

## Review Article

### A Review on Physiological Disorders in Tomato: Environmental Triggers, Nutrient Imbalances and Control Strategies

#### ABSTRACT

They cause a plant to undergo physical or chemical changes that deviate greatly from normal and are Changing environmental factors such temperature, moisture, uneven soil moisture, insufficient or excessive amounts of specific soil minerals, extremes in soil pH, and inadequate drainage are the main causes of physiological or abiotic illnesses. Physiological or abiotic disorders are distinguished from other disorders by the fact that they arise from inanimate (abiotic) circumstances rather than living organisms such as viruses, bacteria, fungi, insects, etc. and cause deviations from normal growth. usually brought on by an outside source. Physiological disorders encountered in this paper included blossom end rot (BER), catface, cracking, internal white tissue, irregular ripening, puffiness, pox and fleck, zippering and sun scald. Blossom End Rot (BER), a common condition marked by dark, sunken spots at the fruit's blossom end, is sometimes caused by a calcium deficit along with irregular watering. Direct sun exposure causes sunscald, which manifests as pale, dry areas on exposed fruit; on the other hand, quick water uptake following a drought causes cracking, both radial and concentric. Cold temperatures during flower development produce cat facing, which results in malformed fruits, while water stress or excess nitrogen usually causes leaf curl, which affects the foliage. In order to manage these problems, one must use mulch to balance soil moisture, use fertilizers high in calcium to prevent BER, and keep constant irrigation. Pruning correctly and using shade netting helps reduce sunscald and preserve healthy foliage. To mitigate these illnesses and ensure high-quality tomato crops, regular watering, balanced fertilization, and environmental control are essential.

Keywords: Tomato, physiological disorder, abiotic factor, nutrient imbalance, toxicity

#### 1. INTRODUCTION

The demand for food is rising in proportion to the ongoing global population growth. Producing edible crops, mostly from leguminous and solanaceous plants, is essential to the livelihoods of farmers and a number of agriculture-related businesses. The tomato (*Solanum lycopersicum* L.), one of the most widely available solanaceous edible fruits, is widely consumed because of its high carotenoid concentration and antioxidant qualities[1]. A tomato's great nutritional value makes it one of the most important "protective foods." One of the most versatile veggies, it has been used for a very long time in Indian cooking. There are many different ways to use tomatoes in cooking, such as in juice, soup, ketchup, puree, salad dressing, pickles, and more. It can also be consumed raw as a vegetable in a salad[2].

Numerous physiological disorders found during production result in reduced yield globally. Tomato crop growth and productivity are influenced by a number of physiological factors, including biotic

and abiotic stressors that can have a detrimental effect on output and cause financial losses [3]. When evaluating tomato fruit for fresh consumption, factors such as color, shape, size, hardness, texture, dry matter, organoleptic properties, and nutraceutical qualities are taken into consideration. Changing environmental conditions, such as temperature, moisture, unbalanced soil nutrients, excessive or insufficient concentrations of particular soil minerals, extremes in soil pH, and inadequate drainage, are the main causes of physiological or abiotic disorders [4]. The most frequent physiological issues that impact tomatoes are blossom-end rot, catface, irregular ripening, cracking, sunscald, puffiness, yellow shoulder, chemical damage, adventitious root, blotchy ripening, gold spots/specks, and chilling injury [5].

Physiological disorders, in contrast to diseases brought on by pathogens like fungus, bacteria, or viruses, are not communicable and result from environmental, dietary, or cultural factors that interfere with a plant's regular growth processes. These disorders can strike a plant at any point in its life cycle, from the development of seedlings to the ripening of fruit, and they are frequently brought on by stressful conditions in the growing environment. Every one of these conditions has unique symptoms that are readily misinterpreted as being caused by biotic illnesses, particularly by novice growers. BER, which is defined by dark, sunken lesions at the fruit's blossom end, is sometimes misdiagnosed as a fungal infection when, in fact, it results from an insufficient amount of calcium brought on by inconsistent watering [6]. The problem known as irregular ripening of fruit is brought on by the feeding of Silverleaf whitefly (*Bemisia tabaci*) nymphs on tomato foliage. While green fruit does not exhibit any symptoms, when it ripens, the colour does not develop evenly. A star-burst look is often produced by colour developing along locule walls, with intermediate portions staying green or yellow. A fruit characterized by tiny scars that stretch either completely or partially from the stem scar location to the blossom end is called a zippering fruit. There are tiny transverse scars all throughout the longitudinal scar [7]. Zebra stripe is made up of a row of dark green spots that are placed from the stem end to the blossom end. The spots may combine to form longer stripes. Blotchy ripening causes greenish-yellow and whitish spots to form on ripened fruit, especially on the stem end region. The blotched area may also contain white or brown tissues. The afflicted regions, which are still green or yellow, are typically located almost at the tomato fruit's stem end. When a green fruit ripens, little, irregular green spots called "golden flecks" appear on its surface [8]. These spots eventually turn yellow or gold in colour. There can be few or numerous spots.

In addition, cultural techniques such as excessive pruning, excessive fertilization, or inadequate irrigation control can intensify the stress experienced by the plant and heighten its vulnerability to physiological problems. The prevention of production losses and the maintenance of healthy tomato crops depend on the management of these illnesses. Physiological problems, in contrast to biotic diseases, are treatable with appropriate growing practices and preventative measures. Effective measures to stop the emergence of these illnesses include utilizing mulches to stabilize soil moisture,

making sure that nutrients are supplied in a balanced manner, watering plants consistently and efficiently, and giving them enough shade [9]. Furthermore, by being aware of the environmental factors that make plants more vulnerable to these issues, producers can reduce the risk by modifying their production techniques in response to shifting weather patterns. They cannot spread and are not caused by infections, but if left unchecked, they can have disastrous effects on fruit yield and quality. Growers may greatly lessen the effects of these illnesses and encourage healthier, more productive tomato plants by recognizing the symptoms early, comprehending the underlying reasons, and implementing efficient management techniques [10].

## **2. PHYSIOLOGICAL DISORDERS OF TOMATO**

### **2.1 BLOSSOM END ROT**

On both green and ripe tomatoes, blossom end rot is a highly prevalent issue. The lesion starts off as a light tan, water-soaked area that grows till becoming black and leathery [11]. While blossom end rot alone just affects the affected area, it is often the result of secondary organisms invading the lesion and causing the fruit to completely rot [12]. It usually affects the earliest mature fruit the most and frequently appears in quickly developing fruit during hot, dry conditions [13]. Because calcium is not a very mobile element, a localized deficit can emerge with a fluctuation in water supply, even for brief periods of time, leading to blossom-end rot in the fruit's distal end. Extremes in moisture hence increase the probability of the illness [14]. The problem can be made worse by other factors that inhibit the plant's ability to absorb calcium, such as high salinities, the usage of ammonium nitrogen, and high relative humidity [15]. Plants that develop quickly are more vulnerable to the illness [16]. Blossom-end rot can be prevented by planting cultivars that are resistant to the disease, managing water, and applying the right fertilizer [17]. When the fruits are green, brown lesions emerge at the terminal of the blossom. Water-soaked patches appear where the senescent petals attach, and these areas get bigger [18]. The disease causes the damaged fruit portion to become sunken, leathery, and black in colour. Wide variations in soil moisture can momentarily lower the calcium concentrations in developing fruit [19]. This is because calcium is transported through the plant by water flow, so while calcium is often just adequate in fruit, it is more abundant in rapidly transpiring plant parts [20]. Any moisture stress will cause plants to absorb less calcium and hence have less concentration [21]. The tomato plant's ability to absorb and concentrate calcium can be reduced by nitrogen in the form of ammonium [22]. The intake of calcium from the soil is decreased when the root system is damaged by disease, nematodes, or severe pruning. Calcium applied topically to the leaves does not prevent blossom end rot because the calcium is not transferred to the fruit in a sufficient amount [23]. This fruit problem can be most easily prevented with good water management and proper fertilization.



**Image-1 (BLOSSAM END ROT)**

## **2.2 CATFACING**

Catfacing is a generic term used to describe a tomato fruit that has a gross deformity and is usually not marketable. The defect is usually located on the blossom end of the fruit[24]. The deformity is caused by something (internal or external) that occurs during the formation of the flower that results in the fruit not developing normally[25]. The blossom end of the cat face tomato is deformed, with increased scars and holes. Any aberrant growth situation during bloom development induces pistil cell deformation[26]. As a consequence, cells in the ovary's bloom end die, become black, and create leathery patches towards the fruit's end[27]. The abnormalities are caused by cold temperatures during flower set, which distorts and destroys specific cells that should grow into fruit. Cool or cold temperatures that occur about 3 weeks before bloom can increase the amount of catfacing[28]. In general, jointless varieties are more prone to catfacing than jointed varieties. Heavy pruning in indeterminate varieties has been shown to increase catfacing but this has not been shown to happen in our short-stake varieties[29]. In indeterminate varieties, catfacing is thought to be related to reduction in auxins in the plant from removing the growing points. Cultivation condition makes favorable as much as possible by adopting appropriate and timely management[30]. Jointless tomato varieties seem to be more prone to catfacing than jointed varieties. Unfortunately, there is little that can be done for control of catfacing, except selecting varieties that are not prone to the problem. Older cultivars and large fruited varieties are more susceptible[31].



**Image-2 (CATFACING)**

### **2.3 CRACKING**

Fruit surface cracking at the stem end occurs frequently. Rather than in fully green or breaker stage fruit, it typically develops in fully ripe fruit. When strong rains and high temperatures follow a dry spell, fruit that has reached the ripening stage may exhibit significant cracking. Variations in the water supply cause fruit to develop and shatter quickly[32]. Tomatoes expand too rapidly for the skin to handle and break when they go through dry spells followed by periods of intense watering or rain. There are effects from both environmental and genetic variables [33]. Two types of cracking are frequently observed. During the ripe stage, radial cracking is most prevalent, and it extends from the pedicel end to the stylar end. The epidermis surrounding the stem scar breaks in a circular pattern known as concentric cracking [34]. It can be seen around the fruit's shoulder even when it is still green. Rapid fruit growth and significant fluctuations in the plant's water supply are associated with cracking [35]. A protracted drought interspersed with a burst of heavy irrigation, a wide range of day and night temperatures, and high humidity can also induce cracking. Tomatoes with cracks can still be eaten, but they might not look or store as well [36]. Boron deficiency can also result in fruit breaking, especially in calcareous soil. Reducing growth cracking may be achieved by planting tolerant cultivars as Manulucie, Ohio 832, Sioux, supersonic, Jetstar, Anagha, and Crack Proof, among others [37]. Cultivars resistant to fruit breaking have a soft, low-acid fruit skin and a thick pericarp or cuticle. Fruit cracking can be minimized by mulching, preventing defoliation from foliar diseases, avoiding excessive nitrogen fertilizer treatments, and managing water properly [38]. Applying 15–20 kg of borax per hectare and sprinkling 0.25 percent of the soil Between the fruiting and ripening stages, fruit breaking is decreased by two to three times [39]. Planting cultivars tolerant of cracking, managing water well, adhering to a healthy nutritional regimen to prevent excessively succulent plants, and limiting foliar disease-induced defoliation to reduce fruit exposure are all ways to reduce growth cracking [40]. Gardeners may reduce cracking and ensure a successful and productive tomato harvest by learning the causes and taking preventive action [41].



**Image-3 (CRACKING)**

#### **2.4 SUNSCALD**

The dead, bleached tissues in the fruit progressively collapse as it ripens, leaving behind a relatively depressed area that may become wrinkled and pale yellow in colour. The fruit rots as a result of secondary organisms quickly infesting the dead tissue [42]. This condition is characterized by bleached patches on green tomato fruit that rapidly desiccate and result in sunken sections. The colour of the sunken parts is usually yellowish in red fruits and white or grey in green fruits. Fruit that grows in the canopy's shade but is unexpectedly exposed to sunlight may become sunburned [43]. Fruit tissue exposed to sunlight can become beyond 104°F (40°C), which can harm non-adapted tissue. Excessive trimming and leaf moving during harvesting might expose fruit to sunlight. Foliar infections can also cause defoliation. Sunken and wrinkled tissue results from the damage. Secondary black Mold fungi can colonize the necrotic tissue [44]. Tomato fruits typically have damage on their sides or tops. This is a major issue in India during the months of May and June since it exposes fruits to the sun and raises the risk of sunburn. When very high temperatures occur, the severity of the injury is greater. Inadequate leaf cover, trellising, and vulnerable types (caused by a specific genetic predisposition) exacerbate the situation [45]. Pruning and harvesting with caution, controlling foliar diseases effectively, and selecting cultivars with sturdy foliage that keeps the fruit hidden can all help prevent sunscald. When pruning and harvesting, take care to keep the fruit covered by leaves [46]. Prevent defoliation by controlling foliar diseases. Select tomato cultivars that offer fruit with sufficient foliar cover. Sunscald can be lessened by using shade cloth or whitewashing greenhouses. Prevent postponing the harvest of fruits [47].



**Image-4 (SUNSCALD)**

## **2.5 PUFFINESS**

Tomato puffiness, also called hollow tomato syndrome, is a condition in which the inside of the tomato is largely empty or hollow due to insufficient tissue formation, although the outside of the tomato appears full and ripe. Puffiness, also called hollowness or boxiness, is the presence of open voids between the outer walls and the locular contents in one or more locules [48]. When the fruit is cut, it may have cavities that don't have the typical "gel" and isn't as thick overall. If this issue is minor, it might not be feasible to see puffiness until the fruit is sliced. Severe inflated fruit will have an angular or flat appearance [49]. Cut fruit reveals open spaces between the seed gel layer and the exterior wall. Fruits weigh extremely little in comparison to their size. Because of their relative softness and absence of gel in the locules, puffer fruit is not well-liked by consumers and does not travel well. Poor pollination, nutrient imbalances, temperature swings, and erratic watering are the usual causes of this problem [50]. Poor seed development is the result of incomplete pollination, which is frequently caused by insufficient pollinators or harsh weather during the flowering stage. Proper fruit growth depends on healthy seed development. Deficits in certain nutrients, particularly potassium and nitrogen, can also impair the structure of the interior tissues, which makes puffiness more likely [51]. Internal tissue growth is slowed when fruit is about two thirds of its typical size. Extremes in temperature, such as intense heat or cold, can also impede pollen production and fruit set. Uneven watering, on the other hand, strains plants and prevents fruit from developing evenly. Because of their genetic composition, some heirloom tomato cultivars are inherently more prone to this problem [52]. In order to avoid puffiness, it's critical to choose tomato varieties that are less likely to develop this illness, maintain regular watering, promote healthy pollination techniques, and guarantee balanced nutrition through appropriate fertilization. Extremes in temperature (low K and high N) and precipitation have been related to puffiness [53]. Puffiness may be reduced by keeping the temperature steady and using Borax spray at a concentration of 10–15 ppm during the peak flowering

period. Growers may produce healthier, fully formed tomatoes and lessen the occurrence of puffiness by effectively regulating these elements [54].



**Image-5 (PUFFINESS)**

## **2.6 BLOTCHY RIPENING**

A physiological condition known as "blotchy ripening" in tomatoes alters the fruit's consistent pigmentation, resulting in irregular patches of softly coloured green, yellow, or red on the surface. Another name for this condition is graywall [55]. The name "graywall" refers to the appearance of partial wall tissue collapse, which is recognized as the reason of its greyish appearance. Irregular patches of the fruit devoid of colour are among the symptoms. Usually, the upper part of the fruit is the affected area. This issue is especially common in chilly, damp, and frequently gloomy weather [56]. Both too little and too much water aggravates this issue. Its severity will rise in soils that are poor in potassium and/or high in nitrogen. Numerous reasons, including as nutritional imbalances, environmental pressures, and incorrect cultural behaviours, might be blamed for this problem. Lack of potassium, which is essential for the production of pigments like lycopene, which gives tomatoes their red color, is one of the main culprits [57]. Elevated quantities of nitrogen can worsen the issue by encouraging uncontrollably high foliage growth at the price of poor fruit quality. Additionally, the regular ripening process might be interfered with by temperature swings, especially during times of intense heat or cold. Overshading, inadequate air circulation, and erratic watering exacerbate the issue by impeding photosynthesis and nutrient uptake by the plant. Viral infections that can produce comparable symptoms, like the Tomato Spotted Wilt Virus (TSWV), are another culprit. By making sure that fertilization is balanced, keeping regular watering schedules, and optimizing plant spacing for improved air flow and sunlight penetration, farmers and gardeners can reduce blotchy ripening [58]. Mulching and the application of fertilizers high in potassium can also help to keep moisture levels constant and minimize temperature swings. Variations between cultivars Among the causative elements are low K, high N, low temperature, low light intensity, and excessive soil moisture [59]. The conditions previously mentioned as causative variables can be avoided in order to control this

illness. It is feasible to lessen the occurrence of blotchy ripening and enhance the general quality and marketability of tomato crops by taking care of these elements [60]. Fruit with a low incidence of blotchy ripening/yellow shoulder was generated by tomatoes grown in soils with organic matter levels above 3.5%, whereas fruit with a high frequency of the condition was produced by tomatoes grown in soils with organic matter levels below 2.5%. Grown tomatoes with soil pH levels below 6.4 had a low frequency of yellow shoulder, but tomatoes grown on soil pH levels above 6.7 exhibited a significant frequency of the condition [61].



**Image-6 (BLOTCHY RIPENING)**

## **2.7 GOLDEN FLECK**

A physiological condition in tomatoes known as "golden fleck" causes tiny, yellow-golden dots or flecks to appear on the fruit's surface, especially on the skin close to the shoulders. This disease can have an impact on marketability, particularly in fresh produce markets where appearance is vital, although it is mostly cosmetic in nature and has no effect on the fruit's interior quality or taste. Customers may find the tomatoes less appetizing due to the flecks, which can range in size from a few tiny spots to bigger, more noticeable areas[62]. Research has demonstrated that gold specks are cells that contain a granular mass of tiny crystals of calcium oxalate. Excess fruit calcium and/or high Ca/K ratio, high P, high relative humidity, and high average temperature are among the potential causes of gold spot/gold speck. The aesthetic appeal of tomato fruit is impacted by the presence of gold flecks, which also shortens the fruit's shelf life. One potential control strategy is to stop excessive Ca absorption. In green fruit, the speck is white and less in number. The fruit's beauty is diminished, and its shelf life is significantly shortened, by the particles. Cells containing a granular mass of tiny calcium salt crystals—likely calcium oxalate—have a golden tint. These particles are believed to be indicators of excessive calcium content in the apple. A rise in the P level was accompanied by an increase in the rate of speckling and calcium absorption [63]. Throughout the growth season, gold spot occurs more frequently when temperatures rise, particularly when average temperatures are higher than usual. Rather than infections or pests, environmental conditions are the main cause of golden fleck. It is thought to be related to nutritional abnormalities, including deficits or imbalances of

potassium and calcium. The formation of the golden flecks can result from an imbalance in the growing medium between calcium and potassium levels, or from high calcium levels and low potassium levels interfering with the physiological activities of the plant. Stressful climatic circumstances including irregular watering, extreme heat, or abrupt changes in humidity are also associated with the illness. The issue can be made worse by rapid fruit growth in hot weather since the plant finds it difficult to meet the high demands for water and nutrients at this time. A multimodal strategy centered on maximizing plant nutrition and growing conditions is needed to manage golden fleck. It is imperative to maintain an equilibrium of calcium and potassium in the body to avert this condition. This can be accomplished by conducting routine tissue or soil tests to track nutrient levels and modify fertilizer as necessary. While potassium can be added with potassium sulphate or potassium nitrate, depending on the demands of the soil, calcium-rich amendments like gypsum or calcium nitrate can assist balance calcium levels [64]. It's also essential to water consistently. Watering tomatoes evenly will help prevent droughts that are followed by heavy irrigation, which can cause imbalances in the uptake of nutrients. A reliable water supply can be ensured by putting in drip irrigation systems or applying mulch to keep soil moisture in the ground. Controlling humidity and temperature is also crucial. Controlling the humidity and temperature in controlled spaces, like greenhouses, helps lessen the stress that causes golden fleck. In hot weather, plants can be helped to cool down by shading or using ventilation; abrupt changes in humidity can be avoided by keeping enough air circulation. If golden fleck is a persistent problem in your area, choosing tomato types that are less prone to the disorder might also be helpful. Resistant cultivars can lessen the disorder's occurrence and severity when combined with appropriate management techniques [65].



**Image-7(GOLDEN FLECK)**

## **2.8 TOMATO IRREGULAR RIPENING**

A physiological condition known as tomato irregular ripening disrupts the fruits' uniform development, resulting in uneven texture, firmness, and colour formation by the time the fruits reach maturity [66]. In commercial tomato agriculture, this disease is highly common, especially in warm climates or under stressful conditions for the plants. It frequently shows up as green or yellow patches on the fruit, with some sections not ripening and others turning the typical red colour. The disorder mainly affects the fruit's shoulders and sides, leaving some sections tough and unripe even after the fruit has mostly ripened [67]. It is brought on by the silver white fly (*Bemisaargentifolii*), which feeds on tomato plants, and appears on tomato fruit. Unmarketable fruit may arise from plants with exterior longitudinal white or yellow streaks caused by silver white fly infestations [68]. The absence of colour inside the fruit is a sign of internal symptoms, which lower postharvest quality. Stress in the environment is one of the main causes of uneven ripening, while there are other aspects as well. Elevated temperatures, insufficient precipitation, and overabundance of nitrogen fertilizer can upset the normal hormonal equilibrium of the plant and impact the fruit's ethylene production, which is the hormone accountable for fruit ripening [69]. Unbalanced soil nutrients can also make the condition worse, especially if there are calcium or potassium shortages. Potassium deficit can prevent fruit from developing and ripening properly since it is necessary for controlling the flow of water and nutrients within the plant [70]. On the other hand, a lack of calcium can cause other ripening-related conditions such blossom end rot, which can occur concurrently with uneven ripening. Calcium is essential for the strength and integrity of cell walls. Inconsistent ripening has also been connected to pest pressure, namely from whiteflies and other sap-sucking insects [71]. These pests' feeding activities have the potential to directly interfere with the physiological functions of the plant, lowering the fruit's quality [72]. The major goals of control methods for irregular ripening are to preserve ideal growing environments and lessen plant stress. Sufficient irrigation is essential, particularly in the summer when water stress aggravates the symptoms. It's common advice to use drip irrigation to guarantee constant moisture levels [73]. Additionally, uniform fruit development is aided by a balanced fertilization schedule that pays particular attention to the levels of calcium and potassium. In areas with high temperatures, shade nets can also be useful in reducing heat stress [74]. Preventing uneven ripening also requires effective pest control. Pest populations can be managed and the risk of virus transmission decreased with the use of timely actions and routine monitoring [75]. Examples of these actions include the application of pesticides or biological controls like beneficial insects. Lastly, this disease can be lessened by choosing tomato types that are resistant to environmental stressors and pests [76].

## **2.9 ZIPPERING**

It alters the fruit's outward look, which causes concerns more with marketability and attractiveness than with nutrients or insides. It can be identified by a line or scar that runs parallel to the fruit's stem and ends at the blossom end, giving the appearance of a "zipper." [77] There might be small holes or

depressed spots along this scar, which occasionally reveal the tomato's locular cavity. While zippering has no discernible effect on the fruit's texture or flavor, the unattractive scars lower the fruit's market value. The reason of the zipper scar is still unknown, while it is occasionally ascribed to high humidity or an anther that is linked to the fruit that is just beginning to form [78]. The best way to keep things under control is to choose kinds that don't often zipper. The longitudinal scars are accompanied by little transverse scars that give the overall scars a zipper-like look. Along the scar, a locule hole will occasionally appear. Anther adhering to the wall of the freshly produced fruit results in zippering. The disease typically manifests in the early phases of growth and fruit set [79]. The most common causes of zippering are hereditary and environmental variables. The adherence of dead floral parts (anthers) to the developing fruit, which mechanically obstructs the smooth growth of the tomato's skin, is one of the main causes of zippering. The fruit has a zipper-like look due to this mechanical injury [80]. Furthermore, variations in temperature, especially at night, can make zippering more likely during the pollination phase. Because they are sensitive to environmental stress, tomatoes can develop abnormally, which can result in a variety of physiological diseases like zippering. Low temperatures and sluggish fruit development may be the cause. Genetic factors also play a role in its causation. It is most likely a genetic abnormality that only appears in specific environments and could be connected to fleck and the pox. [81] Some tomato varieties—particularly those with larger fruit—are more likely to zipper. By choosing cultivars that are less susceptible to certain environmental triggers, breeding initiatives have attempted to lower the occurrence of zippering. Additionally, growers can reduce zippering by optimizing pollination circumstances, which include utilizing appropriate irrigation strategies, keeping temperatures constant during the flowering time, and making sure there is adequate air circulation within the crop canopy to reduce stress on the plants [82].



**Image-8 (ZIPPERING)**

## **2.10 INTERNAL WHITE TISSUE**

A physiological problem known as internal white tissue (IWT) disorder in tomatoes damages the fruit's quality and can result in large-scale production losses. This disease appears as white, spongy patches in tomato flesh that typically begin close to the vascular tissue and extend throughout the interior of the fruit. [83] When a fruit has internal white tissue disease, it seldom ever exhibits any outward signs. But when ripe fruits are cut, the outer walls have firm, white spots. The symptoms appear to be triggered by high temperatures during the ripening stage. While symptoms may not completely disappear, they can be lessened by continuing a potassium fertilization program that is adequate (soil exchangeable potassium [K<sup>+</sup>] level of 130 PPM in sandy loams). Certain fruit kinds are more susceptible to the condition than others, as is the case with many of these fruit-related issues. When fruits grow on the vine, this condition is more prevalent. Appropriate potassium fertilization may lessen the issue, although it might not completely solve it. IWT is a non-infectious disorder that is generally linked to dietary imbalances, environmental stressors, and specific cultural traditions, in contrast to diseases that are caused by germs [84]. Stress from temperature, particularly during fruit growth, is one of the main causes of interior white tissue. Inadequate cooling throughout the night coupled with high daytime temperatures can cause physiological imbalances in the fruit that impact tissue development and ripening consistency. The plant's capacity to absorb and transport calcium, a nutrient necessary for preserving the integrity of its cell walls, is similarly hampered by high temperatures. Water stress is another important aspect. Drastic weather or excessive watering can lead to irregular water circulation in plants, which can interfere with the uptake of nutrients. Stress from water can worsen calcium deficiency and accelerate tissue deterioration. Furthermore, during crucial stages of fruit growth, insufficient mulching or poor irrigation management might amplify environmental fluctuations, making tomatoes more susceptible to this illness [85]. Beyond calcium, other nutrients may also be out of balance. For example, overfertilization with nitrogen encourages fast vegetative development at the expense of poor fruit quality. Excessive nitrogen causes the plant to devote less energy to the fruit, which results in localized nutritional deficits that compromise tissue integrity. Another important nutrient that, if out of balance, might affect calcium transport and aid in the development of white tissue is potassium [86]. There are preventive steps that can lessen the incidence of internal white tissue, even if the precise biochemical mechanisms underlying it are still being investigated. Water stress can be decreased by using drip irrigation, in particular, to maintain constant moisture levels. Heat-related stress can be lessened by controlling the temperature in greenhouses or adding shade structures to open fields. It's also critical to fertilize in a balanced way, emphasizing potassium and calcium while avoiding too much nitrogen. To reduce the incidence of IWT, cultivars with enhanced resistance to physiological diseases are also being developed [87].



**Image-9 (INTERNAL WHITE TISSUE)**

### **2.11 POX**

Pox is a physiological disorder affecting tomatoes, primarily caused by environmental stressors rather than pathogens like bacteria or fungi [88]. It manifests as small, raised, corky lesions on the surface of the tomato fruits, leaves, and stems. Pox is described as small cuticular disruptions whose number can vary from a few to many found at random on the fruit surface[89]. These pox-like lesions are usually more prominent on green, unripe fruits and can cause significant cosmetic damage, reducing the marketability of the produce. However, the internal quality of the fruit is typically not affected [90]. The real cause of pox is not clearly understood. However, the condition seems to be genetic in nature but are difficult to breed out of a variety since the disorders only show up under certain environmental conditions[91]. Differences of opinion exist as to the real conditions or genetic makeup lead to susceptibility to pox. The primary cause of pox is fluctuations in environmental conditions, particularly high humidity and excessive moisture levels combined with irregular water supply. When tomatoes experience rapid changes in water availability [92], the skin of the fruit may crack or develop these raised blemishes due to uneven growth. Poor air circulation around the plants, high temperatures, and inadequate irrigation practices can further exacerbate the condition. While pox does not directly harm the plant's overall health, it can lead to secondary infections if not managed properly [93]. To prevent the disorder, growers need to ensure consistent watering practices and improve ventilation around tomato plants. Mulching and proper spacing of plants can help regulate soil moisture and reduce the risk of water stress. Pox can also be minimized by selecting tomato varieties that are more resistant to environmental fluctuations [94].



**Image-10 (POX)**

### **2.12 ZEBRA STRIPING**

Tomatoes can develop a physiological condition called "zebra striping," which results in noticeable dark green or yellowish stripes on the fruit's skin. The term comes from the fact that these stripes mimic a zebra's pattern [95]. The condition mostly affects the tomato's appearance; its flavour and nutritional value are not markedly changed [96]. Striped tomatoes are less appealing to customers because they are associated with consistency in appearance, which might negatively affect the marketability of tomatoes. Although the precise origins of zebra striping are not entirely known, environmental factors- specifically, changes in temperature, light intensity, and food imbalances—are thought to play a significant role [97]. Elevated temperatures have the potential to worsen the condition, particularly when fruit is ripening. Since UV light influences the production of pigments in the fruit's skin and the destruction of chlorophyll, excessive light exposure may also be the cause of the striping [98]. It is thought that nutrient imbalances, especially those involving excesses or deficits in potassium and calcium, further stress the plant and increase its vulnerability to zebra striping. Controlling the environmental elements that cause stress in tomato plants is essential to managing zebra striping [99]. The danger of heat-induced striping can be decreased by mulching the area around the plant to assist control soil temperature and moisture retention [100]. The impacts of temperature and light changes can be lessened by providing adequate shade during periods of intense sunlight and by adhering to regular watering regimens [101]. Preventing nutrient-related stress also requires balanced fertilization, which makes sure the plant gets enough calcium and potassium. Additionally, some gardeners have claimed success with calcium and other trace nutrients applied topically [102].



**Image-11 (ZEBRA STRIPING)**

### **3. DISCUSSION AND CONCLUSION**

Abnormalities in fruit growth and development are the result of tomato physiological diseases, which are caused by non-pathogenic reasons such as environmental pressures, nutrient imbalances, and poor cultural practices. Common problems include sunscald, blossom end rot, cracking, zippering, zebra striping, internal white tissue, golden fleck, tomato irregular ripening, pox and catfacing; these are frequently brought on by inconsistencies in watering, a calcium deficit, temperature swings, and mechanical damage. These illnesses are not brought on by pests or diseases, yet they can drastically lower fruit quality and output. Farmers should use regular watering, balanced fertilizer, appropriate pruning, and temperature management to successfully address these issues. Tomato output can be enhanced and plants can be healthier when these problems are identified early and treated appropriately.

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