



diagnose the abiotic and biotic stress that cause diseases/disorders in vegetable crops for management and enhanced productivity.

**Keywords:** Diagnosis, Biotic stress, Abiotic stress, Diseases, Vegetables, Management.

## INTRODUCTION

Stress is obstructing the proper growth of plants. The exposure of plants to biotic and abiotic stressors leads to significant deficits in the production of agriculture worldwide<sup>1</sup>. There are two types of stresses, biotic and abiotic those are observed in plant tissues<sup>2</sup>. Abiotic stress is caused by nonliving factors and biotic stress is caused by living organisms. An increased number of abiotic and biotic stress combinations severely affect plant growth and yield.<sup>3,4</sup> Plant stress depends upon the stress factors being living or nonliving and thus the stress divides into biotic (living) stress and abiotic (nonliving) stress in plants.<sup>5</sup> In response to stress, the plants adapt newer metabolic reactions to resist the stress. The majorities of such reactions regulate and sustain themselves against various environmental factors.<sup>6</sup> Abiotic stresses are nonliving factors that influence plants' metabolism, growth, and development.<sup>7,8</sup> Abiotic stresses such as excessive heat, extreme cold, salinity, drought, and both mineral availability and toxicity are significant factors affecting plant health and growth<sup>9,10</sup>. The abiotic stress factors have negatively impacted crop yields, highlighting the urgent need to generate resistant plant varieties that can withstand these environmental challenges.<sup>7</sup> Toxins are also regarded as stress responses released by plant tissues in reaction to various abiotic stress factors.<sup>11</sup> The stresses on plants significantly influence their growth and development. Various types of plant metabolism are triggered by these stresses, including alterations in the expression of inherited genes, changes in cellular metabolism, and shifts in growth patterns and crop yields.<sup>5</sup> Adverse weather conditions such as drought, flood, high winds, frost, hail, snow, and lightning can damage or kill plants and create opportunities for pathogens to infect them. Abiotic stresses are of greater importance that cannot be prevented, such as drought, salinity, cold, heat, metal, etc. Plant reactions to abiotic stress are dynamic and complicated, they can be reversible or irreversible.<sup>12</sup> The inanimate factors affecting living beings are described as abiotic stress. Abiotic stress has significant negative impacts on crop morphology, biochemistry, and physiology, all of which directly affect plant growth and yield. Abiotic stresses such

as water scarcity, high salinity, extreme temperatures, droughts, stagnation, mineral deficiencies and metal toxicities reduce the crop's productivity. Climate change has greatly threatened food security as additional external pressures which directly impact the agricultural output. Abiotic stress changes in the growth of plants as well as stress-related phytohormones affect the normal functioning of plants and production. The abiotic factors that influence plant growth in an agricultural ecosystem include temperature, water, salts, essential nutrients, and pH. The high pH (alkaline) in soils reduces the availability of essential macro and micronutrients viz., phosphorus, manganese, zinc, copper, and iron causing nutrient deficiency and osmotic imbalance.<sup>13</sup> Other factors are linked to each other that are influenced by climate change, that increased rainfall causes flood and no rainfall results in drought causing a negative impact on crops. In drought, farmers turn to irrigation, which adds more salts to the soil causing salinity.<sup>14</sup> The three stages of plant viz., vegetative development, pre-anthesis and terminal phase that affected by the drought.<sup>15</sup> Multiple abiotic stresses such as salinity and drought affect the crop in semi-arid tropical regions.<sup>16</sup> Water is a crucial element of plant survival and is essentially needed for the transportation of nutrients. Plants undergo various physiological, molecular, and biochemical changes under these environmental stresses that impact overall plant development and growth. Water deficit stress, salt stress, imbalances in nutrients (toxicity and deficiencies) and temperature are significant limitations on the productivity of crops<sup>17</sup>. Plant growth and crop yield are affected by cold, drought, salt, and heavy metals. The deficiency of water leads to drought stress, which reduces plant vitality.<sup>18</sup> Cell elongation decreases under drought conditions due to a decrease in turgor pressure.<sup>19</sup> Temperature directly affects physiological processes such as photosynthesis, respiration, membrane permeability, water and nutrient absorption, transpiration, enzyme activity, and the denaturation of proteins. Low temperatures may kill the young roots and tree bark to split allowing canker development. Low-temperature damage to the formation of ice crystals inside plant cells, and chilling injury occurs in a wide range of vegetables. Plants show a variety of responses to high temperatures, seedlings may show symptoms

of 'stem girdling' due to radiating heat from the soil scorching young stem tissue, the stem above the injured zone swells, and a 'heat canker' formed. High temperatures can significantly influence seed germination, as well as overall plant growth and development. These elevated temperatures often trigger drought stress, which can ultimately lead to plant death.<sup>20</sup> High-temperature stress can lead to substantial protein damage, disrupt protein synthesis, inactivate essential enzymes, and harm membranes, all of which significantly affect the cell division process.<sup>21</sup> Cold stress affects plants adversely by altering their membrane structure, leading to decreased protoplasmic streaming, increased electrolyte leakage, and plasmolysis. These changes result in cellular damage, disrupted metabolism, stunted plant growth, abnormal fruit ripening, internal discoloration (vascular browning), and a heightened risk of plant death.<sup>22</sup> Increase in salt content in soil is referred to as soil salinity.<sup>23</sup> Climate change reduced cultivated lands, exhausting soil nutrition, less responsiveness to agrochemicals, and environmental degradation.<sup>24</sup> The use of chemical pesticides and fertilizers often leads to a decline in soil richness and contributes to environmental contamination. Therefore, it is essential to find safe and ecologically viable solutions for sustainable agricultural practices that can effectively adapt to environmental challenges.<sup>25</sup> Abiotic stress affects plants significantly, influencing them at molecular levels and manifesting visible changes in their morphology throughout all phases of development.<sup>17</sup> Plant physiological reactions to stress include wilting of the leaf, abscission of the leaf, decreased leaf area, and reduced water loss through transpiration.<sup>26</sup> Abiotic stresses like drought and heat can be particularly destructive to crops.<sup>27</sup> Abiotic stresses such as drought, high and low temperatures, and salinity significantly affect the occurrence and spread of pathogens, insects, and weeds.<sup>28</sup> *Fusarium* pathogens exist in the soil more severely under drought conditions. Abiotic stress can significantly influence plant-pathogen interactions in both positive and negative ways. Most studies examining drought and heat stress alongside biotic stress interactions indicate that abiotic factors play a significant role in facilitating plant diseases caused by weakly aggressive facultative pathogens.<sup>29-31</sup> Abiotic diseases are the result of genetic changes that occur in the meristematic cells that cannot be transmitted from affected plants to healthy plants. Biotic stresses, which derive from micro and macro-organisms, damage or infection by various pathogens. Biotic stress arises from interactions with living organisms, including viruses, bacteria,

fungi, nematodes, insects, and weeds, among others.<sup>32</sup> These stressors deplete host plants of essential growth factors and nutrients, ultimately leading to their decline and death. Consequently, biotic stress factors are a primary cause of significant pre- and post-harvest losses in plants. In response to stress factors, signal transduction pathways activate specific response genes.<sup>33</sup> Abiotic stress factors, which plants often cannot mitigate, prompt them to develop adaptive mechanisms within their metabolism.<sup>9</sup> Plants employ a variety of mitigation strategies to cope with abiotic stress factors.<sup>9</sup> The activation of stress-responsive genes enhances plants' tolerance to challenging conditions, allowing them to better withstand various hazards. Identifying targeted genes is essential since the overall mechanism of response to stress relies heavily on gene regulation.<sup>2</sup> Reducing oxidative stress enhances stress tolerance in plants, contributing to their long-term sustainability in adverse conditions.<sup>2</sup> The close relationship between abscisic acid (ABA) and salicylic acid (SA) as well as jasmonic acid/ethylene (JA/ET)-mediated defense signaling is significant in the context of plant-pathogen interactions.<sup>34</sup> Abscisic acid increases plant-cause susceptibility to bacterial and fungal pathogens, and inhibition of ABA signalling increases plant defense against pathogens.<sup>35-38</sup> Abscisic acid usually antagonizes SA and JA/ET defense signaling thereby interfering with plant responses.<sup>39,40</sup> Stress is the intense pressure that affects the normal functions of life in plants that prevented them from expressing their genetic potential for growth, development and reproduction.<sup>41</sup>

### Diagnosis of diseases

Diagnosis is the identification of the cause of the problem under examination to conclude that the problem is caused by an infectious agent. Plant symptoms caused by biotic factors such as infectious diseases are often similar to those caused by other factors. Leaf spots, chlorosis blight, defoliation, deformities, wilting, stunting and plant death can be common symptoms of both biotic and abiotic problems. Biotic diseases are caused by living microorganisms and typically affect one species or cultivar of the same age. They are often observed in random locations, with variations in the time of appearance and severity of damage among affected plants. Symptoms can include the presence of fungal mycelium, spores, bacterial ooze, and nematode cysts, which can spread when environmental conditions are favorable. It's also possible that the crop has been affected by

conditions from previous growing seasons. Soil and root analysis is required to confirm the diagnosis and management of diseases. If a problem is caused by a pathogenic fungus, bacterium, nematode, and virus, it is necessary to have symptomatic tissues analyzed through microscopic and isolation procedures by a plant pathologist. Quick test kits are available that are used to rapidly identify many diseases in the field such as test strips for viruses. The most evident signs of mycelium and spores are produced by rust, powdery mildew and downy mildew. Nonpathogenic fungi can grow on damaged tissues, and the signs of the pathogen may possibly be misdiagnosed. Diagnosing plant diseases requires careful examination of the entire plant specimen.

Many abiotic stresses have been shown to weaken the defense mechanisms of plants, enhancing their susceptibility to pathogen infection. Abiotic factors affect various species of plants across different ages, often related to environmental conditions, physical factors, and cultural practices. The effects are relatively uniform, and damage appears similar among plants. There is usually no evidence of pathogens causing the symptoms, and the damage is not typically infectious. It does not spread and is possibly associated with environmental conditions or cultural practices. Nutrient deficiencies and toxicities can hinder shoot growth and reduce leaf size, leading to symptoms such as leaf chlorosis, necrosis, and dieback of plant parts. The macronutrients are carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur. Iron, zinc, manganese, copper, boron, molybdenum, and chlorine are essential micronutrients for plant growth, required only in relatively small amounts. Cobalt is essential for nitrogen fixation in both legumes and non-legumes. Deficiencies or excesses of these elements can result in plant damage. Nutrient deficiencies cannot be diagnosed solely based on symptoms, as other plant issues can create similar manifestations. The nutrient deficiencies usually confirm the problem by leaf tissue and soil sample analysis. Soil acidity or alkalinity influences the availability of nutrients between 5.5 and 6.5 pH, below and above this range some nutrient elements may be toxic. Herbicides are used to control weeds in crops, and the mode of action of the herbicide can determine the symptoms observed in the plants. The herbicides are growth regulators, photosynthetic inhibitors and enzyme inhibitors such as 2, 4-D a growth regulatory, and glyphosate enzyme inhibitors. Insecticides and fungicides occasionally cause plant damage. Flower petals are more susceptible to damage from pesticides than leaves. The younger and tender leaves are more

susceptible to pesticides; the active ingredients of pesticides can adversely affect the photosynthetic mechanism and physiological processes, causing general leaf chlorosis, interveinal chlorosis, leaf curling, and stunting. Pesticides applied as soil drenches can cause poor germination, seedling death, and distorted plant growth.

The disorders occur of environmental restrictions too much or too little such as light, temperature, water, or wind. Sunburn is damage to foliage caused by too much light and heat and insufficient moisture. A yellow area develops on foliage, which dies between the veins. Frost damage causes shoots, buds and flowers to curl turn brown or black and die. Hailstones injure leaves and twigs, while chilling damage affects sensitive plants, leading to the development of dark, water-soaked spots on leaves. Physical and mechanical injuries occur mishandled during transport and cultural practices. Wounds might serve as entry sites for plant pathogens. Plants exposed to toxic levels of ethylene gas, damaged, decaying plants, and decaying fruit can experience issues as ethylene gas causes premature abscission of flower buds, petals, and leaves. The nursery plants by air pollutant gases such as ozone, carbon monoxide, nitrous oxides and sulfur dioxide can cause damage. Mutants in nursery beds such as Albino of seedlings, lack chlorophyll and quickly die. Sometimes plants exhibit sudden changes in colour producing markings of variegation, and new shoots such as a chimera as produce when a genetic mutation occurs. The Chimeras are often confused with nutritional or chemical disorders. "Chimera" is a term that describes a single plant with two genetically different tissue types. Sometimes variegation can be caused by viruses. Viruses usually cause non-uniform chlorosis, such as mosaics, while chimeras typically produce patterned forms, such as variegation of color on leaf margins, stripes, or complete loss of pigment. Diseases can affect plants at any stage of growth, making rapid and accurate diagnosis crucial for crop protection. Identifying the cause of a disease promptly enables effective management strategies to be implemented, helping to mitigate potential losses.

#### **Abiotic factors and Biotic cause**

The stresses divide plants into two categories: biotic and abiotic. Biotic stresses arise from interactions between different organisms, whereas abiotic stresses are influenced by the interactions between organisms and their physical environment. Abiotic stresses negatively impact growth and productivity, leading to various morphological, physiological, biochemical, and molecular changes in plants. (Fig. 1).

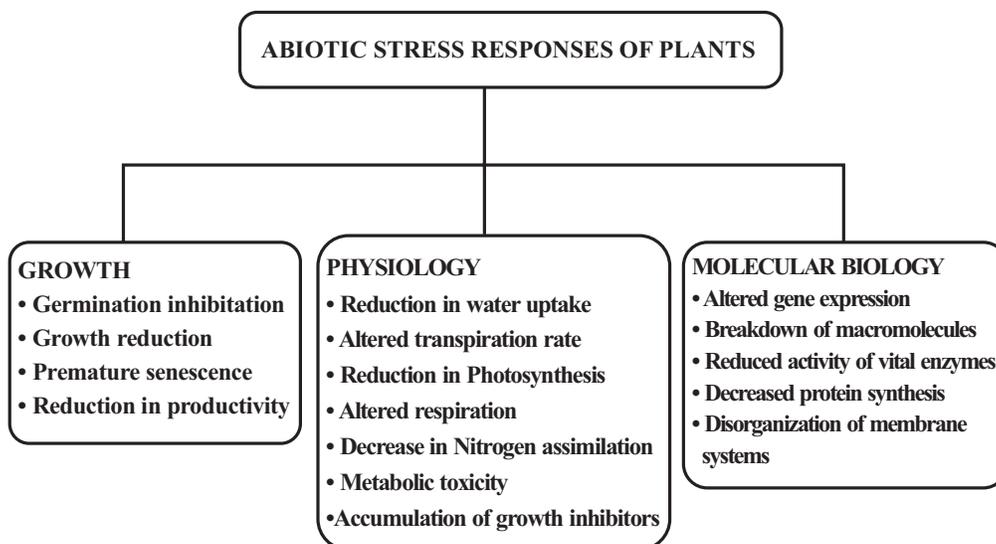


Fig. 1: Plants responses to abiotic stress

Abiotic stresses include potentially adverse effects of Salinity, Drought, Flooding, Metal toxicity, Nutrient deficiency, High temperature and Low, UV exposure, Air pollution, Wind, Hail and Gaseous

deficiency. In some cases, such as the supply of water in case of drought and flooding, both impose stress on plants. (Fig. 2).

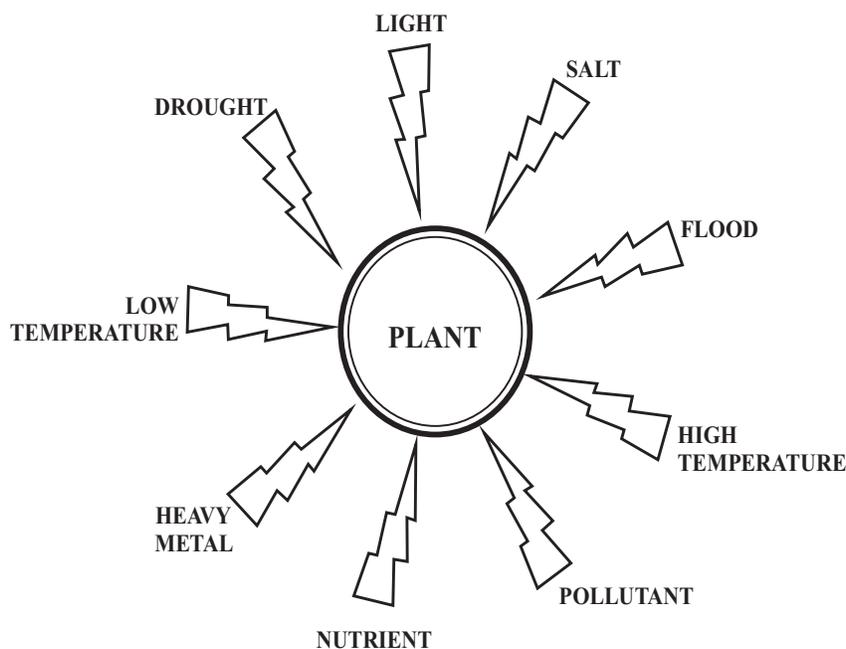


Fig. 2: Abiotic factors that cause disorder in plants

These diseases are caused by living organisms. Plant pathogens are organisms that infect plants. They can spread from one plant to another and can target various types of plant tissue, including leaves, shoots, stems, crowns, roots, tubers, fruit, seeds, and vascular tissues. Fungi, bacteria, phytoplasmas, viruses, viroids, nematodes, and parasitic higher plants are plant pathogens that cause diseases. Fungi are the most common causal

agent of plant disease. These microscopic organisms lack chlorophyll, visible threadlike filaments, and hypha that make up the mycelium. "Resting structures" include rhizomorphs and sclerotia. Fungi reproduce by spores and conspicuous fruiting bodies that aid in identification. These fruiting bodies are called the signs. Bacteria are single-celled organisms that lack chlorophyll and reproduce by cell division. Visual identification is

difficult; their physical characteristics by electron microscope, the virus consists of a small genetic material within a protein coat called a capsid. In advanced serological or genetic testing of plant sap is used to confirm diagnosis. Phytoplasmas are specialized bacteria that lack cell walls and are difficult to identify, only survive and reproduce in living plant tissue. They cannot be isolated and cultured in a laboratory; an electron microscope is needed to detect structures of phytoplasmas in the cells of the host. Nematodes are unsegmented, microscopic roundworms that generally have a threadlike form. A plant parasitic nematode has a needlelike stylet, which is a tube-like structure that can pierce plant cells to withdraw nutrients. Nematodes that live in the soil sometimes cause severe plant damage.

### (A) Abiotic diseases

Diseases caused by non-living things are more difficult to diagnose. The abiotic disorders are linked to non-living causal factors, including weather conditions, soil characteristics, chemical influences, mechanical injuries, cultural practices, and inherent genetic tendencies within the plant itself (Table 1). Abiotic disorders can arise from a single extreme environmental event, such as a severe cold night following a warm period, or from a complex interplay of various interrelated factors. They can also result from chronic conditions like drought, as well as existing site factors such as acidic or alkaline soil. Abiotic plant problems are occasionally referred to as “physiological disorders.” Abiotic stress factors impact plant growth and development, leading to a decline in the overall health and development of plants. Abiotic stresses usually reduce plant growth by slowing down photosynthesis. The primary metabolism of plants involves photosynthesis and related processes, respiration, sugars, and amino acid metabolism. Heat stress occurs when temperatures rise above a critical threshold for a duration long enough to cause permanent damage to plant growth and development<sup>42</sup>. Chilling stress by plants from 0 to 15°C causes major crop losses<sup>43</sup>.

**Table 1:** List of abiotic disorders of vegetable crops

S no.	Abiotic disorders	Cause of disorders
1	Edema of cabbage	Water excess (poor drainage)
2	Black or <b>hollow heart</b> of potato	Oxygen deficiency

S no.	Abiotic disorders	Cause of disorders
3	Greening of tubers	Exposure of tubers to sunlight
4	Sunscald of vegetables	High light intensity
5	Etiolation	Low light intensity
6	Chilling and freezing injuries	Low temperature
7	Catface	Low temperature
8	Potato freezing necrosis	Low temperature
9	Blindness of cauliflower	Low temperature
10	Puffiness of tomato	Various abiotic factors
11	Buttoning of cauliflower	Nitrogen deficiency
12	Blossom end rot of tomato	Calcium deficiency
13	Hollow stem (browning) of cauliflower	Boron deficiency
14	Pitting of pepper	Calcium deficiency
15	Whip-tail of cauliflower	Molybdenum deficiency
16	Foliage distortion and malformation of tomato	Herbicide injury
17	Hail injury of cabbage	By Hail storm
18	Lightning injury of cabbage	By lightning
19	Silver leaf	Peroxyacyl nitrates (PAN)

Abiotic diseases in tomatoes can arise from various factors, including nutrient deficiencies, temperature extremes, abnormal lighting, improper chemical applications, alterations in water uptake, mechanical damage, and genetic mutations. Flowers that dry and drop from stems without forming fruit are primarily caused by temperatures that are not suitable for effective pollination. Blossom drop can occur when daytime temperatures exceed 90°F and nighttime temperatures remain above 72°F. Excessive heat desiccates pollen, resulting in poor fruit set and dried blossoms that eventually drop. Blossom-end rot is a disorder caused by a lack of calcium in the fruit. Calcium is a nutrient that contributes to healthy cell walls, and when deficient, cell breakdown occurs, leaving water-soaked spots on the bottom of the fruit. Blossom-end rot can occur on other crops, including summer squash,

peppers, eggplant, and more. Blossom-end rot is most common during periods of intense heat or when irrigation management is less. The cat-facing refers to tomatoes that are generally distorted, misshapen, or dimpled. The damage usually results from injuries that cause the fruit's blossom scar to become enlarged. The damage by piercing-sucking insects' of tomato skin by piercing-sucking insects causes cat-facing symptoms. Cat-facing occurs when flowers are formed, and the symptoms can be observed on the fruit throughout the growing season.

Cracking and splitting in fruit occur due to changes in soil moisture. Cracking appears as vertical splits or a circular pattern on the top of the fruit, which can reduce fruit quality and increase susceptibility to rotting organisms. Cold injury occurs by exposure between 33°F and 50°F temperatures, in combination with other factors, causing damage to leaf tissue that reduced flower formation and fruit production. Freeze damage occurs when temperatures drop below 32°F, causing leaf, stem, and fruit tissue to freeze, expand, and rupture. Edema is identified by watery blisters that form along the leaf veins and typically occur on the undersides of leaves, edema is induced by high relative humidity, overwatering, and low light quality. Edema most commonly occurs during extended periods of cloudy and humid weather. Green shoulder of tomato fruit ripening disorder that appears, the top "shoulder" of the fruit remains green and yellow. It is caused by genetics in some susceptible cultivars and can also arise from environmental conditions, such as temperatures above 90°F or below 60°F, high humidity, and exposure to direct sunlight. Herbicides can damage plants either directly or indirectly through residues in the soil, leading to symptoms such as small misshaped leaves, thick and tightly curled stunted growth, and dieback. "Legginess" occurs in newly germinated seedlings when weak stems with long internodes develop due to little to no available light, causing the seedlings to stretch in an attempt to reach a light source. Nose development in tomato fruits is a genetic mutation, during early fruit development few cells divide incorrectly, forming an extra fruit locule. High temperatures during the night and day cause this mutation. A chimera is a genetic mutation characterized by foliage with distinct yellow and white patches, often leaf is delineated by veins, it is a genetic abnormality that occurs spontaneously.

Nitrogen is a macronutrient essential for plant growth and development. Symptoms of nitrogen deficiency are indicated by light green to yellow coloration, beginning on the lower, older foliage. Phosphorus is also a macronutrient necessary for plant growth and development. It is a component of adenosine triphosphate (ATP) that forms during photosynthesis and stimulates root development, stem strength, flower formation, seed production, and overall crop quality. Phosphorus deficiency is expressed by small, rigid leaf growth and erect, dark green leaves with purplish-red discoloration on the underside. Potassium is a macronutrient necessary for plant growth and development, as helps water movement and enzyme activation of plants, deficiency expressed on the leaf edges that veins remain green, and whitish, necrotic dots develop among the chlorotic areas. Iron is a micronutrient essential for plant growth and development, particularly in the synthesis of chlorophyll. It is also important for maintaining chloroplast structure and function. Iron deficiency manifests as interveinal chlorosis, with symptoms typically appearing first on the younger leaves of the plant. In high pH soils, iron becomes fixed in an insoluble form, making it unavailable to plant roots. Long-term standing water prevents absorbing of oxygen by roots and the chance of infection with soil-borne pathogens. Heavy rain, hail, and strong winds can damage vegetable crops, strong winds and hail can tear through foliage, removing leaves, and leaving the plant vulnerable to other problems such as sunburn to fruit or reduced photosynthesis. Upward curling or rolling of leaves can be caused by various factors, including herbicide application, virus infections, and environmental stresses. Additionally, physiological factors such as early planting, root damage, pruning, drought, heat, excess or deficiency of nutrients, and excessive moisture can also lead to this condition.

Sunscauld occurs on fruits when intensive sunlight damages the skin, leading to white or light-colored, blister-like spots. Both green and ripened fruits can be affected. Vivipary occurs when seeds sprout inside a ripe fruit and grow. It may cause over-ripening, deficiency and abundance of nutrients, which happens when the abscisic acid hormone reduces and the seed germinates in the fruit. Zippering is characterized by a thin, brown longitudinal scar that extends from the stem to the blossom end of the fruit, making it resemble a zipper. It occurs when the flower anther sticks to the developing fruit as it grows. A single fruit may

exhibit multiple scars; however, this does not impact the overall yields or the quality of consumption.

### Abiotic disorders management

Abiotic stress management is one of the most important challenges facing agriculture. Abiotic stress can persistently limit the choice of crops and agricultural production over large areas, and extreme events can lead to total crop failures. Crop tolerance to various abiotic stresses is achieved through the activation of specific defense mechanisms and biosynthetic pathways.<sup>44</sup> Plants respond with changes in their pattern of gene expression and protein synthesis when exposed to low temperatures.<sup>45</sup> Nutritional imbalances limit growth by reducing photosynthetic rate, as well as physiological and metabolic processes, which can be improved by application. The successful management of plant disease required regular monitoring of plants, and detects diseases early and selects available options to manage the diseases. The stress-responsive genes are expressed so that the plants can survive. The stress biotechnology research recently emphasizes the strength and stress-induced expression of transgenes, combined with the regulatory machinery involving transcription factors; it serves as a genetic manipulation tool for controlling the expression of many stress-responsive genes. Abiotic stresses adversely affect the livelihoods of individual farmers and their families as well as national economies and food security.

### (B) Biotic diseases

Plants are suffering from biotic stresses caused by different kinds of living organisms such as fungi, bacteria, viruses, nematodes, and phytoplasma. These biotic agents cause various types of diseases in agricultural crops and cause yield losses (Table 2). Typical fungal symptoms include seed rot, seedling blights, root and crown rots, vascular wilts, leaf spots, rusts, cankers, and stem and twig blights. Fungi produce specialized structures, such as spores and sclerotia for survival and dispersal. Bacteria cause tumours like galls, crown galls, common scabs, and foliar diseases caused by bacteria such as leaf lesions and blight soft rots. They are transmitted by wind-driven rain, insects, and the movement of infected plant parts and seeds. Typical viral symptoms include stunting and chlorosis, mottling, puckering, ring spotting, and mosaic patterns in leaves. These viruses often have wide host ranges, including weeds that are not related to the crops. Viruses are spread by infected seed or pollen, poor sanitation when handling or

pruning plants, or insect vectors such as aphids, leafhoppers, whiteflies, and thrips for transmission from plant to plant. Nematodes are microscopic roundworms. The root-knot nematode produces root galls on a wide range of crops. Phytoplasma symptoms in vegetables include yellows, witch's broom, little leaf, and phyllody, which are transmitted by leafhoppers.

**Table 2:** List of biotic diseases of vegetable crops

S. no	Biotic diseases	Caused of diseases
<b>(A) Fungus</b>		
1	Damping off	<i>Pythium spp.</i>
2	Powdery mildew	<i>Erysiphe spp.</i> , <i>Podosphaera sp.</i> , <i>Leveillula sp.</i>
3	Downy mildew	<i>Pseudoperonospora sp.</i> , <i>Hyaloperonospora sp.</i>
4	Gummy stem blight of cucurbits	<i>Didymella bryoniae</i>
5	Choanephora wet rot of cucurbits	<i>Choanephora cucurbitarum</i>
6	Fusarium wilt	<i>Fusarium oxysporum</i>
7	Alternaria leaf blight	<i>Alternaria spp.</i>
8	Anthracoise	<i>Colletotrichum spp.</i>
9	Late blight of potato	<i>Phytophthora infestans</i>
10	Early blight of potato	<i>Alternaria solani</i>
11	Cercospora leaf spot	<i>Cercospora spp.</i>
12	Verticillium wilt	<i>Verticillium spp.</i>
13	Phomopsis blight	<i>Phomopsis vexans</i>
14	Rust	<i>Puccinia sp.</i> , <i>Uromyces sp.</i>
15	White rust	<i>Albugo candida</i>
17	Rhizoctonia blight	<i>Rhizoctonia solani</i>
18	Sclerotinia blight	<i>Sclerotinia sclerotiorum</i>
19	Color rot	<i>Sclerotium rolfsii</i>
20	Charcoal rot	<i>Macrophomina phaseolina</i>
21	Wart disease of potato	<i>Synchytrium endobioticum</i>
22	Leaf mould of tomato	<i>Cladosporium fulvum</i>
<b>(B) Bacteria</b>		
1	Bacterial wilt of solanaceous crop	<i>Ralstonia solanacearum</i>
2	Bacterial wilt of cucurbitaceous crop	<i>Erwinia tracheiphila</i>
3	Black rot of cruciferous crops	<i>Xanthomonas campestris</i> sp. <i>campestris</i>
4	Bacterial leaf spot of chilli	<i>Xanthomonas campestris</i> sp. <i>vesicatoria</i>

5	Scab of potato	<i>Streptomyces scabies</i>
6	Brown rot of potato	<i>Ralstonia solanacearum</i>
7	Bacterial blight of beans	<i>Xanthomonas campestris</i> pv. <i>phaseoli</i>
8	Bacterial canker of tomao	<i>Corynebacterium</i> spp.

**(D) Nematodes**

1	Root-knot nematode	<i>Meloidogyne</i> spp.
2	Reniform nematode	<i>Rotylenchulus reniformis</i>
3	Cystnematode	<i>Heterodera</i> spp. and <i>Globodera</i> spp.
4	Stem Nematode	<i>Ditylenchus dipsaci</i>
5	Needle Nematode	<i>Longidorus elongatus</i>

**(C) Viruses**

1	Tomato spottedwilt virus
2	Tomato leaf curl
3	Chiilileafcurl virus
4	Common bean mosaic
5	Cucumber mosaic virus
6	Cauliflower mosaic virus
7	Yellow vein mosaic of okra
8	Mosaic of potato and tomato
9	Leaf roll of potato
10	Fern leaf of tomato

**(E) Phytoplasmas**

1	Little leaf of eggplant
2	Marginal flavescence of potato
3	Witch's broom of potato
4	Purple top roll of potato
5	Potato phyllody

**1. Solanaceous crops**

Solanaceous crops, including tomatoes, chillies, eggplants, and potatoes, are widely cultivated and economically important. However, they are susceptible to various diseases caused by pathogens that can significantly impact their yield and quality. Tomato crops suffering from fungal diseases viz., damping-off (*Pythium* spp), early blight (*Alternaria solani*), late blight (*Phytophthora infestans*), Septoria leaf spot (*Septoria lycopersici*), Fusarium Wilt

(*Fusarium oxysporum* f. sp. *lycopersici*), Powdery Mildew (*Leveillula taurica*), gray mould (*Botrytis cinerea*) buck eye rot (*Phytophthora parasitica*). Bacteria cause wilt (*Ralstonia solanacearum*), bacterial leaf spots (*Xanthomonas campestris* pv. *vesicatoria*), bacterial canker (*Clavibacter michiganensis* pv. *michiganensis*), Virus cause disease tomato mosaic, tomato spotted wilt, tomato leaf curl, phytoplasma caused tomato big bud and root-knot caused by *Meloidogyne* spp. Chilli crops suffering from fungal diseases such as damping off (*Pythium aphanidermatum*), Anthracnose (*Colletotrichum capsici*), wet rot (*Choanephora cucurbitarum*), Phytophthora blight (*Phytophthora capsici*), bacterial wilt (*Ralstonia solanacearum*), bacterial leaf spot (*Xanthomonas vesicatoria*), viral diseases as leaf curl virus, mosaic and root-knot nematodes (*Meloidogyne incognita*). Brinjal, also known as eggplant, can be susceptible to damping-off (*Pythium* spp., *Phytophthora* spp., *Rhizoctonia* spp.), phomopsis blight (*Phomopsis vexans*), Alternaria leaf spot (*Alternaria melongenae*), Cercospora leaf spot (*Cercospora melongenae*) Verticillium Wilt (*Verticillium dahlia*), Collar rot (*Sclerotium rolfsii*), Bacterial wilt (*Ralstonia solanacearum*), little leaf brinjal caused by a phytoplasma and virus caused tobacco mosaic. Nematode diseases root-knot caused by *Meloidogyne* spp. Potato crops are commonly affected by late blight (*Phytophthora infestans*), early blight (*Alternaria solani*), black scurf (*Rhizoctonia solani*), common scab (*Streptomyces scabies*) and Brown rot (*Ralstonia solanacearum*), Soft rot (*Erwinia carotovora* subsp. *carotovora*), viral disease potato Virus Y. Additionally, phytoplasma diseases pose a threat to potato crops, leading to distorted growth and reduced productivity, cyst nematode, specifically caused by *Globodera* spp., can damage roots and impair nutrient uptake. Black Heart is caused by a lack of oxygen during storage.

**2. Leguminous crops**

Bean crops are susceptible to various diseases caused by biotic agents such as Rust (*Uromyces phaseoli* typical), Anthracnose (*Colletotrichum lindemuthianum*). white mold or white rot (*Sclerotinia sclerotiorum*), Bacterial blight (*Xanthomonas phaseoli*), Bean common mosaic virus. Pea crops suffering from Fusarium wilt (*Fusarium oxysporum* f.sp. *pisi*), Powdery mildew: (*Erysiphe pisi*). Ascochyta blight (*Ascochyta pisi*). White mould (*Sclerotinia sclerotiorum*). *Pythium* seed and seedling rot (*Pythium ultimum*, *P. aphanidermatum*, *P. irregulare*, *P. debaryanum*) Rust *Uromyces fabae*) and other biotic diseases.

### 3. Cucurbitaceous crops

Cucurbits, belonging to the Cucurbitaceae family, include a variety of important vegetable crops such as ridge gourd, bitter melon, sponge gourd, pumpkin, and bottle gourd. These crops play a vital role in global agriculture and provide essential nutrients, making them a staple in many diets around the world. Several diseases caused by fungi, bacteria, nematodes, and viruses significantly affect cucurbit crops, leading to substantial losses in yield and quality. The disease can be transmitted by soil, seed, wind, or insect vectors. To manage diseases in crops, a combination of fungicides, bactericides, and insecticides is commonly employed. Effective disease control can be achieved through a variety of approaches, including cultural practices that improve plant health, biological methods that utilize natural predators or agents, and chemical treatments that directly target pathogens. Integrating these methods helps in achieving sustainable pest and disease management. Cucurbitaceous crops are vulnerable to several diseases, including Damping-Off of Seedlings (*Pythium*, *Rhizoctonia* and *Fusarium*), Scab (*Cladosporium cucumerinum*), Gummy Stem Blight (*Didyma llabryoniae*), Fusarium Wilt (*Fusarium oxysporum* f. sp. *niveum*, *Fusarium oxysporum* f. sp. *melonis* and *Fusarium oxysporum* f. sp. *Cucumerinum*), Anthracnose (*Colletotrichum orbiculare*), Powdery mildew caused by airborne fungus *Sphaerotheca fuliginea* and *Erysiphe cichoracearum*, Alternaria Blight (*Alternaria cucumerina* and *Alternaria alternata*), Downy mildew (*Pseudoperonospora cubensis*), Bacterial Wilt (*Erwinia tracheiphila*), Angular leaf spot (*Pseudomonas lachrymans*), root-knot nematode (*Meloidogyne* spp), Cercospora leaf spot (*Cercospora citrullina*). Cucurbits are susceptible to virus infection. Common viral diseases include cucumber mosaic virus (CMV), squash mosaic virus (SqMV), watermelon mosaic virus (WMV), zucchini yellow mosaic virus (ZYMV), and papaya ring spot virus (PRSV).

### 4. Cruciferous crops

Cruciferous vegetable crops (cabbage, cauliflower and knol-khol) suffering from diseases caused by fungi viz., Damping-off (*Pythium* spp.), Alternaria Blight (*Alternaria* spp.), white Rust (*Albugo candida*) downy mildew (*Hyloperonospora parasitica*), wire stem (*Rhizoctonia solani*), black leg (*Phoma lingam*), black spot (*Alternaria* sp.) club root (*Plasmodiophora brassicae*), powdery mildew (*Erysiphe polygoni*), by bacteria such as black rot (*Xanthomonas campestris* pv. *campestris*), root-knot nematode (*Meloidogyne* spp) caused by nematodes.

### 5. Okra crop

Okra (*Abelmoschus esculentus* L. Moench), belonging to the Malvaceae family, is known as lady's fingers. Crops can suffer from diseases caused by fungi such as Cercospora leaf spot, which is attributed to *Cercospora abelmoschi* and *C. malayensis*. Symptoms of *C. abelmoschi* include the absence of definite spots but the presence of a sooty black mold on the lower surface of the leaves. In contrast, *C. malayensis* produces irregular brown spots with a grey center and dark margins. Powdery mildew (*Erysiphe cichoracearum*) produce characterized by grey-coloured powdery growth on both the upper and lower surface of the leaves. Root-knot (*Meloidogyne incognita* and *M. javanica*) nematode invasion from root rot cause the formation of knots or galls in the root a characteristic symptom caused by the nematode. Viruses can cause diseases such as Yellow Vein Mosaic Virus and Enation Leaf Curl Virus, both of which can significantly affect the health and yield of crops.

#### Biotic diseases management

Pathogens can attack one member of a plant family and subsequently infect other members of the same family. Many biotic stresses can be effectively managed by improving their habitat using various technologies, including trap crops, cover crops, multiple cropping systems, flowering plants, mulching, and push-pull technology. The common methods of disease management of crops are using healthy seeds, seedlings and resistant varieties, and cultural, and chemical practices for minimizing vegetable diseases. Disease-resistant varieties are an effective, safe, and relatively inexpensive method of control of many crop diseases. The best practices to apply biological controls agent in disease management, green manuring and application of selective chemicals. Biological control involves utilizing organisms known as antagonists, which naturally occur within the host's environment. These antagonists help manage pest populations and diseases by promoting a balanced ecosystem. Cultural practices favour naturally occurring antagonists and exploit beneficial action and are effective in reducing diseases, few antagonists developed for use in plant-disease control. Sanitation is crucial because nematodes can be easily spread through infested soil or plant material. Proper sanitation practices help prevent the spread of these pests and protect plant health. Soil-borne nematodes can be killed by applying granular or liquid nematicides. Bacterial genera such as *Pasteuria*, *Bacillus*, and *Pseudomonas* show potential as biocontrol agents

for managing plant-parasitic nematodes. These beneficial bacteria can help suppress nematode populations and promote healthier crop growth. Plant growth-promoting rhizobacteria (PGPR) have been reported to be effective against plant-parasitic nematodes while also enhancing plant growth.<sup>46</sup> The members of Cruciferae crops such as Indian mustard, cabbage, cauliflower, and radish were used as biofumigants. Sorghum, marigold, and neem also be used as biofumigants.<sup>47</sup> They produce glucosinolates, which degrade in the presence of myrosinase to release isothiocyanates. These compounds are known to effectively kill plant-parasitic nematodes.<sup>48</sup> A range of chemicals is available to control diseases by inhibiting the growth and killing the causing pathogens, as applied to seeds, foliage, flowers, fruit, and soil to prevent infections. Bacterial diseases are difficult to manage because of few chemical controls such as antibiotics, and often develop resistance. The applications of copper compounds, antibiotics: streptomycin, oxytetracycline may suppress plant pathogenic bacteria. The diseases caused by phytoplasma have no cure; only the removal of the infected plants and nearby weedy hosts, along with control of leaf hoppers and other insect vectors, can be effective. Phytoplasmas are susceptible to certain antibiotics such as tetracycline. Cycloheximides are effective to control certain diseases caused by fungi. The fungicides are generally used in crop protection belonging to the groups of organic sulphur compounds (Thiocarbamates) and copper compounds, Quinones, benzene compounds, heterocyclic nitrogen compounds, systemic fungicides such as oxathiins, benzimidazoles, and pyrimidines, organophosphate, sterol biosynthetic inhibitors for seed treatment and foliar spray. All fungicides are excellent coverage of plant tissue and the most fungicides should be reapplied when residues are no longer. Eliminate the organisms from the soil before planting, and apply chemicals before diseases appear or as the disease is detected to reduce the severity and spread of the disease. Integration of chemicals and biotic agents along with resistance for managing plant disease has been considered a novel approach.<sup>49</sup> They control root-rot fungi by amending soil, planting material with fungicides, crop rotation with non-hosts, and use of resistant cultivars.<sup>50</sup> In weed management practices using plastic for mulch, selective herbicides, hand weeding, and tillage, weeds may be a host of diseases. There is no cure for viral diseases; the virus causes severe symptoms that can spread to nearby plants of the same species, and the infected plants should be destroyed. Most viruses are transmitted

by insects; the use of insecticides is usually ineffective for virus control, weed control around the boundary of the field can help control certain viruses. Irrigating crops at times and maintaining crop cleanliness and avoiding the movement of water from infected plants to healthy plants and other preventative measures should be used for the management. Drip irrigation minimizes pathogen spread within a field. The vegetables are planted on raised beds to allow for drainage of excess water from the root zone. Saturated soil favours some root rot fungi. The cultural practices aimed at reducing the risk of developing diseases of crops. The application of K reduced the infection of obligate and facultative parasites.<sup>51</sup> The Si is known for improving plant tolerance to many biotic and abiotic stresses; the Poaceae family plants were very good Si accumulators, followed by Cucurbitaceae and some of the Solanaceae.<sup>52</sup> Abiotic stress conditions, namely drought, temperature, nutrient deficiency, and salinity, are known to influence the occurrence and spread of pests and diseases.<sup>53</sup> Genetics is used to manipulate genetic material in order to produce a new characteristic in an organism. The pathogen resistant transgenic plants; certain genes are inserted into the plant's genome that confer resistance to such pathogens as viruses, and fungi.

Induced resistance is a technique that is widely accepted as an effective disease management strategy. It is an alternative approach to chemical pesticides in controlling plant diseases that boosts the host's natural defense array. Induced systemic resistance (ISR) in plants is an important defense mechanism against pathogens. It involves complex signaling pathways that activate the plant's immune response, providing a way to protect crops and manage diseases effectively. Interactions between plants and pathogens lead to compatible response or incompatible response, these responses comprise an oxidative burst<sup>54</sup>, which lead to cell death and the pathogen 'trapped' in dead cells and prevented from spreading from the site of the initial infection.<sup>55</sup> Salicylic acid plays a crucial role in the signaling pathways that lead to the development of systemic acquired resistance (SAR) in plants.<sup>56-59</sup> Induced systemic resistance (ISR) is often mediated by the plant hormones jasmonic acid (JA) and ethylene (ET).<sup>60</sup> Before induced systemic resistance (ISR) occurs, the endogenous levels of salicylic acid (SA) increase both locally and systemically within the plant. This rise in SA levels is particularly evident in the phloem, where it plays a key role in signaling the plant's defense mechanisms<sup>61,62</sup> as the mechanism of some *Trichoderma* strains recently discovered. PGPR is known to start the ISR in plants

against various stresses<sup>63,64</sup>. *Trichoderma harzianum* T39 was found to induce resistance against downy mildew in grapevine by priming<sup>65</sup>. Plant growth-promoting rhizobacteria (PGPR) have gained recognition in agriculture for their beneficial effects on plant growth and health. These microorganisms can enhance seedling emergence, increase plant weight, and improve overall crop yield<sup>66-68</sup>. The local and systemic defense responses triggered by microorganisms involve a signaling network in plant hormones such as salicylic acid (SA), jasmonic acid (JA), and ethylene (ET). These pathways are known to communicate with each other, enhancing the plant's ability to respond to threats<sup>69</sup>. Systemic acquired resistance (SAR) triggered by necrosis-inducing pathogens is dependent on salicylic acid (SA) signaling<sup>70</sup> while induced systemic resistance (ISR) triggered by beneficial rhizobacteria typically relies on the jasmonic acid (JA) and ethylene (ET) signaling pathways, it plays a crucial role in enhancing the plant's defense mechanisms against pathogens<sup>71</sup>.

## CONCLUSION

Diagnosing diseases in plants can indeed be challenging, especially when it comes to distinguishing between biotic diseases (caused by pathogens like fungi, bacteria, or viruses) and abiotic disorders (resulting from non-living environmental factors). A clear understanding of both types is essential for effective management. The causal agents of plant diseases are indeed classified as biotic or living organisms, commonly referred to as pathogens. These include a variety of entities such as fungi, bacteria, viruses, and nematodes. Abiotic disorders in plants arise from nonliving environmental factors, and recognizing the distinction between these and biotic influences is crucial for accurately diagnosing the cause of plant injury. The plant shows symptoms of abnormal growth caused by both abiotic and biotic as considered. The plant health problem needs accurate diagnosis, for recommendation disease management. Abiotic stressors can lead to various symptoms in plants that resemble those caused by diseases from biotic agents. A plant exhibiting necrotic leaf margins is often assumed to be suffering from a fungal blight; however, the underlying cause may actually be abiotic. Identifying the cause of plant issues is crucial for effective management. In general, infectious diseases tend to have a narrow host range, often affecting a specific species, genus, or family of plants. In contrast, abiotic disorders can

cause similar symptoms across unrelated species. Abiotic stressors can significantly influence plant susceptibility to pathogens and are often linked to various biotic diseases in crops. Diagnosing problems related to abiotic and biotic injuries in plants requires careful observation and analysis. Plant problems if not recognized and controlled early in their development, result in significant economic damage. Therefore, timely and accurate diagnoses are required to appropriate disease management.

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