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WHEAT YIELD AND ANTIOXIDANT ENZYMES RELATIONSHIP UNDER DIFFERENT SOIL WATER CONTENT

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ABSTRACT

The objectives of this study were to examine the relationship between wheat yield cultivars (Sakha 93 and Giza 168) and antioxidant enzymes such as catalase (CAT), superoxide dismutase (SOD), peroxidase (POD), ascorbate peroxidase (APX) and phenylalanine ammonia-lyase (PAL) activities under different soil water content i.e. low, moderate and high content by irrigation at 80% ETo (1280m^3/fed.), by 100% ETo (1600m^3/fed.) and120% ETo (1920m^3/fed.), respectively. Two lysimeter experiments were carried out in two successive seasons i.e. 2006/2007 and 2007/2008 to estimate wheat yield and one experiment in plastic bags carried out of the greenhouse to determine the antioxidant enzymes of 28 days wheat plant under three different soil water content i.e. providing wheat seedlings with aforementioned treatment. Exposing wheat cultivars i.e. Giza 186 or Sakha 93 to water stress by irrigation at 80% ETo (1280 m^3/fad.) exerted an increase in CAT, SOD, POD, APX and PAL over those irrigated at 100% ETo (1600 m^3/fad.) or at 120% ETo (1920 m^3/fad.), but the previous enzyme activities in the tissue of Saka 93 surpassed of that of Giza 168 cultivar. spike weight and weight of 100 grain/plant of Sakha 93 cultivar overcome that of Giza 168 at low soil moisture content (80% ETo), whereas opposite results were obtained at high and moderate water content (120% and 100% ETo) in the first growing season (2006/2007) and spike weight/plant in second growing season (2007/2008). There was a proportional relationship between increasing soil moisture content and grain yield/plant but the difference between moderate water content 100% ETo (1600 m^3/fed.) and high water content 120% ETo (1920 m^3/fed.) was not significant. Providing 28 days wheat plant with low water content, decreased wheat yield/plant and its attributes comparing with moderate water content for the two studied cultivars. The current study indicates that Sakha 93 cultivar was the most tolerant cultivar compared with Giza 168.

INTRODUCTION

Water deficiency limits wheat productivity and influences its quality. However, there is limited understanding about the relationship between antioxidant basis and wheat productivity under different soil water content which may be contribute towards adaptation to such unavoidable environmental constraints **(Blum, 1996 and Saranga *et al* 2002).** Among crop plants, wheat (*Triticum aestivum* L.), which often experiences water-limited conditions, is an attractive study system because of the natural genetic variation in traits related to different soil water content **(Loggini *et al* 1999).** Drought stress invariably leads to oxidative stress in the plant cell due to higher leakage of electrons towards O_2 during photosynthetic and respiratory processes, leading to enhancement in reactive oxygen species (ROS) generation **(Asada, 1999).** During optimal conditions, the balance between ROS formation and consumption, is tightly controlled by an array of antioxidant enzymes and redox metabolites **(Noctor and Foyer, 1998).** This includes superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX), peroxidases (POX), Phenylalanine ammonialyase (PAL) which provides an efficient protection against lethal ROS in all the sub-cellular organelles of the plant cell

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(Moller, 2001). The level of the activities of antioxidant enzymes are generally increased during abiotic stress conditions and correlate with enhanced cellular protection. During different soil water, the plant water relations play a key role in the activation and/or modulation of antioxidant defense mechanism **(Menconi *et al* 1995; Srivalli *et al* 2003 and Selote & Chopra, 2004).** In addition, exposing plants to drought caused a reduction in grain yield **(Pan *et al* 2003),** grain weight/spike **(Charti and Lales, 1990),** number of grains/spike **(Wang *et al* 1993)**, grain weight, grain index **(Imam *et al* 1995**). The present study was an effort to understand the yield of Sakha 93 and Giza 168 cultivars and antioxidant enzymes relationship under three different soil water content.

MATERIALS AND METHODS

Three experiments, two on lysimeter and one on plastic bags were conducted. The first two of the lysimeter in the Experimental farm at Arid Lands Agricultural Graduate Studies and Research Institute- Hadayek Shobra-Kalubia Governorate- Egypt, during 2006/ 2007 and 2007/2008 growing seasons, whereas the third of plastic bags in the campus of the Experimental Farm of Faculty of Agriculture, Ain Shams University at Hadayek Shobra- Kalubia Governorate- Egypt out of the Green House to study the relationship between two wheat (*Triticum aestivum*. L.) cultivars Sakha 93 and Giza 168 yield and antioxidant enzymes under three different water content i.e. low, moderate and high by irrigation at 80%, 100% and 120% ETo respectively. Every lysimeter experiment concluded the combinations of the two cultivars with the three treatments of water content allocated in a randomized complete block design in three replicates. The total amount of irrigation water was calculated according to Penman-Montieth method **(Allen *et al* 1995)** for studying the effect of water content on yield of the aforementioned cultivars from fifty plants chosen at random from three replicates at harvest (dead yellow stage). The following data were recorded, tillers No./plant, spike weight/plant (g), grain yield/plant (g), weight of 100 grains (g), straw yield/plant (g), biological yield/plant (g), tillering index % (No. of spikes/No. of tillersx100), crop index% (total grain wt./ straw wt. x100) and Harvest indexes (%) (total grain wt./biological yield x100).

The third experiment included 180 plastic bags which were the combinations of the previous 6 treatments and 30 replicates arranged in a randomized complete block design to study the response of antioxidant enzyme to different soil water content of wheat plants. Every plastic bag was 10 x 10 x15cm size, it was filled with the same sandy soil of the lysimeter then sown with wheat grains. After 28 days from sowing, 60 plants were chosen randomly from every replicate and the following data were measured;

Peroxidase activity (POD) **(Hammer-Schmidt *et al* 1982),** superoxide dismutase activity (SOD) **(Beauchamp and Fridovich 1971),** ascorbate peroxidase activity (APX) **(Nakano and Asada, 1981),** catalase (CAT) activity **(Aeby, 1984)** and phenylalanine ammonia-lyase activity (PAL) **(He *et al* 2001).**

Statistical analyses

Data of the experiment was subjected to proper statistical analysis of variance according to (**Snedecor and Cochran 1980).** Duncan test was used to compare between means. Data were statistically analyzed using the analysis of variance adopting a SAS package.

RESULTS AND DISCUSSION

Yield response to different soil water content

Data reported in **Table (1)** elucidate the effect of soil water content on number of tillers/plant, spike weight/plant, 100 grain weight, grain yield/plant and biological yield /plant. Wheat plants were provided with low, moderate and high water amount by irrigation at 80% ETo (1280m³/fed.), 100% ETo (1600m³/fed.) and 120% ETo (1920m³/fed.) respectively to Sakha 93 and Giza 168.

Data revealed that low water content significantly increased the number of tillers/plant for Sakha 93 and Giza 168 by 49.3% and 47 % comparing with moderate water content treatment respectively in the first season, whereas the difference was not significant in the second season. In addition the numbers of tillers/plant under low water content for Sakha 93 overcome that of Giza 168.

The pattern change of spike weight/plant as well as 100 grain weight by exposing to low water content of the two cultivars was similar to those of number of tillers/plant.

Regarding grain yield/plant, decreasing was noticed in it by increasing water amount from 1280m³/fed. to 1600m³/fed. under the current investigation but the rate of Sakha 93 reduction was less than Giza 168 i.e. 37.9% and 46.5% respectively. In the same time, there was not significant increase in grain yield/plant for Sakha 93 over Giza 168, indicating that harmful effect of exposing Giza 168 to soil moisture stress was more pronounced than Sakha 93. Consequently, Sakha 93 was more tolerant to the reduction of soil moisture than Giza 168 cultivar.

Data reported in **Table (2)** indicate the effect of soil water content on crop, tillering and harvest indexes. Concerning crop index, increasing soil moisture content significantly increased by irrigation at 80% ETo (1280m³/fed.) to 100% ETo (1600m³/fed.) and decreased at 120% of ETo (1920m³/fed.) for Sakha 93 Giza 168 cultivars in the two growing seasons except Sakha 93 in the second season which did not differ significantly. These results indicate that the increase in the grain weight overcome that of straw weight reaching its maximum at 100% ETo (1600m³/fed.) for both two cultivars. In the first growing season, the reduction of Sakha 93 crop index by irrigation 80% ETo (1280m³/fed.) (20%) exceeded these of Giza 168 (18.66) comparing to 100% ETo (1600m³/fed.) indicated that the rate of increase in grains of straw weight of Sakha 93 was more pronounced than Giza 168 compared with their straw weight. In the second growing season, the difference was most significant.

Comparing harvest index of Sakha 93 cultivar to Giza 168 cultivar under moisture content of the soil, revealed that they were less in Sakha 93 cultivar than that of Giza 168 in the first season.

The number of spike to the number of tillers % in the first growing season tended to increase significantly by increasing soil moisture content up to 100% ETo (1600m³/fed.) in the first season, on the contrary, these increases were not significant in the second growing season. These results were similar for both cultivars. It could be concluded that the grain yield to the aboveground biological yield increased by increasing soil moisture content from 80% ETo (1280m³/fed.) to 100% ETo (1600m³/fed.) for Sakha 93 and Giza 168 cultivars but this percentage was more for the former cultivar than the latter one indicated that the dry matter allocated wheat grain was greater in Sakha 93 than in Giza 168. It could be noticed that Giza 168 cultivar was more sensitive to lack of water than Sakha 93 cultivar, **Table (2). Singh and Bhan (1998)** reported that the increase in wheat yield attributes was due to more water supplies, which may increase cell turgidity, opening of stomata and finally increasing the partitioning of photosynthesis to sink. Water deficit induced oxidative stress which causes inhabitation of photosynthesis activity due to imbalance between light capture and its utilization **(Foyer 2004). Sairam and Saxena (2000)** found that a marked reduction in chlorophyll content under stress for all tested wheat cultivars, whereas some genotypes were able to maintain the reduction of its content.

Antioxidant enzymes response to different soil water content

The effect of soil water content on antioxidant enzymes of 28 days wheat plant cultivars are reported in **Table (3)** and **Figures (1), (2), (3), (4)** and **(5),** respectively.

Data reported in **Fig. (5)** indicate that exposing wheat cultivars i.e. Giza 186 or Sakha 93 to different water content i.e. low amount by irrigation at 80% ETo (1280 m³/fad.) exerted an increase in superoxide dismutase over those moderate content by irrigation at 100% ETo (1600 m³/fad.) or high amount by irrigation at 120% ETo (1920 m³/fad.). These results were similar for both cultivars. The percentage increase for Sakha 93 cultivars under low content (1280 m³/fad.) was 284.2% and 19.6% comparing to moderate and high amount, whereas for Giza 168 cultivar was 82.7% and 194.4% for the same respective treatments. **Alscher *et al* (2002)** found that reactive oxygen species (ROS) are produced in both unstressed and stressed cells, they added that plants have developed defense systems against ROS, involving both limiting the formation of ROS as well as instituting its removal.

Maximum values of ascorbate Peroxidase **Fig. (1),** catalase **Fig. (2),** Phenylalanine ammonialyase **Fig. (3),** peroxidase **Fig. (4),** superoxide dismutase **Fig. (5),** were found in the leaf tissues of 28 days

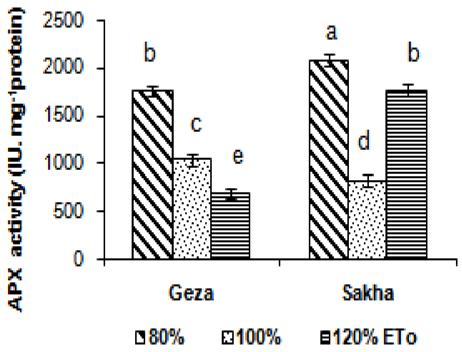

Fig. 1. Ascorbate Peroxidase

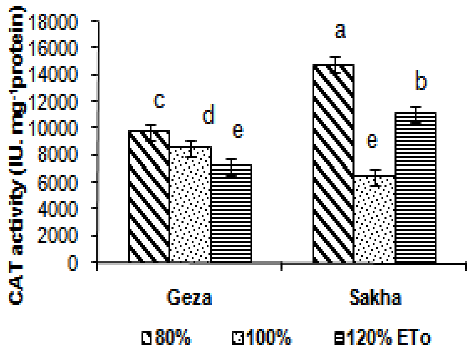

Fig. 2. Catalase

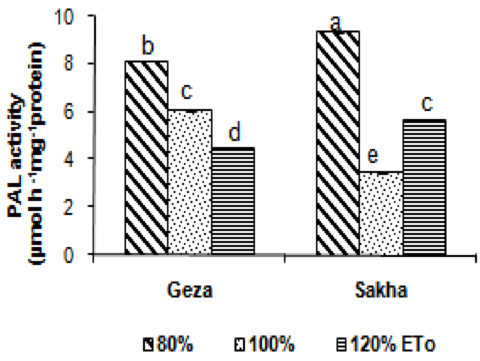

Fig. 3. Phenylalanine ammonialyase

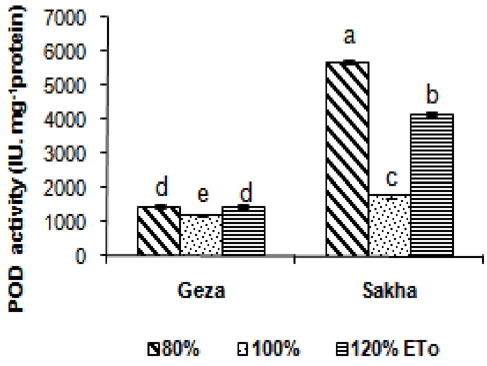

Fig. 4. Peroxidase activity

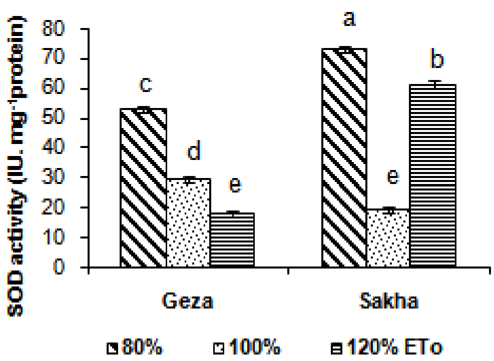

Fig. 5. Superoxide dismutase

Effects of different soil water content on activity of antioxidant enzymes of two 28 days wheat cultivars (Giza 168 and Sakha 93). Means of 3 samples ± SE. Bars with different letters are significant different (P< 0.05)

wheat plant cultivars i.e. Sakha 93 and Giza 168 by irrigation with low amount of water (80% ETo, 1280 m³/fad.). Moderate values of the aforementioned antioxidants were obtained by irrigation with moderate amount of water (100% ETo, 1600 m³/fad.) for both cultivars. These results indicate that there was a great harmony between soil water content and antioxidant activities in leaf tissues of 28 days wheat plant. In addition, values of these antioxidant enzymes in leaf tissues of Sakha 93 cultivar surpassed those of Giza 168 under water stress condition except ascorbate peroxidase. These results were in harmony with the results of wheat yield and its attributes to great extent. **(Foyer 2004 and Pei *et al* 2000)** reported that water deficit is known to generate active oxygen species (AOS). Among these, H_2O_2 is produced mainly in the chloroplasts and mitochondria of stresses cells and is the source of important cell damage **(Foyer & Harbinson, 1994 and Chaudiere & Ferrari-Iliou, 1999)**. H_2O_2 is a key antioxidant enzyme in plants **(Orvar and Ellis, 1997).** One of the most crucial functions of plant cells is their activity to respond to fluctuation in their environment.

It could be concluded that antioxidant enzymes such as superoxide dismutase, ascorbate peroxidase, peroxidase, Phenylalanine ammonialyase, and catalase activities are acted as antioxidant defense enzymes to minimize the concentration of superoxidases and hydrogen peroxide under stress conditions. Their activities are important in limiting oxidative damage and destroying active oxygen species that are produced in excess of those normally required for metabolism **(Hertwig & Feierabend, 1992; Azevedo *et al* 1998 and Chopra & Selote 2007). Shao *et al* (2007)** reported that superoxide dismutase is component of antioxidant machinery for drought resistance in higher plant.

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