

ABIOTIC DISORDERS OF CULTIVATED CROPS

Abstract

Abiotic disorders are linked with non-living causal factors as a result of one or more factors *viz.*, space for root growth, presence of air, water pollutants, temperature, drought, salinity, mineral toxicity, presence of moisture, heat, light, soil pH, and nutrients are limiting plant growth and productivity worldwide and can spread from plant to plant. Crops are continuously threatened by abiotic stresses to world agriculture productivity. Abiotic disorders can reduce plant health, even kill plants, and affect farmers' livelihoods, national economies and food security. Abiotic diseases don't show the presence of disease signs, and it is difficult to diagnose as it's a necessary step in managing the diseases. The damage caused by abiotic factors is very similar to that caused by biotic agents. Abiotic stresses change the interactions and enhance host plant susceptibility to pathogenic organisms. Plants defend against abiotic stress in their roots, reactive oxygen species and stress hormones interacting with signaling pathways. The abscisic acid hormone is involved in many abiotic stresses. The crop yield reduces gradually due to various factors and necessary to diagnose the factors in crops that cause disorders for management and enhance their productivity.

Keywords: abiotic factors, disorders, diagnosis, management.

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I. INTRODUCTION

The stresses are affecting the plant's growth and leading to major scarcity in the production of agriculture worldwide (Shinwari et al. 1998). Plant stress depends upon the living or nonliving factors, so the stress factors divide into biotic (living) stress and abiotic (nonliving) stress (Bechtold and Field 2018). Abiotic and biotic stresses affect plant growth and yield (Suzuki et al. 2014; Ramegowda and Senthil 2015). Drought, cold, salt, and heavy metals are affecting crop growth and yield. Drought affects the three stages of plants such as vegetative growth, pre-anthesis and lethal phase (Shavrukov et al. 2017). Abiotic stresses such as salinity and drought in semi-arid tropical regions affect the crop (Cairns et al. 2012). Abiotic stresses *viz.*, drought and heat have been shown to be more injurious to crops (Mittler 2006). Abiotic stress such as drought, high and low temperature and salinity are known to influence the incidence and spread of insects, pathogens and weeds (Coakley et al. 1999). Plants sustain themselves against various environmental factors (Andjelkovic 2018). Abiotic stresses are nonliving factors influencing plants' metabolism, growth, and development (Dresselhaus and Hückelhoven 2018; Hasanuzzaman et al. 2020). Abiotic stresses such as extreme hot and cold temperatures, drought, salinity, mineral availability and toxicity are the major abiotic stress to plants (Sharma et al. 2019; Gull et al. 2019). Physiological processes of plants affected by temperature such as photosynthesis, respiration, permeability, transpiration, enzyme activity, water and nutrient absorption and denaturation of proteins. Low temperatures may kill the young roots and tree bark to split allowing cankering development. Low-temperature occur formation of ice crystals inside plant cells and chilling injury in a wide range of crops. High temperature affects seed germination, growth and development which cause drought that leads to the death of plants (Takahashi et al. 2013). High temperatures cause Protein damage, interrupt protein synthesis, inactivate enzymes, and damage cell membranes affecting the cell division process (Smertenko et al. 1997). Plants show a variety of responses to high temperature *viz.*, seedlings stem girdling due to soil scorching of young stem tissue by radiating heat, above the injured zone swells and formed heat canker. Cold stress causes injury by changes in the membrane structure of plants, reduce protoplasmic streaming, leakage and plasmolysis, changed metabolism, reduced plant growth, irregular ripening of fruits, internal discoloration (vascular browning), and increased susceptibility to cause the death of the plants (Devasirvatham and Tan 2018). Salt increased in soil cause salinity of soil (Bockheim and Gennadiyev 2000). In drought, farmers try irrigation, which adds more salts to the soil causing salinity (Enebe and Babalola, 2018). Under adverse conditions *viz.*, drought, flood, high winds, frost, hail, snow and lightning damage plants and pathogens access for infection. Abiotic stresses cannot be prevented, such as drought, salinity, cold, heat, metal, etc. Plant reactions to abiotic stress are active and complex (Cramer et al. 2011). Abiotic stresses such as water scarcity, high salinity, extreme temperature, droughts, stagnation, mineral deficiency and metal toxicities reduce the crop's productivity. Climate change threatens food security, which effect directly the agricultural output. Abiotic stress changes the growth of plants as well as stress-related phytohormones that affect the normal functioning of plants. Toxins are also considered stress to the plant tissues in response to abiotic factors (Nadarajah 2020). Abiotic stress influences plants at molecular levels from morphological levels that are visible in all phases of plant development (Fahad et al. 2017). The abiotic factors have negatively impacted crop yields and breed-resistant plant varieties that sustain against abiotic factors (Dresselhaus and Hückelhoven 2018). These stresses on the plants influence their growth and development, several types of plant metabolism get triggered by stresses, such as the altered expression of the inherited genes, metabolism of the cells, and changing patterns of growth and crop yields

(Bechtold and Field 2018). Abiotic stress has adverse effects on crop morphological, biochemistry and physiology that are directly related to the growth and yield of plants. The abiotic factors such as temperature, water, salts, essential nutrients, and pH that influence plant growth in an agricultural ecosystem. The high pH (alkaline) reduces the availability of essential macro and micronutrients *viz.*, phosphorus, manganese, zinc, copper, and iron in soils, causing nutrient deficiency and osmotic imbalance (Chen et al. 2011). Water is a vital element of plants and essential for the transportation of nutrients. Under stresses environmental condition various physiological, molecular, and biochemical changes of plants, that influence on the development and growth. Water deficit, salt stress, imbalances in nutrients (toxicity and deficiencies) and temperature are significant limitations on the productivity of crops (Fahad et al. 2017). The deficiency of water leads to drought, which reduces plant vitality (Ashkavand et al. 2018). Under drought conditions plant cell elongation decreases due to a decrease in turgor pressure (Shaheen et al. 2016). Abiotic diseases are the result of genetic changes that occur in the meristematic cells that cannot be transmitted from affected plants to healthy plants. Climate change reduced cultivated lands, draining soil nutrition, less sensitivity to agrochemicals and environmental degradation (Shinwari et al., 1998a). It is essential to find safe and ecologically viable solutions for sustainable agriculture (Kumar and Verma 2018). Plant physiological reactions to stress include wilting of the leaf, abscission of the leaf, decreased leaf region and water loss through transpiration (Fghire et al. 2015). Abiotic stress influences the plant-pathogen interaction both positively and negatively, thereby enhancing and decreasing the severity of the disease. Fusarium pathogens exist in the soil more severely under drought conditions.

II. DIAGNOSIS

Diagnosis is the identification of the cause of the agent. The symptoms caused by biotic and abiotic problems are common such as leaf spots, chlorosis, blights, defoliation wilting, stunting and plant death. Soil and root analysis is required to confirm the diagnosis and management of diseases. The diseases of plant required careful examination of the specimen. Plants shown weaken of defence mechanisms and enhance their susceptibility to pathogen infection under abiotic stress. Plants show a reduction in shoot growth, leaf size, leaf chlorosis, necrosis and dieback during nutrient deficiencies and toxicities. Carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium magnesium and sulphur are macro nutrients and iron, zinc, manganese, copper, boron, molybdenum and chlorine are essential and needed in relatively small amounts for plant growth known as micro-nutrients. Cobalt is essential for legumes and non-legume crops in nitrogen fixation. Plants are damaged during the deficiencies or excesses of these elements. Nutrient deficiencies diagnosis is difficult on the symptoms basis alone since plant can produce similar symptoms by another factor also. The deficiencies are usually confirmed by leaf tissue and soil sample analysis. Soil acidity or alkalinity is influences the availability of nutrients between 5.5 and 6.5pH, below and above this range some nutrient elements may toxic. Abiotic affects plants of various ages, in connection to the environment, physical factors and cultural practices; relatively uniform and damage appears similar plants, with no evidence of the pathogens to cause the symptoms, and not infectious commonly. It does not spread and is possibly associated with environmental conditions or cultural practices. The disorders occur by light, temperature, water or wind under environmental limits in too much or too little. Sunburn is damage to foliage caused by too much light and heat and insufficient moisture. A yellow area develops on foliage, between the veins which dies. The frost damage the plant part such as shoots, buds, and flowers to curl turn brown or black and die. Hailstones injure leaves, and

twigs, and chilling damage sensitive plants and develop dark water-soaked spots on leaves. Physical and mechanical injuries occur during transport and cultural practices by mishandling. Plants exposed to ethylene gas, damaged, decaying, plants; and decaying fruit, ethylene gas cause premature abscission of flower buds, petals and leaves. The air pollutant gases viz., ozone, carbon monoxide, nitrous oxide and sulfur dioxide can cause damage nursery plants. 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 produced when a genetic mutation occurs. "Chimera" is a single plant with two genetically different tissue types and is often confused with nutritional or chemical disorders. Viruses generally cause non-uniform chlorosis such as mosaic, and chimaeras usually produce patterned forms such as variegation of colour on leaf margins, stripes or complete loss of pigment sometimes variegation caused by viruses. Diseases occur at any stage during the course of plant growth, and the rapid and accurate diagnosis cause of a disease is essential to the protection of the crop. Herbicides control weeds in crops, and their mode of action can determine the symptoms. The herbicides are growth regulators, photosynthetic inhibitors and enzyme inhibitors viz., 2, 4-D is a growth regulator and glyphosate enzyme inhibitors. Flower petals are more susceptible to pesticides than leaves, but younger and tender leaves are more susceptible, active ingredients of pesticides adversely affect the photosynthetic mechanism and physiological processes that cause leaf chlorosis, interveinal chlorosis, and leaf curling and stunting, soil drenches leaf curling and stunting, soil drenches can cause poor germination, seedling death, and distorted plant growth.

III. ABIOTIC FACTORS

Abiotic stresses affect the growth, and productivity of crops, that cause morphological, physiological, biochemical and molecular changes in plants. Abiotic stresses such as salinity, drought, flooding, metal toxicity, nutrient deficiency, high and low temperature, UV exposure, air pollution, wind, hail and gaseous deficiency cause adverse effects on plants. In some cases, the supply of water in drought and flooding, both impose stress on plants (Figure 1).

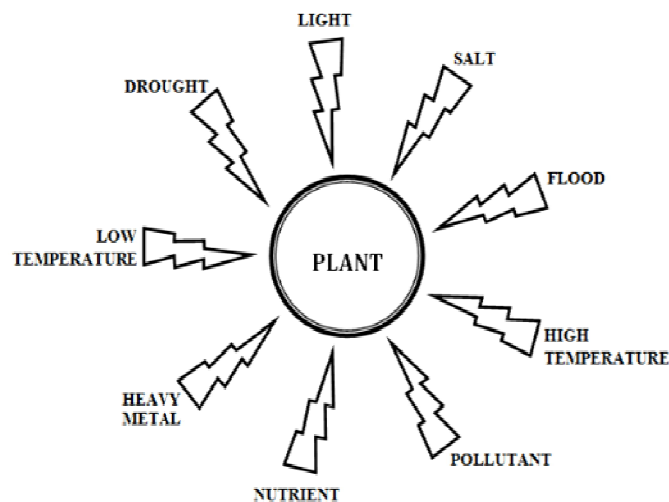


Figure 1: Abiotic factors that cause disorder in plants

IV. ABIOTIC DISORDERS

Biotic plant diseases are more difficult to diagnose, sometimes termed “physiological disorders”. The abiotic disorders are associated with non-living factors viz., weather, soils, chemicals, mechanical injuries, cultural practices and genetic tendencies within the plant itself (Table 1). Abiotic disorders are caused by a single incident such as a night severe cold following a warm complex of interrelated factors. They can be caused by chronic conditions such as drought, acid and alkaline soil. Abiotic factors affect plant growth and development by slowing down photosynthesis and leading to a decline overall development of plants. The primary metabolism such as photosynthesis processes, respiration, sugars, and amino acid metabolism affected by abiotic factors. Heat rises in temperature beyond a threshold level to cause permanent damage to plant growth and development (Hasanuzzaman et al. 2013). Chilling stress from 0 to 15°C to plants causes major crop losses (Yadav 2010). The diseases occur through abiotic factors viz., extreme temperature, abnormal lighting, nutrient deficiencies, chemical application, mechanical damage, changes in water uptake and genetic mutations. Temperatures are responsible for flowers drying and dropping from stems and no fruit formation. The daytime temperatures are above 90°F and night time temperature above 72°F blossom drop. Excessive heat shrivel pollen, subsequent in poor fruit set and dried blossoms finally dropping. The lack of calcium in the fruits caused blossom-end rot disorder. Calcium contributes to healthy cell walls, deficiency causes cell breakdown and water-soaked spots on the bottom of the fruits occur. Blossom–end rot occurs in other crops also such as summer squash, peppers, eggplants etc. The most common of blossom-end rot during intense heat and less irrigation of the crops. The cat-facing of tomatoes fruits are generally distorted, malformed or dimpled. The damage resulting from injuries causes the fruits blossom scar to become enlarged. The damage caused by piercing-sucking insects on tomato skin causes cat-facing symptoms. Generally cat-facing occurs when the flowers are formed, and fruit symptoms occur throughout the season.

Cracking and splitting occur in vertical splits or circular patterns on the top of the fruit due to changes in soil moisture, reducing fruit quality and susceptibility to rotting organisms. Cold injury occurs by exposure from 33° to 50°F temperatures, causing damage to leaf tissue that reduces flower formation and fruit production. Temperatures below 32°F causing freeze injure leaf, stem and fruits tissue freeze, enlarge and rupture. Edema is a watery blister down the leaf veins and occurs on the undersides of leaves, cause by high relative humidity, over watering and low light quality. Edema most occurs during continued cloudy and humid weather. The green shoulder of the tomato is a ripening disorder of the fruit the top remains green and yellow appears. It is caused by genetics, in susceptible cultivars and environmental conditions viz., temperature above 90°F or below 60°F, high humidity, and direct sunlight. Herbicides damage the plant by residues in soil, such as small misshaped leaves, thick, curled stunted growth, and dieback. Newly germinated seedlings occurs “Legginess” by weak stems with long internodes caused by little to no light available, seedlings stretch to reach a light source. Tomato fruits development nose during early fruit development few cells divide mistakenly, forming an extra fruit locule is a genetic mutation. During the night and day high temperatures cause mutation. A chimera is characterized by foliage with distinct yellow and white patches that are delineated by veins; it is a genetic abnormality that occurs spontaneously.

Nitrogen is a macronutrient for the growth and development of plants; deficiency symptoms appear light green to yellow colouration starting on the lower older leaves. Phosphorus is also macronutrients for the plant growth and development as a component of adenosine triphosphate (ATP) the forms during photosynthesis and stimulates root development, stem strength, flower formation, seed production, and crop quality. Phosphorus deficiency appears as a small rigid leaf, erect and dark green, purplish-red discolouration on the underside of leaves. Potassium is a macronutrient for the development of plant growth, and helps water movement and enzyme activation, deficiency appears on the leaf edges as veins remain green, whitish, necrotic dots develop between the chlorotic areas. Iron is a micronutrient for plant growth and development, synthesis of chlorophyll, important for maintaining chloroplast structure and function. Iron deficiency causes inter-veinal chlorosis, first appearing on the plant's younger leaves. Iron fixed insoluble form at high pH of soils, and unavailable to plant roots. Long-term standing water prevents oxygen absorption by roots and the chance of infection with soil-borne pathogens. Heavy rain, hail and strong winds can damage the foliage, removing leaves and leaving the plant vulnerable such as sunburn to fruit or reduced photosynthesis. Herbicide, virus infection, and environmental stress cause upward curling or rolling, it is also caused by physiological factors viz., early planting, pruning, drought, root damage, heat, excess or lack of nutrients, and extreme moisture.

Sunscald occurs on fruits when intensive sunlight damages the skin, blister-like spots, and green and ripened fruits can be affected. In vivipary condition seeds sprout inside ripe fruit and grow, it causes over-ripening, deficiency and abundance of nutrients, and happens when abscisic acid hormone reduces and the seed germinates in the fruit. Zippering occurs as thin, brown longitudinal scars appear and extending from the stem to the blossom end of the fruit, like a zipper. It happens when the anther of flower sticks to the developing fruit and grows. Multiple scars can be seen on a single fruit, but it does not affect yield and consumption quality.

Table 1: List of Abiotic Disorders of Crops

Sl No.	Abiotic disorders	Cause of disorders
1	Edema of cabbage, Splitting and water injury of citrus	Water excess (poor drainage)
2	Black or hollow heart of potato	Oxygen deficiency
3	Greening of tubers	Exposure of tubers to sunlight
4	Sunscalds of vegetables, sunburn	High light intensity
5	Etiolation	Low light intensity
6	Chilling and freezing injuries, Catface, Potato freezing necrosis, Blindness of cauliflower,	Low temperature
7	Water core of apple, Tip burn of leaf, Scorch of leaf	High temperature
8	Puffiness of tomato	Various abiotic factors
9	Crinkle leaf disease in cotton,	High concentration of manganese
10	The buttoning of cauliflower, Pansukh/tip burn disease of paddy	Nitrogen deficiency
11	Tip burn and marginal necrosis of mango	Phosphorus deficiency

12	Tip drying of onion, Spongles of bidi tobacco, Marginal chlorosis of plum leaves	Potassium deficiency
13	Blossom end rot of tomato, Pitting of pepper, Blossom-end-rot of grape berries	Calcium deficiency
	Pahala blight of sugarcane, Top yellowing of gram	Manganese deficiency
13	Hollow stem (browning) of cauliflower, Black tip of mango	Boron deficiency
14	Khaira disease of rice	Zinc 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)

V. DISORDERS MANAGEMENT

Abiotic stress is one of the most important challenges in agriculture management. It adversely affects the livelihoods of individual farmers and their families, national economies and food security. Crop tolerance to various abiotic stresses, and defends themselves by activation of defense mechanisms through biosynthetic pathways (Caretto et al. 2015). Stress is the strong pressure that affects the normal life functions in plants and prevents them from expressing their genetic potential for growth, development and reproduction (Levitt 1980). The abiotic stress cannot be mitigated by the plants, plants develop mechanisms in their inner metabolism to balance the adverse effects created by the external environment (Sharma et al. 2019). Such strategies adapted for mitigation of plants to overcome abiotic stress (Sharma et al. 2019). The induction of the stress-responsive genes of plants more tolerant and they can survive against such hazards and it is essential to identification of targeted genes and their mechanism as depends upon gene regulations (Zhang et al. 2021). Oxidative stress increases the stress tolerance factors of the plants in long-term sustainability in adverse conditions (Zhang et al. 2021). The close connection of abscisic acid (ABA) with SA and JA/ET-mediated defense signaling of plant pathogen interaction in the field, abiotic stress leads to ABA accumulation and likely to suppress diseases (Sivakumaran et al. 2016). Abscisic acid increases in plants cause susceptibility to the bacterial and fungal pathogens, and their inhibition increases plant defense signaling against pathogens (Audenaert et al. 2002; Mohr and Cahill 2003; Anderson et al. 2004; Asselbergh et al. 2007). Abscisic acid generally antagonizes SA and JA/ET defense signaling thus interfering with plant (Ton et al. 2009; Lievens et al. 2017). In plants respond with changes in patterns of gene expression and protein synthesis when exposed to low temperatures (Sanghera et al. 2011). The stress-responsive genes are expressed so the plants can survive. The successful management of plant disease requires regular monitoring of plants for early detection of diseases and selecting available options to manage the diseases. Nutritional imbalances limit growth by reducing photosynthetic rate, and physiological and metabolic processes which can be improved by application. The biotechnology research recently highlighted on strength that stress-induced expression of the transgenes, combination with the regulatory machinery that involving transcription factors, Biotechnology research is a tool for controlling the expression of stress-responsive genes by genetic manipulation.

VI. CONCLUSION

The plant health problem needs accurate diagnosis, for recommendation disease management. Abiotic stressors symptoms in plants are similar to diseases caused by biotic agents. Abiotic stress influences plants to pathogens and is linked to several biotic diseases in crops, understanding of abiotic disorders for managing overall plant health. The differences in the plant symptoms are difficult between biotic disease and abiotic disorder for effective management. Abiotic disorders are caused by nonliving factors, the understanding the difference is vital to diagnosing the cause of plant injury. Identifying the cause and understanding the climate, soil type, and management practices is important. The diagnosis of problems can suggest mitigation of abiotic injuries as they occur. The timely and accurately recognized plant problems help in the early management of developing diseases.

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