Journal of Advances in Biology & Biotechnology

Volume 27, Issue 8, Page 409-415, 2024; Article no.JABB.119998
ISSN: 2394-1081

Drought Resistance in Wheat (*Triticum aestivum* L)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i81153

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/119998

Review Article

Received: 12/05/2024
Accepted: 16/07/2024
Published: 22/07/2024

ABSTRACT

Wheat is a grain crop that is farmed all over the world for bread, chapati, and biscuits. Specific wheat breeding and quality development projects that result in high-yielding, genetically superior, disease resistant varieties of desirable quality that are adaptive to growing conditions. Drought is one of the most important factors affecting crop productivity and yield. Drought stress has a variety of effects on crops, including molecular, physiological, biochemical responses and morphological. Wheat has numerous genes that control drought tolerance and produce a variety of proteins and enzymes, including Responsive to abscisic acid (Rab), late embryogenesis abundant (lea), proline, ligase, rubisco, carbohydrates and antioxidant enzyme (GST). The influence of water shortage on

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***Cite as:** Krishna, Kasula Vamshi, Neroju Manasa, and Neroju Vamshi Krishna. 2024. "Drought Resistance in Wheat (Triticum Aestivum L)". Journal of Advances in Biology & Biotechnology 27 (8):409-15. https://doi.org/10.9734/jabb/2024/v27i81153.*

the morphological, biochemical, molecular and physiological responses of wheat to possible drought stress losses was the subject of this review research. Drought is a state in which soil moisture is decreased, resulting in a variety of agricultural changes. Drought reduces crop yield and leads to crop failure. It has an impact on morphology, agricultural productivity and other factors. The vegetative, reproductive which are essential growth stages are affected. Some plants have mechanism to tolerate those conditions. Nearly 50% of the crop production has decreased due to droughts. The various approaches like Quantitative trait locus (QTL) are employed for drought tolerance. Punjab produces 125 metric tonnes of wheat (in lakh metric tonnes), Madhya Pradesh(113.38MT), Haryana (70.65 MT) and Uttar Pradesh (70.65 MT) are the averages (20.39MT) whereas Rajasthan (10.63 MT). The review gives details on latest innovations for the development of resistant genotypes.

Keywords: Drought; tolerance; stress; vitamin C; vitamin B6; transpiration.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) comes under the family Poaceae, which is the largest family within the monocotyledonous plants. Wheat is dominant crop in temperate countries being used for human food and livestock feed. It delivers about 55% of the carbohydrates and 20% of the calories in the food.

It also contributes vitamins, minerals, phytochemicals, dietary fibre components and essential amino acids. Wheat plays prominent role in the international grain production market. The most important species, Triticum aestivum (common bread), covers 90% of the country's total land. Bread wheat is a self-pollinating, hexaploidy annual plant with 42 chromosomes in total. Wheat is the second most important food crop, accounting for approximately half of all grain production. Heat and drought stress are particularly damaging to the crop during grain filling and flowering stages, increased by greater recurring droughts associated to changes in global climate [1]. Drought is a significant concern for agricultural scientists and plant breeders. By 2025, people about 1.8 billion are predicted to face severe water scarcity with 65% of the world's population lives in water-stressed areas. Water stress tolerance is a complex measure that can be altered by a variety of factors. Drought tolerance and dehydration tolerance are two different types of tolerance. Root depth, acceptable use of available water by plants, and changes in plant lifestyle to use rainfall are all factors in drought avoidance. Root depth, appropriate utilisation available water by crops, and changes in plant habit to use rainfall are all factors in drought avoidance. Plant’s ability to partially dry and regrow again when rain continues is known as dehydration tolerance. Plant drought stress adaptation is a critical issue for developing new improved strategies for growing drought tolerant plants. Plants can be affected by drought stress in terms of, antioxidant production, protein changes, hormone composition, osmotic adjustment, extension and root depth, Photosynthesis inhibition, cuticle thickness, Opening and closing of stomata, growth inhibition, reduction in transpiration, and decrease in chlorophyll content to cope with osmotic modifications in their own organs.

1.1 Drought

Drought is defined as the complete depletion of a water supply. It is a natural risk and according to the scientist who analyses crop loss due to water shortage. The root zone gets to permanent wilting Percentage. Estimations improves the tolerance to droughts. It consists some principles.

1.1.1 Types of droughts

Droughts are of three types: Agricultural drought, Hydrological drought and Meteorological drought.

Agricultural drought: It occurs whenever there isn't sufficient soil moisture to fulfil crop requirements. This kind of drought may happen even if there is no significant precipitation shortfall, because high temperatures, low humidity and wind all increase evapotranspiration, leading to soil moisture imbalances.

Hydrological drought: It takes place when the area has insufficient supply of water, affecting the groundwater and surface water resources. It is common during climatic and agricultural droughts and may have long-term effects on the availability of water for irrigation and various agricultural purposes.

Meteorological drought: This type of drought occurs when precipitation falls beneath average for a lengthy period of time. It is effectively a measure of the total volume of precipitation obtained over a certain time period in relation to the region's historical average.

Drought is the greatest significant constraint to agricultural output and in many regions of the world, drought is the most critical problem. Aside from the drought's inherent complication, [2,3]. Dehydration tolerance and drought avoidance are two types of crop plant tolerance to water stress. Drought avoidance includes a deep root zone depth, early crop planting, and the use of drought resistant cultivars. Drought resistance breeding needs a concerted effort from producers, governments, and non-governmental organisations (NGOs) all over the world. As a result, genetic resources, innovative technologies and research facilities can now be shared [4]. The cultivar should be able to generate excellent results in a variety of stressful and non-stress situations, and high yield is crucial. A multitude of factors influence plant responses to water stress, including stress intensity, developmental stage, cultivar genetics and duration. In any drought experiment, appropriate features known as drought tolerant traits are identified.

Some morphology affects wheat resistance to shortage of moisture present in soil, such as root length, tillering, spike number per m^2, grain number per spike, number of tillers per plant,1000 grain weight, plant height, awn length, spike weight, stem weight, spike length Blum, A [5], Plaut et al., 2004; Moustafa et al., 1996; Jhonson et al., [6]. Drought can affect a plant's growth rate, intensity, genotype, and length of stress, as well as the activity of transpiration, respiration, environmental circumstances and photosynthetic machinery.

Drought-tolerant plants try to reduce water loss and photosynthetic activity by increasing proline content, soluble sugars, amino acids, chlorophyll content, and enzymatic and non-enzymatic antioxidant activities.

2. DROUGHT TOLERANCE IN WHEAT PHYSIOLOGICAL PARAMETERS

Physiological characteristics of drought tolerance are physiological properties that affect yield stability and might be used to evaluate drought resistance wheat genotypes, whereas a biochemical feature under stressful conditions affects osmotic adjustment and cell membrane stabilization. Physiological responses include reduced photosynthetic activity, metabolites production, develops oxidative stress, stomatal closing, changes in the cell wall integrity which are dangerous poisonous compounds and they cause death of the plants [7]. According to research there may be a linkage among crop physiological responses and drought resistance functions including potential water and high relative water Ritchie et al., [8] and membrane integrity, [9] The water condition of plants is shown by the content of relative water in their leaves in comparison with their completely turgid stage [10]. Under water stress, genotypes that can retain large amounts of water in leaves are less stressed and can maintain adequate growth and production [11]. When the moisture content in leaves reduces under water deficit stress, the water level in wheat genotypes is affected (Dulai et al*.,* 2006 and Molnar et al., 2004).The relative water content has been distinguished as a positive correlation leaf and yield of grain [12]. Rainfed wheat yields could be raised or at least sustained if wheat genotypes' water retention capacity is improved. Under drought stress conditions the leaf selection characters are identified [13].

3. BIOLOGICAL PARAMETERS

Water stress circumstances reduce photosynthetic potential by reducing rate of photosynthesis per leaf area and unit area, however (Rauf et al*.,*2017 and Landjeva et al.,2008) claimed that photosynthetic rate is primarily decreased by metabolism or stomatal movement. Drought at the seedling stage may be more harmful to output than drought at later growth stages, depending on the severity of the stress (Maccaferri, et al*.,*2011). Plants biochemical responses to water stress include photochemical reduction efficiency, stress gathering metabolites (glutathiones and polyamines), Reduced ROS accumulation and Rubisco efficiency, antioxidative enzymes (superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), and peroxidase (POD). Drought resistance in a variety of plants depends on changes in the composition of these enzymes [14]. Drought causes oxidative injury in plants by increasing ROS production and weakening the antioxidant defence system [15-17]. Drought resistance is higher in wheat genotypes with high and low Malondialdehyde concentration, according to various studies (Apel and Hirt [18], Dhanda et al. [19] Chandler and

Bartels [20] and Tang et al*.,* [21]. In water-stressed conditions, polyamines aid in the development of membranes and nucleic acid [22]. According to (Roy, M and Wu,R [23], increased levels of polyamines can help plants grow faster under water stress [24].

4. MORPHOLOGICAL PARAMETERS

In Leaf the expansions, area, length, senescence, waxiness, pubescence and in root the growth, area, length, senescence, waxiness, pubescence and cuticle tolerance responses to moisture stress were among the morphological parameters investigated (dry weight, density, and length). Moisture stress necessitates careful consideration. Plant crops reproductive and vegetative growth may be affected by the drought. Reports on the association between drought resistance at seedling stage and reproductive stage in wheat are available during the screening for drought resistance at seedling stage. Seed survival, root length, root shoot ratio, Dry weight, seed reserve mobilization and relative water content are all factors to consider are some of the parameters used in germplasm screening.

Drought resistance has been associated with early death, decreased leaf area and small plant size, according to Rizza et al*.,* (2004). Lombani and Arzani [25] discovered that the area and length of wheat flag leaves increased during drought stress, but the diameter of the flag leaf remained same. Dryness reduces leaf area, which lowers photosynthesis, according to Rucker et al*.,* [26]. The root is an essential organ since it has the ability to travel in search of water [27]. Drought stress causes the root to be a first organ to be damaged [28]. The root system of the plant is crucial in the generation of novel wheat genotypes with increased drought tolerance, water uptake efficiency and nutrient. Drought condition causes roots to grow in an attempt to obtain water. The growth of the respiratory organs is hindered. The shoots and roots have diverse growth responses under arid environments, which is an adaptation.

5. MOLECULAR RESPONSES

Breeders now have more sophisticated tools for identifying and selecting complex traits thanks to advances in molecular genetics. When markers and features are coordinated, the impact of the environment is decreased, which is crucial in the selection of traditional complex quantitative characters [29]. Wheat has the lowest rate of polymorphism among cereals, and polymorphism varies by genome, with the less polymorphic D-genome [30]. Wheat polymorphism is low compared to other cereals, which hinders genetic mapping efforts due to the density of markers is affected by polymorphism [31]. Complications in genetic mapping, analysis, gene discovery and genome sequence have resulted from the wheat genome. In genetic mapping, both dominant and Codominant markers have been widely utilised [32,33], Uphaus et al*.,* 2007. Number of molecular markers have been developed in distinct genes whose activities have been researched and are commonly employed in wheat genotype groups based on known sequence variations [34].

6. BREEDING APPROACHES

There are two types of breeding methods: conventional and biotechnology approaches. The introduction of tolerance qualities present in conventional breeding procedures follows the invention of genetic diversity across distinct genes, or sexually compatible cultivars. Conventional breeding is a time-consuming technique that is entirely dependent on the availability of essential genes. Because this is more complicated, it takes careful attention and distinguishes between negative and positive aspects [35-37]. Some crops, for example, are repeatedly backcrossed to detect undesirable features or traits. As a result, conventional methods are not economically viable [38,39].

Biotechnological approaches are less time consuming than conventional methods, and they require less time to generate new varieties with desirable features when compared to conventional methods. Breeding with new level will be observed in approaches [40-42].

In genetic engineering, genes or sequences are drastically altered in order to get a desired result. Plant breeding research is required to produce new wheat cultivars with a higher level of water stress resistance in wheat [43,44]. Improvements are made in the context of genetic engineering by discovering dominants in genetic and transferring them to plants, allowing them to respond to water stress. In conventional breeding, managing drought tolerance is quite tough [45].

Drought affects a wide range of genomes and their functioning. The superior genotypes are chosen to solve the problem of water deficiency while still producing a high yield. To achieve rapid genetic improvement in a plant, the genes for governing physiological changes that help the plant survive water stress situations must be found. Drought-resistant genes have been cloned and identified. Choosing germplasm with the ability to survive water stress conditions is the first step in genetic improvement. Breeding program starts by crossing the potential genotype as donor parent. This crossing takes place after the potential genotypes have been selected (Berkman et al*.,* 2012). Transgenic crops are modified to withstand and perform better under water stress circumstances. Wheat chromosomes and genomes have a wide range of variety [46-48].

7. CONCLUSION

The identification of plant genome effects of water stress is essential. It consists of extensive information on transcriptional responses of plant to stress in drought conditions and later on it permits researchers to study about gene function in difficult conditions. It helps to identify promoters that respond stress and other cis-elements, which are both significant for basic research and crop development [49]. Drought resistance can be quickly improved by altering the genes that control proteins, plant hormones, transcriptional factors and antioxidants [50]. Molecular mapping and QTL research are two other easy methods for determining quantitative and qualitative research features, also including stress tolerance. However, this problem has some limits. For example, QTL discovery is difficult due to interactions between genetic and environmental factors, unpredictable repeatability, a large number of genes affect production, and the incorrect usage of mapping groups. Due to the considerable heterogeneity in the form of water stress and identifying the physiological parameters required for better crop performance has proven difficult due to the great heterogeneity in the nature of water stress and an insufficient information surrounding its complexity. information regarding its complexity, identifying precise physiological features required for increased crop performance has made difficult.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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