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REVIEW ARTICLE

HEAT AND DROUGHT STRESS EFFECT IN WHEAT GENOTYPES: A REVIEW

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ABSTRACT

Bread wheat *(Triticum aestivum L.)* belonging to family Poaceae is the most important cereal crop as it contributes major portion to the world food for the world's population. Similarly, it is the third most cultivated cereal crop in Nepal in terms of production and area. Wheat is a winter season crop which is usually grown within a temperature range of 15-25^{0}C in cold and dry weather. However frequent irrigations are crucial for proper growth of the plant, high yield and high quality of the grain. The annual productivity of wheat has been reported to be 2.49 tons per hectare. Water is found to be one of the most important factors in wheat production and by far not a single water stress tolerant variety has been introduced thus water management is necessary. In Nepal around 35% of the total wheat is cultivated under rainfed condition annually and in Terai this is around 19%. This cultivated area faces a severe drought stress during growing stage and heat stress during anthesis stage. Various studies have suggested that the combined impacts of drought and heat stress had a significant harmful effect on wheat than individual stresses (Stress and Review, 2017). Under drought stress days to anthesis and days to maturity were reduced by 10% and 14% while under heat stress these were reduced by 16% and 20% respectively. Combined effect of drought and heat stress caused reduction in DTA by 25% DTH by and 31%.

KEYWORDS

Poaceae, Productivity, Rainfed, Anthesis, Heat stress, Drought stress

1. INTRODUCTION

Bread wheat *(Triticum aestivum L.)* belongs to family Poaceae and is the most important crop in the as it contributes major portion of staple food for the world's population and provides more calories and protein in the world's diet than any other cereals (Scholar, Factor and Copernicus, 2016). It is grown on 220 million ha of land worldwide with the production of 749 million tons. The production of wheat in Nepal is 1.81 million tons which is grown in 0.75 million hectares of land making annual productivity of 2.49 tons per hectare making it the third most cultivated cereal after rice and maize (Kandel et al., 2019). The productivity of wheat in Nepal is significantly lower than the world average (3.16 tons/ha) and extremely lower than the developed countries like New Zealand and Ireland with productivity 8.4 and 9.1 tons/ha respectively. The factors for limiting the optimum wheat production in Nepal are supposed to be drought and heat stress condition and genetic make-up of the varieties. It has been reported that on an average the yield of wheat in rainfed and irrigated areas were 1.74MT/ha and 2.71MT/ha respectively. Similarly, the yield from the local and improved seeds was 1.12MT/ha and 2.34 MT/ha respectively (Poudel et al., 2019).

However, the area as well production of wheat in Nepal has been distinctly increased after the introduction of semi-dwarf varieties (Subedi et al., 2019). The modern varieties and improved farming practices have had a large impact on improved crop cultivation. Most of the increased production and productivity came from the availability of high yielding varieties as farmers gradually replaced their low yielding traditional varieties with high yielding. This positive change in agricultural development has resulted from the technological progress, which helped to benefit to millions of people and contributed to sustaining food security in the face of growing population pressure to some extent on limited natural resources (Prasai and Shrestha, 2015).

Wheat is one of the most important and strategic cereal crops over all the world and it is commonly known as king of cereals. The importance of wheat lays in the physical and chemical properties of its grain, which makes possible production of bread, a primary source of the staple diet for the poor population and rich one alike. Wheat provides over 20% of the calories and protein requirements for human nutrition, and is a staple food for over 41% of the world's population in more than 40 countries (Aziz et al., 2019). It is consumed by over 2.5 billion people all over the world. Wheat has a high content of starch (60-70%) and 6-26% protein content. It is a good source of carbohydrates, fibers, minerals (2.1%), fat (2.10%), vitamins and sugars and meets half of the energy demand of human population (Poudel et al., 2020). Furthermore, wheat is considered a good source of protein, minerals, B-group of vitamins and dietary fiber (Subedi et al., 2019).

Wheat is a winter season crop which is usually grown within a temperature range of 15-25^{0}C in cold and dry weather. However frequent irrigations are crucial for proper growth of the plant, high yield and high quality of the grain. Water is found to be one of the most important factor in wheat production and by far not a single water stress tolerant variety has been introduced thus water management is necessary (Aryal et al., 2021). In Nepal around 35% of the total wheat is

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cultivated under rainfed condition annually and in Terai this is around 19%. This cultivated area faces sever drought stress during growing stage and heat stress during anthesis stage (Pandey et al., 2021).

2. Objectives

The main objective of this study is to find out the effects of heat and drought stresses in wheat genotypes. This review article focuses on the different parameters of wheat which are affected by drought and heat stresses condition. The specific objectives of this study are:

- ✓ Find out the different effects of drought and heat stresses on wheat plant growth development and grain quality.
- ✓ Find out the best time of sowing to alter heat stress to the plant.
- ✓ Find the best method of cultivation.

3. Methods and Methodology

The source used to prepare this review article is solely secondary sources. Various research articles, journals, online sites and relevant reports were taken as reference for the summarization. Review's guidelines and suggestions from professors are also considered to prepare this review article.

3.1 Impacts On Heat Stress Wheat Morphology

The primary effect of heat stress is the impediment of seed germination and poor stand establishment in many crops including wheat (Akter and Islam, 2017). Some morphological symptoms of heat stress are sunburn of leaves and twigs, branches and stems, leaf senescence and abscission, improper growh of roota and shoots etc. Reduction in number of tillers was observed in wheat plants exposed to heat stress at the early stages of their growth (Hasanuzzaman et al., 2013). High temperature at the time of anthesis affects different physical and physiological parameters of wheat that includes restricted growth and reduced grain yield. During anthesis increased temperature restricts embryo development that decreases grain number and test weight (Poudel et al., 2017). Low yield of wheat cultivars exposed in heat stress condition of reproductive stage may be due to increased production of oxidative reactive species, under developed pollen tube and high mortality of pollen grains (Nawaz et al., 2013).

Heat stress during flowering and grain filling period accelerates maturity and significantly reduces grain size and weight (Puri et al., 2015). A Heat stress affects plant meristems and reduces the plant growth. Warm temperature produces lower biomass compared to the plants grown in cold climate (Akter and Islam, 2017). High temperature affects the survivability of the productive tiller, which result in decrease in yield. HS in wheat results in decrease grain yield (53.57%) and tiller number (15.38%). The life cycleof wheat shortens in HS situation than in normal situation. 1°C-2°C rise in temperature lowers seed weight due to decrease in grain filling duration (Poudel and Poudel, 2020). Similarly heat stress degenerates' different cellular organelles including mitochondria, changes the protein expression profiles, reduces ATP accumulation and oxygen uptake by imbiting wheat embryos (Akter and Islam, 2017).

3.2 Impacts Of Heat Stress on Wheat Physiology

Different metabolic pathways are depended upon enzymes which are sensitive to various degrees of HTs. It has been suggested that, like other abiotic stress, heat stress might uncouple enzymes and metabolic pathways which cause the accumulation of unwanted and harmful ROS most commonly singlet oxygen (O_2), superoxide radical (O_2)•−), hydrogen peroxide (H_2O_2) and hydroxyl radical (OH•)which are responsible for oxidative stress (Hasanuzzaman et al., 2013). Photosynthesis is the most heat sensitive phenomena resulting in high loss of productivity under high temperature. Heat stress inactivates the enzyme Ribulose-1,5-bisphosphate carboxylase, the enzyme responsible for carbon fixation during photosynthesis (Kumar, 2016). The photosynthetic products that should be translocated to different plant parts gets reduced under high temperature stress due to decreased membrane stability (Poudel and Poudel, 2020). Heat stress causes dehydration in plant tissues and eventually limits the growth and development of plants. If the temperature increases consistently wheat plants get exposed to heat stress and substantially decrease the water potential and relative water content in leaves and eventually reduce photosynthetic productivity (Akter and Islam, 2017). Heat stress causes protein denaturation, membranes un stability, degenerated RNA and cytoskeleton and altered efficiency of enzymatic reactions in the cell for which major physiological process obstacle and creates metabolic imbalance (Hasanuzzaman et al., 2013).

3.3 Impacts Of Drought Stress on Wheat

Plants are frequently exposed to drought stress that limits crop production worldwide (Lipiec et al., 2020). Agricultural water deficit arises from both insufficient rainfall and soil water during the growing season to sustain a high crop yield. Drought stress occurs when the humidity of the soil and the relative air humidity are low and the ambient temperature is high (Lipiec et al., 2020). If wheat plant experiences drought stress condition in its early stage then its germination rate decreases affecting optimal plant population. Drought during vegetative phase causes poor plant growth whereas drought during flowering phase causes pollen sterility and hamper grain set (Farooq et al., 2012). Drought and heat can reduce crop productivity and yields leading to lower income for farmers. Reduction in yield of 21% was noted for wheat (Lamaoui et al., 2018). Drought stress significantly decreased shoot dry weight, CO_2 assimilation rate transpiration rate and PSII photochemical efficiency. The effect of drought stress on CO2 assimilation rate (A), transpiration rate (E) and water use efficiency (WUE) has been investigated in many crops including wheat (Lamaoui et al., 2018). Water deficit condition caused by drought and osmotic stress effects changes the morphology, water relations, gaseous exchange and chlorophyll content which are connected with the onset of protective mechanisms in the plants (Jemaa, 2015).

4. Combined Impacts Od Heat and Drought Stress on Wheat

Various studies have suggested that the combined impacts of drought and heat stress had a significant harmful effect on wheat than individual stresses (Stress and Review, 2017). Under drought stress days to anthesis and days to maturity were reduced by 10% and 14% while under heat stress these were reduced by 16% and 20% respectively. Combined effect of drought and heat stress caused reduction in DTA by 25% DTH by and 31%. Overall, phenological processes are found to be were more affected by individual heat stress than individual drought stress (Qaseem et al., 2019).

5. Conclusion

Wheat is one of the major cereal crops of the world that rank first in terms of cultivation and third in case of Nepal. The national income of Nepal depends on the annual production of wheat as well. Heat and drought are the two major abiotic stresses faced by the wheat cultivars cultivated in Nepal. Heat stress is usually caused by late sowing of wheat. Similarly, wheat cultivated under rainfed condition faces an extreme drought stress condition in its different stages limiting productivity. Thus, in order to avoid heat stress condition in wheat we should adjust the panting time accordingly. Late shown wheat faces extreme temperature during anthesis and grain filling that leads to pollen sterility, reduced grain filling and low-test weight. Another abiotic stress heat stress is also responsible for low yield. A frequent irrigation of 2-5 time at different phonological stages is required by wheat in order to avoid drought stress condition.

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