Unleashing the Potential of Wild Relatives: Breeding Resilient Okra Varieties for Sustainable Agriculture

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ABSTRACT

Okra, crucial for Indian agriculture, faces challenges in humid climates, but West African okra exhibits resilience. Wild okra relatives offer traits like disease resistance, enhancing resilience through hybridization. Future breeding focuses on stress-resistant varieties, utilizing advanced techniques like marker-assisted selection, to ensure sustainable production amidst climate change. Incorporating wild okra's genetic diversity enhances cultivated varieties' resilience, safeguarding food security in evolving agricultural landscapes.

INTRODUCTION

Vegetables play a vital role in Indian agriculture and food stability due to their brief cultivation period, prolific yield, nutritional significance, financial feasibility, and capacity to generate employment both on and off the farm (Anbanandan *et al*. 2022). Okra, also known as Bhendi [Abelmoschus esculentus (L.) Moench], stands as a prominent and nourishing vegetable crop in India, falling within the Malvaceae botanical family, characterized by a higher chromosome count of 2n=130 and natural polyploidy. The Malvaceae family encompasses approximately 34 species of Abelmoschus, with 30 variants found in the Old World and four in the New World. (Rambabu *et al*. 2019). Its robust growth, abundance in dietary fiber, and unique

seed protein composition boasting balanced lysine and tryptophan amino acids underscore its nutritional significance. Nevertheless, notwithstanding its resilience, significant reductions in yield have been noted in cultivation regions, attributed to various biotic and abiotic stressors (Kumari *et al*. 2019).

Okra stands as a favored vegetable crop renowned for its abundant dietary fiber and protein, boasting substantial quantities of indispensable amino acids, specifically lysine and tryptophan (Rodomiro Ortiz 2023). The inheritance of resistance to yellow-vein mosaic disease (YVMD) has been recorded in crosses between different okra varieties and species. Among cultivated varieties, those within the A. esculentus species are prized for their adaptability, early maturation, and amphidiploid characteristics. Consequently, recombination breeding has emerged as a viable approach to address significant biotic pressures. Various biotic stresses such as yellow vein mosaic disease (YVMD), Okra enation leaf curl virus (OELCV), cercospora leaf spot, and powdery mildew, along with abiotic stresses such as soil salinization, drought, cold temperatures, and frost, pose challenges. Undomesticated crop wild relatives serve as valuable repositories of genes conferring resistance to diverse diseases, pests, and adverse environmental conditions (Singh *et al*. 2007).

Biotic and Abiotic stresses: Challenges represent the most critical circumstances for plants to navigate in their natural environment. Biotic stressors such as the yellow vein mosaic virus (YVMV) (illustrated in detail in figure number 1), infestations by whiteflies, aphids, spider mites, and similar pests pose significant threats. Notably, the yellow vein mosaic virus is particularly virulent, spreading rapidly across various crops, including okra. Plant breeders employ diverse hybridization techniques to combat YVMV in okra, leveraging the domestication of wild varieties for human benefit. Through interspecific hybridization, specific traits of resistance to diseases and pests are transferred from wild or closely related species to cultivated ones.

A) YVMV resistant (B). infestation of YVMV (C) Cercospora leaf spot

Key abiotic pressures affecting okra include soil salinity, drought, and heavy metal exposure. Elevated soil salinity levels hinder growth and yield by disrupting physiological functions, including alterations in ion equilibrium, water availability, mineral uptake, stomatal regulation, and photosynthetic performance (Muhammad *et al*. 2011).

Exploring Wild Relatives of Okra: - The untamed relatives of okra harbor a plethora of valuable genes suitable for future breeding initiatives, with the potential to transfer these genes from wild species to cultivated ones for human benefit through hybridization breeding techniques. Three wild species closely associated with okra, namely Abelmoschus angulosus (depicted in fig. 2.1), Abelmoschus ficulneus (fig. 2.2), and Abelmoschus moschatus (fig. 2.3), showcasing distinctive flower colors and fruit shapes, have been meticulously collected and preserved at a Plant Genetic Resources Center (PGRC). Notably, these wild variants exhibit numerous coveted traits such as deep green hue, abundant mucilage content, prolonged fruiting period, perennial tendencies, extensive branching, reduced fruit length, resilience to drought, tolerance to high temperatures, and resistance to yellow vein mosaic virus (YVMV), all of which can be assimilated from the wild gene pool. Additionally, it's imperative to conduct thorough genetic analyses to fully comprehend the breadth of beneficial traits present within

these wild varieties and to explore novel avenues for enhancing okra's resilience and productivity. (Narkhede *et al*. 2015).

Fig. 2.1: - (Abelmoschus angulosus)

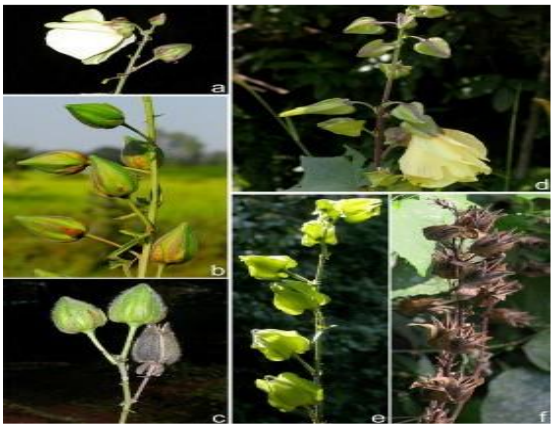

Fig. 2.2: - (Abelmoschus ficulneus)

Fig. 2.3: - (Abelmoschus moschatus)

(Fig. 2.1, 2.2, 2.3 which are mention above are downloaded from google.)

Hybridization experiments involving cultivated Okra and wild Abelmoschus species such as A. ficulneus, A. moschatus, and A. manihot have been undertaken. Notably, the hybridization between A. anamika and A. manihot demonstrated favorable heterosis effects, particularly in enhancing essential yield characteristics (Suma *et al*. 2023).

Difference between cultivated variety and wild variety:

Abelmoschus esculentus, commonly known as okra, occupies approximately 95% of cultivated regions. This variety, an amphidiploid (2n=130-140), potentially emerged from a cross with either A. tuberculatus or A. ficulneus (2n=58-60), coupled with another progenitor. However, it exhibits challenges in humid climates, susceptibility to pests and diseases, feeble vigor, a short life cycle tailored for brief rainy periods, and minimal responsiveness to changes in day length. It's cultivated in both rain-fed and irrigated seasons.

On the other hand, Abelmoschus caillei, referred to as West African okra, accounts for only 5% of cultivated areas. It's characterized as an amphipolyploid (2n = 196-200), likely originating from a hybridization event involving A. esculentus (2n=130-140) and A. manihot (2n = 60-68). Unlike its counterpart, A. caillei thrives in humid environments, boasting superior resistance against pests and diseases, robust growth, a prolonged life cycle, sensitivity to variations in day length, and primarily cultivated during dry seasons.

Unlocking the latent capabilities of wild okra relatives:

The wild relatives of cultivated okra, belonging to the Abelmoschus genus, harbor a wealth of advantageous characteristics that can be leveraged to enhance the resilience and performance of okra crops.

Ornamental and Agronomic Advantages:

- Pleasing aesthetic attributes
- Compact plant structure with abbreviated internodes
- Augmented branching and productivity
- Prolonged harvesting span attributed to extended fruiting
- Enhanced fruit characteristics
- Diminished fruit length, better suiting consumer tastes
- Elevated mucilage content, offering medicinal advantages

Stress Tolerance: -

- Heightened resilience to abiotic pressures such as drought and elevated temperatures.
- Immunity against prevalent biotic menaces like okra Yellow Vein Mosaic Virus (YVMV) and Enation Leaf Curl Virus (ELCV).
- The array of diverse and coveted attributes found within wild Abelmoschus species stands as an untapped genetic reservoir. These traits can be methodically integrated into okra breeding initiatives, fostering the creation of sturdier and more productive okra varieties conducive to sustainable agricultural practices.

Future direction and challenges: -

Future direction in okra varieties is following.

1. Exploration of wild okra species for their inherent resistance to biotic and abiotic stresses will be very important to produce best commercial varieties.
2. Use of advance breeding techniques like marker-assisted selection, genome selection etc.
3. Developing okra varieties which are resilient to climate change, improved drought tolerance, heat tolerance and salinity tolerance.

CONCLUSION

In conclusion, okra stands as a crucial component of Indian agriculture, contributing to food stability and economic viability. Its nutritional significance, coupled with its adaptability and productivity, underscores its importance in meeting dietary needs and generating employment opportunities. While facing challenges from both biotic and abiotic stressors, ongoing research endeavors, including hybridization with wild relatives and advanced breeding techniques, offer promising avenues for developing resilient okra varieties. By unlocking the genetic potential of wild okra relatives and incorporating desirable traits, such as stress tolerance and improved agronomic qualities, into breeding programs, the future of okra cultivation looks promising. However, addressing climate change impacts and ensuring sustainability remain critical challenges that require concerted efforts from researchers, breeders, and agricultural stakeholders.

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