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# Recent Developments in Tomato Crop Enhancement

(Mouli Paul[1], *Basavaraj Devaramane[2], Velavan M[3], Manjunathagowda M G[4], Gayatri Sinha[5] and T.P. Rathour[6])

[1]Department of Genetics and Plant Breeding, Ramakrishna Mission Vivekananda Educational and Research Institute, Kolkata
[2]Department of Horticulture, University of Agricultural Sciences, Raichur, Karnataka
[3]Department of Vegetable and Spices Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari-736165, Cooch Behar, West Bengal
[4]Department of Horticulture, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad-580005, Karnataka
[5]Sr. Technical Officer, ICAR -National Rice Research Institute, Cuttack, Odisha
[6]Department of Fruit Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, West Bengal
*Corresponding Author's email: basavarajdevaramane1@gmail.com

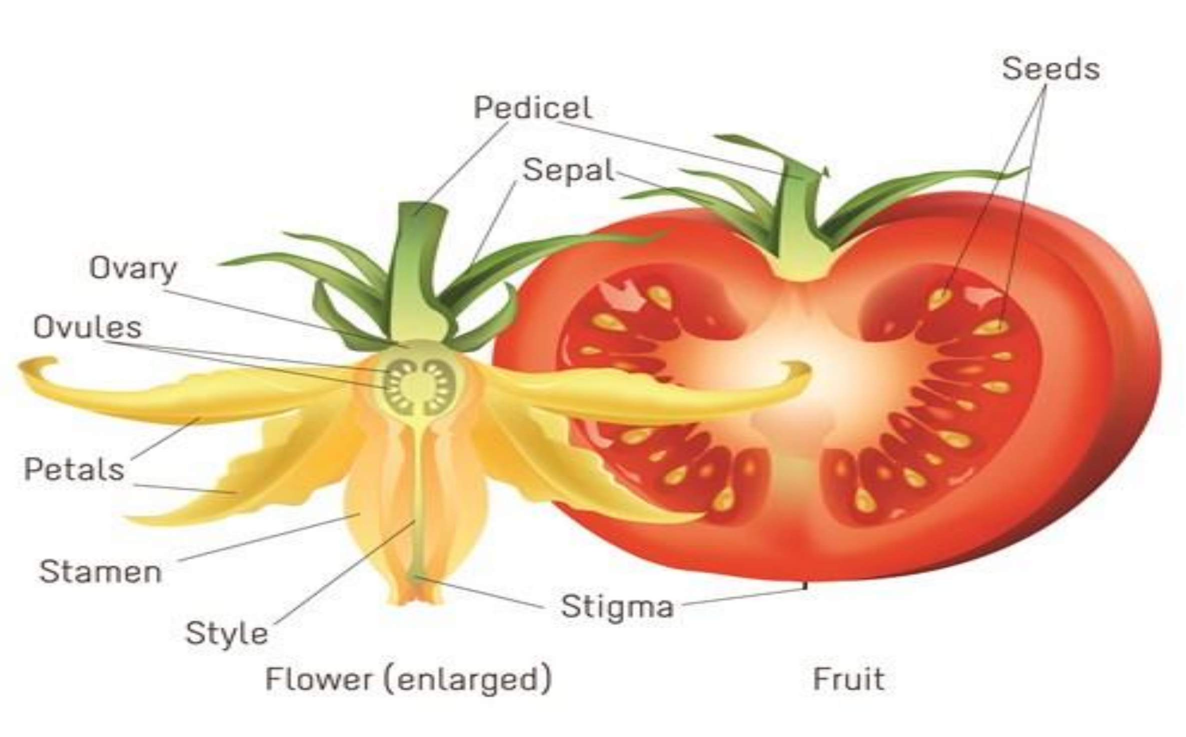
Tomato (*Solanum lycopersicum* L.) is a key solanaceous crop valued for its high lycopene content, which offers antioxidant and anti-cancer benefits. Traditional breeding methods, such as hybridization and backcrossing, have been instrumental in transferring desirable traits from wild species to cultivated varieties. Combining these approaches with molecular techniques like Marker-Assisted Selection (MAS) has enhanced tomato breeding efforts. While traditional methods have yielded significant results, integrating biotechnology can accelerate the development of high-yielding, improved varieties. This is crucial to meet the increasing food demand of a growing population.

## Introduction

Tomato (*Solanum lycopersicum* L.) is a key solanaceous crop that thrives in open fields and greenhouses, playing an important role in human nutrition. Native to Peru and first domesticated in Mexico, it has significant genetic diversity, particularly in wild species like *S. chilense* and *S. peruvianum* (Rick, 1969). Tomatoes are rich in nutrients such as beta-carotene, lycopene, vitamin C, and flavonoids, and have gained popularity due to lycopene's antioxidant and anti-cancer properties (Fentik *et al.*, 2017). Once thought poisonous, they are widely cultivated, with most varieties being self-pollinated (Cheema *et al.*, 2004). However, challenges like diseases, pests, drought, and temperature stress limit production. Breeding for disease resistance and stress tolerance, supported by genetic engineering, is vital for enhancing productivity (Fentik *et al*., 2017).

## Morphology

Tomato (*Solanum lycopersicum* L.) is an annual plant that grows up to 3 meters tall. It has compound, pinnate leaves with oblong or ovate leaflets, some with irregularly toothed margins. When young, the plant has a soft, hairy stem, which becomes woody and highly branched as it matures. It features a strong taproot system with numerous adventitious and fibrous roots that develop quickly if the main root system is injured. Tomato plants are self-pollinated due to the position of the stigma within the anther cone, and they exhibit both determinate and indeterminate growth habits. The flowers are hypogynous and perfect, leading to fruits that vary in shape and size, with some cultivars like Banana Legs and Howard German producing elongated fruits. Controlled pollination in tomatoes is essential for breeding and can be managed efficiently in greenhouses. The crop benefits from its reproductive biology, which includes a high seed yield, making it a valuable subject for genetic studies and hybridization efforts (Cheema *et al.*, 2004; Fentik *et al.*, 2017).




**Longitudinal section of tomato**

## Objective

The breeding objectives for tomatoes focus on improving various traits to meet the demands of farmers, consumers, and processors, while also addressing challenges like yield, disease resistance, and transportation. Here are the key points of the objectives:

1. **Yield Improvement**: The primary goal is to increase yield, as India's average productivity (21t/ha) lags behind global standards (>30t/ha). Some hybrids yield as high as 100t/ha.
2. **Earliness**: Breeding for early flowering and fruit set is crucial, as flowering typically occurs within a month of transplanting.
3. **Uniformity**: Consistent flowering and jointless pedicels (for easy harvest) are prioritized to reduce labor costs and energy consumption in mechanical harvesting.
4. **Adaptation and Stability**: Varieties need to be adapted to specific soil or climatic conditions, ensuring resilience to abiotic stresses like extreme temperatures, humidity, and drought. Hybrids with a high stability index are preferred.
5. **Disease and Pest Resistance**: High-yielding varieties must exhibit resistance to multiple diseases and pests, including nematodes, to maintain their potential yield.
6. **Transportation Resilience**: For tomatoes to withstand short- or long-distance transport, tough-skinned types with ripening inhibitors or non-ripening genes are desirable.
7. **Consumer Preferences**: Tomatoes for local consumption should have good flavor, high vitamin C content, and deep, uniform color. Different market segments, like restaurants or processors, may require large, crispy fruits, or those with good sugar-to-acid ratios, fewer seeds, more flesh, and vibrant color.

8. **Nutraceutical Value**: New varieties, such as purple-skinned tomatoes with anthocyanins, are developed for their health benefits.

## Important tomato genes

| CHARACTERS | GENES |
|---|---|
| Anthocyanin pigments | Af |
| Potato leaved | C |
| Elongated Fruit | El |
| Exerted stigma | Ex |
| Fascicated | F |
| No fruit formation | a,f,hl, |
| High pigment | Hp |
| Jointless pedicel | J |
| Light green foliage | Lg |
| Macro calyx | Mc |
| Yellow flesh | R |
| Compound inflorescence | S |
| Tangerine | T |
| Non ripening | Nor |

Tomato breeding involves several methods aimed at improving traits such as yield, disease resistance, and stress tolerance. Here's a breakdown of the key breeding techniques and examples:

**1. Hybridization and Pedigree Selection**

- Hybridization is the process of crossing two different parent plants to create offspring with desirable traits. This is followed by pedigree selection, where superior plants from each generation are selected and further bred to develop new varieties.
- For example, IIHR (Indian Institute of Horticultural Research) has developed tomato varieties like *Arka Rakshak* and *Arka Vishal* using hybridization to improve yield and resistance to diseases.

**2. Backcrossing**

- Backcrossing is a method where a hybrid is repeatedly crossed with one of its parent plants to introduce specific desirable traits, such as disease resistance, while retaining most of the parent's original characteristics.
- Wild relatives of tomato, such as *S. peruvianum* and *S. pimpinellifolium*, are often used in backcrossing to introduce resistance to diseases like Tomato Yellow Leaf Curl Virus (TYLCV) or bacterial wilt into cultivated varieties.

**3. Pure Line Selection**

- Pure line selection involves selecting and propagating plants that have desirable traits, ensuring all the offspring are genetically identical to the selected plant.
- Varieties like *Arka Vikas* and *Arka Saurabh*, developed by IIHR, are examples of pure line selection. These varieties are rainfed and suitable for fresh markets and long transport.

**4. Mass Selection**

- In mass selection, a large number of phenotypically superior plants are selected, and their seeds are bulked together for the next generation. This process is repeated until the desired traits are consistently expressed.
- Varieties like *Arka Meghali* and *Pusa Ruby* have been developed using this method. *Arka Meghali* is a cross between *Arka Vikas* and *IHR 554*.

**5. Heterosis Breeding (Hybrid Vigour)**

- Heterosis breeding exploits the phenomenon where hybrid offspring outperform their parents in terms of yield, vigor, and other traits. In tomato, heterosis has been used to increase fruit yield and improve quality.
- Crosses like *AVTO-5* × *GT-2* and *JTL-12-12* × *GT-2* show significant heterosis for yield and component traits, making them promising for hybrid development.

**6. Interspecific Hybridization**

- Interspecific hybridization involves crossing two different species of tomatoes to introduce traits such as disease or stress resistance.
- For example, crossing *S. pimpinellifolium* (high in Vitamin C and carotene) with *S. lycopersicum* resulted in the development of varieties with improved nutritional content and resistance to bacterial wilt and salinity.

**7. Mutation Breeding**

- Mutation breeding uses chemicals or radiation to induce mutations in plants, leading to new traits such as disease resistance or stress tolerance.
- Varieties like *Pusa S12* were developed using mutation breeding, where seeds were exposed to radiation to create desirable mutations.

**8. Stress-Tolerant Varieties**

- Several institutions, such as IARI (Indian Agricultural Research Institute) and IIHR, have developed tomato varieties that can tolerate extreme environmental conditions:
- *Pusa Sheetal* is resistant to low temperatures.
- *Solan Vajr* can tolerate drought.
- *HS-101* and *HS-102* are tolerant of high temperatures.
- *Pusa Ruby* has been bred for salinity resistance.

## Conclusion

A combination of hybridization, backcrossing, and modern breeding techniques has significantly improved tomato varieties, enabling them to perform better under various environmental stresses and resist diseases while providing better yield and quality.

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