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Review Article

Adaption and mitigation of drought and heat stress on wheat under changing climates

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Wheat is Nepal's third most important crop, and is nutrient-dense, easy to store and transport and can be converted into a variety of ingredients. Nepal has the lowest cereal yield per hectare among the South Asian countries that export domestic crops to the region. Many physical, chemical and biological factors have a great impact on wheat. Drought and heat stress are the most significant physiological factors. Wheat yield in marginal rainfed condition has also been downregulated by 50-90% of their irrigated potential due to drought. To get high yields, both the seed and the field must be of excellent quality. Wheat production management, as well as the development of high yielding, disease resistance, climate adaptive, and location specific varieties should be focused to increase wheat output sustainability**.** Our review attempts to shed light on tolerance mechanisms, adaption strategies, and morphophysiological and molecular effects.

Keywords: *wheat**,** heat stress, drought resistance, climate change, genotype*

Introduction

One of the most extensively grown cereal crops worldwide, wheat (*Triticum aestivum* L.) contributes significantly to both global cereal production (28%) and commerce (41.5%) (Yadav et al., 2022). With a yield of 3.5 t /ha on average (with 11% moisture content) and a global production of 765 million tons, wheat covers 216 million hectares (Pequeno et al., 2021). According to estimates, in order to feed the world's 9 billion people by 2050, wheat production will need to rise by 60% globally (Dhakal, 2021). Crop growth and productivity are influenced by the spatiotemporal interactions of many climate conditions. The effects of the climatic factors (such as temperature and rainfall) need to be measured and comprehended in order to effectively manage them. The negative effects of Wheat productivity is clearly threatened by heat stress (HS), which is brought on by rising ambient temperatures and erratic weather patterns in all ecologies (temperate, subtropical, and tropical) (Yadav et al., 2022). Climate change increases the likelihood of certain natural disasters occurring more frequently, including storms, cyclones, floods, droughts, and shifts in the pattern of precipitation. Since agriculture is so important, Variations in temperature, humidity, and rainfall have a negative effect on crop plant productivity because they are climate-dependent and susceptible to agro climatic conditions (Hossain et al., 2021).

It is very nutritious, easy to store, transport and can be processed into various types of food (Subedi et al., 2019). Cereals account for around 37% of Nepal's agricultural GDP, with wheat accounting for 7.14% of the total and the Terai region, which accounts for 57.8% of the total farmed land, produced the majority of the wheat (65.2%) improved varieties cover around 95.8% of the entire wheat area in Nepal, which makes up only 23% of the country's total geographical area (Bhandari et al., 2021). The rise in temperature will have a significant negative impact on wheat yield among all crops and the world's wheat yield would decrease if temperatures rise by just 1°C. There are 701 million tons of wheat produced worldwide (Poudel et al., 2020).

Wheat is mainly affected by the drought condition globally with widespread consequences which is unpredictable phenomenon of changing climate, and increasing extreme weather events such as flood (Hamal et al., 2020). Among abiotic pressures on agricultural crops, drought is the most detrimental and an abiotic threat that works concurrently on multiple features, resulting in a reduction in production as well as also affecting the yield stability of food cereals throughout their lives (Singh et al., 2020). Drought conditions or moisture stress limiting wheat production worldwide. Almost half of the area sown to wheat in developing countries and 70% of developed countries suffer from periodic drought (Pokharel & Pandey, 2012a). All phases of plant growth are impacted by drought, but at the key stage of growth and the reproductive stage, dryness significantly reduces grain yield by 70% to 80% (Gupta et al., 2022) and Grain yield decreases by up to 92% occur when the anthesis and grain filling period are affected by terminal drought conditions (Timalsina et al., 2023). Drought stress affects the numerous gene located as the quantitative trait loci which exhibits the additive and non-additive gene effect (Bhandari & Kharel, 2021). Drought condition affects the development of plant by reducing the no. of spikes, no. of grain and time period of cycle by morphologically and physiologically by closing their stomata. If long water duration occurs stomata dies due to denaturation of starch in guard and mesophyll cells (Poudel et al., 2020d).

For making good yield and agriculture sustainable, the varieties with drought resistance can be used in drought condition areas which is the key strategy for food and nutrition security. Some of the drought resistance varieties in wheat are: NL1373, NL1308, NL1407 and BL4868 (Rijal et al., 2024). To increase the crop, yield excessive application of inorganic N-fertilizer inputs, long term excessive use of inorganic fertilization and leguminous crops can also be used for better production (Qaswar et al., 2019c). Environmental problem is the main problem for the yield stability i.e. water stress. To analyze the stability in many environments the varieties are tested and can take a leap CMR (Crop Management Research) to tolerate the biotic and abiotic stress and for choosing the right varieties according to the environmental climate (Poudel et al., 2020d).

Numerous secondary sources, including research and review papers that have been accepted by respectable journals, have been consulted in the compilation of this content. It is a compilation of articles and additional materials that we have been looking at from various sources.

Effect of heat stress

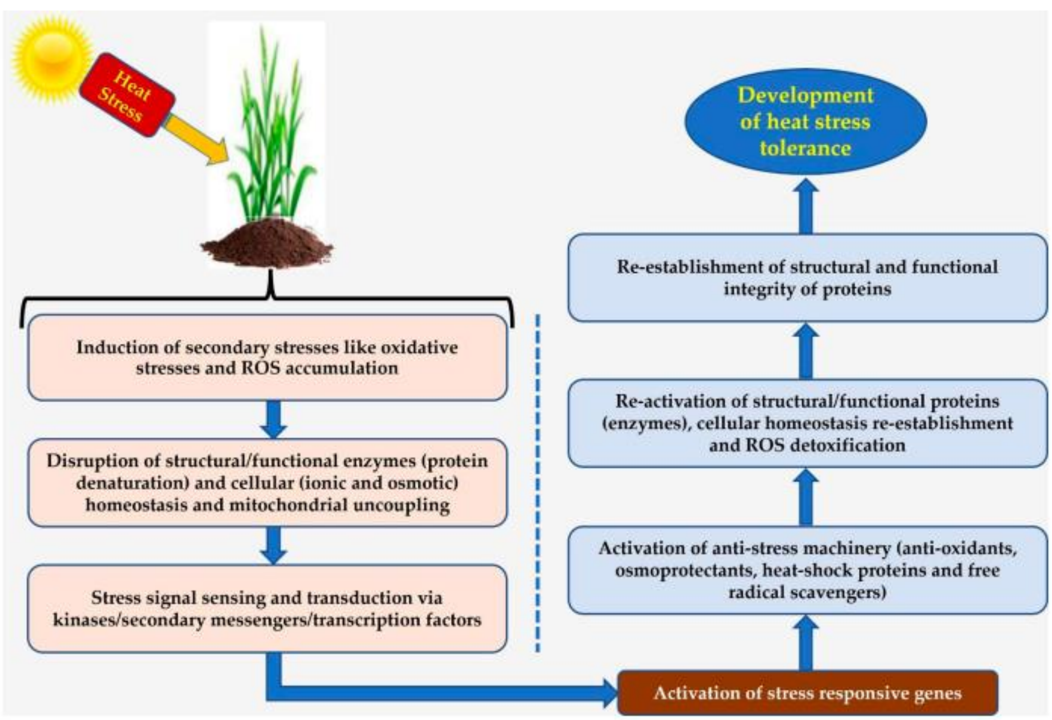

Figure 1. Development of heat tolerance responses and mechanism under HS in wheat (Yadav et al., 2022).

In the event of the anticipated climate change scenario, wheat productivity will need to be sustained through the development of heat-tolerant genotypes and the adoption of improved agronomic practices. Current developments in breeding, biotechnology, and agronomic techniques to increase heat tolerance and produce higher wheat yields in high-stress conditions. Creating wheat cultivars that are tolerant of high temperatures is a practical and effective way to address the rising temperature in the ecology of wheat agriculture (Yadav et al., 2022) . The first step in breeding for HS resistance is screening under testing conditions, after which HS tolerant cultivars are often selected, as shown in figure 1. Heat stress mainly induced the oxidative stress and ROS accumulation along with disruption of structural, functional and cellular homeostasis. For the development of heat stress tolerance genotypes re-establishment and re-activation of structural, functional and cellular homeostasis is the major concern. Along with this, activation of anti-stress machinery is also carried out.

Effect of drought stress

Among the different physical factors, drought is the main. Drought is at the top of the list of factors that affect food security around the world. It has deleterious impact on the development, growth, morphology and physiology of plants. As, it decreases the number of spikes and decreases the time to complete its life cycle (Poudel et al., 2020). Drought is a period of dry weather that can last months or years. Drought stricken areas which do not receive typical amount of rain, but wheat yield is heavily influenced by water availability (Kaur Oberoi, 2020). Drought has been found to diminish wheat yield in marginal rainfed areas by 50-90% of their irrigated potential (Sareen et al., 2014) . The Factors including genotype, agronomic management and weather affects the yield in crop production system. Since nineteen fifties genetic improvement contributed dramatically to increase yield and genetic grain yield varied in different investigation (Chen et al., 2018). In comparison to the norm the higher temperature and lower rainfall has decreases the yield during the period of active growth (Chamurliyski, n.d.). There are numerous stages of drought-related yield loss, and the degree of reduction in yield is contingent upon the phenological stage at which the drought occurs, as well as its severity and persistence (Gyawali & Khanal, 2021).

Effect of climate change

According to simulation data, by the middle of the century, wheat production worldwide is expected to decline due to climate change (Pequeno et al., 2021). Global food security is under the risk due to the detrimental impacts of climate change on wheat production, and sustained wheat yield is predicted to be adversely impacted by rising global temperature (Farhad et al., 2023).

Mitigation of drought and heat stress

The varieties of wheat should be productive by maintaining the soil fertility and crop ideotype, hybrid varieties and water resistance variety can be used. In Himalayan areas varieties with low temperature needed and long duration life cycle can be grown. For winter wheat two trimesters after sowing date, NDJ and FMA can be considered to maintain the stability (Bocchiola et al., 2019). High yields will be achieved by a good seed and good field. The productivity of the same genotype of crop cultivated under different environmental conditions fluctuate. This variation in yield is due to the interaction between genotypes and the environment (Poudel et al., 2020d). To enhance wheat output sustainable, wheat production management as well as the creation of high yielding, disease resistance, climate adaptive and location specific varieties, should be prioritized (Krishna Joshi, n.d.). Crop rotation is beneficial for land and water resources protection and productivity have been identified but there are many of others rotation factors, processes and mechanism responsible for increasing yield in wheat .The other contributing factors which plays vital role to increase yield are increasing in nitrogen supply, improvement in soil water availability, soil nutrient availability, Soil structure, soil microbial activity and weed control, decrease insect pressure and disease incidence and the presence of growth promoting substances originating from crop residue (Berzsenyi et al., 2000).

Conclusion

After study this we have to the conclusion that the drought stress and heat stress on wheat under changing environments is the main problems to decrease the stability rate of our country. Water stress or drought conditions harm the growth and development of wheat production due to which the production of wheat in our country decreases year after year. In this, we can also find the varieties of the wheat that can be grown in drought and heat conditions i.e. NL1373, NL1308, NL1407, BL4868, and BL4947 and can be helpful for the high production of wheat. We can also find the ways to improve the adoption and its mitigation by maintaining the drought and heat stress conditions in the present changing environment and by using the drought resistance varieties of wheat we can beat the drought condition and by using the good production varieties which is stable and can be used in various climatic condition the stability can be maintained. By the various experiments and study different varieties in the NARC we can find the quality variety of the wheat that can be grown in Nepal under the heat stress and drought by challenging this changing environment condition. By overcoming this drought condition and heat stress problem the adoption and mitigation of wheat under the changing environment can be maintained which gives the more production in every climatic condition.

Author contributions

Sharada phullel was responsible for creating the study and writing the protocol. Sharada phullel and Santosh Gupta handled the preparation of the materials, data collection, and analysis. Sharada Phullel wrote the first draft of the manuscript, and Santosh Gupta provided feedback on earlier iterations. Author Sharada Phullel, Santosh Gupta, Pratikshaya Pokhrel was the literature searches and contributed a lot to Strategies Portion. The final part of the manuscript is Hinder Hunger written by Sharada Phullel and Santosh Gupta was in charge of managing the references and citations. All authors read and approved the final manuscript.

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Ethics approval

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The authors not used any AI and related tools to write this manuscript.

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