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Okra- an important vegetable crop of India

******Satyawada Rama Rao, Rihunlin H. Nongsiang and Merita Keisham Devi*
Department of Biotechnology and Bio-informatics
North-Eastern Hill University
Shillong 793 022, India
*Corresponding author: srrao22@yahoo.com

Abstract

Abelmoschus esculentus, commonly known as Okra, is a major vegetable crop of India. It is very popular among farmers and consumers because of its diverse usage as fiber yielding and ornamentals for their beautiful flowers. It is distributed in tropics, all over the world with several local variant genotypes. While A. esculentus show less genetic variability, it has genomic similarities identical with those of diploid A. tuberculatus and allopolyploid A. tetraphyllus var. tetraphyllus respectively. This homology confirms the lineage of A. esculentus from either of the two taxa.

Keywords: *Abelmoschus esculentus,* origin, distribution, diversity, phylogeny

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench], also known as *Hibiscus esculentus* L. is a member of the mallow (Malvaceae) family and can be found as an annual (primarily the U.S.) or as a perennial in India and Africa (Lamont, 1999). Varying chromosome numbers (about n=36; 33; 59 to 72) have been reported for *A. esculentus* (Joshi et al. 1974). *A. esculentus* L. (Moench) is an economically important annual vegetable grown from seed, in tropical, subtropical and Mediterranean climatic zones. In West and Central Africa it is cultivated, in association with *A. caillei* where the former, which flowers earlier, is known as 'the rainy season okra' and the latter, which has a longer cycle (up to 1 year) is known as the 'dry season okra'. This crop is suitable for cultivation as a garden crop as well as on large commercial firms. It is grown commercially in India, Turkey, Iran, Western Africa, Yugosavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopian, Cyprus and the Southern United States. India ranks first in the world with 3.5 million tonnes (70% of the total world production) of okra produced from over 0.35 million ha land (FAOSTAT, 2008). Okra is known by many local names in different parts of the world. It is called lady's finger in England, gumbo in the United States of America, *guino-gombo* in Spanish, *guibeiro* in Portuguese and bhindi in India. It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. Even within India, different names have been given in different regional languages (Chauhan, 1972).

Origin and Distribution

A. esculentus is cultivated as a vegetable in most tropical and subtropical regions of Africa, India and America. In West Africa, Siemonsma (1982b) has clearly demonstrated that the species has preference for the Sudano-Sahellan zone. However, A. esculentus is also found in forest regions in smaller quantities. It is a case of ecological adaptation to photoperiodic response and to parasitism (different in savannah and forest areas). But in this Guinean bioclimatic zone, Siemonsma (1982a) has given prominence to a new cultivated species provisionally called "Guinean" okra, which can be found in the forest regions of Ghana, Guinea, Ivory Coast, Liberia and Nigeria.

A. esculentus is found all around the world from Mediterranean to equatorial areas. Cultivated and wild species clearly show overlapping in Southeast Asia, which is considered as the centre of diversity. The spread of the other species is the result of their introduction to America and Africa. There are two hypotheses concerning the geographical origin of *A. esculentus*. Some authors argue that one putative ancestor (*A. tuberculatus*) is native to Uttar Pradesh in northern India, suggesting that the species originated from this geographic area. Others, on the basis of ancient cultivation in East Africa and the presence of the other putative ancestor (*A. ficulneus*), suggest that the area of domestication is north Egypt or Ethiopia, but no definitive proof is available today. For *A. caillei*, only found in West Africa, it is difficult to suggest an origin outside. Its origin by hybridization with *A. manihot* is difficult to accept even if its presence, mentioned in the Flora of West Africa (Hutchinson and Dalziel, 1958) was not recently confirmed in this area and herbarium samples are lacking.

Uses

Okra is cultivated for its fibrous fruits or pods containing round, white seeds. The fruits are harvested when immature and eaten as a vegetable. The young fruits produced by this species are used as a vegetable. They are picked when still immature (3-6 cm long), before the differentiation of fibers and before the seeds are fully developed. After cooking, these young fruits have a mucous consistency; the water in which they are boiled becomes thick and ropy. They are consumed alone or in salad, after cooking in salty water, and are used in the preparation of certain African sauces. For year-round consumption, the fruits are conserved either in the form of slices dried naturally in the sun (Africa and India) or frozen or sterilized (USA). The leaves are also eaten as spinach by Africans. The fibers extracted from the stems are sometimes used, as on the banks of the Niger in Mali, to make strings and nets (Chevalier, 1940).

The roots and stems of okra are used for cleaning the cane juice from which gur or brown sugar is prepared (Chauhan, 1972). Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries. Mature fruits and stems containing crude fiber are used in the paper industry. Extracts from the seeds of the okra is viewed as alternative source for edible oil. The greenish yellow edible oil has a pleasant taste and odour, and is

high in unsaturated fats such as oleic acid and linoleic acid. The oil content of the seed is quite high at about 40%.

Okra provides an important source of vitamins, calcium, potassium and other mineral matters, which are often lacking in the diet of developing countries (IBPGR, 1990). Okra pods are used in Asia as a vegetable, food ingredient, as well as a traditional medicine for many different purposes; for example, as diuretic agent, for treatment of dental diseases and to reduce/prevent gastric irritations. The healthy properties are suggested to originate from the high polysaccharide content of okra pods, resulting in a highly viscous solution with a slimy appearance when okra is extracted with water

Genetic Diversity

From careful perusal of published data, it is known that Indian representative taxa of *Abelmoschus*, including *A. esculentus*, indicate that the taxonomic units of *Abelmoschus* are heterogeneous in nature thereby exhibiting deviant chromosome numbers. The occurrence of different somatic chromosome numbers ranging from 2n=58 to 2n=200 in the genus suggest that the classification at the species level is much more complex than elaborated by van BorssumWaalkes (1966). Therefore, it is proposed to undertake investigations with a prime objective of a comprehensive study to understand the quantum of genetic diversity and ascertain genomic relationships among species of Abelmoschus, including *A. esculentus* which are important to systematists, evolutionary biologists, cytogeneticists, molecular biologists and plant breeders as well. The study is expected to find solutions to overcome the taxonomic dilemma that exists in the genus using cytogenetical and molecular approaches in both the cultivated and wild relative species from the Indian sub-continent. Thus, an attempt has been made to analyze the existing genetic variation among these plants in natural habitat to assess the quantum and range, and also to define the genetic basis for the same.

DNA markers for diversity analysis

Molecular marker-based approaches have been successful in characterizing variations both at inter- and intra-specific levels since they generate new genetic diversity parameters to define. Such parameters often extend beyond species boundaries and boast of a great value and significance in diagnostic applications. In the present study, three single primer amplification methods viz., random amplified polymorphic DNA (RAPD), inter-simple sequence repeats (ISSR) and directed amplification of minisatellite DNA regions (DAMD) were utilized (individually and cumulatively) to comprehend the genetic variation that exist both at intra- and inter-specific levels in cultivated and wild species of *Abelmoschus* taxa.

RAPD markers were able to easily distinguish the differences and similarities among 43 genotypes based on their randomness in their genetic make-up (as found in chromosome counts also) by clustering them into four distinct clusters, each cluster representing the respective species. Only one accession belonging to *A. tetraphyllus* var.

tetraphyllus (AT-2) behaved as an out-group, which can be visibly noted, not only from its gel profile but also from its collection site i.e. Nepal. *A. angulosus* var. *grandiflorusis* shown to have close affinity towards *A. tetraphyllus* var. *tetraphyllus* which is evident from the successful F1 hybrids from this cross. *A. esculentus* with a stable chromosome number, 2n=130 is considered low in genetic diversity and genetic similarity individuals in a given population. On closer analysis it is confirmed that RAPD analysis of *A. esculentus*, the cultivated taxon Pusa Sawani, AE-39 and AE-41 had shown the genetic similarity of 100% among genotypes in the population.

When species relationships were probed, *A. esculentus* showed close affinity towards *A. tetraphyllus* and *A. angulosus* var. *grandiflorus*, while *A. moschatus* ssp. *moschatu*s has been clustered separately from the rest. DAMD marker also revealed high polymorphism across the 43 genotypes of the Indian representative Abelmoschus belonging to four species. *A. angulosus* var. *grandiflorus* showed the close proximity towards *A. tetraphyllus* by clustering together, while *A. esculentus* was distantly related from *A. tetraphyllus*. *A. moschatusssp. moschatus* was closely related to *A. esculentus.*

Phylogenetic Analysis

The molecular phylogenetic analysis of various Abelmoschus taxa has been carried out using DNA sequence data of three chloroplast loci viz., *accD, atpB* and *psbK-psbI* which revealed different topologies in all the four tree building methods. The clustering pattern of *accD* and *atpB* sequences were almost similar, though with some exceptions in the positions of the species may differ in the tree. It was recorded that *atpB* had the highest percentage of conserved sites while the highest percentage of variable sites were recorded in intergenic spacer, *psbK-psbI*. The lowest percentage of sequence divergence substitution was recorded as 2.19 in *atpB*, confirming that nucleotide substitutions occur at a relatively slow rate in cpDNA (Curtis and Clegg,1984). These sequence comparisons have further revealed that, although the genome as a whole change slowly, certain genes change either more rapidly or more slowly than the average. The region is highly conserved in Abelmoschus and relatively few sites in the aligned data matrix are parsimony informative, a variety of relationships among the species are revealed by the analyses, some of which are congruent with the known species relationships.

In the present study, the coding gene *accD* and *atpB,* and intergenic spacer region *psbK-psbI* has been combined into a single matrix for a collective approach analysis to obtain greater phylogenetic resolution. The concatenate topologies of the trees constructed by ML, MP, BI and NJ for the consensus sequence were consistent with the clustering of *A. caillei* and *A. tetraphyllus* var. *tetraphyllus,* in all the methods, thereby it supports our earlier hypothesis that *A. tetraphyllus* var. *tetraphyllus* may be one of the probable progenitor species of *A. caillei*. Since cpDNA is maternally inherited, one can conclude that *A. esculentus* and *A. caillei* were essentially identical with those of diploid *A. tuberculatus* and allopolyploid, *A. tetraphyllus* var. *tetraphyllus* respectively, thereby either of the latter two species served as the maternal parents in the inter-specific hybridizations which gave

rise to the hybrid taxa. The origin of amphidiploid, *A.esculentus* is further supported from the inter-specific hybridization studies.

Conclusion

Okra (*A. esculentus*), is an important vegetable crop of India and it has many other uses, for eg. fibres extracted from the stems are sometimes used to make strings and nets. *A. esculentus,* an amphidiploid in origin, is an interspecific hybrid and exhibit low genetic diversity within the population. *A. esculentus* is identical with those of diploid *A. tuberculatus* and allopolyploid *A. tetraphyllus* var. *tetraphyllus* respectively, thereby either of the latter two species served as the maternal parents in the inter-specific hybridizations which gave rise to the hybrid *A. esculentus.*

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