A REVIEW ON THE MAIN STRESS FACTORS IN WHEAT AND SOME STRATEGIES TO MITIGATE THEM

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Abstract

Current agriculture is caught between two major pressures: ensuring food security for a growing population and mitigating the negative effects of climate change and natural resource degradation. In this context, wheat occupies a strategic position, having a direct impact on both economic balance and social stability. At the same time, the vulnerability of this crop to abiotic (drought, high temperatures, salinity) and biotic (diseases, pests) stresses underlines the urgent need for innovative technological solutions. Stress factors, either abiotic or biotic, severely limit the performance of wheat crops and reduce both production and quality, with a direct impact on economic efficiency and food security. Under these conditions, the integration of complex technological solutions is no longer optional, but necessary. Organo-mineral fertilization, careful administration of foliar fertilizers, as well as the use of biostimulants and amino acids have demonstrated visible effects in increasing stress tolerance and increasing yield. They support metabolic processes, maintain physiological balance and contribute to better stability of grain quality.

***Key words**: wheat, abiotic, biotic, stress, mitigation*

INTRODUCTION

The rapid growth of the world population, which is estimated to exceed 9 billion inhabitants by 2050, is generating significant pressure on agriculture. While agricultural production is increasing at a slower pace, the demand for food is constantly expanding. In this context, wheat (*Triticum aestivum* L.), together with rice (*Oryza sativa* L.) and maize (*Zea mays* L.), plays a central role, being the source of over a fifth of the global caloric intake and a basic component of the human diet (Caverzan et al., 2016).

Wheat is very important as a food product, providing a large part of the carbohydrates and proteins needed by humans and representing more than half of the calories consumed by mankind (Ișlicaru et al., 2021). Also, wheat is the most widely distributed food crop in the world, being the staple food for about 40% of the world's population, with a major role in ensuring global food security (Zhou et al., 2018).

The total area cultivated with wheat exceeds 215 million hectares, the crop being present both in temperate regions and in semi-arid areas, where other species encounter major difficulties in adapting. The yields obtained differ significantly depending on the technology applied and climatic conditions, but in recent years global production has consistently exceeded 780 million tons annually, a figure that shows the stability of this crop in relation to other cereals (USDA, 2022).

At the national level, wheat occupies a traditional place in the structure of agricultural crops. In Romania, the annual cultivated area is approximately 2 million hectares, which ensures the constant placement of the country among the main European exporters (MADR, 2023).

The global and national importance of wheat justifies the increased interest in research to improve crop technologies and ensure the sustainability of production. In the face of climate challenges and global market pressures, investments in innovation and genetic improvement will be decisive for maintaining the strategic role of wheat in the coming decades (Reynolds et al., 2022).

MATERIALS AND METHODS

Drought reduces the yield of wheat by an average of 50–60% and facilitates soil erosion as well as environmental degradation, threatening the future food and nutritional security of the world.

In this context, the objective of this review was to presents the main stress factors in wheat and some strategies to mitigate them.

The methodology involved a comprehensive review of some relevant articles from databases such as Web of Science, ResearchGate, PubMed and Google Scholar.

RESULTS AND DISCUSSIONS

Cereals are the world's dominant crops. Drought creates a water deficit that can affect all parts of life, but has the greatest impact on agricultural production (Paunescu et al., 2021, 2023, Yu et al., 2018). To keep up with the demand, modern strategies need to be developed to increase wheat yield under this changing environment (Bonciu et al., 2021; Roșculete et al., 2021).

Water stress is one of the most important limiting factors in wheat cultivation, especially in regions with poor rainfall or irregular rainfall distribution. Lack of water during critical development phases reduces the plant's ability to accumulate biomass and, implicitly, significantly reduces yield per hectare.

Drought stress is one of the major abiotic stresses that farmers are facing all over the world as a result of global climate change. Modern biotechnology methods contribute to the identification of genes responsible for adaptation to drought and heat, accelerating progress in creating high-performance genotypes (Zhang et al., 2017) and has a significant potential to contribute to food security and sustainable development (De Souza and Bonciu, 2022 a, b).

Drought negatively affects essential metabolic processes, such as photosynthesis, cellular respiration and nutrient absorption. At the cellular level, water deficit causes loss of turgor, reduced cell expansion and activation of oxidative defense reactions.

Excessive heat negatively affects the physiological processes of wheat, especially during critical stages such as pollen formation, flowering and grain filling, which is immediately reflected in production (Reynolds et al., 2022). Heat stress has a direct effect on the photosynthetic apparatus. Chloroplasts become more vulnerable, the rate of photosynthesis decreases, and chlorophyll pigments degrade (Wahid et al., 2007).

The effects of heat stress on plants (Figure 1) are very complex resulting in alteration of growth and development, changes in physiological functions, and reduced grain formation and yield (Akter and Islam, 2017; Mondal et al., 2013).

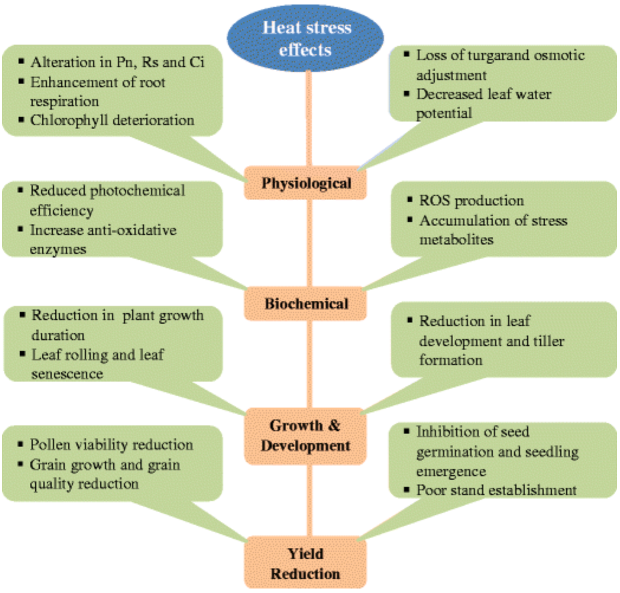

Figure 1. The main effects of heat stress on plant growth and development (Mondal et al., 2013; Akter and Islam, 2017).

The application of biostimulant treatments, such as algae extracts, amino acids or humic acids, has shown positive effects on wheat drought tolerance. These substances contribute to maintaining osmotic balance and stimulating the plant's endogenous defense mechanisms (Khan et al., 2020).

Water and heat stress are major yield limiting factors in wheat cultivation, and combating them requires an integrated approach that includes genetic selection, optimization of agrotechnical technologies and the application of biostimulants or adaptogenic substances.

Salt and chemical stress are among the most important risk factors in wheat cultivation, affecting both physiological processes and production quality (Figure 2).

Excess soluble salts, especially sodium (Na^+) and chlorine (Cl^-) ions, disrupt the osmotic balance at the root level and reduce the plant's ability to absorb water. At the same time, these ions interfere with the absorption of essential nutrients, such as potassium, calcium, or nitrates, seriously affecting the plant's metabolic processes. To cope with this type of stress, plants accumulate osmoprotective compounds, such as proline or glycine betaine, which contribute to maintaining intracellular osmotic pressure. In addition, certain wheat genotypes activate mechanisms to exclude sodium in the roots or to compartmentalize toxic ions in vacuoles, reducing the negative effects on tissues. Management practices are still helpful to improve the wheat performance under salinity stress (Seleiman et al., 2021). Their effective management requires a combination of technological, amelioration and permanent soil monitoring measures.

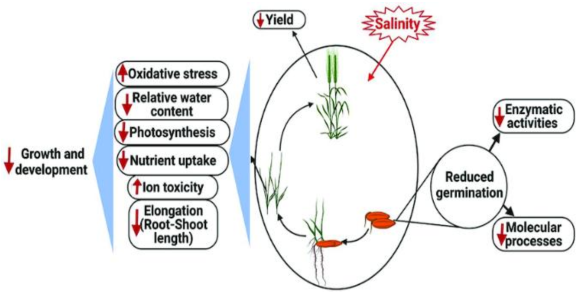

Figure 2. Effects of salinity stress on wheat crop (Seleiman et al., 2021).

Biological stress is one of the main causes of reduced wheat production, having a major impact on crop stability globally. This type of stress is generated by pathogens, insect pests and weed competition, each acting on the plant through different mechanisms and producing significant losses (Savary et al., 2019). Mitigation of biological stress requires an integrated approach. This includes preventive methods (crop rotation, use of resistant varieties), chemical treatments (fungicides, insecticides, herbicides), biological solutions (beneficial entomofauna, biopreparations) and appropriate technological practices (optimal sowing time, correct crop density).

Due to their complexity and dynamics, biological factors can severely compromise the productive potential of wheat. Therefore, an integrated strategy, based on knowledge of the biology of pathogens and the application of appropriate technologies, is essential for maintaining crop health and for the stability of agroecosystems (Savary et al., 2019).

Insect pests are another critical factor. Aphids (*Sitobion avenae*), grain bugs (*Eurygaster integriceps*), and wireworms (*Agriotes spp*.) affect plants both by feeding and by transmitting pathogens (Kalaisekar, 2017).

In sustainable agriculture, it is a common practice to apply amino acids to wheat crops due to their beneficial effects on vegetative growth, plant physiology and productivity. Amino acids act as signal molecules, precursors of phytohormones and secondary metabolites, improving nutrient absorption and plant resistance to stress. Amino acids are also combined with algae extracts or humic acids because they have a stimulating effect on cell division and on the formation of productive elements, due to the synergy between the bioactive components, leading to increased productivity (Canellas et al., 2015).

Also, fulvic acids, an essential fraction of soil organic matter, have emerged as influential agents in enhancing soil fertility and boosting crop productivity (Figure 3).

Fulvic acid application in plants offers numerous advantages, including enhanced nutrient uptake and availability, improved soil structure and water retention, stronger root development, and increased plant resilience to stress. It works by chelating nutrients, making them more soluble and accessible to plants, and by stimulating beneficial microbial activity.

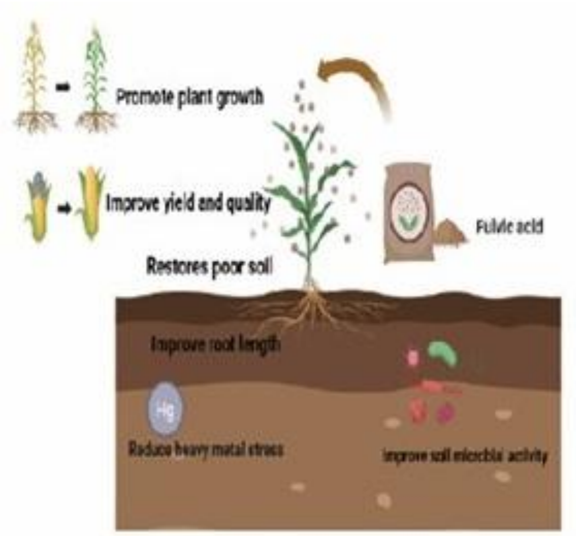

Figure 3. Benefits of fulvic acid application in plants (Pavadharini et al., 2025).

Effective management of abiotic and biotic stress in wheat crop requires a complex and integrated approach. In practice, the farmer combines: tolerant genotypes (deep root system, high WUE, "stay-green"); finely adjusted agrotechnics (sowing time, density, conservative works, balanced fertilization); biostimulants/biopreparations that activate the anti-stress response; precision agriculture for localized decisions. All these interventions aim to mitigate the negative effects of stress on plants and strengthen the resilience of agroecosystems in the face of climate change. These agroecological practices are all the more relevant in areas with low fertility (Altieri et al., 2015).

CONCLUSIONS

The main stress factors for wheat are abiotic stresses like drought, high temperature, and salinity, along with biotic stresses such as rust, powdery mildew, and *Fusarium*.

Solutions to mitigate stress include developing stress-tolerant cultivars through molecular breeding techniques, implementing advanced agronomic practices like precision irrigation and appropriate fertilization, and using biostimulants to improve resilience.

In the context of climate change, the adaptation of wheat crops will depend on combining genetic progress (through drought and temperature-tolerant varieties) with the application of advanced technological inputs. This integrated model ensures stable yields and maintains quality under difficult conditions.

Fertilization remains a decisive factor, but its success is conditioned by the balance between nutrients, the timing of application and the interaction with the soil and climate. Approaches based on real data, obtained through crop monitoring, lead to more accurate decisions and better long-term results.

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