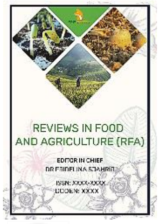
ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 2735-0312 (Online)
CODEN: RFAEAW

Reviews In Food And Agriculture (RFNA)

DOI: http://doi.org/10.26480/rfna.02.2021.69.72



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REVIEW ARTICLE

EFFECT OF ABIOTIC STRESS IN WHEAT: A REVIEW

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ARTICLE DETAILS

Article History:

Received 7 April 2021
Accepted 10 May 2021
Available online 11 May 2021

ABSTRACT

Wheat is the staple food in the Nepalese diet, and it is grown in most part of the country during the winter seasons. This brief analysis article discusses previous research and studies on the effect of abiotic stress on wheat. Different abiotic stresses induce a number of changes in plant metabolism, and several of these changes in plant in response to different abiotic stresses overlap. stress –induced metabolic changes cause crop growth to be impaired, resulting in low yield. Abiotic stresses are also an important factor that affects yield reduction, productivity decline, and net profit shrinkage according to long term research conducted by various researchers in various location .As a result abiotic stress such as drought, salinity, acidity, water logging and heat most be effectively addressed through management practices such as tillage and planting choices, residue management, sowing time, stress resistance cultivars, irrigation scheduling and integrated nutrient management to preserve natural resources while minimizing the negative effects and ensuring long term wheat output.

KEYWORDS

Abiotic stress, Wheat, Temperature stress, Drought stress, Salt stress, Mitigation strategies

1. INTRODUCTION

Wheat *(Triticum aestivium L.)* is a large cereal crop grown world wide in a number of agroecologies(Abhinandan et al., 2018)Due to its economic and social benefits, it is widely grown in Asia, particularly in China, India and Nepal. Wheat is used to produce rice, pasta,pastry, semolina, crumpets, flake, 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 (Mohammadii, 2015). The global wheat production volume in the marketing year 2020-21 was over 768.9 million metric tonnes(USDA,2021). Similarly, wheat production in Nepal was 2,210 thousand tonnes in 2020, up 5.73% on an annual basis(USDA,2020)

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 (Wania, 2016).

The key factor restricting wheat production in many regions is irregular rainfall which decreases average yield by upto 50% and sometimes more. One of the major abiotic factors limiting wheat production in Nepal has been described as drought stress. Wheat yields are decreased as a result of salinity (Mujeeb-Kazi, 2019).Water logging stress reduced the number of spikes per square meter, seed weight and number per spike, protein content, chlorophyll a and b levels and caused an increase in proline levels. As a result, Understanding the effects of these stresses is critical for wheat improvement programs that rely primarily on the genetic variations present in the wheat genome through conventional breeding.

1.1 Various Abiotic stresses and their effects in wheat

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 new abiotic stresses. Among various abiotic stresses, heat, drought, moisture and salt stresses are most prevalent. This section includes insight on the effects of various abiotic stresses on growth and physiology of wheat.

1.1.1 High Temperature Stress/Heat stress

Heat, drought, moisture and salt stresses are the most common abiotic stresses. The effects of various abiotic stresses on wheat growth and physiology are discussed in this section. Wheat is especially susceptible to heat stress during certain physiological growth stages (Dong et al., 2017). 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%(Ni et al., 2018). Heat stress causes pollen sterility, decreases carbon dioxide assimilation, and improves photorespiration in wheat, according to previous studies (Hlaváčová et al., 2017).According to(Wahid et al., 2007), high temperatures damage the photosynthesis process, which has a negative effect on wheat growth and yield(Asseng et al., 2011).

Increased temperature causes chloroplast structure to be disrupted, chlorophyll content to be reduced and chloroplast enzymes to be inactivated, possibly resulting in decreased photosynthesis in crop(Nuttall

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et al., 2017) . In response to heat stress, Wang et al. (2010) observed ultrastructure damage to chloroplast and thylakoid lamellae in wheat. Khan et al. (2013) discovered that heat stress decreased RuBisCo activity, photosynthesis nitrogen use efficiency (NUE), and net photosynthesis in wheat plants subjected to heat stress. High temperature has been reported to inhibit photosystem II there by hampering the photosynthesis apparatus in wheat(Djanaguiraman et al., 2020). Delays in germination and emergence can affect plant density and early crop establishment, resulting in high temperature during anthesis and seed set, which can result in significant yield loss (Almansouri, 2001).

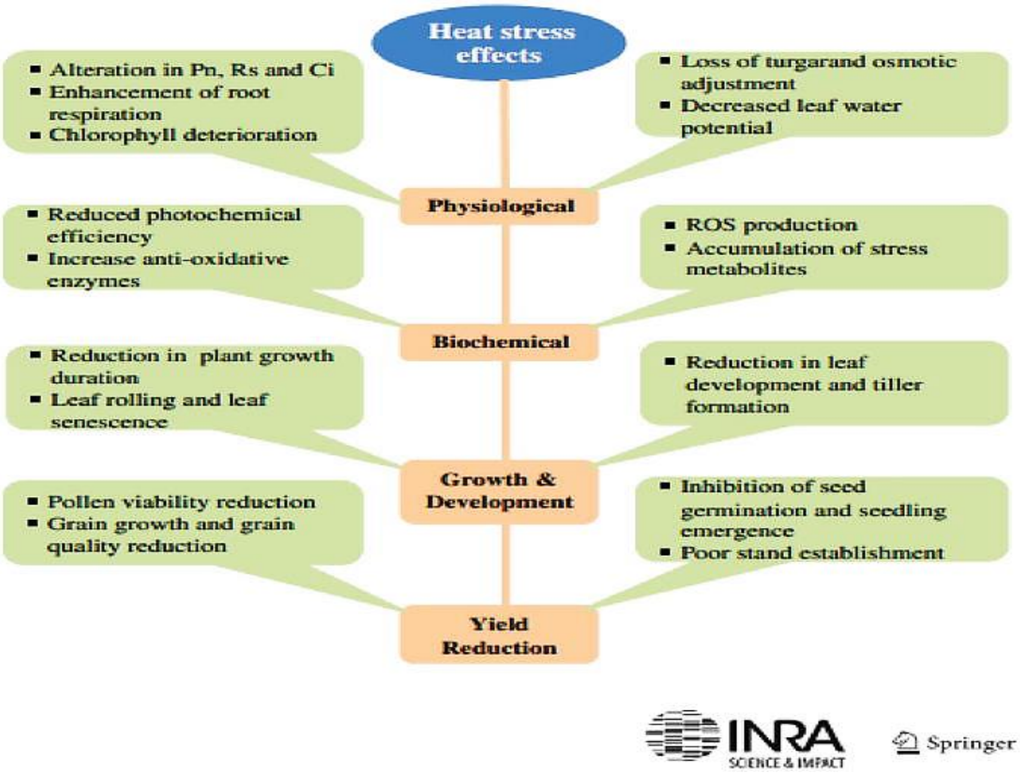

Figure 1: Heat stress effects and management in Wheat

Source: National Institute of Agricultural Research (INRA,1946)

Mitigation strategies

- Selecting optimum time of planting-It helps in avoiding high temperature stress during anthesis and grain filling.
- Use of mulch/Zero tillage-It helps to protect seedlings from temperature stress and conserve moisture.
- Use of sprinkler/drip irrigation- It helps in maintaining adequate soil moisture thereby reduces canopy/soil temperature.

1.1.2 Low Temperature stress

Frost damage decrease the number of kernels per spike during flowering and early grain growth in cereal. For each frost case, a thinner band forms on the spikes, awns become curly and spikes are upright near maturity due to lower grain weight. In both aestivum and durum wheat, low temperature during the anthesis stage increased pollen sterility, limiting pollen grain germination. Extremely cold weather cam induced sterility in as much as 98%of wheat (Bandyopadhyay, 2011). Wheat in its reproductive stage can be seriously harmed by freezing temperatures, resulting in a greatly reduced grain yield. As a result, best practices are required to reduce the negative effects of cold stress in wheat(Puri et al., 2015).

1.1.3 Drought stress

Drought stress is characterized as a lack of water that causes significant changes in morphological, biochemical, physiological, and molecular characteristics. All of this modifications make it difficult for plants to grow and harvest crops. Drought stress has a negative impact at any stage of development, and the magnitude of the negative effects is dictated by stage – specific stresses and the local climate(Ahmed et al., 2019) . More than half of the world's wheat - growing land is subjected to drought on a regular basis, resulting in production losses of up to 10%. Furthermore, as a result of global warming, a decline in precipitation and a rice in evaporation are predicted to increase the frequency and intensity of drought in future.

In terms of irregular climate change and rising temperature, Nepal is considered one of the most vulnerable countries. The pattern of rainfall is also becoming more predictable (Wang et al., 2013). As a result, average monthly rainfall has decreased by 3.7 mm(-3.2%) per decade(Ministry of Education,2020). Drought condition resulted as a result, especially rainfed farming, where farmers rely on monsoon rainfall for major agricultural activities(El Habti et al., 2020).The countries has been dealing with incessant dry spells since 2002, particularly in the monsoon years 2002 and 2004-2006(Subhani et al., 2011).

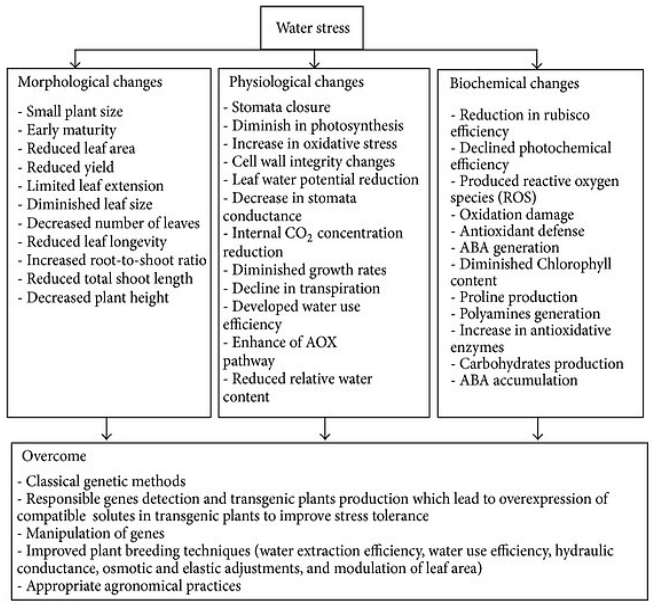

Figure 2: Drought Tolerance in wheat

Source: The information are provided from observations of Powell et al., Lawlor and Cornic, Shiran and Wan, Karthikeyan et al., and Russell et al.

Mitigation strategies

- Using drought tolerant varieties-It is important to identifying drought stress tolerant wheat genotypes, water stress conditions can be imposed to wheat at various stages of crop growth and development. The stresses can be given at tillering, booting and grain forming stages. Root system size (RSS) of wheat can be a selection target for drought tolerance.

- Agronomic Practices-There are many agronomical ways to manage drought stress such as control of field irrigation methods (surface or furrow, sprinkled and drip) and identification of drought resistance sources through developing screening methods under environmental conditions. So, for drought screening, not only analyzing sources of replications, variation among plots and repeated experiments are needed but also sprinkler irrigation, rainout shelters and evaluation of drought susceptibility index (DSI) are important.

1.1.4 Salinity stress

One of the most agonizing abiotic stresses, salinity, is to blame for a major decrease in agricultural productivity (Jan et al., 2017). It is one of the most destructive abiotic pressure, wreaking havoc on plant morphological, physiological and biochemical characteristics such as photosynthesis, nutrient absorption and yield(Hampson & Simpson, 1990). A variety of studies have revealed the affect on salt stress on various wheat cultivars, with some cultivars being salt tolerance and other being salt stress susceptible. 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. In response to salt stress, researcher observe seedling growth, seed reserve utilization, and weight. In two cultivars, salinity stress reduce relative water quality, chlorophyll and carotenoid content, biomass and grain yield, which may be due to increased oxidative stress in response to stress (Yang et al., 2014). At 150 mm NaCl stress, net photosynthetic rate, transpiration rate, stomatal conductance and sub-stomatal carbon dioxide concentration all decrease significantly.

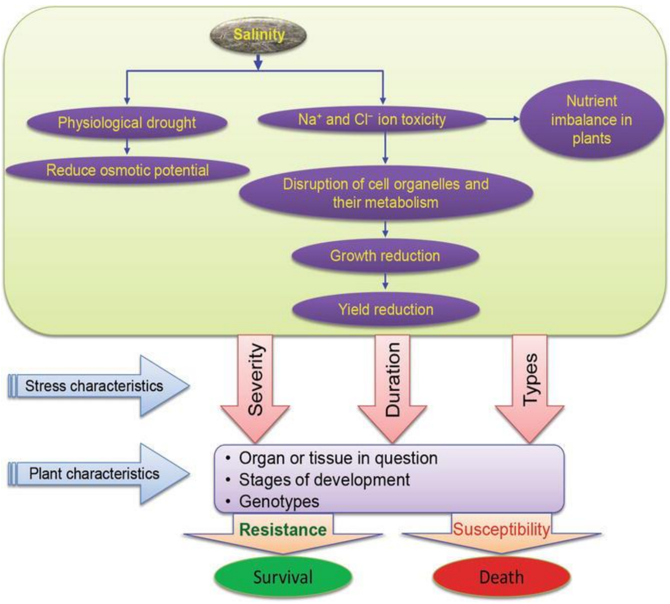

Figure 3: General scheme of salt stress response and adaptation in plants.

Source: Hasanuzzaman, M et al.,2017

Mitigation strategies

- Seed priming-Priming of *T.aestivum* seeds with choline (5 and 10 mM) reduced the damaging effects of NaCl(150 mM) by increasing the K+, GB accumulation, improved ion homeostasis and decreased Na+ and Cl- in both shoot and root.

- Use of plant growth hormone-The plant hormone auxin increased the germination percentage, shoots DW and maintained ion homeostasis under salt stress condition. Foliar application of GA3 also confers salt stress tolerance by upregulating antioxidant enzyme.

2. Conclusion

To sum up, the review paper emphasizes on the effect of abiotic stress in wheat production. With the increasing population, high production of wheat and other cereal crops can minimize the pressure of food insecurity all over the world especially in developing countries like Nepal. To meet the food demand of ever growing population, there is need to reduce yield losses due to various abiotic stresses like high or low temperature stress, drought stress, salt stress, nutrient deficiency or toxicity, depleting water quality etc. because of changing climatic conditions and exhaustive use of natural resources. Hence, there is further scope to increase the productivity of wheat through adaptation of suitable agronomic management practices like adjusting the time of sowing, selection of resistant genotypes, selection of appropriate planting method with respect to edaphic and climatic conditions of the area.

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