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Physiological Response of Some Wheat Cultivars to Antitranspirant under Different Irrigation Treatments

Abd El-hady M.A., M. A. Fergani, M. E. El-temsah and M. A. Abdelkader

Agronomy Dept., Faculty of Agric. Ain Shams Univ., Cairo, Egypt.

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ABSTRACT

Less than 5% of the water absorbed by roots is used for crop growth and development; the remaining 95% is transpired. Antitranspirants are exogenous substances applied to plant leaves to reduce transpiration by regulating stomatal conductance, thus, by understanding effect of film-forming antitranspirants on the physiological traits of wheat (*Triticum aestivum* L.), we can alleviate the adverse effects of shortage water and leading to improve the wheat growth and yield. The current study included six wheat cultivars (Gemeza 9, Gemeza 11, Sakha 93, Sakha 94, Sids 1 and Masr 1), two antitranspirants treatments (without (spray with tap water) and spray with glycerol at 4%) and three irrigation treatments (I1 is normal irrigation during growth season excluding planting irrigation, I2 is irrigation was escaped during tillering stage, and I3 is irrigation was escaped during tillering and heading stages, respectively), through the growing seasons 2015/2016 and 2016/2017, in Agric. Expt. Farm, Fac. of Agric., Ain Shams Univ. at Shalakan, Kaleobia Governorate, Egypt. The following physiological traits; electrolyte leakage percentage (EL%), membrane stability index (MSI%), relative water content (RWC), Chlorophyll a, chlorophyll b, total chlorophyll, chlorophyll a/b ratio were studied. The results revealed that significant increases in the studied physiological traits were recorded except with EL% by exposing wheat cultivars to normal irrigation in comparison with the I2 and I3 irrigation treatments. The antitranspirants caused significant increases in the studied physiological traits for all cultivars except with EL%. In addition, the response of the six wheat cultivars were not the same under the three irrigation treatments as well as with and without the application of antitranspirants.

Key words: Wheat, physiological traits, RWC%, EL%, MSI%, film-forming, Glycerol, prevent irrigation.

Introduction

Wheat crop is the most important cereal crop in the world, it is a stable food for more than one third of the world population. In Egypt, wheat is the main winter cereal crop; it is used as a stable food grain for urban and rural societies. Insufficient soil water content during the sensitive growth stages can lead to a reduction in physiological and chemical traits. Film-forming types: that can create a physical barrier between the leaf and the surrounding (e.g. glycerol). ii) Reflecting materials: that can reflect the radiation falling on the surface of the leaves to reduce leaf temperature and the light needed for signaling during stomatal opening (e.g. Kaolin), and iii) Physiologically active stomata closing types: such as ABA and NO, ethylene etc. capable of affecting metabolic processes in leaf tissues. According to many researchers, there is a link between variation of physiological response of wheat plants to drought such as high electrolytic leakage (EL %), membrane stability index (MSI) and relative water content (RWC) (Ritchie *et al.,* 1990), (RWC) is a measure of the amount of water present in the leaf tissue. High RWC under drought stress conditions would be preferable to maintain water balance (Malik *et al.* 1999 and Rahman *et al*., 2000). Biological membranes are the first target of many abiotic stresses. (MSI) is reciprocal to cell electrolyte leakage (EL %) and both of them are physiological indices widely used for evaluating drought tolerance (Premachandra *et al*., 1991). Therefore, increasing duration and severity of stress led to decreased the (RWC) and (MSI) of wheat plant (Sairam and Saxena, 2000). On the other hand,the drought stress lead to increase in electrolyte leakage in plant leaves (Sairam and Saxena 2000 and Sibet and Birol 2007). Chlorophyll contents such as chlorophyll 'a' and chlorophyll 'b' plays a vital role in photosynthetic process which ultimately

Corresponding Author: Abd El-hady M.A., Agronomy Dept., Faculty of Agric Ain Shams Univ., Cairo, Egypt. E-mail: doctorelhady@gmail.com

increases crop growth and yield (Taiz and Zieger, 2006). Drought stress is one of the factors affecting chlorophyll 'a', 'b', total chlorophyll and a/b ratio (Ashraf *et al*., 1994 and Havaux, 1998). By studying the effect of drought stress on chlorophyll, it was found that drought stress had decreased chlorophyll 'a', 'b', total chlorophyll and a/b ratio (Araus *et al*., 1998; Anjum *et al*., 2003 and Hamayun *et al*., 2010). Anti-transpirant creates a physical barrier between the leaf and the surrounding. Therefore, it is can reducing water loss from leaves of plants (Atwell *et al.* 1999), the highest significant RWC% and MSI and lowest significant EL% compared with control plants might have resulted as Anti-transpirant treatment (Davenport *et al.* 1972). Anti-transpirant films reduced leaf permeability to carbon dioxide exchange consequently restricting photosynthesis, therefore, it was found had relative decreasing in chlorophyll 'a', 'b', total chlorophyll and a/b ratio in comparison with control plants (Davenport *et al*., 1974 and Hsiao, 1973).

Materials and Methods

Plant material:

Six wheat cultivars were used in this investigation to study the effect of film-forming antitranspirants (glycerol at 4%) on the physiology of wheat plants (*Triticum aestivum* L.) under different irrigation regimes. The six wheat cultivars were; Gemeza 9, Gemeza 11, Sakha 93, Sakha 94, Sids 1 and Masr 1. The grains of these cultivars were supplied by Wheat Section, Field Crops Research Institute, Agriculture Research Center at Giza, Egypt.

Experimental site:

The six wheat cultivars were cultivated in November 2015 and 2016 growing seasons. These two experiments were carried out at the Agricultural Research Station, Faculty of Agriculture, Ain Shams University at Shalakan, Kalubia Governorate.
The physical and chemical properties of soil of the experimental site were analyzed mechanically following the method described by Piper (1950) and chemically according to Black *et al.* (1965).

Table 1: Mechanical and chemical analyses of experimental soil at Shalakan area.

	Mechanical analysis	
	0-15 cm	**15-30 cm**
Clay %	58	59
Silt %	24	32
Sand %	18	9
Texture	Clay	Clay
	Chemical analysis	
Total N %	0.3	0.12
Available P-Meq/kg	144.25	69.5
Available K-Meq/kg	762	543
pH	7.87	7.98
EC ds/m	2.84	2.57
Soluble cations and inions (mg /kg soil)		
Ca^{++}	5.4	4.0
Mg^{++}	3.4	1.0
Na^{+}	3.6	2.45
K^{+}	0.36	0.64
Cl^{-}	2.8	1.4
HCO_3^{-}	2.3	0.51
SO_4^{--}	4.0	4.6

Experimental treatments:

The experimental design was split split plot design in 3 replications. The irrigation regimes were arranged in the main plot, antitranspirants spraying treatments in the sub plots and wheat cultivars were allocated in the sub sub plots. The experimental unit area was 16 m^2.

Irrigation treatments

1- The normal irrigation regime during the growing season excluding the plant irrigation (I_1).
2- Irrigation was escaped only during tillering (I_2).
3- Irrigation was escaped during tillering and heading stages, respectively (I_3).

Antitranspirants treatments, were applied at tillirng and heading stages

1- Spraying with tap water (control)
2- Spraying with glycerol at 4% as antitranspirant.

Soil preparation:

The mineral fertilizers and other agricultural practices of wheat were applied as recommended of Agriculture Research Center.

Data recorded for the studied traits

Ten plants were randomly selected from each replicate after ten days from heading stage and the following physiological traits were determined:

1- Relative water content (RWC%)according to Weatherley, 1950.
2- Electrolye leakage (EL%)according to Arora *et al.* 1992.
3- Membrane stability index (MSI %) has been measured as percentage injury of leaf tissues of six wheat cultivars under different irrigation treatments, it can be used to evaluate cultivars tolerance for water shortage according to Premachandra *et al.* 1990.
4- Chlorophyll a (mg g-1 FW) andChlorophyll b (mg g-1 FW) according to Hiscox and Israelstam, 1979, Chlorophyll a/b ratio.

Statistical analysis:

The obtained data were exposed to the proper statistical analysis according to Gomez and Gomez (1984), Data of2015- 2016 and 2016- 2017 growing seasons were subjected to homogeneity variance test for running the combined analysis of the data using the least significant difference (L.S.D.) done by Costat computer program V 6.303, test shown by Waller and Duncan (1969) at the 5% level of probability.

Results and Discussion

The results of the present investigation showed significant differences on all studied physiological traits of the six wheat cultivars grown under different irrigation treatments. The observed physiological changes could be the result of the effects of different irrigation regimes and antitranspirant application on the important metabolic processes as well as responses of various defense mechanisms adapted by the plant.

1- Relative water content (RWC%):

Relative water content (RWC%) is a measure of the amount of water present in the leaf tissue. Data reported in Table 2 indicated that significant differences were observed in RWC% of the studied six cultivars under the irrigation treatments without applying antitranspirant under normal irrigation regime (I1), the highest values of RWC% were observed by Masr 1 and Gemeza 11. While, Sids 1 and Sakha 93 recorded the lowest RWC % values. When irrigation was escaped during tillering (I2), the highest RWC values were recorded by Gemeza 9 and Gemeza 11. While the lowest RWC values were observed by Sids 1 and Sakha 93. When irrigations was escaped during tillering and heading stages treatment (I3), Gemeza 11 and Masr 1 having the highest RWC values, while Sids 1 and Sakha 93 recorded the lowest RWC values. Moreover, the data showed significant differences within each cultivar per se. Results showed clearly that the highest mean values of the RWC% as an average of all wheat cultivars were obtained with the normal irrigation regime (I_1)followed by $I_2$and I_3 recorded the lowest value.

Table 2: Relative water content (RWC%) response of wheat cultivars to antitranspirant under different irrigation treatments (combining analysis across two seasons)

Cultivars	Without antitranspirant application				With antitranspirant application			
	I1	I2	I3	Mean	I1	I2	I3	Mean
Gemeza 11	78.57	68.6	42.31	63.16	86.55	69.59	48.76	68.30
Gemeza 9	72.61	69.34	38.41	60.12	80.65	87.55	45.41	71.20
Sakha 93	53.29	47.95	32.97	44.74	80.28	62.98	38.25	60.50
Sakha 94	58.5	51.85	38.14	49.50	79.99	72.07	39.48	63.85
Sids 1	47.68	41.23	31.55	40.15	67.1	60.53	29.5	52.38
Masr 1	83.45	69.42	40.46	64.44	84.42	72.13	54.98	70.51
Mean	**65.68**	**58.07**	**37.31**	**53.69**	**79.83**	**70.81**	**42.73**	**64.46**

L.S.D. 0.05	
Irrigation treatments	**2.31**
Antitrans	**1.28**
Cultivars	**1.29**
Irrigation X antitrans	**2.21**
Irrigation X cultivars	**2.24**
Antitrans X cultivars	**1.83**
Irrigation X antitrans X cultivars	**3.17**

I1 is the normal irrigation during growth season excluding planting irrigation
I2 is irrigation was escaped during tillering
I3 is irrigation was escaped during tillering and heading stages

It is evident from the data in Table (2) that spraying the glycerol (4%) as antitranspirant significantly increased the RWC in plant leaves of the studied wheat cultivars. Application of Glycerol was significantly effective in enhancing the RWC for the six wheat cultivars under the three tested irrigation regimes. This means that the effect of the interactions between the studied three factors i.e., cultivars, water regimes and antitranspirant were significant. The response of wheat cultivars was not the same, the best results were recorded by Gemeza 11 and Masr 1 in treatmentI_1; and Gemeza 9, Misr 1 and Sakha 94 in treatmentI_2; and Masr 1 and Gemeza 11 in treatmentI_3. On the contrary the lowest values were recorded by Sids 1 and Sakha 94 in treatment I_1; and Sids 1 and Sakha 93 in treatment I_2; and Sids 1 and Sakha 93 in treatment I_3. Results in Table (2) showed clearly significant increase in the values of RWC in leaves of the six investigated cultivars sprayed with antitranspirant compared the similar values without spraying the antitranspirant. The highest response was achieved with Sakha 93 and 94 and the lowest response was achieved with Gemeza 11 and Masr 1. Generally, the antitranspirant agent caused significant increases in RWC% of the six cultivars under the three-irrigation regimes in comparison with the non-sprayed. These results were similar to those obtained by Abdelkader *et al.* (2010). The data showed that the imposed osmotic stress significantly affected water statutes of plants, therefore causes significant decrease in RWC of cultivars. Oxidative injury at the cellular level under water stress have high lipid peroxidation which decreased in membrane stability and led to lose more water from cells. Such variation in the response of cultivars to water deficit was attributed to genetic ability of the resistance trait to undergo certain modification in their osmotic and water potentials with a concomitant preliminary decease in their (RWC). If stress condition prevailed, stomata aperture were closed, photosynthetic rate was declined while respiration rate increased some hydrolysate which is prerequisite for raising the osmotic potential thus increasing cell turgor and eventually growth was presumed once more (Abdalla and Khoshiban, 2007).The opening of stomata allows gas exchange between the plant and its environment. In the course of stomatal opening CO_2 can enter into the plant and water can be lost as a vapor. Hence, to avoid desiccation and eventual senescence, it is vital to have a right balance between carbon gain and water loss through stomatal movements A stoma (plural stomata) is a microscopic pore on the surface (epidermis) of land plants. It is surrounded by a pair of specialized epidermal cells called guard cells, which act as a turgor-driven valve that open and close its pores in response to a given environmental conditions (Atwell *et al.,* 1999).

2- Membrane stability index (MSI %)

Membrane stability index (MSI %) has been measured as percentage injury of leaf tissues of the six wheat cultivars under different irrigation regimes, it can be used to evaluate cultivars tolerance for water shortage. Considerable variations for cell membrane stability index was present among the six cultivars (Table 3). The highest values of MSI% were recorded by the cultivars; Masr 1 followed by Gemeza 11 under the irrigation treatments, while the lowest values of MSI% were recorded by the cultivars; Sids 1 followed by Sakha 93. Moreover the data showed significant differences within each cultivar per se. Also, it is indicated that the cultivars grown under irrigation regime I_1 (normal) showed the highest values of MSI% in the leaves with and without applying the antitransperant.

Table 3: Membrane stability index (MSI %) response of wheat cultivars to antitranspirant under different irrigation treatments (combining analysis across two seasons)

Cultivars	Without antitranspirant application				With antitranspirant application			
	I1	I2	I3	mean	I1	I2	I3	mean
Gemeza 11	60.93	53.83	20.9	45.22	71.75	58.56	37.63	55.25
Gemeza 9	53.6	50.58	16.59	40.26	71.07	67.85	29.58	56.17
Sakha 93	47.8	39.7	9.34	32.28	66.59	51.35	28.44	48.79
Sakha 94	51.92	46.07	16.8	38.26	72.65	57.34	26.41	52.13
Sids 1	44.87	33.57	8.87	29.10	65.93	56.37	26.03	50.17
Masr 1	64.68	55.32	19.94	46.65	76.81	64.19	35.39	58.80
Mean	**53.97**	**46.51**	**15.41**	**38.63**	**70.80**	**59.28**	**30.58**	**53.55**
L.S.D. 0.05								
Irrigation treatments				**0.40**				
Antitrans				**0.17**				
Cultivars				**0.41**				
Irrigation X antitrans				**0.29**				
Irrigation X cultivars				**0.72**				
Antitrans X cultivars				**0.59**				
Irrigation X antitrans X cultivars				**1.01**				

I1 is the normal irrigation during growth season excluding planting irrigation
I2 is irrigation was escaped during tillering
I3 is irrigation was escaped during tillering and heading stages

Applying the antitranspirant on the six cultivars under the different irrigation regimes showed significant differences in MSI% values (Table 3). The highest values of MSI% were recorded by cultivars; Masr 1, followed by Sakha 94, Gemeza11 and Gemeza 9 under treatment I_1; Gemeza 9 and Masr 1 under treatment I_2; and Gemeza11 and Masr 1 under treatment I_3. The lowest values were recorded by cultivars; Sids 1 followed by Sakha 93 under the treatments I_1 and I_2; and Sids 1 and Sakha 93 under treatment I_3. Significant increases in MSI% values of cultivars leaves sprayed with glycerol (4%) under treatment I_1 when compared with the same treatment without antitranspirant spray. Generally, the antitranspirant agent caused significant increases in MSI % under the three-irrigation regimes in contrast with the non-sprayed. The response of wheat cultivars were not the same when sprayed or not sprayed with glycerol (4%). These results are similar to those obtained by Premachandra *et al*., (1991) and Abdelkader *et al* (2010). Water stress caused water loss from plant tissues which seriously impair both membrane structure and function (Cave, 1981). The plasma membrane is generally protected from desiccation-induced damage by presence of membrane-compatible solutes, such as sugars and amino acid. Therefore, a link may exist between the capacity for osmotic adjustment and degree of membrane protection (Sibet and Birol, 2007). The drought stress induces decreasing in membrane stability which indicates that the extent of lipid peroxidation caused by active oxygen species (Sibet and Birol, 2007). Using of film-forming antitranspirants (AT) to increase leaf resistance to the diffusion of water vapour, thereby. Commercially available film-type AT are generally emulsions wax, latex or plastic that dry onto foliage and form a thin film that reduces stomatal conductance (Davenport *et al.,* 1972).

3- Electrolytic leakage (EL%)

Electrolytic leakage (EL%) is routinely used as indicator to assess the integrity and permeability of cell membrane and resulting in leakage of intracellular contents (Arvin and Donnelly, 2008). Membrane stability index (MSI) is reciprocal to cell electrolyte leakage (EL) and both of them are physiological indices widely used for evaluating drought tolerance (Premachandra *et al*., 1991). Data in Table (4) showed significant differences were observed in EL % for the studied wheat cultivars under different irrigation treatments. Similar results were observed by Malik *et al*. (1999); Rahman *et al*. (2000) and Abdelkader *et al* (2010). Results showed that the I_1 treatment caused significant decreases in EL % of the wheat cultivar leaves in comparison with other treatments. Masr 1 followed by Gemeza 11recorded the lowest values of EL % under the three irrigations regimes while Sids 1 followed by Sakha 93 recorded the highest values of EL %. The data also showed significant differences within each cultivar per se. Also, it is indicated that the cultivars grown in normal irrigation condition (I_1) showed the lowest EL % in the leaves.

Table 4: Electrolytic leakage (EL%) response of wheat cultivars to antitranspirant under different irrigation treatments (combining analysis across two seasons)

Cultivars	Without antitranspirant application				With antitranspirant application			
	I1	I2	I3	Mean	I1	I2	I3	Mean
Gemeza 11	10.08	17.56	52.45	26.70	8.8	14.66	48.83	24.10
Gemeza 9	11.29	19.05	54.89	28.41	10.91	15.81	51.70	26.14
Sakha 93	19.55	33.36	68.51	40.47	8.66	26.72	52.46	29.28
Sakha 94	14.39	26.85	58.77	33.34	11.13	23.00	49.39	27.84
Sids 1	24.11	39.05	68.13	43.76	12.3	35.82	55.59	34.57
Masr 1	9.52	15.3	47.18	24.00	7.73	13.3	47.22	22.75
Mean	**14.82**	**25.20**	**58.32**	**32.78**	**9.92**	**21.55**	**50.87**	**27.45**

L.S.D. 0.05	
Irrigation treatments	**0.62**
Antitrans	**0.26**
Cultivars	**0.44**
Irrigation X antitrans	**0.45**
Irrigation X cultivars	**0.76**
Antitrans X cultivars	**0.62**
Irrigation X antitrans X cultivars	**1.07**

I1 is the normal irrigation during growth season excluding planting irrigation
I2 is irrigation was escaped during tillering
I3 is irrigation was escaped during tillering and heading stages

Wheat cultivars, which were sprayed with antitranspirant, showed significant differences under the three-irrigation regimes as shown in Table (4). Results showed that cultivars; Masr 1 followed by Gemeza 11 recorded the lowest values of EL % under irrigation treatments while the highest values of EL % were recorded with the cultivars: Sids 1 followed by Sakha 94. Significant decreases in El% values of cultivars leaves sprayed with antitranspirant under irrigation treatment I_1 compared with the same treatment without antitranspirant spray. Generally, the antitranspirant agent caused significant decreases in EL % under the three-irrigation regimeswhen compared with the non-sprayed. These results are compatible to those obtained by Premachandra *et al*., (1991); Sairam and Saxena (2000); and Sibet and Birol, (2007) and. The plasma membrane is generally protected from desiccation-induced damage by presence of membrane-compatible solutes, such as sugars and amino acid.

Therefore, a link may exist between the capacity for osmotic adjustment and degree of membrane protection (Sibet and Birol, 2007). The water stress-induced decrease in membrane stability indicates the extent of lipid peroxidation caused by active oxygen species (Sibet and Birol, 2007).

4- Chlorophyll content

High chlorophyll content is a desirable characteristic because it indicates a low degree of photo inhibition of photosynthetic apparatus under shortage of water, therefore reducing carbohydrate losses for grain growth (Farquhar *et al*., 1989). Results in Tables (5, 6 and 7) showed significant differences for chlorophyll 'a', 'b' and chlorophyll a/b ratio among the six wheat cultivars under the three irrigation regimes**.** Results also indicated that the highest values of chlorophyll a were recorded by Gemeza 9 followed by Masr 1; and chlorophyll b with Masr 1 followed by Gemeza 11. Results revealed clearly that the first and second interaction effects between the three investigated factors were significant. This means that the values of chlorophyll 'a', 'b' and chlorophyll a/b ratio differed significantly among cultivars under the irrigation regimes as well as with and without antitranspirant treatments. The highest chlorophyll a/b ratio recorded by Gemeza 9 and Sakha 93 under irrigation treatment I_1; and Masr 1 and Sakha 93 under irrigation treatment I_2; and Sids 1 and Sakha 93 under the treatment I_3, while the lowest chlorophyll a/b ratio were recorded by Masr 1 and Sids 1 under the treatment I_1; and Sakha 94 and Gemeza11 under I_2; and Sakha 94 and Masr 1 under the treatment I_3. Likewise, the data showed significant difference within each cultivar per se. Also, it is indicated that the cultivars grown in normal water condition (I_1 treatment) showed the highest chlorophyll content in the leaves.

With antitranspirant application, the cultivars differed significantly by different irrigation regimes as shown in Tables (5, 6, 7 and 8). Results showed that the highest values of chlorophyll a' and chlorophyll b were recorded by Masr 1, Gemeza11 and Gemeza 9. While the highest values of chlorophyll a/b ratio obtained by Sakha 94 and Sakha 93. Regarding to the interaction between wheat cultivars and irrigation treatments the highest values of chlorophyll a/b ratio obtained by Sakha 94 and Sakha 93 under I_1 and I_3 treatments; and Masr 1 and Sakha 94 under I_2. The lowest amounts of chlorophyll ‘a’, ‘b’ and total chlorophyll were recorded by and Sids 1 and Sakha 93 under I_1 treatment; and Sakha 93 and Sids 1 under I_2 and I_3 treatments, lowest amounts of chlorophyll ‘b’ were recorded by: Sakha 94 and Sids 1 under I_2 and I_3 treatments; lowest amounts of chlorophyll a/b ratio obtained by Masr 1 and Gemeza 9 under I_1 and I_3 treatments; and Sakha 93 and Sids 1 under I_2. It is noticed significant decrease in chlorophyll 'a', 'b', total chlorophyll, and chlorophyll a/b ratio values of leaves cultivars were sprayed with antitranspirant in comparison with the same cultivars without antitranspirant spray. Generally, the antitranspirant agent caused significant decrease in chlorophyll 'a', 'b', total chlorophyll, and chlorophyll a/b ratio under the three-irrigation regimes in comparison with non-sprayed. According to Ityrbc *et al*. (1998), different irrigation water caused significant difference in chlorophyll content, similar trends were obtained by Ashraf *et al*. (1994); Havaux, (1998); Anjum *et al.* (2003) and Abdelkader *et al.* (2010). The decrement of chlorophyll content during drought stress could be related to photo-oxidation resulting from oxidative stress which reduces photosynthetic process (Hamayun *et al.*, 2010). The antitranspirant reduces the degrees of vapor/water transport and photosynthesis relative to the control plants and reduced leaf permeability to carbon dioxide exchange consequently restricting photosynthesis (Davenport *et al*., 1972 and Hsiao, 1973).

Table 5: Chlorophyll 'a' (mg g^{-1} f wt.) response of wheat cultivars to antitranspirant under different irrigation treatments (combining analysis across two seasons)

Cultivars	without antitranspirant application				With antitranspirant application			
	I1	I2	I3	Mean	I1	I2	I3	Mean
Gemeza 11	3.46	2	1.16	2.21	2.47	1.73	1.16	1.79
Gemeza 9	3.59	2.07	1.6	2.42	2.16	1.72	1.16	1.68
Sakha 93	2.56	1.62	1.65	1.94	1.75	1.14	0.91	1.27
Sakha 94	2.61	1.6	1.25	1.82	1.81	1.61	1.09	1.50
Sids 1	2.56	1.54	1.28	1.79	1.67	1.25	0.87	1.26
Masr 1	3.48	2.2	1.3	2.33	2.97	2.08	1.22	2.09
Mean	**3.04**	**1.84**	**1.37**	**2.09**	**2.14**	**1.59**	**1.07**	**1.60**

L.S.D. 0.05	
Irrigation treatments	**0.04**
Antitrans	**0.01**
Cultivars	**0.03**
Irrigation X antitrans	**0.02**
Irrigation X cultivars	**0.05**
Antitrans X cultivars	**0.04**
Irrigation X antitrans X cultivars	**0.07**

I1 is the normal irrigation during growth season excluding planting irrigation
I2 is irrigation was escaped during tillering
I3 is irrigation was escaped during tillering and heading stages

Table 6: Chlorophyll 'b' (mg g^{-1} f wt.) response of wheat cultivars to antitranspirant under different irrigation treatments (combining analysis across two seasons)

Cultivars	Without antitranspirant application				With antitranspirant applicatin			
	I1	I2	I3	Mean	I1	I2	I3	Mean
Gemeza 11	1.85	1.34	0.68	1.29	1.59	1.09	0.73	1.14
Gemeza 9	1.00	1.32	0.96	1.09	1.49	1.10	0.76	1.12
Sakha 93	1.22	0.93	0.95	1.03	1.07	0.93	0.52	0.84
Sakha 94	1.04	1.14	0.86	1.01	1.08	0.85	0.58	0.84
Sids 1	1.49	0.94	0.68	1.04	1.04	0.86	0.54	0.81
Masr 1	1.91	0.99	0.89	1.26	2.16	0.95	0.94	1.35
Mean	**1.42**	**1.11**	**0.84**	**1.12**	**1.41**	**0.96**	**0.68**	**1.02**

L.S.D. 0.05	
Irrigation treatments	**0.04**
Antitrans	**0.03**
Cultivars	**0.03**
Irrigation X antitrans	**0.06**
Irrigation X cultivars	**0.05**
Antitrans X cultivars	**0.04**
Irrigation X antitrans X cultivars	**0.08**

I1 is the normal irrigation during growth season excluding planting irrigation,
I2 is irrigation was escaped during tillering,
I3 is irrigation was escaped during tillering and heading stages

Table 7: Chlorophyll 'a/b' (mg g-1 f wt.) response of wheat cultivars to antitranspirant under different irrigation treatments (combining analysis across two seasons)

Cultivars	Without antitranspirant application				With antitranspirant application			
	I1	I2	I3	Mean	I1	I2	I3	Mean
Gemeza 11	1.87	1.49	1.71	1.71	1.55	1.59	1.59	1.57
Gemeza 9	3.59	1.57	1.67	2.21	1.45	1.56	1.53	1.50
Sakha 93	2.10	1.74	1.74	1.88	1.64	1.23	1.75	1.51
Sakha 94	2.51	1.40	1.45	1.80	1.68	1.89	1.88	1.80
Sids 1	1.72	1.64	1.88	1.73	1.61	1.45	1.61	1.55
Masr 1	1.82	2.22	1.46	1.84	1.38	2.19	1.30	1.55
Mean	2.15	1.66	1.64	1.86	1.52	1.65	1.57	1.57

L.S.D. 0.05	
Irrigation treatments	**0.05**
Antitrans	**0.04**
Cultivars	**0.06**
Irrigation X antitrans	**0.07**
Irrigation X cultivars	**0.11**
Antitrans X cultivars	**0.09**
Irrigation X antitrans X cultivars	**0.15**

I1 is the normal irrigation during growth season excluding planting irrigation,
I2 is irrigation was escaped during tillering,
I3 is irrigation was escaped during tillering and heading stages

Conclusion

The current research showed the effects of antitranspirant and different irrigation water on some wheat cultivars. Antitranspirants application have a significant, positive impact on physiological traits and mitigation the effect of drought stress on wheat plants.

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