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Genetic improvement of gourds: sponge gourd [*Luffa cylindrica* (L.) roem.]

T. CHAUBEY[1], D.K. UPADHYAY AND B. SINGH[1]

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AUTHORS' INFO

Associated Co-author :
[1]Indian Institute of Vegetable Research, Jakkhini (Shanshahpur), VARANASI (U.P.) INDIA

Author for correspondence :
D.K. UPADHYAY
Indian Institute of Vegetable Research, Jakkhini (Shanshahpur), VARANASI (U.P.) INDIA
Email:
dhananjay.gpb2011@gmail.com

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Among the various cultivated cucurbitaceous vegetables grown worldwide, sponge gourd or smooth gourd or dischcloth gourd or smooth loofah or vegetable sponge (*Luffa cylindrica* Roem. syn. *aegyptiaca*) and ridge gourd or ribbed gourd or angled gourd or silky gourd or angled loofah or vegetable gourd [*Luffa acutangula* (L.) Roxb.] is very popular in the tropical and subtropical regions. It has been cultivated for centuries in the Middle East and India, China, Japan and Malaysia (Porterfield, 1955). In India, it is cultivated on both commercial scale and in kitchen gardens during the spring-summer and rainy season (Chakravarty, 1990).

Origin :

The *Luffa* has essentially Old World origin in subtropical Asian region including particularly India (Kalloo, 1993). The genus *Luffa* comprises five species of tropical vines, four native to the Old World and one, *L. operculata*, to the New World. Two species, *L. aegyptiaca* and *L. acutangula,* include domesticated plants that are now widespread in the tropics.

Interspecific hybrids are sterile or nearly so. Intraspecific hybrids within *L. acutangula* and *L. aegyptiaca* are fertile, but the hybrid within *L. operculata* is sterile. Phenetic and cladistic analyses indicate that the species are well differentiated with *L. echinata* the most distinct. The cladistic analyses further reveal two phyletic lines, one comprised of *L. aegyptiaca* and *L. acutangula* and the other of *L. echinata*, *L. graveolens* and *L. operculata*. It is concluded that *L. graveolens*. or more likely a species ancestral to it and *L. operculata*, gave rise to *L. operculata*. *Luffa* presents several disjunct distributions, and various possibilities are explored to account for them. Humans may be responsible for the disjunct distribution of feral varieties of *L. acutangula*. Long-distance transport by water may account for the others. Two new varietal combinations are made, *L. acutangula* var. forskalii and *L. aegyptiaca* var. *leiocarpa*.

Botany :

Luffa plants are fast growing, large, many branched, annual vines that can exceed 10 m in length and have ribbed, herbaceous stems that are square to pentagonal in cross-section (Herklots, 1972; Robinson and Decker-Walters, 1997). The foliage of *L. cylindrica* is glabrous, with leaf laminae that are shallowly to deeply and actually three, five or seven lobed and often exhibit silver patches in the axils of the major leaf vines. The foliage of *L. acutangula* is hapsid, with leaf laminae that are pentagonal and unlobed or slightly lobed without silver patches. In both species, the leaf laminae typically are 13 cm long × 16 cm broad and petioles generally are 8-15 cm long. One tendril having five or six branches is borne at the junction of stem and leaf petiole.

Ordinarily, the plants of cultivated *Luffa* are monoecisous (Herklots, 1972; Robinson and Decker –Wellers, 1997). The staminate flowers are borne in elongated racemes and the pistillate flowers are solitary. Both a male flower raceme and a solitary female flower can occur along with the tendril in each

leaf axil. The corolla are bright, intense yellow, quit conspicuous and large, 8-12 cm in diameter. The petals are free, that is not fused even at the base. The five stamens are separate in the male flowers of *L. cylindrica* whilst there are two pairs of two with the fifth unpaired, resulting in the appearance of three stamens in the male flowers of *L. acutangula*. The ovaries are inferior and elongate. The two species also differ in the diurnal period during which the flowers are open: morning for the former species and afternoon for the latter. Both species produce a large quantity of nectar, both within the flowers and the abaxial surface of the pistillate calices, the base of peduncles, and even in some leaf axils. This nectar attract various hymenopterous insects.

Ridge gourd fruit are nearly cylindrical, straight or curved, normally with height farrows or stripes but not ribbed. Seeds are black, flat, smooth, without margins, 10-15 mm long. Sponge gourd fruits are oblong to cylindrical. The rind becomes dry at maturity.

Pathak and Singh (1949) were successful in making reciprocal crosses between these two species. The F_1 plants were generally intermediate between the parents. The F_1 showed various irregularities, like, univalent's, rings, chains of four chromosomes, chromatin, bridges and fragments at metaphase. The percentage of good pollen ranged from 18 to 40 per cent. Thus, the species are not easily crossable and the F_1 appears to be of not much practical value.

Breeding objective :

- High yield
- Greater fruit number
- Greater fruit weight
- Earliness
- More female : Male sex ratio
- Uniform thick cylindrical fruits free from bitterness
- Tender, nonfibrous fruits for longer time
- Resistance to powdery mildew and downy mildew and mosaic disease
- Insect resistance (aphid, gall fly, plue moth, fruit fly)
- Abiotic resistance (low temperature, high temperature, drought , salinity, acidity)

Quantitative genetic :

According to Singh *et al*. (1948), two multiple-allelic loci, A and G, determine sex expression in *L. acutangula*. They indicated that the F_2 of monoceious x hermaphrodite segregated in a digenetic ratio of 9 monoecious : 3 andromomorocious : 3 gynomonoecious : hermaphrodite forms. Richharia (1948) independently reported similar results regarding the inheritance of sex forms in *L. acutangula*. The bitterness has been reported to be governed by a single dominant gene Bi (Thakur and Chaudhary, 1966). Further, these authers have reported that the corolla colour (orange yellow with green veins of *L. cylindrical* vs lemon yellow of *L. acutangula*), the fruit surface (ridged of *L. acutangula*), and the type of androecium *i.e.*, stamens, 5=2+2+1 of *L. acutangula* vs. five free stamens of *L. cylindrical* were monogenically inherited. *Luffa* has one of the most variable and complex sex expression systems, which is regulated by both genetic and environmental factors. Sex expression has a direct effect on breeding and seed production. Sex expression is controlled by three or more for each gene (Robinson and Decker–Walters, 1997).

Breeding approaches :

- Selection and inbreeding
- Hybridization (bulk method / back cross/ single seed descent method)
- Population improvement
- Heterosis breeding
- Mutation breeding
- Biotechnological approaches
- Micro propagation
- Somaclonal variation
- Anther culture
- Genetic engineering

The demand of quality and high yielding varieties can be met either by finding new plant species that fulfill the need or by modifying the existing *Luffa* sp. according to the specifications.

Lines with desired characters have material. Sometimes, an existing variety may be found to possess the desired features. The initial selections/varieties may not be suitable for direct release to some weakness eg. low fertility etc. However, they would serve a source of the desired traits for use in breeding programmes.

Domestication :

Domestication was characterized by the selection for shape, less bitter flesh, larger and fewer seeds, and larger fruits. Selection for non-bitter fruit was a key step in *Luffa* domestication. Seed was probably the first part used as food; generally bitter fruit has non-bitter seeds (Robinson and Decker–Walters, 1997).

Hybridization :

Interspecific crosses are widely used in cucurbits to transfer desirable characteristics from wild progenitors or related species to cultivated genotypes. Interspecific hybrids have been produced in *Cucurbita*, *Citrullus* and *Luffa*. However, interspecific hybridization has only been successfully used for crop improvement in cucurbits (Robinson and Decker–Walters, 1997), which included the development of hybrid cultivars (*C. maxima* and *C. moshata*) after hybridation, selection for the desired characters. But care should be taken in the counting for maternal effect, if present as they would confuse the relationship between genotypes and the phenotypes of the plant under selection.

Mutation :

Physical (X-rays and Gamma-rays) and chemical (EMS, MMS, colchicine) mutagens were used for improvement programe. Colchicine was found to be very effective to induce genetic variability in *L. actangula* and *L. siceraria* (Dutta, 1978), *C. maxima* (Basu and Dutta, 1977), *T. anguina* and *T. cuamarina* (Basu and Dutta, 1997; Dutta, 1991).

Back cross methods :

The backcross methods have been successfully used to transfer simply inherited traits such as disease and insect resistance, to make sterility into agronomically superior genotypes.

Heterosis breeding :

In general heterosis is useful for earliness, fruit size, fruit weight and flesh thickness. Though cultivated varieties in ridge gourd are monoceious in nature, different sex forms were reported in this species and the genetics of inheritance has been extensively studied (Choudhary and Thakur, 1966). So far no male sterility has been reported in ridge gourd. An off-type was detected in a population of ridge gourd which was characterized by the production of rudimentary male flowers in racemes. Like muskmelon male sterility can be exploited in heterosis breeding programme and development of F_1 hybrids in ridge gourd. Maintenance of male sterile line is a major challenge and for genetic dissection of male sterility, it has to be crossed with different pollen parent and create F_1, F_2 and backcross population. Micropropagation is the only viable approach for maintaining this unique source as the genotype can be fixed without any genetic change.

Biotechnological approaches :

Biotechnological approaches are rapidly developing as an important adjunct to crop improvement. The various approaches used/useful for increasing yield and other quality are as follows :

- Micropropagation
- Somaclonal variation
- Anther culture
- Genetic engineering

Somaclonal variation, described as the result of genetic instability of cultured cells (Bajaj, 1990), has often been correlated with the undifferentiated state of the culturs; a possible solution could, therefore, be used cultures of differential tissues such as shoot or roots. Because of their simplicity, root cultures would appear to be easier to handle and more suitable than shoot cultures for large scale industrial production in liquid medium.

Transformation of plants by infection with *Agrobacterium rhizogenes* results the transfer to the host plant cells of part of the Ri (root-inducing) plasmid and in the proliferation of adventitious "hairy roots" (Spano *et al*., 1982). Root transformed by *A. rhizogenes* has an attend phonotype that allows them to grow readily in culture. Moreover, they are genetically stable, easy to manipulate, and can be engineered with foreign genes.

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