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Drought stress and wheat (*Triticum aestivum* L.) yield: A review

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Abstract
The planet is facing the challenge of drought as a result of changing climate patterns. Drought is becoming a serious downside for wheat production because major wheat-producing countries are located in drier parts of the world and depend on monsoon rain for wheat cultivation. In this study, previous works were assessed to explore the effects of drought stress on wheat yield and yield-attributing characters. The plant alters its physio-chemical state. Plant height, spike length, number of spikes per unit area, number of spikelets/spike, number of grains/spike, biomass yield, harvest index, test weight, and other yield-attributing characters are all affected by moisture deficiency are impacted, resulting in a reduction in grain yield. The degree of yield loss varies by genotype and crop development stage, and is influenced by a variety of soil, plant, and environmental conditions. Drought stress and its effects are not only a concern of agronomists, but also of plant breeders, due to the relationship between yield and genetic make-up of the crop. Wheat is the foundation of many food and feed industries, so increasing wheat production is essential for the long-term survival of the world's population. The article focuses solely on the effects of drought on yield and yield-attributing factors, as this is a key problem among modern breeders and world leaders.

Keywords: Wheat, drought, yield components

Introduction

Wheat is the most widely grown cereal crop in the world, accounting for one-fifth of all human food calories (Ali *et al*., 2012; Muhammad Farooq *et al*., 2014), Hawkesford *et al*., 2013) [7, 22], while wheat is the most important crop in India. After rice, it is the second most consumed food grain by humans. In terms of total intake, rice and maize are second and third, respectively. (Khatri *et al*. 2017) [34]. Ben-ari and Makowski say that Wheat output is more widely spread in 2014 than rice production soya bean wheat is believed to have originated in the Middle East. About 11, 000 to 9500 years ago (Lev-Yadun *et al*., Wang *et al*., 2017; Wang *et al*., 2000) [36, 62]. It is derived from South Western Asia (Ali *et al*., 2012) [7] and has spread to large parts of the globe, contributing 30% of the world's food crops. More than 10 billion people depend on it as a staple food, so in the wider sense, it is classified as a first cereal crop (Ali *et al*., 2012) [7]. Wheat is widely used in the production of bread, cookies, and other baked goods. People prefer wheat products such as crumpets, flake, and flour grain as roasted grain, and it is important to feed livestock because of their high nutritional value (Pandey *et al*., 2020) [49]. The global wheat production is expected to be 760.1 million tonnes (FAO 2020) [20]. Wheat yields in developed countries are 14 percent higher than in developing countries, due to irrigation. (Shiferaw *et al*. 2013) [57]. According to MIRCA (2000) [52], the total percentage of wheat-irrigated land is just 31.1 percent (Portmann *et al*., 2010) [52]. Drought stress is the primary abiotic cause of yield reduction in wheat (Budak *et al*., 2013; Tabassam *et al*., 2014) [16, 59], as it is grown under rain-fed conditions in arid and semi-arid regions throughout the world (Boyer, 1982) [15]. By 2025, approximately 1.8 billion people are expected to face an absolute water shortage, and approximately 65 percent of the world population will be forced to live in a water-stressed climate (Nezhadahmadi *et al*., 2013) [45].

During its growth time, about 32% of wheat in developing countries is subjected to various types of drought stress (Keyvan, 2010) [31]. Plants suffer negative consequences as a result of drought stress as they adapt new physiochemical processes to cope with the stress. Drought stress affects the plants' morphology, physiology, biochemistry, and development, resulting in yield loss. Drought has a primary effect on germination, resulting in poor crop stand establishment (Kaya *et al*., 2006) [30]. At different developmental stages, stress can reduce cell expansion and division, alter stomata opening and closing, pigment formation, water and nutrient uptake, protein structure, antioxidant production, hormone composition, cuticle thickness, chlorophyll content, and other yield components such as plant height, number of plants per unit area, and number of spikes per phloem, among others, negatively affecting yield components such as plant height, number of plants per unit area, and number of spikes per ph (Mehraban *et al*., 2019; Nezhadahmadi *et al*., 2013; Mehraban *et al*., 2019) [38, 45]. When wheat is subjected to drought stress during grain filling, it causes leaf senescence (Habu Jercic *et al*., 2018; Yang *et al*., 2003) [27, 64].

Drought stress affects yield and yield-related traits due to pollen abortion, reduced food supplies, and the growth of sterile tillers (Qaseem *et al*., 2019) [53]. (Ashraf & Khan, 1993) [13]. The emphasis of this article is on the Drought Stress and Wheat Yield. Believing that it would aid in comprehending the gravity of the issue, We attempted to identify the factors that contribute to the poor performance of yield and yield-related characteristics. In today's sense, as the population is growing exponentially, if crop yields decline due to climatic conditions, the hungry population will grow exponentially. As a result, the paper outlines several aspects of drought stress on yield-related characteristics, so that efforts can be based on raising wheat yields from existing land rather than expanding wheat land.

Introduces of mechanisms

Various national and international journals were combed for the most recent research papers and review papers suitable for studying the Drought Stress and Wheat Yield. In addition, for more reliable information, statistical data was obtained from international organization such as the FAO. All of the results in this paper are based on secondary data gathered from the sources mentioned above

Drought stress and wheat yield

Yield refers to the amount of product harvested per unit of time. Tons per hectare is a common unit of measurement. Yield-attributing characteristics of plants are the attributes or traits of plants that contribute to the yield of the concerned plant. Plant height, spike length, number of spikes per unit area, number of spike lets per spike, and number of grains are all terms used in the sense of wheat. Biomass yield, harvest index, and test weight are all calculated per spike. Characters that affect wheat yield are said to be the traits that contribute to yield are interconnected, and as a result of the yield, any variation in the above-mentioned Wheat yield changes as a result of traits.

Plant height

Drought stress has a negative impact on plant height in general wheat, regardless of cultivar or species (Kilic and Yagbasanlar, 2010) However, terminal drought has the greatest severity, followed by tillering drought, pre-flowering drought, and post-flowering drought (Mirbahar *et al*., 2009; Saleem, 2003) [39]. Drought stress reduces the height of wheat from the one-leaf stage to the floral initiation stage, resulting in low dry matter accumulation and, ultimately, decreased plant yield (Moayedi *et al.*, 2010) [40]. During a drought, the protoplasm becomes dehydrated and loses its turgidity, affecting cell elongation, growth, and mitosis. The plant often sheds its leaves to avoid moisture loss, reducing the plant's height (Ghulam *et al*., 1999; Hussain *et al*., 2008; Khakwani *et al*., 2012; Nonami, 1998) [24, 28, 46].

Spike length

Spike length is reduced in all wheat cultivars to some degree depending on the period of drought application, but it is less affected by drought stress than other yield attributing characters (Kiliç & Yabasanlar, 2010) [35]. (Saleem, 2003) [55]. Before flowering, there is a lack of moisture regime, which causes Spike length has been severely reduced. Drought has a greater impact on spike duration after the 6th week of emergence than it does after the first week of emergence (F. Nawaz *et al*., 2012) [44]. The spike length is the one that is most affected by the after the tillering period, there is a terminal drought, then a pre-flowering drought, and finally a post-flowering drought (Mirbahar *et al*., 2009) [39].

No. of spikes/unit area

The number of spikes is one of the most important yield components that is affected by drought stress (Kiliç & Yabasanlar, 2010) [35]. The decreased number of spikes per unit area is thought to be caused by a decrease in soil water potential value during stem elongation or a decrease in tiller survivability during grain filling (Giunta *et al*., 1993) [25]. Drought stress is at its most severe during the anthesis period, while drought suggested before or after anthesis does not trigger the same level of severity (Guttieri *et al*., 2001; Khan & Naqvi, 2011; Moayedi *et al*., 2010; Saeidi & Abdoli, 2015) [26, 33, 40, 54] before the spike initiation stage, the potentials of spikes are developed (Araus *et al*., 2002) [11].

No. of spike lets/spike

Drought has a significant impact on the amount of spikelets per spike, which is one of the most important factors deciding the plant's total yield (F. Nawaz *et al*., 2012) [44]. When Qaseem *et al.* (2019) [53] subjected bread wheat to drought stress prior to anthesis, the number of spikelets per spike decreased dramatically, as did Mirbahar *et al.* (2009) [39]. He got less spikelets per spike in the pre-flowering drought field than in the post-flowering drought field. Moustafa *et al*., (1996) [42] Drought stress has a smaller impact on the number of spikelets per spike at the tillering stage than it does at the heading stage. Drought stress, according to Ghulam *et al*., 1999 [24], has a similar silencing effect on spikelet number per spike in both the vegetative and reproductive phases. In wheat, drought stress increases the number of infertile spikelets per spike (Akram *et al*. 2004; Deni *et al*. 2000) [5, 17].

No. of grains/spike

Drought-stressed wheat yields less grains per spike than irrigated wheat (Giunta *et al*., 1993; Kiliç & Yabasanlar, 2010) [25, 35]. According to Ehdaie *et al*. (1988) [18], the number of grains per spike was the most strongly affected of all the yield elements, which is consistent with Fischer & Maurer (1978) [23], Guttieri *et al.* (2001) [26], and Zhang *et al.* (2006) [65]. The number of grains per spike is positively and strongly linked to the plant's relative water content, so a cultivar with a high RWC has a higher drought stress tolerance and a lower grain number reduction. As a result, various cultivars minimise the number of grains in a spike in different ways (Khakwani *et al*., 2012) [32]. Though the degree of reduction varies, all forms of wheat display a decrease in the number of grains per spike when subjected to drought stress (Saleem, 2003) [55]. After the pre-flowering and post-flowering droughts, the terminal drought has the greatest impact on the number of grains held by a spike (Mirbahar *et al*., 2009; Moayedi *et al*., 2010; Qaseem *et al*., 2019) [39, 40, 53]. Drought applied at the heading stage allows the spike potential and number of spikes per grain to be established before spike initiation (Araus *et al*., 2002) [11]. There was a substantial difference in the number of grains per spike at the tillering stage (Abid *et al*., 2018; Moustafa *et al*., 1996) [2, 42], but no effect after anthesis (Abid *et al*., 2018) [2]. (Plaut *et al*., 2004) [51]. The lack of fertilisation of the egg, which results in underdeveloped ovule, is also blamed for the lower grain count. Drought stress during pollen production results in sterile pollen, necessitating fertilization is agitated (Manjarrez-Sandoval *et al*., 1989) [37].

Grain yield

Plant height, spike length, successful tillers/m2, and number of grains/spike all have a linear relationship with grain yield, making yield the most affected factor by drought (Kiliç & Ya basanlar, 2010; F. Nawaz *et al*., 2012 44; Qaseem *et al*., 2019; Sutton & Dubbelde, 1980; Thompson & Chase, 1992) [35, 53, 58, 61]. The taller plant has deeper root penetration, which allows for better water use and more stored assimilates, both of which are lacking during a drought, resulting in lower yields (Amiri *et al*., 2013) [9]. Despite the fact that the grain yield of all wheat genotypes has decreased, When genotypes are subjected to drought, they display dominance (Nouri *et al*., 2011; ztürk, 2011) [47, 48] & (Korkut, 2018; Saleem, 2003) [48, 55], but cultivars are less affected than landraces collected from various countries (Deni *et al*., 2000) [17]. Drought produces a greater relative loss in grain weight than the number of crops. As a result, the pronounced decrease in wheat yield under drought stress is due to reduced grain weight rather than a lower number of grains (Giunta *et al*., 1993) [25]. After the anthesis time, the drought causes Wheat yields are reduced less than when there is a drought during anthesis. Because of decreased carbon fixation and assimilate translocation (Asada, 2006) [12], decreased grain set and grain filling (Muhammad Farooq *et al*., 2014; A. Nawaz *et al*., 2013; F. Nawaz *et al*., 2012) [22, 43, 44], and graining (A Ahmadi & Baker, 2001; A. Nawaz *et al*., 2013) [3, 43]. In the absence of a significant amount of water, leaf senescence is accelerated (Senapati *et al*., 2019) [56], so a lack of water disrupts leaf gas exchange processes, limiting the size of the source and sink tissues and thus hampering assimilate translocation (Anjum *et al*., 2011; M. Farooq *et al*., 2009) [10, 21], Jaleel *et al*., 2009) [29].

Water use during anthesis has a greater impact on grain yield. (Passioura, 1977; Deni 'deni ' c *et al*., 2000) [17, 50]. Drought stress reduces grain yield by reducing photo-assimilates output, sink capacity to absorb photo-assimilates, and grain filling time after anthesis. The decrease in grain yield during this process indicates that a low amount of photo-assimilates is supplied for grain filling, as the initial grain growth and production phases are least affected by the post-anthesis drought (Ali Ahmadi & Siosemardeh, 2005; Bahman Ehdaie *et al*., 2006; Saeidi & Abdoli, 2015) [18, 19, 54]. As stress is applied at the heading stage rather than at the tillering stage, the yield is significantly reduced (Moustafa *et al*., 1996) [42]. Drought stress interferes with plant growth and photosynthesis, which is thought to be the primary cause of lower grain yields (Almeselmani *et al*., 2011) [8].

Biomass yield

The increase in biomass is shown by the disposition of biomass. Above-ground photosynthetic organs stem, and yield Drought stress reduces biomass yield (Alexieva *et al*., 2001; Taheri *et al*., 2011) [6, 60] because leaf expansion and growth are hindered by the water deficit (Anjum *et al*., 2011) [10]. The main cause of biomass loss in wheat is a decrease in grain yield followed by a decrease in plant height (J. Zhang *et al*., 2018) [66]. Although the reduction in biomass yield differs between irrigated and non-irrigated areas, It is not even among genotypes of the same field in stressful fields (Saleem, 2003) [55]. The biomass yield is directly proportional to photosynthesis, but drought accelerates leaf senescence (Senapati *et al*., 2019) [56], and assimilates output is lower under drought, so they are either consumed or deposited by the source (Abdoli & Saeidi, 2013) [1]. As a result, the biomass yield is reduced.

Harvest index

Harvest index is defined as the ratio of grain yield to biological yield, which determines the potential of plants to translocate physiological matter to grains (Moayedi *et al*., 2010) [40]. As a result, stress environments have a significant impact on harvest index (Giunta *et al*., 1993; Qaseem *et al*., 2019) [25, 53]. Grain yield is positively related to the harvest index, while total biomass is negatively related. Wheat's economic yield is decreased when it is stressed, and the harvest index is reduced when wheat is subjected to drought. Under stress, the sink size shrinks, reducing demand for assimilates and allowing retention of photosynthesis in the vegetative organ, lowering the harvest index of wheat under drought stress (Giunta *et al*., 1993) [25].

Test weight

Drought affects the test weight differently at various phenological stages: most negatively after tillering, then before flowering, and least negatively after flowering (Akram *et al*., 2004; Mirbahar *et al*., 2009; F. Nawaz *et al*., 2012; Moayedi *et al*., 2010) [5, 39, 40, 44]. The 1000 grain weight is the product of the combined effects of spike length, fertile spike let number, grain weight per spike, and number of grain (B. Zhang *et al*., 2006) [65]. The 1000-grain weight has a negative relationship with the number of grains per spike, i.e., if the number of grains per spike is decreased due to drought, the grain weight is increased, so the minimum reduction is found in the mean values of 1000 grain weight as compared to other yield components. This may be because the usable assimilates are distributed to a smaller number of plants, resulting in better grain filling (B. Ehdaie *et al*., 1988; Ghulam *et al*., 1999; Giunta *et al*., 1993; Moral *et al*., 2003) [18, 24, 25]. However, nutrient uptake efficiency and photosynthate translocation may be disrupted, resulting in the development of deflated grain as a result of stress-induced accelerated maturity, resulting in a substantial decrease in wheat 1000 grain weight (Khakwani *et al*., 2012) [32].

Conclusion

Drought is the most extreme, but most common, problem facing global wheat producers, and climate change is just adding fuel to the fire. Drought stress has an effect on plant height, biomass, spike number, spikelet number, and grain yield. Drought has a negative impact on all yield components of wheat genotypes, but the severity of the effect varies. The severity of drought stress on crops is largely determined by factors such as the crop's pheno-logical level, intensity, and duration of drought stress. Wheat morphological traits such as effective no. of fertile tillers/plant, no. of spikes/m^2, no. of spike lets/spike, no. of grains/spike, test weight, spike length, spike weight, and biomass can all affect the plant's response to drought stress. Drought during the heading or flowering stages significantly reduces crop yield. The plant's response to drought varies depending on rainfall distribution, evaporative demands, and other factors and the soil's ability to store moisture. Drought stress causes the plant to react physiologically to adapt to the environment, resulting in the closure of stomata, decreased photosynthesis, and low distribution of photo-assimilates, resulting in a reduction in wheat yield and yield components.

To overcome the drought, the crop incorporates physio-chemical and/or drought stress changes during the water-sensitive phenological phases, the wheat should be well irrigated. Drought has a well-known impact on wheat yield and yield components, but agro-morphological shifts are the result of physio-chemical changes at the molecular stage. To cure the effects of drought from the root, the ground level changes in a plant cell that damage yield and yield-attributes should be established.

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