



## PHYSIOLOGICAL DISORDERS OF TOMATO: COMPREHENSIVE INSIGHTS INTO CAUSES, SYMPTOMS, AND MANAGEMENT

**M Velavan, Pranava Praanjal, Raj kumar and Sourav Mollick**

*Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India - 736165.*

*\*Corresponding Author Mail ID: [veluhorti1995@gmail.com](mailto:veluhorti1995@gmail.com)*

### Abstract

Tomato (*Solanum lycopersicum* L.) is a crop of global importance, valued for its nutritional benefits and economic contribution. However, tomato production is frequently limited by physiological disorders—non-infectious problems caused by complex interactions among genetic, nutritional, and environmental factors. These disorders, which include blossom end rot, catfacing, fruit cracking, sunscald, puffiness, blotchy ripening, and others, can significantly reduce both yield and fruit quality. Unlike diseases caused by pathogens, physiological disorders are often overlooked or misdiagnosed, making their management challenging.

This article provides a comprehensive overview of the major physiological disorders affecting tomato, describing their symptoms, causes, underlying mechanisms, and practical management strategies. By equipping growers, researchers, and extension professionals with up-to-date knowledge, this review aims to support improved crop health, minimize losses, and enhance the quality and marketability of tomato fruits.

### Introduction

Tomato (*Solanum lycopersicum* L.) is among the world's most widely grown and consumed vegetables, recognized for its rich nutritional value and versatility in the human diet (Causse et al., 2016; FAOSTAT, 2022). As a key source of vitamins, minerals, and antioxidants like

lycopene and  $\beta$ -carotene, tomatoes play an important role in human health and food security (Rao & Agarwal, 1999; Clinton, 1998). Despite advances in breeding, agronomy, and pest management, tomato production remains vulnerable to a range of physiological disorders. These are not caused by pathogens but by complex interactions between the plant's genetics, nutrition, and environment (Adams & Ho, 1992; Peet & Willits, 1995).

Common physiological disorders—such as blossom end rot, catfacing, fruit cracking, sunscald, internal white tissue, pith necrosis, and chilling injury—can severely affect both yield and fruit quality (de Freitas et al., 2018; Sharma et al., 2016).

Their incidence is often increased by climate change, erratic weather, and intensive cultivation. Because they are non-infectious and often have overlapping symptoms, physiological disorders are frequently misdiagnosed or ignored, yet they can cause significant economic losses and reduce the marketability of fruit (Adams & Ho, 1992; Jones et al., 2014).

Understanding the causes, mechanisms, and management of physiological disorders is essential for sustainable tomato production. This article reviews the major and emerging physiological disorders of tomato, explaining their symptoms, causes and practical management strategies.

## Major Physiological Disorders of Tomato

### 1. Blossom End Rot (BER)

**Symptoms:** Blossom end rot appears as small, water-soaked, sunken spots at the blossom (distal) end of immature or green fruit. These spots enlarge, become brown to black, dry, leathery, and sunken as the fruit matures. In advanced cases, the affected tissue may become moldy if secondary infections occur. Symptoms usually develop when fruits are one-third to one-half their mature size.

**Causes:** The primary cause is a localized deficiency of calcium in the developing fruit. This can result from irregular watering, rapid fruit growth, root damage, acidic or saline soils, excessive potassium, magnesium, or ammonium fertilization, and genetic susceptibility.

**Mechanism:** Calcium is essential for cell wall structure. When calcium supply is inadequate, especially at the blossom end, cell walls break down, leading to tissue collapse and the characteristic sunken lesions. Environmental stress and reactive oxygen species may worsen the disorder.

**Management:**

- Water regularly and evenly; use mulch to conserve soil moisture.
- Test and adjust soil calcium and pH (keep between 6.0 and 6.8).
- Avoid excessive nitrogen and potassium fertilization.
- Protect roots from damage.
- Choose tolerant varieties and remove affected fruit promptly.

### 2. Cat face

**Symptoms:** Cat face causes severely deformed, puckered, or misshapen fruit, often with deep grooves, scars, or cavities at the blossom end. Fruits are often enlarged, irregular, and unmarketable.

**Causes:** Cat face is triggered by low temperatures during flower bud formation and early fruit set, auxin imbalance from heavy pruning or growth regulators, genetic predisposition, and physical injury to flowers or young fruit.

**Mechanism:** Disrupted development of ovary tissues during flowering leads to incomplete pollination, fused floral parts, and irregular cell growth, resulting in malformed fruit.

**Management:**

- Avoid early planting in cool conditions.
- Minimize heavy pruning during early flowering.
- Select tolerant varieties and protect plants from temperature extremes.
- Handle flowers and fruit gently.

### 3. Fruit Cracking

**Symptoms:** Fruit cracking appears as splits in the fruit skin, which may be radial (from stem end downward), concentric (circular around the stem), or irregular. Cracks may be shallow or deep and can expose the inner tissue to secondary infections.

**Causes:** Cracking is most often triggered by sudden water uptake after a dry period, rapid fruit growth, fluctuating temperatures, high humidity, excessive nitrogen, low potassium, and genetic factors.

**Mechanism:** When the fruit expands faster than the skin can stretch, the skin splits. Nutrient imbalances and environmental stress reduce skin elasticity.

**Management:**

- Maintain consistent irrigation and avoid overwatering after drought.
- Apply balanced fertilizer, ensuring adequate potassium and calcium.
- Choose crack-resistant varieties and maintain good foliage cover.

#### 4. Puffiness (Hollow Fruit Syndrome)

**Symptoms:** Fruits appear normal but are light in weight and hollow inside, with poorly developed seeds and tissue. The internal tissue may be spongy, and fruit may be angular or irregularly shaped.

**Causes:** Puffiness is caused by incomplete pollination or fertilization, environmental stress, nutrient imbalance (high nitrogen, low potassium), water stress, and genetic susceptibility.

**Mechanism:** Poor seed set leads to inadequate hormone production, resulting in hollow cavities within the fruit.

**Management:**

- Use balanced fertilization and stable irrigation.
- Encourage pollinator activity and select resistant varieties.
- Foliar sprays of borax during flowering may help.

#### 5. Sunscald

**Symptoms:** Sunscald produces pale, blistered, or water-soaked patches on fruit exposed to intense sunlight. These areas become sunken, leathery, and may turn white, gray, or yellowish.

**Causes:** Direct sun exposure, loss of foliage due to disease or over-pruning, rapid fruit development, and sparse canopies increase risk.

**Mechanism:** Overheating damages fruit tissues, especially in maturing or ripe fruit with thinner skins.

**Management:**

- Maintain good leaf cover and avoid excessive pruning.
- Harvest fruit at maturity.
- Use shade nets or grow robust, foliage-rich varieties.

#### 6. Blotchy Ripening (Gray wall)

**Symptoms:** Fruits show uneven or patchy coloration, especially at the shoulders, with green, yellow, or gray areas that fail to ripen. Internally, brown or gray patches may be present.

**Causes:** Low potassium, excessive nitrogen, low light, poor aeration, and genetic predisposition are common triggers.

**Mechanism:** Potassium deficiency and excessive nitrogen disrupt pigment formation and vascular function, leading to uneven ripening.

**Management:**

- Maintain proper potassium-to-nitrogen balance.
- Optimize plant spacing and light penetration.
- Select tolerant varieties.

#### 7. Golden Fleck

**Symptoms:** Small yellow or golden specks appear on the fruit surface, usually superficial but sometimes reducing marketability.

**Causes:** Excess calcium or phosphorus, high humidity and temperature, genetic predisposition, and imbalanced Ca:K ratio.

**Mechanism:** Calcium oxalate crystals form in the epidermal cells, scattering light and creating flecks.

**Management:**

- Avoid excessive calcium and phosphorus fertilization.
- Maintain balanced Ca:K ratio and select less susceptible varieties.

#### 8. Irregular Ripening

**Symptoms:** Mature fruits show green, yellow, or pale patches, especially at the shoulders, which remain firm and leathery.

**Causes:** Whitefly feeding, nutrient imbalance (low potassium, calcium), temperature and water stress.

**Mechanism:** Whitefly feeding disrupts ethylene production and pigment synthesis, while nutrient imbalances and heat further inhibit ripening.

**Management:**

- Control whiteflies using IPM.
- Ensure balanced nutrition and consistent irrigation.
- Select tolerant varieties.

## 9. Zippering

**Symptoms:** Thin, brown, scar-like lines run from stem to blossom end, sometimes with small holes.

**Causes:** Adhesion of dead floral parts, low temperatures during flowering, and genetic predisposition.

**Mechanism:** Physical barriers from floral parts disrupt skin expansion, causing linear scars.

**Management:**

- Select resistant varieties and optimize planting time.
- Handle flowers gently.

## 10. Internal White Tissue (IWT)

**Symptoms:** Firm, white, corky patches inside ripe fruit, often without external symptoms.

**Causes:** High temperatures, potassium deficiency, genetic susceptibility, and rapid fruit growth.

**Mechanism:** Heat and potassium deficiency disrupt pigment and tissue development, leading to white, unpigmented tissue.

**Management:**

- Maintain optimal potassium levels and moderate field temperatures.
- Avoid excessive nitrogen and select tolerant cultivars.

## 11. Pox

**Symptoms:** Small, raised white or brown lesions or pustules on green or ripening fruit.

**Causes:** Genetic predisposition, environmental factors (temperature, humidity), and calcium/magnesium imbalance.

**Mechanism:** Localized disruptions in epidermal cell development cause corky, raised lesions.

**Management:**

- Select tolerant cultivars and maintain balanced nutrition.
- Consistent irrigation and gentle fruit handling.

## 12. Zebra Striping

**Symptoms:** Green, yellow, or pale longitudinal stripes on the fruit, often with uneven coloration.

**Causes:** Deficiencies of calcium and potassium, temperature fluctuations, genetic susceptibility, and soil pH imbalance.

**Mechanism:** Disrupted pigment synthesis and distribution during fruit development.

**Management:**

- Balanced nutrition and optimal soil pH (6.0–6.5).
- Consistent irrigation and resistant cultivars.

## 13. Chilling Injury

**Symptoms:** Surface pitting, sunken lesions, uneven ripening, and increased decay after storage below 12°C.

**Causes:** Exposure to low temperatures, especially in immature fruit; genetic factors.

**Mechanism:** Low temperatures disrupt membrane integrity and pigment synthesis, often showing after return to warmer conditions.

**Management:**

- Store tomatoes at 13–18°C and harvest at full maturity.
- Use tolerant cultivars and minimize storage duration.

#### 14. Russetting and Boat Fruit

**Symptoms:** Russetting: Rough, corky, brown patches on fruit surface. Boat fruit: Misshapen, elongated, or "boat-shaped" tomatoes.

**Causes:** Environmental extremes, genetic predisposition, nutrient imbalances, water stress, and physical abrasion.

**Mechanism:** Disrupted epidermal cell expansion and uneven growth cause roughness or misshaping.

**Management:**

- Select resistant cultivars and maintain balanced nutrition.
- Consistent irrigation and reduced physical abrasion.

#### 15. Shoulder Check and Greenback

**Symptoms:** Shoulder check: Small cracks or roughness on fruit shoulders. Greenback: Persistent green or yellowish coloration at the fruit shoulder. Temperature fluctuations, p

**Causes:** Potassium deficiency, high light intensity, genetic predisposition, and water stress.

**Mechanism:** Microcracking and persistent chlorophyll due to impaired pigment conversion.

**Management:**

- Maintain potassium nutrition and consistent irrigation.
- Provide partial shading and select resistant cultivars.

#### 16. Silvering

**Symptoms:** Pale, silvery-green patches on leaves, stems, and sometimes fruit; stunted or deformed main shoot; vigorous side shoot growth.

**Causes:** Anatomical changes in the apical meristem, environmental stress, and genetic factors.

**Mechanism:** Changes in sub-epidermal layers alter light reflection and suppress main shoot growth.

**Management:**

- Prune main stem to promote side shoots.
- Select less susceptible varieties and optimize environmental conditions.



Blossom End Rot



Cat Face



Radial Cracking





Concentric Cracking



Puffiness



Sunscald



Blotchy Ripening



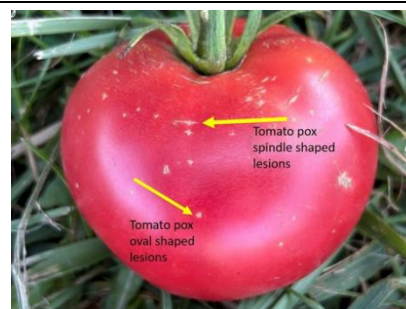
Golden fleck



Zippering



Internal White Tissue



Pox



Zebra stripping

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