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Full Length Research Paper

Influence of some chemical compounds as antitranspirant agents on vase life of *Monstera deliciosa* leaves

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This study was designed to determine the influence of anti-transpiration agents, $MgCO_3$, Na_2CO_3 and glycerol, at four concentrations (2, 4, 6 and 8 %) on prolonging vase life of *Monstera deliciosa* cut leaves. For this purpose, two experiments were performed, through seasons 2008 and 2009. Each treatment sprayed three times 2, 4 and 6 days after cutting leaves. The results significantly revealed that glycerol at 2 or 4% extended vase life of *M. deliciosa* cut leaves by 7-folds of the control (7 days) and better than the other treatments. Also, glycerol treatment at the mentioned concentrations showed the lowest leaf weight reduction rate, as well as water loss rate, which obviously reflected on extending leaf vase life. The response of glycerol on prolonging leaf vase life was accompanied by a decrease in the degradation of pigments and protein as well as decrease the percentage of defense enzymes (superoxide dismutase and catalase) and this correlated with decreasing leaf water loss.

Key words: *Monstera deliciosa,* anti-transpirants vase life, enzyme.

INTRODUCTION

Demand for cut flowers and foliage plants for indoor decoration, is increasing dramatically around the world. The common potted foliage plants species include are the *Monstera deliciosa* and *Philodendron* sp. The foliage of these species are now also widely traded as cut floral greens (Will, 1985). Utilizing foliage plants for their attractive cut stems and the ecomonic values. In general, the average vase life of Monstera is about 5 to 7 days and the globalization of the cut flower market means that *Monstera* greens have to be transported over long distances. Therefore, effective techniques are needed for preserving post-harvest quality in *Monstera* greens for a long time (Łukaszewska and Skutnik, 2003).

Anti-transpiration agents are grouped into three categories (Prakash and Ramachandran, 2000), firstly film-forming types (e.g. glycerol). Secondly, reflecting materials which reflect the radiation falling on the upper surface of the leaves and thirdly stomatal closing types such as ($MgCO_3$ and Na_2CO_3) which affect the metabolic processes in leaf tissues (Ziv and Frederiksen, 1983; Osswald et al., 1984). Unfortunately, cut leaves have inefficient systems for regulating water loss, through transpiration and compensation through water uptake. The amount of water loss through transpiration is much higher leading to premature leaf wilting and death.. In cut leaves. The Monstera leaves have a large surface area, allowing for much water loss through transpiration (Geller and Smith, 1982).

To alleviate the damage from reactive oxygen species (ROS) such as superoxide anion ($O_2^{\cdot -}$) and hydrogen peroxide (H_2O_2). Reactive oxygen species which cause lipid peroxidation and cell death (Mittler, 2002; Imlay, 2003), the foliage plants evolve enzymatic antioxidants such as superoxide dismutase (SOD) and catalase (CAT) (Xu et al., 2008). The objective of the present study was to evaluate the effect of different anti-transpiration

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agents, on the foliage quality and vase life of *M. deliciosa*, through some morphological and chemical characters.

MATERIALS AND METHODS

Experimental design

This experiment was conducted using complete randomized design, during 2008 and 2009 seasons, in the laboratories of Ornamental Horticultural and Biochemistry Department. Mature, healthy and undamaged leaves of *M. deliciosa* plants were harvested in the morning, 1st of October, each year. Leaves were graded for uniformity. Each selected leaf was placed in glass container (750 ml) and filled with 500 ml of tap water. The three different treatments by anti-transpiration agents ($MgCO_3$, Na_2CO_3 and Glycerol) were used each at four concentrations (2, 4, 6 or 8% w/v). Each treatment contained three replicates, each represented by three leaves. The treatments have individual control (spraying with tap water). However, the average of three controls was calculated and used in the statistical analysis. Every treatment sprayed three times, i.e. 2, 4, 6 days. The experiment started with 500 ml as volume solution of all used anti-transpiration treatments.

All the containers were placed under laboratory controlled environmental conditions; temperature at 23±1ºC, relative humidity 60% and 1500 Lux of continuous light (10 to 14 h day/night). The data were taken 2 days intervals till the end of the experiment. The characters studied were vase life, leaf water loss and reduction rate of leaf weight.

Pigments determination

Pigments was determined as chlorophyll and carotenoid contents using the method of Holden (1965).

Electrophoretic fractionation of soluble proteins

Polyacrylamide gel electrophoreses in the presence of sodium dodecyl sulphate (SDS-PAGE), was used for determining the molecular weight of protein fractions (Total soluble protein) according to method of Laemmli **(**1970**).** Standard molecular weight proteins marker was obtained from Sigma, this marker contained different proteins molecular weights, i.e. 250, 150, 100, 70, 50, 40, 30, 20, 15, 10 and 5 kDa.

Enzyme extracts

A ground sample (1.0 g) was homogenized in 3 mL of 50 mM phosphate buffer pH 7.0, 1% PVP, 1 mM ascorbate at 4ºC. After centrifugation at 15,000×g for 15 min, the supernatant was collected according to Vitória et al. (2001).

Catalase (CAT; EC 1.11.1.6)

Catalase activity was determined as H_2O_2 consumption measured by the decrease in absorbance at 240 nm according to the method of Aebi (1983). The assay buffer contained 50 mM KH_2PO_4/K_2HPO_4 (pH 7.0), 10 mM H_2O_2. Extinction coefficient of 39.4 $mM^{-1}cm^{-3}$ was used to calculate activity. Enzyme activity was expressed in µM H_2O_2 hydrolyzed per min.

Superoxide dismutase (SOD; EC 1.15.1.1)

Superoxide dismutase activity was measured by the photochemical method as described by Beauchamp and Fridovich (1971). One unit of SOD activity was defined as the amount of enzyme required to cause 50% inhibition of the rate of nitro blue tetrazolium (NBT) reduction at 560 nm in the presence of riboflavin and light. The reaction mixture contained 45 mM potassium phosphate buffer, pH 7.0, containing 0.1 mM EDTA and 13 mM methionine, 0.17 mM NBT in ethanol, 0.007 mM riboflavin and enzyme aliquot. Blanks were kept in the dark whereas the treatments.

Statistical analysis

Data were subjected to analysis of variance, means were compared using the "Least Significant Difference test (New LSD) at 0.01 and 0.05 levels, using M-STATE software package (1987).

RESULTS

Vase life

Data in Table 1 showed that in both seasons, all foliar applications significantly increased the vase life of treated leaves, as compared to the control (Figure 1). The cut leaves treated with glycerol at 4 or 2 % has the highest values of vase life among all the other treatments.

Leaf water loss

Anti-transpirants have been proposed as a method to reduce water loss, and enhance the water status of plants. Data in Table 2 showed that the effect of using foliar treatments by glycerol, $MgCO_3$ and Na_2CO_3 at different concentrations, decreased the rate of leaf water loss as compared to control. The best results were obtained from glycerol treatment either at 2 or 4% in both seasons and sodium carbonate at 4% and 8% in the first and second seasons, respectively comparing with control.

The vase life of leaves treated by glycerol at 4% was 7 folds that of control, and this was accompanied in treated leaves by the rate of water loss.

Reduction rate of leaf weight

Data in Table 2 represented the reduction rate in leaf weight ($g.day^{-1}$) as affected by anti-transpiration agents. In both seasons, anti-transpiration treatments decrease significantly the reduction rate of leaf weight comparing with the control. Glycerol treatment at concentration 2 or 4% had the lowest value of leaf weight reduction rate which obviously reflected on leaf vase life.

Total pigments

It is obvious from Table 3 that, the total chlorophyll percentage after 6 days was higher with any concentrations

Table 1. Effect of anti-transpiration agents at different concentrations on vase life of *Monstera deliciosa* in both seasons.

Anti-transpiration agents	Concentrations (%)	First season	Second season
		Vase life (days)	
Control		6.33 ±0.33 e	7.00 ±0.76 e
$Na_2 CO_3$	2	11.00 ±1.64 cd	19.33±2.46 c
	4	12.33 ±1.74 cd	14.00±1.82 cd
	6	13.33 ±1.80 cd	10.33±1.49 cd
	8	14.00 ±1.36 cd	18.17±2.17 c
$MgCO_3$	2	15.00 ±1.21 cd	11.33±1.02 cd
	4	15.67 ±1.00 cd	18.50±1.78 c
	6	16.33 ±1.91 b-d	14.00±2.14 cd
	8	17.00 ±2.02 b-d	26.67±2.92 b
Glycerol	2	44.00 ±3.09 a	57.33 ±3.67 a
	4	46.00 ±3.95 a	54.00 ±3.24 a
	6	21.00 ±2.44 bd	18.83±1.68 c
	8	20.00 ±1.68 bd	26.67±2.06 b

Values are the mean of three replication±SD. Mean separation among treatments was done by New LSD test (0.05); Mean values followed by different letters are significantly different.

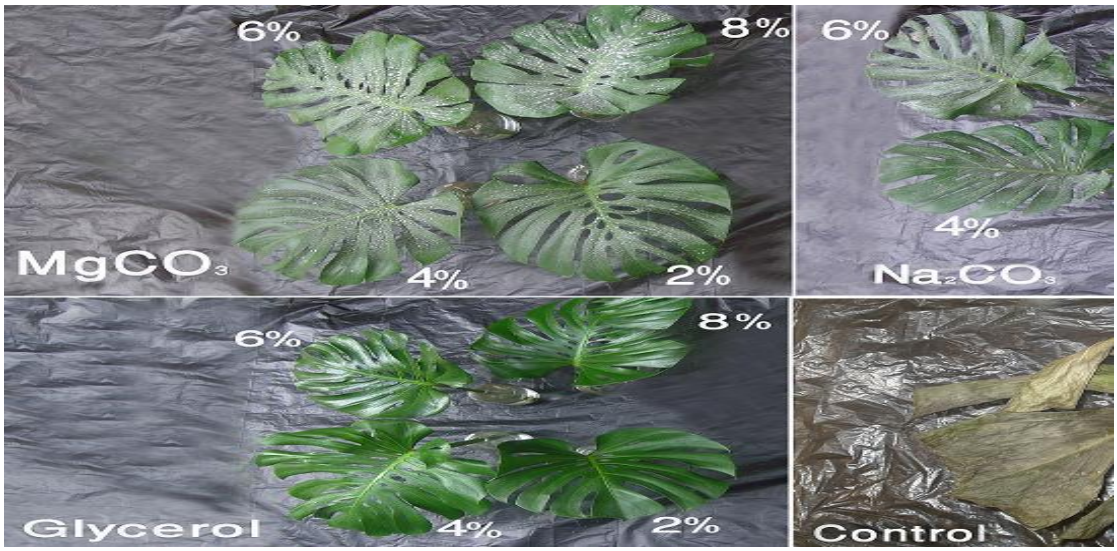

Figure 1. The effect of different antitranspiration agents concentration on the vase life of *Monstera deliciosa* (after 6 days).

of the used antitranspiration agents than control. The highest values of total chlorophyll were with $MgCO_3$ at 4 and 2% among all other treatments. The nearest highest value to that after 2 days was with 2% glycerol. While the total carotenoids was the highest with the three concentrations of glycerol (2, 6 and 8%) and with $MgCO_3$ at 6 and 8% after 2 days. Contrary, after 6 days, most of the concentrations of the used antitranspiration do not influence the total carotenoids expect the minute increase with 2% $Na_2 CO_3$ and 8% glycerol that the pigments concentrations were decreased after 6 days in all treatments

Enzyme activities

The activities of Catalase and Superoxide dismutase (CAT and SOD) enzymes were significantly ($P<0.01$) stimulated, and this stimulation reached its maximum at untreated plant (control) after 6 days for both enzymes. Enzyme activities were significantly stimulated and

Table 2. Effect of anti-transpiration agents at different concentrations on the rate of leaf water loss and reduction rate of leaf weight of *Monstera delicosea* during the first and second seasons.

Antitranspiration agents	Concentrations (%)	First season		Second season	
		Leaf water loss ($g.dm^{-2}.day^{-1}$)	Reduction rate of leaf weight ($g.day^{-1}$)	Leaf water loss ($g.dm^{-2}.day^{-1}$)	Reduction rate of leaf weight ($g.day^{-1}$)
Control		0.32±0.03 a	0.40±0.04 a	0.30 ±0.01 a	0.53± 0.02 a
$MgCO_3$	2	0.30 ±0.03 a	0.12±0.01 de	0.20 ±0.02 cd	0.12±0.01 ezfg
	4	0.25 ±0.03 bc	0.14±0.02 cde	0.19 ±0.02 cd	0.14 ±0.01 ef
	6	0.21 ±0.03 cd	0.17±0.02 bcd	0.27 ±0.03 b	0.23 ±0.03 c
	8	0.20 ±0.03 cd	0.24±0.04 b	0.15 ±0.02 e	0.34 ±0.05 b
Na_2CO_3	2	0.14 ±0.02 f	0.16±0.02 cd	0.22 ±0.02 c	0.10 ±0.01 efg
	4	0.09 ±0.01g	0.42 ±0.05 a	0.14 ±0.02 e	0.30 ±0.04 c
	6	0.17 ±0.02 cd	0.15±0.02 cde	0.15 ±0.02 e	0.18 ±0.02 cd
	8	0.14 ±0.01 d	0.10±0.01 ef	0.09 ±0.01 g	0.12 ±0.01 fg
Glycerol	2	0.07 ±0.01 e	0.07±0.01 fg	0.06 ±0.01 h	0.09±0.02 g
	4	0.05 ±0.01 e	0.06± 0.01g	0.06 ±0.01 h	0.08±0.01 g
	6	0.14 ±0.01 d	0.12 ±0.01 ef	0.15 ±0.01 e	0.15±0.01 def
	8	0.14 ±0.01 d	0.18 ±0.02 bc	0.12 ±0.02 f	0.20 ±0.03 cd

Values are the mean of three replication±SD. Mean separation among treatments was done by New LSD test (0.05). Mean values followed by different letters are significantly different.

Table 3. The pigments percentage (%) after 2 and 6 days from treatments leaves of *Monstera deliciosa* with anti-transpiration agents with three concentrations.

Antitranspiration agents	Concentration (%)	Total chlorophyll	Total carotenoids	Total chlorophyll	Total carotenoids
		After 2 days		After 6 days	
Control		1.13±0.10 h	0.33±0.00 e	0.96±0.15 l	0.30±0.00 b
$MgCO_3$	2	0.99±0.00 k	0.2±0.00 j	1.72±0.15 b	0.24±0.00 g
	4	1.01±0.20 j	0.21±0.05 j	1.96±0.23 a	0.21±0.10 h
	6	1.27±0.10 f	0.39±0.00 c	1.38±0.10 k	0.25±0.05 f
	8	1.51±0.30 c	0.42±0.10 b	1.68±0.30 d	0.24±0.00 g
Na_2CO_3	2	1.23±0.00 g	0.31±0.00 f	1.42±0.00 j	0.31±0.05 a
	4	1.3±0.15 e	0.24±0.00 h	1.69±0.15 c	0.24±0.00 g
	6	1.38±0.00 d	0.29±0.00 g	1.55±0.15 h	0.25±0.00 f
	8	1.38±0.12 d	0.21±0.05 j	1.63±0.20 e	0.25±0.00 f
Glycerol	2	1.71±0.13 a	0.48±0.00 a	1.56±0.15 g	0.28±0.03 d
	4	1.06±0.10 i	0.23±0.02 i	1.58±0.15 f	0.26±0.00 e
	6	1.68±0.30 b	0.35±0.10 d	1.58±0.20 f	0.29±0.04 c
	8	1.68±0.20 b	0.41±0.10 b	1.54±0.10 i	0.31±0.02 a

Values are the mean of three replication±SD. Mean separation among treatments was done by New LSD test (0.01). Mean values followed by different letters are significantly different.

Table 4. Effect of treating *Monstera deliciosa* leaves with anti-transpiration agent on superoxide dismutase (SOD) and catalase (CAT) activities of *(*After 6 days).

Anti-transpiration agents	Concentration (%)	SOD (Unit/mgProtein)	CAT (μmol/mgprotein/min)
Control		7.40±0.20 a	2.90±0.00 a
$MgCO_3$	2	7.10±0.30 c	2.76±0.00 b
	4	7.20±0.10 b	2.70±0.00 c
	6	6.70±0.50 d	2.50±0.20 g
	8	6.65±0.40 e	2.53±0.00 f
Na_2CO_3	2	6.32±0.15 f	2.65±0.20 d
	4	5.50±0.00 j	2.57±0.30 e
	6	5.40±0.20 k	2.50±0.00 g
	8	5.00±0.00 l	2.32±0.10 i
Glycerol	2	5.90±0.20 i	2.40±0.10 h
	4	6.00±0.20 h	2.52±0.10 fg
	6	6.30±0.10 f	2.70±0.00 c
	8	6.20±010 g	2.76±0.00 b

Values are the mean of three replication±SD. Mean separation among treatments was done by New LSD test (0.01). Mean values followed by different letters are significantly different.

negativity correlated, in most cases, with the levels of antitranspirants agents treatment except with glycerol 2 and 4% (Table 4).

Fractionation of total soluble protein

Treatment with anti-transpiration agents not only affected vase life, pigments content but also, the leaf chemical constituents, that is, soluble proteins. Data recorded in Table 5 showed that, the number of protein bands changed from treated and untreated leaves (ranged from 3 bands in plant treated with 2% sodium carbonate to 13 bands in leaves treated with 6% glycerol after 6 days) when compared to untreated leaf (8 bands). From Table 5 the results indicated that, no protein bands of high molecular weights (100-300 kDa) and lower molecular weights (10-0.01 kDa) were detected in untreated leaves, but these bands appear after treatment with the agents at different concentrations.

The results also indicate that the tested anti-transpiration agents affect on physiological functions of treated leaves through synthesis of different short proteins these new proteins might help leaves for defending against stress by stabilizing the quaternary structure of proteins in the membrane as well as the related enzymes, which in turn reflected on extended vase life.

DISCUSSION

Foliar applications significantly increased the vase life of treated leaves. Similarly, Ponce et al. (2009) found that glycerol or sorbitol (1%) extended the shelf-life of fresh apples in 10 days. De-Stigter (1981) treated the cut flowers with the commercial preservatives (8-HQC + 2% Suc) to diminish transpirational loss and maintain flower turgidity and therefore extended their vase life (Łukaszewska and Skutnik, 2003). However, same treatments decreased the rate of leaf water loss, these findings in agreement with Jones et al. (2004) who found that, anti-transpiration treatments did not decrease solution uptake by the holly stems, leading improve marketability of branches. Using anti-transpirants improved the water use efficiency and reduced leaf transpiration rate by 87 to 93% (Nasraoui, 1993; Bora and Mathur, 1998; Makus, 1997). Francisco and Rubio (2009) found that the Anti-transpirant (Pinolene) significantly reduced water uptake but no effect was found with control solution. Moreover, Shen et al. (1999) and Yancey et al. (2005) found that, glycerol can function either as an osmolyte, contributing to the maintenance of water balance, or as an osmoprotectant, allowing the operation of many cellular processes during osmotic stress. Thus, this result supports the present findings, concerning the effect of the glycerol on decreasing the water loss which could enhance the vase life. In addition, it was noticed a parallel increase in the rate of the water loss with increasing both $MgCO_3$ and glycerol over 6%, which were inversely related to vase life. Dubois and Joyce (1992) found the same result in ornamental plants. Generally, it could be concluded that glycerin can be used as a tool for reducing plant water loss, which could be resulted from closing stomata openings and reducing the transpiration rate; as mentioned by previous

Table 5. SDS-Electrophoresis analysis of soluble proteins produced by treatment of *Monstera deliciosa* with different concentration of antitranspirants agents (after 6 days).

Protein band	Molecular weight (kDa)	Control	Anti-transpiration agents											
			Glycerol				Na_2CO_3				$MgCO_3$			
			Concentrations (%)											
			2	4	6	8	2	4	6	8	2	4	6	8
1	292.00	-	-	-	-	-	-	4.0	-	-	-	-	-	8.0
2	277.37	-	-	-	-	-	-		-	-	-	-	-	43.0
3	208.00	-	-	-	5.0	-	-		-	-	-	-	-	3.9
4	187.00	-	-	-	-	-	-	4.2	-	-	-	-	-	-
5	169.33	--	--	--	-	--	--	-	--	5.0	--	-	--	-
6	138.00	-	-	-	5.0	-	-	-	-	-	-	--	-	-
7	118.00	-	-	-	7.5	15.2	-	-	-	-	-	-	-	4.3
8	110.00	-	-	-	7.5	-	42.0	-	-	-	-	-	-	-
9	98.00	16.1	-	-	5.0	-	-	--	-	-	-	7.5	-	-
10	96.00	-	-	-	-	-	-	-	-	-	15.0	-	-	-
11	94.00	7.5	-	-	-	10.0	-	-	-	-	-	-	-	-
12	90.50	-	-	-	-	5.0	-	-	-	7.5	-	-	-	--
13	87.50	7.6	-	17.1	-		--	-	--		-	-	--	5.4
14	84.26	-	-	-	10.9	7.6	-	-	-	5.0	-	--	-	3.4
15	76.62	-	--	-	11.0		-	10.1	-	5.0	--	-	-	-
16	74.8	16.1	-	-	-	-	-	-	-	-	-	-	-	-
17	71.34	17.5	-	-	-	-	-	-	16.1	-	-	-	-	3.5
18	66.93		-	--	-	-	-	-	7.5	-	-	-	-	-
19	50.00	7.5	-	-	-	-	-	5.5	-	-	-	-	-	-
20	44.72	-	-	-	9.0	-	-	-	-	--	-	-	-	-
21	40.00	-	-	-	-	-	-	-	15.0	-	-	-	--	-
22	36.34	-	-	18.1	-	-	-	-	-	-	15.0	-	15.0	--
23	19.82	-	--	-	-	-	-	-	25.1	-	-	7.5	-	-
24	18.97	--	-	-	-	--	--	5.6	-	5.6	-	-	-	-
25	16.61	16.0	20.0	-	7.5	-	-	10.2	15.0	-	-	27.2	7.6	-
26	10.2	13.2	-	30.1	5.0	-	-	5.5	7.8	-	15.0	-	20.0	-
27	7.77	-	-		-	10.1	-	-	7.5	7.4	-	-	35.0	-
28	6.04	-	-	-	-	-	-	-	-	-	-	-	-	-
29	4.14	-	-	20.1	-	-	-	-	-	-	-	-	-	-
30	1.51	-	-	15.0	5.0			15.1	-	7.9	-	27.5	-	-
31	0.55	--	50.0		7.5	7.5	19.8	14.2	-	7.8	28.0	-	-	4.4
32	0.01	-	19.6		20.1		20.0	15.1	7.3	50.2	-	-	30.0	22.0
No. of bands		8.0	3.0	5.0	13.0	6.0	3.0	10.0	8.0	9.0	4.0	4.0	5.0	9.0

investigators and leading to increased leaf vase life. Anti-transpiration treatments decrease significantly the reduction rate of leaf weight**;** it could state that a treatment which showed a slight rate of water loss could has a slight reduction rate of leaf weight which might be reflected on decreasing of transpiration rate. These results are supported by Abd El-kader et al. (2006) who found that foliar sprays of magnesium carbonate as antitranspirants on 'Wiliams banana' increased growth parameters. The same trend was found by Moftah and Al-Humaid (2006) on tuberose plants and Liang et al. (2002) who reported that water consumption was less for the anti-transpiration treated plants.

Pigments percentage (chlorophyll and carotenoids) were increased by all treatments, these results were correlated with the vase life results**,** however, high concentration of pigments in treated leaves could be due to the effect of anti-transpirant, in improving water use efficiency**,** by reducing leaf transpiration rate via increasing leaf reflecting or inducing stomata closure. These results are in agreement with those obtained by Rabiza-Świder and Skutnik (2004) who found that, postharvest longevity of *Zantedeschia* and *Hosta* was extended by inhibiting leaf senescence through delaying chlorophyll loss and soluble protein degradation. Nevertheless, Abd El-Kader et al. (2007) recorded that

spraying antitranspirants increased growth parameters. El-Abd (1996) on citrus, Ranney et al. (1989) on cherry trees recorded that pruning and antitranspirant were successful in delaying plant water stress, and relative growth rate.

Enzyme induction could be due to the effect of antitranspirant agent in improving water use efficiency, by reducing leaf transpiration rate and decrease leaf water loss. This may be due to increasing water loss value in control, than treated leaves and led to increase the free radicals formation ($O2^{\cdot-}$, H_2O_2 and OH^-) this correlated with increasing various defense enzymes especially antioxidant enzymes (Catalase and superoxide dismutase)**.** Nearly, same results were obtained by Zwiazek and Blake (1990), who observed that, drought caused a reduction in sterols, phospholipids, and sterol/phospholipid ratio, along with the increase in membrane leakage in dehydrating black spruce. A shift in phospholipid concentration could explain the membrane damage by induced peroxidation of lipids. This is resulted from the formation of free radicals (O_2^-, H_2O_2, and/or $^-$OH), which destabilize chloroplast, mitochondrial, and/or microsomal membranes. Another study reported that higher plants have active oxygen-scavenging systems consisting of several antioxidant enzymes, such as ascorbate peroxidase (APX), guaiacol peroxidase (GPX) and catalase (CAT). These systems protect membranes from the deleterious effects of ROS, such as superoxide radicals, hydrogen peroxide (H_2O_2), hydroxyl radicals and singlet oxygen, which are produced at elevated rates when plants are exposed to abiotic stress conditions (Noctor and Foyer 1998). The superoxide radical is dissimulated to H_2O_2 by SOD, CAT and APX metabolize H_2O_2 into H_2O. Mohammadkhani and Heidari (2007) found that maize, under drought stress; the activities of GPX, APX and CAT were increased in roots and shoots.

Anti-transpiration agents affected the leaf chemical constituents, that is, soluble proteins. No protein bands of high and lower molecular weights were detected in untreated leaves, but appear only after treatment with the three used agents at different concentrations. These results may be due to the effect of different anti-transpiration treatment on induction or inhibition or both on gene expression which led to absence, presence or increase/ decrease of protein bands intensity**.** These results could be explained by Taravati et al. (2007) who mentioned that, hydroxyl groups in polyols are thought to form a hydration sphere around macromolecules, thus protecting cells against stress by stabilizing the quaternary structure of proteins such as membranes and enzymes.

Conclusion

It could be concluded that, glycerol at concentration is either 2 or 4% exceeded the vase life leaf about 7-folds, and this was accompanied by lowering the reduction rate leaf water loss and leaf weight as compared to other treatments. In addition, the effect of glycerol at the mentioned concentrations could decrease the degradation of pigments and proteins and increase the percentage of defense enzymes (SOD and CAT) and this correlated with its ability to decrease leaf water loss.

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