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Review article

Biochemical, Molecular and Morpho-Physiological Attributes of Wheat to Upgrade Grain Production and Compete with Water Stress

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Abstract

Enhancing grain quality and quantity is going very perilous with the incessant climate changes and rising population. Under these circumstances, to review the current strategies and researches regarding biochemical, physiological, morphological and molecular perspectives gain more consideration. Hence, it's important to have know-how related to this in different parts of the world to utilize possible stratagems to increase our current production. Wheat is one of this foremost considerable crop as it is food of 21% of the world population and 77% developing countries import and consume wheat annually. Wheat is primarily important in Pakistan as it is staple food but adversely affected because of water and heat stresses. By using the information and approaches of expertise, we can achieve our objectives of high yield and admirable quality. In most of countries, yield is less than the actual potential yield, this can be overcome by utilizing appropriate resources and proper techniques. Advance knowledge and extrapolative capabilities can help us to find out best possible tools to contribute in world food security and to withstand changing climatic conditions.

Keywords: Wheat, Morpho-physiological aspects, Molecular techniques, Grain yield, Water stress.

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INTRODUCTION

As we all know that wheat is the staple food for many countries and supplies 20% of the calories (Kulkarni et al., 2017). wheat is considered as the most extensively grown crop for its high nutritious value and covers the area of 237 million hectares annually (Oyewole et al., 2016). This crop is sensitive to heat stresses which also became a factor for drought in wheat. Wheat is sensitive to both of these stresses and the loss is more if these stresses occur at the critical points of wheat growth like flowering and grain development stages and ultimately the yield and grain quality is dwindling. The stress tolerant traits of wheat are polygenic and are convoluted to understand (Mwadzingeni et al., 2016). Due to multifarious nature of drought stress it is the main factor limiting crop yield. Suitable selection of the traits appropriate for drought tolerant has increased the yield.

The water stress limits the root and shoot development resulting in waning of yield and grain quality (Quarrie et al., 1999). Plant endures water stress either when the water supply to the roots is low-down enough to support the growth or when the transpiration rate becomes too high because of wind and temperature. To maintain tolerance to water stress is challenging and laborious as the indicators for drought tolerance usually have low heritability even under ideal condition the heritability is low.

After the first plant genetic transformation, wheat eventually becomes a target for genetic manipulation (Bhalla et al., 2006). Wheat is a strenuous specie for molecular level studies due to its complex genome (95% of wheat grown all over the world is hexaploidy). Genetic transformation is an alternative to conventional breeding as it allows the transfer of specific desirable traits into other genotypes of wheat without affecting the genetic background.

Developing the stress tolerance plants is tiresome job as higher plants develop interconnected strategies in order to survive in the fluctuating environmental conditions (Fleury et al., 2010). The biochemical mechanisms may show feedback response and can alter the byproduct under different stresses. In consequence, developing tolerance for one stress can lead to sensitivity in response to other stress. Some plants lead to increase in stomatal conductance and evaporation in order to avoid the heat stress. However, the loss of water can be decreased by closing stomata this can save water in order to protect the plant against drought stress but in the other way closing of stomata will rise the temperature. So both of these mechanisms conflict with each other.

Before starting work for competing drought stress the plant phenology should be considered (Chaves et al., 2003). The plant can escape drought by completing its life cycle before the onset of water deficiency. The shortening of life cycle can be advantageous for those environment with terminal drought stress and where physical and chemical barriers inhibit root growth. Another factor is plant morphology i.e. plant height and number of tillers, as small plants with lessen number of tillers can show higher water use efficiency as compared to the tall multi-tiller plants (Blum et al., 2005).

The demand for wheat will be up to 60% by 2050, but the production due to climate change and other environmental stresses might decrease by 29%. This prediction emphasizes on improving and developing abiotic stress tolerant plants to meet the food requirements. The genetic improvement of wheat is thus important as it impacts on economy and food security (Kulkarni et al., 2017).

Objective of Review

The main purpose of this review is to study and cognize scientific work related to morphological, physiological, biochemical aspects and biotechnological approaches to combat with drought stress in wheat crop. By knowing results of different researches regarding drought stress in wheat through review of literature, we can improve our genotypes by using all possible successful strategies used in different parts of the world to mitigate this problem to save our future generation from hunger by increasing the grain production.

Review of Literature

Tambussi et al. (2007) endeavored the effect of physiological traits with water use efficiency (WUE) from leaf to full crop level. It was acclaimed that under drought conditions, high to low WUE instantaneously was a suitable criterion for breeding to increase grain yield. WUE is indirectly affected by carbon isotope discrimination (negative correlation was found between these two was found by several studies). Relationship of carbon isotope 13 is complex for grain yield as it changes under different environments. Positive association was found between carbon isotope discrimination and grain yield in crop like wheat, barley etc. While for stored crops low value of carbon isotope discrimination is associated with grain yield. Water use efficiency (WUE) was found as higher for ear than flag leaf stages in durum wheat and barley under both water stressed and normal conditions. In semi-dwarf varieties increase grain yield and vigor was found that optimize water use efficiency at crop yield level.

Wajid et al. (2007) explored wheat in semi-arid regions of Punjab to examine the water use efficiency (for total water applied to crop) and evapotranspiration. Four irrigations based on soil moisture applied were control, irrigation up to stem level, from stem elongation to maturity and full irrigation. Fully irrigated crop was 93.18% high yielding than controlled. When drought is applied before and after anthesis, it reduced the economic part due to decrease in interception of light at this stage.

Veesar et al. (2007) assessed the applied water stress conditions at different growth stages (tillering, booting and grain formation) to analyze the water stress influence on growth and yield of wheat plant. Mutant Sindh_81, Sindh_81, Mutant of Indus_66 and Indus_66 wheat varieties grown in randomized complete block design (RCBD) with triplicates. Significant difference observed among water stress treatments, genotypes and their interactions except seed index interaction that was found non-significant. Results were showed higher number of tillers, grain yield plant height and seed index in Indua_66 while Sindh_81 had more number of spikelet per plants. Indus_66 variety was considered more water stress tolerant. Stress at tillering stage found more adverse for plant height, number of fertile tillers and spikelet per spike. At grain filling stage, maximum reduction in grain yield and seed index observed. These characters can be used for selection and further breeding programs to develop drought tolerant genotypes in wheat.

Mahpara et al. (2008) conducted an experiment to inspect the combining ability among Shahkar-95, Parwaz-94, Iqbal-2000, Uqab-2000, MH-97, 4072 and Punjab-96. They examined different plant morphological characters like leaf area, plant height, tillers/plant, peduncle length, extrusion length, spike length, spikelet/spike, spike density, grains/spike, 1000-grains weight and grains yield/plant. There were significant differences for GCA (General combining ability) and SCA (specific) among genotypes. The greater magnitude of σ^2g than σ^2s for all characters was notice except for grain yield/plant and plant height, representing that additive gene action had importance in the inheritance of characters. It was evident that non-additive gene action contributed in the inheritance of grain yield/plant and plant height. Varieties Punjab-96, Uqab-2000, Iqbal-2000 and MH-97 were best general combiners for nearly all studied

Gosal et al. (2009) deliberated with the help of genetic engineering of plant and molecular markers approaches the drought tolerant germplasm can be developed. Transgenic plants carrying abiotic stresses genes are used to develop water stress resistant plants. Molecular markers were used to identify trait loci related to drought stress and encourage their efficient transfer in the varieties of Wheat crop.

Jalal-du-din and Ali (2009) was enquire experiment on wheat varieties (NR_234, Chakwal_97, Inqilab_91, Wafaq_2001 and Margalla_99) to estimate drought stress effect. Drought was applied at three stages (tillering, pre anthesis and milky stages. It was observed that the varieties were significantly different in grain yield parameters. Water stress applied at pre anthesis stage causes highest reduction of grain yield. It was showed that the Inqilab_91 and Wafaq_2001were high performing verities and also had good grain filling per spike. Wafaq_2001 found out as high anti-oxidants, membrane stability index and proline contents under water stress condition.

Kandic et al. (2009) tested the effect of drought and irrigated conditions on grain yield by estimating five physiological traits in wheat crop using correlation analysis and path coefficient analysis. Flag leaf, early vigor, leaf senescence, early maturity and total biomass were study. It was scout out that correlation between early vigor, grain yield and total biomass was highly significant under both drought and normal conditions. While grain yield showed high negative correlation with leaf senescence and days to flowering. Through path analysis it was reveal that total biomass and days to anthesis exhibited significant and direct effect on grain yield while flag leaf, early vigor and leaf senescence found highly significant indirect effect on the grain yield. Hence, these parameters can be used for selection and evaluation of populations used for further breeding programs.

Mirbahar et al. (2009) investigated 25 wheat varieties to estimate the water stress effect on different growth stages using randomized complete block design (RCBD). Five stress levels were applied (control, pre-flowering, tillering, post flowering and terminal stage drought). It was confer that significant reduction in plant height, grain per spike, 1000-grain weight, spike length and spikelets per spike among all varieties. Results concluded that Kiran_95 and Sarsabz varieties were performed better than others under stress and normal conditions.

Boutraa et al. (2010) worked to estimate the water stress in wheat using Al_gaimi, Sindy_1, Hab_ahmer and Sindy 2 cultivars. Two water stressed levels were apply (mild or 50% and severe or 30% water deficient regimes). Results showed that sindy_2 and Hab_ahmar were affected by mild level of water stress while Al_gaimi was less affected. Under severe water stress level growth of hab_ahmar was declined followed by sindy_2 and sindy_1 while Al_gaimi was not affected by this stress. Relative water contents (RWC) were observe less in Al_gaimi and hab_ahmar under severe stress level while in sindy_1 and sindy_2 RWC were not change. Water use efficiency under severe stress level was less in sindy_2 and hab_ahmar while in Al_gaimi and sindy_2 WUE was not influenced.

Ji et al. (2010) studied the importance of pre anthesis stage for maintain the grain number. Drought at anthesis mainly affects the size of grain, reduce the grain number and may cause abortion of pollens. Drought tolerance germplasm can be used to recognize the genetic variability for the drought, that can maintain accumulation of carbohydrates at reproductive stage to get better yield. It was observed that the depletion of starch content in ovary during drought stress can be maintain by re-watering. Difference in the wheat genotypes to tolerate drought is associated with the sugar contents, invertase gene expression in cell wall and fructans biosynthesis gene expression in anthers. It was concluded that to maintain the carbohydrates contents in pollen for getting good grain number in wheat, protection against abiotic stress should be provided.

Kilic and Yagbasanlar (2010) was investigated the qualitative and certain yield contributing traits in wheat. Genotypes were grown under both natural drought and well irrigated conditions.at anthesis is stage morphological parameters were noted while yield contributing traits were measured at ripening stage. Chlorophyll contents, grain filling, spikelet per spike and number of grains per spike were found positively associated with grain yield under natural drought stress condition while flowering period was negatively correlated with grain yield. Under drought stress condition, spike length was noted as positively associated with drought susceptibility index (DSI) while days to maturity was negatively associated with DSI. Results were shown that Balcali_2000, Gidara_2, Harran_95 and Aydin_93 had high stability and yield.

Kong et al. (2010) quested for the photosynthetic and other structural characteristics of wheat peduncle that are important source for grain filling. Peduncle was usually referred as transport organ but anatomical traits showed that it contributes to the development of the grain. Comparison of peduncle with flag leaf it was found that chloroplast with many granum stacks were present both in peduncle and flag leaf at first three stages of grain filling. Difference was observed in fourth stage of grain filling in which membranes (constituting thylakoids) of peduncle were discrete and abundance while in flag leaf these were interrupted and complete disintegrate at stage 5. By using PS II quantum assay technique it was revealed that photosynthetic efficiency remained same at first three stages while decline in both in next stages. It was noted that PEPcase enzymatic activity was decline in first two stages in peduncle than flag leaf while in later stages its activity in peduncle was highest. Hence, results concluded that peduncle is photosynthetically important active organ that helps during grain filling stage.

Szucs et al. (2010) investigated the effect of water shortage and heat stress in wheat using microarray analysis. Effect of water short along with or without additional heat stress during the first five kernel development days of two wheat varieties that were differ in their drought sensitivity were studied. Water deficient condition affect 0.5% of genes under investigation. By heat treatment the ratio of these genes increased 5-7 % because of both temperature stress and increase of water shortage due to increase rate of evaporation. Under combined stress gene expression of certain enzymes and proteins like enzyme involve in sugar, heat shock proteins, storage proteins, histone proteins, proteases and transcriptional factors were observed to accelerate the embryo and endosperm development.

Yagbasanlar (2010) used 14 wheat cultivars to study the effect of drought. It was found that there exists a negative correlation between flowering period and grain yield while positive relation was observed in no. of spike, spikelet/spike and chlorophyll content for grain yield under drought stress condition. Other than these number of days to maturity had negative correlation for drought susceptibility index while spike length and drought susceptibility index had positive correlation. Relative yield and drought susceptibility was measured to describe the yield potential and yield stability. Among 14 varieties Saricanak_98, Altintopark_98, Harran _95, Balcali_2000 and Gidara_2 showed high yield stability and potential.

Akram (2011) conducted field trial to study the wheat sensitivity to water stress condition and its effect on crop yield at different growth stages. He used two varieties of wheat and four moisture stress levels. It was found that the moisture stress had negative effect on water potential, osmotic potential, relative water contents and yield components. Due to successive stress at tillering and anthesis stages significant reduction in yield was observed.

Almeselmani et al. (2011) analyzed the wheat varieties growing under first and second settlement zone in arid areas. In both zones plants were affected by terminal drought but drought was noted severe 2nd settlement zone. Results were shown that chlorophyll contents, relative water contents and membrane stability index were significantly less in 2nd settlement zone in all growth stages as compare to first. Yield contributing traits were adversely affected by drought while drought tolerance varieties maintain their good yield. Hence these parameters can be used for improving drought tolerance in wheat crop.

Anwar et al. (2011) tested wheat exotic genotypes with local checks under fully irrigated and rain-out conditions. Selection was based on stress tolerance, mean productivity, stress tolerance index and stress susceptible index. It was noted that the average yield of landraces was differ significantly than accessions while tolerance was better in landraces than accessions. Wide diversity for most of the traits was also found in landrace that can be used for improving tolerance under variable water stress environment.

Jatoi et al. (2011) carried out field experiment using 12 wheat cultivars using factorial design with triplicates using two treatments (stressed and non-stressed at anthesis). Results showed that significant variation (for all characters except grain yield) exist between cultivars and treatments as well as their interaction. TD_1, Sarsabz and SKD_1 cultivars showed less decrease in yield characters as well as physiological traits under stress condition, by estimating morphological and physiological traits through correlation analysis it was found that relative water contents, plant height, grains per spike, harvest index, seed index, grain yield per plant leaf area and stomatal conductance can be used as selection tool for improving drought tolerance in wheat as improvements in these traits ultimately increase the grain yield and production.

Khan and Naqvi (2011) determined the water stress susceptible and tolerant genotypes by applying irrigations in wheat to estimate yield contributing traits in wheat. Eight wheat varieties (Rawal_87, Kohistan_97, Chakwal_86, watan, Inqilab_91, Uqaab-2000, Pak_81 and Sarsabz) used in experimental material. Water stress at vegetative, anthesis and both growth stages were applied. Four drought resistance indices were utilized in the base of grain yield in water stress condition that are yield stability index, tolerance index, stress susceptibly index and mean productivity. Results showed that under water stress condition Chakwal_86, Rawal_87 and pak_81 were tolerate stress condition while Kohistan_97, Watan, Inqilab_91 and uqaaab_2000 were highly affected by water stress conditions for yield traits. Hence, plant height, number of spike/plant, number of tillers, number of grains, 1000-grain weight and grain yield considered as useful traits in breeding programs for developing stress tolerance wheat varieties.

Shamsi and Kobraee (2011) recognized the effect of drought at growth stages and yield in wheat crop as drought is serious environmental stress that cause significant reduction in wheat production. Experiment was conducted in split plot design (4 drought stress levels in main plots and 4 cultivars (Marvdasht, Chamran and Shahriar) in sub plots) in randomized complete block design with triplicates. Results showed highest grain yield for full irrigation level (level at which irrigation done after 40% soil moisture depletion) while lowest grain yield was found in drought stress at the start of stem elongation through ripening when 80% moisture depleted. It was noted that the Shahriar cultivar is more affected by drought stress than Chamran cultivar.

Aliyev (2012) grow many genotypes under field condition to assessed drought tolerant wheat varieties by applying normal and stressed water conditions. It was noted that at early tillering to late grain filling stages under drought stress were adversely affect grain yield and protein contents. Protein synthesis is related to the ear photosynthesis, because of ear photosynthesis more than 60% of protein synthesis and grain yield was found in drought tolerant genotypes. Under dry condition, dry biomass accumulation and leaf area were declined. Enzymatical activity of NADP_glyceraldehyde dehydrogenase and phosphoglycerate kinase were also decline in water stress condition in stress sensitive genotypes.

Iftikhar et al. (2012) assayed the relationship among yield and yield contributing traits using correlation and path coefficient techniques for wheat varieties under water stress conditions. It was observed that grain yield had positive correlation with spike length, peduncle length, grain weight and 1000- grain weight while negative correlation with plant height, number of tillers per plant and peduncle length. In path correlation, high positive and direct effect on yield was observed for 1000-grain weight followed by spike length and days to headings. From these results, it was concluded that 1000 grain weight and spike length can be used as selection criteria for high grain yield in wheat.

Monneveux et al. (2012) emphasized on breeding strategies in wheat for drought tolerance which include defining of the target environment, choice and classification of target environments, characterization and management of water stress and selecting of highly heritable phenotyping traits. Application of new technologies can be helpful for phenotyping selection which results in yield improvement under drought stress environments.

Reynolds et al. (2012) deliberated the way for achieving high yield in wheat plant. Wheat contain protein and 20% of calories. It was observed that radiation use efficiency in wheat can be alleviate by regulation of Rubisco enzyme activity, modification of specific catalytic rate, introduction of CO2 concentration mechanism in chloroplast, Calvin cycle enzyme regulation by proper light and minimizing the photoinhibition. Other than these strategies, maintenance of physiological and structural development of stem and leaves also play important role to maximize the yield. Hence, proper crop management and agronomic impacts of plant should be focused for crop improvement.

Vassileva et al. (2012) evaluated grain yield of four wheat cultivars to compare their chemical and ultra-structural responses under drought (prolong) stress. By using immunoblotting and gel electrophoresis two cultivars were found as drought tolerant and two were drought susceptible. Drought susceptible cultivars were associated with decrease in heat shock proteins and increase in protease activity degradation of Rubisco enzyme. It was noted that drought susceptible cultivars were more affected by ultra-structural damages (destruction of chloroplasts membrane and decrease in starch level). Results were shown that multiple interactions in traits under drought stress in wheat can be used as indirect mean of selection criteria.

Ali et al. (2013) worked on twelve wheat genotypes to investigate physiological traits and selecting drought tolerant genotypes under drought stress. Water stress was applied through 4 irrigation treatments after fifteen days interval. Results showed that relative water contents, turgidity and plant yield were decreased through successive increase of drought stress. Four genotypes (ZAS 08, Tatara, Ghaznavi_98 and ZAS 42) considered drought tolerant genotypes with normal physiology. To improve the crop productivity drought tolerant genotypes were grown under rain fed areas.

Fellahi et al. (2013) inspected nine wheat genotypes and 20 F1's using line by tester mating design in randomized complete block design. Results showed significant genetic variability for all traits. Among crosses A899 line when crossed with Wifak as well as Rmada testers and line A1135 when crossed with Wifak were found good combiners for number of grains per spike. For 1000 grain weight MD (mid-duration) is found as good combiner, for reduced height HD (high-duration) and for early duration of vegetative growth Ramada are good combiners. For reduced plant height, 1000-grain weight and grains/spike A901×Wifak was found best specific combiner. For grain yield A899×Wifak showed highest heterosis, this cross also showed positive heterosis for number of fertile tillers and spike length while negative heterosis value for days to heading and 1000-grain weight. Results showed that due to non-additive gene action selection of superior plants should be delayed.

Lohithasawa et al. (2013) conducted a trial to study yield related traits through combing ability effects (GCA and SCA effects) using line × tester analysis. Five lines along with seven testers were used in this experiment and results were interpreted using analysis of variance that significant difference was found in lines, testers and line × tester for flowering days, days to maturity, plant height, rust resistance, spike length, peduncle length, no. of grains, yield of grain and for weight of 1000-grains. Among lines, Vijay and DK-1001 showed highly significant general combing ability while among testers DWR-1006 and RAJ-1555 were showed maximum GCA effects. On the other hand, among cross combination NIDW × RAJ-1555 was identified as best specific combiner.

Nawaz et al. (2013) assessed 25 varieties of wheat to study morphological and yield contributing traits. Significant variations were observed in plant height, flag leaf area, peduncle length, awn length, number of grains per spike, yield per plant while non-significant results were noted for number of tillers per plant. Local white genotype for plant height, Khyber_79 for flag leaf area, Pirsaba_85 for awn length, SA_42 for grains per spike, kaghan_93 for yield per plant were performed best. It was concluded that Kaghan_93 can be used for general cultivation because of its best performance for most of the characters.

Nezhadahmadi et al. (2013) examined the effect of drought stress in wheat crop. Drought is considered as vulnerable stress for crop yield and production because it adversely affects the physiological, morphological and biochemical responses of plant. Water stress condition also effect vegetative and reproductive stages of crop. Drought tolerance is controlled by polygenically and their expressions are sensitive to various environmental factors, so it is considered as complicated trait. Some recent molecular techniques and QTL mapping techniques were used to generate drought tolerance plants as breeding for drought tolerance is difficult. Several types of enzymes and proteins are also responding under drought stress condition like in late embryogenesis LEA protein responsive for abscisic acid, proline, helicase, rubisco and carbohydrates. Plants can be improved through genetic engineering by detecting some important genes and their expression. A lot of drought resistant genes have been identified by this method. Crop genetic engineering and molecular markers helped a lot in identifying the genes in the available germplasm. Particle gun techniques for transgenes for drought resistance were applied. GM (genetically modified) plants are produced, and markers used to identify drought related QTL which then transferred into different crops.

Razzaq et al. (2013) worked on nine commercial wheat varieties (Auqab 2000, AA-2002, Bhakkar 2002, GA-2002, Shafaq 2006, Sehar 2006, Chakwal 50, Inqilab 91, Fareed 2006) and evaluated them for drought resistance and physiological performance. Germination percentages tested by inducing osmotic stress with PEG (poly-ethylene-glycol), highest germination was observed in Chakwal 50, AS 2002, GA 2002 and Fareed 2006. Physiological response was observed under different moisture stress. Results showed the significant decrease in chlorophyll contents, leaf succulence, cell membrane stability index, relative water contents, number of grains/spike and 1000 grain weight under water stressed conditions.GA 2002, Bhakkar 2002 and Chakwal 50 found as best under water stressed environment.

Aslam et al. (2014) assayed the inheritance of certain quantitative yield contributing traits using line × tester analysis in wheat crop. Three line were used as female parent (9444, 9452, 9436) while three testers were used as male parents (Lasani_2008, Sehar_2006 and SH_2002). Nine crosses were made that were study for yield related traits like no. of productive tillers, plant height, 1000-grain weight and yield. Results were showed that among F1crosses 9452 × Lasani_2008, 9452 × Sehar_2006 and SH_2002 cross with 9436 and 9444 were performed best for these traits while among parents 9452 and SH_2002 were reported as best parents.

Biesaga-Koscielniak et al. (2014) tested the soil drought effect on seedling stage in 20 varieties wheat crop. Effect on carotenoids a and b, gas exchange, photochemical activity of photosystem II, leakage of electrolytes and accumulation of water were studied. It was observed that drought decrease the photosynthesis rate growth vigor of seedlings while increase leakage of electrolytes from leaves. In some varieties, high accumulation of carbon dioxide (CO_2) was also observed under drought stress condition. Results showed that varieties had significant difference for seedling development and gas exchange. Hence, carbon dioxide assimilation and growth tolerance parameters can alleviate the final yield.

Hammad and Ali (2014) organized field as well as pot experiments to estimate the effect of foliar spray along with bio-stimulants to reduce drought stress condition stress in wheat. It was found that water stress condition was negatively affected the total amino acid, carbohydrates, photosynthetic pigment, soluble sugars grain quality and enzymatic activity while significant increase was found in total phenols, osmotic potential and proline contents. Water stress condition and application of bio-stimulants was noted as significant for most of the physiological and yield contributing characters.

Mehraj et al. (2014) executed experiment by using twenty-four (L1 to L24) wheat lines with triplicated in randomized complete block design. Plant height, number of productive tillers, 1000-grain weight, grain yield, no. of grains, yield of straw, total number of tillers, spike length, LAI (leaf area index) and biological yodel were measured in all lines. Results revealed that maximum values for these traits were present in L13 followed by L15 and L16 while lowest values for these traits were found in L1.

Noorka and Silva (2014) studied morphological and physiological traits in wheat under water stresses and non-stressed conditions. Seven genotypes were crossed in line × tester mating approach and F_1's along with their parents were grown under two different conditions. Inqilab 91, Dharawar dry and Nesser selected as best combiners through combining ability analysis. For grain yield Dharwar Dry and genotype 9252 were best performing genotypes under water-stresses and normal irrigation conditions, respectively.

Al-Naggar et al. (2015) conferred about markers that simple sequence repeats are present in all eukaryotic genomes. The repeated sequence can be used as primers and so the SSRs are more specific than RAPDs. 20. Investigators found that SSRs molecular markers are associated with wheat drought and salinity tolerance. This research was conducted to develop drought tolerant genotypes by mutation and hybridization. SSR analysis were done to identify drought tolerant lines. The results show variation between parents and 12 families. The SSR show unique bands for drought tolerance. The bands are useful as the marker is associated with drought tolerance in wheat.

Bentahar et al. (2015) assessed water use efficiency in wheat as it is considered as an important parameter to study under drought stress. Plants were grow at different water level viz 95%, 60 % ,20% 20% and leaf area, leaf temperature, chlorophyll contents and stomatal conductance were measured. Different genotypes were investigated and estimated through analysis of variance, genotypes that showed high value for leaf area, water use efficiency and chlorophyll contents were suggested as best genotypes for drought conditions.

Istipliler et al. (2015) evaluated the combining ability analysis to study yield contributing traits in bread wheat. From the nine genotypes used in this study, five were used as lines (female parent) and four were used as tester (male parent). Twenty crosses made from this line by tester scheme and categorized according for quantitative traits. As less SCA/GCA ratio indicates that effect is non-additive in nature but in this study results showed more value of specific combining ability than general combining ability.

Maqbool et al. (2015) carried out pot experiment to investigate the effect of water stress on yield at critical growth stages in wheat. Lasani_2008, Kohistan_97 and Faisalabad_2008 varieties were grown in pots and checked under five water stressed conditions applying at different growth stages viz booting, tillering, anthesis, grain filling stages. It was observed that water stress condition cause significant reduction in number of fertile tillers, number of nodes, spikelet per spike, plant height and 100-grain weight as compare to well-watered condition. Faisalabad_2008 found as more tolerant to drought condition than other varieties.

Saeidi et al. (2015) studied water stress respond on grain yield and physiological traits in wheat. Trails were conducted in green house with three replications. Different wheat cultivars were evaluated by applied stress at vegetative growth stages. Water stress was significantly decreased the number of grains/spike and hence adversely effected the grain yield. Results showed the significant decline in relative water constant (RWC), chlorophyll content and photosystem 1 while increase in concentration of carotenoid was also observed at the same time.

Zare et al. (2015) conducted field experiment to estimate the effect of different irrigations on grain yield in wheat using split plot experiment based on RCBD (randomized complete block design with triplicates. Five water stress treatments were used in main plot. It was estimated that the significant effect of genotype, irrigation and their interaction on number of spike, 1000-grain weight0number of seeds per spike, dry weight of spike, harvest index, grain yield and biological yield. Result showed that the behrang genotype was more tolerant to drought stress then other genotypes. It was also found through correlation that effects of biological yield and harvest index were highest and effective to be used for selection for improving crop production.

Ihsan et al. (2016) examined the effect of drought stress on phenological development, grain yield and growth indices of wheat genotypes under arid environment to evaluate their tolerance and adaptability. Work was done to estimate the effect of water stress at five critical growth stages i.e. tillering stage, jointing stage, booting stage, heading and maturity stages. The results showed that the booting and grain filling are important growth stages as they are sensitive to drought.

Mwadzingeni et al. (2016) assessed that drought stress enhances the expression of several genes effecting the metabolism. The biochemical helps the plant to tolerate the drought stress by osmotic adjustment and membrane stabilization. However, many of the mechanisms are still hidden. The large number of genes influenced the trait and the large size of genome make it challenging for examination through QTL. Several QTL for drought related traits had already mapped but still no QTL analysis has been done for grain quality. The limitations in QTL analysis can be decreased by using advance sequence-based techniques in order to improve QTL analysis.

Rahman et al. (2016) worked on genetic parameters in wheat and association between traits for yield improvement under drought stress. Thirty wheat genotypes were grown under field condition and traits like canopy temperature, relative water content, early ground coverage, number of spikes/m2 and 1000 grain weight were measured for water stress condition. Results through correlation analysis showed that grain yield exhibits positive and significant relation with 1000 grain weight and early ground coverage. Hence, these three traits considered to be most important for selecting and breeding wheat genotypes under drought stress.

Rangan et al. (2016) explored that C4 pathway in plants allow the maximum CO_2 capture in the dry and hot environmental conditions. To develop the C4 pathway in leaf of wheat which is C3, genes for C4 were found that expressed in pericarp tissues of caryopsis. To optimize the relative contribution of C3 and C4 pathway in wheat can promote the efficiency of wheat plant to cope with the changing environment and can be used for global food security program.

Rebetzke et al. (2016) studied the role of awns to increase the grain size and yield of crop. Ear morphology variations are linked to the photosynthetic potential that increase yield in cereals. Awns play important role in photosynthesis in irrigated as well as rainfed conditions. The performance was noted up to 45 backcrosses, NILs (awned/awn-letted) represented four backgrounds that were diverse genetically in 25 irrigated and drought environments. Awnletted genotypes showed more grains per unit area, more fertile spikelets and tertiary floret grains. The increase in number of grains were compensated by increase in frequency of small shriveled grains and reduction in the size of grains that decrease the quality. Emergence of large awns decreases the fertility of floret to reduce the number of grains and individual grain size is increase especially in drought conditions. It was concluded that such awn-less lines should be identified that can combined the high yield of grain with large size to increase the quality.

Vikram et al. (2016) checked the genetic diversity in wheat crop as change in climate and low gain in yield cause reduction in world wheat production. It was found that landraces had wide range of genetic variations that can be used for improving crop against abiotic stresses as they contain wide range of rare alleles.

Kulkarni et al. (2017) elaborated the recent sequences in wheat genome. Microarray based gene expression analysis is an important tool to understand transcript modulation under stress condition. The wheat genome sequencing helps to analyze gene associated with different traits of drought tolerance. It facilitates the analysis of genetic basis of wheat for drought tolerance.

Liu et al. (2017) conducted an experiment to estimate the effect of early drought on grain yield and NUE (nitrogen use efficiency) in wheat.at post anthesis stage. At first the plants were exposed to the moderate level of drought stress for 11 days at 5th leaf stage to investigate the grain yield, NUE, yield component and leaf water retention at primed and non-primed plant at post anthesis stage in wheat. It was found that the chlorophyll contents, leaf water retention, NUE and grain yield were higher in drought primed plants. At vegetative stage, agronomic NUE and carbon assimilation were improved in drought priming plants at post anthesis stage under drought and heat stress. It was concluded that the combination of these (NUE and Carbon assimilations) can be used as tool for screening plants and improving stress tolerance in varying abiotic stress environments.

Salman et al. (2017) assessed physiological and yield contributing traits in wheat under water stress condition. NR371 and 8126 having contrasting traits for water stress used as parental lines. F_1, F_2 and their backcrosses (B_1, B_2) were also include in the breeding material. 8126 and subsequent generations along with backcrosses exhibited stable performance under both moisture treatments as compare to NT371 (susceptible parent). It was also observed that proline contents, canopy temperature and osmotic potential were highly heritable as well as fixable genetic effects indicated that these traits can be used for the development of drought tolerant varieties. This study shown that yield can be increased in water stress areas by screening and developing physiologically efficient genotypes.

Saira et al. (2018) aimed to find out drought tolerant genotypes in wheat using combining ability analysis on various traits that are valuable to upgrade grain production. Experiments conducted in 5×3 line by tester mating design with factorial arrangement. Three replications were randomized and grown under field condition. Both normal watered and drought stressed trails were organized to compare the estimated traits and found the best possible general combiner and specific combiner. Results concluded that 9737× Kohistan_97 showed best performance among crosses and 9737, K_97 and 9738 can be used in varietal development programs as they sorted out as best general combiners.

Yadav et al. (2018) applied ISSR primer to determine drought tolerant lines. Through, cluster analysis he divided wheat varieties into two major clusters, one is of drought sensitive and other is of drought tolerant varieties. Results showed that ISSR markers are valuable tool to study genetic variability in wheat.

Dolferus et al. (2019) worked on QTL mapping to found drought tolerant lines. The whole genome was used for QTL mapping. The markers were assumed to follow spatial correlation method, and this results in smooth marker profiles that can be used to find position of putative QTL. By using this technique, he screened some lines that were tolerant to soil drought.

Iqbal. (2019) deliberated that the best method to develop drought tolerance is by molecular mapping and marker assisted selection (MAS). AFLPs, microsatellites SSRs, SNPs, RAPDS and SSR markers were used for mapping of leaf flag. QTLs mapping is used to detect gene for drought tolerance.

Molecular markers were also used for this purpose. ISSR markers can be used for genetic mapping, to find genetic diversity and DNA fingerprinting etc.

Hoisington et al. (2019) determined that QTL (Quantitative trait loci) increases the understanding of gene inheritance. Markers are also used to identify the genetic diversity. The application of these and some others methods like varietal fingerprinting for identifying and understanding genetic resources. The development of molecular genes is slow in wheat in comparison to other crops because of its ploidy nature. But its hexaploidy nature on the other hand is challenging to create and use unique tools with successful strategies to fulfil our objectives of high production.

Conclusion

Drought stress limits the production of Wheat. The present goal of the breeders is to develop drought tolerant wheat genotypes. Strategies applied to tackle this stress are still limited. Wheat has a complex genome and continuous efforts and work on the genome of this crop can be beneficial. With breeding advances in biotechnology and molecular biology tolerance can be more easily induced. Methods like QTL, markers, genome sequencing, backcrossing for desirable gene, genetic engineering can be a game changing methods in case of drought stress. This stress does not occur independently like other stresses but is caused due to the heat stress. With drought stress the plant face a severe reduction in yield therefore, studies should be conducted to make the plant tolerant to drought stress to gain maximum profit by increasing quantity and quality of wheat grains.

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