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Review Article

MECHANISM OF DROUGHT STRESS TOLERANCE IN WHEAT

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***Abstract*:** *Wheat is one of our major cereal crops worldwide, facing different challenges. Drought is a combination of adverse effects because of global warming and climate change. About ¼ of the world is under these effects, which were not under consideration till 2019. This article will discuss multiple harmful effects on our major cereal crop, wheat. The retarded growth and overall yield of 39% have a great effect on the economy of any country. No doubt, the plant itself has natural mechanisms to alleviate the adverse effects, but long-term and periodic stresses greatly affect wheat's gene pool. Some goods are involved in improving wheat plants, which are briefly described in this article.*

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Keywords: wheat, drought, cereal, climate change, gene pool

Introduction

Wheat, being a major cereal crop, is widely cultivated and utilized all over the world. At the end of 2022, FAO presents the annual report of wheat production, which contributes 38% stock-to-use ratio by producing 781.1 million tons and 194.0 million tons used for trade (Nations, 2022). Global climatic changes are predicted to quicken in the coming 10 years due to the continued increase of overall temperature and the earth's atmospheric CO2 levels that change the patterns of our natural rainfall and distribution (Atif et al., 2022; Balqees et al., 2020; Masood et al., 2022; Naseem et al., 2020; Yin et al., 2018). Gradual increase in the earth's temperature and CO_2 leads to a high evaporation rate and land moisture in the air, which becomes a cause of the drought. As reported by Intergovernmental Panel on Climate Change (IPCC), "Drought is a continuous lack or obvious scarcity of rainfall and a scarcity of rainfall fallouts in the shortage of water for activities of some groups or a period of sufficiently prolonged abnormal dry weather for the lack of humidity to cause a serious hydrological break. About one-third of the world is facing droughts due to a lack of precipitation. The Organization named as Global Drought Observatory (GDO) released a report on August 22, 2022 that said 2/3 area of Europe is under an alarming drought condition, the water level has dropped to 28% in Spain, Lake Powell is now at its lowest level at just 26% of capacity, its lowest point since 1967 (EarthSky.org, 2022).

Based on environmental changes in the environment, the plant could face many stresses and Stimulations (SS) that may adversely affect growth and developmental regulations. (Battaglia et al., 2019; Bukhari et al., 2019). Multiple changes in expression genes and metabolism changes in plants allow them to continue their life spans under these circumstances (Ahanger et al., 2017; Farooq et al., 2021; Iqra et al., 2020; Mostofa et al., 2018). , The quality of seed grains and yield, can be affected by drought stresses and high demand for wheat in the world, it requires intensive care for higher biological yield. Thus, examining the abilities of plants to tolerate water limitation is fruitful, and is constantly absorbing attention for the future, particularly in arid and semi-arid areas. (Sobhanian et al., 2020). Fodder and sugar-cultivated crops require adequate moisture in soil and air for their potential growth, lowering the potential of water in the cell in ariel parts of plants such as leaves. The gradual increases in the rate of leaves senescence and drooping, burning, rolling of leaf and delicateness, etiolation, drooping, turgidity, immature falling, and turning into yellowish leaves are the universal indications of drought stress in plants (Khan et al., 2018; Rafi et al., 2022; Ruehr et al., 2019; Sarwar et al., 2022; Tahir et al., 2020).

Effects of drought on wheat

Some basic ecological factors, including an interval of drought, strength and occurrence of drought, characteristics of soil, conditions and stages for growth, and species of plant, strongly affect the degree and time of symptoms related to drought in plants (Ammar et al., 2022; Iqbal et al., 2021; Zoghi et al., 2019).

Vegetative effects

Wheat seedling is highly sensitive to heat, and drought stresses, decreasing out 1000 grain weight, and altering protein contents and quality at the reproductive and developing stage of grain. Recent studies showed that grain yield, yield components, the height of the plant, area of the leaf, the weight of dry matter in grains and harvest index (HI) decrease by drought stresses and normal under proper-irrigation treatments. Overall yield is decreased in cultivated, synthetic, hexaploid wheat shown in Table 1 (Wang et al., 2017).

Table 1. Effect of yield parameters in reduction with comparing growth of hexaploid wheat under favorable conditions.

Site of effect	%Age of reduction under drought stress
Numbers of grain	16%
Leaf area	30%
Plant height	19-24%
Number of tillers	26%
Above ground Dry weight (AGDW)	27%
Root dry weight (RDW)	29%
Overall Yield	39%

Reproductive effects

At any reproductive stage, drought has vulnerable effects on plants and reduces grain yield. (Saini & Westgate, 1999). Injury due to drought occurs during the initiation of flower, gametophyte development, pollination, initiation of grain, and growth of grain (Saini & Westgate, 1999). The effect of drought in wheat starts at the flowering initiation stage, which is found in all cereals still examined, and is centered around the main dividing cell; pollen mother cell (PMC), where meiosis occurs but tetrad breaks up. In female floral organs of wheat, this period bears a similarity to the meiosis, which takes place in the megaspore mother cell (MGC) and the succeeding deterioration of these three redundant megaspores out of 4 cells; tetrad (Bennett & Hughes, 1972; Idrees et al., 2022; Mazhar et al., 2020; Zahoor et al., 2022). These incidents changed the patterns of inflorescence and timings of flowering, ultimately retarded the growth of the flower. The apical part, the spike of wheat, is highly sensitive to water deficiency during its vegetative and reproductive growth stages. (Husain & Aspinall, 1970).

Mechanism of drought Tolerance

Different adaptive mechanisms that plant has developed in its body through evolution to minimize the dangerous effects of drought stress (Batool et al., 2020). Resistance against drought stress ends with escape, avoidance, and tolerance ,which a wheat plant follows to prevent its exposure to drought (Aslam et al., 2015).

Stress Escape Mechanism

This mechanism involves the plant's response to drought to grow faster, shortening its reproductive and vegetative cycle, early flowering, and self-reproduction (Álvarez et al., 2018). By evolution, the plant's learning behavior makes its growth faster before the start of the driest time of the year. By this mechanism, a plant can imply shortened growth periods which ultimately cause a reduction in yield (Blum, 2011; Seleiman et al., 2021).

Avoidance Mechanism

Naturally, Drought sensitive Plants have limitations in their activities. Some plants like xerophytes have -established roots and stems with extra cuticle waxy layer, which prevent it from losing water. (Boulard et al., 2017). In the absence of sufficient water availability, wheat plants choose an avoidance mechanism by reducing stomatal transpiration and absorbing more water by penetrating deeper through a well-established root system (Dobra et al., 2010). These activities reduce the plant productivity and average size of the plant in terms of vegetative and reproductive growth (Fatima, Saeed, Khalid, et al., 2022; Fatima, Saeed, Ullah, et al., 2022; Seleiman et al., 2021; Wasaya et al., 2018). On the same side, the adaptive mechanism reduces the leaf area and increases numbers. However, the Root system of the wheat plant also alters, including size of the root, roots' density, root length, proliferation, expansion and growth rate, which assist the plant against drought stress (Ali et al., 2014; Balqees et al., 2020; Tzortzakis et al., 2020).

Tolerance Mechanism

Tolerance is based on the plant's potential and is a complex process that evolves from an adaptation from multiple physiological and molecular stages. However, Wheat plants tolerate the stress of drought by changing in itself shown in **Error! Reference source not found.** (Aslam et al., 2015).

Table 2: Tolerance Mechanism in wheat Plant involving different methods

Mechanism	Action in Plant
Osmotic adjustment	it involves the adjustment of the water gradient by adding more solute in the cytoplasm, which helps to maintain the water potential of water in the cell
	Glycine betaine is an organic, non-toxic, and hydrophilic compound which plays a vital role in tolerance against drought, cold, salt affected land, and heat. It also helps protect the apparatus of photosynthesis, helps to stabilize cellular proteins called (Rubisco), which reduces the load of reactive

	oxygen species and acts as osmoprotectant.
Antioxidative Defense Mechanism	Antioxidants are chemicals which assist in the protection of oxidation of molecules by hunting reactive oxygen species and help to prevent oxidative damage caused by reactive oxygen species.
	Some enzymatic and non-enzymatic compounds are antioxidant defence systems. Enzymatic components are of catalase (CAT), superoxide dismutase (SOD), glutathione reductase (GR), ascorbate peroxidase (APX), peroxidase and polyphenol oxidase while non-enzymatic antioxidant compounds are α-tocopherol, ascorbic acid, β-carotene, glutathione, and cysteine
Growth Regulators	Plant essential hormones, also called plant growth regulators, Phyto-hormones, and growth enhancer, are those chemical substances which assist the growth and development of plants body. Hormones act as signaling molecules, trigger cellular differentiation, act locally at the site of origin or transported to distant targets.

Methods of making wheat drought-resistant

Drought resistance is improved in wheat by biotechnology and conventional breeding methods (Galaitsi et al., 2016).

Conventional Breeding

Conventional breeding methods involve selection and breeding strategies to enhance the frequency of drought resistance genes from germplasm (Ali et al., 2013; Ali et al., 2016; Seleiman et al., 2021). Some methods like mass selection, pure line selection, pedigree selection and backcrossing methods are desirable in developing drought resistance variety. Classical breeding is an effective approach for selecting offspring to express the characteristics in improved drought tolerance in diverse environments (Aaliya et al., 2016; Ahmad et al., 2021; Ali et al., 2017; Araujo et al., 2015). Backcross in wheat for the improvement of drought tolerance is shown in Figure 1 Backcross in wheat.

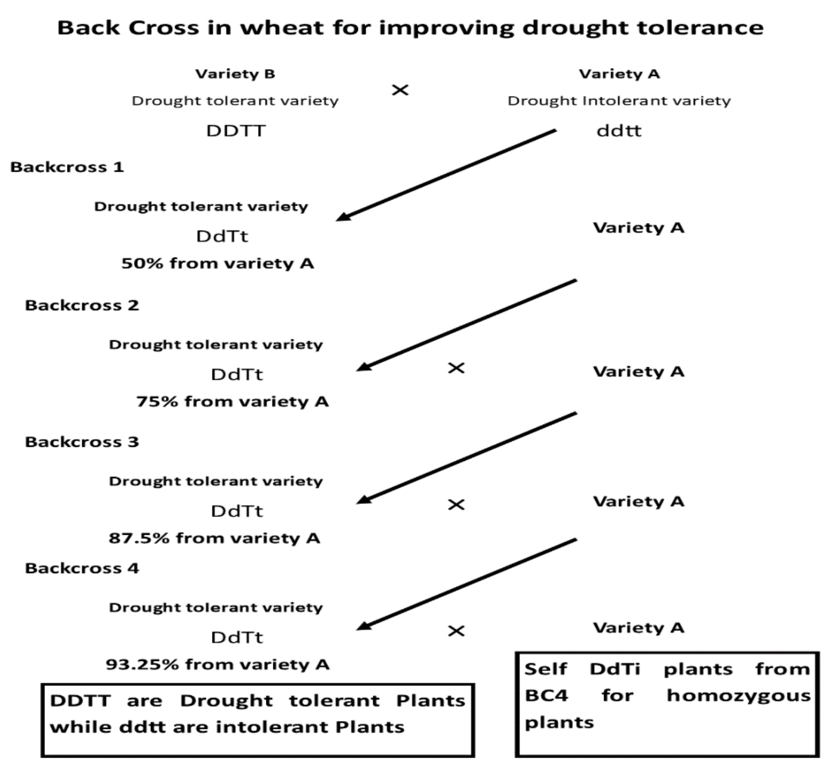

Figure 1 Backcross in wheat

Traditional Breeding: In recent studies, multiple processes have been found to improve drought tolerance. Some tools are used for the enhancement shown in

Figure 2 Gene tools used for assessments of drought resistance. (Wang et al., 2021)

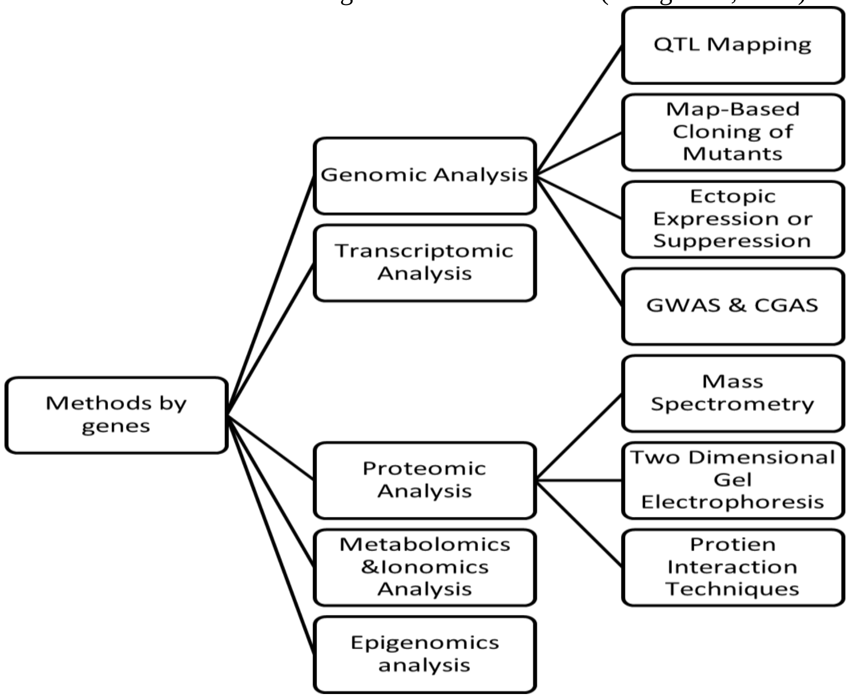

Figure 2 Gene tools used for assessments of drought resistance

Genes Responsible for Drought resistance in wheat

Some known genetic, molecular markers like CDO395 and BCD1661 are associated with high grain yield, which claims high-yielding selection for drought tolerance through marker-assisted selection (MAS) (Nachit et al., 2000). Some genes responsible for high yields invented during trails at field are; TaNAC69 which help enhance tolerance against drought (Azhar et al., 2021; Balqees et al., 2020; Budak et al., 2013; Seleiman et al., 2021), F-box gene TaFBA1 (Zhou et al., 2014).

Induction of Drought Resistance

Plants and agriculturists adopt various methods and strategies to minimize the dangerous effects of drought by applying exogenous regulators, chemicals, synthetic hormones and compounds. (Seleiman et al., 2021).

Method	Action
Seed Priming	The main aim of this early sowing technique is to start the process of germination in the seed's metabolism and prepare the seed for radicle flange without radicle emergence from its seed (Asif et al., 2020; Ghafoor et al., 2020; Nawaz et al., 2013). Osmopriming maintains RWC of the wheat plant, increases the accumulation of proline, and chlorophyll and helps in the emergence of the leaf (Ashraf et al., 2022; Farooq et al., 2013; Naseem et al., 2020).
Plant Growth Regulators	Growth regulators or growth enhancers are natural or synthetic compounds that can help drought tolerance (Ashraf & Foolad, 2011; Sarwar et al., 2021). In wheat, application of GA in the water-deficit areas results in higher grain yield, stomatal conductance, respiration and photosynthesis rate (Javid et al., 2011; Nawaz et al., 2017).
Osmo protectants	When growing conditions are not suitable for plant growth and development, these are naturally occurring compounds in plants which accumulate and act as maintainers of plant internal physiological conditions (Munir et al., 2022; Rafi et al., 2022)(Brito et al., 2019; Hasanuzzaman et al., 2019).
Selenium; As An Antioxidative Protectant	Element selenium (Se) can result in the solutes in the plants grown under drought conditions and also cause a reduction in the oxidative stresses in the plants. Through the accumulation of osmolytes can reduce the cellular dehydration of plants (Ebeed et al., 2017).
Plant Microbes Crosstalk	Microorganisms play important roles in reducing the harmful effects of drought stress, thereby improving plants' productivity. (Khan et al., 2020). In wheat, Azospirillum brasilense NO40, Mesorhizobium ciceri (CR-30 and CR39), and Rhizobium phaseoli (MR-2) help in Catalase, exopolysaccharides and IAA production by the Rhizobia which improve the growth and drought tolerance index. (Kasim et al., 2013; Seleiman et al., 2021).

Conclusion

Under these present climatic changes, biotic (living) and abiotic (non-living) stresses are serious peril for food security globally, and plants yield and production sustainability. Between the abiotic stresses, drought stress is gaining high consideration due to its drastic effects on plant growth, their developments, reduction in the yield of plants, and biological biomass causing food insecurity globally. Drought stress has adverse effects on plants throughout their life spans, from germination until maturity. In this article, we learnt about how drought has dangerous effects on wheat productivity. But on the same hand, scientists are working hard for the improvement to aid food security worldwide. The role of genes is a great ability to respond and maintain crop yield. Different induction methods, as described above, can also help to neglect the adverse behavior of drought while keeping our crop healthy and sustainable.

Conflict of interest

The authors declared absence of conflict of interest.

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