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REVIEW PAPER

Physiological Traits and their Importance in Wheat Breeding

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Throughout the last century, the main focus in wheat breeding was to improve the productivity which was efficaciously achieved (Reynolds et al., 2012). As the human population increasing day by day to cope up with this factor we need one more rapid jump in wheat production (Austin, 1982). Remarkable success has been already noticed in the wheat productivity in last of the 20th century (Lin and Huybers, 2012).

With plant breeding, we often mainly concentrate on the traits which have economic values, shows significant genetic variations. However, in breeding programmes, we breed the genotypes for high yielding varieties which will be stable in the terms of yield potential in most spring wheat environments (Berzonsky et al., 2010). Whereas, research experiments based on in the plant physiology which focused on getting short and long term benefits in crop improvement. (Aguirrezábal et al., 2015).

Numerous research experiments have shown that there are associations of a number of physiological traits viz; leaf conductance, photosynthetic rate and canopy temperature depression with the performance of series of cultivars in a high-yielding environment (Fischer, 1966). For example in CIMMYT, Mexico work is majorly concentrated on the development of germplasm towards a number of discrete mega- environments that mainly focus on drought and heat stress (Braun *et al.,* 2010; González-Dugo et al., 2006) factors are among the greatest challenges to breed the cultivars which are tolerant to these stresses and these cultivars will be adaptive to future scenarios, so now in this time we have to think to concentrate on physiological approaches which will assist the conventional breeding approaches (Afzal et al., 2015) .

In this review, we enlisted few important physiology-based strategies which have the efficiency to improve the adaptability of wheat cultivar against the continuously changing environments.

Physiological Traits

Canopy temperature depression (CTD)

Canopy temperature depression has been recognised as one of the indicators of overall plant water status and used in such practical applications as evaluation of plant response to environmental stress like tolerance to heat and drought (González-Dugo et al., 2006). CTD can be calculated by deduction of canopy temperature from air temperature (Amani et al., 1996; Balota et al., 2007; Pinto and Reynolds, 2015)it. High CTD has been used as a selection criterion to improve tolerance to drought and heat and has been associated with yield increase among the wheat (Reynolds *et al* 1994). CTD is related to the evapotranspiration rate, which can be calculated with a number of physiological and metabolic processes viz; stomatal conductance, photosynthetic rate, vascular capacity among others (Pinto and Reynolds, 2015). There is several hypotheses related to CTD, one of them is that higher CTD value is the indicator of a high demand for photo-assimilates by rapidly filling kernels in physiologically well adaptive cultivars (Pinter et al., 1990).

Research experiments when conducted at CIMMYT, Mexico indicated that by using breeder's F4 population in drought condition showed that CT is well associated with the ability to extract water from soil (Lopes and Reynolds, 2010). Studies conducted in hot environments at late vegetative stage and flowering stage showed that cooler canopies were had an association with yield among the random lines and it can be used as for the selection of advanced lines which perform best or tolerant against a number of heat-stressed environments (Ayeneh et al., 2002).

Leaf chlorophyll

Leaf chlorophyll content gives an important idea regarding physiological status about plant and it can also be used as an indicator of crops potential photosynthetic rate (Palta, 1990). A positive correlation has been found between leaf chlorophyll (Allahverdiyev, 2015; Ma et al., 2012) concentration and grain yield in wheat under drought stress conditions (Allahverdiyev, 2015; Ma et al., 2012). Correlation reported between Chlorophyll content and grain yield might be associated with greater radiation use efficiency in cultivar with high chlorophyll content and this chlorophyll content found positively correlated with grain yield and biomass content per plant in wheat cultivars. A positive correlation has been found between leaf colour and chlorophyll content and concluded that loss in chlorophyll content is the main factor which is responsible for the change in leaf colour (Fischer et al., 1998) . A strong association between chlorophyll content, photosynthetic rate and grain yield in wheat was noticed by Rodricoz *et al* 2004.

Chlorophyll fluorescence

Chlorophyll fluorescence analysis has become one of the most powerful and widely used techniques available to plant physiologists these days (Barbagallo *et al* 2003). This technique has been used in the studies to predict wheat stress response under different unfavourable conditions, such as drought stress (Lu and Zhang 1998), heat stress (Lu *et al* 2001), cold stress (Ying *et al* 2002) and salt stress (Lu *et al* 2003). Chlorophyll fluorescence closely associated with photosystem II (PS II), which can reflect the photosynthesis efficiency in different plants (Bruce and Vasil'ev, 2004; Karukstis, 1992).

The fluorometer is based on the principle that uses a sensitive photodiode which detects pulsed fluorescence signal and ignores any kind of non-pulsed signal. The value of this modulated technique is that it provides a continuous measure of the relative quantum yield of fluorescence. This parameter measures the proportion of the light which is absorbed by chlorophyll associated with PSII that is used in photochemistry (Shangguan et al., 2000). Moaed *et al* (2012) showed that significant differences in the values between the three groups studied based on the values obtained from fluorometer, however, highest values for chlorophyll fluorescence in drought tolerant varieties at vegetative stage and the values were 0.79, 0.82 and 0.83 for susceptible, moderately tolerant and tolerant wheat varieties respectively.

Stomatal conductance

Stomatal conductance has a close association with economic yield in wheat. It is mainly regulating the intake of CO_2 and diffuses out of H_2O from the leaf (Cheng et al., 2010; Clarke, 1997). Araus *et al* (2003) reported that genotypes which can keep the stomata more open are those which are more productive. Fischer *et al* (1998) likewise found a high positive correlation between the overall mean of stomatal conductance and mean yield in wheat. Stomatal conductance correlates with canopy temperature depression in a wide range of climatic conditions and it was reported that high stomatal conductance in wheat cultivars was associated with cooler canopies and higher photosynthetic rates (Rebetzke et al., 2013) . Wheat varieties in relation to available water, having high rates of leaf conductance when soil moisture was favourable, and markedly reduced leaf conductance when soil moisture was limiting, so this criterion can be considered significant for selection of improving (Nakhforoosh et al., 2016).

Stem reserve mobilisation

Remobilization of assimilates is an active process that involves translocation of stored reserves from stems and sheaths to grains (Zhang *et al* 1998). Pre-anthesis assimilate reserves in stem and sheath of wheat contribute 25-33% of the final grain weight (Gebbing and Schnyder 1999). Water deficit conditions resulted in early senescence and more remobilization of pre-anthesis stored assimilates to grains in cereals. Drought-induced earlier mobilisation of non-structural reserve carbohydrates (largely, fructans) from stem and leaf sheaths, which provided a greater proportion of kernel dry weight at maturity.

Stay green habit

Stay green habit is an important trait in wheat because it has a positive correlation with resistance to different stresses. Stay green plants are characterised by a post-flowering drought resistance phenotype that gives plants resistance to premature senescence, stalk rot, and lodging when subjected to drought during grain-filling (de Luche et al., 2017; Spano et al., 2003). Stay green has been extensively used in plant breeding to improve yield potential and yield stability in all environments, including drought-prone areas (Tian et al., 2012). Kumar *et al* (2010) have reported that stay green or delayed senescence is considered to play a crucial role in grain development in wheat when assimilates are limited and stay green cultivars are well adapted to drought and heat stress conditions. Stay green habit can be measured based on visual screening using scale 1-4.

1. < 25% of foliar tissue showing green colour
2. 25-50% of foliar tissue showing green colour
3. 50-75% of foliar tissue showing green colour
4. > 75 of foliar tissue showing green colour

Flag leaf area

Flag leaves play key role in wheat breeding because it is the chief photosynthetic organs in wheat (Mcneal and Berg, 1977; Simón, 1999) . So, the plants with greater flag leaf area play an important role in yield increase under varying environments. Flag leaf is desirable because it has lower water potential and turgor pressure but produces maximum photosynthates and thus more dry matter production than lower leaves of the plant (Takashi et al., 1989). Under stress environments, leaves should have more surface area (Foutz *et al* 1974). Flag leaf area is positively correlated with yield and it has good heritability (Yang et al., 2016). . It is concluded that research focused on the basis of physiological traits can potentially implemented in conventional breeding by the utilization of various key traits that may serve as indirect selection criteria for higher yield under adverse environmental conditions. Trait based introgression strategies may increase the efficiency of parental and progeny selection and providing clear understanding into the physiological and genetic basis of higher yield production to meet projected demands for wheat production in the near future.

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