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Morphological Characterization of Okra (Abelmoschus [Medik.]) Accessions

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Abstract

Okra (Abelmoschus [Medik.] species) is a prominent vegetable due to the diverse economic roles of its leaves, fruits, seeds, floral parts, and stems. This study investigated the morphological distinctiveness among varieties and between species of okra. Five okra accessions were obtained from the National Centre for Genetic Resources and Biotechnology, Nigeria, including two A. esculentus (NG/OA/03/12/157 and NG/OA/05/12/159) and three A. caillei (NG/OA/03/12/158, NG/SA/DEC/07/0475, and NG/SA/DEC/07/0482) species. During the developmental stage, the accessions exhibited a degree of similarity; however, at maturity, the leaf and fruit color, height, leaf shape, and flowers of the five accessions became distinct. A cluster of the phenotype was observed at 4.123 level of coefficient of similarity with two distinct clusters. Distinct morphological features included the nature of the epicalyx segment, the position of the fruit on the stem, fruit shape, and fruit color. These features may be used to identify the accessions. The common morphological features of clusters 1 and 3 were leaf shape and fruit length at maturity. Significant differences were observed among all the five accessions in terms of stem length, petiole length, and leaf node. This study suggests that morphological variations exist among the accessions, which can be further enumerated through molecular characterization. The characteristics could distinguish the Abelmoschus accessions into A. caillei and A. esculentus and provide credence to the use of morphological characteristics to characterize plant genetic resources. These characteristics may be exploited by plant breeders for sustainable utilization of the okra germplasm.

Keywords: Okra (Abelmoschus), Morphological characteristics, Plant resources, Systematics

Karacterisasi Morfologi Lima Aksesi Okra (Abelmoschus [Medik.])

Okra (Abelmoschus [Medik.] species) adalah sayuran terkemuka karena peran ekonominya yang beragam mulai dari daun, buah, biji, bagian bunga, dan batang. Studi ini meneliti kekhasan morfologi di antara varietas dan di antara spesies okra. Lima aksesi okra diperoleh dari Pusat Nasional Sumber Daya Genetik dan Biotechnologi, Nigeria, termasuk dua spesies A. esculentus (NG/OA/03/12/157 dan NG/OA/05/12/159) dan tiga spesies A. caillei (NG/OA/03/12/158, NG/SA/DEC/07/0475, dan NG/SA/DEC/07/0482). Selama tahap perkembangan, lima aksesi Okra tersebut menunjukkan tingkat kesamaan; namun, setelah dewasa, warna daun dan buah, tinggi, bentuk daun, dan bunga dari lima aksesi menjadi berbeda. Ditemukan sekelompok fenotif yang memiliki nilai tingkat koefisien kesamaan 4,123 dengan dua kelompok lain yang berbeda. Fitur morfologi yang berbeda termasuk sifat segmen daun kelopak tambahan (epicalyx), posisi buah pada batang, bentuk dan warna buah. Fitur-fitur ini dapat digunakan untuk mengidentifikasi aksesi. Gambaran morfologi umum dari kelompok 1 dan 3 adalah bentuk daun dan panjang buah pada saat dewasa. Perbedaan signifikan yang diamati di antara semua aksesi adalah dalam hal panjang batang, panjang tangkai daun, dan simpul daun. Studi ini menunjukkan bahwa ada variasi morfologi di antara aksesi, yang dapat ditelah lebih lanjut melalui karakterisasi molekuler. Karakter- karakter yang digunakan dapat membekan aksesi Abelmoschus menjadi A. caillei dan A. esculentus, dan dapat memberi kepercayaan bagi penggunaan karakter morfologi untuk mengkarakterisasi sumber daya genetik tanaman. Karakteristik morfologi ini dapat dimanfaatkan oleh pemulia tanaman untuk pemanfaatan berkelanjutan plasma nutfah okra.

Keywords: Okra (Abelmoschus), Morphological characteristics, Plant resources, Systematics
Introduction

Okra (Abelmoschus [Medik.] species) is native to the paleotropics and has also become popular in the wild in some neotropical areas [1]. It is grown for its leaves, fruits, seeds, floral parts, and stems. It is a prominent vegetable due to its various virtues, including high nutritive and medicinal values, ease of cultivation, wide adaptability, and pleasant flavor [2, 3].

The genus Abelmoschus is believed to have been originated from South and Southeast Asia [4, 5]. Furthermore, Lamont [2] suggested that okra originated around Ethiopia and was cultivated by the ancient Egyptians during the 12th century BC from where it spread throughout the Middle East and North Africa. The genus belongs to the family Malvaceae [6]. In the Angiosperm Phylogeny group classification [6], the genus Abelmoschus Medik. was transferred to the genus Hibiscus L. There are eight species under the genus Abelmoschus (L.). Three of them are wild, including A. angulosus, A. crinitus, A. tetraphyllus, and A. ficulneus; two are both cultivated and occur in the wild, including A. manihot and A. moschatus; and the other two are primarily cultivated, which include A. esculentus and A. caillei [7]. Okra is not a single species but a polytypic complex exhibiting both polyploidy and hybridity [8]. Several taxonomists have classified okra based on its morphological traits using biochemical or cytological methods. Osawaru et al. [9, 10] concluded that the taxon is complex. Cytogenetically, West African okra contains 194 diploid chromosomes as against 130 of the common okra [11]. Okra grows in regions of low latitude with marked high humidity. It is sensitive to low temperature and develops poorly below 15 °C [12]. Sometimes, it can be cultivated in a well-irrigated environment with none or low-humid conditions. The soil requirement for the growth and development of Abelmoschus species till maturity has been extensively analyzed by several researchers such as Chinatu et al. [13] and Jamala et al. [14]. Osawaru et al. [9] presented a detailed discussion on the basic growth requirement for okra.

Collections and documentation of okra accessions are maintained both as a base collection in National Gene banks and as an active collection in different countries across the world. According to the International Plant Genetic Resources Institute germplasm database, more than 46 institutions in different countries worldwide possess about 11,000 accessions of cultivated okra and related wild species. In Nigeria, major institutions such as the National Centre for Genetic Resources and Biotechnology; the Institute of Agricultural Research and Training, Ibadan; the National Horticultural Research Institute; and the Nigeria Institute of Horticulture have more than 100 accessions [15].

This study was conducted to investigate the morphological distinctiveness among varieties and between species of okra accessions. This research would contribute to okra systematics as well as the conservation and utilization of the plant germplasm.

Materials and Methods

Plant material. Okra accessions were obtained from an active collection at the National Centre for Genetic Resources and Biotechnology, Ibadan. The passport data of these accessions are presented in Table 1. The collections included two A. esculentus (NG/OA/03/12/157 and NG/OA/05/12/159) and three A. caillei (NG/OA/03/12/158, NG/SA/DEC/07/0475, and NG/SA/DEC/07/0482) species.

Study Area. The five accessions were grown simultaneously at the Experimental field of the Department of Plant Biology and Biotechnology, University of Benin, Benin City, Nigeria. The climatic conditions of the study area are as follows: high rainfall of 2,000–3,000 mm of bimodal pattern with peaks in July and September, respectively; high temperature ranging between 20 °C and 40 °C; and high atmospheric humidity [16]. A detailed description of the study area, including the soil characteristics, has already been provided by Ogwu and Osawaru [17] and Osawaru and Ogwu [18].

Crop husbandry. Before conducting the field trials, seed viability test was carried out to select viable seeds from each accession. Three seeds per accession were planted at random into holes of 3-cm-depth on five different ridges. Among these numerous stands, 10 stands were tagged from 1 to 10. On the five ridges, each ridge had 10 tagged stands, totaling 50. These stands were counted for study during the field trials and under the same climatic conditions. Watering of the plants was rain-fed. Agronomic practices such as mulching and using fertilizer were not applied. The accessions were sown in July 2013 and harvested in February 2014 before the shatter stage. Weeding was

| S/N | Accession Number | Status | Location | Source |
|-----|------------------|--------|----------|--------|
| NG/OA/03/12/157 | Landrace | 7.4°N and 3.84°E | NACGRAB Ibadan |
| NG/OA/03/12/158 | Landrace | 7.4°N and 3.84°E | NACGRAB Ibadan |
| NG/SA/DEC/07/0475 | Landrace | 7.4°N and 3.84°E | NACGRAB Ibadan |
| NG/SA/DEC/07/0482 | Landrace | 7.4°N and 3.84°E | NACGRAB Ibadan |
| NG/OA/05/12/159 | Landrace | 7.4°N and 3.84°E | NACGRAB Ibadan |

Table 1. Identity of Okra Accessions Used
normally done as at when due. Roguing was carried out on all suspected off types on each row.

**Data collection.** Data (quantitative and qualitative) were collected from the 50 tagged stands before and after flowering based on the IBPGR [19] descriptor list for okra. Data included plant growth habit, general growth appearance or branching, flowering characteristics, and fruit characteristics (Table 2). Leaf and flower shape was characterized according to Charrier [20] (Figure 1).

### Table 2. Qualitative and Quantitative Morphological Characteristics Evaluated in the Study and their Codes

| S/N | Parameter measured                  | Parameter key | Character codes                                                                 |
|-----|-------------------------------------|---------------|----------------------------------------------------------------------------------|
| 1   | General aspect of stem              | GAS           | 1 = erect, 2 = medium, 3 = procumbent                                             |
| 2   | Stem color                          | STC           | 1 = green, 2 = green with red patches, 3 = purple                                 |
| 3   | Stem pubescence                     | STP           | 1 = glabrous, 2 = slight, 3 = conspicuous                                          |
| 4   | Nature of branching                 | BRA           | 1 = orthotropic stem only, 2 = medium, 3 = strong                                  |
| 5   | Leaf shape                          | LSH           | From types 1 to 11                                                                |
| 6   | Leaf color                          | LC            | 1 = green, 2 = green with red veins, 3 = red                                      |
| 7   | Red coloration of petal base        | RCPB          | 1 = Inside only, 2 = Both sides                                                   |
| 8   | Number of ridges per fruit          | NRF           | 1 = Smooth fruit, 2 = from 8 to 15 cm, 3 = More than 15 cm                        |
| 9   | Number of epicalyx segments         | NES           | 1 = from 5 to 7, 2 = from 8 to 10, 3 = more than 10                               |
| 10  | Fruit color                         | FCL           | 1 = yellowish green, 2 = green, 3 = green with red patches, 4 = red               |
| 11  | Position of fruit on main stem      | PFS           | 1 = erect, 2 = horizontal, 3 = pendulous                                          |
| 12  | Persistence of epicalyx segment     | PES           | 1 = Non-persistence (7 days after flowering), 2 = Partially persistence (up to 7 days), 3 = Persistence. |
| 13  | Fruit pubescence                    | FPU           | 1 = downy, 2 = slightly rough, 3 = prickly                                        |
| 14  | Length of peduncle                  | LP            | 1 = from 1 to 3 cm, 2 = more than 3 cm                                            |
| 15  | Fruit length at maturity            | FLM           | 1 = less than 7 cm, 2 = from 8 to 15 cm, 3 = more than 15 cm                      |
| 16  | Shape of epicalyx segment           | SES           | 1 = Linear, 2 = Lanceolate, 3 = Triangular.                                        |
| 17  | Petal color                         | PTC           | 1 = Cream, 2 = Yellow, 3 = Golden                                                 |

![Figure 1. Leaf and Flower Shape Descriptor Key for *Abelmoschus* (Medik.). Source: Adapted from Charrier [20]](image-url)
Statistical analysis. Multivariate statistical analyses were applied to enumerate the possible relationship between the okra accessions based on the collected quantitative and qualitative morphological characteristics. The collected data were analyzed using SPSS (version 16.0) and Squared Euclidean distance, which was used as a measure of distance for cluster formation after standardization of quantitative and qualitative data. Pairwise distance matrices between accessions were derived using Statistic XL Excel.

Results and Discussion

The morphological characteristics of the five okra accessions were investigated in this study. According to Osawaru et al. [9], morpho-agronomic characteristics of okra can be used to describe the plant. These characteristics complement the molecular and biochemical basis of characterizing the plant germplasm. These characteristics are the raw materials for crop breeding on which selection acts upon to evolve superior genotypes. Thus, the higher the amount of variation expressed for a character in the breeding material, the greater the scope for its improvement through selection [9, 10, 15]. Hence, morphological characteristics are an important tool for the evaluation of okra for systematic classification and breeding. The morphological characteristics expressed by the five okra accessions are presented in Table 3. Eighteen qualitative characteristics were used in the construction of a cluster diagram, which is presented in Table 4 and Figure 2.

A cluster of the genotype was observed at 4.123 level of coefficient of similarity for two clusters (3 and 1). Cluster 4 genotype had fruit length at maturity and leaf shape in common. As the level increased, two distinct clusters were observed at 2.236 and 2.446 levels of coefficient of similarity for the following clusters: 1 (NG/OA/12/159 and NG/OA/03/157) and 3 (cluster 2+ NG/SA/DEC/07/0482), respectively.

Table 3. Major Distinguishing Qualitative Features among the Five Accessions of Cultivated Okra

| S/N | Parameter | NG/OA/03/12/157 | NG/OA/03/12/158 | NG/SA/DEC/07/0475 | NG/SA/DEC/07/0482 | NG/OA/05/12/159 |
|-----|-----------|-----------------|-----------------|-------------------|-------------------|-----------------|
| 1   | GAS       | 2               | 1               | 1                 | 1                 | 2               |
| 2   | BRA       | 1               | 3               | 3                 | 3                 | 1               |
| 3   | STP       | 3               | 2               | 2                 | 2                 | 3               |
| 4   | STC       | 1               | 2               | 2                 | 2                 | 1               |
| 5   | LCL       | 1               | 2               | 2                 | 2                 | 1               |
| 6   | NES       | 2               | 1               | 1                 | 2                 | 2               |
| 7   | SES       | 2               | 3               | 3                 | 3                 | 2               |
| 8   | PES       | 2               | 3               | 3                 | 3                 | 2               |
| 9   | PCL       | 1               | 2               | 2                 | 2                 | 1               |
| 10  | RCPB      | 2               | 1               | 1                 | 1                 | 2               |
| 11  | PFS       | 1               | 1               | 3                 | 1                 | 1               |
| 12  | FCL       | 2               | 1               | 1                 | 1                 | 3               |
| 13  | FLM       | 2               | 2               | 2                 | 2                 | 2               |
| 14  | LP        | 1               | 2               | 2                 | 2                 | 1               |
| 15  | NRF       | 2               | 3               | 2                 | 2                 | 2               |
| 16  | FP        | 1               | 2               | 2                 | 2                 | 1               |
| 17  | LSH       | 4               | 4               | 4                 | 4                 | 4               |
| 18  | FSH       | 6               | 6               | 6                 | 4                 | 4               |

Table 4. Cluster Strategy of 18 Qualitative Morphological Characteristics among the Five Accessions of Abelmoschus spp.

| Cluster | 1st item | 2nd item | Distance |
|---------|----------|----------|----------|
| 1       | E        | A        | 2.236    |
| 2       | C        | B        | 2.236    |
| 3       | Cluster 2| D        | 2.449    |
| 4       | Cluster 3| Cluster 1| 4.123    |

A = NG/OA/03/12/157; B = NG/OA/03/12/158; C = NG/SA/DEC/07/0475; D = NG/SA/DEC/07/0482; E = NG/OA/05/12/159
Although accessions NG/OA/03/12/158 and NG/SA/DEC/07/0475 (cluster 2) were separated together at the same distance, a level of distinctiveness still existed at the position of the stem. Figures 3–7 show the characteristic fruit and leaf shape for each accession observed during field trials. The two *A. esculentus* accessions exhibited fruit shapes that were distinct from those of the three *A. caillei* accessions. The fruit and leaf characteristics of the five accessions are consistent with those reported by Osawaru et al. [9, 21] and Ogwu et al. [22, 23] for *A. caillei*. These findings suggest that diverse patterns exist in *A. caillei* within the study area, which are diagnostic rather than circumscriptive. However, the nature of these parts influences the utilization of these germplasm [24, 25]. Some similarities observed within cluster 1 were medium stem, red coloration on both sides of the petal, lanceolate epicalyx shape, and partial persistence of the epicalyx segment, which are common features found among the accessions. The common morphological features among cluster 3 were strong stem, triangular epicalyx segment, and persistence of the epicalyx segment but separated with nature of the epicalyx segment, and fruit shape. The common morphological features of clusters 1 and 3 were leaf shape and fruit length at maturity.

In this study, the variation among the accessions was inferred from the morphological characteristics analyzed (Table 3). The *Abelmoschus* species characterized in this study formed four major cluster groups. Variance in the analyzed characteristics is an important attribute in plant breeding programs [9, 26, 27]. Therefore, these characteristics may be exploited for further characterization of okra germplasm with a view to conserving them or utilizing them for crop breeding. This is in agreement with the recommendations of Osawaru and Ogwu [28], Ogwu et al. [29], and Osawaru et al. [30]. Furthermore, Omonhinmin and Osawaru [27] reported that *A. caillei* species have a determinate growth pattern and are highly branched, whereas *A. esculentus* have an indeterminate growth pattern and orthotropic branching. Cluster 1, which comprised the accessions NG/OA/05/12/159 and NG/OA/03/12/157, possessed medium or procumbent stem, orthotropic branching system, red coloration on both sides of the petal, fruit shape, fruit pubescence, lanceolate epicalyx shape, and partial persistence of the epicalyx segment, characterized as *A. esculentus*. These findings are consistent with the reports of Aladele et al. [15], Omonhinmin and Osawaru [27], and Oppong-Sekyere et al. [31]. Moreover, the nature of *A. esculentus* allows for easy and continuous harvesting of the fruit, whereas an erect nature allows for maximum and uniform exposure of all leaves and other vegetative parts to better sunlight and would also result in an increase in dry matter production and an increase in yield [8, 13, 22, 30].

The orthotropic branching recorded for *A. esculentus* indicates high yield potentials, as branches were found around the fruit production site, and hence, the higher their number, the greater the potential yield. Fruit pubescence is an appreciable attribute to consumers as...
downy nature will not hinder usage. Cluster 3 exhibited common morphological features for *A. caillei*, which comprises the accessions NG/SA/DEC/07/0475, NG/OA/03/12/158, and NG/SA/DEC/07/0482. These features were strong and erect stem, densely branched, slightly rough fruit pubescence, stem color, leaf color, triangular epicalyx segment, persistence of the epicalyx segment, petal color, fruit color, and length of peduncle. These characteristics were consistent with those reported by Osawaru et al. [9]. Omonhinmin and Osawaru [27] reported that strong erect stem and dense branching recorded for *Abelmoschus* species indicated a high yield potential, as branches were found at the production sites and there was extended harvest throughout the year. However, the potential yield for both species cannot be compared because of a higher production of *A. caillei*. Fruit pubescence is not an appreciable attribute in *A. caillei* compared with *A. esculentus* because consumers consider its prickly nature, which would hinder usage. However, there was variation in the nature of the epicalyx segment and fruit shape in cluster 3, which caused a separation, thereby forming cluster 2. The deviation of this cluster showed a considerable degree of morphological variation within the species. The common morphological features of clusters 1 and 3 were number of fruit ridges, leaf shape, and fruit length at maturity. The number of observed ridges was found to be independent of the fruit size, as *Abelmoschus* species with large fruit size included *A. caillei*. Fruit ridge is a feature aiding the dispersal of seeds and facilitates seed removal during threshing. All the accessions showed the same result for the number of ridges, except for the accession NG/OA/03/12/158 that had more than 15 ridges. However, a distinct attribute was observed for the accession NG/SA/DEC/07/0475 regarding the position of the fruit on the main stem (pendulous), and the same result was also observed for the accessions NG/SA/DEC/07/0482, NG/OA/03/12/158, NG/OA/05/12/159, and NG/OA/03/12/157 (erect/ horizontal). Cluster 4 showed similarity among the other three clusters. This result proves that all the five accessions investigated in this study are of the genus *Abelmoschus*.

Character codes: GAS - general aspect of stem, STP - stem pubescence, BRA - branching, PES - persistence of the epicalyx segment, STC - stem color, LCL - leaf color, PCL - petal color, PFS - position of the fruit on the main stem, FCL - fruit color, FLM - fruit length at maturity, LP - length of peduncle, FSH - fruit shape, FP - fruit pubescence, SES - shape of the epicalyx segment, NES - number of epicalyx segments, LSH - leaf shape, PES - persistence of the epicalyx segment, RCPB - red coloration of petal base, NRF - number of ridges per fruit. NG/OA/03/12/157 and NG/OA/05/12/159 = *A. esculentus*. NG/OA/03/12/158, NG/SA/DEC/07/0475, and NG/SA/DEC/07/0482 = *A. Caillei*.

Germination of the accessions occurred from the 3rd week of emergence at a week interval from a representative of each accession. 50% germination was observed in the accession NG/SA/DEC/07/0482, while 40% was observed in the others, i.e., NG/OA/03/12/157, NG/OA/03/12/158, NG/OA/05/12/159, and NG/SA/DEC/07/0475. During the developmental stage, all the accessions showed a degree of similarity; however, at maturity, the leaf and fruit color, height, leaf shape, and flowers showed significant differences. All seedlings were observed to have epigal germination. When the quantitative characteristics were subjected to ANOVA, no significant difference was observed at the end of 11 weeks for leaf width in all the five accessions; however, a significant difference was observed in all the five accessions in terms of stem length, petiole length, and leaf node. These results are shown in Table 5.

The quantitative attributes assessed in this study were recorded before flowering for each accession to prevent cross-pollination from one stand to another. These attributes were fruiting period, number of leaves, leaf width, length of petiole, and stem length. Akinyele and Osekita [32] reported that days to bud emergence and plant height at maturity, among other morphological traits, are some of the most variable traits of okra that are necessary for selection programs aimed at improving desirable traits. Similar results were obtained in Corchorus, a member of the same family as *Abelmoschus* [33]. The accessions NG/SA/DEC/07/0475, NG/OA/03/12/158, and NG/SA/DEC/07/0482 had trait for tallness, which may be important to farmers who have little space for cultivation. However, for early returns of harvest, the accessions

Table 5. Quantitative Attributes of the Mean ± Standard Error of Mean of All the 10 Stands in Each Accession during Maturity

| Accession      | Petiole length (cm) | Leaf width (cm) | Leaf node count per leaf | Length of stem (cm) |
|----------------|---------------------|----------------|-------------------------|--------------------|
| NG/OA/03/12/157| 17.78 ± 1.43        | 16.81 ± 0.85   | 16.80 ± 0.85            | 23.11 ± 2.24       |
| NG/OA/03/12/158| 13.04 ± 0.92        | 14.49 ± 0.72   | 12.85 ± 1.01            | 35.65 ± 3.17       |
| NG/SA/DEC/07/0475 | 13.74 ± 0.74   | 15.08 ± 0.75   | 9.60 ± 0.50             | 22.21 ± 2.03       |
| NG/SA/DEC/07/0482 | 16.63 ± 1.34   | 16.45 ± 0.72   | 14.80 ± 1.31            | 18.70 ± 1.52       |
| NG/OA/05/12/159 | 16.63 ± 1.34        | 16.14 ± 0.60   | 11.15 ± 0.62            | 17.75 ± 1.30       |

* Significant at P < 0.05  **NS**: Not significant at P < 0.05

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Figure 3. The Fruit Shape, Fresh Fruit Color, Shape, and Position, as Well as Flower Blotch of Accession NG/SA/DEC/07/0482 (A. caillei)

Figure 4. The Fruit Shape and Position of Accession NG/SA/DEC/07/0475 (A. caillei)

Figure 5. The Fruit Shape, Color, and Position of Accession NG/OA/03/12/158 (A. caillei)
NG/OA/05/12/159 and NG/OA/03/12/157 should be cultivated as bud emergence will give rise to fruit. However, this may require large space for cultivation due to their procumbent or intermediate nature. These expressions make accession NG/SA/DEC/07/0482 an important variety that can be cultivated in small farming spaces with an earlier return compared with the other four accessions. NG/OA/03/12/157 and NG/OA/05/12/159 showed almost similar results, with 9 and 10 weeks to flowering, respectively (when they started to bud, accession NG/SA/DEC/07/0482 was drying up). This result is also in accordance with the findings of Ashraful and Hossain [34] and Katung [35], who reported similar behavior among the different okra cultivars in terms of days to flowering. In addition, plant physiologists agree that for a crop to flower, it must be mature and must have accumulated sufficient metabolites for the process [36], i.e., accumulated adequate photosynthetic materials, and then the appropriate photoperiodic regime (most likely long day length for *A. caillei* and short day length for *A. esculentus*) will initiate induction. Buds of *A. esculentus* formed during the heavy rains (before mid-year) and borne fruit, whereas those of *A. caillei* formed before the onset of the dry season, following
which time leaves are lost and enter dormancy until the release of flowering occurs with the onset of dry season. This permitted for proper identification of the five accessions for okra breeding in Nigeria and across the world.

Conclusion

Using the morphological characteristics analyzed in this study, we were able to distinguish the *Abelmoschus* accessions into *A. caillei* and *A. esculentus*. This further provides credence to the relevance of using morphological characteristics to characterize plant genetic resources. Nevertheless, these morphological characteristics may be complemented by more reliable means such as molecular and biochemical tools. Furthermore, the characteristics studied here can be suggested as key characteristics for the genus.

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