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Genetic diversity, correlation and path analyses of okra (*Abelmoschus* spp. (L.) Moench) germplasm collected in Ghana

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Abstract

Thirty (30) accessions of okra (*Abelmoschus* spp. (L.) Moench) germplasm were collected from four major production regions in Ghana and were evaluated under field conditions at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, KNUST, during the minor and major seasons of 2008 and 2009. The International Plant Genetic Resources Institute (IPGRI) descriptor list for okra was used as a guide for data collection. Variations were observed among the different accessions based on their vegetative traits, inflorescence, fruit and seed characteristics. There was a wide variation in plant height among the accessions; flowering and fruiting periods varied considerably among all accessions based on the output of the Principal Components, Correlation and Cluster analyses. There was a strong positive correlation between total fruit production and first fruit producing node (r = 0.76); first fruit producing node and first flowering node (r = 0.79); and number of fruits per plant and stem diameter at base (r = 0.88). The observed variabilities in the traits studied strongly indicate the possibility of selecting plants with suitable morphology when considering integration into any improvement programme towards preservation and conservation of okra diversity in Ghana. The distant relatedness among the various accessions could also be considered and incorporated into hybridisation programme in breeding for different consumer preferences and market demands.

Keywords: *Abelmoschus* spp. (L.), Cluster analysis, Principal component analysis, Correlation analysis, Genetic diversity

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1. Introduction

Cultivated okra (*Abelmoschus* spp (L.) Moench) constitutes a major economic crop in West and Central Africa (WCA) as a result of its vital importance as a component of various recipes in many cuisines and preparations. It has considerable area under cultivation in Africa and Asia in particular because of its contribution to human diet by supplying fats, proteins, carbohydrates, minerals and vitamins. Its mucilage is suitable for medicinal and various industrial applications. However, its productivity is very low in the WCA sub-region because of several factors such as lack of adapted genotypes, pest and disease constraints and narrow genetic base of existing cultivars. Thorough characterisation of germplasm of the crop may play a very important role in reversing these challenges in the okra value chain. The value of germplasm collection depends not only upon the number of accessions but also on extent of diversity inherent in them (Ren et al., 1995). Improvement of okra requires a broad spectrum of genetic variability from which useful characters can be selected for developing broad-based populations to be used in hybridisation programme towards improvement (Lester et al., 1990; Hammond and Charrier, 1983). Therefore, to harness and utilise useful traits in okra genetic resources, it is essential to assemble, characterise and evaluate them so as to maximise their utilisation in any improvement programme. This study was carried out to assess the genetic variation in the collections of okra and recommend accessions with rich agro-morphological traits for utilisation in future breeding programme in Ghana.

2. Materials and methods

The study was carried out at the Department of Horticulture research fields of the Kwame Nkrumah University Science and Technology (KNUST), Kumasi. Thirty (30) accessions of okra were collected directly from farmers in the Brong Ahafo, Ashanti, Greater Accra and Volta regions of Ghana (Table 1). The land was cleared using a tractor mounted slasher, ploughed and harrowed. Seeds of okra were extracted and planted in rows, with an average of ten stands at a spacing of 60cm x 40cm. Five (5) seeds were sown per stand and later thinned to one per stand. Weeds were controlled manually by hoeing and handpicking fortnightly prior to canopy closure. Poultry manure was applied at rate of 0.5kg/stand and mulching done after one month. Watering can was used to supply water in the lean season.

Data was collected on five selected stands using the International Plant Genetic Resources Institute (IPGRI) descriptor list on okra. Data were collected on the following agro-morphological characters: general aspect of plant, branching type, stem pubescence, stem colour, leaf shape, leaf colour, 50% germination (FPGer), maximum plant height, MPH (cm), stem diameter at base, STB (mm), maximum number of internode (MNI), number of epicalyx segments, shape of epicalyx segments, persistence of epicalyx segments, petal colour, red colouration of petal base, position of fruit on main stem, fruit colour, fruit length at maturity, length of peduncle, fruit shape, number of ridges per fruit, fruit pubescence, 50% flowering (FPFl), first fruit-producing node (FFPN), total production of fresh fruit (g), total production of fruit, TPF (g), mucosity of fruit after cooking, seed shape, aspect of seed surface, weight of 1000 seeds (TSwt) and average number of seeds per fruit.

These were further separated into qualitative and quantitative characters and subjected to statistical analyses using the Statgraphics Centurion XVI, (version 16.1.11) (Statgraphics, 2010). Cluster analysis was done to assess extent of relatedness among the accessions; principal components and correlation analyses were done on the quantitative characters to determine percentage contribution of each character to total diversity and degree of association among these characters.

3. Results and discussion

3.1. Cluster analysis

Table 1 displays the identities of the 30 accessions, the geographical collection sites and specific localities in Ghana. The largest collection of twelve accessions was made in the Greater Accra region. This is to be expected as the region has a large number of farmers and farmers' associations engaged in urban and peri-urban vegetable production for export or sale locally.

A furthest neighbour dendrogram using Euclidean distances of morpho-agronomic characters of the 30 accessions of okra is shown in Figure 1. All the 30 accessions were initially grouped into two major clusters at a genetic distance of 45.2% and further placed into three cluster entries at genetic similarity indices of 75.8 and 77.9%, respectively (Figure 1).

From the dendrogram, it can be observed that ten of the accessions from the Ashanti (Asante abe', Tech Nkuruma, Bekwaso and Gyeabatan), Greater Accra (Ngruma, Agbodrofe, Voltui and Spineless) and Volta (Fetiri and New York) regions are possible duplicates (Andersson et al., 2007). The inter-cluster genetic distances among these accessions were above 95%. There was a direct relation between the eco-geographical origins of the Okra collections and their clustering patterns. All accessions collected from the Brong Ahafo region were clustered together except Nkuruma tia, likewise accessions from Ashanti and Greater Accra regions. Local cultivators of okra in these regions may have mixed these lines up during selection for cultivation to meet different demands, as evident from the clustering pattern. It may also be ascribed to the narrow genetic base of these cultivars of okra grown by farmers in Ghana. Farmers within the same locality share planting materials and over time mutations arise as seeds are selected, given new names and used as farmer's varieties, which are often genetically identical. Therefore, there is the need for broadening of the genetic base of these lines (landraces) for better adaptation to the local conditions.

The weights of quantitative agro-morphological characters of the thirty (30) lines of okra collected from the four major production zones of the crop in Ghana are shown in Figure 2 displaying the contributions by the individual characters to total genetic variance. Genetic positions of these traits are indicated in the quadrants, showing inter and intra-genetic proximities of these characters in the genepool. Three pairs of characters (Maximum plant height, maximum number of internode, stem diameter at base, 50% germination, Number of fruits per plant and 50% flowering) with substantial contributions to total genetic variance were closely associated, suggesting simultaneous selection of these characters for improvement. Characters that are closely related may result in low divergence level and hence may account for the narrow genetic base of okra, as evidenced in most of the accessions from the Ashanti and Volta regions. Positions of these traits based on their relative contributions to genetic divergence may be as a result of genes controlling the inheritance of these traits in okra (Adeniji and Aremu, 2007).

3.2. Principal Components Analysis (PCA)

Table 2 shows factor scores of eleven (11) quantitative characters among the 30 accessions of okra, eigen values and percentage total variance accounting for the four principal component axes. The four Principal Components (PC) accounted for 82.97% of total variance with the first principal component (PC_1) contributing the highest (46.62%). The second, third and fourth principal components (PC_2, PC_3 and PC_4) accounted for 15.23%, 11.75% and 9.37%, respectively. The eigen value gives the relative discriminating power of the principal axes with (5.128) for axis 1 and as low as (1.031) for axis 4.

First fruit-producing node, first flowering node and total fruit production contributed substantially to genetic variance in axis one (1), while major yield components such as 1000 seed weight and number of seeds per fruit made the greatest contribution to variation in the principal component axis two (PC_2). Maximum plant height, 1000 seed weight, 50% flowering and first flowering node made relatively significant contribution to variation in all axes. This observation confirms the individual contributions of these traits to variations observed in the 30 okra accessions as well as their contributions to seed yield in the 30 accessions. Reports of Ogunbodede (1997) and Ariyo and Odulaja (1991) concurs with this observation; thus emphasising the relevance of these traits when selecting for seed yield from any cluster group.

The first four principal axes accounted for 82.97% of the total variation among the 11 characters of the accessions, which is higher than observations made by Campos et al. (2005) and Ogunbayo et al. (2005) where the principal component axes contributed 76.62% and 64.5% to variation, respectively. These characters may be potentially effective in differentiating accessions of okra germplasm (Clifford and Stephenson, 1975). Eigen values in this study were variable attesting to the variability in the accessions of okra used in the study. First fruit producing node, 50% flowering and number of seeds per fruit were found to have contributed positively and significantly to variation similar to that reported by Ogunbodede (1997). The factor scores of these characters imply that high priority be given to these genetic traits, if selection is to be made for any future improvement programme in okra.

3.3. Correlation analysis of quantitative traits

Table 3 shows the correlation coefficients among the eleven (11) quantitative traits in the accessions of okra studied. Selection for a single character may increase the trait values of positively correlated characters and decline the values for negatively correlated traits. Fifty percent germination (50% germination) had positive and significant correlations ($P \leq 0.05$) with maximum number of internode ($r = 0.68$), maximum plant height ($r = 0.55$); stem diameter at base ($r = 0.55$); but negatively correlated with major yield determining traits such as total fruit production ($r = -0.62$) and first fruit producing node ($r = -0.58$). This corroborates the findings of Hazra and Basu (2000); Kaul et al. (1978); Singh and Singh (1977) and thus, suggests that, component breeding would be very effective in the event of strong positive associations of major yield characters (Hazra and Basu, 2000) as evidenced in this study.

Maximum number of internode (MNI) and stem diameter at base had the strongest positive association ($r = 0.93$). MNI was also positively correlated with maximum plant height and number of fruit per plant (Table 3). It was however; negatively correlated with total fruit production, first fruit producing node, seeds per fruit, first flowering node and 1000 seed weight. These results contrast reports of Ogunbayo et al. (2005) and Ariyo et al. (1987). Additionally, plant height is negatively correlated to number of fruits per plant ($r = -0.14$), while stem diameter at base and maximum number of internode ($r = 0.93$) is strongly and positively correlated. This may be ascribed to accumulation and partitioning of photosynthates to these characters. Verma (1993), Ariyo et al. (1987) and Perdosa (1983) suggested that plant height is controlled by genetic factors and is closely associated with number of flowering node, average fruits per plant and number of internodes, which is consistent with observations in this study.

There was a strong positive correlation between total fruit production and first fruit producing node ($r = 0.76$); first fruit producing node and first flowering node ($r = 0.79$); and then the number of fruits per plant and stem diameter at base ($r = 0.88$). Adeniji and Aremu (2007) and Mehta et al. (2006) reported negative correlations among these traits. Hence, total fruit production, first fruit-producing node, first flowering node, number of fruits per plant and stem diameter at the base should be given more attention when selecting for higher yield and high dry matter in okra.

3.4. Mean values of morphological and yield characters

Number of fruits per plant, mean fruit weight and total fruit production had the greatest variability among the quantitative traits measured (Table 4). Bennet-Lartey and Oteng-Yeboah (2008) and Adeniji and Aremu (2007) similarly reported greater coefficient of variations in these traits. This gives credence to the relevance of these characters in selecting accessions for yield improvement since they possess greater variability for exploitation of desirable traits for overall yield and productivity.

Generally, early flowering is detrimental for overall productivity of okra as the source to sink ratio will be potentially limited for effective photosynthesis (Aboagye et al., 1994). Wide range of flowering periods among the accessions implies varying maturity periods even on the same plant making it difficult for harvesting and practically unfeasible for mechanisation. Majority of the accessions exhibited compact growth habit (Table 5). This trait might have been selected by farmers over the years as such plants are able to combine high number of fruit per plant per unit space, an economic indicator for yield (Bonsu et al., 2003). Height of plant can potentially affect yield as plants with higher heights are usually prone to windstorms in the events of heavy downpour. Intense variation was observed in the fruiting and maturity periods of the various accessions of okra. Accessions with late maturity periods were at the full rigours of insect and pest infestations. Height at flowering and fruiting (final height) are of particular interest for breeding programmes because tall, thin stems increase rate of lodging near harvesting and this could culminate in loss of dry matter and a subsequent decrease in fruit yield (Akinyele and Oseikita, 2006; Myanmar, 1995). There were also intense variation in number of branches per plant, number of seeds per fruit, total number of leaves per plant, stem pubescence, fruit shape, type of pod axis, branching type, seed shape, fruit peduncle and fruit length (Table 5). These agree with results found in okra morphological diversity studies by (Khanorkar and Kathiria, 2010; Mishra and Chhonkar, 1979).

4. Conclusion

Narrow variations and interrelationships were observed in the 30 accessions of okra. Variability in the various traits studied gives ample scope for manipulation of okra and its components for higher economic returns. The accessions; Asontem, Nkuruma tia, Debo, Awoale Nkuruma were generally early maturing and high yielding. Muomi, Fitiri, Nsafitaa, Nsapan and Mamolega may be utilised as parent stocks for breeding for high seed yield in Ghana. From this study, a combination of Principal Components Analysis (PCA), Correlation analysis (CA) and Complete Link Cluster Analysis (CLCA) will yield better results when considering genetic variability among okra accession. However, CLCA proved to be a better tool in multivariate analysis since it provided much clearer information concerning the extent of relatedness among the genotypes.

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Figures

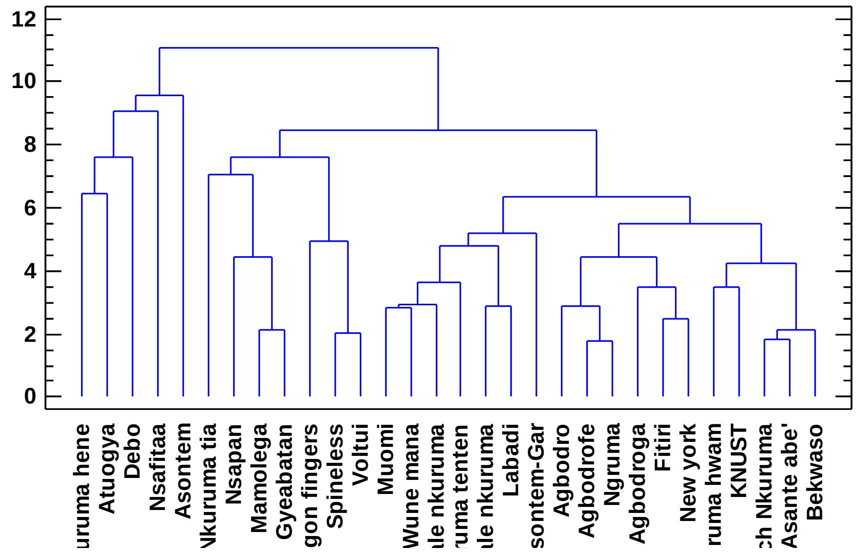

Figure 1. A dendrogram (complete link) showing relatedness of 30 okra accessions

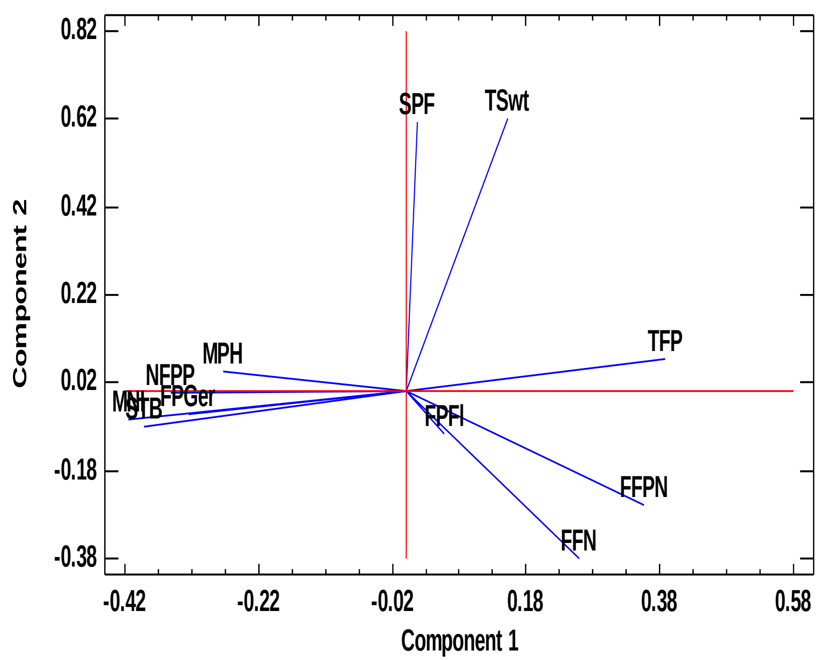

Figure 2. Plot of components weight of quantitative morpho-agronomic traits of okra. FPGer = 50%Germination; FPFl = 50%Flowering; MPH = Maximum Plant Height; STB = Stem Diameter; MNI= Maximum Number of Internode; FFN = First Flowering Node; FFPN = First Fruit Producing Node; TFP = Total Fruit Production; TSwt = 1000 Seed Weight; SPF =Number of Seed per Fruit; NFPP = Number of Fruit per Plant.

Tables

Table 1. Names and Geographical collection sites of 30 accessions of okra

Accession	Geographical Regions	Specific Locality
Nkuruma hene	Brong Ahafo	Berekum
Asontem	Brong Ahafo	Kintampo
Nkuruma tia	Brong Ahafo	Berekum
Nsafitaa	Brong Ahafo	Jema
Debo	Brong Ahafo	Nsokaw
Atuogya	Brong Ahafo	Kintampo
Muomi	Greater Accra	Accra
Asontem-Gar	Greater Accra	Accra
Awoale Nkuruma	Greater Accra	Prampram
Labadi	Greater Accra	Accra
Legon fingers	Greater Accra	Accra
Spineless	Greater Accra	Dowenya
Voltui	Greater Accra	Accra
Awoale Nkuruma	Greater Accra	Accra
Agbodro	Greater Accra	Dodowa
Agbodrofe	Greater Accra	Dodowa
Agbodroga	Greater Accra	Dodowa
Fitiri	Volta	Agbozome’
New york	Volta	Dzodze
Ngruma	Greater Accra	Ayikuma
Nkuruma hwam	Ashanti	Kumasi
KNUST	Ashanti	Kumasi
Nkuruma tenten	Ashanti	Kumasi
Tech Nkuruma	Ashanti	Kumasi
Nsapan	Ashanti	Mankranso
Asante abe’	Ashanti	Mankranso
Bekwaso	Ashanti	Bekwai
Wune mana	Upper East	Navrongo
Mamolega	Upper East	Bolgatanga
Gyeabatan	Ashanti	Bekwai

Table 2. Principal components analysis showing factor scores of 11 quantitative characters among the 30 Okra accessions, Eigen values and Percentage total variance accounted for by four principal components *

TRAIT	PC_1	PC_2	PC_3	PC_4
First flowering node	0.259	-0.378	0.358	0.380
First fruit producing node	**0.356**	-0.256	0.054	0.416
50%flowering	0.057	-0.095	**0.767**	-0.361
50% Germination	-0.324	-0.049	0.325	-0.128
Maximum internode	-0.414	-0.062	0.157	0.135
Maximum plant height	-0.273	0.045	0.124	0.396
Number of fruits per plant	-0.352	-0.001	0.043	0.221
Number of seed per fruit	0.018	**0.613**	0.122	**0.469**
Stem diameter at base	-0.391	-0.078	0.129	0.208
Total fruit production	**0.388**	0.076	0.183	0.172
1000 seed weight	0.152	**0.622**	0.263	-0.135
Eigen value	**5.128**	1.676	1.293	1.031
% variance	**46.62**	15.23	11.75	9.37
Cumulative % variance	46.62	61.85	73.60	**82.97**

** Values bolded and asterisked made substantial contribution to total variance in the respective axes. Maximum and least discriminating power (eigen value), maximum and least percentage variance and maximum cumulative percentage variance values are bolded.*

Table 3. Correlation Coefficients among 11 Quantitative Agro-morphological Characters of *Abelmoschus* spp (L.)

Trait	*FPGer*	*FPFl*	*MPH*	*STB*	*MNI*	*FFN*	*FFPN*	*TFP*	*TSwt*	*SPF*	*NFPP*
FPGer											
FPFl	0.18										
MPH	0.55	-0.13									
STB	0.55	-0.02	0.47								
MNI	**0.68**	0.01	**0.61**	**0.93**							
FFN	-0.28	0.30	-0.23	-0.34	-0.40						
FFPN	-0.58	0.05	-0.39	-0.54	<u>-0.66</u>	**0.79**					
TFP	-0.62	0.21	-0.41	-<u>0.71</u>	<u>-0.74</u>	0.56	**0.76**				
TSwt	-0.20	0.20	-0.21	-0.33	-0.35	-0.07	-0.03	0.44			
SPF	-0.07	-0.10	0.15	-0.01	-0.01	-0.13	0.00	0.15	0.53		
NFPP	0.43	-0.14	0.34	**0.88**	**0.79**	-0.32	-0.55	-0.59	-0.20	0.03	

P (≤ 0.05) is considered significant. Values bolded refer to strong positive correlation, values underlined refer to strong negative correlation. FPGer = 50% Germination; FPFl = 50%Flowering; MPH = Maximum Plant Height; STB = Stem Diameter; MNI= Maximum Number of Internode; FFN = First Flowering Node; FFPN = First Fruit Producing Node; TFP = Total Fruit Production; TSwt = 1000 Seed Weight; SPF = Number of Seed per Fruit; NFPP = Number of Fruit per.

Table 5. Vegetative, Inflorescence, Fruit and Seed characteristics of 30 accessions of Okra (*Abelmoschus* spp (L.))

ACCESSION	GAP	BR	StP	SCr	LSp	LCr	NES	PES	PCr	SEP
Nkuruma hene	Erect	Strong	Conspicuous	Green	2	Green with red veins	>10	Partially persistent	Cream	Lanceolate

ACCESSION	GAP	BR	StP	SCr	LSp	LCr	NES	PES	PCr	SEP
Asontem	Procumbent	Medium	Glabrous	Purple	3	red	>10	Non-persistent	Cream	Linear
Nkurumatia	Erect	Strong	Slight	Green with red patches	1	Green	>10	Partially persistent	Golden	Triangular
Nsafitaa	Procumbent	Medium	Conspicuous	Purple	1	Green	>10	Non-persistent	Yellow	Linear
Debo	Medium	Strong	Glabrous	Green with red patches	1	Green	5-7	Partially persistent	Cream	Lanceolate
Atuogya	Medium	Strong	Glabrous	Purple	2	Green with red veins	>10	Persistent	Yellow	Linear
Muomi	Erect	Medium	Slight	Green	3	Green	8-10	Partially persistent	Yellow	Triangular
Asontem-Gar	Erect	Strong	Glabrous	Green	4	Green	>10	Partially persistent	Yellow	Triangular
Awoale nkuruma	Erect	Medium	Slight	Green	4	Green	8-10	Partially persistent	Yellow	Triangular
Labadi	Erect	Medium	Slight	Green	3	Green	8-10	Partially persistent	Yellow	Triangular

ACCESSION	GAP	BR	StP	SCr	LSp	LCr	NES	PES	PCr	SEP
Legon fingers	Erect	Medium	Glabrous	Green	2	Green with red veins	>10	Partially persistent	Yellow	Linear
Spineless	Erect	Medium	Glabrous	Green	2	Green	8-10	Partially persistent	Yellow	Triangular
Voltui	Erect	Medium	Glabrous	Green	2	Green	8-10	Partially persistent	Yellow	Triangular
Awoale nkuruma	Erect	Medium	Glabrous	Green	3	Green	8-10	Partially persistent	Yellow	Triangular
Agbodro	Erect	Orthotropic	Glabrous	Purple	3	Green	8-10	Partially persistent	Yellow	Lanceolate
Agbodrofe	Erect	Medium	Glabrous	Green	3	Green	8-10	Partially persistent	Yellow	Lanceolate
Agbodroga	Erect	Orthotropic	Glabrous	Purple	3	Green	8-10	Partially persistent	Yellow	Linear
Fitiri	Erect	Orthotropic	Glabrous	Purple	3	Green	8-10	Partially persistent	Yellow	Lanceolate
New york	Erect	Orthotropic	Glabrous	Purple	3	Green	8-10	Partially persistent	Yellow	Lanceolate

ACCESSION	GAP	BR	StP	SCr	LSp	LCr	NES	PES	PCr	SEP
Ngruma	Erect	Orthotropic	Glabrous	Purple	3	Green	8-10	Partially persistent	Yellow	Lanceolate
Nkuruma hwam	Erect	Medium	Slight	Green	3	Green	5-7	Partially persistent	Yellow	Linear
KNUST	Erect	Medium	Glabrous	Green	4	Green	8-10	Partially persistent	Yellow	Triangular
Nkuruma tenten	Erect	Medium	Glabrous	Green	4	Green	>10	Partially persistent	Yellow	Triangular
Tech Nkuruma	Erect	Medium	Glabrous	Green	3	Green	8-10	Partially persistent	Yellow	Triangular
Nsapan	Erect	Strong	Glabrous	Green	2	Green with red veins	>10	Partially persistent	Yellow	Triangular
Asante abe'	Erect	Medium	Glabrous	Green	2	Green	5-7	Partially persistent	Yellow	Triangular
Bekwaso	Erect	Medium	Glabrous	Green	3	Green	5-7	Partially persistent	Yellow	Triangular
Wune mana	Erect	Medium	Slight	Green	4	Green	5-7	Partially persistent	Yellow	Triangular

ACCESSION	GAP	BR	StP	SCr	LSp	LCr	NES	PES	PCr	SEP
Mamolega	Erect	Strong	Glabrous	Green	3	Green with red veins	5-7	Partially persistent	Yellow	Triangular
Gyeabatan	Erect	Strong	Glabrous	Green	3	Green with red veins	5-7	Partially persistent	Yellow	Triangular

GAP = general aspect of plant; BR = Branching type; StP = stem pubescence; SCr = stem colour; LSp = leaf shape; LCr = leaf colour; NES = number of epicalyx segements; PES = persistent of epicalyx segements; PCr = petal colour; SEP = shape of epicalyx segements.

Table 5. (Cont'd)

Accession	RCPB	PFMS	FCr	FrtL	LP	FSHp	NRPF	FrtP	SSHp	ASS	MFC
Nkuruma hene	Inside only	Horizontal	Green/red patches	b/n 8-15cm	1-3cm	8	None	Slightly rough	Reniform	Glabrous	Strong
Asontem	Inside only	Erect	Yellowis h green	b/n 8-15cm	>3cm	4	None	Prickly	Round	Downy	Strong
Nkuruma tia	Both sides	Pendulous	Yellowish green	b/n 8-15cm	>3cm	8	5-7	Prickly	Round	Downy	Slight
Nsafitaa	Inside only	Horizontal	Green	< 7cm	>3cm	16	8-10	Downy	Reniform	Glabrous	Slight
Debo	Both sides	Pendulous	Green	>15cm	1-3cm	7	None	Slightly rough	Reniform	Glabrous	Strong
Atuogya	Inside only	Horizontal	Green/red patches	b/n 8-15cm	>3cm	18	5-7	Prickly	Reniform	Glabrous	Strong

Accession	RCPB	PFMS	FCr	FrtL	LP	FSHp	NRPF	FrtP	SSHp	ASS	MFC
Muomi	Both sides	Erect	Green	b/n 8-15cm	>3cm	7	None	Downy	Round	Glabrous	Strong
Asontem-Gar	Both sides	Erect	Green	< 7cm	>3cm	18	None	Prickly	Round	Glabrous	Strong
Awoale nkuruma	Both sides	Erect	Green	b/n 8-15cm	>3cm	18	None	Slightly rough	Reniform	Glabrous	Strong
Labadi	Both sides	Erect	Green	b/n 8-15cm	1- 3cm	18	None	Downy	Reniform	Glabrous	Strong
Legon fingers	Both sides	Erect	Green	>15cm	>3cm	1	8-10	Downy	Reniform	Downy	Strong
Spineless	Both sides	Erect	Green	b/n 8-15cm	1-3cm	1	5-7	Downy	Reniform	Downy	Strong
Voltui	Both sides	Erect	Yellowish green	b/n 8-15cm	1-3cm	8	5-7	Downy	Reniform	Downy	Strong
Awoale nkuruma	Both sides	Erect	Green	b/n 8-15cm	1-3cm	8	5-7	Downy	Round	Glabrous	Strong
Agbodro	Inside only	Erect	Yellowish green	< 7cm	>3cm	2	None	Downy	Round	Glabrous	Slight
Agbodrofe	Inside only	Erect	Yellowish green	b/n 8-15cm	>3cm	7	5-7	Downy	Round	Glabrous	Slight

Accession	RCPB	PFMS	FCr	FrtL	LP	FSHp	NRPF	FrtP	SSHp	ASS	MFC
Agbodroga	Inside only	Erect	Green	< 7cm	>3cm	18	None	Downy	Round	Glabrous	Slight
Fitiri	Inside only	Erect	Green	< 7cm	>3cm	16	None	Downy	Round	Glabrous	Strong
New york	Inside only	Erect	Green	< 7cm	>3cm	16	5-7	Downy	Reniform	Glabrous	Strong
Ngruma	Inside only	Erect	Yellowish green	b/n 8-15cm	>3cm	7	5-7	Downy	Round	Glabrous	Slight
Nkuruma hwam	Both sides	Erect	Green	< 7cm	1-3cm	18	None	Downy	Round	Glabrous	Slight
KNUST	Both sides	Erect	Green	< 7cm	1-3cm	18	None	Downy	Round	Glabrous	Slight
Nkuruma tenten	Both sides	Erect	Green/red patches	b/n 8-15cm	1-3cm	3	None	Downy	Round	Glabrous	Strong
Tech Nkuruma	Both sides	Erect	Green	< 7cm	1-3cm	8	None	Downy	Round	Glabrous	Strong
Nsapan	Both sides	Pendulous	Green/red patches	b/n 8-15cm	>3cm	2	8-10	Downy	Round	Glabrous	Strong
Asante abe'	Both sides	Erect	Green	< 7cm	1-3cm	8	None	Downy	Round	Glabrous	Strong

Accession	RCPB	PFMS	FCr	FrtL	LP	FSHp	NRPF	FrtP	SSHp	ASS	MFC
Bekwaso	Both sides	Erect	Green	< 7cm	1-3cm	18	None	Downy	Round	Glabrous	Strong
Wune mana	Both sides	Erect	Green	< 7cm	1-3cm	7	None	Downy	Round	Glabrous	Strong
Mamolega	Both sides	Pendulous	Green	b/n 8-15cm	>3cm	17	8-10	Prickly	Round	Glabrous	Strong
Gyeabatan	Both sides	Pendulous	Green	b/n 8-15cm	>3cm	16	8-10	Prickly	Round	Glabrous	Slight

RCPB = red colouration of petal base; PFMS = position of fruits on main stem; FCr = fruit colour; FrtL = fruit length at maturity; LP = length of peduncle; FSHp = fruit shape; NRPF = number of ridges per fruit; FrtP = fruit pubescence; SSHp = seed shape; ASS = aspect of seed surface; MFC = mucosity of fruit after cooking.