Effect of Abiotic Stress and it's Mitigation Strategies in Wheat

Jaimin N. Patel[1*], Pradip M. Sindha[2], Mit A. Patel[3]

[1,2]Department of Agronomy, College of agriculture, Navsari Agricultural University, Campus Bharuch – 392012

[3]Department of Plant Pathology, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agriculture University, Dantiwada – 385506

*Corresponding Author

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Abstract— *India's staple grain is wheat, which is cultivated in the majority of the nation in the winter. The earlier investigations and studies on the impact of abiotic stress on wheat are covered in this succinct analytical piece. Numerous alterations in plant metabolism are brought about by various abiotic stressors and many of these modifications overlap with one another. Low yields are the result of crop growth being hindered by metabolic changes brought on by stress. Abiotic stressors have also been found to be a significant role in yield loss, productivity decline and net profit shrinkage in long-term studies carried out by different researchers in different locations. As a result abiotic stress such as Heat, drought, salinity, water logging and Heavy metal most be effectively mitigate through management practices such as stress resistance cultivars, irrigation scheduling, tillage and planting choices, residue management, sowing time and integrated nutrient management to preserve natural resources while minimizing the negative effects and ensuring long term wheat output*.

Keywords— Wheat, Abiotic stresses, Heat stress, Salinity, Waterlogging, Drought, Mitigation Strategies.

I. INTRODUCTION

Wheat (*Triticum aestivum* L.) is a cereal crop grown on large area worldwide in a number of agro ecologies. Due to its economic and social benefits, it is widely grown in Asia, particularly in China, India and Nepal. Wheat production in India has progressively scaled new heights over the years with phenomenal increase in area, production and productivity. Globally, wheat is grown on 221.85 million hectares area with annual production around 785.12 million MT [1]. Wheat is called as the "King of cereals" because of its large cultivation in area, economic importance and potential for high productivity. Wheat is used to prepare pasta, pastry, semolina, chapatti and cookies among other items. It is a major staple food that accounts for approximately 35% of all food eaten by the world's population. In India, wheat is cultivated across five agro-climatic zones covering an area of about 29.8 million hectares with annual production of 110.59 million MT [1] and holds second position in wheat production worldwide. To provide food security for its growing population, the country has to produce 140 MT wheat by 2050 with productivity of 4.7 MT ha^{-1} [2].

Despite the fact that wheat has the highest total harvested area (38.8%) among cereals (including rice and maize), its total productivity is the lowest. Various factors such as biotic and abiotic stresses are responsible for the majority of wheat production losses. Biotic stress in wheat contains a number of pathogenic fungi and viruses that causes root diseases. Abiotic stresses, which include low or high temperature, inadequate or excessive water, high salinity, heavy metals and ultra-violet radiation, are all detrimental to wheat posing a significant threat to agriculture and the environment and responsible for substantial crop yield loss. Abiotic stress decreases productivity by 50% in most agriculturally valuable plants, including wheat [3]. Even though over 95% of India's wheat crop is irrigated, large portions of the country experience water shortages as a result of limitations on the amount of water available, especially during crucial periods of plant growth. Since the remaining wheat is dependent on rainfall, it is particularly susceptible to water stress, which lowers output and productivity. Although 21 to 24 degrees Celsius are thought to be the most ideal temperature range for wheat plant growth and development, the actual temperature range may differ based on the local agro climatic conditions. The whole wheat-cropped area in India experiences heat. While the central and peninsular parts experience heat stress all through the crop season, significant parts of north-western and north-eastern plains experience terminal heat. The trend by farmers in north-western and central India towards early sowing of wheat to take advantage of residual moisture is demanding development of wheat genotypes for both early and terminal heat tolerance.

II. WHAT IS ABIOTIC STRESS?

- The negative impact of non-living factors on living organisms in a specific environment called Abiotic stress.
- In the recent past years, global warming and climate change have drastically affected the agricultural crop productivity grown in tropical and subtropical areas by appearing of several abiotic stresses.

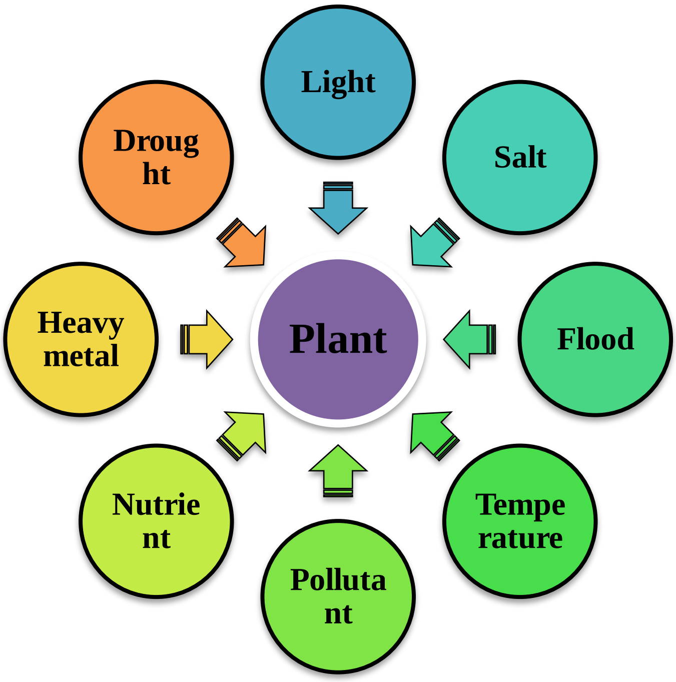

FIGURE 1: Various type of Abiotic stresses

2.1 High Temperature/ Heat Stress

Temperature regulates the growth and developmental processes of plants. Plant faces generally two types of stress with reference to temperature; high and low temperature. High temperature in plants adversely affects the normal metabolic processes which can induce premature leaf senescence, reduce the rate of photosynthesis and biomass production in plants.

Wheat is especially susceptible to heat stress during certain physiological growth stages [4]. Heat stress caused by high temperature is characterized as a rise in air temperature above a threshold level for a specific period of time that is sufficient to cause injury or irreversible damage to crop plants in general. For every 1 degree Celsius increase in temperature, there is a yield loss about 4.1 % to 6% [5]. Heat stress causes pollen sterility, Decreases carbon dioxide assimilation and improves photorespiration in wheat, according to previous studies [6]. According to [7], high temperatures damage the photosynthesis process, which has a negative effect on wheat growth and yield [8].

2.1.1 Mitigation strategies:

- **Selecting optimum time of planting:**

It helps in avoiding high temperature stress during anthesis and grain filling

- **Improving soil Quality**

Enhancing soil quality and structure to improve water retention and Nutrient Availability, thereby helping plants better cope with heat stress.

- **Implementing shade structure**

Erecting temporary shade structure or planting cover crops to provide shade and reduce direct exposure of wheat plants to heat stress.

- **Use of mulch/Zero tillage-**

It helps to protect seedlings from temperature stress and conserve moisture.

- **Selection of heat/high temperature tolerant variety**

GW 513, DBW 187, DBW 327, HI 8823 etc.

- **Use of sprinkler/drip irrigation-**

It helps in maintaining adequate soil moisture thereby reduces canopy/soil temperature.

- **Adoption of Precision Agriculture technologies**

Utilizing advanced technologies such as remote sensing and precision irrigation to monitor and manage wheat crops more effectively, including during periods of heat stress.

2.2 Drought Stress

Drought is one of the most significant abiotic stresses which have adverse effect on growth and development of plants. The productivity in wheat is most affected by water deficits. Water scarcity is a global problem that has major constrain in wheat production. The effect of drought on wheat becomes more conspicuous when the south-west monsoon fails to precipitate sufficient soil moisture essential for early establishment of the crop. Drought stress occurs when the available water in the soil is low to some critical levels for the plants. Drought causes huge damage to the physiological machinery of the plants resulting in degradation of morphological topology, anatomical structure and biochemical activity i.e. enzyme activity, protein content, sugar content, etc. It may be the most serious problem that diminishing wheat productivity by affecting various perspectives such as water relations, membrane integrity, pigment content. Crop yield is reduced mostly when water stress occurs at heading time, but its effect on yield is highest when it occurs after anthesis.

2.2.1 Mitigation Strategies

Drought-Tolerant Varieties: Developing and cultivating wheat varieties that exhibit enhanced tolerance to drought conditions through conventional breeding or biotechnology.

Optimized Irrigation Management: Implementing efficient irrigation practices such as drip irrigation, soil moisture sensors and scheduling irrigation based on crop water requirements to conserve water and minimize drought stress.

Conservation Tillage: Adopting conservation tillage practices such as no-till or reduced tillage to conserve soil moisture, improve soil structure and reduce evaporation, thereby mitigating drought stress.

Mulching: Applying organic or synthetic mulches to the soil surface to reduce water evaporation, maintain soil moisture levels and suppress weed growth, thus helping to alleviate drought stress on wheat crops.

Soil Amendments: Incorporating organic matter, such as compost or manure, into the soil to improve its water-holding capacity, nutrient availability and overall resilience to drought conditions.

Regulated Deficit Irrigation (RDI): Applying water strategically during critical growth stages to optimize water use efficiency and minimize the impact of drought stress on wheat yield and quality.

Seed Priming: Priming of seed enables the faster and better germination in plants under stressful conditions.

2.3 Salinity Stress

The salinity of arable land is considered as one of the most important abiotic stressors that restricted wheat production as well as its quality and security. It is one of the most destructive abiotic pressures, wreaking havoc on plant morphological, physiological and biochemical characteristics such as photosynthesis, nutrient absorption and yield. Higher salinity decreases germination and increases the concentration of Na^+ and Cl^- ions, disrupting wheat plants normal metabolic processes. Salt stress affects plants in a number of ways including osmotic effects, ion toxicity and nutritional disorders. Salinity also negatively affects wheat phenological developments such as leaf number, leaf expansion rate and root/shoot ratio and biomass. The saline environment disturbs plant water relations including relative water content, leaf water potential, water uptake, transpiration rate, water retention and water use efficiency.

2.3.1 Management of Salinity Stress:

- Application of gypsum @ 50% Gypsum Requirement (GR).

- Incorporation of Dhaincha (6.25 t/ha) in soil before planting.
- Foliar spray of 0.5 ppm brassinolode for increasing photosynthetic activity.
- Foliar spray of 2% DAP + 1% KCl (MOP) during critical stages.
- Spray of 100 ppm salicylic acid.
- Foliar application of ascorbic acid alone increased number of leaves and leaf area, while in combination with zinc sulfate increased the plant height and total plant biomass.

2.4 Waterlogging Stress

Wheat (*Triticum aestivum* L.) Is one of the most intolerant crops to soil waterlogging and the plants that are not tolerant to waterlogging may suffer from Fe or Mn toxicity. Wheat is very sensitive to waterlogging at sowing time and during seedling, flowering and grain-filling periods; waterlogging for 30 days during these periods reduced grain yield by 50-70% due to poor seed set and fewer spikes per unit area. In waterlogged soil, diffusion of gases through soil pores is so strongly inhibited by their water content that it fails to match the needs of growing roots. A slowing of oxygen influx is the principal cause of injury to roots and the shoots they support. Oxygen deficiency caused by waterlogging reduces shoot and root growth of plants, as well as yield. Waterlogging affects physiological processes of plants, such as absorption of water, root and shoot hormone relations and decreases the uptake and transport of ions through roots, causing nutrient deficiencies.

2.4.1 Management of Waterlogging Stress

- Surface drainage
- Raised bed system
- Early sowing and vigorous crop
- Nutrient application in particular
- Use of Plant growth regulator
- Use of Tolerant species and varieties
- Use of anti-ethylene agents
- Strategic deep tillage and subsoil manuring
- Controlled traffic farming

2.5 Heavy Metal Stress:

2.5.1 Major source of heavy metal release:

Natural: Rocks, Volcanic eruption, dust particle, aerosols, sea spray

Agricultural: inorganic fertilizer, pesticides, wastewater, fungicides, sea sludge, fly ash

Industrial: thermal power, industrial waste, Mining industries, rifaenaries, chemical industries

Domestic waste: organic waste, inorganic waste, biomass burning, e-waste,used filters, used batteries,

2.5.2 Management of Heavy Metal

- **Phytoremediation:** It is the best effective way for removal of heavy metals from contaminated soil with low and moderate heavy metal concentrations. It is eco-friendly and low cost way.
- **Phytoextraction:** The use of plants to remove heavy metals from soil
- Bioremediation of heavy metal toxicity:
    - Exclusion
    - Active transport of metals away from the cell
    - Intracellular and extracellular sequestration

- Enzymatic degradation of toxic metals to lesser toxic forms
- Reduction in metal sensitivity of cellular targets

- Soil washing
- Landfilling and leaching
- Soil immobilization

III. CONCLUSION

Abiotic stresses like high temperature (20%), low temperature (7%), salinity (10%), drought (9%) and other form of stresses (4%) are adversely affect wheat crop by physiologically, morphologically, biochemically that result in poor yield which ultimately affects the farmer's socio-economic condition. Hence, there is further scope to increase the productivity of wheat through adaptation of suitable agronomic management practices like adjusting the time of sowing, use of mulches, antitranspirants and reclamation of soil through appropriate soil conditioners with respect to edaphic and climatic conditions of the area.

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