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MORPHOLOGICAL CHARACTERIZATION OF JUTE MALLOW, Corchorus sp. TO ASSESS ITS GENETIC DIVERSITY IN WESTERN KENYA

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Abstract

Jute mallow is an important African Leafy Vegetable, grown in western Kenya. It is highly nutritious and is a source of income for farmers. However, jute mallow is facing extinction due to replacement by high yielding commercial, exotic vegetables varieties. Unavailability of seeds of appropriate and improved cultivars has also led to underutilization of jute mallow vegetables. One of the ways to address these problems is through genetic enhancement. Genetic enhancement requires the assessment of genetic diversity in an area. This study characterized various morphotypes of jute mallow in Kakamega, Vihiga and Siaya districts of Western Kenya. Morphotypes were identified using various parameters. These parameters were leaf length and width, pod length and width, plant height, length of internodes and number of seeds per pod. Statistical analysis of these parameters was done by analysis of variance (ANOVA) using the Statistical analysis Software (SAS) package. Means were separated using Scheffe's multiple comparison procedure. Cluster analysis of the morphotypes was done usingsquared Euclidean distances method to find out the relationships between the morphotypes. Eight morphotypes of jute mallow were observed. Complete identification of all the jute mallow morphotypes was not possible due to overlap of the descriptors among the morphotypes. Only 3 morphotypes were identified which were *Corchorus trilocularis* L., *C. tridens* L. and *C. olitorius* L. Data obtained will be useful to breeders and seed production entities in their efforts to come up with high yielding varieties that are well adapted to local ecological conditions.

Key words: *Corchorus* sp., genetic diversity, jute mallow, morphotypes.

Introduction

Jute mallow is an important leafy vegetable commonly produced and consumed in many tropical regions (Maundu et al., 1999). It is an important source of nutrients and income (Abukutsa-Onyango, 2003). Jute mallow is used to produce bast (soft) fibers which are used to weave Hessian or burlap bags and sacks (Maundu *et al.*, 1999). It has medicinal properties as well as other ceremonial roles (Mnzava & Chweya, 1997; Schippers, 2002). For example jute mallow is used as a laxative and scrapings from the roots are also to ease teeth pain (Maundu et al., 1999). Enhanced production of these vegetables can help farmers to tap into all these uses.

Jute mallow plants belong to the genus *Corchorus* sp. of the family Tilliaceae. There are more than 15 species of *Corchorus*. They are characterized as an annual upright, branching, glabrous, slightly woody herb. Leaves are narrow and serrate, about 5-13 cm in length. Flowers are small, yellow, petioled and borne in small clusters in the leaf axils. The cylindrical capsules of 2-5 cm are produced in large numbers, especially during the short days (Schippers, 2002). Seeds are dark bluish-green, angular, and about 2 mm long. Jute mallow varieties differ in plant height. They also differ in leaf and fruit shape, leaf and stem colour, pubescence, branching habit, and height. The most widely cultivated species is *C. olitorius* L., *C. capsularis* L. is closely related

but differs in fruit shape. *Corchorus* sp. is self pollinating. The choice of species and variety for vegetable production is dictated mainly by what is available (Palada & Chang, 2003).

African leafy vegetables (jute mallow included) are storehouses of genetic diversity and beneficial traits such as drought tolerance, resistance to some pests and diseases and tolerance of poor soil conditions that breeders can use to improve crops (Abbass, 2000). ALVs are easier to grow and more resistant to pest and diseases than exotic vegetable varieties (Ruibaihayo et al., 2002 – unpublished report). One of the main constraints facing production of these important yet underutilized vegetables is unavailability of improved cultivars (Raymond, 2000). Currently, very little selection has been made to obtain optimum varieties. Consequently, jute mallow vegetables grown by farmers are a mixture of landraces. However, clear differences have been reported in plant size and architecture, branching capacity, shape and size of the leaves and other characteristics which warrants basic breeding efforts (Schippers, 2002). Even though cultivation and utilization has been increasing in the recent years, jute mallow vegetables are still undergoing genetic erosion and loss of indigenous knowledge concerning them. This is due to less than optimum cultivation and utilization (Rubaihayo et al., 2002). There is an urgent need for intervention to avoid loss of this very useful crop.

One of the interventions that can be used is genetic enhancement. Genetic enhancement would ensure availability of high yielding varieties that are well adapted to local ecological conditions hence leading to *in-situ* conservation (conservation of the varieties in the farmers' fields through cultivation). Genetic enhancement can be done through a series of steps. These steps include collection of germplasm, screening of germplasm by scientists, identification of desirable varieties by farmers, traders and consumers, seed multiplication for a number of varieties and selection of desirable varieties by farmers or traders, development of new varieties by combining the preferred varieties, agronomic research and development of a technical package on appropriate agronomic practices for seed production (Schippers, 2002; Watson & Eyzaguirre, 2002).

The present study concentrated on the first two steps which were collection of germplasm and screening of germplasm for morphological differences. The objective of the study was to assess the genetic diversity of jute mallow found in western Kenya using morphological descriptors. Information obtained can be used to breed varieties that have desirable traits such as high seed and leaf yield, longer vegetative phase, adaptation to environmental stress such as drought, high leaf nutrients and palatability.

Materials and Methods

Seed collection

Jute mallow seed samples were collected from farmers in Kakamega, Vihiga and Siaya districts using scientific germplasm collection techniques in December 2004. This first entailed studying the maps of Kakamega, Vihiga and Siaya districts and selecting 10 seed collecting sites per district along transects made in each district. Possible routes to be used during collection were noted. Collection sites were selected taking into account the ecological variations in the study area. Sampling was done in farmers' fields, in farmers' stores and in market centers. Collection in farmers' fields was done systematically at regular intervals of 3 paces along small transects made at each site. 3 different members of the team walked the 3 different transects and sampled from plants that produced a lot of seeds. Twenty percent of seed available on each plant was collected. Number of plants sampled per site was 21 and the seeds from different plants were kept separate. This was done to capture as much of genetic alleles in the population as possible. Care was taken not to harvest empty pods or immature seeds from the farms. Pods found on the ground were not collected as they may have been subjected to deterioration. Harvesting of pods was done by cutting off the pods using a knife. Seeds collected were put into non-glossy brown paper bags to ensure good aeration for the seeds. The brown paper bags were double packed and stapled at the top. Each brown paper bag was labeled using an accession number,

species and location collected. More information was recorded on data sheets and included accession number, collection number (same as bag number) collection date, name of main collector, institution, other collectors' names and institutions, country, district, division, location and sub location, latitude and longitude, taxon name, vernacular name(s), number of plants sampled, number of flowers versus fruits, sampling method, sampling area visited (in m2), slope, soil texture, soil PH, land use, threats to the species, site notes (observations or any relevant information) associated species (plants commonly grown alongside the species being studied), collecting notes (e.g. problems encountered, collecting method, estimate of seed numbers, flower colour etc). Seeds collected from farmers' stores in the homesteads and market places collection were done as randomly as possible (by selecting every 4th farmer/trader) and similar data sheets as the ones for the collection in the farms filled. Seeds were stored in brown paper bags up to January 2005 when the characterization of morphotypes began.

Laboratory experiments

Composite sample of jute mallow seeds were made. Inert materials like stones, crops residues and seeds of other crops were removed to obtain pure seed samples. Germination tests were carried out to assess their seed viability. Jute mallow seeds exhibited dormancy which was broken using mechanical scarification which entailed rubbing the seeds between two sand papers (Gauge – P180) with moderate pressure for 3 minutes.

Green house experiments

Soil collected at Chepkoilel University College, Eldoret was mixed with farm yard manure at the rate of 2.5 g /m2 and used to fill 4 wooden boxes (measuring 47cmx 29 cm x 6.5 cm). Soil type was identified as oxisols (Soil survey staff, 1992). Shallow drills were made in the soil using a stick at a spacing of 15 cm apart. Pure seed samples whose dormancy was broken were sown into the drills. The boxes were placed in a green house. Watering was done three times a week. Weeding was done 3 times during the growing season to keep the plants weed free. Thinning was done when the plants had 3 true leaves to obtain a spacing of 10 cm between the plants for both vegetables. Spraying against spider mites was done twice, at 3 weeks and 6 weeks using Dictator plus 250 (active ingredient 21.2% propargite and 75% tetraddefon) at a rate of 1.5ml/ha. No leaf defoliation was done as leaf defoliation could affect leaf surface area available for photosynthesis hence affecting seed filling and deposition of seed storage materials (Bewley & Black, 1994). Eight morphotypes were identified through simple observation of parameters such as leaf and pod length and width, leaf and stem colour. Seeds formed by each morphotype were harvested separately and cleaned.

Seeds from each morphotype were planted in separate boxes in a randomized complete design (RCD) with 3 replicates for each morphotype. Agronomic practices described in the preceding paragraph were used to establish the varieties. Measurements of various parameters (leaf length and width; pod length and width; plant height; number of internodes) were done after 3 months using string and ruler. Leaf and flower colour, was observed. The results obtained were compared to descriptions of jute mallow in related literature (Schippers, 2002; Maundu, et al., 1999).

Data on measurements of various parameters (leaf length and width, pod length and width, plant height, number of internodes, length of internodes and number of seeds per pods) were analyzed using Analysis of variance (ANOVA) and means were separated Scheffe's multiple comparison procedure. Cluster analysis of the morphotypes was done using squared Euclidean distances method. Statistical analysis software (SAS) package was used (SAS, 1998).

Results

Using general descriptors (leaf colour, leaf shape, colour at the stem node, colour of stem and average plant height) eight jute mallow morphotypes were identified (Table 1). All the morphotypes were erect woody herbs whose leaves ranged from ovate to elliptic with serrated leaf margins and basal protrusions. Leaf colour

among the morphotypes ranged from light green to dark green, with some leaves being glossy while others were not. Morphotype 3 was the only one with elliptic leaf shape while the rest had oval leaves.

Morphotypes differed in the colour of the nodes and stems which ranged from red to pink to green. All the flowers were yellow and the fruits were short stalked cylindrical capsules which split into 2 - 5 parts. The seeds were greyish black and angled. Morphotypes differed in plant height. There were some tall varieties and short varieties (Table 1).

Table 1
Summary of general characteristics of jute mallow morphotypes

Morphotype	Leaf colour	Leaf Shape	Colour at stem node	Colour of stem	Average height
1	Non glossy light green serrated leaves	Oval	Green	Pink	64 cm
2	Non glossy light green with red serrated leaves	Oval	Red	Red	76 cm
3	Glossy dark green leaves	Elliptic	Green	Light green	35 cm
4	Non glossy light green leaves	Oval	Green	Red	72 cm
5	Non glossy dark green	Oval	Green	Pink	79 cm
6	Glossy light green with red serrated margins	Oval	Red	Dark red	38 cm
7	Non glossy dark green leaves	Oval	Green	Red	75cm
8	Non glossy light green	Oval	Green	Light green	52 cm

Leaf length and width, pod length and width, plant height, length and number of internodes significantly differed among the morphotypes (Table 2).

Table 2
Analysis of variance for various parameters of jute mallow morphotypes during characterization

Parameter	Source	df	Mean square	F	Significance
Leaf length	Morphotypes	7	14.155	8.584	.000*
	Error	67	1.649		
Leaf width	Morphotypes	7	10.405	12.039	.000*
	Error	67	.864		
Pod length	Morphotypes	7	1.327	6.849	.000*
	Error	24	.194		
Pod width	Morphotypes	7	.096	5.287	.001*
	Error	24	.018		
Plant height	Morphotypes	7	1699.314	75.489	.000*
	Error	28	22.511		
Length of internode	Morphotypes	7	18.921	116.401	.000*
	Error	28	.163		
Number of internodes	Morphotypes	7	127.311	75.925	.000*
	Error	28	1.677		

*Significant at P = 0.01

Morphotype 3 had the longest and widest leaves compared to the other morphotypes (Table 3). Morphotype 3 had the widest pods compared to others. Morphotype 2 had the longest pod length compared to others (Table 3).

Table 3
Means of leaf and pod parameters of jute mallow morphotypes

Morphotype	Mean leaf length (cm)	Mean leaf width (cm)	Mean pod length (cm)	Mean pod width (cm)
1	8.03± 0.55b	4.21±0.40a,b	5.00±0.22b,c	0.83±0.07a
2	8.20±0.41b	2.73±0.30a	6.00±0.22d	0.85±0.07a
3	10.42±0.33b,c	5.83±0.23d	4.05±0.22a	1.13±0.07b
4	9.30±0.52c	3.06±0.37a,b,c	5.30±0.22c	0.75±0.07a
5	6.19±0.42a	4.94±0.30c	4.90±0.22b,c	0.83±0.07a
6	9.70±0.79b	5.37±0.57b,c	4.50±0.22a,b	1.13±0.07b
7	8.62±0.79b,c	4.02±0.57b,c	5.15±0.22b,c	0.88±0.070a
8	9.20±0.35b,c	3.89±0.26a,b	4.75±0.22b,c	1.10±0.07b

Means having the same letters within the same column are not significantly different at P = 0.01

Mean plant heights significantly differed among the morphotypes. Morphotype 3 and 6 were short while the rest were tall (Table 4). The internode length differed among the morphotypes. Morphotype 5 had the longest mean internode length compared to others and morphotype 3 had the shortest internodes (Table 4). Mean number of internodes also significantly differed among the morphotypes with morphotype 4 having the highest number and morphotype 3 having the lowest number compared to other morphotypes.

Table 4
Mean plant height, length of internode and number of internodes

Morphotype	Mean plant height (cm)	Mean length of internode (cm)	Mean number of internode
1	68.000±2.122a	5.000±0.180a	21.000±0.579a
2	77.800±2.122b	6.880±0.180a	19.800±0.579a
3	34.000±2.122c	2.000±0.180b	12.800±0.579b
4	72.500±2.122a	4.500±0.180c	30.000±0.579c
5	80.800±2.122b	7.660±0.180d	20.600±0.579a
6	37.500±2.122d	2.500±0.180b	15.000±0.579d
7	75.000±2.122b	4.000±0.180e	20.000±0.579a
8	53.200±2.122e	4.120±0.180e	20.200±0.579a

Means having the same letters within the same column are not significantly different at P = 0.01

Cluster analysis of the morphological traits of the 8 jute mallow morphotypes revealed 4 clusters as shown by the distances from each other. Morphotype 2, 7 and 5 are closely related while 1 and 4 were also close in terms of morphological characteristics. Morphotype 3 and 6 were closely related while 8 was fairly distinct from the rest of the morphotypes (Figure 1).

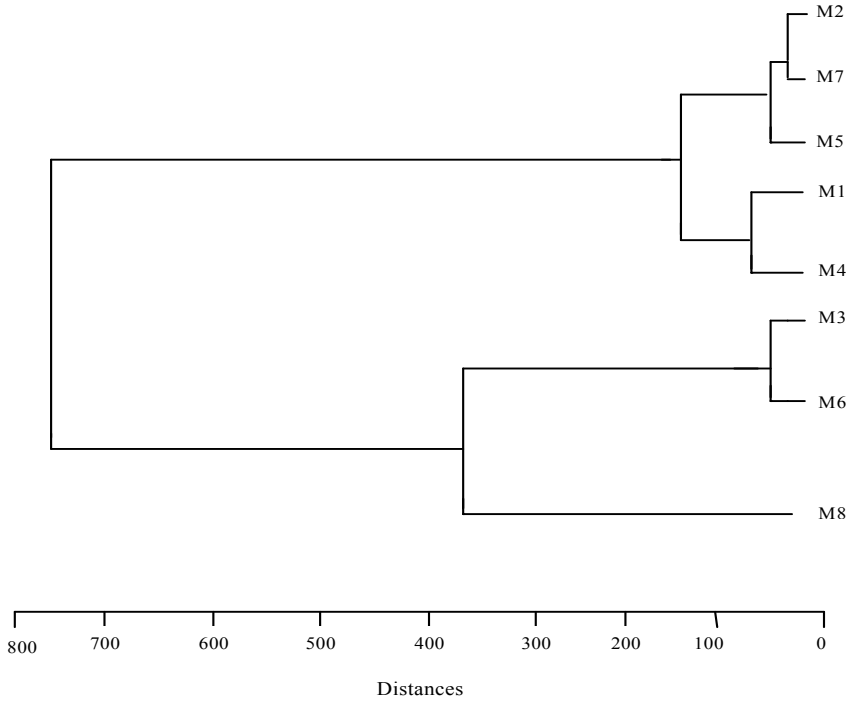

Figure 1
Dendogram based on squared Euclidean distances generated by mean morphological trait data for the 8 jute mallow morphotypes in Western Kenya

Discussion

Eight morphotypes were identified according to various parameters considered. This is consistent with other research findings which indicate farmers in Western Kenya cultivate up to 8 types of jute mallow morphotypes (Maundu et al., 1999). All the morphotypes except morphotype 3 had red / pink colourations along the leaf margins or on the stem nodes. A study in Kakamega also found that there are several lines of jute mallow (KARI, 2004 – unpublished report). Similarly, one line was found to have green stems while another had red stems with red leaf margins and internodes. Stem and petiole colour have high heritability and are useful as descriptors for farmers (IBPGR, 1981). This colouration is due to the presence of anthocyanins which accumulate in certain plant tissues and are responsible for a variety of colours like red, blue and purple. The accumulation is controlled by environmental factors such as light, temperatures, nutrients and stress as well as genetic factors (Beggs & Wellman, 1994). These pigments belong to the general class of flavonoids, which have many functions that include pre-infection mechanisms of disease resistance, increase in osmotic pressure of the cell sap hence enhancing absorption of water by the root hairs from the soil and water movement within the plant, assistance in respiratory and photosynthetic processes as well as protection of chlorophyll from being decomposed by strong lights (Hill, et al., 1981; Kochlar & Krishnamoorthy, 1992). These roles of anthocyanins may also be applicable to jute mallow morphotypes and may be part of the reason they are able to survive in various agro ecological zones in Kenya.

Studies in other countries indicate that jute mallow species differ in leaf and fruit size, leaf and stem colour and height (Palada & Chang, 2003; Akoroda, 1985). This study also found this to be the case in western Kenya. Morphotype 1 was *Corchorus trilocularis* L. as it corresponded to the description given in literature for this species (Maundu et al., 1999, K'Opondo, 2004 - unpublished report). It had oval, broad, non glossy light green leaves. Morphotype 2 was *C. tridens* L. as it was similar to *C. trilocularis* L. except that it had narrow leaves. Morphotype 3 was identified as *C. olitorius* L.due to its elliptic leaf shape, short plants, glossy and large leaves (Maundu *et al.,* 1999). Specific identification of the rest of the 8 morphotypes in this study was not possible due to some overlap in characteristics. Some of the jute species (e.g. *Corchorus olitoriu*s L.) have various cultivars which vary significantly in morphological characteristics (Maundu et al., 1999; K'Opondo, 2004 – unpublished report). One study classified *C. olitorius* L. into 3 groups *Olitorius*, *Incisifolius* and *Geant de Bertoua,* based on leaf shapes (Westphal, 1983). The clear differences plant size and architecture, branching capacity, shape and size of the leaves and other characteristics are important as they may determine desirable traits such as high seed and leaf yield, longer vegetative phase, adaptation to environmental stress such as drought, high leaf nutrients and palatability (Schippers, 2002 & Abbas, 2000).

The dendogram on the jute mallow morphotypes revealed 4 clusters. Morphotype 2, 7 and 5 were closely related and so were 1 and 4. Morphotype 3 and 6 were also closely related while 8 was fairly distinct from the rest of the morphotypes. Molecular characterization of these morphotypes may be a clearer way of establishing the exact identity of the morphotypes. However this was beyond the scope of this study.

Conclusions

- Eight jute mallow morphotypes were identified using various parameters.
- Although leaf length and width, pod length and width, plant height, mean number and length of internode varied significantly among the morphotypes there was considerable overlap hence the exact identity of some the jute mallow morphotypes could not be ascertained. Genetic mapping could be used to ascertain the identity of these morphotypes
- Clear differences in plant size and architecture, branching capacity, shape and size of the leaves and pods among the morphotypes warrants basic breeding efforts

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