Journal of Advances in Biology & Biotechnology

Volume 27, Issue 11, Page 221-231, 2024; Article no.JABB.124794
ISSN: 2394-1081

A Review on Common Physiological Disorder of Tomato and Their Management

Hareesh Kumar Maurya [a++*], Diksha Sangh Mitra [a++], Rubee Lata [a#], G.C. Yadav [a†] and Shyam Sundar [a++]

[a] Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, (A Central University), Lucknow, (UP) - 226025, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i111607

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/124794

Review Article

Received: 01/08/2024
Accepted: 03/10/2024
Published: 02/11/2024

ABSTRACT

Tomato plants are susceptible to various kinds of physiological problems, which can reduce fruit quality and productivity. Unlike pathogen-caused diseases, these problems are the result of environmental conditions, nutritional imbalances, and poor growing practices. Blossom-end rot, caused by calcium deficiency and inconsistent watering; blotchy ripening, often due to imbalanced nutrient availability; fruit cracking, often caused by rapid water uptake; sunscald, caused by excessive sunlight exposure; catfacing, caused by temperature fluctuations during fruit development; and uneven ripening, linked to poor nutrient distribution. These difficulties can be

[++] *Research Scholar;*
[#] *Assistant Professor;*
[†] *Professor;*
**Corresponding author: E-mail: hareshmmsln@gmail.com;*

Cite as: *Maurya, Hareesh Kumar, Diksha Sangh Mitra, Rubee Lata, G.C. Yadav, and Shyam Sundar. 2024. "A Review on Common Physiological Disorder of Tomato and Their Management". Journal of Advances in Biology & Biotechnology 27 (11):221-31. https://doi.org/10.9734/jabb/2024/v27i111607.*

mitigated with proper mulching, pruning, and the use of shade netting. Effective management of these problems necessitates integrated techniques such as continuous irrigation, balanced fertilization, temperature adjustment, and protection from environmental extremes such as direct sunshine. Management of these disorders, which includes the use of mulch, optimal temperature control, correctly pruning, proper irrigation, balanced manure and fertilizer, protective measures against excessive sunlight, and integrated cultural practices, are some important keys that can help reduce their incidence. Furthermore, choosing tomato cultivars that are less susceptible to physiological problems will improve crop resilience. By addressing these issues, growers can improve overall crop health, resulting in higher-quality yields and lower economic losses. This review article gives an overview of the causes physiological disorder and reducing these disorders of tomatoes.

Keywords: Tomato; physiological disorder; abiotic factor; nutrient imbalance; nutrient management.

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 lyopersicum* L.), one of the most widely available solanaceous edible fruits, is widely consumed because of its high carotenoid concentration and antioxidant qualities (Olson, 2004). 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 (Fageria et al., 2016).

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. When evaluating tomato fruit for fresh consumption, factors such as colour, 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 (Dorais et al., 2001). 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. 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 diseases 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 (Bose et al., 1993). 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. The problem known as irregular ripening of fruit is brought on by the feeding of Silverleaf whitefly (*Bemisia tobaci*) nymphs on tomato foliage. While green fruit does not exhibit any symptoms, when it ripens, the colour does not develop evenly (Mishra, 2021). A star-burst look is often produced by colour developing along locule walls, with intermediate portions staying green or yellow (Rick & Butler, 1956). 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. 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. These spots eventually turn yellow or gold in colour. There can be few or numerous spots (Singh, 2010).

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. 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 (Peter, 2009). 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 (Sharma et al., 2019).

2. PHYSIOLOGICAL DISORDERS OF TOMATO

2.1 Blossam 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. 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 (Image 1). It usually affects the earliest mature fruit the most and frequently appears in quickly developing fruit during hot, dry conditions (Saure, 2001). 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. 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. Plants that develop quickly are more vulnerable to the illness. Blossom-end rot can be prevented by planting cultivars that are resistant to the disease, managing water, and applying the right fertilizer. When the fruits are green, brown lesions emerge at the terminal of the blossom (Ho et al., 2016). Water-soaked patches appear where the senescent petals attach, and these areas get bigger. 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. 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. Any moisture stress will cause plants to absorb less calcium and hence have less concentration. The tomato plant's ability to absorb and concentrate calcium can be reduced by nitrogen in the form of ammonium. 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. This fruit problem can be most easily prevented with good water management and proper fertilization (Ho et al., 1995).

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. 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. 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 (Image 2). As a consequence, cells in the ovary’s bloom end die, become black, and create leathery patches towards the fruit’s end (Chadha, 2001). 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. In general, jointless

varieties are more prone to catfacing than jointed varieties (Sikes & Coffey, 1976). Heavy pruning in indeterminate varieties has been shown to increase catfacing but this has not been shown to happen in our short-stake varieties. 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. 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 (Wienl & Turner, 1994).

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 (Image 3). Variations in the water supply cause fruit to develop and shatter quickly (Mustafa et al., 2017). 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. 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 concentratic cracking. 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. 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 (Panigrahi et al., 2015). 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. 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. 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. 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. Gardeners may reduce cracking and ensure a successful and productive tomato harvest by learning the causes and taking preventive action (Sadhankumar et al., 2001).

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 (Image 4). 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. 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 (Department of Crop Sciences University of Illinois at Urbana-Champaign, 2014). Secondary black Mold fungi can colonize the necrotic tissue. 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. 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. 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 (Masarirambi et al., 2009).

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 (Image 5). 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 (Jarvis & Mckeen, 1991) 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. 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. 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 (Gangadhara et al., 2021) Because of their genetic composition, some heirloom tomato cultivars are inherently more prone to this problem. 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. 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 (Peet, 2008).

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 (Image 6). The name "graywall" refers to the appearance of partial wall tissue collapse, which is recognized as the reason of its greyish appearance (Dangler & Locasio, 1990). 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. 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. 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. Mulching and the application of fertilizers high in potassium can also help to keep moisture levels constant and minimize temperature swings (James et al. 1990). Variations between cultivars Among the causative elements are low K, high N, low temperature, low light intensity, and excessive soil moisture. 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. 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 (Aakash & Kumar, 2021).

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 (Image 7). 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 (Verma et al., 2019) 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. A rise in the P level was accompanied by an increase in the rate of speckling and calcium absorption. Throughout the growth season, gold spot occurs more frequently when temperatures rise, particularly when average temperatures are higher than usual. It is thought to be related to nutritional abnormalities, including deficits or imbalances of potassium and calcium. It is imperative to maintain an equilibrium of calcium and potassium in the body to avert this condition (Hazara & Som, 2009) 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. It's also essential to water consistently. 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. Resistant cultivars can lessen the disorder's occurrence and severity when combined with appropriate management techniques (Dhiman et al., 2024).

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. In commercial tomato agriculture, this disease is highly common, especially in warm climates or under stressful conditions for the plants (Dorais et al., 2004). It frequently shows up as green or yellow patches on the fruit, with some sections not ripening and others turning the typical red colour (Image 8). The disorder mainly affects the fruit's shoulders and sides, leaving some sections tough and unripe even after the fruit has mostly ripened. It is brought on by the silver white fly (*Bemisa argentifolii*), 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. 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. Unbalanced soil nutrients can also make the condition worse, especially if there are calcium or potassium shortages (Srinivasulu et al., 2020). 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. Calcium is essential for the strength and integrity of cell walls (Hanger, 1979). Inconsistent ripening has also been connected to pest pressure, namely from whiteflies and other sap-sucking insects. These pests' feeding activities have the potential to directly interfere with the physiological functions of the plant, lowering the fruit's quality. 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. Pest populations can be managed and the risk of virus transmission decreased with the use

of timely actions and routine monitoring Lastly, this disease can be lessened by choosing tomato types that are resistant to environmental stressors and pests.

2.9 Zippering

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." The assessment of tomato cultivars' vulnerability to zippering disorder is critical for enhancing crop quality and output (Image 9). Brandywine is a tomato variety that is reported to be sensitive to zippering disorder." There might be small holes or depressed spots along this scar, which occasionally reveal the tomato's locular cavity (Mishra, 2021). While zippering has no discernible effect on the fruit's texture or flavour, the unattractive scars lower the fruit's market value. To manage zippering disorder in tomatoes, several cultural practices can be employed. These include maintaining consistent irrigation to prevent water stress, ensuring proper soil drainage, and applying balanced fertilization to support healthy growth. 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. 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 (Olson, 2004). Consistent and adequate watering helps to maintain uniform soil moisture, reducing stress that can cause fruit deformities. Drip irrigation can provide precise moisture control by eliminating surplus water on the leaves and encouraging healthy root development. 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. A balanced fertilization program with proper quantities of nitrogen, phosphorus, and potassium promotes good fruit development (Sperry et al., 1996).

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. When a fruit has internal white tissue disease, it seldom ever exhibits any outward signs (Image 10). 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 (Sharma et al., 2016). While symptoms may not completely disappear, they can be lessened by continuing a potassium fertilization program that is adequate (soil exchangeable potassium [K+] level of 130 PPM in sandy loams). 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. 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. Some significant cultivars include Kewalo, Tornado, Ponderosa Pink, and San Marzano, which are resistant to internal white tissue (Villanueva, 2018). The occurrence of interior white tissue in tomatoes can be considerably altered by different growing conditions. Preventive measures that can reduce the incidence of internal white tissue include soil nutrient levels, water management, temperature and climate, crop rotation, and management methods. 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 (Olson, 2017).

2.11 Pox

These pox-like lesions are usually more prominent on green, unripe fruits and can cause significant cosmetic damage, reducing the marketability of the produce (Image 11). However, the internal quality of the fruit is typically not affected. 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 (Muthukumar & Selvakumar, 2017). To manage pox in tomatoes, crop rotation, field sanitation, selection of resistant types, correct spacing, and planting density were employed as cultural methods. Calcium and magnesium foliar spray reduces pox disease in tomatoes by enhancing nutrient uptake through the leaves (Adams & Holder, 1992). Calcium strengthens cell walls, which reduces skin cracking, but magnesium improves general plant health and photosynthesis. Regular foliar spraying speeds up the correction of deficiencies, reduces pox-like symptoms, and promotes healthy fruit growth. Evaluating tomato cultivars for resistance to pox diseases (which are frequently associated with viral infections) is an important step in developing sustainable tomato production strategies. Some significant kinds that are resistant to pox disorder include Sungold, Celebrity, Samantha, Tornado, and Big Beef. Irrigation measures are critical in regulating the pox in tomato crops. optimum irrigation methods for the field include drip and sprinkler irrigation, optimum irrigation timing, and soil moisture management. Inconsistent soil moisture can enhance the incidence of pox in tomatoes. Fluctuations between drought and overwatering stress the plant, affecting fruit production. This stress might result in small, raised, white or brownish pox-like patches on the fruit's surface. Maintaining regular soil moisture reduces plant stress and lowers the chance of pox formation (Singh, 1989).

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 (Image 12). Temperature fluctuations, especially throughout the day and night, can cause uneven ripening and stripe formation. Inconsistent moisture practices, such as dryness followed by overwatering, can cause stress and produce striped fruit (Adams & Ho, 1995). Calcium shortage is essential for cell wall formation and stability, and it can cause blossom end rot and increase zebra striping. Apply lime, gypsum, or calcium nitrate to the soil to provide an acceptable calcium level. Mulch also promotes soil health, inhibits weeds, and increases nutrient availability, resulting in consistent fruit development and reduced striping. Test the soil pH on a regular basis to ensure adequate calcium uptake (pH 6.0-6.5). Potassium promotes fruit development, colour consistency, and ripening. Use potassium-rich fertilizers, such as potassium sulphate or potassium nitrate. Regular soil testing will allow you to follow K levels and modify fertilization accordingly (Adams & Ho, 1993). Controlling the environmental elements that cause stress in tomato plants is essential to managing zebra striping. 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. Conduct soil testing to evaluate nutrient levels and apply balanced fertilizers that contain enough calcium, potassium, and other critical nutrients. Additionally, some gardeners have claimed success with calcium and other trace nutrients applied topically (Subode et al., 2024).

Image-1 (Blossam End Rot)

Image-2 (Catfacing)

Image-3 (Cracking)

Image-4 (Sunscald)

Image-5 (Puffiness)

Image-6 (Blotchy Ripening)

Image-7 (Golden Fleck)

Image-8 (Tomato Irregular Ripening)

Image-9 (zippering)

Image-10 (Internal White Tissue)

Image-11 (Pox)

Image-12 (Zebra Striping)

Images 1-10. Tomato physiological disorders

3. CONCLUSION

Abnormalities in fruit growth and development are the result of tomato physiological diseases, which are caused by non-pathogenic reasons such 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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The authors hereby state that NO generative AI tools, such as Large Language Models (COPILOT, ChatGPT, etc.) or text-to-image generators, were utilized during the creation and editing of this work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Aakash, & Kumar, A. (2021). Physiological disorder of tomato. *The Agriculture Magazine, 1*.

Adams, P., & Ho, L. C. (1993). Effects of environment on the uptake and distribution of calcium in tomato and on the incidence of blossom-end rot. *Plant and Soil, 154*(1), 127-132.

Adams, P., & Ho, L. C. (1995). Differential effects of salinity and humidity on growth and Ca status of tomato and cucumber grown in hydroponic culture. *Acta Horticulturae, 401*, 357-362.

Adams, P., & Holder, R. (1992). Effects of humidity, Ca and salinity on the accumulation of dry matter and Ca by the leaves and fruit of tomato (*Lycopersicon esculentum* Mill.). *Journal of Horticultural Science, 67*(1), 137-142.

Bose, T. K., Som, M. G., & Kabir, J. (1993). *Vegetable Crops* (Vol. 1). Naya Prokash.

Chadha, K. L. (2001). *Handbook of Horticulture*. Indian Council of Agricultural Research.

Dhiman, S., Sohi, A., Nishchala, & Pathania, R. (2024). Physiological disorders in tomato. *Greeneria, 2*(8).

Dorais, M., Demers, D. A., Papadopoulos, A. P., & Ieperen, W. V. (2004). Greenhouse tomato fruit cuticle cracking. *Horticultural Reviews, 30*, 163-184.

Dorais, M., Papadopoulos, A. P., & Gosselin, A. (2001). Greenhouse tomato fruit quality. *Horticultural Reviews, 26*, 239-319.

Fageria, M. S., Choudhary, B. R., & Dhaka, R. S. (2016). *Vegetable production technology*, *II*, 40-43. Kalyani Publisher.

Gangadhara, K., Selvakumar, R., Singh, P. K., Manjunathagowda, D. C., & Kumar, J. (2021). Tomato physiological disorder and their management. *Biotica Research Today, 3*(10).

Hanger, B. C. (1979). The movement of calcium in higher plants. *Communication in Soil Science and Plant Analysis, 10*(1-2), 171-193.

Hazara, P., & Som, M. G. (2009). *Technology for Vegetable Production and Improvement*. Naya Prokash.

Ho, L. C., Adams, P., Li, X. Z., Shen, H., Andrews, J., & Xu, Z. H. (1995). Responses of Ca-efficient and Ca-inefficient tomato cultivars to salinity in plant growth, Ca accumulation and blossom-end rot. *Journal of Horticultural Science, 70*(6), 909-918.

James, M. D., & Locascio, S. J. (1990). External and internal blotchy ripening and fruit elemental content of trickle-irrigated tomatoes as affected by N and K application time. *Journal of the American Society for Horticultural Science, 115*(4), 547-549.

Jarvis, W. R., & McKeen, C. D. (1991). *Tomato Disease* (Agriculture Canadian Publication, 1479/E). Ottawa, Canada.

Marlina, M., Muhamad, S., Surjono, H. S., & Sobir. (2017). Inheritance of fruit cracking resistance in tomato (*Solanum lycopersicum* L.). *Asian Journal of Agricultural Research, 11*, 10-17.

Masarirambi, M. T., Mhazo, N., Oseni, T. O., & Shongwe, V. D. (2009). Common physiological disorders of tomato (*Lycopersicon esculentum*) fruit found in Swaziland. *Journal of Agricultural and Social Sciences, 5*, 123-127.

Mishra, A. (2021). Physiological disorders of tomato: An overview. *International Journal of Farm Sciences, 11*(4), 46-50.

Muthukumar, P., & Selvakumar, R. (2017). *Glaustas Horticulture*. New Vishal Publication.

Olson, S. (2017). Physiological, nutritional, and other disorders of tomato fruit. *University of Florida IFAS Extension*, HS-954.

Olson, S. M. (2004). Physiological, nutritional and other disorders of tomato fruit. *University of Florida IFAS Extension*, HS-954.

Panigrahi, T., Kujur, A. N., & Singh, N. (2015). Common physiological disorders in tomato (*Solanum lycopersicum*). *Journal of Plant Development Sciences, 7*(5), 465-468.

Peet, M. M. (2008). Physiological disorders in tomato fruit development. *Acta Horticulturae, 821*, 151-160.

Peter, K. V. (2009). *Basics of Horticulture*. New India Publishing Agency.

Physiological Disorders of Tomato. (2014). *Department of Crop Science, University of Illinois at Urbana-Champaign*. Plant Disease RPD No. 981.

Rick, C. M., & Butler, L. (1956). Cytogenetics of the tomato. *Advances in Genetics, 8*, 267-382.

Sadhankumar, P. G., Rajan, S., & Peter, K. V. (2001). Concentric cracking in tomato: Biochemical, physical and anatomical factors. *Vegetable Science, 28*, 192-194.

Saure, M. C. (2001). Blossom-end rot of tomato (*Lycopersicon esculentum* Mill.): A calcium- or a stress-related disorder. *Scientia Horticulturae, 90*(3), 193-208.

Sharma, N., Kumar, A., Kumar, V., Kumar, M., Jamwal, A., Singh, S., Jamwal, S., Rai, A. P., Khajuria, S., & Arora, R. K. (2016). Physiological disorders in solanaceous and bulb crops: A review. *International Journal of Agriculture Sciences, 8*(52), 2566-2568.

Sharma, P., Thakur, S., & Negi, R. (2019). Recent advances in breeding of tomato: A review. *International Journal of Current*

Microbiology and Applied Sciences, 8(3), 1275-1283.

Sikes, J., & Coffey, D. L. (1976). Catfacing of tomato fruits as influenced by pruning. *HortScience, 11*(1), 26-27.

Singh, J. (2010). *Principles of Horticulture*. Kalyani Publishers.

Singh, S. P. (1989). *Production Technology of Vegetable Crops*. Agriculture Communication Research Centre.

Sperry, W. J., Davis, J. M., & Sanders, D. C. (1996). Soil moisture and cultivar influence cracking, blossom-end rot, zippers, and yield of staked fresh-market tomatoes. *HortTechnology, 6*(1), 21-24.

Srinivasulu, B., Rao, G., & Singh, P. (2020). Physiological disorders of tomato and their management. *Journal of Pharmacognosy and Phytochemistry, 9*(3), 2149-2150.

Subode, S., Cho, J., & Francis, D. M. (2024). Quantitative trait mapping for zebra-stem in tomato confirms a genetic cause involving the interaction of unlinked loci. *59*(7), 999-1006.

Verma, A., Goyal, P., Singh, K., & Suvalk, R. L. (2019). Major physiological disorders of tomato and their management. *Indian Journal of Science Research, 18*(2), 55-59.

Villanueva, E. E. (2018). *An overview of recent studies of tomato (Solanum lycopersicum spp) from a social, biochemical and genetic perspective on quality parameters* (Introductory Paper, 2018:3). Alnarp-Sweden: Sveriges lantbruksuniversitet.

Wienl, H. C., & Turner, A. D. (1994). Screening fresh-market tomatoes for susceptibility to catfacing with GA3 foliar spray. *HortScience, 29*(1), 36-37.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/124794