Morphological characters of guava landraces in Western and Coastal Kenya

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Abstract

Morphological characterization was of guava landraces from Western and Coastal landraces was done using 13 qualitative and 2 quantitative descriptors. Root descriptors between the landraces in the two regions did not show differences while the leaf, fruit, branching of stem showed variations. Leaf shape varied, being oblong, trapezoidal, elliptical and ovate. Branching habits were either axial,erect or irregular. Ripe fruit color varied from pink to cream.Grouping of characters using unweighed neighbour joining (Darwin software) resulted to three clusters.The clusters had landraces within the region and others clustered across the region.The results revealed that Kenyan landraces varied morphologically within and across regions.

Key words: Morphological variation; fruit character; Root; Leaf shape; Branching habit

1.1 Introduction

Guava (*Psidium guajava* L.) is native to tropical America where it exists as a wild and cultivated plant. In East Africa, guava grows well from sea level to an altitude of about 2000 m above the sea level. The tree generally begins bearing 1 or 2 years after planting and continues fruiting for 30 years [1]. The fruit is an excellent source of vitamin C, calcium, potassium and iron [2]. It is consumed ripe or after being processed; leaves are used in traditional therapy in dysentery, diabetes, acute diarrhea, cough and intestinal spasmodic diseases [3]. Several guava cultivars have emerged as a result of seedling selection. Seedlings have also given rise to several types which are not true to the recognized guava cultivars and vary greatly from the parental populations [4]. Morphological traits are phenotypic markers that can aid in identification of plants [5]. Morphological characteristics such as leaf shape, leaf size, color of leaf veins, color of leaf apex, pubescence on apical leaves, leaf margin, root hairs, root shape, color of root cortex, color of root pulp, branching habit, color of fruit epidermis, color of fruit endocarp [4] have been used to differentiate plants. Morphological characterization may be useful in improvement of guava [6] in the Western and Coastal Kenyan regions.

2.0 Materials and Methods

2.1 Study site and sampling

Samples were collected from 9 sites; 6 sites from Western Kenya in Butere, Mumias districts and three sites from Coastal region. Western sites included Kisa, Evukambuli, Bumamu, Bukura, Makunga and Sabatia. Temperature in the Western Kenya ranged from 17°C-22°C. Coastal sites included Shimba, Ukunda and Msambweni; the temperature at the Coastal sites had an annual temperature of 24.2°C (Fig.1).

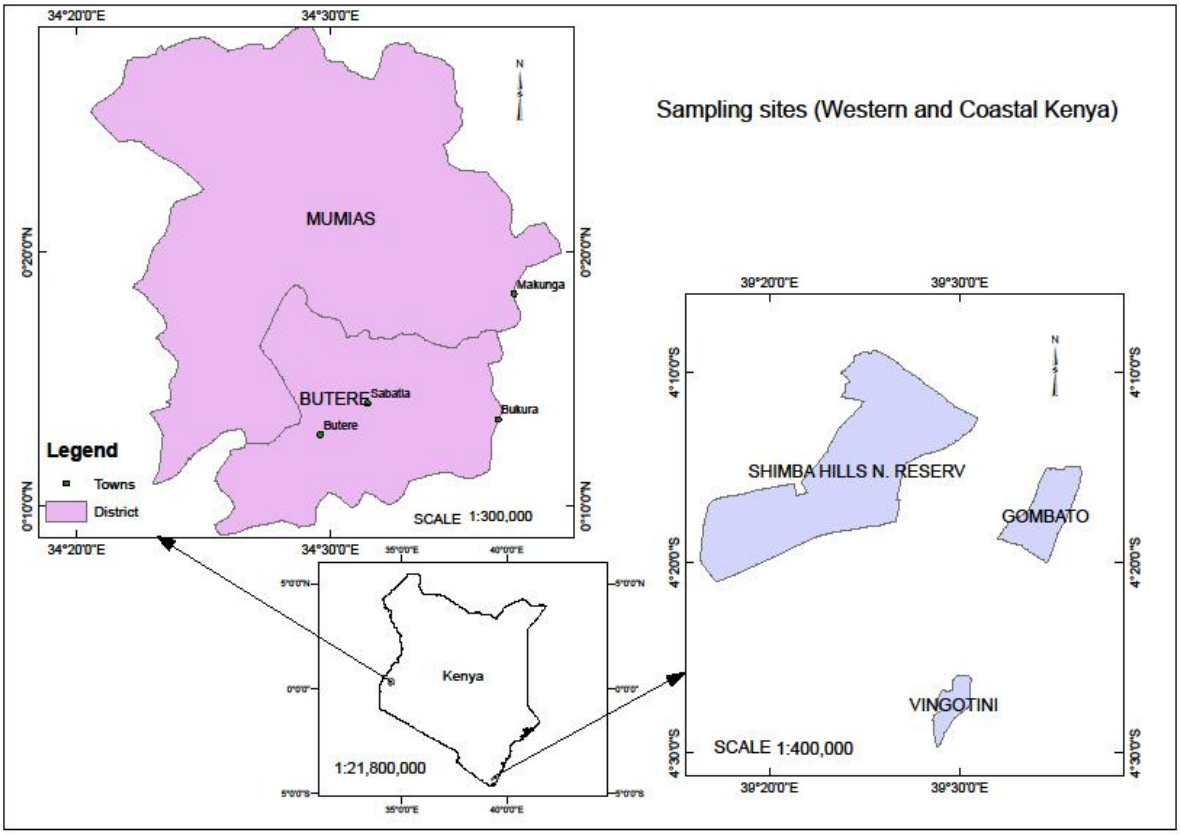

Fig. 1. Collection sites in Kenya

Purposive sampling technique was used and the trees under study were tagged. An average of 6 trees at each site was studied. Samples from Kisa were denoted as SHIS001- SHIS006. Evukambuli samples were labeled as EVUK001- EVUK006. Bumamu samples were labeled as BUM001-BUM006. Bukura samples were labeled as BUK001-BUK009.Samples from Makunga were labeled as MAK001-MAK006. Sabatia samples were labeled as SAB001- SAB01. Shimba samples were labeled as SHIM001-SHIM006.Ukunda samples were labeled as UK001-UK004. Msambweni samples were labeled as MSA001-MSA005. Morphological descriptors were based on [7, 8].The descriptors were scored as in table 1

Table 1.Leaf, stem, root and fruit descriptors with scores

Descriptor						
Colour of apical leaf	1-yellow green with brown margin	2-light green with brown margin	3-greenish brown	4-reddish brown	5-brilliant reddish brown	6-green
Pubescence on apical leaf	0-Absent	1-present				

Leaf retention	1-very poor	2-less than average	3-average	4-better than average	5-average
Petiole colour	1-yellow green	2-green	3-Reddish green	4-red	
Colour of leaf vein	1-light green	2-green	3-reddish green	4-red	
Leaf shape	1-ovate	2-trapezoidal	3-oblong	4-elliptical	
Leaf colour	1-light green	2-dark green	3-green	4-green maroon	
Orientation of petiole	1-Inclined upwards	2-horizontal	3-inclined downwards	4-irregular	
Branch colour	1-light grey	2-dark grey			
Root					
Root hair	0-absent	1-present			
Root shape	conical	2-Conical cylindrical	3-cylindrical	4-irregular	
Colour of root pulp	1-white	2-cream	3-yellow	4-orange	5-pink
Colour of root cortex	1-white cream	2-yellow	3-Pink	4-purple	
Fruit					
Colour of fruit	1-green	2-yellow	3-Yellow pink		
Colour of fruit endocarp	1-White	2-yellow	3-Pink	4-red	

3.0 Results

3.1 Leaf and stem analysis

In the nine sites the leaf petiole were oriented upwards, the leaves were dropping. Variation was observed in color of apical leaves, leaf retention, petiole color, leaf shape stem color and branching habit.

In Sabatia the apical leaves were light green with brown margin and greenish brown. Leaf retention varied from very poor, less than average, average, better than average to outstanding. Petiole color observed was yellow green and green. Leaf shape was elliptical and oblong. Stem color was dark grey and branching habit was axial and irregular (Table 2)

Table 2: Variation of leaf and stem analysis in Sabatia

Sample	CAL	LR	PC	LS	SC	BH
SAB001	light green with brown margin	less than average	yellow green	elliptical	dark grey	axial
SAB002	greenish brown	better than average	green	elliptical	dark grey	irregular
SAB003	greenish brown	average	green	oblong	dark grey	irregular
SAB004	greenish brown	average	green	elliptical	dark grey	irregular
SAB005	greenish brown	average	green	oblong	dark grey	irregular
SAB006	greenish brown	average	green	oblong	dark grey	irregular
SAB007	greenish brown	very poor	green	oblong	dark grey	axial
SAB008	light green with brown margin	outstanding	green	elliptical	dark grey	axial
SAB009	light green with brown margin	average	green	elliptical	dark grey	irregular
SAB01	greenish brown	better than average	green	oblong	dark grey	axial

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf vein, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Bukura site, color of apical leaves was green. Leaf retention was better than average, average and outstanding. Petiole color was yellow green. Leaf shape observed was elliptical and oblong. Stem color varied from light grey to dark grey and branching habits were axial irregular and horizontal (Table 3)

Table 3. Variation in leaf and stem color of guava populations at Bukura

Sample	CAL	LR	PC	LS	SC	BH

BUK001	green	better than average	yellow green	elliptical	light grey	irregular
BUK002	green	better than average	yellow green	oblong	light grey	irregular
BUK003	green	better than average	yellow green	oblong	light grey	axial
BUK004	green	outstanding	yellow green	elliptical	light grey	irregular
BUK005	green	better than average	yellow green	elliptical	light grey	irregular
BUK006	green	better than average	yellow green	oblong	dark grey	horizontal
BUK007	green	outstanding	yellow green	oblong	dark grey	irregular
BUK008	green	outstanding	yellow green	elliptical	dark grey	horizontal
BUK009	green	average	yellow green	elliptical	dark grey	erect

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Makunga color of apical leaves observed was light green with brown margin and greenish brown. Leaf retention was average and outstanding. Petiole color was green. Color of leaf veins was green. Leaf shape observed was elliptical, oblong ovate and trapezoidal. Stem color was dark grey and light grey while branching habit was axial and irregular (Table 4)

Table 4. Variations in leaf and stem color of guava populations at Makunga

Sample	CAL	LR	PC	CLV	LS	SC	BH
MAK001	light green with brown margin	average	green	green	elliptical	dark grey	irregular
MAK002	greenish brown	average	green	green	ovate	light grey	irregular
MAK003	light green with brown margin	average	green	green	oblong	light grey	irregular
MAK004	greenish brown	outstanding	green	green	trapezoidal	dark grey	irregular
MAK005	greenish brown	outstanding	green	green	trapezoidal	dark grey	axial
MAK006	greenish brown	outstanding	green	green	oblong	dark grey	axial

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Evukambuli all apical leaves were light green with brown margin. Leaf retention was average, better than average and outstanding. Petiole color and color of leaf veins were green. Leaf shape was trapezoidal, oblong and elliptical. Stem color was dark and light grey while branching habits was axil, irregular and erect (Table 5)

Table 5. Variation in leaf and stem color of guava populations at Evukambuli

Sample	CAL	LR	PC	CLV	LS	SC	BH
EVUK001	light green with brown margin	outstanding	green	green	trapezoidal	dark grey	axial
EVUK002	light green with brown margin	outstanding	green	green	trapezoidal	light grey	irregular
EVUK003	light green with brown margin	outstanding	green	green	oblong	light grey	irregular
EVUK004	light green with brown margin	better than average	green	green	elliptical	light grey	axial
EVUK005	light green with brown margin	average	green	green	oblong	light grey	erect
EVUK006	light green with brown margin	average	green	green	oblong	light grey	irregular

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Bumamu, apical leaves were light green with brown margin and greenish brown. Leaf retention was average, better than average and outstanding. Petiole color was green Color of leaf veins was light green. Leaf shape was oblong and elliptical. Stem color was light grey while branching habits was axial, horizontal and erect (Table 6).

Table 6. Variations in leaf and stem color of guava populations at Bumamu

Sample	CAL	LR	PC	CLV	LS	SC	BH
BUM001	light green with brown margin	outstanding	green	light green	oblong	light grey	axial
BUM002	greenish brown	average	green	light green	oblong	light grey	erect
BUM003	light green with brown margin	outstanding	green	light green	oblong	light grey	axial
BUM004	greenish brown	outstanding	green	light green	elliptical	light grey	horizontal
BUM005	greenish brown	better than	green	light	elliptical	light grey	axial

BUM006	greenish brown	average better than average	green	green light green	oblong	light grey	erect

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Kisa apical leaves were light green with brown margin and greenish brown. Leaf retention was outstanding. Petiole color was green and color of leaf veins was light green. Leaf shape observed was trapezoidal and oblong. Stem color was light grey while branching habits was axial and irregular (Table 7).

Table 7. Variation in leaf and stem color in guava populations at Kisa

Sample	CAL	LR	PC	CLV	LS	SC	BH
SHIS001	greenish brown	outstanding	green	light green	trapezoidal	light grey	irregular
SHIS002	greenish brown	outstanding	green	light green	oblong	light grey	irregular
SHIS003	greenish brown	outstanding	green	light green	trapezoidal	light grey	irregular
SHIS004	light green with brown margin	outstanding	green	light green	trapezoidal	light grey	axial
SHIS005	light green with brown margin	outstanding	green	light green	oblong	light grey	axial
SHIS006	light green with brown margin	outstanding	green	light green	oblong	light grey	erect

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Shimba leaf apex was greenish brown and green. Leaf retention was less than average, average and better than average. Petiole color and color of leaf veins was green. Leaf shape observed was ovate, elliptical and oblong. Stem color was light grey while branching habits was erect (Table 8).

Table 8. Variations in leaf and stem color of guava populations at Shimba

Sample	CAL	LR	PC	CLV	LS	SC	BH
SHIM001	greenish brown	less than average	green	green	oblong	light grey	erect
SHIM002	greenish brown	less than average	green	green	elliptical	light grey	erect
SHIM003	greenish brown	better than	green	green	elliptical	light grey	erect

		average					
SHIM004	green	average	green	green	ovate	light grey	erect
SHIM005	green	better than average	green	green	ovate	light grey	erect
SHIM006	green	better than average	green	green	oblong	light grey	erect

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Ukunda apical leaves were light green with brown margin. Leaf retention was less than average, average and better than average. Petiole color was green and yellow green Color of leaf veins was green. Leaf shape observed was ovate and oblong. Stem color was light grey and dark grey while the branches showed erect habits (Table 9).

Table 9. Variations in leaf and stem shape and color in guava populations in Ukunda

Sample	CAL	LR	PC	CLV	LS	SC	BH
UKU001	light green with brown margin	better than average	green	green	oblong	light grey	erect
UKU002	light green with brown margin	better than average	green	green	ovate	dark grey	erect
UKU003	light green with brown margin	average	yellow green	green	oblong	dark grey	erect
UKU004	light green with brown margin	less than average	yellow green	green	oblong	dark grey	erect

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

In Msambweni apical leaves were light green with brown margin and green. Leaf retention was outstanding and better than average. Petiole color was green and green yellow. Color of leaf veins was green. Leaf shape observed was elliptical, ovate and oblong. Stem color was light grey and dark grey while branch habits was erect (Table 10)

Table 10. Variations in leaf and stem color and shape of guava populations in Msambweni

Sample	CAL	LR	PC	CLV	LS	SC	BH
MSA001	light green with brown margin	outstanding	green	green	oblong	dark grey	erect
MSA002	green	outstanding	green	green	oblong	dark grey	erect
MSA003	light green with brown margin	better than average	green	green	elliptical	light grey	erect

MSA004	light green with brown margin	better than average	yellow green	green	ovate	light grey	erect
MSA005	green	better than average	green	green	ovate	light grey	erect

LR- Leaf retention, PC-Petiole color, CLV- Color of leaf veins, LS-Leaf shape, SC-stem color, BH- Branching habit, RS-Root shape, CRP- Color of root pulp, CRC- Color of root cortex

The predominant color of young apical leaves was greenish brown, green and light green with brown margin (Fig.1.A-C) and predominant color of mature leaf varied from dark green, green and light green (Fig.1. D-F)

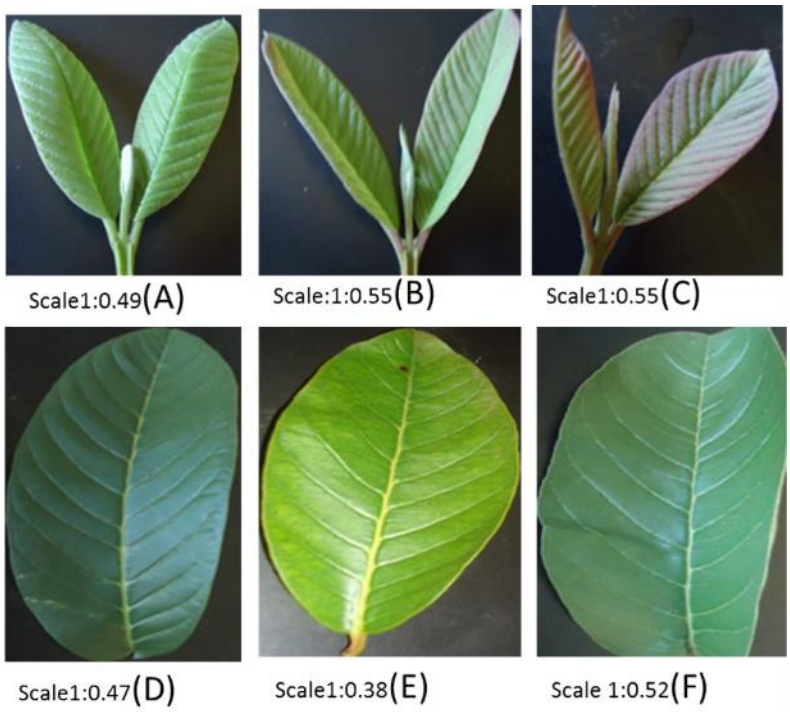

Fig 1. Variation of apical leaf analysis and color of mature leaf analysis; green young apical leaves(A), light green apical leaves with brown margin(B),greenish brown apical leaves(C),dark green leaf(D),light green leaf(E),green leaf(F).

Five leaf shape color were observed; trapezoidal, ovate, oblong and elliptical (Fig.2.A-D)

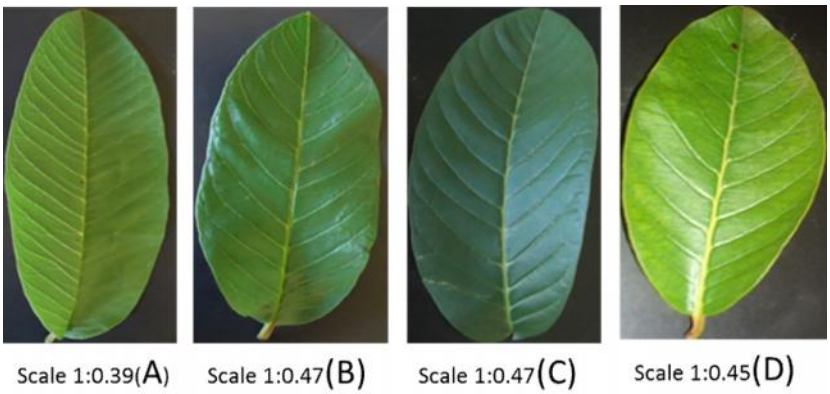

Fig 2. Variation of leaf shape morphology**;** trapezoidal leaf shape **(A),**oblong leaf shape (B), ovate leaf shape **(**C**),**elliptical leaf shape **(**D**)**

Branch habit that was observed were axial, erect branching, irregular branching and two stem colors dark gray and light gray (Fig. 3.A-E).

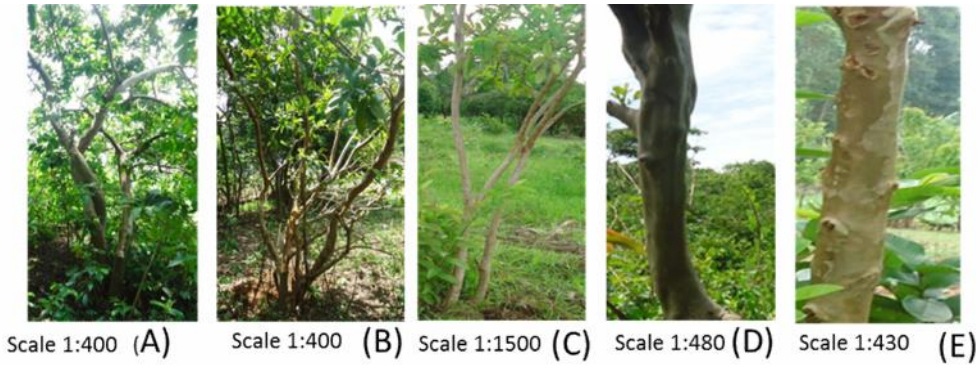

Fig 3. Variation of stem branching and color analysis; axial branching (A) irregular (B) Erect branching(C), dark gray stem (D) light gray stem (E)

Root analysis

In western and Coastal region, all plants had fibrous roots which were many when the plants were still young and the propensity reduced as the plants grew in age with pink root cortex, white creamy root pulp .All the roots were cylindrical in shape (Fig. 4.A-D).

Fig.4. variation of root morphological characters in Western and Coastal regions; fibrous roots (A) pink cortex of young root (B), white pulp (C), pink cortex of mature root (D)

Fruit characters

In Western region, the fruits at Sabatia site had a green pericarp when unripe and yellow pericarp on ripening. Mesocarp of ripe fruits differed, 4 were cream while 6 were pink. In Coastal region, the fruits had green pericarp, mesocarp varied, 3 had cream while the other 3 had Pink mesocarp (Fig. 5. A-D)

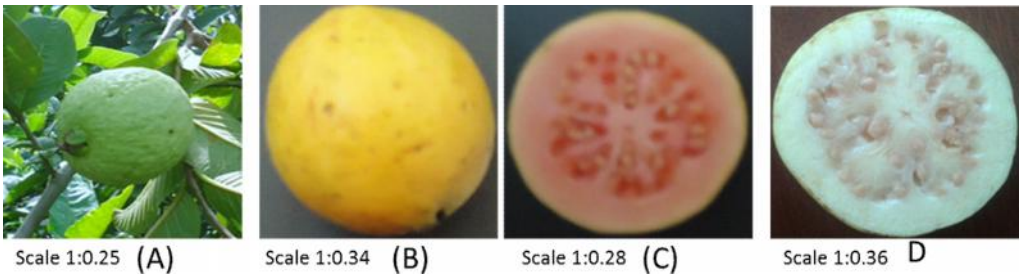

Fig 5. Variations in fruit characters in guava from Western and Coast regions; unripe green pericarp (A), ripe yellow pericarp (B), pink mesocarp (C), cream white mesocarp (D)

Morphological clustering

DARwin software was used to cluster the accessions based on morphology: three clustered were observed within the Western and Coastal regions (Fig. 6). Cluster 1 comprised of BUM006, SAB007, SAB001 and BUM005; Cluster 2 comprised of BUM004, BUK003, BUK007, BUK002, BUK006, BUK009, BUK001, BUK005, BUK004, BUK003, SAB009, MAK001, BUM002, SHIS002, SHIS001, SHIS003, SAB002, SAB004, MAK002, SAB003, SAB005 and SAB006 and Cluster 3 comprised of EVUK004, SAB01, SAB008, SHIS006, BUM003, SHIS004, BUM001, SHIS005, MAK004, MAK005, MAK006, EVUK006, MAK003, EVUK005, EVUK001, EVUK002, EVUK003, SHIM003, SHIM001, SHIM002, MSA001, MSA002, SHIM004, SHIM005, SHIM006, MSA005, UKU003, UKU004, UKU001, MSA003, UKU002 and MSA004

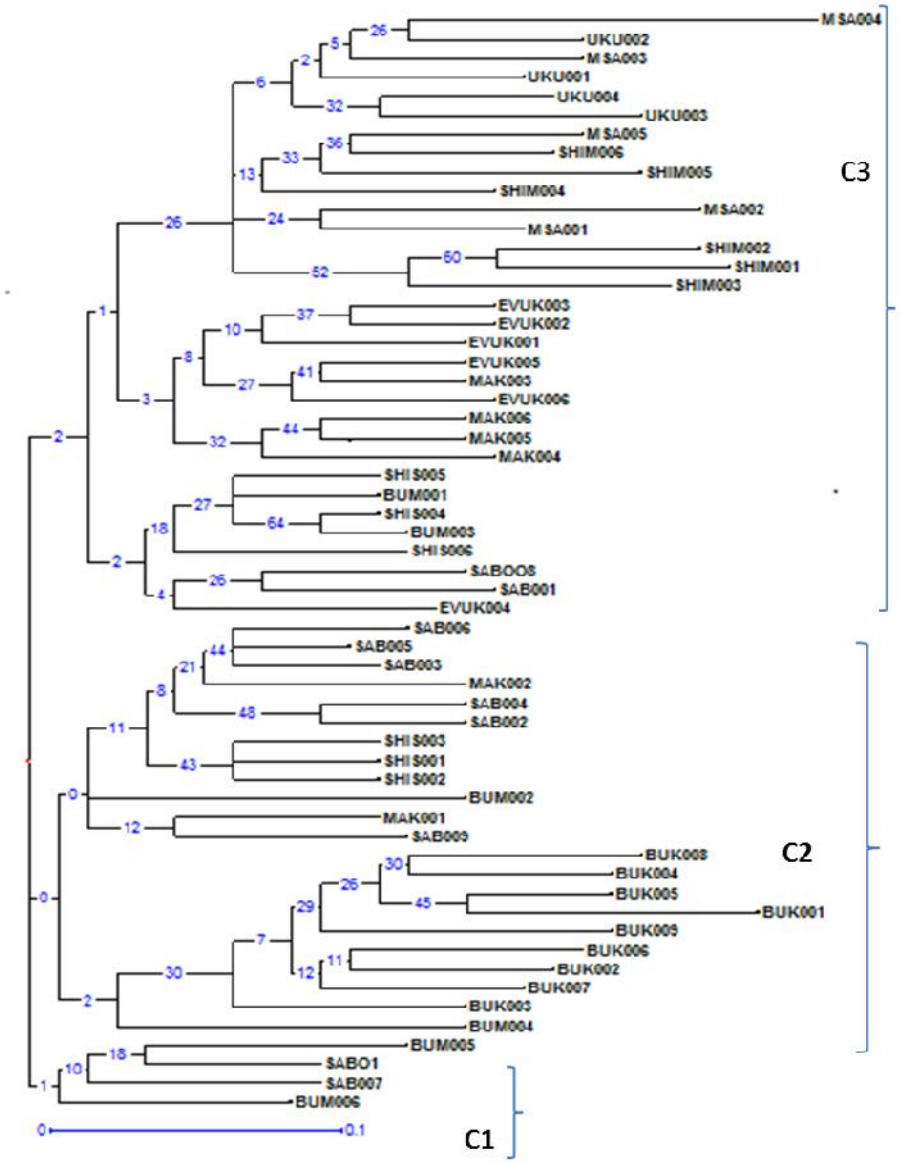

Fig 6. Clustering of 58 guava landraces based on morphological characters

4.0 Discussion

Differences in morphological descriptors may be attributed to the genetic makeup of the landraces, geographical locations and the climatic conditions of the sites [9, 10]. In this work, morphological differences were reported [11]. Color of young apical leaves of light green with brown margin, greenish brown and green with green margin and branching habits of erect, axial and irregular were reported [4]. Leaf shape: oblong, trapezoidal, ovate, elliptical and lanceolate

similar to those reported earlier [12, 10] .Color of mature leaves: dark green and green were reported [13, 10]. All leaves were oriented upwards

Color of stem was green and dark green. Red and green color of stem was reported earlier [9]. Color pigmentation of the stem that varied from brown to green color, light brown and red brown colors were obtained as reported [12]. According to [14] the chest nut red color was common; there was no earlier report on pigmentation of guava stem.

Green fruit pericarp, white cream and pink mesocarp color of guava was reported [13, 15, 16 and 9]. Guava fruits with pink pulp were very common [17, 10]. Reported Color of fruit pulp in guava as white and red and that absence of color was considered to be recessive and linked with other traits was reported [12]. Roots showed minor morphological differences. The color of root cortex, shape of the root and color of root pulp was similar in guava from both the regions. This is the first report on root morphology of guava in the region.

Morphological descriptors of 58 landraces were used to generate similarity matrices and were used to generate a dendrogram by using unweighted neighbour joining to reveal morphological relationship between the landraces. The cluster tree analysis based on morphological characterization divided the guava landraces into 3 major classes (Fig. 6). Cluster 1 comprised of landraces from Western region (14.04%). Cluster 2 comprised of 46.51% landraces from Western Kenya. Cluster 3 had landraces from both regions 100% of Coastal landraces and 39.45 % of Western landraces. Cluster one and two is based on the region as the region has most climatic conditions similar while cluster 3 had most landraces from Western Kenya. Despite of the region cluster three showed more similarity as this could have been caused by seed dispersal and agents of pollination retaining their genetic make-up.

Conclusion and recommendation

There exists morphological diversity among guava landraces in Western and Coastal Kenya. Coastal landraces have erect branching, Shimba had green apical leaves, Msambweni with yellow green petiole color, Ukunda had leaf retention less than average, Bukura had yellow green petiole color, Bumamu had horizontal branching, Makunga had either irregular or axial branching habits, Sabatia the landraces had either light green with brown margin or greenish brown apical leaves, Evukambuli had light green with brown margin apical leaves, Kisa had outstanding leaf retention. To the recommendation is that morphological information to be used in guava improvement through breeding programs and in gene banks

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Competing interests

Authors of this work have no competing interests

Authors' contribution

LMK- did sampling, did characterization and prepared draft, AAE supervised the study from field to manuscript preparation, ABN supervised the work and corrected publication manuscript

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