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Wild Genetic Resource in Okra for Future Breeding

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Abstract

Wild relatives of okra give a wide diversity in okra germplasm. The number of species recognized varies from 6 to 15. The major limitation is yellow vein mosaic disease (YVMD) transmitted by whitefly (*Bemisia tabaci*) and Enation leaf curl Virus, fruit borer, powdery mildew in okra which results in substantial losses of yield up to 95% in India, and also deterioration of fruit quality. Hence, Knowledge about wild species and their crossability behaviour helps us to mitigate this problem.

Introduction

Okra (Abelmoschus esculentus (L.) Moench), originated in tropical Africa; is an important vegetable throughout the tropical and subtropical regions of the world. It is considered to be an often-cross-pollinated crop since insects such as honey bees (*Apis mellifera*) and bumblebees (*Bombus auricomus*) can affect cross-pollination. The word *Abelmoschus* possibly originated from the Arabian word "*abul-l-mosk"* meaning "source of musk," referring to the musky smell of the seeds. Okra is one of the most popular vegetable crops cultivated throughout India because of high consumer demand and thereby better prices, farmers grow okra widely during the summer season. Okra has great potential as a foreign exchange earner and accounts for about 60% of the export of fresh vegetables from India to the Middle East and European countries. Okra is considered an important constituent for balanced food due to its dietary fibres and amino-acid composition which is rich in lysine and tryptophan. Its fruits are harvested when immature and are commonly consumed in salads, soups, and stews. The roots and stems are used for cleaning the cane juice during brown-sugar preparation. The seeds have also gained much interest as a new oil (30–40%) and protein (15–20%) source. It also contains considerable amounts of iron, calcium, manganese, magnesium, vitamins A, B, C, and K, as well as folates (USDA

National Nutrient Database, 2016). It has been found to possess various ethnopharmacological and medicinal properties against cancer, high cholesterol, and Diabetes mellitus.

Okra is susceptible to the various Biotic and abiotic stresses that cause serve losses in yield and quality. Among the biotic stress, one of the most serious and destructive diseases like "Yellow Vein Mosaic Virus (YVMV)" transmitted by the white fly (*Bemisia tabaci* Gen.) is the most serious disease of okra. Infection of 100% of plants in a field is very usual and yield losses range from 50 to 94% depending on the stage of crop growth at which infection occurs (Sastry & Singh, 1974). Viruses pose serious constraints to okra production. Okra is susceptible to at least 19 plant viruses. These viruses severely affect okra production in terms of yield and fruit quality. Among these viruses, yellow vein mosaic virus (YVMV) causes significant losses in okra production. Various types of resistance/tolerance have been reported to occur in some cultivated and wild species. Some scientists have reported that the resistance is controlled by two dominant complementary genes (Thakur, 1976; Sharma & Dhillon, 1983; Sharma & Sharma, 1984) but others have reported that a single dominant gene (Jambhale &Nerkar, 1981) or two recessive genes (Singh *et al.*, 1962) are responsible for the resistance. Besides YVMD, Okra Enation leaf curl virus, Cercospora leaf spot/ blight, powdery mildew, fusarium wilt, and sooty leaf blight also damage the crop significantly. Apart from diseases, several pests also cause serious damage to the okra, such as jassids, Whitefly, aphids, Shoot and fruit borer, Root-knot nematode, mites, and spotted bollworm considered the most destructive pest of okra.

Utilization of wild species for biotic stress breeding

A putative ancestor (*A. tuberculatus*, 2n = 58) being native to Uttar Pradesh in India, suggests the Indian origin whereas, the presence of another putative ancestor (*A. ficulneus*, 2n = 72) in East Africa, suggests northern Egypt and Ethiopia as its geographical origin (Charrier, 1984). Okra is an allopolyploid, having the lowest known chromosome number as 2n = 56 in *A. angulosus* and the highest around 200 in *A. caillei*, which is an amphipolyploid (allotetraploid) between *A. esculentus* (2n = 130–140) and *A. manihot* (2n = 60–68) (Siemonsma, 1982). Even within *A. esculentus*, a regular series of polyploids having chromosome numbers 2n = 72, 108, 120, 132, and 144 which are derived with a basal n = 12 are reported (Datta and Naug, 1968). Of fifty described species, eight are most widely accepted by the scientists working on okra globally. Among the genus Abelmoschus, *A. esculentus* is most widely cultivated for its pods throughout Asia and Africa. In West and Central Africa, *A. caillei* is cultivated for leaves and pods, whereas; in the South Pacific islands, *A. manihot* is extensively grown for its leaves. *A. moschatus* is grown as an ornamental plant and also for its aromatic

seeds. The other species namely, *A. tetraphyllus, A. tuberculatus, A. ficulneus, A. crinitus, A. enbeepeegearense, A. palianus, and A. angulosus* are true wild species (Patil et al., 2015). The morphological and distinguished character of various wild species of okra commonly exploited for disease resistance breeding is as follows:

1. *Abelmoschus angulosus:* India describes two varieties *var. grandiflorus*, with scabrous (not hispid) petioles, yellow petals, and sub pyriform seeds, and *var. purpurens*, with rigid spreading hairs on the petiole, purple petals and globose seeds. resistance to YVMV and powdery mildew consistently under all experimental conditions. (Samrajeewa*et al*. 2004). The chromosome number of *Abelmoschus angulosus*: 2n = 56 (Ford, 1938).
2. *Abelmoschus crinitus*: It is a perennial herb, growing between 0.5 to 2.0 m in height. The root is fusiform. The plant has an indumentum composed of 5-6 mm long yellow hairs and a minute grey pubescence. The corolla is around 10 to 13 cm in diameter and is yellow with a purple center.
3. *Abelmoschus tuberculatus:* Morphologically it can be distinguished by the tuberculate fruits, and by being smaller in most parts, especially the fruits. *Abelmoschus tuberculatus* is resistant to the spiny bollworm *Eariasinsulana* and to Okra yellow vein mosaic virus, and therefore is of interest for the potential transfer of those traits to *Abelmoschus esculentus*.
4. *Abelmoschus tetraphyllus: Abelmoschus tetraphyllus*is sometimes classified as a subspecies of *Abelmoschus Manihot.* There are two different species that come under *var. tetraphyllus* like *Abelmoscusmanihot var. tetraphyllus*and *Abelmoschus manihotssptetraphyllus var. pungens.*
5. *Abelmoschus ficulneus: Abelmoschus ficulneus* is a prickly annual herb, with palmately 3-5-lobed glabrous leaves. Flowers 12 cm in diameter.
6. *Abelmoschus manihot*: It is an annual or perennial herb growing 1 to 2 m. The corolla is yellow with a purple centre, and about 12 cm in diameter. The fruit is with 8 ridges on it.
7. *Abelmoschus moschatus*: It is an annual or perennial herb growing 1 to 2 m. The corolla is yellow with purple centre and about 7 to 12 cm in diameter. *Abelmoschus moschatus* is grown commercially for its musk-scented seeds. It also sometimes grows as an ornamental.
8. *Abelmoschus caillei*: it is originated as an allopolyploid hybrid between *Abelmoschus manihot* and *Abelmoschus esculentus*.
9. *Abelmoschus muliensis:* The foliage is alternate, stipulate, and shortly petiolate. The stipules are narrow, and 1 to 1.5 cm long. The petiole is 1 to 4 cm long. The flowers have not been observed,

however from the fruiting stage it is known that the flowers are born singly or in clusters in the leaf axils.

10. *Abelmoschus sagittifolius: Abelmoschus sagittifolius*is often classified as subspecies (tuberous) of *Abelmoschus moschatus.* The flowers are white, pale yellow or pink, and 4 or 5 cm in diameter, and they are borne solitary in the leaf axil.
11. *Abelmoschus enbeepeegearensis:* Morphologically allied to *Abelmoschus crinitus and Abelmoschus moschatus,* but not freely crossable.
12. *Abelmoschus spp (Guinean type)*: It is a polyploid form that might be derived from *Abelmoschus esculentus* and *Abelmoschus manihot (Siemonsma, 1981).* The fruits of Guinean type okra are ridgeless, cone-shaped with a slight red tinge on them.

Major Biotic stress in okra

1. Powdery mildew

This is one of the most destructive diseases which cause serve losses in the yield and quality of fruit. This is caused by the fungi *Erysiphae cichorocearum*. A white-colored powdery growth appears on the upper leaf surfaces of okra. This growth slows photosynthesis and results in a reduction in economic yield. The leaves detached and fall to the ground in heavy infestation. The pathogen spreads via airborne conidia and survives on the infected plant debris. None of the species showed resistant reactions among *A. esculentus, A. caillei, A. tuberculatus, and A. ficulneus*.

2. Fusarium Wilt

fusarium wilt in okra is caused by soil-born fungi like *Fusarium oxysporum var. vasinfectum.* The genus Fusarium includes saprophytic species, as well as plant pathogens, and is widely distributed throughout tropical and subtropical areas of the world (Burgess 1981). Fusarium wilt, caused by the fungus *Fusarium oxysporum f. sp. vasinfectum* (Snyder & Hansen), is one of the most important diseases on Malvaceae species. Greenhouse screening was initially carried out with one FOV isolate (‘Fus-194’) and (“Fus -204 “). Inoculation was carried out with 21-day-old plantlets, using the root-dipping inoculation technique and disease incidence was scored by using a disease scored chart generally ranging from 0-4 grade scale which as follows like 0 (plants with no symptoms), 1(plants with no symptoms of wilt or yellowing, but with darkened vascular bundles), 2(plants with intensely darkened vascular bundles and with incipientwilt or yellowed leave), 3 (plants with severe wilt, associated with yellowing and premature leaf drop), 4 (dead plants).

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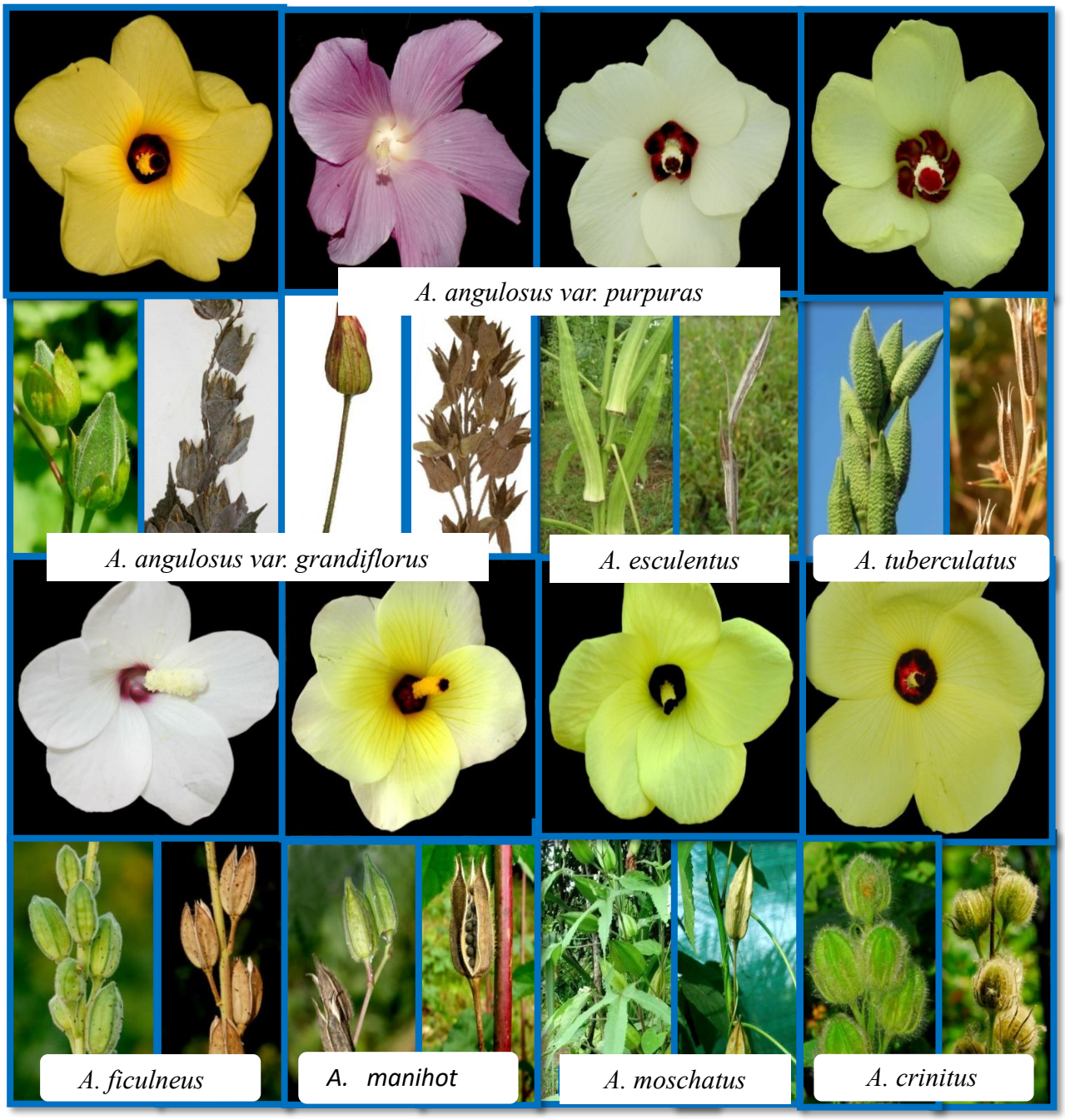

3. Yellow Vein Mosaic Virus

YVMV disease of okra was first reported in 1924 (Kulkarni 1924) during the erstwhile Bombay Presidency in India and later studied by Capoor and Verma (1950) and Verma (1952). This is the earliest report of this virus, implying that BYVMV might have originated in India. Further Uppal et al. (1942) established the viral origin of the disease and coined the name yellow vein mosaic (YVM).

It has been shown to be a Gemini virus based on its morphology and its serological relationship with African cassava mosaic virus. In the recent past, frequent break down of the YVMV resistance have been observed in popular varieties like Parbhani Kranti, P-7, Arka Anamika, Arka Abhey in all over the country as they were in all probability symptomless carriers or else new strains of virus have evolved. The hypothesis of evolution of new strains of virus seems to be one of the factors leading to break-down of tolerance as the tolerance in most of the cases has 269 been reported to be location specific. The emergence of the polyphagous 'B' biotype of *B. tabaci* with its increased host range of more than 600 plant species, has resulted in Gemini viruses infecting previously unaffected crops. Whiteflies and YVMV are largely influenced by weather conditions. In north India, YVMV severity is pronounced in rainy season crops due to high temperature and humidity. It has been reported that okra sown in June and pods reaching to marketable stage in July-August were least susceptible to YVMV (4.1 %) as compared to 92.3 % infection in okra sown in July and maturing in August-September. In India, inter-varietal hybridization followed by pedigree selection produced the widely cultivated, high yielding, yellow vein mosaic virus tolerant cultivar, Pusa Sawani. This was called as symptomless carrier and is no more tolerant. Kashi Pragati (VRO 6), Kashi Mohini (VRO 3), Varsha Uphar, Hisar Unnat came later on as a result of inter varietal crosses and were reported to be tolerant to YVMV. Inter-specific hybridization (with *Abelmoschus manihot* L. Medikus subsp. manihot) has been followed in development of YVMV tolerant cultivars like Punjab Padmini, P 7, Parbhani Kranti, Arka Anamika, Arka Abhaya, etc. In case of inter-specific hybridization, 1-2 backcrosses have normally been used and then the material has been handled as per pedigree method of breeding.

4. Enation Leaf Curl of Okra

This disease was first observed at Indian Institute of Horticultural Research, Hessarghatta, Bangalore as reported by Singh (1984) and Singh and Dutta (1986). Later on, Chakraborty et al. (1997) reported the occurrence of this disease from Varanasi in Uttar Pradesh. Initial symptoms of this disease include small, pin-headed enations on leaves, leaf curling, followed by warty and rough texture of the leaves. Later on, leaves begin to curl in adexial direction. The under surface of the leaves is characterized by mild, bold and prominent enations. There is twisting of main stem, lateral branches and leaf petiole. The leaves become thick and leathery. Leaf curling and enations are more prominent in middle aged leaves. In severe cases, there are enations, leaf thickening and curling even in the young leaves. At times, the twisting and the bending of the stem are so severe that the entire plant looks spreading on the soil surface. The virus is transmitted by whitefly (*Bemisia tabaci*). Electron microscopic

observations of ultrathin sections of leaf mid-rib of okra plants infected with enation leaf curl disease revealed the presence of bacilliform particles measuring approximately 85 x 300 nm in size. Depending upon the stage of infection, yield losses from 30 to 100 % have been reported. A minimum of 15 minutes of acquisition feeding on the virus source is required by the whiteflies to acquire the virus from the infected plant.

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