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Impact of drought and genetic drought resistance in crop plants

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ABSTRACT

Among abiotic stresses, drought is the most severe abiotic stresses in many parts of the world and is one of the grand problem in present-day climatic scenario. Drought is the prominent environmental stresses, which significantly hampering crop yield and its quality in the world. Climate change increases the odds of worsening drought in many parts of the world in the decades ahead, which damage the crop that has occurred because of abnormal metabolism and may reduce growth and death of crop development. The physiological activity of the crop also influenced by water stress through suppressing photosynthesis and the consumption of assimilates in the expanding leaves.Crop production is determined by the existence of sufficient rain fall, especially in areas where crop production is totally relied on rain fall, there is always risk of crop failure or yield loss due to moisture stress. In severe cases, the moisture stress could lead to total crop loss. Drought stress occurs at different stages of growth and adversely affect yield and yield related traits, which lead to reduction in yield. The effect of drought stress is mainly depending on the developmental stage of the plant, degree and duration of the stress, genotypic capacity of species and environmental interactions. Crop plants have adaptation strategies to survive under drought stress by the development of various morphological, physiological and biochemical mechanisms. However, a plant may exhibit more than one strategy to cope with drought stress. Drought resistance is the mechanism(s) causing minimum loss of yield in a drought condition. Drought escape, dehydration avoidance, reduced transpiration or physiological factors are some drought resistance mechanisms. Eventually, the global food security is threatened by climate change and the most challenging in the 21st century to supply sufficient food for the increasing world population. The use of well-adapted and high-yielding varieties with resistance to drought stress is important to reach maximum yield potential as long as possible through minimizing the risk of climate change. Climate-smart agriculture is the only way to reduce the negative impact of climate variations on crop adaptation, before it might affect global crop production drastically.

Keywords: Drought resilience; Yield loss; Resistance; Genetic bases; Climate smart; Food security.

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Introduction

The growing global population coupled with the increasing challenges of climate change, limited arable land and environmental stressors pose significant threats to global food security. Meeting the ever-rising demand for food requires innovative approaches to enhance crop productivity while minimizing the environmental impact of agricultureclimate (Lesk *et al*., 2016).Global food security is being haunted by the rapid increase in population and drastic changes in the climate (Lesk *et al*., 2016). In the wake of changing climate, drought and heat stress have become the most important limiting factors to crop productivity and ultimately the food security. The reduced precipitation and changed rainfall patterns are causing the frequent onset of droughts around the world (Lobell *et al*., 2011). Severe droughts cause substantial decline in crop yields through negative impacts on plant growth, physiology and reproduction (Barnabas *et al*., 2008).

Plants are subjected to the drought conditions when either the water supply to the roots is limited or the loss of water through transpiration is very high (Anjum *et al*., 2011). The severity of the damage caused by the drought is generally unpredictable as it is driven by various factors including the rainfall patterns, moisture-holding capacity of the soil, and water losses through evapotranspiration.Drought interferes with growth, nutrient and water relations, photosynthesis, assimilate partitioning and ultimately cause a significant reduction in crop yields (Farooq *et al*., 2009). The plant

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response to drought stress generally varies from species to species depending on plant growth stage and other environmental factors (Demirevska *et al*., 2009).

Drought is one of the major environment constraints that limits agricultural production worldwide and leads to the lack of adequate moisture that is required for normal plant growth and development and to complete their life cycle (Chen *et al*., 2020). Drought stress severely affects the plants by causing substantial reductions in the crop growth and biomass accumulation. The main consequences of drought stress in plants are the reduced rate of cell division and expansion, root proliferation, stem elongation and leaf size. Drought also disturbs the stomatal oscillations, plant water and nutrient relations that result in declining the crop productivity, and water use efficiency (Anjum *et al*., 2011). Drought is a significant limiting factor for agriculture, and it is the leading cause of crop yield reduction. The identification of genetic factors involved in plant responses to drought stress will pave the way for breeding drought-resistant plants.

Food productivity is decreasing due to detrimental effects of various biotic and abiotic stresses; therefore minimizing these losses is a major area of concern to ensure food security under changing climate. Environmental abiotic stresses, such as drought, extreme temperature, cold, heavy metals or high salinity severely impair plant growth and productivity worldwide. Drought being the most important environmental stress, severely impairs plant growth and development, limits plant production and the performance of crop plants, more than any other environmental factor (Shao *et al*., 2009). Plant experiences drought stress either when the water supply to roots becomes difficult or when the transpiration rate becomes very high. Drought impacts include growth, yield, membrane integrity, pigment content, osmotic adjustment water relations, and photosynthetic activity (Praba *et al*., 2009). Drought stress is affected by climatic, edaphic and agronomic factors. The susceptibility of plants to drought stress varies in dependence of stress degree, different accompanying stress factors, plant species and their developmental stages (Demirevska *et al*., 2009).

There are multiple production constraints, particularly rapid population growth and climate changes are two critical issues that require immediate action to achieve sustainable development goals. The rising population is posing increased demand for food, thereby pushing for acceleration in agricultural production. Therefore, increasing crop yield is required to meet the needs of increasing population growth, however yield reduction is observed in areas where drought is predominantly devastated crop production. Short duration drought stress mostly reduces grain yield while prolonged drought stress leads to complete death of plant. Improving the crop traits is highly required for the development of superior crop varieties to deal with climate change and the associated abiotic and biotic stress challenges. Climate change-driven global warming can trigger higher insect pest pressures and plant diseases thus affecting crop production sternly. The traits controlling genes for stress or disease tolerance are economically imperative in crop plants.

Generally, drought is a periodic phenomenon that endangers crop yields and threatens the livelihoods of populations all over the world (Liedtke *et al*., 2020). The development of droughtresistant crop varieties through breeding or biotechnology is a major challenge for agriculture. Understanding how drought affects plants is therefore crucial for designing superior cultivars with consistent high yields. Plant responses to drought stress, on the other hand, are complicated and vary based on environmental conditions, stress frequency and duration, plant species and variety, and physiological stage at the time of stress. Drought limits the agricultural production by preventing the crop plants from expressing their full genetic potential. Global climate change gives rise to numerous environmental causes including biotic and abiotic stresses, which affect crop productivity (Raza *et al*., 2023). Among them, drought stress is a destructive natural threat to food security, affecting a substantial fraction of the overall population, mainly those living in arid and semi-arid areas (Rai *et al*., 2021).

Drought stress can usually be described as a prolonged time of irregular, lower-than-average natural water accessibility because drought stress mainly occurs from a substantial shortage in humidity supply as precipitation. Generally, plants are exposed to the drought stress when (a) the water transfer to the roots is inadequate or (b) the water loss via transpiration is extremely high

(Cheng *et al.*, 2021). The damage resulting from drought stress severity is usually unstable, as several aspects such as the rainfall forms determine it, moisture availability in soil, and water deficiencies because of transpiration. Consequently, drought stress hinders crop growth, water-nutrient relations, and photosynthesis and eventually triggers a substantial decline in crop yields (Mubarik *et al.*, 2021). Plant responses to drought stress usually differ from species to species, varying on growth phase and further environmental influences (Ansari *et al.*, 2019).

Drought stress is a critical agronomic issue that causes severe production losses around the world. Developing crops that are well adapted to drought-prone environments could help to alleviate this agricultural constraint. The mechanisms that allow this crop to thrive in such severe environments are complicated and poorly understood. Drought in agriculture, specifically water scarcity, has a negative impact on plant and crop productivity by reducing leaf size, stem extension, and root proliferation, disrupting plant water and nutrient relationships, and diminishing water-use efficiency. During periods of severe drought, these losses can be significantly larger, and crop failure is a distinct possibility. Drought is a major constraint in sorghum production around the world, and it is the leading cause of crop yield reduction (Sabadin *et al.*, 2012).

To cope with drought stress, plants reprogram a wide range of responses at the molecular, biochemical, and physiological levels (Thatcher *et al.*, 2016). Depending on the tissue type, developmental stage, and stress level, these changes can happen rapidly and with a lot of precision. At the molecular level, drought stress causes transcriptional and post-transcriptional regulation of gene expression (Takahashi *et al.*, 2018). Differential expression of genes involved in various metabolic pathways is caused by transcriptional modulations, resulting in changes in metabolite flow and physiological changes associated to cellular damage protection (Knight H and Knight M.R, 2001).

In the process of evolution, plants have developed complex regulatory networks to cope with drought, including drought escape, drought avoidance, drought tolerance, and drought recovery after stress. Three mechanisms, namely, drought escape, drought avoidance and drought tolerance are involved in drought resistance. Various morphological, physiological and biochemical characters confer drought resistance. Morphological and physiological characters show different types of inheritance pattern (monogenic or polygenic) and gene action (additive and non-additive), whereas the genes responsible for biosynthesis of different compatible solutes have been identified and cloned from plants, yeasts, mouse and human. Different breeding approaches for drought resistance have emerged with their merits and demerits. Efficient screening techniques are pre-requisite for success in selecting desirable genotypes through any breeding program.The objective of the paper was to understand the impact of drought stress and genetic drought resistance mechanism under water-limited environments.

Drought Resistance Mechanisms in Crop Plants

Plants are influenced by both biotic and abiotic factors, and in response to these factors, numerous internal changes occur in plants. These biotic and abiotic factors influence plant growth and development along with productivity. Biotic factors are interactions of organisms with plants that have both positive and negative effects. Positive effects may have a beneficial influence on plant growth. Negative effects may include allelopathy, herbivory influence, or pathogen infection in plants (Ciura and Kruk, 2018). Plant defense systems with various chemical compounds help to resist those negative effects (Li *et al.*, 2019).

Drought resistance is mechanisms causing minimum loss of yield in a drought environment. Different mechanisms through which a crop is capable of minimize the loss in yield due to drought stress. In response to drought stress, plants activate their drought response mechanisms, such as morphological and structural changes, expression of drought-resistant genes, synthesis of hormones, and osmotic regulatory substances to alleviate drought stress.Drought resistance or tolerance is a broader term applied to plant species with adaptive features that enable them to escape, avoid, or tolerate drought stress (Levitt, 1980).

Critical evaluation of progress in plant breeding over a period of several decades has demonstrated a genetic improvement in yield under both favorable and stress conditions (Castleberry, Crum & Krull, 1984). The yield improvement under drought stress occurred before many of the physiological issues of drought resistance were understood and resulted partly from the genetic improvement of yield potential and partly from the improvement of stress resistance. For example, Bidinger *et al.* (1987) found that the yield of millet varieties under drought stress was largely explained by their yield potential and growth duration. Early varieties with a high yield potential were most likely to yield best under stress. Fischer & Maurer (1978) also recognized the effect of potential yield on yield performance of wheat under drought stress and proposed a 'susceptibility index' (S) which estimated the relative susceptibility of a variety to drought stress. In analyzing their wheat data, they found that susceptibility index was not very independent of the potential yield of the variety.

The improvement of yield under stress must therefore combine a reasonably high yield potential (Blum *et al.*, 1983) with specific plant factors, which would buffer yield against a severe reduction under stress. On the other hand, potentially lower yielding genotypes occasionally have been found to perform very well under drought stress conditions especially under severe drought stress (Blum, 1982). One is left with the long-standing practical conclusion of Reitz (1974) that 'Varieties fall into three categories: (a) those with uniform superiority over all environments; (b) those relatively better in poor environments; and (c) those relatively better in favored environments'.

Drought Escape: The simplest way of survival under drought conditions is to escape drought. Generally, drought occurs either in the mid or late-crop season. Drought escape is most common in case of plants grown in desert regions. They complete their life cycles in 4 to 6 weeks. Drought escape also plays an important role in some crop plants. For Example, yields of early varieties of wheat, sorghum, maize, and rice arc less affected by severe drought than late maturing ones. All these crops have determinate growth habit. In spring wheat, late maturing varieties give higher yield than early types especially when drought occurs early in the season and is over before anthesis.

Drought Tolerance: The ability of crop plants to withstand low tissue water content is referred to as drought tolerance. Drought tolerance is more desirable because the crop can produce more yield at lower water potential. In cereals, drought tolerance generally operates during reproductive phase. Tolerant cultivars exhibit better germination, seedling growth and photosynthesis. In Sorghum, a drought resistant line exhibited higher photosynthetic rate at leaf water potential than a less drought resistant line. Drought tolerance differs from drought avoidance in several aspects.

Table 1: Traits associated with drought tolerance

No	Category	Traits
1	**Morphological &Anatomical**	Yield; More Root length, Root Volume, Root Dry Weight, Root Thickness; Root surface area, More Plant Biomass; Harvest index; Leaf drying; Leaf tip firing; Delay in flowering.
2	**Phenological**	Early to maturity, Late Flowering; Anthesis, Silking Interval; Seedling vigor; Weed competitiveness; Photosensitivity; perennially.
3	**Physiological & Biochemical**	Osmotic Adjustment; Carbon Isotope Discrimination; Stomatal conductance; Remobilization of stem reserves; Specific leaf weight; ABA; Electrolyte leakage; leaf rolling, tip firing, Stay-green; Epicuticular wax; Feed forward response to stress; Heat shock proteins; Cell wall proteins; Leaf water potential; Water use efficiency; Aquaporins; Nitrogen use efficiency; Dehydrins.

Drought Avoidance: Drought avoidance refers to ability of the plant to maintain a favorable internal water balance under moisture stress. In other words, plants that avoid drought retain high water contents in their tissues. Drought avoidance can permit a longer growth period in the crop through reduced water use or increased water uptake. However, drought avoidance leads to reduction in photosynthesis and thereby reduction in the growth of aerial parts. It leads to increase in root development and therefore, is more important than drought tolerance. In cereals, drought avoidance operates during vegetative phase, while tolerance operates during, reproductive phase. Drought avoidance mechanisms are of two types. First,those that reduce water loss through transpiration. Such features include stomatal characteristics and shape, size and orientation of leaves. The second, those that maintain water uptake during drought period.

Drought Resistance: Drought resistance is the sum of drought avoidance and drought tolerance. In other words, drought resistance refers to the ability of crop plants to give good yield under moisture deficit conditions. Drought resistance is measured in terms of various mechanisms associated'; with drought tolerance and yield under soil moisture deficit. In winter wheat, both avoidance and tolerance features are important for drought resistance.

Major Traits Contributing to Drought Resistance

A range of morphological and physiological traits have been linked to drought tolerance in plants, which include root morphology and rooting depth, plant architecture, leaf area, cuticular resistance and thickness, stomatal conductance, osmotic adjustment, antioxidative defense, hormonal regulation, desiccation. The most important include root architecture, leaf morphology, physiological characters such as osmotic adjustment or proline accumulation, partitioning of total biomass (determined by dry matter or harvest index), timing of plant development (e.g. earliness), or others associated with the plant reproductive biology. Some of these characteristics are specific while others are common for many species. Some reports indicate a significant association between crop tolerance to heat and respective adaptation to drought-prone environments in the warm tropics.

Leaf Traits: Senescence, Stay-Green, and Leaf Area:

Plant functional traits are useful tools for exploring how plants adapt to the environment and studying global climate change (Fyllas *et al*., 2020). Among these traits, leaf traits have received particular attention due to their sensitivity to climate change and their ability to reflect plant resource acquisition and utilization (Ye *et al*., 2022). In dry conditions, plants tend to have thicker leaf thickness (LT), higher leaf dry mass per area (LMA), and larger leaf dry matter content (LDMC), in order to reduce water loss and enhance their ability to adapt to the drought environments (Akram *et al*., 2022). Leaf nitrogen content is closely related to photosynthesis (Zhan *et al*., 2018). The leaf carbon capture strategy can be represented by nitrogen content per unit area (Narea), nitrogen content per unit mass (Nmass), and carbon: nitrogen ratio (C/N) (Zhan *et al*., 2018). Plants typically had higher nitrogen content per unit area and higher leaf dry mass per area under hot and dry environmental conditions, as this increased investment of nitrogen in structure enhanced their survival in adversity (Blumenthal *et al*., 2020). As essential members of plant functional traits, leaf traits can provide insight into the relationship between plants and the environment at both the regional and global scales (Toledo-Aceves *et al*., 2022).

Senescence is a developmental stage of plant leaves that leads to the arrest of photosynthesis, the degradation of chloroplasts and proteins, and the mobilization of nitrogen, carbon, and other nutrient resources from the leaves to other organs. As most cereals are monocarpic annual species, these resources are directed to developing seeds, and senescence therefore plays a relevant role in crop yield. Environmental stresses like temperature, lack of nutrients, and drought might initiate senescence prematurely, affecting seed nutritional composition and crop yield (Distelfeld *et al*., 2014). In crops threatened by terminal drought, the ability to sustain photosynthetic activity longer by delaying or slowing down senescence could be an effective strategy to avoid yield losses. Plant breeders commonly refer to the trait that confers extended photosynthetic activity as stay-green, also defined as green leaf area at maturity (GLAM). This trait is well studied in sorghum, a dry climate-adapted cereal in which a number of stay-green quantitative trait loci (QTLs) have been identified (Vadez *et al*., 2011). However, the genes underlying these QTLs have not yet been identified (Harris-Shultz *et al*., 2019).

Stay-greenness in sorghum is a complex trait, and it is connected with the perennial tendencies of some varieties (Thomas and Howarth, 2000). Other plant species achieve stay-green characteristics via substantially different pathways that include disabling chlorophyll catabolism (like in the case of Gregor Mendel's green peas), (Armstead *et al*., 2007), and altering the responses to plant hormones. Indeed, some stay-green genes have also been identified in Arabidopsis and rice (Hortensteiner, 2009), notably the stay-green rice (SGR) genes and their homologs in Arabidopsis SGR1, SGR2, and SGR-like (SGRL). The respective molecular pathways have been elucidated, with the phytohormones ethylene, ABA, cytokinin (CK), and strigolactone (SL) having a prominent role in stress-induced leaf senescence (Abdelrahman *et al*., 2017). The connection between ethylene and leaf senescence is long known (Bleecker *et al*., 1988), and numerous attempts to improve photosynthetic activity and drought performance by manipulating ethylene biosynthesis have been published in dicots (John *et al*., 1995) and cereal plants (Young *et al*., 2004).

Stomatal-Mediated Drought Responses: Stomata, which are openings on the surface of the aerial portion of plants, are enclosed by two specialized guard cells that can open and close the pore by changing their turgor pressure. Stomata are vital for CO_2 uptake in photosynthetic organs and are finely regulated by a molecular pathway that allows plants to acquire CO_2 while minimizing water loss. Manipulating stomatal number, size, and regulation was one of the earliest strategies adopted by scientists in attempt to produce drought-resistant plants, and recent advances in Arabidopsis and crops. The main hormone signal that triggers stomatal closure in water-limited conditions is ABA (Sussmilch and McAdam, 2017). The manipulation of ABA sensitivity to increase stomatal responses in response to drought could help plants to survive. However, diminished photosynthetic activity due to limited CO_2 uptake is usually detrimental to carbon assimilation and negatively affects crop yield. In addition, water evaporation through stomatal openings prevents plants from overheating.

As drought in a natural environment is likely to be accompanied by warm temperatures, reducing stomata capacity might not be a sustainable approach to enhance drought resistance while securing yield and biomass production. For instance, a series of rice mutants of the ABA receptors pyrabactin resistance 1-like-1 (pyl1), pyl4, and pyl6 have improved yield but are more sensitive to drought (Miao *et al*., 2018), a result that resonates with the improved drought resistance but reduced yield of the transgenic plants that overexpress PYL5 (Kim *et al*., 2014). The trade-off between stomatal conductance and drought resistance could be avoided by manipulating stomatal kinetics, or more precisely, by improving the speed of stomatal responses (McAusland *et al*., 2016). Recently, enhanced plant stomatal kinetics was achieved by expressing a synthetic, blue light-induced K+ channel 1 (BLINK1) under the control of the strong guard cell-specific promoter pMYB60 (Cominelli *et al*., 2011). This effectively accelerated stomatal responses, producing plants that responded faster to changing light conditions.

Cuticular Wax Production: Aerial plant organs have an external cuticle layer of which waxes are a major component. This hydrophobic barrier physically protects the epidermis against a plethora of external factors including UV light, cold temperatures, fungal pathogens, and insects, and regulates permeability and water loss. However, despite the fact that a number of studies in Arabidopsis and crops have shown a connection between drought stress and changes in cuticular wax content, composition, and morphology, many of the key genes involved in wax metabolism, regulation, and transport still need to be characterized (Patwari *et al*., 2019). Cuticular wax composition has been studied both in Arabidopsis and in crop species; wax composition not only varies between plant species, but also between specific tissues or organs within the same plant. All wax components are synthesized in the endoplasmic reticulum and need to be exported to the plasma membrane and then secreted from the cell wall of the epidermal cells where they constitute the cuticle (Fernández *et al*., 2016).

Root Traits: Drought resistance is a polygenic trait, controlled by a complex genetic network and an array of genes working together to ensure plant survival. Many studies have aimed at dissecting the genetic mechanisms underlying drought resistance.Roots adapt their structure in response to drought to increase penetration, distribution, and contact with the soil for improved water and nutrient uptake. These structural adaptations ensure necessary nutrition and water acquisition, maintaining plant physiological activities and productivity during drought.Each individual root has specific development, resource acquisition, and transport traits, which change with root growth. The integration of individual root traits in the root system could exhibit crop performance in the various environments via root distribution in the soil.

For a long time, deep roots have been considered one of the most effective ways to facilitate full utilization of subsoil water when topsoil water is not available under drought conditions. However, a deeper root system is not always associated with a higher drought resistance. Plants with taproots tend to be very drought tolerant. Many desert plants can send roots down more than 75 feet allowing them to find water, even in dry climates or conditions. Taproots can also serve to store food reserves, making them even more self-sufficient and resilient.In response to drought, roots adjust their traits, improving plant adaptation, survival, and yield. Among these traits, root system architecture (RSA) is essential in increasing water uptake (Maurel and Nacry, 2020).

Root traits associated with maintaining plant productivity under drought include small fine root diameters, long specific root length, and considerable root length density, especially at depths in soil with available water. In environments with late season water deficits, small xylem diameters in targeted seminal roots save soil water deep in the soil profile for use during crop maturation and result in improved yields. Capacity for deep root growth and large xylem diameters in deep roots may also improve root acquisition of water when ample water at depth is available.

Roots are among the first defense towards drought with other morpho-physiological and biochemical mechanisms employed by plants. The crop root system (Hulugalle *et al*., 2015) plays an important role in water and nutrient uptake, which largely determines the environmental adaptability and yield of crops. Because of the difficulty of underground research, the research of the plant root system is far behind that of plant aboveground part. For crops, the main strategy to cope with drought is to regulate root growth and root structure. Some studies have assessed breeding and field management, and considered that they have the same significance in improving crop yield (Li *et al*., 2017).

Conclusions

Abiotic stresses are one of the major constraints to crop production and food security worldwide. Among abiotic stresses, drought is the most severe abiotic stresses in many parts of the world and is one of the grand problems in present-day climatic scenario. Moisture stress occurs when plants are unable to meet evapotranspiration demand. Drought is induced by absence of water due to irregular rainfalls or insufficient irrigation but it can be impaired by other factors like soil salinity and physical properties and high air or soil temperature. Drought is insufficiency of water availability, including precipitation and soil moisture storage capacity, in quantity and supply the life cycle of a crop to restrict the maximum genetic grain yield possibility of the crop. Drought is undoubtedly the most important stress having huge impact on growth and productivity of the crops. It is very important to understand the physiological, biochemical, and ecological interventions related to these stresses for better management. A wide range of plant responses to this stress could be generalized into morphological, physiological, and biochemical responses.

Drought is one of the most critical environmental stresses adversely disturbing the yield and growth of plants worldwide. One of the leading issues that agriculture is facing today is the water scarcity due to the effects of global climate change. The global water scarcity is threatening agricultural and food security, since agriculture is largely dependent on water.Crop yield improvement is required to meet the needs of future population growth; however, abiotic stresses cause significant yield reductions throughout the world. Plant growth and productivity is determined by the several abiotic and biotic environmental factors. The effect of drought stress has significant negative impact on crop productivity through affecting various plant traits as photosynthesis, respiration, water relation and biomass production. It has severe effect on the seed germination, growth, phenology, water and nutrient relations, photosynthesis, assimilate partitioning, respiration, and yield component in plants. The effect of drought stress ranges from morphological to molecular levels, which are evident as plant growth is affected at all phenological stages.

Drought resistance is the mechanism(s) causing minimum loss of yield in a drought condition. Drought escape, dehydration avoidance, reduced transpiration or physiological factors are some drought resistance mechanisms. Drought resistant genotypes maintain high photosynthesis under moisture stress condition by restricting transpiration water loss. Finally, the global food security is threatened by climate change and the most challenging in the 21st century to supply sufficient food for the increasing world population. The use of well-adapted and high-yielding varieties with resistance to drought stress is important to reach maximum yield potential as long as possible through minimizing the risk of climate change. Climate-smart agriculture is the only way to reduce the negative impact of climate variations on crop adaptation, before it might affect global crop production drastically.To overcome the drought stress challenge, plants develop certain efficient strategies. Such adaptation strategies are morphological, anatomical, biochemical and molecular approaches used to adapt and defense themselves from the drought stress. Drought stress effects on plants are complex in nature and it affects all the stages of plant growth from the seed germination to reproduction. Eventually, drought is the most yields reducing factor in areas where the rain fall is erratic, unevenly distributed, and the water availability is limited to crop plants to survive and provides the anticipated potential yields. In addition to natural drought resistance mechanisms of plants, developing drought resistant or tolerant varieties is crucial in balancing future population growth and food demand all over the world.

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