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Effect of Drought and Heat Stress on Growth and Yield and Quality of Wheat (*Triticum aestivum* L.)

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ABSTRACT

Many agricultural crops in various parts of the world are exposed to biotic and abiotic stresses such as heat and drought. Including the wheat crop, which is considered the first crop in the world, and therefore the seriousness of both stresses is represented in their threat to global food security. In terms of the impact on the rate of yield production and the contribution to reducing the production of wheat grains, where drought can be considered compared to other factors as the most dangerous factor in recent years due to climate change and lack of rain. Accordingly, agricultural specialists and researchers must work to reduce this potential risk by finding and developing agricultural varieties that are able to withstand and resist heat stress and drought, and that can produce a good amount of wheat under the pressures of both stresses, which is guaranteed by securing food globally. Through this research, we touched on the seriousness of drought and heat on the wheat plant, and showed some mechanisms of resistance and adaptation shown by the plant in those conditions.

***Keywords**:* Drought Stress, Wheat quality, Resistance

INTRODUCTION

Despite the existence of many cereal crops, the wheat crop still occupies the global throne of crops, in terms of cultivated areas, as it constitutes (17% of the global cultivated areas) compared to other grain crops. Accounting for 21% of food and 200 million hectares of farmland worldwide (Ortiz *et al.*, 2008). The demand for wheat is expected to increase by 60% by 2050 (Gomez *et al.*, 2021). It is also considered the main and basic food for about 35-40% of the world's population. It is also distinguished by its nutritional importance, as it covers 20% of calories and protein in human food (Kiss, 2011). As a result of the increasing population growth, this means an increase in the demand for the wheat crop, so one of the tasks of plant breeders is the continuous development of this crop to ensure that there is no shortage in global production in the future. The global population expansion rate is expected to increase to reach 8 billion by 2025, and the percentage will be slightly more From 9 billion by 2050, and therefore to meet the increasing numbers of population, the desires to manufacture food in the world will double (PRB, 2008; Heydari *et al*., 2009). Climate changes cause an increase in the concentration of pollutants, especially CO2 as well as the expansion of the hole in the ozone layer and global warming and the resulting rise in temperatures, the possibility of exposure of plants to many non-vital stresses, including heat stress and drought, which affect the plant in general. Heat stress poses a major threat to successful crop production in the world (Lobell and Gourdji, 2012; Bheemanahalli *et al.*, 2022). Define heat stress as a rise in soil and air temperature beyond a minimum threshold, while drought occurs when the soil moisture and atmospheric humidity are low and the ambient air temperature is high this condition is caused by the imbalance between the evapotranspiration flux and the water uptake from the soil (Beigzadeh *et al*., 2019; Lebeck *et al.*, 2013). Drought and temperature must be considered together because their combined effect is higher than if they were taken individually (Drezen *et al.*, 2012). As a result of the lack of rain in recent years and the scarcity of water resources, iarge losses occurred in the global production of the wheat crop as shown in Figure (1) in below.

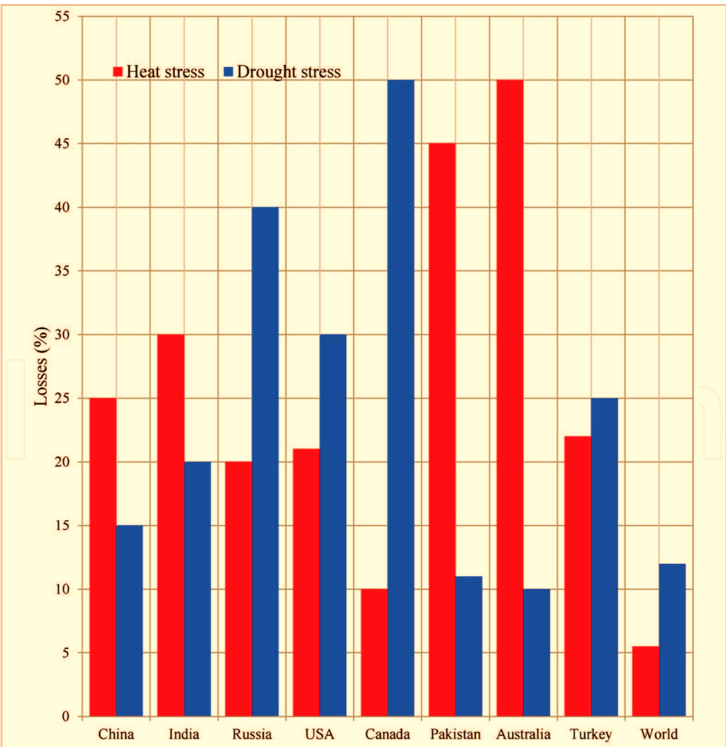

Figure 1. Estimated yield losses (%) of foremost wheat-producing countries due to heat and drought stresses (Muhammad *et al*, 2021)

RESEARCH METHODS

In this review electronic searches were conducted in many of databases such as (Direct science, Google scholar, PubMed, scientific journals, Wikipedia, eBooks) and searching in library sources, for the latest updates regarding the effect of drought and heat stress on growth and yield and quality of wheat.

Environmental stressors

Stress is any environmental factor adversely affect the life of living organisms (Grme, 1979). Among these stresses that living organisms, including plants, are exposed to be water stress and heat stress. (Sinha, 1996) gave precise definition of water stress as a decrease in the abundance of water in terms of quantity and method of distribution during the crop life cycle, which causes a decrease in production. (Jenks *et al*., 2007), explained that the best definition of drought tolerance for plant breeders is Water Productivity, which is an expression of the ability of water to produce a higher yield than the crop under drought conditions. Drought is one of the most important meteorological disasters affecting crop growth and productivity, and it has become one of the important reasons of agricultural land ecosystem degradation and yield reduction (Lesk *et al*., 2016). Heat stress (HS) is a major threat to global agricultural food security.

Growth, morphological and physiological variables under influence

Heat stress and dehydration he environmental stresses that the plant is exposed to are divided into two main groups, the first being the biological stresse which includes different pathogenic microorganisms (bacteria, fungi, and viruses), while the second is called abiotic stress, which includes temperature, drought, salinity, and high light intensity (Vickers *et al*., 2009; Ganjineh *et al*., 20019). Water stress is one of the most dangerous types of abiotic stresses that affect the growth, development and productivity of plants in many regions of the world, especially arid and semi-arid regions (Khan *et al*., 2009). It has become necessary to know the impact of water stress. In the growth stages to find a balance between the amount of water given and the yield, as well as to know which of these stages are critical and the most specific in the yield, water stress negatively affects the duration of plant growth and development, but the degree and nature of that damage depends on the severity and time of occurrence, the length of time the plant is exposed to it, and the growth stage in which the stress occurred, as well the genetic makeup (Ronco and Beltrrano, 2008).Under the influence of heat and drought, most of the morphological characteristics (leaf size, plant height, grain size and weight, root length, plant length, spike length) decrease. In light of the water shortage, cell elongation weakens by interrupting drift. Water from the xylem to the developing cells, resulting in reduced growth. Heat and drought stresses, lead to a decrease in the spike length, a rise in the spikelets or the biomass, and they are positively associated with each other as well as with the grain yield. (Hafiz *et al*., 1998; Gholipor *et al*., 2022) note a decreasing deviation in the root length ranging from 17.2-23.0 cm (normal) and from 15.3-17.7 cm (dry), and the length of the plant from 13, 2 - 29.2 (normal) and 11.0 - 25.0 cm (dry). Drought affects the growth of the plant as it contributes to the reduction of the leaf area and the shortening of the plant height, due to the inhibition of cell elongation and division, which negatively affects the yield of the crop per unit area. Under field conditions when water deficit and high temperature occur simultaneously, plant growth and performance decline rapidly, especially in tropical and subtropical environments (Wahid *et al.*, 2007; Feilinezhad *et al*., 2022). Where the structure of the leaves is affected by the high temperature and often leads to the growth of thinner leaves with a higher leaf area (Porter *et al.*, 2009). Combined heat, dehydration, and stress also reduce photosynthesis rate. Relative water content, membrane stability, and osmotic potential are maintained through a physiological mechanism of osmosis regulation, which loses its viability under both stresses. As an indicator of water condition, the relative water content is a significant determinant of heat and drought tolerance because it indicates the stability of the membrane and the balance between water supply and evapotranspiration. The willingness of plants to conserve a high capacity of water in tissues under drought avoidance, and the tolerance that determines the plants, willingness to water from a lack of water is called desiccation resistance (Blum, 2005).

Effect of heat stress, drought and combined stress on wheat production

Wheat production is diminishing exclusively or jointly due to abiotic stresses primarily heat and drought with a large part of the potential in the major wheat producing countries and globally at the same time. The average assessment of agricultural crop losses of 50% is due to abiotic dynamics, temperature at low latitudes, and drought stress common in most arid and semi-arid regions. Global losses of wheat due to heat and drought stresses include 5.5 and 12% percent, respectively. Elevated temperatures affect crops in various ways, including impaired germination and plant establishment, decreased photosynthesis, leaf senescence, decreased pollen viability, and consequently fewer grains with a smaller grain size (Ugarte *et al.*, 2007).The appearance of heat stress led to unusual losses in wheat yield in Australia and Pakistan, followed by India and China, while the effect of heat stress was evident in Canada, Russia and the United States. America and Turkey, while drought damage was severe in Canada, Russia and the United States of America, then followed by Turkey, India and China, while Pakistan and Australia remained on an equal footing. The frequency and magnitude of these losses may increase in the future because projections call for global temperatures to rise by 0.6-2.5°C by 2050 and 1.4-5.8°C by 2100, accompanied by an increase in drought intensity (IPCC). It has been reported in many studies that drought conditions affect agriculture in several ways, one of which is its direct impact on the productivity of the wheat crop (Arora, 2019). Drought is a natural hazard that may lead to a decline in agricultural production Drought and heat can reduce crop production and yields, leading to lower incomes for farmers. Yield declines of up to 40% for maize and 21% for wheat are observed at 40% water depletion (Darianto *et al.*, 2016). Thermal stress reduces the number of grains, which leads to a decrease in the yield index in wheat (Lukac *et al*., 2011). However, the effect of heat stress on both the number of grains and their size varies according to the different stages of growth that experience heat stress, for example, temperatures greater than 20 °C between the initiation of the spike and anthers accelerate the development of the spike. But it reduces the number of spikelets and grains per spike (Seminov, 2009).Heat stress negatively affects the pollen cell and microspore, which leads to male sterility (Anjum *et al.,* 2008). An increase in the day and night temperature at 20-31 °C may also cause grain shrinkage resulting from alteration of the aleurone layer and endosperm structures (Dias *et al.,* 2008). The optimum temperature for wheat germination and grain fullness ranges from 12 to 22 degrees Celsius (Shewry, 2009). Plants exposed to temperatures higher than 24 degrees Celsius during the reproductive stage led to a significant decrease in grain yield and the yield continued to decrease with an increase in the duration of exposure to high temperature (prasad and Djanaguiraman, 2014).

Wheat Quality

Heat and drought are factors determining the quality of wheat. Under protein amplification in temperature, which continued to be high due to the density of essential amino acids, sedimentation index, and the effect of condensation however, the strength of the douph decreased due to early ripening, which led to a shortening of its duration (Labuschagne *et al*., 2009). Under drought conditions, the nutritional value of protein and starch is negatively affected. In the end on the properties of dough for making bread (Tsenov *et al.,* 2015). Balla, 2011 was found that both dehydration and heat combined or dehydration alone had a much greater effect on protein G than heat alone. In the case of dehydration alone, the new observed negative correlation was realistic between the sizes of starch grains and the relative protein content, which indicates that this information contributes significantly to the bread quality of the flour because heat stress can reduce the grain group and combined with the accumulation of abscisic acid can increase the response of Compare with just one stress. All this indicates that the effects of heat and stress Dehydration is useful for some quality attributes such as ash and protein but at a cost Quantity to quotient because quality and quantity are inversely proportional to each other Among Protein components (glutin, gliadin, albumins and globulins), albumin and globulin have only a small effect on the quality of the dough, but glutenin and gliadin are responsible for the elasticity and extensibility of the dough, they reported a decrease in the proportion of gluten and globulin in flour, while the proportion of albumin and globulin did not increase proportionally response to heat and drought and by aggregation after anthesis. Heat stress significantly reduced starch biosynthesis in wheat grains but caused a significant increase in total sugar and soluble protein (Esther and Bhatia, 2014). Gluten is an important and essential part of wheat proteins for its main role in the process of manufacturing bread and other products. The gluten, which is the water-insoluble protein fraction, constitutes 85% of the total wheat protein.

Plant mechanisms of resistance to heat stress and drought

Many plants can resist heat and drought through certain mechanisms by which the plant can withstand stress or avoid stress. The physiological responses of plants to drought and heat stress can be classified into two different mechanisms. The avoidance mechanisms are basically morphological and physiological modifications that provide escape to water and heat stress, including This includes an increase in the root system, a decrease in the number of stomata and connection, a decrease in leaf area, an increase in the thickness of the leaves, and the rolling of the leaves at the bottom to reduce evaporation (Secher *et al.*, 2012; Maleki *et al*., 2014). Levitt, 1960 divided plants according to their tolerance to drought or water stress into two categories. The first category is plants that have the ability to grow and develop in drought conditions, the second category is plants that have the ability to survivor, these were divided into drought avoidance and drought tolerant plants, and stress avoiding plants were divided into drought escaping plants and drought tolerant water storage plants. While May, 1962 identified three mechanisms that the plant may perform to resist stress, the first is escaping from stress or drought, i.e. the ability of the plant to complete its life cycle before exposure to stress, such as annual plants, and the second is avoidance of stress or drought, i.e. the ability of the plant to live in conditions Drying while maintaining water content. High in the drought stage thanks to the deep root system or by reducing transpiration, which are generally succulent plants. As for the third, they bear stress or drought, which is living in drought conditions with a low internal water content in drought that has the ability to recovery and rapid growth when water is available to the soil. Plants have resistance or tolerance to drought or stress, through some characteristics Physiology, such as reducing the water potential of its tissues in order to pass the gradient of water potential in favor of the plant, and it includes:

1-Negative water potential of its tissues and thus maintain the gradient of water withdrawal in favor of the plant. The role of this process has been confirmed in many studies, including a study (Morgan, 1988), as he indicated that it is possible to rely on the process of osmosis regulation in Resistance of wheat genotypes in the field of drought tolerance.
2- Increasing the elasticity of the roots, due to the small size of the cells, which leads to the accumulation of solutes.
3- Changes in the plasticity of the root through a change in certain compounds that lead to change root elasticity.

DISCUSSION

In this research, we provide a comprehensive overview of the effects of heat stress and drought on wheat plants in regions suffering from high temperatures and water scarcity. We found that there are negative effects on crop yield while quality is better. We also found that plants have established mechanisms to resist heat and drought the temperature is as follows
1- Water retention through morphological and anatomical transformations.

a- Closing the stomata, as it reduces the water lost through transpiration, and this may be in two ways, either by closing the stomata before losing a large amount of water from the tissues, or Keep the stomata closed for some time after absorbing the water as the stomata are able to open without being subjected to stress.

b- Changes in the surface area of the leaves, such as reducing the area, falling leaves, producing small and thick leaves and accelerating the death of the old leaves.

c- Changes in the values of radiation absorbed through leaf curling and changes in Inclination angle.

d- Increasing the thickness of the coctail layer and increasing the percentage of fatty substances on the surface Presence of capillaries and recessed stomata.

2- Rapid absorption of water through acclimatization of the roots through the rush of the roots To the depths of the soil to extract water or increase the efficiency of the root in absorbing water in a certain space through changing the permeability or morphological modifications in the roots and increasing the ratio of the root system compared to the vegetative system under stress conditions. The plant’s tolerance to drought is enhanced through more comprehensive root systems (Rizza et al., 2004).

CONCLUSION

Through the above research, it was found that the most important growth stage in relation to the water needs of wheat and affected by drought was the preparation period for flowering, because the lack of water in the flowering stage affects pollination and fertilization and reduces the amount of seeds and thus affects the production of yield.

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