye long'	Savanne district	1985
24	*S. macrocarpon*	Anguive	Savanne district	1985
51	*S. melongena*	Unknown	Savanne district	1985
57	*S. melongena*	'Farcie'	Savanne district	1985
65	*S. melongena*	'Cipaye Narain'	Savanne district	1985
75	*S. melongena*	'Cipaye Narain'	Savanne district	1985
106	*S. violaceum*	Anguive marron	Savanne district	1985
124	*S. melongena*	Unknown	Savanne district	1985
142	*S. melongena*	Unknown	Savanne district	1985
255	*S. violaceum*	Anguive marron	Unknown	2002
294	*S. melongena*	Bringelle blanc ronde	Camp de masque	2001
303	*S. melongena*	Bringelle blanc longue	Black River	2001
306	*S. melongena*	Unknown	Rodrigues island	2001
312	*S. melongena*	Unknown	Rodrigues island	2001
334	*S. melongena*	Unknown	Rodrigues island	2001
335	*S. melongena*	'Farcie'	Rodrigues island	2001
336	*S. melongena*	Unknown	Rodrigues island	2001
349	*S. melongena*	Unknown	Rodrigues island	2001
355	*S. violaceum*	Anguive marron	Rodrigues island	2001
474	*S. melongena*	'Cipaye long'	Belle Ombre	2006
479	*S. melongena*	Unknown	Belle Ombre	2006
480	*S. melongena*	'Rosita'	Barkly Expt station	2008
481	*S. melongena*	'Farcie'	Barkly Expt station	2008
482	*S. melongena*	'Cipaye long'	Belle Mare	2008
483	*S. melongena*	'Cipaye Narain'	Belle Mare	2008
484	*S. melongena*	'Rosita'	Belle Mare	2008
485	*S. melongena*	'Farcie'	Belle Mare	2008
486	*S. melongena*	Unknown	Belle Mare	2008
487	*S. torvum*	Bringelle marron	Caroline	2008
488	*S. nigrum*	Brede Martin	Sebastopol	2008

MRU: Accession registration code used for Mauritius.

Experiment site

The experiment was conducted at Roches Brunes Experiment Station of the Ministry of Agro-Industry and Fisheries, Food Production and Security at Bambou located in the western sub humid zone of the Island (Fig. 5) so as to ensure that all eggplant accessions were at the same stage of growth for morphological characterization.

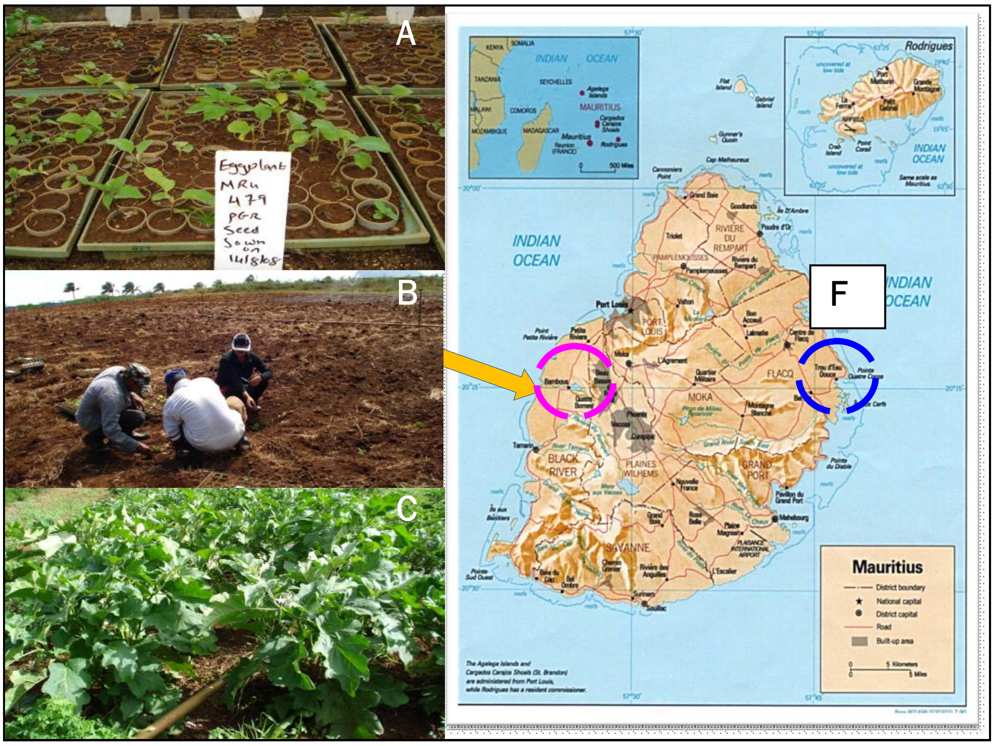


Fig. 5. Establishment of field evaluation plot (photo slide B & C) using Completely Randomised Block Design by transplanting four weeks old eggplant seedlings (photo slide A & B) at Roches Brunes Experiment Station encircled region marked by arrow in Mauritius map (Source: geographicguide.net). On farm characterization of five farmers eggplant varieties in the Eastern coastal region labelled as Farmers Field (FF) on Mauritius map. (All Photo A, B and C by H. Naujeer).

The experiment site receiving a mean annual rainfall of <800 mm and with a Low Land Humic soil type had suitable agro-climatic conditions favourable for growth and development of eggplant crops with successful expressions of all traits.

Establishment of field evaluation plot

A completely randomized block design was used to set up an evaluation plot in an open air field at Roches Brunes Experiment Station. Three plants per accession with 5 replicates were grown such that 15 plants per each accession with a total number of 510 plants from all the 34 accessions were grown. Five plants from each of the 15 plants per accession were characterized. Seeds of different accessions were sown in PVC (Polyvinyl chloride) tubes (8cm height and 4.5 cm diameter) and raised in nursery at 25-28 °C under mist irrigation system.

Prior to seed sowing, hot water treatment was performed by soaking seeds in hot water bath at 50°C for 25 minutes followed by fungicide dressing with Thiulin to prevent any incidence of seed and soil borne diseases such as phomopsis fruit rot(*Phomopsis vexans)*.

Four *S. torvum* accessions from the gene bank materials failed to germinate due to poor seed viability. Four weeks old seedlings were transplanted into 15 cm deep holes of size 15 cm width and 15 cm length at spacing of 1m x 1m between plants and rows.

All cultural practices in terms of pest and disease control, fertilization regime, and irrigation management were followed according to "Guide Agricole 2004", a vegetable cultivation manual published by Agricultural Research and Extension Unit (AREU) as described in Tables 3, 4 & 5 to obtain a successful crop production.

Table 3. All pesticides spraying and soil drenching were done in early morning. Pest and disease infestation rate was mild with a relatively low number of plants infested as compared to severe infestation rate observed at farmer's fields. The round eggplant fruits were severely attacked by fruit flies. Adequate field sanitation was maintained by rouging and destroying all infested plant parts.

	Pesticide	Dosage per litre of water	Infestation rate	Application Frequency per fortnight
Pests				
Red spider mites	Peropal	3 g	Mild	Twice
Fruit and shoot borer	Karate 5CS (lambda-cyhalothrine)	0.5 ml	Mild	Once
Red ants	Dursban 4E	2.0 ml	Mild	Only once
Fruit Fly	Decis (deltametrine) alternated with Cymbush (cypermetrine)	0.5 ml	Severe	Twice
Diseases				
Cercospora leaf spot	Dithane M45 (mancozeb)	2 g	Mild	once
Phomopsis fruit rot	Mancozeb 80 WP (mancozeb)	2 g	Mild	once
Powdery mildew	Microthiol	3 g	Mild	Once

Table 4. The fertilisation regime applied for establishing field plantation. Eggplant crop was fertilised adequately to yield a good crop production.

Plant Growth Stage	Application rate	Field establishment
Nursery	Per square metre	Seedling production
Farm Yard Manure (FYM)	3 kg	Soil was sieved first to obtain a fine soil texture free from all kind of plant debris and small stones to allow smooth growth and development of seedling roots and then mixed with fertilisers and FYM. Eggplant seeds were sown in PVC tubes filled with growing media and raised under mist irrigation system in nursery.
Ammonium sulphate	15 g	
Triple Superphosphate	9 g	
Potassium Sulphate	30 g	
Transplanting	Per hole	Field plantation
Farm Yard Manure	1 kg	All fertilisers were applied at the prescribed rate and mixed thoroughly with soil in holes. Eggplant seedlings were transplanted in fertilised holes with the first true leaves just above soil surface and irrigated immediately after transplantation.
Calcium Ammonium nitrate	10 g	
Triple Superphosphate	8 g	
Potassium Sulphate	30 g	
Ammonium sulphate	65 g	
Three weeks after transplantation	Per hole	Field plantation
Ammonium sulphate	30 g	Top dressing was applied at a distance of 10-15 cm from transplant.
Six weeks after transplantation	Per hole	
13:13:20:2 complex NPK fertiliser	25 g	

Table 5. Overhead sprinkler irrigation system was used to irrigate eggplant field once per day depending on availability of irrigation water (Table 4). Heavy weed infestation problem was encountered due to overhead irrigation system unlike in drip irrigation system which provides a more efficient water use with less weed occurrence.

Plant growth stage	Water supply per week
Seedling	-
Vegetative	18 mm
Flowering and fruiting	31 mm
Harvesting	26 mm

Weed control

Heavy weed infestation problem occurred due to overhead irrigation system as compared to drip irrigation system. Basta systemic herbicide was sprayed in field once per fortnight at a concentration of 100 ml per knapsack sprayer (18 lt) to control weed invasion.

Morphological Characterization

Five plants from the 15 plants grown per each accession were chosen at random for bagging, given that they were free from pests and disease attacks without showing any characteristic symptoms of stunted or poor plant growth development. Flowers free from any pest or disease attack were isolated from these five plants through bagging to prevent any cross pollination and tagged for morphological characterization using FAO (IBPGR 1990) eggplant crop descriptors developed by Bioversity International (Appendix 1). Morphological data was recorded for 23 characters corresponding to 14 qualitative and 9 quantitative traits (Table 6.). Each of the five isolated plants was treated as one replicate and five measurements for each of the twenty three descriptor states were recorded.

Table 6. Morphological descriptor states measured in an arbitrary scale; codes for traits and description of the scale used in morphological diversity study of eggplant collections listed

Quantitative traits	Range (scale)
Plant height	5-9 (5= intermediate~60cm, 9= very tall> 100 cm)
Leaf blade length	3-7 (3= short~10 cm, 7=long ~30 cm)
Leaf blade breadth	3-7 (3= narrow~5 cm, 7=wide~ 15 cm)
Fruit length	1-9 (1= very short<1 cm, 9=very long >30 cm)
Fruit breadth	1-9 (1= very small< 1 cm, 9=very large > 10 cm)
Fruit stalk length	1-7 (1=very short <3 cm, 7=long ~10 cm)
Fruit weight	Not coded
Number of fruits per plant	Not coded
Yield per plant	Not coded
Qualitative traits	**Range (scale)**
Plant growth habit	3-7 (3= upright, 7= prostrate)
Leaf blade lobbing	1-9 (1= very weak, 9= very strong)
Leaf tip angle	1-5 (1= very acute, 5= intermediate)
Leaf prickles	0-7 (0=none, 7= many)
Leaf hairs (lower surface)	1-5 (1=very few < 20, 5=intermediate ~ 50-100)
Fruit calyx prickles	0-7 (0= none, 7= many)
Flower (corolla) colour	3-9 (3= white, 9= bluish violet)
Fruit shape	1-5 (1=round, 5= long)
Fruit apex shape	3-7 (3= protruded, 5= rounded, 7=depressed)
Fruit colour at commercial ripeness	1-9 (1=green, 3= white, 4-7 = purple gradient, 9= black)
Fruit patches/stripe distribution	1-7 (1=uniform, 7=striped)
Fruit glossiness	3-7(3=dull, 7=very shiny)
Fruit curvature	1-9(1=none, 9= U shaped)
Fruit position	1-9 (1=erect, 9=pendant)

All measurements and observations of a given trait were done on the same day to avoid any differences in environment or developmental stage of plant growth. Quantitative traits were measured on a metric scale whereas qualitative traits were recorded on an arbitrary scale.

On- farm characterization of five farmer's varieties

As regard on farm characterization of the five farmer's varieties, the same characterization technique was repeated with five plants per accession isolated through bagging and tagged for morphological characterization of the twenty three morphological characters based on IBPGR (1990) eggplant descriptor states.

Survey on eggplant landraces, their ethno botanical features and cultivation practices

A survey was conducted to document on the cultivation practices, ethno botanical features of eggplant landraces and local varieties grown by farmers. A questionnaire was designed (Appendix 2) and used to conduct a face to face interview with five farmers at Trou Deau Douce, Palmar and Belle Mare in the Eastern coastal region of the Island where the bulk of commercial eggplant production is undertaken. Two farmers from the Northern and Southern part of Mauritius were also interviewed. Although the questionnaire was set in English, farmers were interviewed in local language "Creole". The total number of farmers interviewed was small with seven respondents only due to time constraint and availability of farmers for survey.

Data Analysis

The morphological traits recorded for the different eggplant accessions were grouped into three main categories: (a) Plant and Inflorescence characteristics, (b) Leaf characteristics and (c) Fruit characteristics. Excel data sheets were prepared to document the above mentioned groups of plant characters. All survey questionnaires were also analyzed to record eggplant landraces grown, their interesting ethno botanical features and cultivation practices.

Quantitative morphological data were subjected to Analysis of Variance (ANOVA) in order to compute the means for each of the morphological traits under study and their average standard error and standard deviations calculated from these ANOVA. Duncan´s multiple range tests (Duncan 1955) was used to compare means. The coefficient of variations for these quantitative traits given by the ratio of standard deviation to the mean and their range of minimum and maximum values were obtained to provide an overall indication of the level of variations manifested by the quantitative traits.

A phenogram was generated using the Unweighted Pair-Group Arithmetic Mean (UPGMA) clustering method via the SAHN module in the Numerical Taxonomic System (NTSYS) software to determine the relationship between eggplant accessions. Twenty standardised qualitative and quantitative traits (excluding yield, fruit weight and number of fruits per plant) with zero mean and standard deviation 1, were subjected to Principal Component Analysis (PCA). Common component coefficients, Eigen values and Eigen vectors and relative and cumulative proportion of the total variance expressed by single traits were calculated.

The first two components explaining the maximum variance were selected for ordination analysis, and the correlation between the original traits and the respective principal component was calculated. Plant traits with a correlation value > 0.6 were considered as relevant for that component. A (dis)similarity matrix based on Euclidean Distance Coefficient (EDC) was generated to assess the level of similarity between accessions. Ordination analysis was performed to compare accessions and they were projected on bivariate vector matrix to show the relationship between accessions and traits. Plant traits that most effectively discriminated between accessions could be easily determined through such multivariate PCA analysis. All calculations and analyses were made using the appropriate options of SPSS statistical software version 15.0 (Apache Software Foundation Chicago, IL) and Numerical Taxonomic System Software (NTSYS) pc version 2.11L by Applied Biostatistics Inc. (Rohlf, 2000).

Result

The twenty three quantitative and qualitative descriptor states characterized displayed high level of morphological diversity among eggplant accessions. Morphological traits recorded were grouped accordingly under: (a) Plant and inflorescence, (b) Leaf and (c) Fruit characteristics. The range of variation for the different quantitative descriptors (Table 7) revealed wide variability for all the quantitative descriptors studied.

Table 7. Range of variation in quantitative descriptors, their minimum and maximum values and coefficient of variations given by the ratio of the standard deviation to the mean

Descriptors	Min	Max	CV (%)
Fruit weight (g)	2.00	440.00	55.21
Fruit length (cm)	0.70	39.50	51.05
Number of fruits per plant	16.00	145.00	49.44
Yield per plant (kg)	0. 24	11.88	44.88
Fruit width (cm)	0.40	11.20	42.17
Fruit stalk Length(cm)	1.00	7.00	32.38
Plant height (cm)	60.00	225.00	30.06
Leaf blade width(cm)	4.00	34.50	28.75
Leaf blade length (cm)	9.50	40.00	23.23

Min, Minimum value; Max, Maximum value; CV, Coefficient of variation

A large coefficient of variation (>30 percent) was observed for fruit characters and yield. Mean values for the quantitative descriptors together with their standard deviations are presented at Table 8.

Plant and inflorescence characteristics

The plant and inflorescence characters varied considerably among eggplant accessions (Table 9). Analysis of variances showed significant difference ($P < 0.05$) in plant height between different accessions (Table 8). Plant growth habit ranged from upright to intermediate and prostrate types. Flower (corolla) colour intensity increased from pale violet to light violet in *S. melongena* accessions.

Table 8. Mean values and standard deviation of quantitative descriptors studied

Acc No.	PLT HT (cm)	LBD L (cm)	LBD W (cm)	FRT L (cm)	FRT W (cm)	FRT STLK L (cm)	No. of Frts / PLT	FRT WT (g)	Yield/PLT (Kg)
14	83.40	28.98	26.40	34.90	4.36	3.92	27.20	205.00	5.43
17	84.80	37.00	29.78	24.80	6.62	5.40	19.20	280.00	5.31
18	85.60	27.16	20.20	23.20	4.72	4.70	42.80	162.00	6.86
19	70.00	31.38	17.60	5.06	4.86	2.34	50.00	56.00	2.75
21	86.60	27.70	19.54	31.80	3.64	5.10	43.00	145.00	6.13
24	83.20	35.68	24.90	6.70	5.66	2.10	43.60	80.00	3.26
51	79.00	22.90	18.08	17.00	6.32	4.90	30.60	220.00	6.55
57	72.20	28.64	24.64	16.36	8.04	3.84	28.80	245.00	6.83
65	75.80	23.18	20.40	21.80	5.84	4.88	38.00	180.00	6.70
75	73.00	22.76	16.70	23.40	4.50	4.82	42.00	150.00	6.20
106	103.60	13.44	10.36	4.60	3.38	2.26	72.40	12.48	0.90
124	83.60	20.19	14.84	21.60	7.18	5.64	32.60	220.00	7.23
142	77.80	23.74	19.14	24.40	4.70	6.46	37.40	125.00	4.60
255	109.00	18.90	11.70	4.82	2.90	2.08	70.80	12.22	0.86
294	64.00	22.66	17.38	11.60	6.76	2.74	34.20	180.00	5.55
303	77.80	27.40	22.28	20.20	3.50	3.84	38.00	75.00	2.82
306	77.60	24.86	18.70	21.50	7.04	5.50	18.20	295.00	5.33
312	66.20	24.50	20.04	21.98	4.66	4.78	41.00	160.00	6.49
334	74.00	21.90	15.76	25.56	3.62	4.78	31.80	140.00	4.22
335	66.80	23.44	20.54	15.40	9.44	4.84	28.20	270.00	7.26
336	78.80	26.74	19.84	24.60	4.60	5.40	23.60	235.00	5.37
349	87.40	26.64	21.32	23.00	8.60	3.64	17.80	315.00	5.58
355	101.20	17.28	12.80	4.76	3.06	2.26	68.60	13.24	0.91
474	81.00	23.74	21.68	25.58	3.64	4.66	40.40	155.00	6.11
479	81.20	21.18	17.64	25.50	4.96	5.18	39.60	165.00	6.41
480	79.20	23.20	18.24	14.96	6.42	3.52	37.60	181.00	6.71
481	70.20	23.28	18.46	13.42	9.92	4.76	32.20	300.00	9.38
482	90.80	21.10	14.30	32.48	3.66	4.12	40.40	169.00	6.69
483	85.60	19.66	13.26	21.92	4.84	4.64	40.40	169.00	6.72
484	82.60	19.64	15.76	15.04	5.46	3.20	33.40	212.00	6.99
485	68.20	21.96	15.80	9.78	7.86	3.56	38.20	280.00	10.04
486	76.60	21.42	16.46	16.82	5.98	5.58	39.00	196.00	7.47
487	213.80	26.08	15.34	1.30	1.28	1.04	121.20	2.47	0.30
488	89.40	11.20	4.70	0.86	0.48	-	-	-	-
Mean	84.71	23.81	18.08	17.84	5.25	4.14	40.67	169.86	5451.96
SD	25.46	5.53	5.20	9.11	2.21	1.34	20.11	93.78	2447.087
P(<0.05)	*	*	*	*	*	*	*	*	*

PLT HT: Plant Height; LBD L: Leaf Blade Length; LBD W: Leaf Blade Width; FRT L: Fruit Length; FRT W; Fruit Width; FRT STLK L: Fruit Stalk Length; No. of Frts / PLT; Number of fruits per plant; FRT WT: Fruit Weight; Yield/PLT: Yield per plant. SD: Standard Deviation.
* Significant at *P <0.05*

Table 9. Plant and Inflorescence characteristics observed for the 34 eggplant accessions characterized

Acc No.	Plant Growth Habit	Plant height (cm)	Corolla Colour
14	Prostrate	83.40	Pale Violet
17	Upright	84.80	Light Violet
18	Intermediate	85.60	Pale Violet
19	Upright	70.00	Bluish Violet
21	Intermediate	86.60	Light Violet
24	Upright	83.20	Bluish Violet
51	Intermediate	79.00	Light Violet
57	Prostrate	72.20	Light Violet
65	Intermediate	75.80	Pale Violet
75	Prostrate	73.00	Pale Violet
106	Prostrate	103.60	Deep Bluish Violet
124	Intermediate	83.60	Light Violet
142	Intermediate	77.80	Pale Violet
255	Prostrate	109.00	Deep Bluish Violet
294	Prostrate	64.00	Bluish Violet
303	Intermediate	77.80	Bluish Violet
306	Upright	77.60	Light Violet
312	Prostrate	66.20	Pale Violet
334	Intermediate	74.00	Light Violet
335	Prostrate	66.80	Pale Violet
336	Upright	78.80	Light Violet
349	Upright	87.40	Light Violet
355	Prostrate	101.20	Deep Bluish Violet
474	Intermediate	81.00	Pale Violet
479	Intermediate	81.20	Pale Violet
480	Prostrate	79.20	Light Violet
481	Prostrate	70.20	Light Violet
482	Intermediate	90.80	Light Violet
483	Intermediate	85.60	Pale Violet
484	Intermediate	82.60	Light Violet
485	Prostrate	68.20	Light Violet
486	Intermediate	76.60	Light violet
487	Upright	213.80	White
488	Upright	89.40	White

Deep bluish violet corolla colour was noted in the wild *S. violaceum* and bluish violet flower colour in *S. macrocarpon* the African eggplant (Fig. 6). Both the round and egg shaped and semi long white fruited *S. melongena* accessions also had bluish violet inflorescence unlike in the other *S. melongena* accessions.

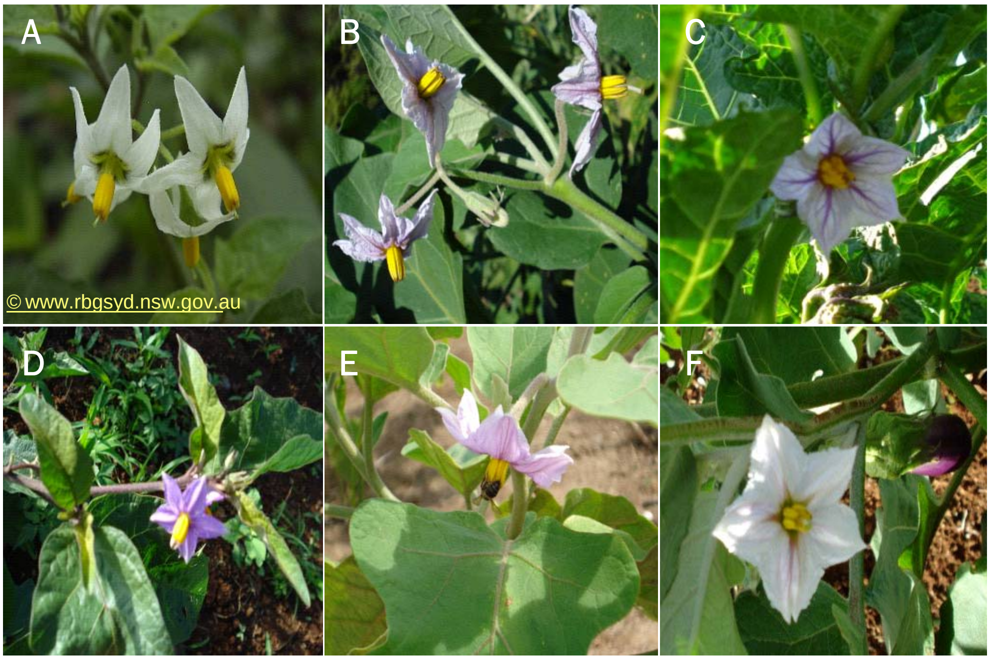


Fig. 6. Examples of flower (corolla) colour variation in eggplant, their related species and wild types in Mauritius (all photos by H. Naujeer except for (A) S. nigrum). (A) White flowers of *Solanum nigrum* the black nightshade plant, (B) bluish violet corolla colour of the white round fruited *S. melongena* accession; (C) bluish violet corolla colour of *S. macrocarpon* (African Gboma eggplant); (D) Deep bluish violet colour of wild *S. violaceum*; (E) light and (F) and pale violet flower colour of *S. melongena* accession.

Leaf Characteristics

Above 80 percent of *S. melongena* accessions and related species had broad prickle less leaves with acute leaf tip angle and intermediate leaf hairs as shown in Table 10. Leaf blade width ranged from 4 cm to a maximum of 34.5 cm while leaf blade length varied from 9.5 cm to 40 cm .They were the least diverse among all the traits phenotyped with a low coefficient of variation of 28.75 percent and 23.23 percent respectively (Table 7). The smallest leaf size was noted in *S. nigrum*, the black nightshade plants among all accessions. Presence of an intermediate number of leaf prickles along the midribs of relatively small leaf size was observed in wild types.

Table 10. Leaf characteristics recorded for all 34 eggplant accessions

Acc No.	Leaf Blade L (cm)	Leaf Blade W (cm)	Leaf Blade Lobbing	Leaf Tip Angle	Leaf Prickles	Leaf Hairs
14	28.98	26.40	Strong	Acute	None	Intermediate
17	37.00	29.78	Intermediate	Acute	None	Intermediate
18	27.16	20.20	Intermediate	Acute	None	Intermediate
19	31.38	17.60	Very Strong	Intermediate	None	Very few
21	27.70	19.54	Strong	Acute	None	Intermediate
24	35.68	24.90	Very Strong	Intermediate	None	Very few
51	22.90	18.08	Intermediate	Acute	None	Intermediate
57	28.64	24.64	Intermediate	Acute	None	Intermediate
65	23.18	20.40	Intermediate	Acute	none	Intermediate
75	22.76	16.70	Strong	Acute	None	Intermediate
106	13.44	10.36	Very Strong	Acute	many	Intermediate
124	20.19	14.84	Strong	Acute	none	Intermediate
142	23.74	19.14	Intermediate	Acute	none	Intermediate
255	18.90	11.70	Weak	Very Acute	Intermediate	Few
294	22.66	17.38	Intermediate	Acute	none	Intermediate
303	27.40	22.28	Strong	Acute	none	Intermediate
306	24.86	18.70	Intermediate	Acute	none	Intermediate
312	24.50	20.04	Intermediate	Acute	none	Intermediate
334	21.90	15.76	Strong	Very Acute	none	Intermediate
335	23.44	20.54	Intermediate	Acute	none	Intermediate
336	26.74	19.84	Intermediate	Acute	none	Intermediate
349	26.64	21.32	Intermediate	Acute	none	Intermediate
355	17.28	12.80	Weak	Acute	Intermediate	Few
474	23.74	21.68	Strong	Acute	none	Intermediate
479	21.18	17.64	Strong	Acute	none	Intermediate
480	23.20	18.24	Intermediate	Acute	none	Intermediate
481	23.28	18.46	Intermediate	Acute	none	Intermediate
482	21.10	14.30	Strong	Acute	none	Intermediate
483	19.66	13.26	Strong	Acute	none	Intermediate
484	19.64	15.76	Intermediate	Acute	none	Intermediate
485	21.96	15.80	Intermediate	Acute	none	Intermediate
486	21.42	16.46	Strong	Acute	none	Intermediate
487	26.08	15.34	Very strong	Acute	Few	Very few
488	11.20	4.70	Weak	Very acute	None	Intermediate

Leaf Blade L: Leaf Blade Length; Leaf Blade W: Leaf Blade Width.

Significant ($P < 0.01$) correlations were also observed between several related traits (Fig. 7). As expected leaf blade width was logically correlated ($r = 0.85$; $P < 0.01$) with leaf blade length. A significant positive correlation was also found between leaf blade length and fruit length ($r = 0.27$; $P < 0.01$) and leaf blade width and fruit width ($r = 0.37$; $P < 0.01$). Leaf blade width was also positively correlated with fruit weight ($r = 0.33$; $P < 0.01$) but negatively correlated with plant height ($r = -0.21$; $P < 0.01$) and number of fruits ($r = -0.41$; $P < 0.01$).

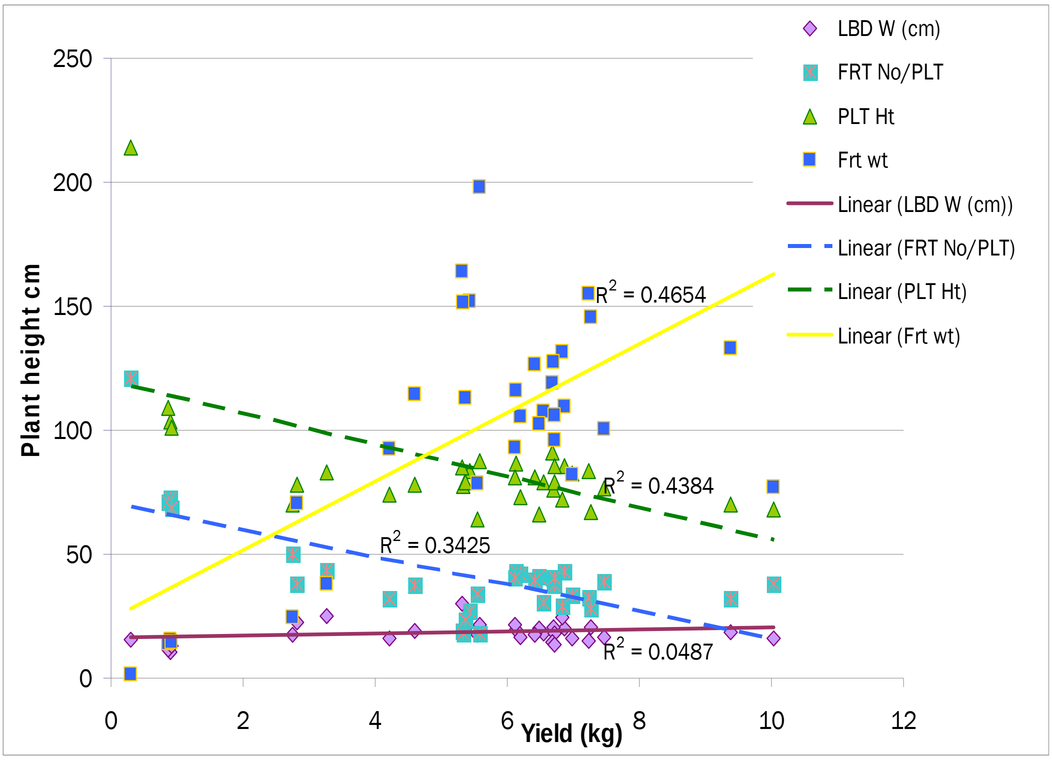


Fig. 7. Regression analysis showing the positive and negative trend of relationship between different related traits and R2 regression values displayed indicating the strength of relationship between them. Positive regression was obtained between fruit weight (Frt wt) and leaf blade width (LBD W) with yield and inverse relationship between plant heights (PLT Ht) and fruit number per plant (FRT No/PLT) with yield.

Fruit Characteristics

Fruit shape, size and colour were the most variable traits recorded among eggplant accessions (Table 11) and (Fig. 8a-c). A large coefficient of variation above 40 percent applied to number of fruits per plant, fruit length, width and weight suggesting that fruit traits were the most diverse quantitative morphological characters observed (Table 7).

The four characteristic fruit shapes recorded were round, oval or egg shaped, oblong, semi long and long types. Fruits of semi long type (44.1 percent) occurred most frequently among the eggplant accessions characterized. The maximum fruit length and width recorded were 39.5 cm and 11.2 cm respectively whereas their minimum values ranged from 0.7 cm to 0.4 cm.

Fruit colour ranged from white to pale green and dark green, lilac to purple, purple black and black. All cultivated *S. melongena* accessions produced shiny to very shiny fruit in a pendant fruit position with uniform colouration. The

Table 11. Wide diversity in fruit characters observed in eggplant accessions

Acc.	FRT SHP	FRT C L	FT PST	FT C V	FT CLPRK	F APX SHP	FTCLDTR	FTGLOS
14	Long	lilac	Pendant	Slighly curved	Few	Protruded	Unifom	Fair
17	Semi long	Purple Black	Pendant	None	None	Depressed	Unifom	Shiny
18	Semi long	Purple	Pendant	None	None	Protruded	Unifom	Very Shiny
19	Round	Green	Pendant	None	None	Round	Striped	Shiny
21	Long	Purple	Erect	Snake shape	None	Protruded	Unifom	Shiny
24	Round	Green	Erect	None	None	Round	striped	Shiny
51	Semi long	Purple	Pendant	None	None	Depressed	Unifom	Shiny
57	Round	Purple	Pendant	None	Few	Depressed	Uniform	Shiny
65	Semi long	Purple	Pendant	Slightly curved	Few	Protruded	Unifom	Shiny
75	Semi long	Purple	Pendant	Slightly curved	None	Protruded	Unifom	Shiny
106	Round/Oval	Green	Semi pendant	None	Intermediate	Protruded	Striped	Dull
124	Semi long	Purple black	Pendant	None	Few	Depressed	Unifom	Shiny
142	Semi Long	Purple	Pendant	Slightly curved	None	Protruded	Unifom	Shiny
255	Oval	Pale Green	Semi pendant	None	Many	Protruded	Striped	Dull
294	Egg shape	Milk white	Pendant	None	Few	Round	Unifom	Shiny
303	Long	Milk white	Pendant	None	None	Protruded	Unifom	Shiny
306	Semi long	Purple Black	Pendant	None	None	Depressed	Unifom	Very Shiny
312	Semi long	Purple	Pendant	None	Few	Protruded	Unifom	Shiny
334	Long	Lilac purple	Pendant	Slightly curved	Few	Protruded	Unifom	Shiny
335	Round	Purple	Pendant	None	None	Round	Unifom	Shiny
336	Semi long	Purple Black	Pendant	None	None	Depressed	Unifom	Very Shiny
349	Semi long	Purple Black	Pendant	None	None	Depressed	Unifom	Very Shiny
355	Oval	Green	Semi pendant	None	Intermediate	Protruded	Striped	Dull
474	Semi long	Purple	Pendant	Slightly curved	None	Protruded	Unifom	Shiny
479	Semi long	Purple	Pendant	Slightly curved	None	Protruded	Unifom	Shiny
480	Oblong	Lilac	Pendant	None	Intermediate	Protruded	Unifom	Fair
481	Round	Purple	Pendant	None	Few	Depressed	Unifom	Shiny
482	Long	Purple black	Pendant	Snake shape	None	Protruded	Unifom	Very Shiny
483	Semi long	Purple black	Pendant	none	Pendant	Protruded	Unifom	Shiny
484	Oblong	Purple	Pendant	None	Few	Protruded	Unifom	Shiny
485	Round	Purple	Pendant	None	Few	Protruded	Unifom	Shiny
486	Semi long	Black	Pendant	None	Few	Depressed	Unifom	Very Shiny
487	Round	Green	Erect	None	None	Round	Unifom	Dull
488	Round	Green	Semi pendant	None	Few	Round	Unifom	Shiny

FRT SHP: fruit shape, FRTCL: fruit colour, FTPST: fruit position, FTCV: fruit curvature, FT CLYPRK: fruit calyx prickles, F APX SHP: fruit apex shape, FTCLDTR: fruit colour distribution, FTGLOS: fruit glossiness.

African eggplant (*S. macrocarpon* L.) as compared to *S. melongena* produced relatively smaller round to spherical shiny pale green fruits with dark green stripes in an erect position. Similarly, wild *S. violaceum* accessions bear small but dull pale green oval to round fruits with an intermediate number of fruit calyx prickles in a semi pendent fruit position. Unlike *S. violaceum* accessions, the fruits of *S. torvum* and *S. nigrum* accessions were dark green with uniform colour distribution.

As expected fruit weight ranged from 2 to 440 g and was inversely related to number of fruit per plant (r = -0.78; P < 0.01) and plant height (r = -0.54; P < 0.01). Yield was positively correlated with leaf area (r = 0.2), fruit length and width (r > 0.5) and fruit weight (r = 0.8) but inversely related to number of fruits per plant (r =-0.6) and plant height (r = -0.5). Similarly fruit weight positively correlated (r= 0.33; p< 0.01) with leaf blade width, fruit length (r=0.44; p<0.01), fruit width (r=0.77; p<0.01) and yield (r= 0.77; p<0.01).

Regression analysis performed on these related traits clearly showed the positive relationship between fruit weight and leaf blade width with yield and negative relationship between plant heights and fruit number per plant with yield.

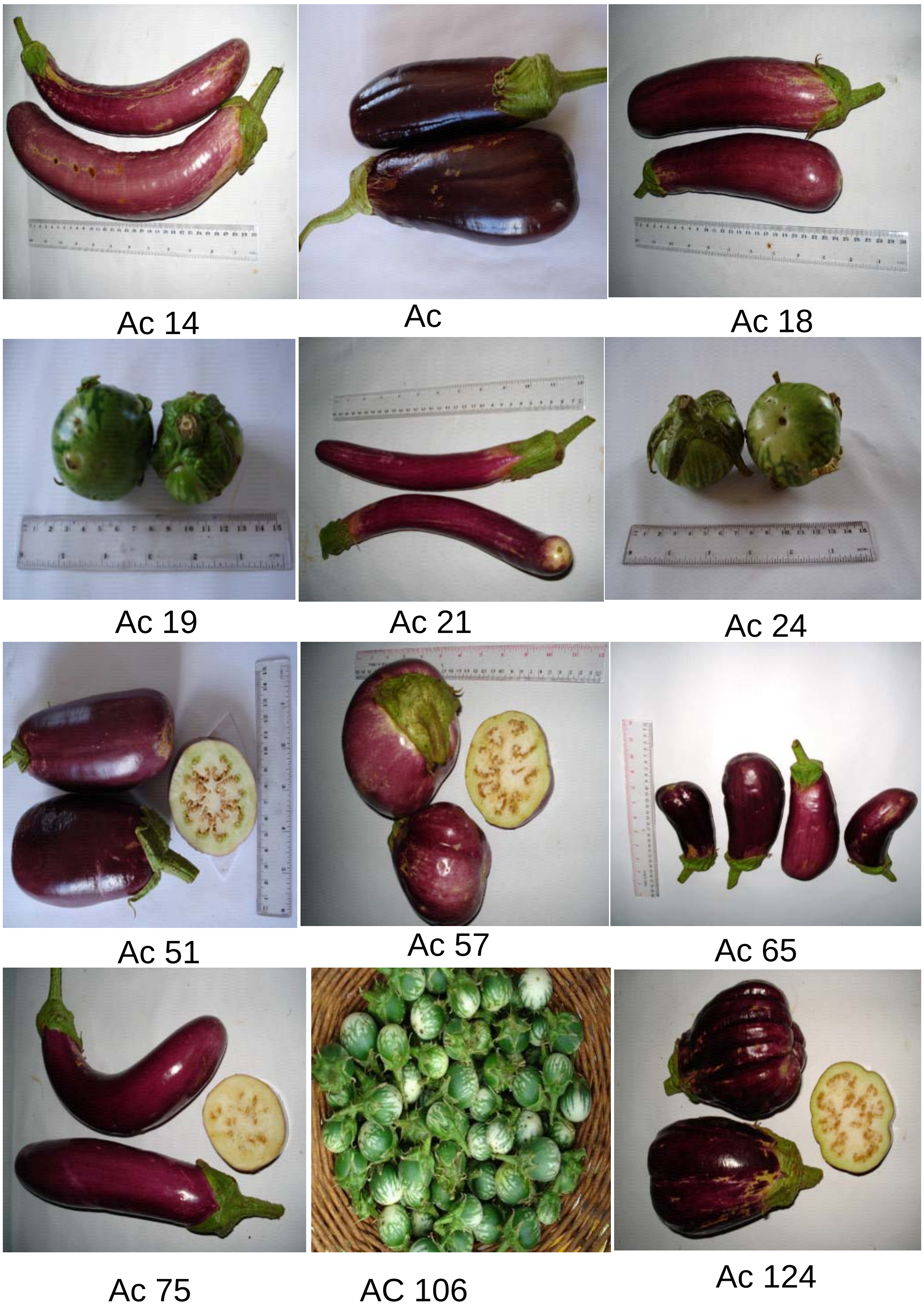
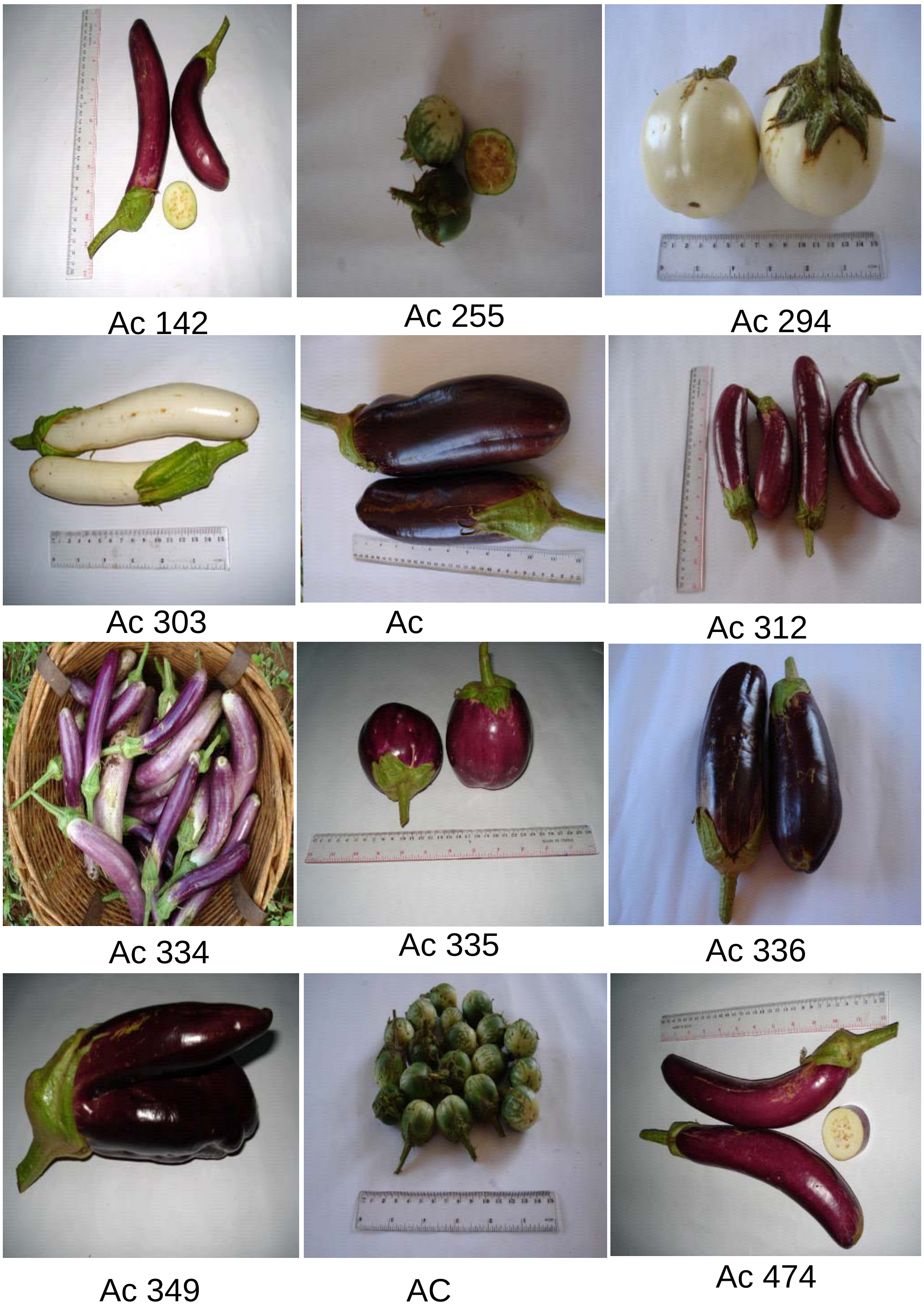


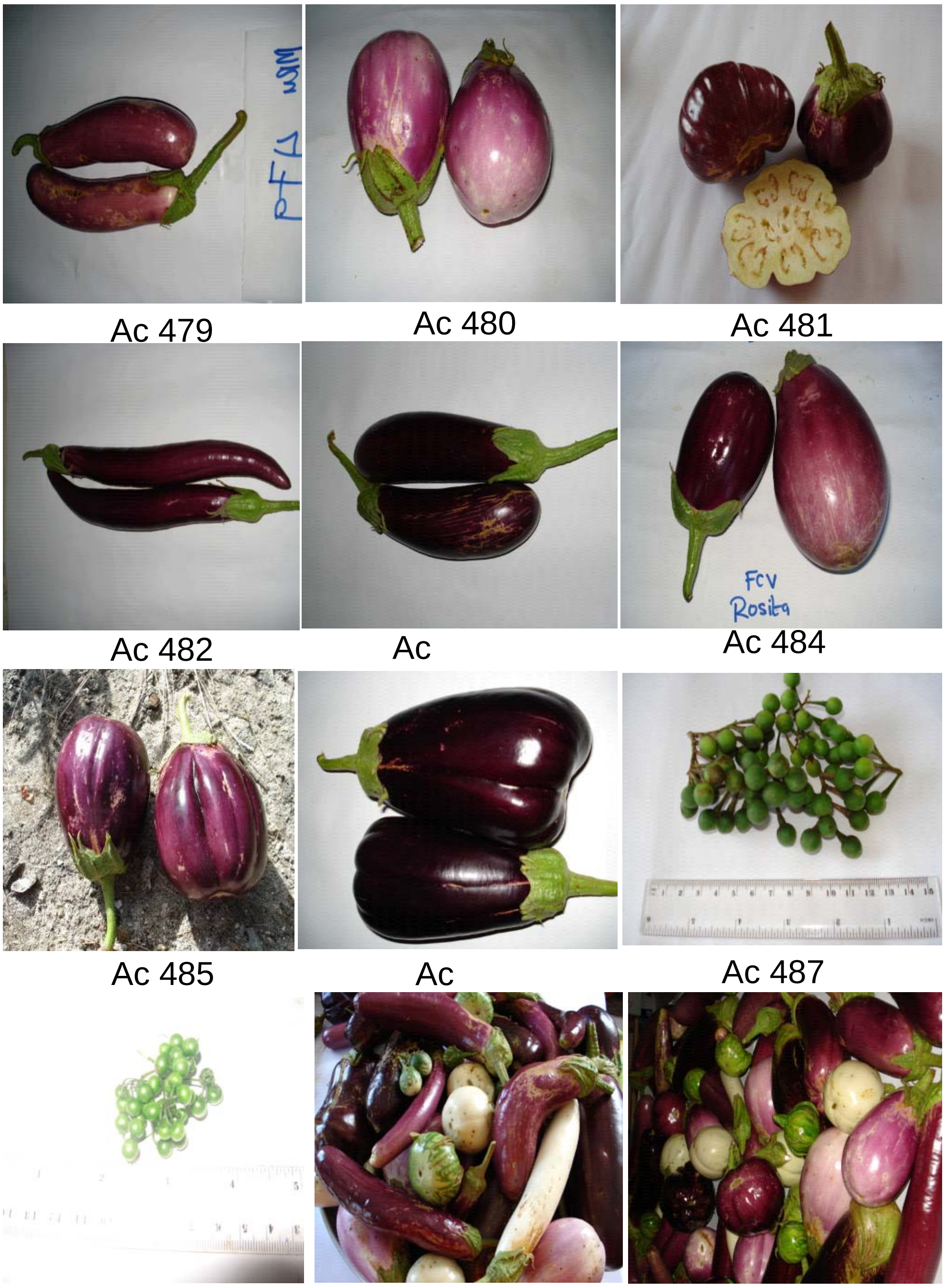
Fig. 8a.

Fig. 8a-c Fruit diversity in the 34 eggplant accessions characterized displaying wide variation in shape, size and colour. All passport photos of eggplant fruits with their consecutive accession numbers labelled taken by H. Naujeer, 2008.



Ac 142 | Ac 255 | Ac 294
Ac 303 | Ac | Ac 312
Ac 334 | Ac 335 | Ac 336
Ac 349 | AC | Ac 474

Fig. 8b.



Ac 488 Fruit diversity in 34 eggplant accessions

Fig. 8c.

Principal Component Analysis

The phenogram generated using 20 morphological descriptors based on Euclidean Distance Coefficient and UPGMA clustering method (Fig. 9) clearly showed the phenetic relationship between *S. melongena* accessions, their related species and wild types.

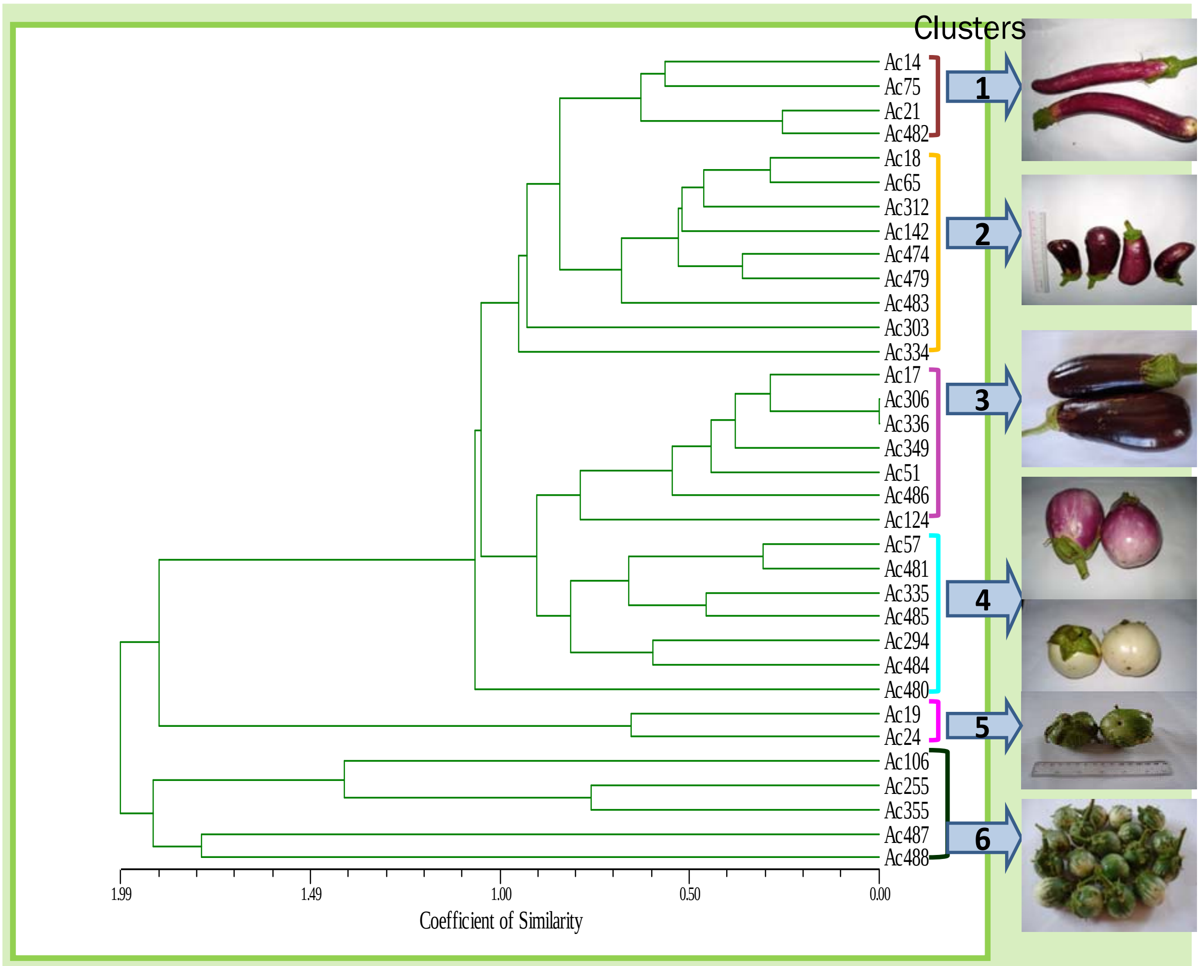


Fig. 9. Phenogram constructed from morphological data using Euclidean Distance Similarity Coefficient and UPGMA clustering method. 34 eggplant accessions grouped into six distinct clusters. The *S. melongena* accessions were classified into the 'Long' cluster (1); 'Semi Long' clusters (2) (narrow width) and cluster (3) (broader width), 'Round' and 'Oblong' cluster (4) specific cultivar groups based on their fruit shape, size and colour. *S. macrocarpon* (Gboma) eggplant grouped in a distinct cluster (5) close next to *S. melongena* accessions. The wild types used as out group were clearly separated from *S. melongena* and *S. macrocarpon* species and grouped under cluster 6. Different cluster groups are illustrated by passport photos (by H. Naujeer) of some of their related accessions.

The phenogram separated the 34 accessions studied into six distinct clusters by grouping accessions sharing close phenotypic similarities into distinct clusters. Consequently, the *S. melongena* accessions were classified into the 'Long' cluster (1); 'Semi Long' cluster (2) (narrow width) and cluster (3) (broad width > 6.0 cm) and the 'Round' and 'Oblong' cluster (4) specific cultivar groups based on their fruit shape, size and colour as revealed by multivariate PCA analysis.

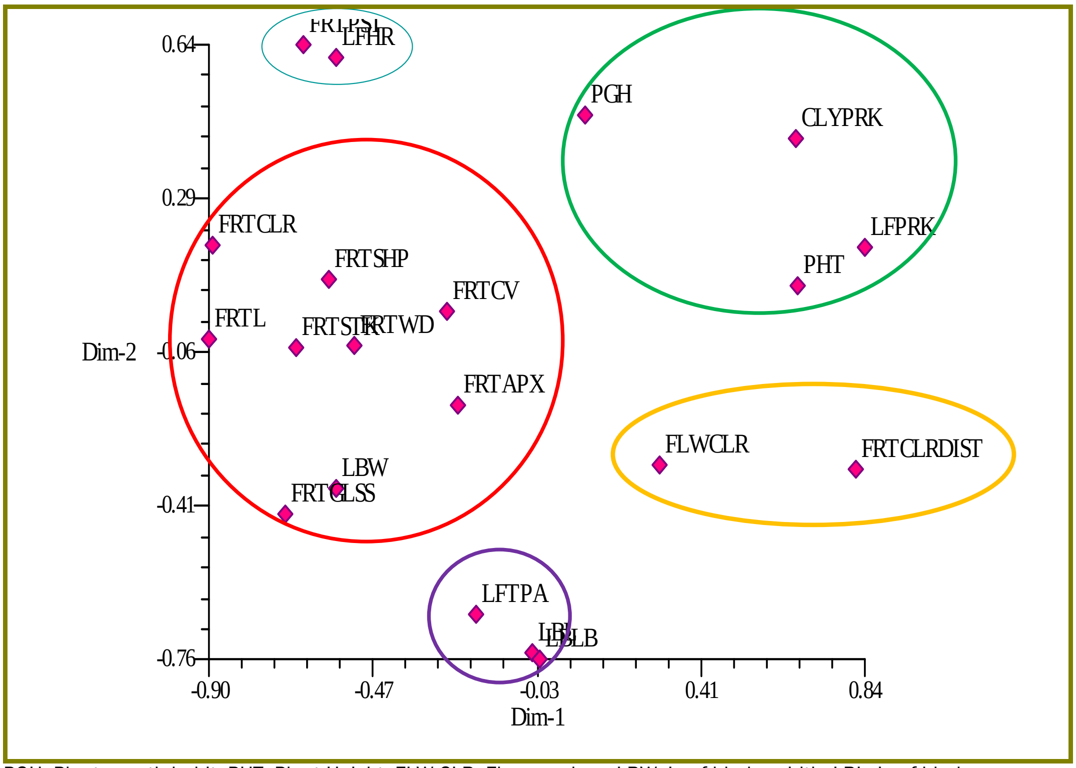
The African (Gboma eggplant) *S. macrocarpon* accessions was grouped as the next close species under cluster (5) indicating their close genetic affinities and phenotypic relationship to *S. melongena* species.

The wild type characterized by a syndrome of morphological traits such as tall plants height, spiny leaves, small green fruits with many seeds, prickles on fruit calyx and plant stem allowed them to be distinguished from the cultivated *S. melongena* and *S. macrocarpon* accessions and grouped under a distinct cluster (6).

Although consumed as a vegetable crop, the black nightshade plant *S. nigrum* morphologically distinguished by their very small ripe black fruits and white corolla colour closely resembled the wild *S. torvum* species and hence grouped under cluster (6).

The clustering pattern of accessions obtained in phenogram was further investigated through PCA to determine the relationship between plant traits and accessions. It indicated set of traits that caused clustering of accessions into specific groups and that most effectively discriminated between accessions. Multivariate PCA analysis revealed that the first two principal components cumulatively accounted for 50.7 percent of the total variance. The first principal components which explained 33.7 percent of the total variations and second principal components contributing to 17 percent of total variations were calculated from Eigen values and correlation matrix.

Principal Component Analysis performed on 20 morphological descriptors through ordination analysis displayed their clustering patterns. The reproductive (fruit and flower traits) and vegetative (leaf and plant characters) clustered separately from each other as reflected in their distribution pattern in bivariate matrix plot presented in Fig. 10.



PGH, Plant growth habit; PHT, Plant Height; FLW CLR, Flower colour; LBW, Leaf blade width; LBL, Leaf blade length; LF TPA, Leaf tip angle; LBLB, Leaf blade lobbing; LF PRK, Leaf prickles; LF HR; Leaf hairs; FRT L, Fruit length; FRT WD, Fruit width; FRT PST, fruit position; FRT SHP, fruit shape; FRT CV; fruit curvature; CLY PRK, Calyx prickles; FRT STK, fruit stalk length; FRTAPX, fruit apex shape; FRTCLR, fruit colour at commercial ripeness; FRTCLRDIST, fruit colour distribution and stripe; and FRTGLSS, fruit glossiness.

Fig.10. Projection of traits on two dimensional bivariate matrix plots based on ordination analysis using similarity correlation coefficients among traits, Eigen vectors and Eigen values. The reproductive (fruit and flower traits) and vegetative (leaf and plant characters) clustered separately from each other as reflected in their distribution pattern in matrix plot.

Accessions were also compared through ordination analysis and projected on two dimensional matrix plots to show the relationship between the 34 accessions studied. Although the 27 *S. melongena* accessions were characterized by wide variability in plant and inflorescence, leaf and fruit characters, their overall close similar morphology allowed them to be grouped in a distinct cluster. The bivariate matrix plot was also projected on a three dimensional scale to display the similarity or dis (similarity) distance between different accessions in space (Fig. 11a & Fig. 11b).

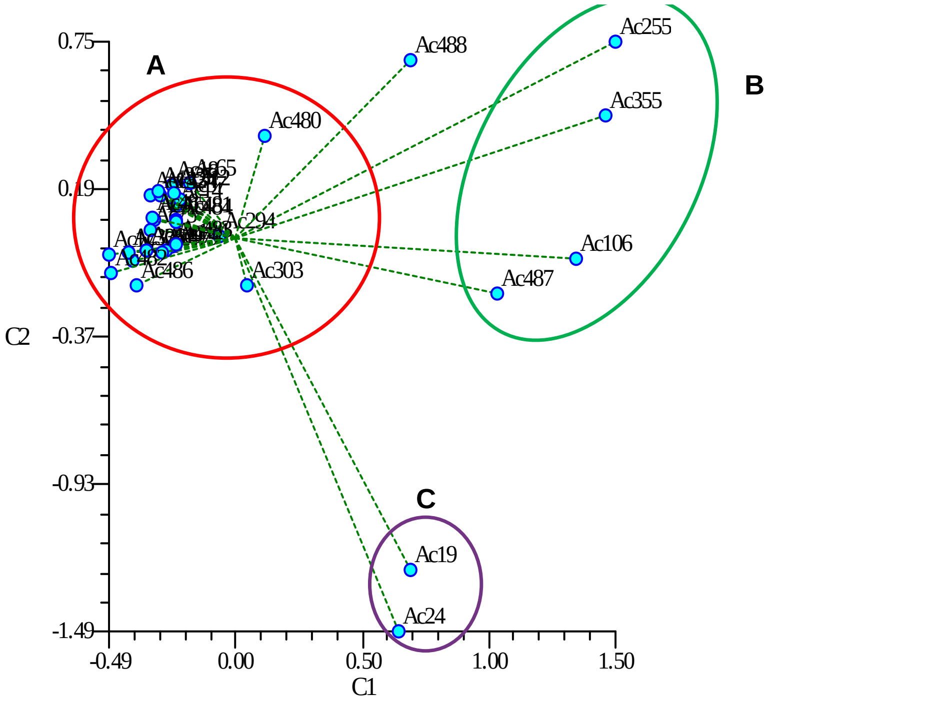


Fig. 11a. Relationship between 34 eggplant accessions studied based on principal components analysis C1 (33.7%) and C2 (17%) using data for twenty morphological traits. Group A= all *S. melongena* accessions, Group B= all wild types used as out group and *S. nigrum* species and group C= *S. macrocarpon* accessions, the African Gboma eggplant.

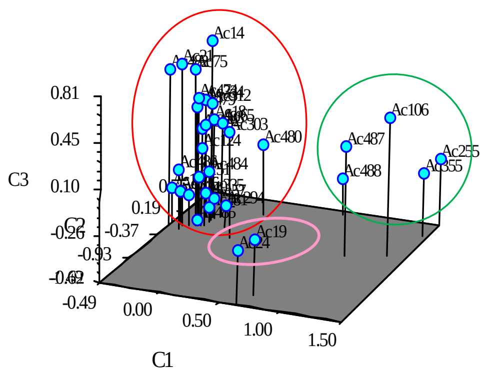


Fig. 11b. Projection of the 34 eggplant accessions morphologically characterized on a three dimensional basis to illustrate the dis(similarity) distance between them in space and hence their clustering pattern into distinct groups of similar accession.

The 34 accessions plotted on the bivariate matrix was ultimately projected on Eigen vector matrix to display the relationship between these 34 accessions and their morphological traits characterized (Fig. 12).

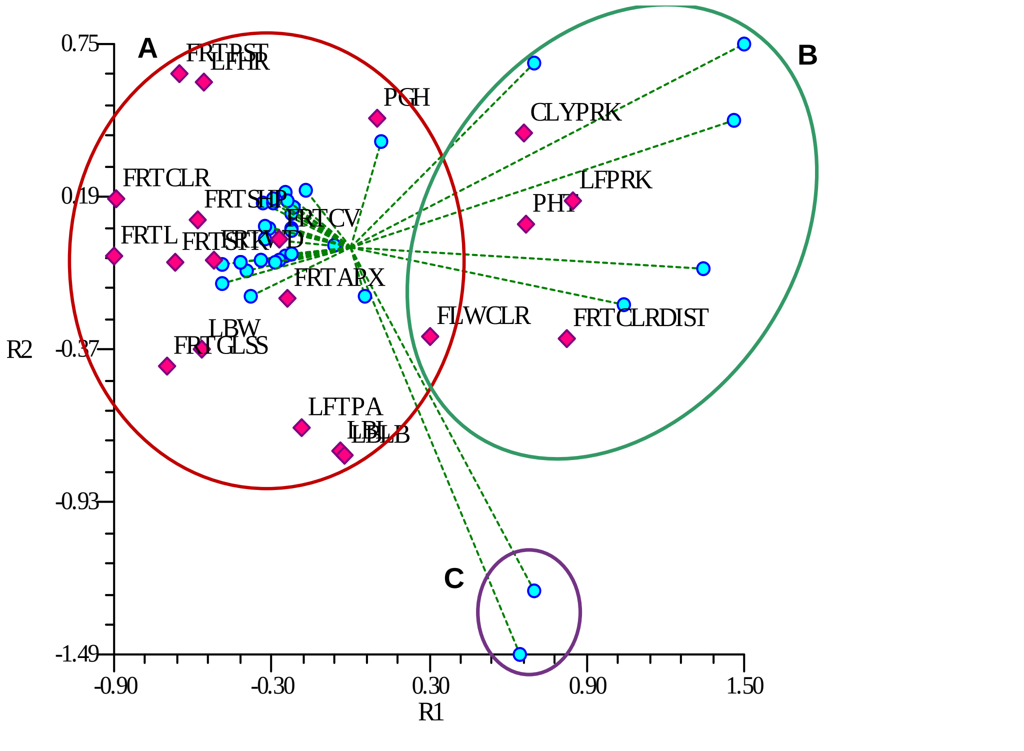


Fig. 12. The bivariate matrix plot shows the relationship between the 34 eggplant accessions studied marked by circles and their 20 morphological traits characterized abbreviated in diagram. Group A represented all 27 *S. melongena* accessions that were closely associated with fruit traits that most effectively discriminated them from other accessions. Group B included all wild types and *S. nigrum* grouped together based on leaf, calyx prickles, plant height, flower colour and fruit colour distribution. The *S. macrocarpon* African eggplant represented by Group C was equally separated from *S. melongena* and wild *S. torvum* and *S. violaceum* species.

PCA multivariate analysis demonstrated that the 27 *S. melongena* accessions were highly correlated with fruit traits (shape, size and colour) which caused them to cluster into a distinct group. These fruit traits are therefore identified as important marker traits that most effectively discriminated between the eggplant accessions, their related species and wild types.

On Farm Field Survey

Eggplant is an agronomically important vegetable crop in the sub humid Eastern coastal region of the Island where the bulk of eggplant production is undertaken, although it can be successfully grown in some Southern and Northern parts in Mauritius.

The Eastern Coastal region of Palmar, Trou Deau Douce and Belle Mare was surveyed whereby five farmers were interviewed. Two farmers operating in the Northern and Southern region of the Island respectively were also interviewed.

The survey conducted at farmer's fields' generated important information and key findings about eggplant landraces grown, their characteristic ethno botanical features and cultivation practices although only seven farmers were interviewed. The major constraints faced in commercial eggplant production and threats to cultivation of landraces were also addressed. Farmer's perception on the importance of maintaining eggplant landraces diversity and the future strategies necessary to promote both *ex-situ* and *in-situ* (on farm) conservation was discussed as well during survey.

Crop production information gathered from survey questionnaires showed that eggplant is the next major vegetable crop after onion into the surveyed region which is cultivated on a commercial scale. The majority of respondents were predominantly small to medium scale farmers cultivating eggplant landraces for more than 15 years.

The four most common eggplant landraces grown on sandy loam soils are the long 'Cipaye long', semi long 'Cipaye Narain', oblong 'Rosita' and round 'Farcie' varieties (Fig. 13). They produce purple to lilac coloured fruits shiny in appearance and differing in taste, flesh texture and flavour.

According to some old farmers, the eggplant landraces have been continuously improved across many generations through deliberate or unintentional selections of fruit traits for improved on farm production (Fig. 13). Eggplant farmers usually save seeds for the next planting season by leaving the first "good looking" big fruits that have interesting shape, uniform colour distribution, very shiny in appearance and are free from any pest or disease attacks on the plant until they reach physiological or seed maturity. Afterwards seeds are extracted manually, washed, sun dried and stored in sealed glass bottles at room temperature. Seed extraction by hitting the ripe eggplant fruit on a rock to split it open, is a traditional seed extraction method practiced among old farmers. They believe that such a practice prevents seeds from becoming defective and producing abnormal seedlings as reported by an old eggplant farmer. However the new generation among eggplant farmers prefer to use knife to cut fruits for seed extraction and have also started conserving seeds at low temperature in refrigerators.

Fig. 13. Common eggplant varieties grown by commercial eggplant producers in the Eastern coastal region in Mauritius. (A) the long 'Cipaye long'; (B) oblong 'Rosita' and (C)round to oblong 'Farcie' varieties; (G) semi long 'Cipaye Narain'. Improved commercial eggplant varieties (D, E, F & H) (All photos by H. Naujeer)

Eggplant is usually intercropped with chilly local varieties 'Cipaye' and 'Cabrie' at a row spacing of 1m by 1 m. Crop rotation is barely practiced among farmers. With the growing demand and increasing market price, farmers are now practicing intensive monocrop eggplant cultivation to expand production volume (Fig. 14). All fields are irrigated with overhead sprinkler irrigation systems although some of farmers are looking forward to adopt more efficient drip irrigation systems because of water shortage problems most particularly during peak summer time and also for increased crop yields with better fruit quality and low pest and disease incidence. Eggplant fruits are harvested manually and sold either directly to the consumers but most frequently through auction sale at the vegetable market (Fig. 14). Since onion is the major crop being cultivated into that region, almost all farmers are registered at Belle Mare Onion Farmers Cooperative Society to gain access to all tangible and intangible benefits such as farm mechanisation tools and machinery, irrigation facilities and training workshops on innovative vegetable farm production techniques.

Fig. 14. Commercial eggplant production cultivated on sandy loam soil in the Eastern coastal region of Palmar, Trou Deau Douce and Belle Mare. (A) Intensive monocrop eggplant field; (B) manual eggplant fruit harvesting; (C) harvested fruits for auction sale at vegetable market and (D) intercropping of eggplant crop with pepper as marked with arrow (All photos by H. Naujeer).

As a common vegetable crop, *S. melongena* is widely consumed by the local people in several types of dishes in curries, as grilled chutney and fried snacks (the famous "Gateau Bringelle") but also highly appreciated in hotels in cold salad, moussaka and ice cream. Small round to oblong black coloured seedless fruits are usually preferred in hotels as compared to purple or lilac coloured fruits with a rough texture and irregular in shapes. The African eggplant *Solanum macrocarpon* L., also locally known as "Anguive" produces small round or spherical shiny green striped fruits with bitter taste which is widely grown and consumed by the local people as well. However, unlike in African countries only the fruits are eaten here and not the large glabrous green leaves.

Solanum nigrum L., the black nightshade plant also referred to as "Brede Martin" in the local Creole language grows most abundantly as a weed in the periphery of farmer's fields. Tender leaves and not the fruits are consumed in soup locally called as "Bouillon Brede Martin" and interestingly it is also widely referred to as the "poor people vegetable" since as a weed it can be easily harvested from farmers fields or other remote areas at free of cost. However today, due to agricultural intensification and elimination of undesirable weeds, it has become a very rare vegetable commodity and is not known to many youngsters in the new upcoming generation.

Although the bulk of eggplant production comes from the traditional varieties and landraces, there is a growing tendency among local farmers to switch to more profitable high yielding hybrid varieties that fetches more lucrative market demands in hotels and supermarkets chains with wider consumer acceptability with respect to better fruit shape, size and colour preferences.

A major constraint faced by eggplant producers is the high susceptibility of modern hybrid cultivars to serious pest and disease attacks including red spider mites, fruit fly, fruit and shoot borers, bacterial wilt (*Pseudomonas solanacaerum*) and fruit rot (*Phomopsis vexans*) (Fig. 15). Farmers also reported that modern hybrid varieties demand intensive crop management practices in terms of pesticides, fertilisers and irrigation applications at a rising cost of production and are more prone to cyclones as compared to landraces.

Their wild relatives *Solanum torvum* and *Solanum violaceum* in contrast confer better resistance against these devastating pests and pathogens and show higher tolerance to abiotic stress condition such as drought and salinity problems. The wild African eggplants were found growing in extreme saline conditions in some coastal areas of the Island, 10m from the seashores. However those wild species occurring in remote wild habitat are under constant threat of massive deforestation, land clearing and accelerated urbanization activities to support the rapid socioeconomic growth of the fast developing Island state.

Replacement of local varieties and landraces, changing agricultural practices and heavy use of pesticides is resulting in erosion of varietal diversity and loss of genetic diversity in eggplant landraces. Besides, old landraces such as the lilac to purple coloured 'Cipaye long' and purple coloured 'Elongated' variety are being gradually replaced by high yielding hybrid cultivars producing very shiny fruits ranging from purple black to black in colour.

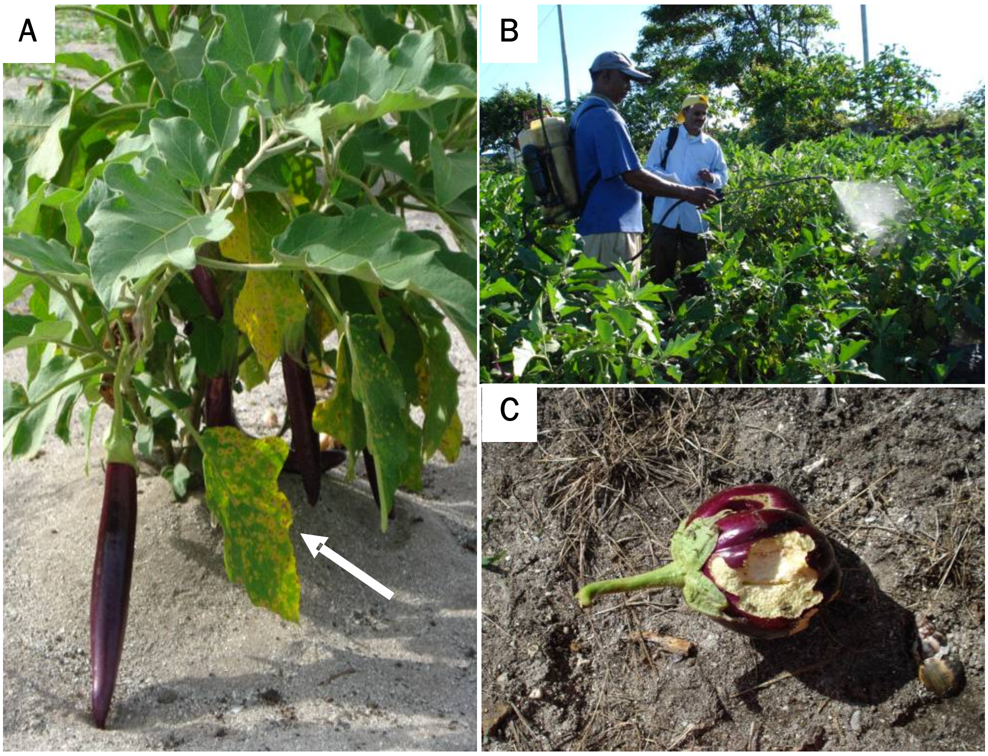


Fig. 15. Serious pest and disease infestation problems encountered in commercial eggplant cultivation. Leaves are seriously infected by leaf spot diseases marked by arrow in photo slide A and fruits also damaged by pests and rodents (photo slide C of 'Farcie' eggplant variety eaten by rodents) or fungal diseases such as phomopsis fruit rot reducing yield and incurring heavy use of pesticides (photo slide B) (All photos by H. Naujeer).

The commercial eggplant farmers expressed their deep concern for the need of a wider range of high yielding eggplant varieties with better resistance to serious pests and diseases, although there exits some interesting eggplant varieties that can be fully exploited for commercial eggplant production. For instance many farmers are not aware about the existence of the white eggplant varieties in Mauritius which are good for diabetic patients (Chen and Li 1996) and widely consumed in other parts of the world and that can be successfully grown in the Island too. Exploitation of this important white eggplant variety (Fig. 16) will not only add extra flavour to the Mauritian cuisine but also help to diversify the commercial eggplant production sector while adding to crop varietal diversity.

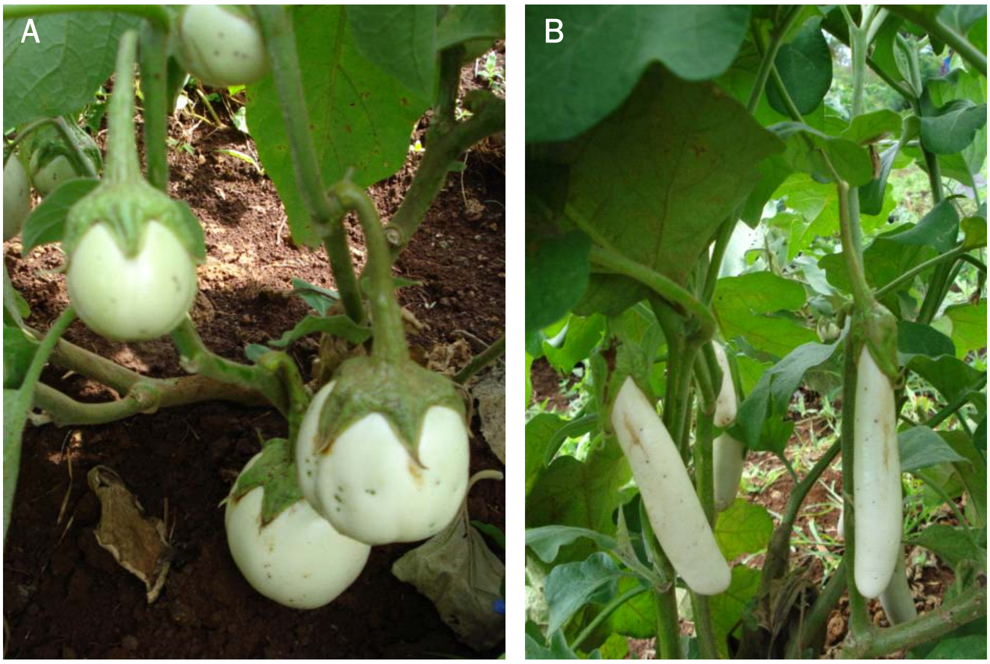


Fig.16. The less known white round (A) and semi long (B) eggplant varieties, characterized at Roches Brunes experiment station as part of the gene bank material and that can be exploited in commercial eggplant production in Mauritius (Photos by H. Naujeer)

Discussion

The results obtained in present investigation revealed wide morphological diversity among the 34 accessions for all the twenty three quantitative and qualitative morphological descriptors studied. Plant and inflorescence, leaf and fruit characters varied considerably among accessions.

Although the 27 *S. melongena* accessions studied were characterized by wide diversity in vegetative, inflorescence and fruit characters, their overall close morphology allowed them to be grouped in a distinct cluster (Fig. 11a & 11b) as reported by Furini and Wunder (2004).

PCA multivariate analysis revealed that fruit traits (Shape, size and colour) with a cumulative total variation of 50.76 percent most effectively discriminated between *S. melongena,* their related species and wild types. They can be used as important marker traits (Prohens et al. 2005) in the classification of *S. melongena* accessions into specific cultivar groups at the National gene bank in Mauritius. However morphological diversity observed in accessions was not restricted to fruit characters only. Other vegetative, inflorescence and fruit traits such as leaf prickles, leaf blade lobing and fruit stripes, plant height, flower colour and leaf calyx prickles were identified as useful marker traits that also distinguished between *S. melongena* accessions, their related species and wild types. Like wise leaf prickles in eggplant are important character to use as marker trait, since prickle less plants are generally more susceptible to insect attacks. However farmers are in favour of these non prickled leaf types for ease of harvest and intercultural practices (Chowdhury et al. 2007).

As discussed above, a high level of morphological diversity in vegetative, inflorescence and fruit traits was manifested in the 27 *S. melongena* accessions characterized and a significant number of local variants were also noted among different *S. melongena* accessions within the four distinct cultivar groups. Adaptation to local pedoclimatic conditions and farmers selections for certain desirable plant traits generally directed at fruit morphology across many generations appear to have generated a significant degree of differentiation at both the inter and intra specific levels in eggplant landraces thus giving rise to a significant number of local variants with interesting characteristic features among them. A similar observation was reported by Portis et al. (2006) in Italian pepper landraces. Here the authors suggested that independent selection pressures across a number of crop generations to a restricted gene pool can result in genetic divergence within a particular landrace. This could also explain the phenotypic variation manifested in plant characters such as fruit traits among individuals within the different accessions studied. Mace et al. (1999) reported a high degree of morphological plasticity in *S. melongena*, their related species and wild types which may have further contributed in the differentiation process and accumulation of variation in eggplant landraces and traditional varieties.

This high level of intra and inter specific variations displayed within *S. melongena* accessions could be effectively used in genetic improvement of cultivated eggplant varieties as well as *in-situ* (on farm) and *ex situ* conservation. Historical evidence points out that there has been frequent exchange of crop germplasm between Mauritius and its sister Island Rodrigues. The *S. melongena* accessions (MRU 303 and 306) collected in Rodrigues Island in 2001 was found to bear close morphological resemblance with *S. melongena* accession (MRU 17) collected in Mauritius in 1985. Furthermore MRU 306 and MRU 336 which tied together in phenogram (Fig. 9) could be assumed as duplicate accessions. The three *S. melongena* accessions (MRU 17, 306 and 336) all produced semi long but broad shiny purple black fruits with spongy tender flesh (Table 11). According to Furini and Wunder (2004) diverse geographic origin of two accessions may not necessarily reflect in genetically diverse plant materials although these parameters are central in genetic diversity studies. Frary et al. (2003) explained this observation by the fact that the phenotypes for certain traits (leaf and fruit characters)are controlled by a limited number of genes with major effects on phenotypic traits and their quantitative trait loci are conserved during domestication and plant evolution. The close similarities and morphological ties between these semi long *S. melongena* accessions implies that they have conserved their gene functions linked to the successful expression of morphological traits over geographical space isolation and time. Despite the very close morphological similarities between *S. melongena* accessions (MRU 306 and MRU 336) and *S. melongena* accession (MRU 349), the latter could be distinguished by their much broader fruit width (≥ 8.6 cm) and shorter fruit length (≤ 23 cm) with their fruits splitting at one end to form a finger like extension (Fig. 8).

This low level of morphological differentiation observed between the semi long *S. melongena* accessions (MRU 17, 306, 336 and 349) collected from different agro ecological regions both in Mauritius and from Rodrigues Island nevertheless contradicts the high level of morphological plasticity generally manifested in eggplant crop in response to adaptation to different agro ecological environment. These four *S. melongena* accessions are presumed to be introduced from Egypt but their exact origin still remained to be confirmed. They represent important eggplant landraces with high breeding potentials and commercial values that can be successfully exploited by plant breeders and local farmers.

Unlike the *S. melongena* accessions (MRU 306, 336 and 349), the wild *S. violaceum* species also collected from Rodrigues Island showed some degree of morphological plasticity in leaf characters with regard to leaf blade lobbing as compared to those occurring in Mauritius although no significant difference (*P*< 0.05) was noted in their fruits traits.

In many crops simple and useful systems of classification have been developed that rely on a few inherited and easily observable traits (Riley et al. 1996). Given the wide diversity of eggplant varieties and their high number of local variant, a simple classification of *S. melongena* accessions into specific cultivar groups based on key morphological traits such as fruit shape (long, semi long, oval or egg shaped, oblong or round) and fruit colour (white, green, purple or black) and size (big or small fruits with broad or narrow width) will allow a quick and easy discrimination between them. Furthermore it will enhance the assessment of crop varietal diversity structure in relation to inter and intra specific levels of variations, farmer's variety names and crop performance in specific *in situ* locations. Moreover, duplications and redundancies present in eggplant accessions, their related species and wild types could be eliminated while facilitating the establishment of core collections when combined with geographical data. For instance, very close phenotypic similarities for all the morphological descriptor states characterized was observed between the two accessions of *S. macrocarpon* the African (Gboma) eggplant, indicating a high probability of duplication in gene bank accession collections for that particular species.

Eggplant accessions could be effectively divided into specific geographical units and representative samples of cultivar groups or individual accession selected from each morphological cluster within specific geographical regions. The core collection concept apart from facilitating regeneration and multiplication programme will also contribute towards enhancement of conservation and sustainable use of eggplant genetic resources in Mauritius. Improved yield and enhanced fruit quality are defined as the major breeding objectives in eggplant crop. Significant positive correlations were found between yield and leaf area, fruit size and weight and number of fruits per plant. This is in accordance with the findings of Kumar et al. (2008) who reported that a high positive correlation between yield, a complex and polygenic trait with low heritability and other heritable component traits such as leaf and fruit characters can assist in selection and breeding of high yielding varieties. The authors also pointed out that hybridization between genetically diverse parents produces F1 hybrids that are expected to manifest heterosis and their progenies expected to display higher level of genetic variability.
The round, oblong and semi long *S. melongena* accessions were noted as high yielding cultivars and hence could serve as potential candidates in the selection of both morphologically and genetically divergent parents for hybridization.

However Kumar et al. (2008) further acknowledged that wider consumer acceptability is also dependent on certain qualitative fruit descriptors such as shape, colour, glossiness, size and prickliness that are considered as important selection criteria while choosing parents for hybridization. Presence of a wide morphological diversity in *S. melongena* accessions with useful agronomic traits suggests that improved cultivated eggplant varieties could be obtained by recombining eggplant germplasm collections conserved at the National gene bank.

The five farmer's commercial varieties characterized on farm were found to produce fruits of better quality in terms of shape, size, colour and glossiness with higher yields as compared to their representative samples characterized in field experiment at Roches Brunes. The differences noted in crop performance and fruit characters could be explained by the difference in agro climatic conditions prevailing in these two locations since yield is strongly influenced by its growth conditions.

The survey conducted at farmer's fields' generated important information about eggplant landraces grown in Mauritius, their characteristic ethno botanical features and cultivation practices that can guide future *ex-situ* and *in-situ* (on farm) conservation strategies. Furthermore eggplant landraces have been continuously improved through deliberate or unintentional selections of useful traits expanding the number of local variants among them and their morphological diversity. Crop production data gathered from survey questionnaires indicates that four major eggplant landraces, the long 'Cipaye long', semi long 'Cipaye Narain', oblong 'Rosita' and round 'Farcie' varieties are cultivated among local farmers.

Eggplant crop is grown on light sandy loam soils in the Eastern coastal region of the Island inducing early fruit production as compared to heavy humic soil type. Although eggplant is traditionally intercropped with other vegetables crops such as chilly and onions crops, increase in demand and remunerative market prices are leading to intensive monocrop cultivation system with higher planting density to boost up production. Moreover farmers are shifting to cultivation of high yielding hybrid eggplant varieties instead of landraces which nevertheless are identified as more robust plants with better resistance to pests and diseases and better tolerance to abiotic stress conditions. Habitat loss through land conversion activities on the other hand have resulted in small isolated and highly vulnerable fragmented populations of the wild types with a high risk of inbreeding depression and loss of population viability. They represent a valuable irreplaceable gene pool for future use in genetic improvement programme of the cultivated *S. melongena* species.

However the decline in eggplant landraces diversity due to agricultural intensification and rapid introduction of modern high yielding hybrid varieties is leading to increase incidence of genetic erosion into these species but also causing the loss of traditional knowledge associated with them.
Conservation is not an end in itself (Ayad et al. 1995). Eggplant genetic resources need to be actively reintroduced and integrated in the current crop vegetable production sector while increasing and maintaining crop varietal, morphological and genetic diversity.

Conclusion and Recommendations

Mauritius has rich eggplant genetic resources with important implications for research and conservation. The present study revealed wide morphological diversity in *S. melongena* accessions, their related species and wild types conserved at the National gene bank.

Multivariate Principal Component Analysis classified *S. melongena* accessions into four main cultivar groups. Fruit traits (shape, size and colour) were identified as important marker traits that most effectively discriminated between *S. melongena* accessions, their related species and wild types. Other useful marker traits were leaf and fruit calyx prickles, leaf blade lobbing and corolla colour that differentiated the wild types from *S. melongena* accessions and their related species. Simple classification of accessions into specific cultivar groups based on useful visual key marker traits such as fruit shape and colour will enable an effective management, enhanced conservation and sustainable use of eggplant genetic resources in Mauritius.

Heterogeneity in pedoclimatic conditions and farmers selection pressure for desirable traits across many generations has resulted in a significant degree of differentiation at inter and intra specific levels resulting in an important accumulation of morphological diversity in eggplant landraces. However the survey conducted at farmer's fields demonstrated the unprecedented erosion of eggplant landraces diversity. Modern hybrid varieties on the other hand were found to be highly susceptible to serious pests and diseases accounting for a rising cost of production with heavy use of pesticides. The wild *S. torvum* and *S. violaceum* species in contrast offer better resistance to these highly destructive pests and pathogens. They represent a valuable source of natural gene pool for hybridization and introgression of desirable genes into the cultivated varieties.

Since genetic diversity of traditional varieties (landraces) is the most economically valuable component of global biodiversity (Wood and Lenne 1997), both *ex-situ* and *in-situ* (on farm) conservation of eggplant landraces, their related species and wild types is essential to ensure their continued existence and availability for future use in crop improvement programme.

However a more complete in depth inventory and comprehensive documentation of all eggplant landraces, their related species and wild types occurring throughout the whole Island of Mauritius, supported with herbarium live plant specimen and annexed crop catalogue needs to be undertaken. Further investigation of genetic erosion intensity and ecological mapping of population diversity structure of eggplant landraces, their related species and wild types is considered as primordial. Simultaneously, on farm conservation of morphological diversity in eggplant landraces can be encouraged through incentive proactive measures such as preferential market prices with guaranteed niche market outlets, provision of seed planting materials, subsidy grant on irrigation and fertiliser costs and awareness raising among local farmers on the long term importance and mutual benefits of maintaining landraces for a more resilient diversified crop production system.

The legal protection of the local eggplant landraces, their related species and wild types also plays an important role in recognition of farmer's right under the ITPGRFA treaty.

Although morphological characterization is recognised as the starting point in assessment of genetic diversity, morphological markers should be complemented with molecular markers for more advanced genetic diversity study in eggplant crop germplasm conserved at the National gene bank in Mauritius.

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Appendix 1 Modified IBPGR (1990) Eggplant Descriptor List

1.0 Vegetative characters

1.1 Plant growth habit

3	Upright
5	Intermediate
7	Prostrate

1.2 Leaf blade length

3	Short	(~10 cm)
5	Intermediate	(~20 cm)
7	Long	(~30 cm)

1.3 Leaf blade width

3	Narrow	(~5 cm)
5	Intermediate	(~10 cm)
7	Wide	(~15 cm)

1.4 Leaf blade lobbing (Fig 1.)

1	Very weak
3	Weak
5	Intermediate
7	Strong
9	Very strong

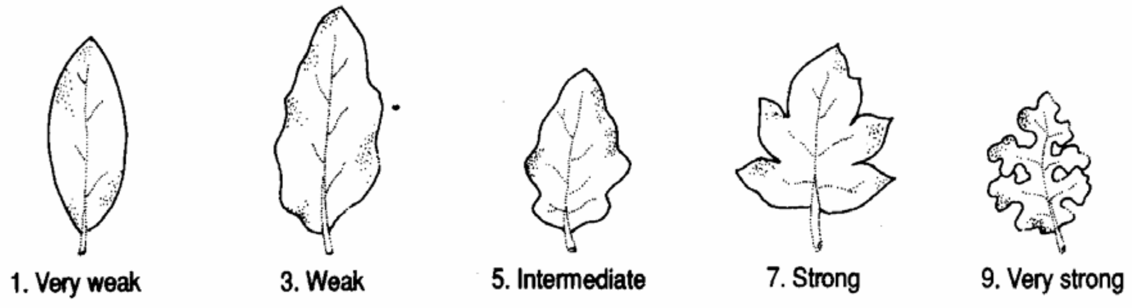


Fig. 1. Leaf blade lobing

1.5 Leaf blade tip angle (Fig. 2.)

1 Very acute ($<15^0$)
3 Acute ($\sim 45^0$)
5 Intermediate ($\sim 75^0$)
7 Obtuse ($\sim 110^0$)
9 Very strong ($>160^0$)

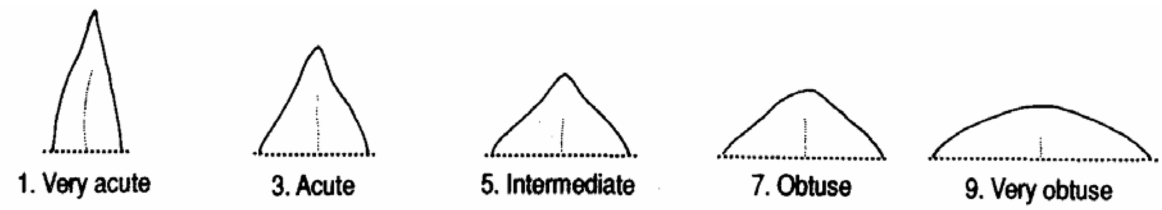


Fig. 2. Leaf blade tip angle

1.6 Leaf prickles
Number of prickles on upper surface of the leaf

0 None
1 Very few (1-2)
3 Few (3-5)
5 Intermediate (6-10)
7 Many (11-20)
9 Very many (>20)

1.7 Leaf hairs
Number of hairs per mm^2 on lower leaf surface of the leaf

1 Very few (<20)
3 Few (20-50)
5 Intermediate (50-100)
7 Many (100-200)
9 Very many (>200)

1.8 Plant height
At flowering stage

1 Very short (< 20 cm)
3 Short (~ 30 cm)
5 Intermediate (~ 60 cm)
7 Long (~90 cm)
9 Very long (>100 cm)

2.0 Inflorescence characters

2.1 Corolla colour

3	White	(Methuen 1A1)
5	Pale violet	(Methuen 18 A3)
7	Light violet	(Methuen 18 A5)
9	Bluish violet	(Methuen 18 A7)

3.0 Fruit Characters

3.1 Fruit length

From base of calyx to tip of fruit

1	Very short	(<1 cm)
3	Short	(~2 cm)
5	Intermediate	(~5 cm)
7	Semi long	(~20 cm)
9	Long	(>30 cm)

3.2 Fruit width

Diameter at broadest part

1	Very small	(<1cm)
3	Small	(~3cm)
5	Intermediate	(~5cm)
7	Large	(~10 cm)
9	Very large	(>10 cm)

3.3 Fruit curvature (Fig. 3.)

1	None (fruit straight)
3	Slightly curved
5	Curved
7	Snake shape
8	Sickle shape
9	U shape

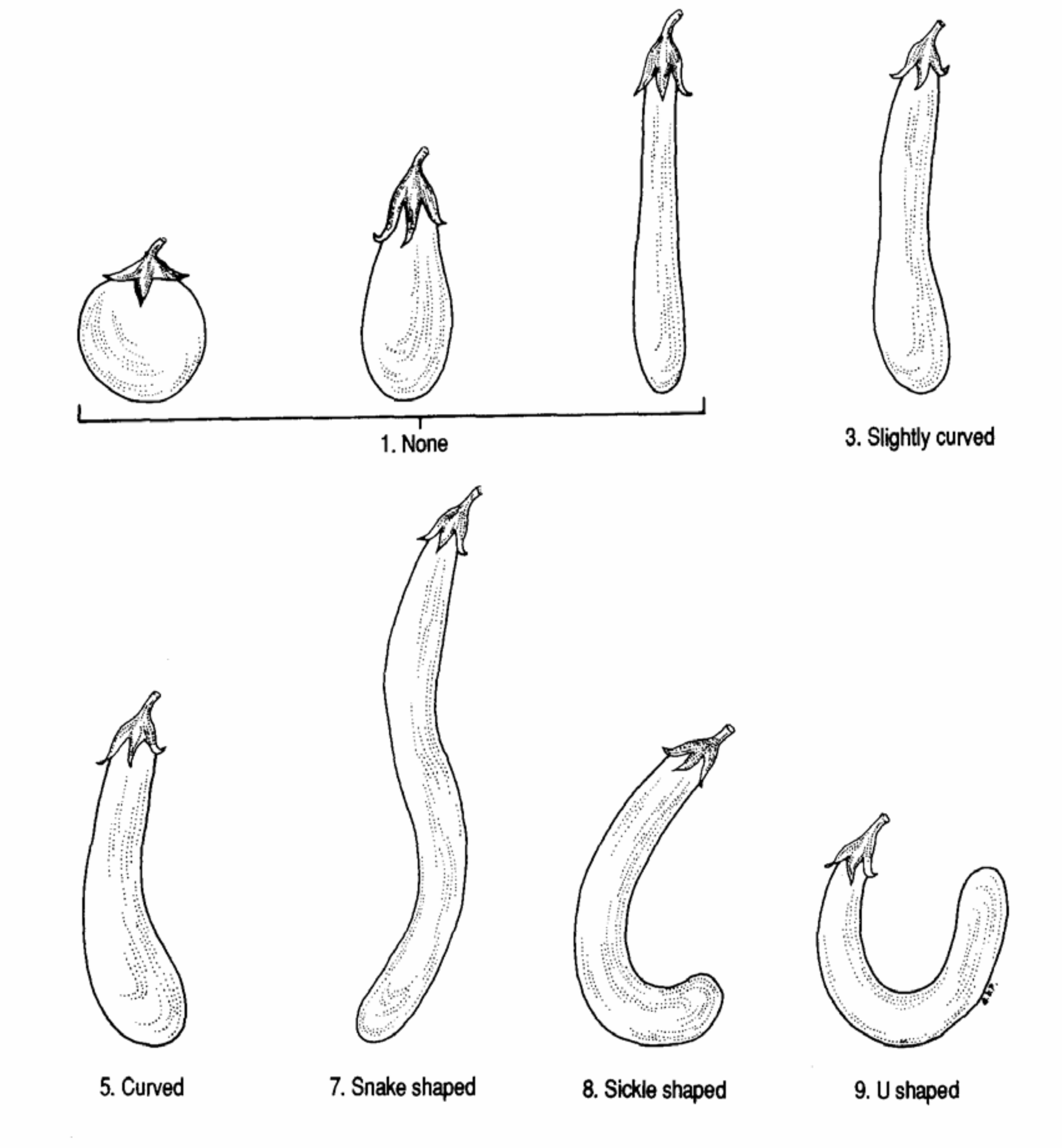
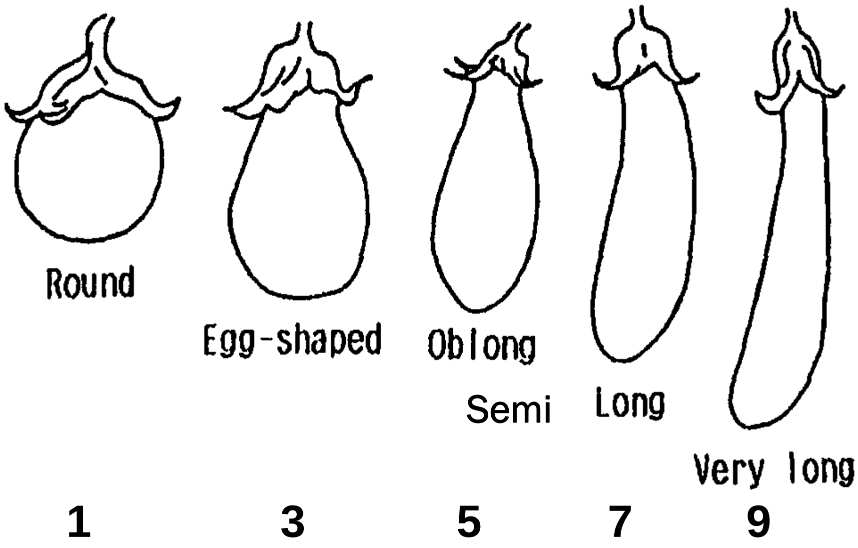


Fig. 3. Fruit curvature in eggplant

3.4 Fruit shape

1 Round
3 Egg shaped
5 Oblong
7 Semi long
9 Long



3.5 Fruit apex shape

3	Protruded
5	Round
7	Depressed

3.6 Fruit colour at commercial ripeness

1	Green	(Methuen 27D8)
3	Milk white	(Methuen 1 A2)
4	Lilac purple	(Methuen 16C3)
5	Purple	(Methuen 16D-E8)
7	Purple black	(Methuen 15 F5-8)
9	Black	

3.7 Fruit colour distribution at commercial ripeness

1	Uniform
3	Mottled
5	Netted
7	Striped

3.8 Fruit glossiness

3	Dull
5	Shiny
7	Very shiny

3.9 Fruit calyx prickles
Average number of prickles per calyx

0	None	
1	Very few	(<3)
3	Few	(~5)
5	Intermediate	(~10)
7	Many	(~20)
9	Very many	(>30)

4.0 Fruit position

1	Erect
3	Semi erect
5	Horizontal
7	Semi-pendant
9	Pendant

4.1 Fruit stalk length

1	Very short	(<3 cm)
3	Short	(~5 cm)
5	Intermediate	(5-8 cm)
7	Long	(~10 cm)
9	Very long	(>10 cm)

Appendix 2 Survey Questionnaire

Morphological diversity in eggplant genetic resources conserved at National gene bank. Master-thesis 2009

1 Questionnaire number Date:……………………

2. Characteristics of respondents

2.1 Name of Farmer: ……………………………………………………...

2.2 Address: ....

2.3 Age (yrs):……………Sex:................Education level:................................

2.4 Occupation: Part time ☐ Full time ☐

2.5 Experience in eggplant cultivation:…………… Years

2.6 Are you a member in any co-operative society? Yes ☐ No ☐

2.7 If yes, specify organisation:…...

2.8 Other agricultural activities: Yes ☐ No ☐

	Size of holding (m2 or ha)
Eggplant cultivation	
Other Vegetables (specify)	
Others (specify)..........................	

3. Ecology

3.1 Location of eggplant field:

……………………..…………………………...

……………………………………………………………………….........................

4. Planting materials

4.1 Source of planting material and eggplant varieties grown.

Source	Eggplant Varieties			
	Old landraces	Commercial hybrids	Farmer varieties	Others
On farm Seeds				
Market				
Ministry of Agro Industry				
Others(Specify)................				

4.1.1 If you save on farm seeds, how do you select fruits, extract seeds, dry and store them for next planting season and what kind of problems do you encounter during seed storage.

……………………………………………………………………………………...

……………..............……………………………………………………………………

……………………………………..…………………………………………………….

……………………………………………………………………………………......

4.2 What are the common eggplant varieties you prefer to grow & why?

	Common Varieties grown						
Fruit characteristic	Cipaye long	Cipaye narain	Rosita	Farcie	Black beauty	Suraba	Anguive
Fruit shape							
Fruit Colour							
Fruit yield							
Crop cycle							
Cultivation system							
Fruit uses							

Fruit shape: (1) long (2) Semi long (3) Oblong (4) round

Fruit Colour: (1) Purple: P (2) Green: G (3) White: W (4) Yellow: Y

Crop cycle: (1) 6 months (2) 9 months (3) 12 months

Market Demand: (1) High (2) Average (3) low

Fruit Yield (Kg/Ha): (1) High (2) Average (3) low

Cultivation system: (1) Open Field (2) Plastic House (3) Green house

Uses: (1) Cooked vegetable (2) pickles (3) cakes (4) Desert (5) medicine (6) salad or others…………………………..

4.2.1 Why did you choose to grow theses eggplant varieties?

Good Adaptability to local climate	
Easy to grow	
Low susceptibility to pests & diseases	
High Yield	
Good fruit quality	
High market demand	
High market price	

5. Eggplant cultivation practice

5.1 Land Preparation

	Types of machines used
Manual	
Mechanical	
Others (specify) ……………………	

5.2 Planting

5.2.1 Seedling production

	Nursery	Open Fields
Direct sowing in beds		
Seedling raised in pots PVC cylinder tubes		
Others (Specify)		

5.2.2 Do you perform any seed treatment with fungicide & hot water treatment at 50 ^{0}c for 25 mins before sowing seed?.

………
………
…………………………………………………………………………………….

5.2.3 What are the problems encountered in seedling production?

Poor seed germination	
Weak seedling plants	
Pests & disease infection	

Comments…………………………………………………………………..
…………………………………………………………………………...
……………………………………………………………………………

5.2.4 What percentage of seedlings is successfully transplanted in field?

…………………………………………………………………………...

5.3 Field layout

	Soil	Sand loam soil
Ground level		
Raised Beds		
Furrows		

5.3.1 Planting spacing used.

	Soil		Sand loam soil	
Variety	Distance between rows (m)	Distance between Plants (m)	Distance between rows (m)	Distance between Plants (m)

5.4 Planting season………………….Sowing month……………….........

5.5 Do you practice intercropping? If yes, what crops do you intercrop and why?

…………………...………………………………………………………………

……………………………………………………………………………………...

6. Cultural Practices

6.1 Fertilisation regime

Time of application	Type of fertiliser used	Frequency of application	Rate kg/arp
Seedling stage			
At transplanting			
Flowering & Fruiting			
At Harvesting			

6.2 Irrigation management

Type	Rate (L/day)	Time
Rain-fed		
Watering can		
Drip		
Overhead		
Sprinkler		

6.3 Weed control

Manual	
Mechanical	
Chemical	

6.4 Pests and Diseases control

Pests & Diseases	Control	Frequency	Dosage (ml per application if chemical control is used)

6.5 Is there any type of pruning or thieving practiced to induce early fruiting?

…………………………………………………………………………………

…………………………………………………………………………………

6.6 Do you practice any type of grafting? If yes, how you do it?

…………………………………………………………………………………

…………………………………………………………………………………

6.7 Windbreaks

6.7.1 Do you think a windbreak is important? Yes ☐ No ☐

6.7.2 If yes, types of windbreak used?

…………………………………………………………………………………......

6.7.3 Is cyclone a major threat to eggplant cultivation? Yes ☐ No ☐

If yes, extent of damage: ……………………………………………………

7. Labour

7.1 Type of labour used and costs

………………..…………………………………………………………………

…………………………………………………………………………………

8. Yield

Cultivar	Harvest stage	Frequency harvest (D-daily, W-weekly, F-fortnightly, M-monthly)		Total yield (Kg/Ha)	
		Summer	Winter	Summer	Winter

8.1 Do you intend to grow any new or other varieties and why?

…………………………………………………………………………………

…………………………………………………………………………………

8.2 Do you think that it is important to conserve old eggplant landraces?

☐ Yes ☐ No If yes, why is it important?

……………………………………………………………………………………

…………………………………………………

8.3 How do you intend to increase your average yield/production unit?

High Yielding Varieties with better resistance to pest & diseases	
More efficient fertilisation and water management regime	
More investment to infrastructure (Nursery)	
Others (specify)	

9. Constraints in commercial eggplant production

9.1 Constraints regarding inputs

9.1.1 Planting materials

Is availability of planting materials and suitable varieties a constraint? Yes ☐ No ☐
Is planting material and new varieties expensive? Yes ☐ No ☐
Please state any other problem/s with respect to planting materials.
……………………………………………………………………...………
………..…………………………………………………………………………
9.1.2 What other constraints do you face in eggplant cultivation?

……………………………………………………………………………………

……………………………………………………………………………………

9.1.3 Constraints due to biotic factors

	Occurrence	
	Winter	Summer
Pest invasion		
Disease invasion		
Drought		
Torrential rainfall		

10. Additional comments

………………………………………………………………………………

……………………………………………………………………………......

....