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Managing Drought Stress in Wheat (*Triticum aestivum* L.): Effects and Sustainable Production Strategies

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The most significant, nutrient-dense, extensively cultivated, and eaten cereal in the world is wheat (*Triticum aestivum* L.) It is grown on 220 million hectares of land worldwide 778 million metric tons of wheat are produced year, adding 10% value to agriculture. It produces 3.5 tons per hectare on average each year. It contains 2.5% fat, 69% carbs, 9.4% protein, and 1.8% Fiber.

The wheat harvest is even more important because of the rising need for food and nutrition brought on by population expansion. Additionally, it has a significant historical and cultural contribution to the cattle and animal feed industries. In order to meet the projected food demand caused by world population expansion, the average yearly wheat output has grown by 2%. Low water availability for production in arid and semi-arid locations is mostly caused by abiotic stressors. Global climate change trends reveal long-term variations in temperature and precipitation patterns, as well as environmental catastrophes such rising sea levels, melting glacier caps, and biotic and abiotic stressors.

One of the main abiotic pressures that farmers worldwide are dealing with as a result of climate change is drought stress. Only 346,895 thousand hectares of land are irrigated worldwide; all other land is entirely dependent on rainfall. The earth's temperature increases by 0.06°C per year, but precipitation decreases by 16.09 mm.

Drought stress

Causes of drought stress

In Africa, climate change has become a major worry due to rising temperatures, erratic rainfall patterns, and a major role in drought stress in crops that are economically significant. In the twenty-first century, Africa's mean annual rainfall
by 16.09 mm while the average annual air temperature rose by 0.9°C. Crop plants may experience water stress due to a variety of edaphic variables, even in the presence of sufficient soil moisture. These elements include floods, salt, and low soil temperatures which prevent the plant from using its roots to absorb water.

Drought stress's effects on wheat performance

Significant changes are brought about by drought stress at several physiological, biochemical, and Argo- morphological levels. Figure 1 shows the main alterations brought on by drought stress.

Impact of drought stress on Agro morphological changes:

Wheat's Agron-morphological characteristics during heading, anthesis, and grain filling are greatly impacted by drought stress. Grain quality, weight, and size are all decreased mostly when drought strikes during the period of grain-filling. As a survival tactic, certain wheat genotypes mature earlier during droughts. Early-maturing genotypes exhibit poor source-tosink mobilization and decreased assimilation. Reduced plant height results from protoplasm dehydration and turgidity loss brought on by drought.

Drought stress decreased plant height by 5.78% as compared to non-stressed circumstances. The reduction of plant height under Spike length is substantially reduced under drought stress situations.

Drought circumstances caused a 12.50% reduction in wheat spike length. Regardless of the generated stress, low spike length is linked to genes that affect height. There are fewer spikes when there are fewer tillers per plant because of tiller death during drought circumstances.

In addition, reduced water availability, impaired photosynthesis, restricted growth, and premature senescence reduce grain yield under drought stress. This is consistent with findings from Shamuyarira et al. (2022), who noted a significant decline in yield ($p < 0.05$).

Effect of drought stress on wheat physiology:

Grain yield is severely impacted by drought stress because it disrupts a number of physiological processes, including decreased nutrient uptake, mobilization, and stem reserve buildup, endosperm development, gametogenesis, fertilization, embryogenesis, and seed growth. Relative water content, chlorophyll content, osmotic potential, leaf water potential, leaf turgor potential, leaf diffusive resistance, and leaf transpiration rate are all decreased by drought stress.

Drought decreases nutrient mass-flow, diffusion, and mineralization in the soil, which lowers nutrient assimilation. (Fierer & Schimel, 2002; Barbara et al., 2007). Drought decreases active transport, transpiration flux, and cell membrane permeability, which lowers the plants' capacity to mobilize nutrients. Low water potential causes plant parts, such the stem and leaves, to shrink in order to store food.

The gamete production stage in plants is extremely vulnerable to abiotic stressors like heat and drought. The due of the morphological, structural, and metabolic changes that result in early gametes and reproductive sterility, reproductive organs subjected to such pressures displayed meiotic abnormalities. Drought lowers pollen viability, which results in poor fertilization, and decreases the moisture needs in reproductive regions like style and stigma.

The plant's capacity to absorb water from the soil is diminished by drought stress, which lowers turgor pressure. Low turgor pressure causes the decrease in affects plant growth by reducing cell extensibility and delaying the development of embryos.

Impact of drought stress on biochemical changes:

Crop plants' metabolic activity change as a result of the effects of drought stress on biochemical processes. Drought stress in the rhizosphere increases respiratory carbon loss, which lowers the synthesis of adenosine triphosphate. Drought disrupts the oxidative phosphorylation process in mitochondria, which results in the production of reactive oxygen species.

Furthermore, drought stress reduces photosynthesis by increasing the production of abscisic acid for stomal closure. The decrease in the pace of photosynthesis restricts the intake of carbon and the buildup of sugar. Under water stress, proline levels increase, but they quickly decrease as a result of changes in cytosolic synthesis and mitochondrial breakdown rates.

Consequently, the interaction of various biochemical processes shows a complicated network in which drought affects wheat's metabolic structure and pathways. Gaining knowledge of these relationships can help generate drought-tolerant wheat genotypes through breeding.

Methodologies for improving water use efficiency

Cultural practices

Mulching

According to He et al. (2023), mulching is the process of covering the soil's surface with organic or inorganic material to maintain moisture and regulate soil temperature, hence enhancing WUE and production of grain yield. mulching improves penetration into the soil profile during rainstorms, reducing surface water flow and increasing WUE. In an evaluation of several mulching techniques, Ali et al. (2018) discovered that adding 5 t ha-1 of wheat residue together with 350 mm of irrigation raised plant WUE by 35%.

Precision irrigation

Wheat productivity is enhanced when water is applied through irrigation. Improving irrigation control is essential in lowering drought stress and raising WUE in situations with restricted water resources. However, the use of precision irrigation techniques like drip irrigation and micro-sprinklers is advised in order to administer water effectively during irrigation. By delivering water straight to the crop's root zone, these techniques minimize water loss from runoff Additionally, by increasing yields per hectare while consuming less water, fertilizer, and energy, precision irrigation boosts profitability in commercial wheat fields.

Soil Management Practices Organic matter

The soil's ability to store water is positively impacted by methods that raise the soil's organic matter content. Arise in for a variety of settings, an organic matter level between 0.5 and 3% more than doubled the soil's water capacity. According to reports, the SSA area is affected by this problem.), for example, showed that adding compost and biochar to the soil improved its ability to retain water and decreased water stress in Ghana.

Tillage technique: WUE is greatly impacted by tillage techniques in SSA dryland areas and agricultural systems. It has been demonstrated that conservation tillage techniques, such no-till and reduced tillage, enhance soil water retention. For example, research carried out showed that conservation tillage techniques significantly increased the amount of water in the soil when compared to traditional tillage techniques. This benefit is ascribed to less soil disturbance, which minimizes soil compaction and maintains soil structure, improving water infiltration and lowering surface runoff.

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