

## Effect of Superabsorbent Polymer Aquasorb on Chlorophyll, Antioxidant Enzymes and Some Growth Characteristics of *Acacia Victoriae* Seedlings under Drought Stress

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**ABSTRACT** To investigate the effect of drought stress on chlorophyll content, enzymatic responses and some growth characteristics of *Acacia victoriae* seedlings and the effect of superabsorbent polymers (SAP) in reducing drought stress, a split plot experiment based on the completely randomized design was conducted. The treatments included four levels of drought stress (15, 30, 60 and 100% of field capacity) and four levels of SAP (0, 0.2, 0.4 and 0.6% weight percentages). The results of ANOVA showed a significant effect of drought stress on all growth characters, chlorophyll content and catalase and peroxidase enzymes activity, while the SAP didn't show any significant effect on the weight and areas of the leaves. The interaction effect between drought stress and SAP on the weight, number of leaves, proportion of root dry weight to aerial organs, chlorophyll and peroxidase enzyme activity was also significant. The effect of drought stress on reducing the number of the leaves, leaf area, length, volume and surface of roots and also increasing the root dry weight to aerial organs dry weight ratio, amount of chlorophyll and activity of antioxidant enzymes was significant. The different levels of SAP could absorb and hold water and consequently reduce the effect of drought stress and improve the growth characteristics and reduce the activity of catalase and peroxidase enzymes.

**Key words:** *Catalase, Drought tolerance, Hydrogel, Peroxidase*

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### 1 INTRODUCTION

Drought is the most common environmental tension and one of the most important limiting factors in plants growth around the world. Drought stress affects different aspect of plant growth, through a series of anatomical, morphological, physiological and biochemical changes (Du *et al.*, 1998). Two important responses of plant to drought stress are reduction

of leaf area and increase dry weight ratio or the root length to shoot (Osugwu *et al.*, 2010). In the drought stress, leaf response is more than roots and stems. Even a very slight stress at the early stages of growth can reduce the leaf growth rate and in later stages can reduce the leaf area index and with prolongation of this period the leaves number will be decreased (Hsiao, 1973). The ability to access to the water

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has an important role in leaf structure (Osugwu *et al.*, 2010). This stress prevents the plant photosynthesis and cause a change in chlorophyll content and damage to the structures of the photosynthetic. One of the reasons that environmental stresses such as drought reduce the growth and the plant ability to photosynthesis is disturbance in the balance between the production of oxygen free radicals and defensive mechanisms which remove these radicals (Fu and Huang, 2001). Allen has reported that the most damage that is applied to the plants through the various stresses is in connection with oxidative damage in different levels of cell (Allen, 1995). Drought stress leads to the production of reactive oxygen species (ROS) such as superoxide ( $O_2^-$ ), hydrogen peroxide ( $H_2O_2$ ) and hydroxyl (OH). ROS can seriously disturb the normal metabolism through oxidative damage to membrane lipids, proteins, pigments and nucleic acids (Moslemi *et al.*, 2011). Plants have different protection mechanisms for reduction or elimination of ROS that are effective in different levels of stress. Antioxidant enzyme system is of one of these protective mechanisms. Two catalase and peroxidase enzymes are the most important antioxidant causing the breakdown of  $H_2O_2$  to water and oxygen molecule (Yong *et al.*, 2008). Different researches have shown that there is a strong association between tolerance to oxidative stresses that is caused due to environmental stresses and increase in concentration of antioxidant enzymes in photosynthetic plants (Sairam and Srivastava, 2002).

Iran has an arid and hot climate and more regions are arid and semi-arid (Ghasemi and Khoshkholi, 2007). In addition to low rainfall, its spatial and temporal distribution is very unsuitable as even the areas with high rainfall in Iran need to irrigation during summer season (Sayyari and Ghanbari, 2012). Therefore, it is necessary to include strategies for increasing the efficiency of irrigation and optimal utilization of

scattered rainfall in arid and semi-arid areas. The using of SAP could be one of these strategies (Zangooinasab *et al.*, 2012). SAPs are hydrogels that can absorb water 400 times more than their weights. The absorbed water by SAP is gradually released in soil under water deficiency. Hydro-gels function as an additional water reservoir for the soil-plant-air system (Bhardwaj *et al.*, 2007); therefore reduce drought stress on seedlings and trees (Bouranis *et al.*, 1995). Due to these properties, hydrogels have been used to aid forest establishment and seedling growth in drought-affected areas (Arbona *et al.*, 2005; Hüttermann *et al.*, 1999). The improving effect of hydrogels for drought stressed seedlings was evaluated for *Ligustrum lucidum* (Taylor and Halfacre, 1986), *Conocarpus erectus* (Challaghan *et al.*, 1988), *Pinus* (Hüttermann *et al.*, 1999) *Citrus* (Arbona *et al.*, 2005), *Quercus* (Apostol *et al.*, 2009), *Populus* (Beniwal *et al.*, 2010) and *Fagus* (Jamnicka *et al.*, 2013).

*Acacia victoriae* belongs to Mimosaceae family. This species can well grow and develop on light soils, gravel and also on sand hills, therefore, this species can be very importance in combat to desertification and stabilizing moving sands in desert regions. *Acacia victoria* is also proper forage to feed camel and sheep in desert and dry regions. Although this species is resistant to draught, but the seedlings would get damaged in intense dry years (Jazirehi, 2011). Based on our knowledge, there is not any study concerning the effects of SAP on the irrigation regime and photosynthetic activity with *Acacia victoriae*. Although, there are some studies about the application of SAP for increasing the yield of agricultural products or increasing the capacity of water holding in soil for agricultural products, very few studies have been conducted regarding the application of SAP in forest nurseries or its positive effects on a forest species. Therefore, the main objective of this study was to evaluate the effects of SAP on growth characteristics,

chlorophyll content and activity of antioxidant enzymes for *Acacia victoria* seedlings under drought stress.

## 2 MATERIAL AND METHODS

### 2.1 Plant material and experiment design

This pot experiment was conducted in the plant nursery of Forest Sciences department at University of Ilam (altitude of 1174 m above sea level and an average annual rainfall of 446.81 mm) during spring and summer in 2012. Experimental design was a split plot arrangement based on a completely randomized design with 10 replicates. Because of the lack of complete germination (100%) of seeds, the experiment was conducted with unequal repetition (variance analysis with unequal repetition). The effect of two factors namely drought stress (15, 30, 60 and 100% of field capacity as main plot) and SAP (0, 0.2, 0.4 and 0.6% weight percentage (wt) as subplots) was considered. With respect to factors level (treatment 4×4=16) and replication number, 125 pots were applied. At first, the pots (20×25 cm) were filled with 2 kg soil with proportions of field soil, animal manure and fine sand (ratio 1:1:2 respectively) (Table 1). Then polymer dry matters with mentioned values were added, mixed and poured into the pots. After that, three seeds were planted in each pot. The pots were irrigated to the extent of field capacity (determined by weight method). The irrigation treatments were started after the total establishment of seedlings and selection of the strongest seedling in each pot. Finally, at the end of growth period (6 months later), the

measurements in relation to the number of leaves, leaf weight, leaf area (with apparatus CI 203-Area meter Made: U.S.A. in cm<sup>2</sup>), root volume and length, ratio of dry weight of root to aerial organs, chlorophyll and activity of catalase and peroxides enzymes were done.

### 2.2 Estimation of chlorophyll

Photosynthetic pigments content was determined by taking fresh leaf samples (0.1 g) from young and fully developed leaves. The samples were homogenized with 5ml of acetone (80% v/v) using pestle and mortar and centrifuged at 3,000 rpm. The absorbance was measured with a UV/visible spectrophotometer at 663 and 645 nm and chlorophyll contents were calculated using the equations proposed by Strain and Svec (1966) given below:

### 2.3 Estimation of catalase

To estimate catalase 50 mg of frozen material was homogenized in potassium phosphate buffer 100 mM (pH 7.0) contained PVP (poly vinyl pyrrolidin) 5% and EDTA 1mM. The extract was centrifuged at 4°C for 20 min at 3000 rpm. The supernatant was used for enzyme assay. The activity of enzyme catalase was measured using the method of Aebi *et al.* (1984). The assay mixture contained 100 mM potassium phosphate buffer (pH 7.0), 70 mM hydrogen peroxide and 20 ul of enzyme extract. The decomposition of H<sub>2</sub>O<sub>2</sub> was followed by the absorbance decline at 240 nm. Absorption changes were computed by absorption differences at the beginning time of reaction from absorption during 3 minutes.

**Table1** Soil analysis result for Physical and chemical properties

Soil texture (%)			Sodium (mg kg <sup>-1</sup> )	Potassium (mg kg <sup>-1</sup> )	Organic carbon (%)	Organic material (%)	Organic Nitrogen (%)	EC (mS cm <sup>-1</sup> )	pH
Clay	Silt	Sand							
5	54	41	12	42	1.44	2.48	0.144	3.59	7.2

## 2.4 Estimation of peroxidase

The activity of peroxidase enzyme was measured using the method of Chance and Maehley, (1955). The POD activity was assayed by adding tissue extract (100  $\mu$ l) to the reaction mixture, containing 10 mm guaiacol, 70 mm  $H_2O_2$  and 100 mm potassium phosphate buffer. Absorption changes at 470 nm were computed by absorption difference at the beginning time of reaction from absorption during 3 minutes.

## 2.5 Statistical analysis

To data analysis first Kolmogorov-Smirnov test and Leven test were considered to test normality and homogeneity of data variance. Then using ANOVA and Duncans Multiple Range Test we have done a total comparison and means comparison respectively at  $P < 0.05$ . SAS-9.1-portable software was used to do statistical analysis.

## 3 RESULTS

The results of variance analysis (Table 2 and 3) showed that drought stress has a significant effect ( $P < 0.01$ ) on all the evaluated properties, whereas the effect of SAP on leaf weight, leaf area, and chlorophyll was not significant. In addition, interaction effects of drought stress and SAP were significant on attributes such as leaf weight and number, leaf area and ratio of dry weight of root to aerial organ ( $p < 0.01$ ), content of chlorophyll and peroxidase enzyme ( $p < 0.05$ ). The comparison of the means simple effects of drought stress on the studied attributes (Table 4) showed that by increasing drought stress weight, number and leaf area, length, volume and root area were reduced and ratio of roots dry weight to aerial organ, chlorophyll and activity of catalase and peroxides enzymes were increased. The highest number of leaves (196.81), leaf weight (4.56 gr) and leaf area (0.99  $cm^2$ ), root length (24.84 cm) and root area (39.01  $cm^2$ ) were obtained in 100% field capacity (control treatment) and the highest root volume (5.39  $cm^3$ ) in 60% field capacity which didn't show a significant difference to control treatment.

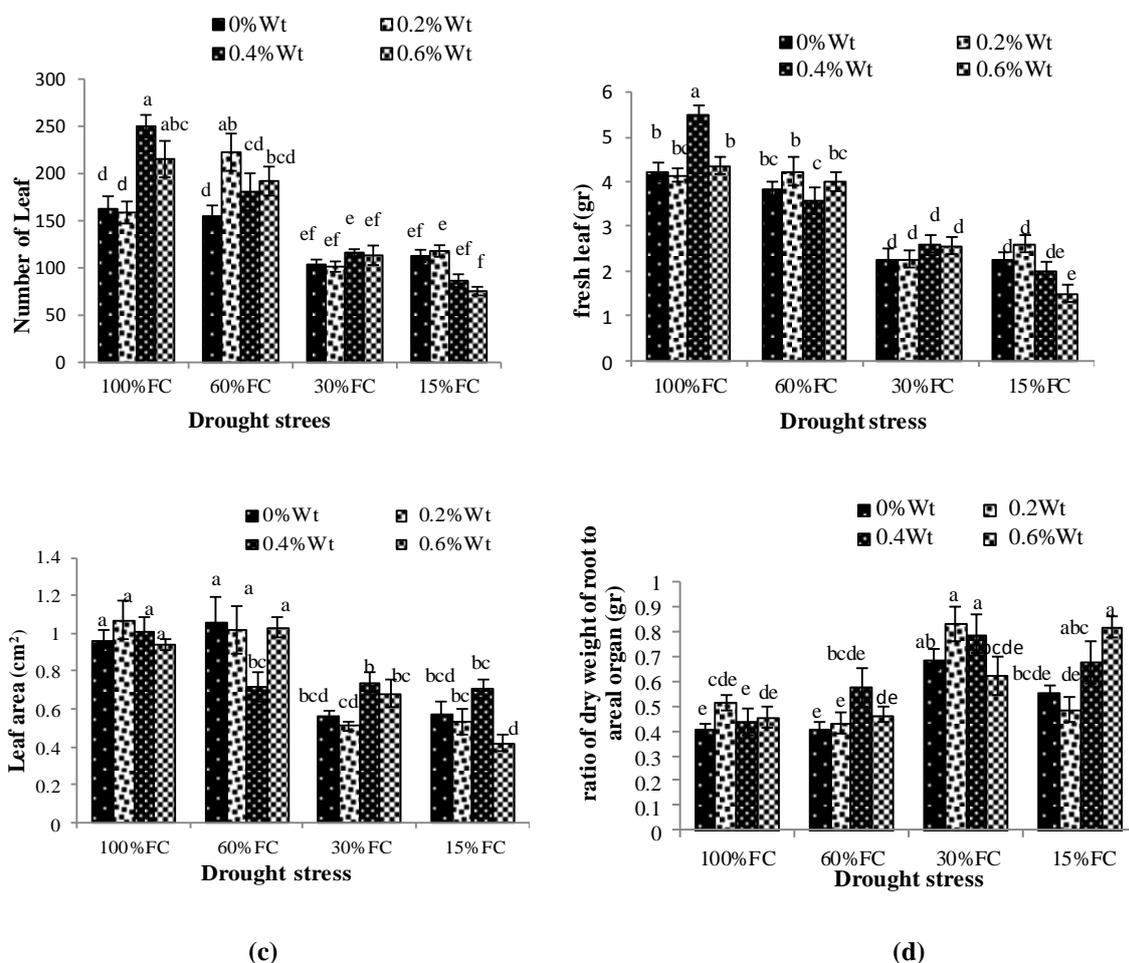
The highest root to aerial organs ratio (0.73 gr) and total chlorophyll (5.77  $ml \mu g^{-1}$ ) were observed in 30% field capacity as didn't have a significant difference with 15% drought stress treatment. The highest CAT (0.147  $\mu mol H_2O_2 \min^{-1} g^{-1}$ ) and POX (3.90  $\mu mol H_2O_2 \min^{-1} g^{-1}$ ) enzymes activity were achieved in intense stress (15% field capacity). The comparison of the means of simple effects of SAP on the studied properties (Table 4) showed a positive significant effect of this substance in increasing growth parameters. The highest number of leaves (157.64), Leaf fresh weight (3.42 gr), leaf area (0.80  $cm^2$ ), root to aerial organs ratio (0.62 gr) in 0.4% SAP treatment, the highest root length (26.40 cm) and root area (36.85  $cm^2$ ) in 0.2% SAP treatment and the highest total chlorophyll (5.01  $ml \mu g^{-1}$ ), CAT (0.131  $\mu mol H_2O_2 \min^{-1} g^{-1}$ ) enzyme and POX (3.15  $\mu mol H_2O_2 \min^{-1} g^{-1}$ ) enzyme in control were measured.

The highest number (250.12) and leaf weight (5.5 gr) were obtained in the control and 0.4% SAP treatments and the lowest value for this attributes were observed in the combined treatment of 15% field capacity and 0.6% SAP (Figure 1a and 1b). The highest leaf area (1.07  $cm^2$ ) was measured in combined treatment of 100% field capacity (control) and 0.2% SAP and the lowest value (0.42  $cm^2$ ) in combined treatment of 15% drought stress with 0.6% SAP (Figure 1c). The highest (0.83 gr) proportion of root dry weight to aerial organs was achieved in combined treatment of 30% drought stress and 0.2% polymer and the lowest value (0.40 gr) was measured in the control treatment (Figure 1d). The highest total chlorophyll value (6.17  $ml \mu g^{-1}$ ) was measured in combined treatment of 30% drought stress and without applying polymer and the lowest value (2.87  $ml \mu g^{-1}$ ) was achieved in combined treatment of 15 % field capacity with applying 0.4% SAP (Figure 2a). The highest activity of peroxidase enzyme (4.69  $\mu mol H_2O_2 \min^{-1} g^{-1}$ ) happened in 15% field capacity with non-polymer and the lowest activity (1.07  $\mu mol H_2O_2 \min^{-1} g^{-1}$ ) was in 100% field capacity with applying 0.4% polymer (Figure 2b).

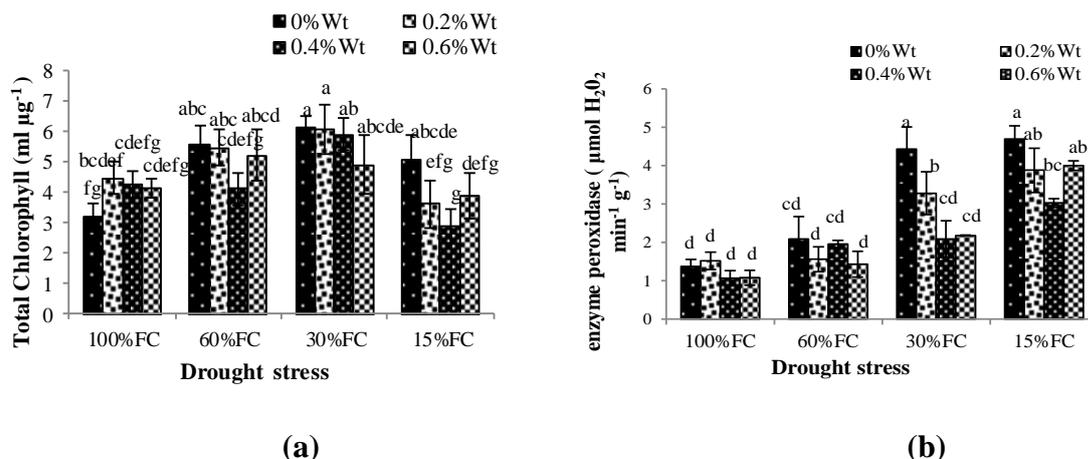
**Table 2** ANOVA for effect of drought stress and SAP on some morphological characteristics of *Acacia Victoriae* seedlings

Source of Variation	df	MS						
		Number of leaf	Fresh leaf (gr)	Leaf area (cm <sup>2</sup> )	Root Length (cm)	Root Volume (cm <sup>3</sup> )	Root area (cm <sup>2</sup> )	R/Arial organ dry wight of ratio (gr)
Drought (D)	3	77913.65**	36.21**	1.303**	77.54*	41.50**	1054.94**	0.48**
R (D)	31	1293.21	0.41	0.037	39.88	3.57	66.74	0.022
SAP (S)	3	3623.71*	0.67 <sup>ns</sup>	0.006 <sup>ns</sup>	340.18**	26.87**	1009.57**	0.065*
D × S	9	7495.93**	1.75**	0.13**	50.63 <sup>ns</sup>	6.75 <sup>ns</sup>	136.77 <sup>ns</sup>	0.074**
Error	78	1112.20	0.32	0.031	27.02	3.57	73.01	0.021
C.V		22.41	17.46	22.41	23.32	23.70	25.96	25.57

\*\* and \* represent significant at the 0.01 and 0.05 levels, respectively, and <sup>ns</sup> represent non- significant



**Figure 1** Comparison mean effect of SAP levels on Leaf Number (a), Leaf fresh weight (b), Leaf area (c) and ratio of dry weight of root/ aerial organ (d) of *Acacia victoriae* seedlings under different levels of drought stress



**Figure 2** Comparison mean effect of SAP levels on total Chlorophyll (a) and enzyme peroxidase (b) of *Acacia Victoriae* seedlings under different levels of drought stress

## 4 DISCUSSION

### 4.1 Leaf

The results of this study showed (Table 4) that by increasing drought stress, the number, weight and leaf area decreased significantly. Some studies like Arji *et al.* (2002) on olive trees, have confirmed the effect of drought stress on reducing the number and weight of leaf. It seems that drought would affect generating primary cells of leaf and their distinction and causes decreasing the leaf number (Lobito *et al.*, 2008). On the other hand, drought stress caused to closing the stomata therefore gas exchange necessary to photosynthesis and finally photosynthetic material would reduce that result in reducing growth (Hsiao, 1973). In parallel with above scientific justification in present research highest numbers, weight and leaf area observed in control treatment (100% of field capacity) and lowest values were observed in highest level of stress (15% of field capacity). Comparing means of leaf weight showed that drought stress is located in four different statistical groups, whereas in leaf number, drought stress 60% and control treatment with each other and so 15% and 30% together

haven't shown a significant difference. These results have showed the effect of SAP in reducing drought stress (Table 4). Using absorbent substances such as SAP with considerable storage capacity of water can keep humidity in the soil and the amount of water absorption is increased in the plant. These results is in accordance with the results of Ghasemi and Khoshkhoi (2007) in *Chrysanthemum* plant. In this study, a change of leaf area was related to leaf falling, twisting and reducing leaf pressure turgor. By increasing drought stress, leaf area showed a significant reduction, while the most leaf area was obtained in the condition with moisture availability and the lowest was in 15% of field capacity treatment (drought stress condition) (Table 4). That is because of reducing internal osmotic pressure of cells subsequently, reducing cell division or cell size (Petropoulos *et al.*, 2008). Leaf area reduction is one of the mechanisms of plants to escape drought and reduce the effect of low water stress. Thus, there was a significant relation between the reduction of cell size and reduction of water in plant tissues. By reducing leaf area, the extent of evaporation and transpiration would reduce,

consequently sustaining plant increases in low water conditions (Hong-Bo *et al.*, 2008). Leaf falling or producing small leaves is a general procedure to adjustment with water shortage (Arji *et al.*, 2002).

#### 4.2 Root

In this study, by increasing drought stress, root area, length and root volume decreased, significantly. Considering the extent of root accessibility to water, it was determined that unlike many plants that develop their root system in order to absorb more water, *Acacia victoriae* would develop its roots even in the conditions of field capacity which there is enough water in soil. The longest roots were observed in 100% field capacity treatment and the shortest one was related to 15% field capacity. Reducing root length from 24.84 cm in 100% field capacity to 21.14 cm in 15% field capacity treatment suggested a very high effect of drought stress on root performance, therefore deep penetration of roots to obtain more water from soil (water's drainage to soil depth) in 100% and 60% field capacity treatments by developing pilose and secondary roots, is a process to absorb more soil water by *A.victoriae*. Although the root system of some plants in order to find water goes to the depth, there are some plants which their root system growth is a genetic characteristic (Alizadeh, 2004). There is the possibility of developing root system to more than 20 meters for *Acacia* species (Maiden, 1988). Rad *et al.* (2010) obtained the same results in *Eucalyptus*. Results obtained from comparing means of simple effects of SAP showed that applying SAP causes increasing the length, volume and root area. The most length and area of roots was obtained in 0.2% polymer treatment while the most root volume was observed in 0.6%. The least rate was related to control treatment (Table 4). Results of Panayiotis *et al.* (2004) studies have confirmed the effect of polymer on

root density and growth. By improving physical conditions of soil, polymers caused an increase in the root density and secondary roots. Therefore, the root has more access to the useable water and the plant has been less affected by drought stress. Results of present research confirmed this subject and are in accordance with the results of Zangooinasab *et al.* (2012) in *Haloxylon* species.

#### 4.3 Root dry weight to aerial organs dry weight ratio

According to the results by increasing drought stress, the ratio of root dry weight to aerial organs has increased. The highest proportion was obtained in relatively intense stress treatment (30% field capacity) and the lowest in moisture availability conditions (Table 4). Through preventing leaf development in stress conditions, drought stress would decrease the extent of carbon and energy consumption in aerial organs and larger proportion of plant photosynthetic materials are distributed in roots. As a result, the ability to absorb water and minerals by roots is increased, and the ratio of root weight to aerial organs weight would be increased (Banwarie *et al.*, 1994). Therefore, it seems that the mentioned feature in this species depends on resistance to drought. In the present study, applying SAP caused to increase the ratio of root dry weight to aerial organs compared with the treatments without polymer. This effect is probably due to the absorption of significant amounts of water in polymer structure, subsequently water absorption by soil around the roots during drought and removing humidity stress, so that the seedling has continued to grow in a proper condition. Increasing the proportion of root dry weight to aerial organs has been shown by applying SAP in *Chrysanthemum* species as well (Ghasemi and Khoshkholi, 2007).

#### 4.4 Chlorophyll (a+b) contents and activity of antioxidant enzymes

One of the signs of environmental stress in plants is reduction of chlorophyll and this reduction depends on the plant genotype (Colom and Vazzana, 2001). In the present study by increasing drought stress, firstly, chlorophyll content was increased but at the end it was decreased. Chlorophyll content of leaves is a key factor to determine the rate of photosynthesis and dry matter production (Ghosh *et al.*, 2004). Results obtained from comparison of the means of total chlorophyll showed that there were not significant differences between treatments 30% and 60% drought stress and between 100% and 15% (Table 3). The highest chlorophyll content was measured in 30% drought stress treatment and the lowest chlorophyll content was observed in intense stress (15% field capacity) (Table 4). Similarly, Delkhosh *et al.* (2006) reported increasing total chlorophyll content under drought stress in *Brassica napus* species that corresponds to present research findings. It seems that increasing chlorophyll content in drought stress conditions is because of reducing leaf areas due to decreasing cell size. Therefore during the emergence of mild stress because of presence of more cells in leaf weigh unit, chlorophyll content will also be increased (Greco *et al.*, 2007), and in intense stress,

chlorophyll loss will occur (Ahmadi and Ceioceмарdeh, 2004). Pessaraki (1999) showed that keeping chlorophyll and durability of photosynthesis of the leaf under stress conditions are considered as physiological strength to stress indices.

With regards to comparison of means table (Table 4), the activity of peroxidase and catalase enzymes increased by increasing the extent of drought stress from control treatment level to intense drought stress. The results of many studies showed that environmental stress conditions followed by increasing antioxidant enzymes lead to the decrease of ROS in plants. Drought stress causing increasing production of all kinds of reactive Oxygen, including hydrogen peroxide that, in turn caused to oxidative response in plant to prevent damages due to reactive oxygen types (Wassmann *et al.*, 2004). Results from comparing means of simple effects of SAP showed this material cause reducing activity of antioxidant enzymes and wasn't observed a significant difference between different levels of consumed SAP.

The positive effect of SAP under drought stress on the reduction of activity of antioxidant enzymes was reported in mustard and red bean that corresponds to the findings of present study.

**Table 3** ANOVA for effect of drought stress and superabsorbent polymer on chlorophyll and activity of antioxidant enzymes (catalase and peroxidase)

Source of variation	Df	Mean Square			
		Chlorophyll (a+b) (ml $\mu\text{g}^{-1}$ )	Df	Enzyme Catalase ( $\mu\text{mol H}_2\text{O}_2 \text{ min}^{-1} \text{ g}^{-1}$ )	Enzyme peroxidase ( $\mu\text{mol H}_2\text{O}_2 \text{ min}^{-1} \text{ g}^{-1}$ )
Drought (D)	3	19.48**	3	0.029**	17.16**
R (D)	20	1.34	8	0.004	0.49
Super-absorbent (S)	3	2.64 <sup>ns</sup>	3	0.006**	2.97**
D $\times$ S	9	3.05*	9	0.001 <sup>ns</sup>	0.83*
Error	60	1.24	24	0.001	0.35
C.V		23.77		17.07	24.02

\*\* and \* represent significant at the 0.01 and 0.05 levels, respectively, and ns represent non- significant level

**Table 4** Comparison of means effect of drought stress and SAP on characteristics of morphological, total chlorophyll and activity of antioxidant enzymes in seedlings of *Acacia Victoria*

Treatments	Number of leaf	Fresh leaf (gr)	Leaf area (cm <sup>2</sup> )	Root Length (cm)	Root Volume (cm <sup>3</sup> )	Root area (cm <sup>2</sup> )	Root/aerial organ ratio(gr)	Chl (a+b) (ml µg <sup>-1</sup> )	CAT (µmol H <sub>2</sub> O <sub>2</sub> min <sup>-1</sup> g <sup>-1</sup> )	POX (µmol H <sub>2</sub> O <sub>2</sub> min <sup>-1</sup> g <sup>-1</sup> )
100% (FC)	196.81 <sup>a</sup>	4.56 <sup>a</sup>	0.99 <sup>a</sup>	24.84 <sup>a</sup>	5.14 <sup>a</sup>	39.01 <sup>a</sup>	0.45c	4.03 <sup>a</sup>	0.051 <sup>b</sup>	1.26 <sup>c</sup>
60% (FC)	190.12 <sup>a</sup>	3.93 <sup>b</sup>	0.97 <sup>a</sup>	22.05 <sup>a</sup>	5.39 <sup>a</sup>	37.84 <sup>a</sup>	0.47c	5.10 <sup>b</sup>	0.062 <sup>b</sup>	1.78 <sup>c</sup>
Drought 30% (FC)	108.77 <sup>b</sup>	2.43 <sup>c</sup>	0.63 <sup>b</sup>	21.27 <sup>b</sup>	2.73 <sup>b</sup>	25.95 <sup>b</sup>	0.73a	5.77 <sup>a</sup>	0.134 <sup>a</sup>	2.99 <sup>b</sup>
15% (FC)	98.12 <sup>b</sup>	2.09 <sup>d</sup>	0.56 <sup>b</sup>	20.92 <sup>b</sup>	3.36 <sup>b</sup>	28.46 <sup>b</sup>	0.63b	3.88 <sup>b</sup>	0.147 <sup>a</sup>	3.90 <sup>a</sup>
0% (Wt)	133 <sup>b</sup>	3.13 <sup>a</sup>	0.778 <sup>a</sup>	18.24 <sup>c</sup>	2.70 <sup>b</sup>	23.83 <sup>b</sup>	0.52 <sup>b</sup>	5.01 <sup>a</sup>	0.131 <sup>a</sup>	3.15 <sup>a</sup>
SAP 0.2% (Wt)	151.50 <sup>a</sup>	3.33 <sup>a</sup>	0.785 <sup>a</sup>	26.40 <sup>a</sup>	4.27 <sup>a</sup>	36.85 <sup>a</sup>	0.56 <sup>ab</sup>	4.92 <sup>ab</sup>	0.089 <sup>b</sup>	2.56 <sup>b</sup>
0.4% (Wt)	157.64 <sup>a</sup>	3.42 <sup>a</sup>	0.80 <sup>a</sup>	21.29 <sup>b</sup>	4.64 <sup>a</sup>	34.11 <sup>a</sup>	0.62 <sup>a</sup>	4.30 <sup>b</sup>	0.086 <sup>b</sup>	2.04 <sup>b</sup>
0.6% (Wt)	152.73 <sup>a</sup>	3.18 <sup>a</sup>	0.79 <sup>a</sup>	23.29 <sup>b</sup>	5.01 <sup>a</sup>	36.70 <sup>a</sup>	0.58 <sup>ab</sup>	4.54 <sup>ab</sup>	0.087 <sup>b</sup>	2.17 <sup>b</sup>

Means with the same letters within the same column are not significantly different at  $p < 0.05$  using Duncan's multiple Range Test

## 5 CONCLUSION

Generally, the results obtained from this research showed that increasing the activity of antioxidant enzymes (Catalase and Peroxidase) in *A. victoriae* species suggests the ability of this species to tolerate drought stress conditions and this is often accompanied to decreasing leaf area and increasing chlorophyll content. Therefore, it seems that increasing the activity of antioxidant enzymes could be an important factor to enhance the rate of resistance of plants to drought stress. Additionally, applying SAP in improving drought stress resistance for this species would be helpful. Thus, applying SAP that has the ability of absorbing considerable amount of water, caused improving in physio-chemical conditions of soil and affected the plants response to drought stress indirectly and can help plants in water shortage conditions.

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## اثر سوپر جاذب آکوازورب بر کلروفیل، آنزیم‌های آنتی‌اکسیدان و برخی خصوصیات رشدی نهال *Acacia victoriae* تحت تنش خشکی

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**چکیده** برای بررسی اثر تنش خشکی بر محتوی کلروفیل، پاسخ‌های آنزیمی و برخی خصوصیات رشدی نهال آکاسیا ویکتوریا و تأثیر پلیمر سوپر جاذب در کاهش تنش خشکی، آزمایشی به صورت پلات‌های خرد شده بر پایه طرح کاملاً تصادفی اجرا شد. تیمارهای آزمایش شامل چهار سطح تنش خشکی (۱۵، ۳۰، ۶۰ و ۱۰۰ درصد ظرفیت زراعی) و چهار سطح سوپر جاذب (۰، ۰/۲، ۰/۴ و ۰/۶ درصد وزنی) بود به طوری که تنش خشکی به عنوان تیمار اصلی و مقادیر سوپر جاذب به عنوان تیمار فرعی در نظر گرفته شد. تجزیه واریانس داده‌ها اثر تنش خشکی را بر کلیه خصوصیات رویشی، میزان کلروفیل و فعالیت آنزیم کاتالاز و پراکسیداز معنی‌دار نشان داد در حالی که پلیمر سوپر جاذب بر وزن و سطح برگ غیر معنی‌دار شد. اثر متقابل پلیمر سوپر جاذب و تنش خشکی بر نسبت تعداد برگ، وزن خشک اندام هوایی به ریشه، کلروفیل و فعالیت آنزیم پراکسیداز معنی‌دار شد. به طور کلی تنش خشکی تأثیر معنی‌داری بر کاهش شاخص‌های رشدی تعداد و وزن برگ، سطح برگ، طول، حجم و سطح ریشه، افزایش نسیت وزن خشک ریشه به اندام هوایی، میزان کلروفیل و فعالیت آنزیم‌های آنتی‌اکسیدان داشته است. استفاده از سطوح مختلف پلیمر سوپر جاذب با جذب و نگهداری آب توانسته است بسیاری از اثرات ناشی از تنش خشکی را کاهش داده و باعث بهبود شاخص‌های رشدی و کاهش میزان فعالیت آنزیم‌های کاتالاز و پراکسیداز شود.

**کلمات کلیدی:** پراکسیداز، تحمل خشکی، کاتالاز، هیدروژل