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Some Physiological Responses of Drougt Stress in Wheat Genotypes with Different Ploidity in Turkiye

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Abstract: Drought, one of the environmental stress, is the most significant factor restricting plant production on majority of agricultural fields of the world. Wheat is usually grown on arid-agricultural fields and drought often causes serious problems in wheat production on these fields. In the current study drought stress was assessed in terms of Relative Water Content (RWC), Chlorophyll (Chl) and Carotenoid (Car) content and Membrane Stability Index (MSI). Physiological responses were studied under water stress by keeping water supply during preanthesis phase at 50, 60 and 70 Days after Sowing (DAS) and samples were collected at 60, 70 and 80 DAS. Irrigated and fully turgid plants were used as a control. The plant materials used in this experiment were hexaploids *(Triticum aestivum)* Atay-85 (drought susceptible) and Bezostaja-1 (drought tolerant) and 2 tetraploids *(Triticum durum)* Gerek-75 and Cakmak-79. Significant reductions were observed in RWC, MSI and Chl contents of all the cultivars under water stress. Of these, Cakmak-79 showed the highest MSI in both irrigated and water stressed conditions, at all the three stages of sampling. Compared with tetraploid wheats, hexaploid wheats were found to possess the highest total Chl content at all the stages in the irrigated condition. While the cultivars studied showed no significant differences at any stage in their Car contents in the irrigated condition, Atay-85 showed the lowest Car content in the stress condition.

Key words: Carotenoid content · chlorophyll content · membrane stability · water content

INTRODUCTION

Plants are exposed to numerous stress factors during their lives, which is of a significant effect on the growth of plants. Biotic (pathogen, competition with other organisms) and abiotic (drought, salinity, radiation, high temperature or freezing etc.) stress cause changes in normal physiological functions of all plants, including economically important cereals as well. All these stresses reduce biosynthetic capacity of plants and might cause some destructive damages on plants [1]. Drought stress has the highest percentage (26%) when the usable areas on the earth are classified in view of stress factors. It is followed by mineral stress with 20% part, cold and freezing stress with 15% part. Whole the other stress get 29% part whereas only 10% area is not exposed to any stress factor [2]. Therefore, drought stress is one of the most widespread environmental stress, which affect growing and productivity; it induces many physiological, biochemical and molecular response on plants, so that plants are able to develop tolerance mechanisms which will provide to be adapted to limited environmental conditions [3].

Wheat (specially *Triticum aestivum L.*) is the world's widely adapted crop, providing one-third of the world population with more than half of their calories and nearly half of their protein. Wheat is mainly grown on rainfed land and about 35% of the area of developing countries consists of semiarid environments in which available moisture constitutes a primary constraint on wheat production. Climatic variability in these marginal environments causes large annual fluctuations in yield. Selection of wheat genotypes with better adaptation to drought stress should increase the productivity of rainfed wheat [4]. Improvement of wheat productivity for this abiotic stress is therefore an important objective of

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research. Because of their better adaptation under hot and arid regions, *Triticum durum* wheat is usually regarded as more tolerant to stress conditions than hexaploid wheat [5]. In addition among crop plants, *durum* wheat, which is often grown in water limited conditions, is an attractive study system due to of the natural genetic variations in traits related to drought tolerance.

However, the physiological basis of their stress tolerance is not well understood. An understanding of how plants respond to water deficits and in certain instances, are able to tolerate them should lead us eventually to ways of optimizing plant productivity in marginal environments [6].

According to researchers, there is a link between various physiological responses of crop plants to drought and their tolerance mechanisms such as high relative water content and water potential [7, 8] membrane stability [9, 10] and pigment content stability under stress [10-12]. On the other hand, reports concerning variations in these physiological parameters on genotypic basis or owing to of ploidy levels are very rare.

In conclusion we aimed to investigate drougth resistance of two hexaploid wheat commonly grown in Turkiye and the drought resistance of which was only determined by agronomic observations and two tetraploid wheat which should be of the ability of resisting drought on account of its genetic structure according to above mentioned characters.

MATERIALS AND METHODS

The present study was conducted during the winter season of 2003-2004 under pot-culture conditionals. Physiological responses were studied under water stress by keeping water supply during preanthesis phase at 50, 60 and 70 Days after Sowing (DAS) and samples were collected at 60, 70 and 80 DAS. Irrigated and fully turgid plants were used as a control. The plant materials used in this experiment were hexaploids (*Triticum aestivum*) Altay-85 (drought susceptible) and Bezostaja-1 (drought tolerant) and 2 tetraploids *(Triticum durum)* Gerek-75 and Cakmak-79. Earthen pots 30×30 cm in size were filled with clay-loam soil and farm yard manure in 6:1 ratio. Each pot was fertilized equivalent to 120, 60 and 60 kg ha^{-1} of N, P and K, respectively. 4 seedlings were retained in each pot.

Cultivars were divided into groups according to their stress duration and three replication were formed for each kind in every group. 5 pots were used in each replication of every kind whereas totaly 180 pots in investigation period and trial randomized plots were constituted according to trial leaf samples were randomizedly taken from these pots. It was determined that while moisture content in irrigated stage of pot soil ranged from 35 to 38.7%, moisture content to which drought stress was applied was 11.0 to 12.2%. Elmetron PWT 101 was used in the evaluation of soil moisture content. Plants were watered when required to keep them fully turgid. Samples were collected in quadruplicate from control and stressed plants between 9.30 am to 10.30 am from the first fully expanded leaf. The response of drought stress was assessed in terms of Relative Water Content (RWC), Chlorophyll (Chl) and Caretenoid (Car) content and Membrane Stability (MSI).

RWC was calculated according to the method of Weatherley [13]. Leaf samples (0.5 g) were saturated in 100 ml of water for 4 h and their turgid weights were recorded. Then, they were rolled in a dried butter paper at oven dried at 65°C for 48 h and their dry weights were recorded. RWC was calculated as :

$$RWC = \left[\frac{\text{(fresh weight-dry weight)}}{\text{(turgid weight-dry weight)}} \right] \times 100$$

Table 1: Effect of water stress on plant height and total dry matter production at harvest in wheat genotypes

	Plant height (cm)			Total dry matter (g $plant^{-1}$)		
Cultivar	Irrigated	Stress	Percent decrease	Irrigated	Stress	Per cent decrease
Atay-85	86.00	75.50	13.0	70.50	50.90	27.80
Bezostaja-1	93.00	84.80	9.12	53.80	38.90	27.70
Gerek-75	90.00	83.00	8.22	45.34	33.50	26.10
Cakmak-79	88.00	80.50	9.14	49.60	38.80	21.80
LSD (%5)						
Cv.	2.20			3.25		
Stress	2.25			3.35		
Cv. x stress	3.82			4.03		

Leaf Membrane Stability Index (MSI) was determined according to the method of Premachandra *et al.* [14] as modified by Sairam [15]. Leaf stripes (0.2 g) of uniform size were taken in test tubes containing 10ml of double distilled water in two sets. Test tubes in one set were kept at 40°C in a water bath for 30 min and electrical conductivity of the water containing the sample was measured (C_1) using a conductivity bridge. Test tubes in the other set incubated at 100°C in the boiling water bath for 15 min and their electrical conductivity was measured as above (C_2). MSI was calculated using the formulae given below:

$$MSI = [1-C_1/C_2] \times 100$$

Chlorophyll and carotenoids were extracted by the non-maceration method of Hiscox and Israelstam [16]. Leaf samples (0.05 g) were incubated in 5 ml of dimethyl sulfoxide (DMSO) at 65°C for 4h. Absorbances were recorded at 645, 663 and 470 nm and Chlorophyll a, b and total Chlorophyll were estimated according to Arnon [17] and carotenoid content according to Lichtenthaler and Wellburn [18].

Water stress was applied to 3 pots of each genotype at preanthesis stage (50 DAS) for 10 days and after the stress period ended, the pots were irrigated and kept separately for yield analysis. After maturation the plants were harvested from stressed and irrigated pots. Parameters such as plant height and total plant biomass were obtained for comparative study and effect of moisture stress on such characteristics (Table 1).

Data of all the parameters were statically analyzed for SPSS-13 computer programme and differences with $p< 0.05$ were considered significant.

RESULTS

Under irrigated conditions the highest R CW was shown by hexaploid wheats Atay-85 and Bezostaja-1 at 60 DAS but at 70 and 80 DAS by hexaploid Atay-85 and

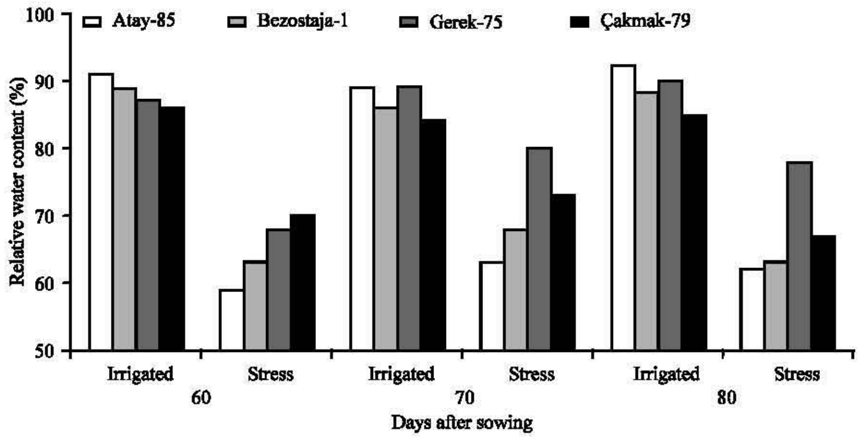

Fig. 1: Effect of water stress on (A) relative water content. Vertical bars indicate+SE of mean. Data significant at p = 0.05

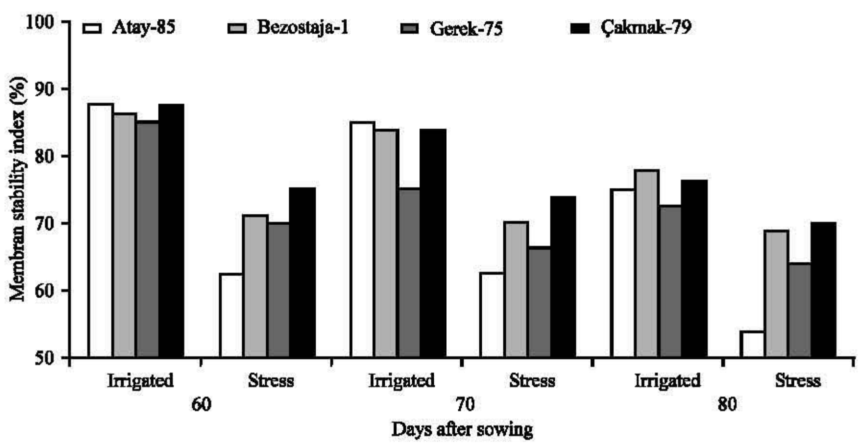

Fig. 2: Membrane stability index in wheat genotypes. Vertical bars indicate+SE of mean. Data significant at p = 0.05

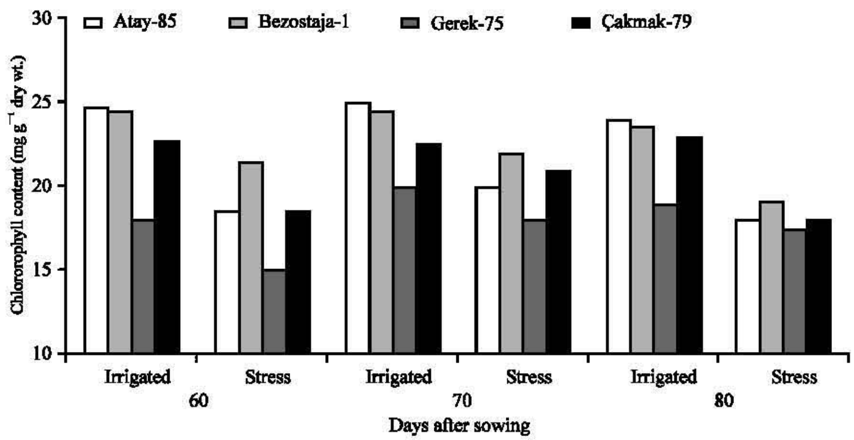

Fig. 3: Chlorophyll content in wheat genotypes. Vertical bars indicate+SE of mean. Data significant at p = 0.05

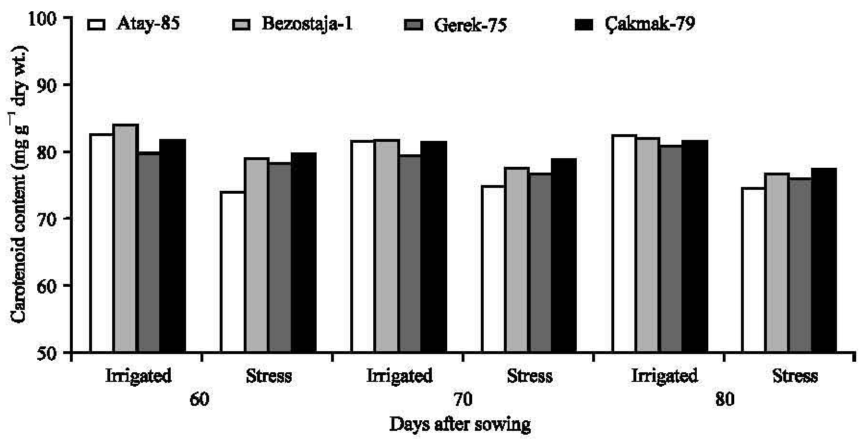

Fig. 4: Carotenoid content in wheat genotypes. Vertical bars indicate+SE of mean. Data significant at p = 0.05

tetraploid Gerek-75 whereas under stress conditions RWC in tetraploids was noted to be higher than that of hexaploids. RWC in Gerek-75 was the highest at 70 and 80 DAS (Fig. 1).

Cakmak-79 and hexaploid wheats exhibited similar Membrane Stability Index (MSI) values under irrigated conditions but Gerek-75 showed a higher per cent decline especially at 70 and 80 DAS. MSI values of hexaploid Atay-85 were observed to be the highest under irrigated conditions but lowest under stress conditions, followed by Gerek-75. MSI values were similarly high in both hexaploid Bezostaja-1 and Cakmak-79 (Fig. 2).

Tetraploid All the hexaploids and Cakmak-79 exhibited the highest Chlorophyll contents (Chl) both under irrigated water and stress conditions but among the tetraploids both Cakmak-79 and Gerek-75 had similar values especially at 80 DAS. In this study Bezostaja-1 was found to have the highest Chl content.

The CAR contents of Atay-85 at 70 and 80 DAS were observed to be highest under irrigated conditions but lowest water stress conditions. No significant differences were observed between CAR contents of Atay-85 and Bezostaya-1 especially 70 and 80 DAS under irrigated conditions. The highest CAR contents at all stages were exhibited by tetraploid Cakmak-79 under stress conditions (Fig. 4).

DISCUSSION

Wheat crop responds to water deficit in the form of changes in various physiological and biochemical processes. The physiological changes observed could be the result of deleterious effects of water deficit on important metabolic processes as well as responses of various defence mechanisms adapted by the plant under drought stress.

Significant differences in RWC/water potential in tolerant and susceptible genotypes of wheat [12] have also been reported. The tetraploid genotypes showed the highest RWC as well as a lower per cent decline under stress at all the stages. The results are in agreement with the findings of researcher [19] who reported high leaf water potential and RWC under drought in tetraploids. Bezostaja-1 a hexaploid variety suggested for rainfed cultivation showed higher RWC under water stress than Atay-85.

The plasma membrane is generally protected from desiccation-induced damage by the presence of membrane-compatible solutes, such as sugars and amino acids. Therefore, a link may exist between the capacity for osmotic adjustment and the degree of membrane protection from the effect of dehydration [20]. Maintenance of membrane integrity and function under a given level of dehydration stress has been used as a measure of drought tolerance by various workers [14, 21]. This indicated that the underground part of the plant plays an important role under drought stress conditions [22, 23]. This experiment the highest membrane stability and minimum per cent decline under water stress in tolerant genotype Cakmak-79 followed by Bezostaja-1 and Gerek-75 is in agreement with the findings of researchers [24, 25] in wheat. Decrease in MSI reflects the extent of lipid peroxidation caused by active oxygen species [26]. The better performance of tetraploid genotypes under water stress in terms of MSI points to their better adaptation under adverse conditions. However, in our study Bezostaja-1 hexaploid wheat had the best result, which is not exactly in consistent with what the researchers found.

Chlorophyll maintenance is essential for photosynthesis under drought stress. Higher Chl content and lower per cent decrease under stress in tolerant genotype of wheat have also been reported [11, 12, 27]. The results suggest that drought tolerant genotypes hexaploid Bezostaja-1, tetraploid Cakmak-79 and hexaploid Atay-85 showed lower reduction in Chl content than susceptible tetraploid Gerek-75.

Higher levels of Car in drought tolerant genotypes have also been reported [11,12, 28]. Carotenoids also have critical role as photoprotective compounds by quenching triplet Chlorophyllll and singlet oxygen derived from excess light energy, thus limiting membrane damage. This area of carotenoid function has been reviewed extensively elsewhere [29-33]. As well as their functions in photosynthetic tissue, carotenoids play important roles in plant reproduction, through their role in attracting pollinators and in seed dispersal and are essential components of human's diets. It is thus apparent that drought tolerance of a given genotype is not limited to a particular physiological character. Carotenoids are responsible for the scavenging of singlet oxygen [34], thus comparatively higher Car levels in Cakmak-79, Bezostaja-1 and Gerek-75 demonstrates their tolerance capacity.

It was determined that of the tetraploid wheat Cakmak-79 and hexaploid wheat Bezostaja-1 showed a better performance in view of resistance to drought stress. However if this research is realized on field conditions, it will increase the reliability of the above mentioned results.

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