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Influence of some chemical anti-transpirant agents on vase-life of *Monstera deliciosa* leaves

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ABSTRACT

This study was undertaken to determine the influence of anti-transpirants, Mg_2CO_3, Na_2CO_3 and glycerol, at four concentrations (2, 4, 6 and 8%) on prolonging vase-life of *Monstera deliciosa* cut leaves. Each treatment was applied as spray three times on 2, 4 and 6 days after cutting of leaves. The results significantly revealed that glycerol at 2 or 4% extended vase-life of *M. deliciosa* cut leaves by 7-fold of the control (7 days). Glycerol treatment at 2 or 4% showed the lowest value of 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 in enzyme activity (superoxide dismutase and catalase) and this correlated with decreasing leaf water loss.

Key words: Anti-transpirants, monstera, vase-life, enzyme.

INTRODUCTION

Purchasing cut-flowers and foliage plants for indoor decoration, is increasing dramatically around the world. The most common foliage plants are *Monstera deliciosa* and *Philodendron* sp. Recently, these have made way into the floral trade as a large floral greens, especially *Monstera* (Will, 21). The average vase-life of *Monstera* is about 5 to 7 days. Therefore, effective techniques are needed for prolonging the post-harvest quality in *Monstera* leaves for a long time. Anti-transpiration agents are grouped into three categories (Prakash and Ramachandran, 17), firstly film-forming types (glycerol) which coat leaf surface with films that are impervious to water vapour, reduce water losses and protect plant organs against invading microorganisms. Secondly, reflecting materials which reflect back a portion of the incident radiation falling on the upper surface of the leaves and thirdly stomata closing types such as ($MgCO_3$ and Na_2CO_3), which affect the metabolic processes of leaf tissues. These coating polymers used as protective barriers are non-phytotoxic, permeable to gases, resistant to changing environmental conditions and penetration of solar irradiation, and biodegradable (Osswald *et al*., 15). Unfortunately, cutting leaves had inefficient systems for regulating water loss, through transpiration and compensation through water uptake. The amounts of water loss through transpiration were much higher than the plant water uptake and then eventually, the leaf wilt, dry and die. The *Monstera* leaves have a large surface area, allowing for much water loss through transpiration (Geller and Smith, 7).

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The environmental stress induces the excessive generation of reactive oxygen species (ROS) such as superoxide anion (O_2^-) and hydrogen peroxide (H_2O_2). Reactive oxygen species can cause lipid peroxidation and lead to the death of cells (Imlay, 9). To alleviate the damage from ROS, plants evolve enzymatic antioxidants such as superoxide dismutase (SOD) and catalase (CAT) (Xu *et al*., 22). The objective of the present study was to evaluate the effect of different anti-transpiration agents, on the foliage quality and vase-life of *Monstera deliciosa*.

MATERIALS AND METHODS

This experiment was conducted using complete randomized design during 2008 and 2009 in the laboratory of Ornamental Horticulture Deptt. Mature, healthy, uniform and undamaged leaves from *Monstera deliciosa* plants were harvested in the morning on 1st October each year. Leaves were graded for uniformity and put in glass container (750 ml) and filled with 500 ml of tap water. The three different 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 had three replicates, each having three leaves. Each treatment had a control (spraying with tap water). However, the average of three controls was calculated and used in the statistical analysis. Each treatment was sprayed three times on different days, *i.e.* 2, 4, 6 days. The experiment was started with 500 ml vase solution for all anti-transpiration treatments. All the containers were placed under laboratory controlled environmental conditions (temp. at 23±1°C, relative humidity 60% and 1,500 lux of light (10-14/14-10 h day/night). The data were taken at 2 days intervals till the

end of the experiment. The data including; change rate in fresh weight, water loss and vase-life. Leaf quality was determined as chlorophyll and carotenoids content using the method of Holden (8).

Polyacrylamide gel electrophoreses in the presence of sodium dodecyl sulphate (SDS-PAGE), were used for determining the molecular weight of protein fractions (total soluble proteins) according to method of Laemmli (11). 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. 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 4^{0}C. After centrifugation at 15,000 ×g for 15 min., the supernatant was collected for analysis (Vitória *et al*., 20). Catalase (CAT; EC 1.11.1.6) activity was determined as H_2O_2 consumption measured by the decrease in absorbance at 240 nm according to the method of Aebi (1). 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 min^{-1}. Similarly, superoxide dismutase (SOD; EC 1.15.1.1) activity was measured by the photo-chemical method as described by Beauchamp and Fridovich (3). 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.

Data were subjected to analysis of variance, means were compared using the "Least Significant Difference test (New LSD) at 0.05 levels, using M-STATE software package (13).

RESULTS AND DISCUSSION

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 (Fig. 1). The cut leaves treated with glycerol at 4 or 2% had the highest vase-life. In this respect, Ponce *et al*. (16) found that glycerol or sorbitol (1%) extended the shelf-life of fresh apples in 10 days. De-Stigter (4) treated the cut flowers with the commercial preservatives (8-HQC + 2% sucrose) to diminish transpiration loss and maintain flower turgidity and therefore extended their vase-life.

Data in Table (2) showed that the effect of foliar treatments, i.e. 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% and sodium carbonate at 4% compared to control. The vase-life of leaves treated by glycerol at 4% was 7-fold to that of control. Jones *et al*. (10) 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

Table 1. Effect of anti-transpiration agents on vase-life of *Monstera deliciosa*.

Anti-transpiration agent	Conc. (%)	First season	Second season
		Vase-life (days)	
Control		6.33±0.33e	7.00±0.76e
Na_2CO_3	2	11.00±1.64cd	19.33±2.46c
	4	12.33±1.74cd	14.00±1.82cd
	6	13.33±1.80cd	10.33±1.49cd
	8	14.00±1.36cd	18.17±2.17c
$MgCO_3$	2	15.00±1.21cd	11.33±1.02cd
	4	15.67±1.00cd	18.50±1.78c
	6	16.33±1.91b-d	14.00±2.14cd
	8	17.00±2.02b-d	26.67±2.92b
Glycerol	2	44.00±3.09a	57.33±3.67a
	4	46.00±3.95a	54.00±3.24a
	6	21.00±2.44bd	18.83±1.68c
	8	20.00±1.68bd	26.67±2.06b

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

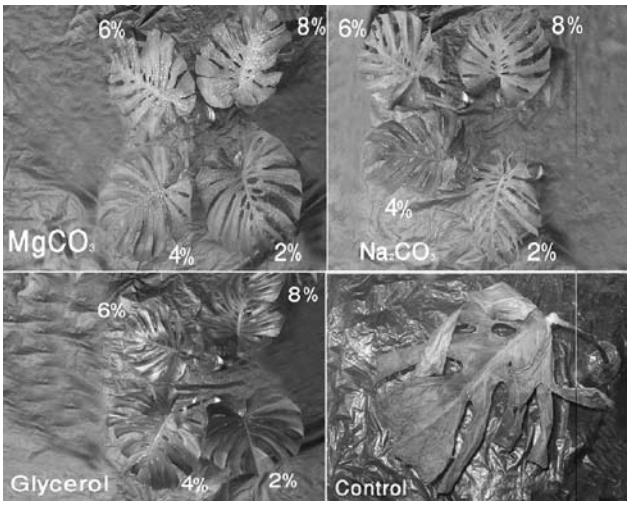

Fig. 1. The effect of different anti-transpiration agents concentrations on the vase-life of *Monstera* leaves (after 6 days).

transpiration rate by 87-93% (Makus, 12). Francisco and Rubio (6) found that the anti-transpirant (Pinolene) significantly reduced water uptake but no effect was found with control. Earlier, Yancey *et al.* (23) found that glycerol can function either as an osmolyte, contributing to the maintenance of water balance, or as an osmo-protectant, allowing the operation of many cellular processes during osmotic stress. Dubois and Joyce (5) found the same result in ornamental plants by reducing plant water loss.

Data in Table 2 show the reduction rate in leaf weight (g day^{-1}) as affected by anti- transpiration agents. Glycerol treatment at concentration 2 or 4% had the lowest value of leaf weight reduction rate which obviously reflected on leaf vase-life. These results are supported by Abdel-Kader *et al*. (2) who found that foliar sprays of magnesium carbonate as anti-transpirant on Williams banana increased growth parameters. Similar trend was found by Moftah and Al-Humaid (14) on tuberose plants. It is obvious from Table (3) that, data of pigments percentage (chlorophyll and carotenoids) were increased by all treatments, comparing with the control at 2 and 6 days from start. The treatment with glycerol, resulted in the highest pigment content, especially at 2 and 4% concentrations. These results were correlated with vase-life (Tables 1&2). 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. The results also indicated that the pigments concentrations decreased after 6 days in all treatments. These results are in agreement with those obtained by Rabiza-wider and Skutnik (18) on *Zantedeschia* and

Table 2. Effect of anti-transpiration agents on the rate of leaf water loss and reduction rate of leaf weight of *Monstera delicosa*.

Anti-transpiration agent	Con. (%)	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 efg
	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
$Na_2\ CO_3$	2	0.14±0.02 f	0.16±0.02 cd	0.22±0.02 c	0.10±0.01 efg
	4	0.09±0.01 g	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±0.01 g	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±0.01d ef
	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 pigment percentage after 2 and 6 days from treatments of *Monstera deliciosa* leaves with anti-transpiration agents.

Anti-transpiration agent	Conc. (%)	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 replications ± SD. Mean separation among treatments was done by New LSD test (P>0.01). Mean values followed by different letters are significantly different.

Hosta. Nevertheless, Abdel-Kader *et al*. (2) recorded that spraying anti-transpirants increased growth parameters.

The activities of catalase and superoxide dismutase enzymes were significantly (P<0.01) stimulated, and reached maximum in untreated plant (control) after 6 days for both enzymes. Enzyme induction was significantly stimulated and negativity correlated in most cases with the levels of anti-transpirant except with glycerol 2 and 4% (Table 4). These results could be due to the effect of anti-transpirant agent in improving water use efficiency, by reducing leaf transpiration

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

Anti-transpiration agent	Conc. (%)	SOD (unit/mg protein)	CAT (µmol/ mg protein/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 replications ± SD. Mean separation among treatments was done by New LSD test (p>0.01). Mean values followed by different letters are significantly different.

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

Protein band	Mol. wt. (kDa)	Control	Anti-transpiration agent											
			Glycerol				Na_2CO_3				$MgCO_3$			
			Conc. (%)											
			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

rate and decrease leaf water loss, comparing with control leaves. This may be due to increasing water loss value in control, than treated leaves and led to increase the free radicals formation ($O2^{-}$, 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 (24), 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 membrane damage induced peroxidation of lipids, which 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).

Treatment with anti-transpiration agents not only affected vase-life, pigments content but also, the leaf chemical constituents, i.e. 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). 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 anti-transpirants. 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. Our results also indicate that the anti-transpiration agents influence physiological functions of treated leaves through synthesis of different short proteins, which might help leaves for standing against stress by stabilizing the quaternary structure of proteins such as membrane and an enzyme, which was by the end reflected as extended vase-life. Taravati *et al*. (19) mentioned that hydroxyl groups in polyols are thought to form a hydration sphere around macro-molecules, thus protecting cells against stress by stabilizing the quaternary structure of proteins such as membranes and enzymes.

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

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