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Abstract - Wheat is a cereal of choice in most countries of the world and it is a staple food crop for more than 35% of the world population and also one of the widely cultivated crops in Syria. Constant efforts are therefore needed to boost its production to keep the pace with ever increasing population. But unfortunately, these efforts are seriously being hampered by a number of abiotic stresses among which is drought. Considerable attention over the years from plant breeders with the purpose of increasing the grain yield and to minimize crop loss due to unfavourable environmental conditions. Drought tolerance is a difficult trait to define as it encompasses a wide range of characteristics involving multiple genetic, physiological, cellular and biochemical strategies in the plant. Nine tolerant, moderately tolerant and susceptible durum wheat varieties were used in this experiment with major objective of examine the efficiency of the physiological system of these varieties under rainfed condition. Our result clearly showed significant differences between the three groups of varieties under study at vegetative and anthesis stage.

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PHYSIOLOGICAL PERFORMANCE OF DIFFERENT DURUM WHEAT VARIETIES GROWN UNDER RAINFED CONDITION

Strictly as per the compliance and regulations of :

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Abstract - Wheat is a cereal of choice in most countries of the world and it is a staple food crop for more than 35% of the world population and also one of the widely cultivated crops in Syria. Constant efforts are therefore needed to boost its production to keep the pace with ever increasing population. But unfortunately, these efforts are seriously being hampered by a number of abiotic stresses among which is drought. Considerable attention over the years from plant breeders with the purpose of increasing the grain yield and to minimize crop loss due to unfavourable environmental conditions. Drought tolerance is a difficult trait to define as it encompasses a wide range of characteristics involving multiple genetic, physiological, cellular and biochemical strategies in the plant. Nine tolerant, moderately tolerant and susceptible durum wheat varieties were used in this experiment with major objective of examine the efficiency of the physiological system of these varieties under rainfed condition. Our result clearly showed significant differences between the three groups of varieties under study at vegetative and anthesis stage. Drought tolerant varieties showed better physiological performance (membrane stability index, relative water content, chlorophyll content and chlorophyll florescence), higher yield and yield components (total biomass, grain yield, tiller number/m2, grain number/ear and 1000 grain weight) compared to susceptible one. Our finding indicates that the physiological approach would be the most attractive way to develop new varieties rapidly with better adaptation to dry and semidry area.

Abbreviations : RWC: relative water content; MSI: membrane stability index; Fv/Fm: chlorophyll florescence.

Keywords : Drought; rainfed; wheat; chlorophyll; membrane stability; relative water content; Fv/Fm

I. Introduction

Wheat is widely grown as a rainfed crop in semi-arid areas, where large fluctuations occur in the amount and frequency of rainfall events(Pakniyat and Tavakol, 2007).Drought is generally accepted to be the most widespread abiotic stress experienced by crop plants, and is becoming an increasingly severe problem in many regions of the world (Demirevskaet al., 2008, Ashraf and Harris, 2005, Quarrieet al., 2003). It considered as the main causes for crop yield reduction in the majority of agricultural regions of the world,particularly in the dry and semi dry areas (Mollasadeghiet al., 2011).Plant growth and productivity are negatively affected by water stress and genetic improvement of water stress tolerance is important to agricultural plants. Water stress tolerance has been documented in almost all plants but its extent varies from species to species (Chaitanyaet al., 2003).Water stress limiting durum wheat distribution and productivity in the Mediterranean environment and its major contributors to yield reduction in the semiarid regions, therefore improving drought resistance is a major objective in plant breeding programs for rainfed agriculture (Zareiet al., 2007).

Drought tolerance does not exist as a unique and easily quantifiable plant attribute, it is a complex physiological, morphological and molecular character connected with relative water content (RWC), relative water loss (RWL), chlorophyll fluorescence, stomatal resistance, cell membrane stability (CMS) and accumulation of free proline (Farshadfaret al., 2008). The integration of these novel approaches with conventional system of crop genetic improvement should provide exciting results to breed for drought tolerance in wheat in the near future (Khan and Iqbal, 2011). The development of drought tolerant cultivars of wheat will give great opportunities to obtain high productivity in stressed environments(Abdel-Hady and El-Naggar, 2007)But it is hampered by low heritability for drought tolerance and lack of effective strategies(Kirigwiet al., 2004; Pakniyat and Tavakol, 2007).Conventional plant breeding attempts have changed over to use physiological selection criteria since they are time consuming and rely on present genetic variability (Zhu, 2002). A physiological approach would be the most attractive way to develop new varieties rapidly (Turner and Nicolas, 1987). The scientists pay attention to the physiological basis for improving yield under abiotic stress and the use of physiological indices in the breeding program. Physiological traits that are integrative, either in time or at an organizational level (Arauset al., 2002)constitute ideal selection criteria for drought adaptation. In recent

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years they have acquired increased importance in breeding programmes largely due to a greater understanding of their relative contribution to yield (Rebetzkeet al., 2002, Reynolds et al., 2005).

This experiment was conducted with major objective of understanding physiological response of some durum wheat varieties differ in their response to drought stress (susceptible, moderately tolerant and tolerant) grown under rainfed conditions and its effect on yield and yield components

II. Materials and Methods

a) Plant materials and growth conditions

Nine drought tolerant and susceptible durum wheat varieties were chosen to represent a range of genetic diversity within Syrian wheat varieties, viz., Sham3, Sham5 and Doma3 (drought tolerant), Bohouth7, Bohouth11 and Sham9 (moderately drought tolerant), Bohouth5 Bohouth9 and Sham7 (drought susceptible) were used in this study. Seeds were obtained from Crop Research Directorate, GCSAR, and sown under rainfed conditions in the field on 20th Nov. 2010 in the first settlement zone (Jellen research station, annual rainfall 400mm). Crops were sown at an adjusted rate of 300 viable seeds/m2 in three replications. Normal agronomic practices were performed and relevant metrological parameters were obtained from the observatory at each research station and daily minimum and maximum temperature and rainfall were recorded. Chlorophyll content (chl), membrane stability index (MSI), relative water content (RWC), chlorophyll fluorescence Fv/Fm were estimated on the first fully expanded leaf (third from top) at vegetative stage and flag leaf at anthesis stage.

b) Chlorophyll Content

The chlorophyll meter (SPAD meter) was used for chlorophyll estimation and it is a simple, portable diagnostic tool that measures the greenness or the relative chlorophyll concentration of leaves. The meter makes instantaneous and non-destructive readings on a plant based on the quantification of light intensity (peak wavelength: approximately 650 nm: red LED) absorbed by the tissue sample. A second peak (peak wavelength: approximately 940 nm: infrared LED) is emitted simultaneous with red LED for to compensate the thickness leaf. Compared with the traditional destructive methods, this equipment might provide a substantial saving in time, space and resources.

c) Membrane Stability Index

A conductivity test to estimate drought tolerance as suggested byAlmeselmaniet al. (2006). 100 mg leaf sample was placed in a test tube containing 10 ml of double distilled deionized water. Electrical conductivity of the solution was measured after incubating the test tubes at 45^{o}C and 100^{o}C.

e) Relative Water Content (RWC)

Was determined by the method described by Barrs and Weatherley, (1962). 100 mg leaf material was taken and kept in double distilled water in a petridish for two hours to make the leaf tissue turgid. The turgid weight, dry weight of the leaf materials was measured and RWC was calculated.

d) Chlorophyll fluorescence

The polyphasic rise of fluorescence transients of intact leaves was measured by a Plant Efficiency Analyzer (PEA, Handsatech Instruments Ltd., King's Lynn, UK) according to Strasseret al., (1995). For the measurement of the chlorophyll fluorescence all the samples were covered with clips, kept in dark for 30 minutes before fluorescence measurements. The transients was induced by red light of 3000 μmol m-2 s-1 provided by an array of six light emitting diodes (peak 650 nm), which focused on the sample surface to give homogenous illumination over exposed area of sample surface and maximal quantum yield of PS II (Fv/Fm) was measured.

On mid Jun plants harvested from m2 and used for recording number of tillers, grain number per ear, 1000 grain weight, total biomass and grain yield.The experimental design was complete randomized blocks. Analysis of variance and L.S.D. values were estimated.

III. Result and Discussion

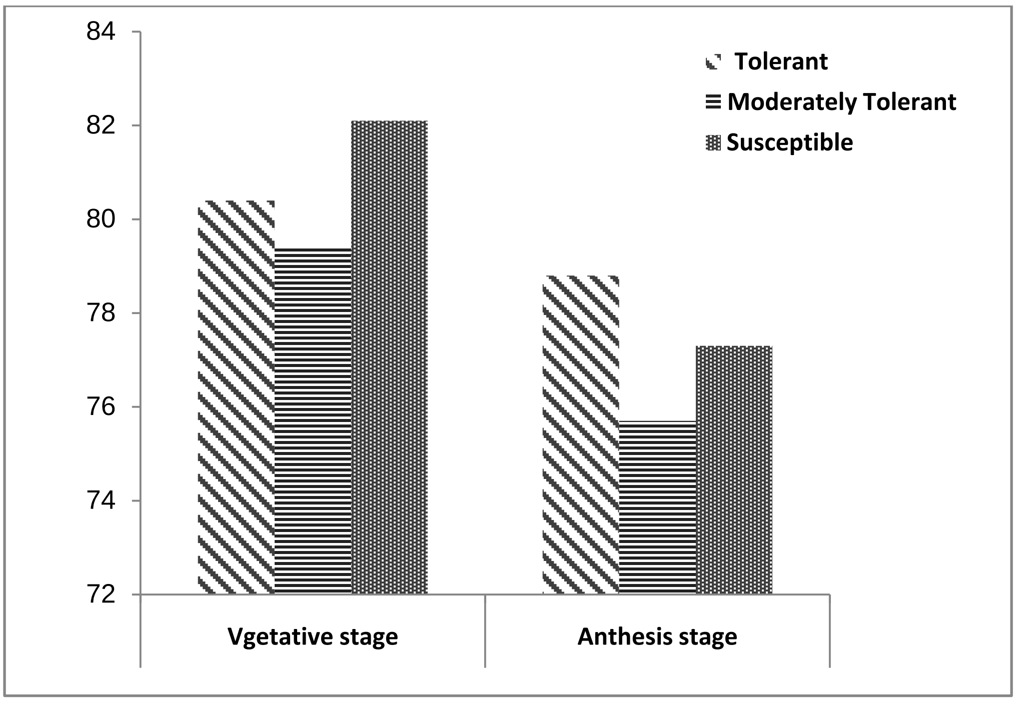
In this study some physiological parameters were examined in the field under rainfed condition of the most important durum tolerant and susceptible wheat varieties grown in Syria. The total amount of rainfall received during the growing season was 388mm as shown in table(1).Only 148mm were received at the most sensitive stage (anthesisand grain filling stage) which may have adverse effect on growth and productivity of susceptible varieties.

Table 1 : Total amount of rainfall (mm) in Jellen research station during the growing season

Month	mm
Oct-10	1
Nov-10	
Dec-10	85
Jan-11	44.5
Feb-11	109.5
Mar-11	60.5
Apr-11	61.5
May-11	26
Jun-11	
Total amount of rainfall	388

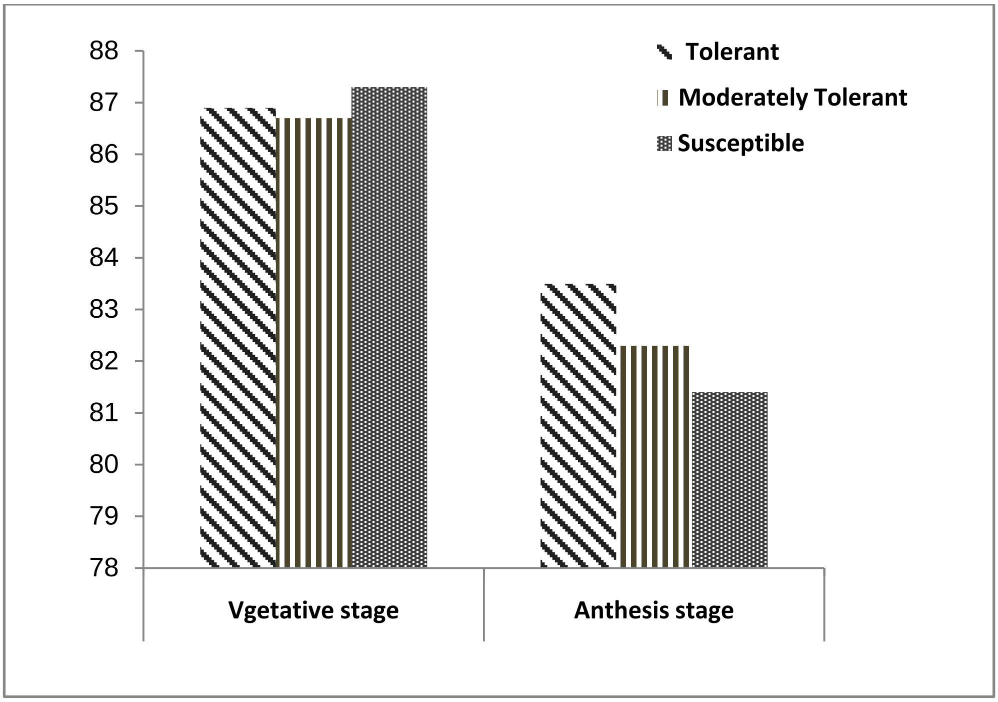
Cell membrane is one of the first targets of plant stresses (Levitt, 1972) and membrane stability is a widely used criterion to assess crop drought tolerance. This indicates the importance of this test in discriminating among tolerant and susceptible varieties. Drought susceptible varieties showed highest MSI value i.e., 82.1compared to moderately tolerant and tolerant one, i.e., 79.4 and 80.4 % respectively at vegetative stage, however no differences were recorded between tolerant and moderately tolerant varieties. While at anthesis stage drought moderately tolerant varieties showed lowest MSI values i.e., 75.7% and the highest value were recorded in drought tolerant varieties i.e., 78.8% as shown in figure (1), in general, MSI decreased as plant advanced in age. Water stress caused water loss from plant tissues which seriously impair both membrane structure and function. Martin et al., (1987) reported that electrolyte leakage was correlated with drought tolerance. The leakage was due to damage to cell membranes which become more permeable.

Figure 1 : Effect of drought stress on membrane stability index (%), of drought tolerant, moderately tolerant and susceptible wheat varieties at vegetative and anthesisstages, LSD values at vegetative and anthesis stage: 1.5 and 1.2 respectively.



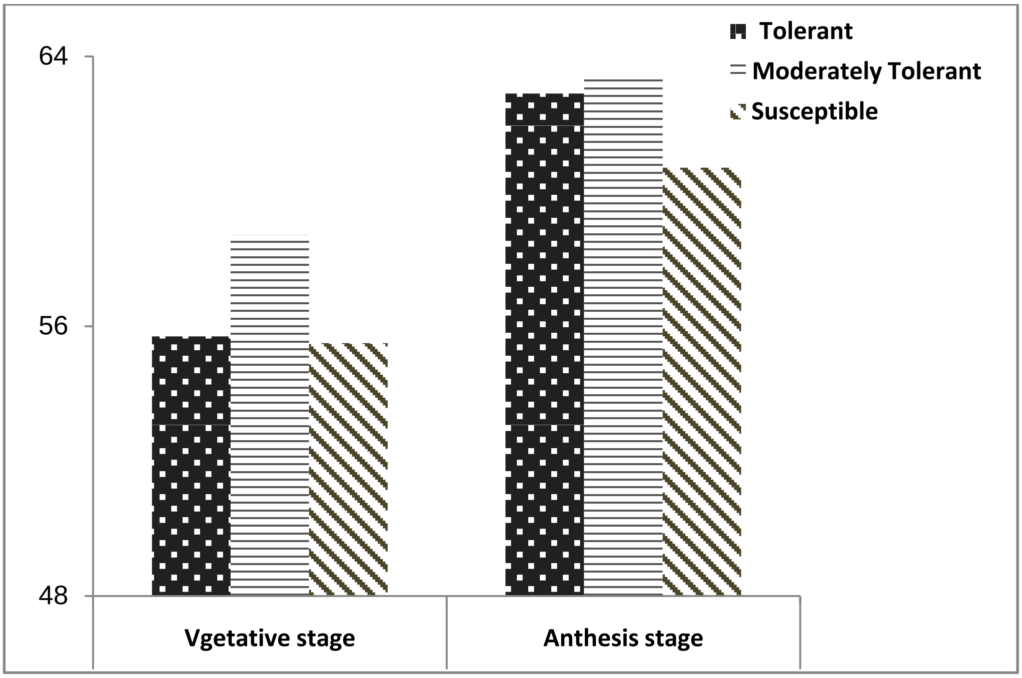
No differences in RWC were recorded between drought tolerant, moderately tolerant and susceptible wheat varieties at vegetative stage, however RWC values at this stage were more higher compared toanthesis stage. Data at anthesis stage showed that drought tolerant varieties had highest value of RWC in compared to the other varieties, the values were, 83.5, 82.3 and 81.4% for tolerant, moderately tolerant and susceptible varietiesrespectively as shown in figure(2).A decrease in the RWCin response to drought stress has been noted in wide variety of plants (Nayyar and Gupta, 2006).According to Almeselmaniet al.,(2011; 2006) RWC indicates the water status of the cells and has significant association with yield and stress tolerance. Sinclair and Ludlow, (1985) reported that RWC of the leaves is a better indicator of water stress than other growth or biochemical parameters of the plants. RWC of the leaves is very responsive to drought stress and has been shown to correlate with drought tolerance (Colom and Vazzana, 2003).

Figure 2 : Effect of drought stress on relative water content (%), of drought tolerant, moderately tolerant and susceptible wheat varieties at vegetative and anthesisstages, LSD values at vegetative and anthesis stage: 1.6 and 0.8 respectively.



The results in this experiment showed no differences in chlorophyll content between tolerant and susceptible varieties at vegetative stage and highest value were recorded in moderately tolerant varieties. At anthesis stage lowest chlorophyll content were recorded in drought varieties and no significant differences between drought tolerant moderately, tolerant varieties at this stage, however, the values were 60.7, 63.4 and 62.8 for drought susceptible, moderately tolerant and tolerant varieties respectively as shown infigure (3).This trait has been used successfully by many workers for screening and selection of drought tolerance wheat cultivars (Almeselmaniet al., 2011). According to Izanlooet al., (2008) water deficit leads to an increased depletion of chlorophyll and a decreased concentration of chlorophyll. Zaharievaet al., (2001) reported that leaf color and chlorophyll content were correlated, as expected, since chlorophyll loss is the main factor responsible for change in leaf color. According to Manivannanet al., (2007) chlorophyll is one of the major chloroplast components for photosynthesis and relative chlorophyll content has a positive relationship with photosynthetic rate and flag leaf chlorophyll content is an indicator of the photosynthetic activity and its stability for the conjugation of assimilate biosynthesis (Bijanzadeh and Emam, 2010).

Figure 3 : Effect of drought stress on chlorophyll content, of drought tolerant, moderately tolerant and susceptible wheat varieties at vegetative and anthesisstages, LSD values at vegetative and anthesis stage: 0.6 and 0.8 respectively.



Use of a chlorophyll fluorescence technique as a tool to investigate drought tolerance in different wheat genotypes has been reported. The data presented in figure(4) showed significant differences in Fv/Fm values between the three groups under study, however, highest values for chlorophyll florescence in drought tolerant varieties at vegetative stageand the values were 0.79, 0.82 and 0.83 for susceptible, moderately tolerant and tolerant wheat varieties respectively as shown in figure (4), however the values for all varieties at this stage were more higher compared to anthesis stage which may indicate high photosynthetic efficiency at this stage compared to anthesis stage. While at anthesis stage lowest Fv/Fm values were recorded in drought susceptible varieties i.e., 0.75 and no significant differences were recorded between moderately tolerant and tolerant one which had the same value i.e., 0.79. Chlorophyll fluorescence has been used in several studies to detect the genotypic differences in response to drought in many plant species, including wheat. Various studies reported that Fv/Fm ratios indicate the maximum efficiency of photosystem II and in healthy plants, the value of Fv/Fm is 0.83. A similar effect of water stress on the PS II efficiency and a significant decline in Fv/Fm values were reported in intact wheat leaves (Xuet al., 1999). Chlorophyll fluorescence quick variation can be used as a valuable index for evaluation of plants tolerance to environmental stresses (Paknejadet al., 2007). Flagella et al., (1995) also reported that drought tolerant cultivars showed a smaller decrease in photosynthetic efficiency (Fv/Fm ratios) and higher osmotic adjustment and leaf water potential under water stress.

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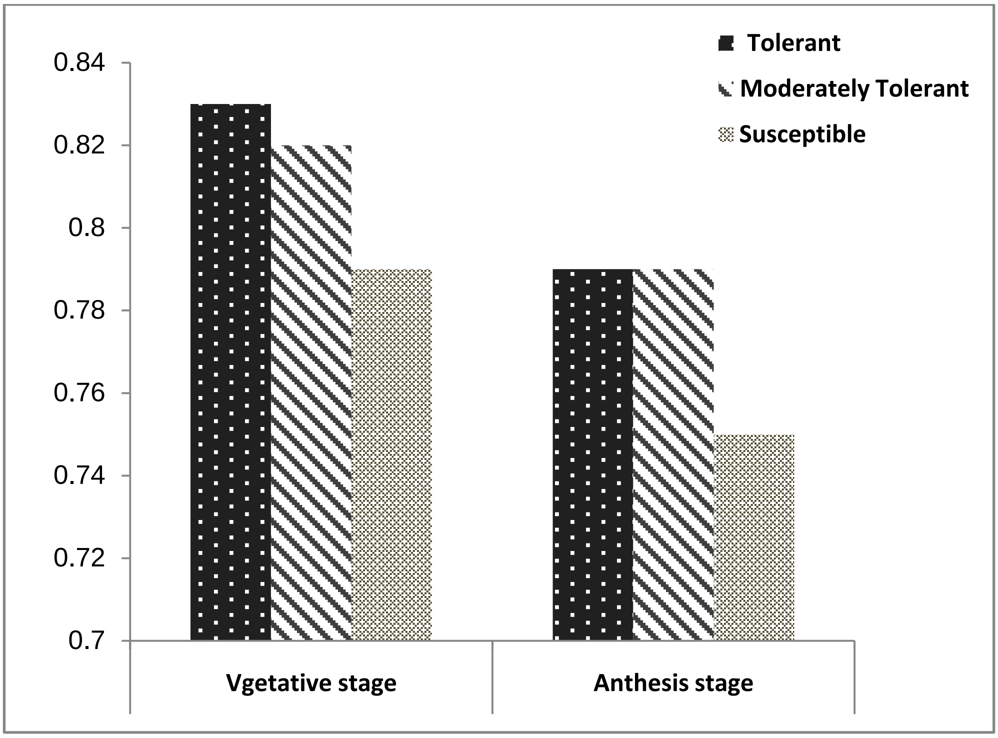
Figure 4 : Effect of drought stress on chlorophyll fluorescence, of drought tolerant, moderately tolerant and susceptible wheat varieties at vegetative and anthesisstages, LSD values at vegetative and anthesis stage: 0.06 and 0.03 respectively.



Drought, being the most important environmental stress, severely impairs plant growth and development, limits plant production and the performance of crop plants, more than any other environmental factor (Shao et al., 2009). Significant differences were recorded between drought tolerant, moderately tolerant and susceptible varieties with regard to total biomass i.e., 1202, 1287 and 1183g/m2 respectively as shown in table (2), however,Drought moderately tolerant varieties showed highest total biomass values compared to other two groups. Plant produces their maximum biomass under adequate water supply, whereas moisture stress causes a marker decrease in plant biomass production (Clarke et al., 1991; Ashraf, 1998).

Table 2 : Effect of drought stress on wheat yield and yield components (total biomass g/m^2, grain yield g/m^2, grain number per ear, tiller number/m2, 1000 grain weight (g) in drought tolerant, moderately tolerant and susceptible group.

	Total biomass (g)	Grain yield (g)	Tillers number/m^2	Grain number/m^2	grain weight 1000 (g)
Tolerant	1184	588	349	50.5	51.6
Moderately Tolerant	1287	568	374	49.3	50.1
susceptible	1202	563	363	48.2	49.8
LSD at 5%	18	7	15	0.88	0.63

Blum and Pnuel (1990) reported that yield and yield components of twelve spring wheat varieties were significantly decreased when they received minimum annual precipitation. Our data showed thattolerant wheat varieties were superior in grain yield as shown in table (2) and drought susceptible varieties showed lowest grain yield i.e., 563g/m2 compared with moderately tolerant and tolerant one i.e., 568 and 588g/m2 respectively. However significant differences were reported between the three groups of varieties.

Drought stress may reduce all yield components, but particularly the number of fertile spikes per unit area and the number of grains per spike (Giuntaet al., 1993; Simaneet al., 1993), while kernel weight is negatively influenced by high temperatures and drought during ripening (Atefehet al., 2011). Our data on tillers number/m2 showed no significant differences between the moderately tolerant and susceptible one i.e., 363 and 374 respectively and lowest value were recorded in drought tolerant varieties i.e., 349.

While in case of grain number per ear, significant differences between susceptible and moderately tolerant and tolerant wheat varieties and the values were 48.2, 49.3 and 50.5 respectively as shown in Table (2), which indicates that drought tolerance varieties had highest grain number per ear. Drought stress reduced the number of gain/spike and grain yield (Saleem, 2003) and the genotypes with higher number of grain/ear produce more yields (Iqbalet al., 1999).

In general the highest 1000 grain weight was observed in tolerant varieties i.e., 51.6g and no significant differences between susceptible and moderately tolerant varieties. However lowest 1000 grain yield were recorded in drought susceptible varieties i.e., 49.8g. Chandler and Singh (2008) reported that number of grains per main spike, 1000-grain weight, number of tillers per plant, biological yield per plant and grain yield per plant were decreased under stressed environment.

Plant growth and productivity are negatively affected by water stress and genetic improvement of water stress tolerance is important to agricultural plants. Generally, drought stress reduces growth (Levitt, 1980) and yield of various crops by decreasing chlorophyll pigments and photosynthetic rate (Asada, 1999). It's obvious that all these traits have directly or indirectly transfer their effects to yield particularly at anthesis stage, at the time the tolerant varieties showed better Physiological performance and maintain efficient physiological system the same varieties showed better yield. Considering that any improvement in grain yield must be a result of an underlying physiological change it is surprising that direct selection for a physiological trait has not contributed more to yield progress.

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