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Analysis of antitranspirant chemicals in relation to the post-harvest attributes of cut rose CV. Naranjo

Parul Punetha and Himanshu Trivedi

Abstract
In order to evaluate the effect of some antitranspirants on the post harvest attributes of cut rose cv. Naranja an experiment was conducted in the laboratory of Department of Horticulture, GBPUAT, Pantnagar. The experiment was arranged in factorial completely randomized block design with different concentrations of antitranspirants (Glycerol, $MgCO_3$, Paclobutrazol) as one factor and storage durations (0, 3, 6, 9 days) as other. The results significantly revealed that foliar application of 8% glycerol increased the vase life to about 3 times as compared to control. Also this was accompanied by minimum water uptake and water loss and appearance was improved by the application of it. Stomata opening which serve as portals for both loss of water vapour and for the intake of CO_2, was also decreased by the application of 8% glycerol and this is correlated with minimum transpiration rate recorded in those flowers.

Keywords: antitranspirants, rose, glycerol, vase life

Introduction

Poor post production environments such as exposure to high or low temperatures during shipping or retailing can cause rapid drying, wilting and accelerated senescence in flowers. Nearly 99 per cent of the water absorbed by the plant is lost in transpiration, causing a reduction in life of plants. So there is a dire need to explore certain chemicals with some biological activities which can reduce the transpiration rate and mitigate plant water stress by increasing leaf resistance to diffusion of water vapor. These compounds are now being exploited in many agricultural and horticultural crops to improve their quality and are called as anti-transpirants (Goreta *et al*. 2007) [6]. However, use of anti-transpirants in flowers to improve the plant water status is limited.

Anti-transpirants are the materials or chemicals which decrease the water loss from plant leaves by reducing the size and number of stomata. Anti-transpirants is any natural applied to transpiring plant surfaces for reducing water loss from the plant. Anti-transpiration agents are grouped into three categories (Prakash and Ramachandran, 2000) [12], 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 ($MgCO_3$) which affect the metabolic processes in leaf tissues (Osswald *et al*. 1984) [11]. Growth retardants are also used as antitranspirants. They have been found to be effective in controlling stem elongation of some foliage plants, thereby increasing the plants' aesthetic value (Wang and Blessington, 1990) [16]. Antitranspirants have different modes of action, and effective formulations are those that prevent excessive water loss without reducing CO_2 uptake. It may be applied in the form of foliar sprays. Foliar sprays may reduce transpiration in three different ways. The first method is that the spray of reflecting materials reduce the absorption of radiant energy and thereby reduce leaf temperatures and transpiration rates. Secondly the antitranspirant sprayed can form thin transparent films which hinder the escape of water vapor from the leaves and another method by which they work is that they prevent stomata from opening fully (by affecting the guard cells around the stomatal pore), thus decreasing the loss of water vapor from the leaf (Davenport *et al*.1969) [2].

Rose is an important cut flower having highest world production, and a great market potential, but the vase life of flowers is not very much, though various techniques are there to extend its life but information on the use of antitranspirants is meager. Enhancing the use of such chemicals can help to reap maximum profit. Hence this study was planned to investigate the effect of some different types of antitranspirants such as $MgCO_3$, Na_2CO_3 and Glycerol on the vase life of rose.

Materials and Methods

This experiment was conducted using completely randomized design, during 2011-13, in the laboratory of Department of Horticulture, GBPUAT, Pantnagar, U.S. Nagar, Uttarakhand. Crop was raised under naturally ventilated polyhouse of the university following standard cultural practices. The stems were harvested with sharp secateurs at 8.00 am in the morning with the help of secateurs at a stage when calyx was fully reflexed and outer petal started to unfurl. After harvesting, cut flowers were immediately placed in a bucket containing water and taken to laboratory for further experimentation and filled with 500 ml of tap water. The different treatments by anti-transpiration agents (Glycerol, $MgCO_3$) were used each at four concentrations (2, 4, 6 or 8% w/v) and Paclobutrazol at a concentration of 0.5ml/l, 1 ml/l, 1.5 ml/l and 2 ml/l. Each treatment contained three replicates. The treatments have individual control (spraying with tap water). 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. The data were taken at four different durations, i.e. D1= 0 days (24 hrs), D2= 3 days, D3= 6 days, D4= 9 days intervals. The characters studied were vase life, water loss, water uptake, stomatal conductance and transpiration rate. The data of both the years were pooled and was statistically analysed as per the methods of Gomez and Gomez (1983) [5].

Table 1: Effect of various anti-transpirants and storage durations on the water uptake (g/stem) of rose cv. Naranja

Treatments	Water Uptake (g/stem)					Water Loss (g/stem)					Water Balance (g/stem)				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
A_1	2.02	9.88	20.24	25.56	14.42	2.20	4.23	15.21	20.58	10.55	-0.18	5.65	5.04	4.98	3.87
A_2	2.55	8.00	21.64	27.19	14.84	2.38	4.70	14.83	20.44	10.59	0.17	3.30	6.81	6.75	4.26
A_3	2.27	8.77	20.98	26.39	14.60	1.87	5.13	15.55	21.28	10.96	0.40	3.63	5.43	5.11	3.64
A_4	2.43	6.92	18.54	24.14	13.01	1.50	4.65	12.67	19.49	9.58	0.93	2.27	5.87	4.65	3.43
A_5	2.67	10.99	21.35	26.39	15.35	2.53	6.03	16.30	21.27	11.53	0.13	4.96	5.05	5.12	3.81
A_6	3.25	13.71	22.03	26.90	16.47	2.81	6.65	16.33	22.37	12.04	0.44	7.06	5.70	4.53	4.43
A_7	3.38	13.65	22.66	26.89	16.65	3.12	6.45	17.26	23.09	12.48	0.27	7.20	5.40	3.80	4.17
A_8	3.63	14.40	23.11	25.91	16.76	3.30	7.57	18.32	21.92	12.78	0.33	6.83	4.79	3.99	3.99
A_9	3.77	15.65	24.74	26.20	17.59	3.62	8.30	19.54	23.45	13.73	0.15	7.35	5.20	2.75	3.86
A_{10}	5.07	14.90	24.18	27.78	17.98	3.98	8.14	20.26	24.27	14.16	1.09	6.75	3.91	3.51	3.82
A_{11}	5.85	15.20	25.43	27.77	18.56	4.28	8.63	20.64	23.78	14.33	1.57	6.57	4.79	3.99	4.23
A_{12}	5.53	15.49	29.21	31.92	20.54	4.07	9.54	21.77	25.31	15.17	1.47	5.95	7.44	6.61	5.37
A_{13}	6.80	17.71	30.48	38.61	23.40	5.05	9.99	24.01	26.57	16.40	1.75	7.73	6.47	12.04	7.00
MEAN	3.79	12.71	23.43	27.82	16.94	3.13	6.92	17.90	22.60	12.64	0.65	5.79	5.53	5.22	4.30
	Days		Treatments	Days x Treatments		Days	Treatments		Days x Treatments		Days		Treatments	Days x Treatments	
Se M±	0.067		0.121	0.243		0.074	0.133		0.266		0.108		0.194	0.388	
CD 0.05	0.188		0.340	0.680		0.207	0.372		0.745		0.302		0.544	1.088	

Note: A_1 = 2% Glycerol; A_2 = 4% Glycerol; A_3 = 6% Glycerol; A_4 = 8% Glycerol; A_5 = 2% $MgCO_3$
A_6 = 4% $MgCO_3$; A_7= 6% $MgCO_3$; A_8= 8% $MgCO_3$; A_9= 0.5ml/l Paclobutrazol; A_{10}= 1ml/l Paclobutrazol
A_{11}= 1.5ml/l Paclobutrazol; A_{12} = 2ml/l Paclobutrazol; A_{13} = Control
D_1 = 0 days; D_2= 3 days; D_3= 6 days; D_4= 9 days

Table 2: Effect of various anti-transpirants and storage durations on the water uptake (g/stem) of rose cv. Naranja

Treatments	Stage of Bud Opening					Flower Diameter (cm)					FLOWER APPEARANCE				
	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean	D_1	D_2	D_3	D_4	Mean
A_1	1.0	1.0	2.6	3.2	1.9	3.34	4.14	5.55	6.12	4.79	10.0	8.3	7.2	6.2	7.9
A_2	1.0	1.0	2.6	3.2	2.0	3.34	4.39	5.67	6.06	4.87	10.0	8.4	7.4	6.3	8.0
A_3	1.0	1.0	2.6	3.4	2.0	3.52	4.56	6.04	6.54	5.16	10.0	8.2	7.2	6.3	7.9
A_4	1.0	1.0	2.7	3.1	2.0	3.43	4.55	5.93	6.40	5.08	10.0	8.7	7.7	6.6	8.2
A_5	1.0	1.0	2.8	3.3	2.0	3.58	5.01	5.76	5.88	5.06	10.0	8.2	6.8	5.5	7.6
A_6	1.0	1.0	2.9	3.3	2.0	3.51	4.91	6.01	5.91	5.09	10.0	8.0	7.0	5.6	7.6
A_7	1.0	1.0	2.6	3.2	2.0	3.45	4.94	5.82	6.01	5.06	10.0	8.2	6.6	5.4	7.5
A_8	1.0	1.0	2.4	3.4	1.9	3.40	4.63	5.81	5.97	4.95	10.0	7.9	6.2	5.6	7.4
A_9	1.0	1.0	2.2	3.3	1.9	3.39	4.90	5.80	6.08	5.04	10.0	7.9	6.6	5.3	7.5
A_{10}	1.0	2.0	2.5	3.4	2.2	3.44	4.93	5.62	6.04	5.01	10.0	7.4	6.9	4.3	7.2
A_{11}	1.0	1.0	2.5	3.6	2.0	3.40	5.03	5.88	6.13	5.11	10.0	8.0	7.2	4.3	7.4
A_{12}	1.0	1.3	2.9	3.9	2.3	3.45	4.91	5.85	6.00	5.05	10.0	8.3	7.0	4.6	7.5
A_{13}	1.0	2.7	3.4	3.9	2.7	3.35	5.66	6.53	6.19	5.43	10.0	6.8	6.0	3.5	6.6
MEAN	1.0	1.2	2.7		3.4	2.1	3.43	4.81	5.87	6.10	5.05	10.0 8.0	6.9	5.4	7.6
	Days	Treatments		Days x Treatments		Days	Treatments		Days x Treatments		Days		Treatments	Days x Treatments	
SeM±	0.037	0.067		0.133		0. 01	0.02		0.05		0.108		0.194	0.388	
CD 0.05	0.103	0.186		0.372		0.04	0.07		0.14		0.062		0.111	0.223	

Note: A_1 = 2% Glycerol; A_2 = 4% Glycerol; A_3 = 6% Glycerol; A_4 = 8% Glycerol; A_5 = 2% $MgCO_3$
A_6 = 4% $MgCO_3$; A_7= 6% $MgCO_3$; A_8= 8% $MgCO_3$; A_9= 0.5ml/l Paclobutrazol; A_{10}= 1ml/l Paclobutrazol
A_{11}= 1.5ml/l Paclobutrazol; A_{12} = 2ml/l Paclobutrazol; A_{13} = Control
D_1 = 0 days; D_2= 3 days; D_3= 6 days; D_4= 9 days

Results and Discussion

Among different antitranspirants used during the course of investigation, presented in Table 1 clearly indicated that among various antitranspirants, maximum score (2.7) was obtained with the flowers that were not sprayed with any antitranspirant (T_{13}), i.e. the flower was opened to a larger extent as compared to other treatments whereas, minimum score of 1.9 was in the flowers which were sprayed with 2% Glycerol (A_1), 8% $MgCO_3$ (A_8) and 0.5 ml/l Paclobutrazol (A_9) and they were statistically at par with each other except the treatment A_{10} and A_{12}. Data pertaining to different durations of treatments revealed that on the 9th day (D_3), flowers attained maximum score (3.4), while minimum score (1.0) was recorded in the flowers that were freshly harvested (D_0).

Interaction among various antitranspirants and durations revealed that on the 9th day flowers that were sprayed with 2ml/l paclobutrazol (D_3A_{12}) and the flowers that were not sprayed with antitranspirant (D_3A_{13}) attained a maximum score of 3.9 while minimum score of 1.00 was recorded with freshly harvested flower for all the treatments (A_1D_0, A_2D_0, A_3D_0, A_4D_0, A_5D_0, A_6D_0, A_7D_0, A_8D_0, A_9D_0, $A_{10}D_0$, $A_{11}D_0$, $A_{12}D_0$ and $A_{13}D_0$) and in the flowers which were sprayed with different antitranspirants and kept for a duration of 3 days, i.e. in the treatment combinations A_1D_1, A_2D_1, A_3D_1, A_4D_1, A_5D_1, A_6D_1, A_7D_1, A_8D_1, A_9D_1 and $A_{11}D_1$ and all were statistically at par with $A_{12}D_1$. Thus, the results indicated that all the antitranspirants delayed the flower bud opening. This might be due to the reason that antitranspirants provide a physical barrier to water loss and stomatal closure leading to slower flower opening. Similar results were obtained by Song *et al*. (2011) [11] in cut Rose cv. First Red that use of antitranspirants delayed the process of flower opening.

It is evident from the data presented in Table 1 that among the different antitranspirants used, flowers sprayed with 8% glycerol (A_4) had minimum water uptake (13.01 g/stem), while maximum water uptake (23.40 g/stem) was recorded in the flowers that were not sprayed with any antitranspirant, i.e. A_{13}. Among the different durations for which the flowers were kept, it was recorded that on the 9th day (D_3) flowers had maximum water uptake (27.82 g/stem), while on the day when the flowers were freshly harvested (D_0) they had minimum water uptake (3.79 g/stem). The interaction between different antitranspirants and durations revealed that on the 9th day flowers that were not sprayed with any antitranspirant (D_3A_{13}) had maximum water uptake (38.61 g/stem) and minimum water uptake (2.02 g/stem) was recorded with the flowers that were freshly harvested and sprayed with 2% glycerol (D_0A_1) and was statistically at par with the treatment combinations D_0A_4, D_0A_2, D_0A_3 and D_0A_5.

Thus the results revealed that antitranspirants significantly reduced the water uptake as compared with the control and among the different antitranspirants used the lowest water uptake was found at 8% glycerol. And it might be due to the reason that glycerol served as an osmolyte, contributing to the maintenance of water balance (Shen *et al*. 1999) [14]. The same trend was found by Moftah and Al-Humaid (2006) on tuberose plants and Liang *et al*. (2002) [9] in wheat who reported that water uptake was less for the antitranspiration treated plants. Effect of glycerol was studied by Asrar 2000 [1], in rose cv. Dallas and cv. Texas. He found that glycerol at a concentration of 7.5% and 10% had minimum water uptake leading to an improved vase life.

The data pertinent to water loss presented in Table 1 revealed that maximum water loss (16.40 g/stem) was in the flowers which were not sprayed with antitranspirant, i.e. A_{13} while minimum water loss (9.58 g/stem) was in the flowers which were sprayed with 8% glycerol (A_4). Among the different durations, flowers kept for 9 days (D_3) resulted in maximum water loss (22.60 g/stem) whereas freshly harvested flowers (D_0) had minimum water loss (3.13 g/stem). Interaction of pooled data between different antitranspirants and durations revealed that maximum water loss (26.57 g/stem) was recorded with the flowers which were kept for 9 days and not sprayed with any antitranspirant (D_3A_{13}) and minimum water loss (1.50 g/stem) was recorded for the flowers which were freshly harvested and sprayed with 8% glycerol (D_0A_4) and it was statistically at par with the treatment combinations D_0A_1, D_0A_2, D_0A_3 and D_0A_5. The results pertaining to water loss clearly indicated that use of antitranspirants decreased the water loss as compared to control and enhance the water status of plants and in the present investigation, glycerol was effective in reducing water loss as compared to other antitranspirant agents. Glycerol treatment at a concentration of 2% and 4% gave lowest water loss that reflected the extended leaf vase life in *Monstera deliciosa.* (Shanan and Shalaby, 2011) [11].

Minimum water balance (3.43 g/stem) was recorded in the flowers which were sprayed with 8% glycerol (A_4) and it was statistically at par with A_3, A_4, A_5, A_9 and A_{10} and maximum water balance (7.00 g/stem) was in the flowers that were not sprayed with any antitranspirant (A_{13}). Among the durations, flowers that were kept 6 days (D_2) had minimum water balance of 5.79 g/stem and the flowers that were freshly harvested (D_0) had maximum water balance of 6.65 g/stem. Interaction between antitranspirants and durations of storage revealed that minimum water balance (-0.18 g/stem) was recorded in the flowers that were freshly harvested and sprayed with 2% glycerol (D_0A_1) and it was statistically at par with the treatment combinations D_0A_2, D_0A_5, D_0A_6, D_0A_7, D_0A_8 and D_0A_9, while maximum water balance (12.04 g/stem) was recorded with the flowers that were kept for 9 days and not sprayed with any antitranspirant (D_3A_{13}).

The data presented in Table 2, revealed that 8% glycerol (A_4) gave maximum freshness and colour and value obtained after scoring was 8.2 and it was statistically at par with A_2, while poor appearance of flowers was in the flowers that were not sprayed with any antitranspirant, i.e. A_{13} (control) and the value obtained was 6.6. The durations for which the observation was recorded it was noticed that freshly harvested flower (D_0) had scored maximum value of 10.00, whereas on the 9th day (D_3) it had minimum value of 5.4. The interaction data for the pooled values among various antitranspirant agents and durations revealed that freshly harvested flowers for all the treatments (D_0A_1, D_0A_2, D_0A_3, D_0A_4, D_0A_5, D_0A_6, D_0A_7, D_0A_8, D_0A_9, D_0A_{10}, D_0A_{11}, D_0A_{12} and D_0A_{13}) had maximum value (10.00) while minimum value of 3.5 was scored with the flowers which were kept for 9 days and not sprayed with any antitranspirant, i.e. D_3A_{13}.

Thus the results indicated that use of antitranspirants can help in retaining freshness and colour of flowers and leaves for a longer time and this might be due to the reason that the thin transparent layer of antitranspirant hinders the escape of water vapour from the leaves (Davenport *et al*., 1972) and helps in improving the appearance.

The data presented in Table 2 exhibited that maximum flower diameter (5.43 cm) was recorded with the flowers that were not sprayed with any antitranspirant (A_{13}) and was statistically higher than all other treatments, while minimum flower diameter (4.79 cm) was found in the flower sprayed with 2%

glycerol (A_1). The durations, for which the flowers were kept in the pooled data, revealed that flowers kept for 9 days (D_3) had maximum flower diameter (6.10 cm) and minimum flower diameter (3.43 cm) was recorded with the freshly harvested flower (D_0). The interaction for the pooled data revealed that minimum flower diameter (3.34 cm) was recorded in the flowers that were freshly harvested and sprayed with 2% glycerol (D_0A_1) and 4% glycerol (D_0A_2) and were statistically at par with the treatment combinations D_0A_4, D_0A_7, D_0A_8, D_0A_9, D_0A_{10}, D_0A_{11}, D_0A_{12} and D_0A_{13}, while, maximum flower diameter (6.54 cm) was attained in the flowers kept for 9 days and sprayed with 8% glycerol (D_3A_4) and it was statistically at par with the treatment combinations D_3A_4 and D_2A_{13}.

Table 3: Effect of various antitranspirants on stomatal conductivity g_s ($mmolm^{-2}s^{-1}$) of rose cv. 'Naranja'

Treatments	Stomatal Conductivity g_s ($mmolm^{-2}s^{-1}$)	Transpiration Rate	Vase Life (days)
A_1 = 2% Glycerol	0.34	3.13	9.67
A_2 = 4% Glycerol	0.28	4.12	10.33
A_3 = 6% Glycerol	0.26	3.32	10.00
A_4 = 8% Glycerol	0.22	2.58	12.17
A_5 = 2% $MgCO_3$	0.34	3.57	8.17
A_6 = 4% $MgCO_3$	0.35	2.45	8.50
A_7 = 6% $MgCO_3$	0.41	3.35	9.00
A_8 = 8% $MgCO_3$	0.37	3.22	8.83
A_9 = 0.5ml/l Paclobutrazol	0.37	3.38	8.17
A_{10} = 1ml/l Paclobutrazol	0.33	4.08	7.50
A_{11} = 1.5 ml/l Paclobutrazol	0.44	4.77	7.67
A_{12} = 2 ml/l Paclobutrazol	0.42	3.48	7.50
A_{13} = Control	1.02	6.55	4.67
Sem±	0.029	0.157	0.421
$CD_{0.05}$	0.087	0.457	1.224

The data presented in Table 3 clearly indicated that use of antitranspirants reduced the stomatal conductivity. Minimum stomatal conductivity (0.22 $mmolm^{-2}s^{-1}$) was recorded in the flowers sprayed with 8% glycerol (A_4) and it was statistically at par with the treatments A_2 and A_3, whereas maximum stomatal conductivity (1.02 $mmolm^{-2}s^{-1}$) was recorded in the flowers that were not sprayed with any antitranspirant (A_{13}), i.e. in control (Table 3). This decrease in stomatal conductance is might be due to the reason that antitranspirant compounds prevent stomata from opening fully by affecting the guard cells around the stomatal pore thus decreasing the loss of water vapour (Davenport *et al*., 1969) [2]. Various antitranspirant solutions respond differently to various crops, in salvia (*Salvia splendens*), drench applications of s-ABA resulted in rapid stomatal closure, and stomatal conductance (gS) decreased within 3 hrs of application (Kim and van Iersel, 2008) [8].

Antitranspirants are chemical compounds which are used to limit the transpiration process and to keep advantageous parameters of the water balance of plants (Song *et al*., 2011) [11]. In the present investigation application of antitranspirants also reduces the transpiration rate and the data presented in Table 3 revealed that maximum transpiration rate (6.55 ml cm^{-2}) was recorded in the flowers which were not sprayed with any antitranspirant (A_{13}), and minimum transpiration rate (2.45 ml cm^{-2}) was recorded in the flowers which were sprayed with 8% glycerol (A_4) and was statistically at par with the treatment A_6. The use of antitranspirant solution which have reduced the transpiration rate as compared to control may be due to the reduction in water absorption (Durkin, 1979) [3] and also antitranspirant films curtail transpiration by offering resistance to the passage of water vapor (Gale and Hagan, 1966) [4]. Similar results of reduced transpiration by the application of antitranspirants have been reported by Javan *et al*., 2013 [7] in soyabean.

The data pertaining to the vase life depicted in Table 3 revealed that spraying of 8% glycerol (A_4) increased the vase life of 12.17 days and was recorded in the flowers that were sprayed with. 8% glycerol i.e. A_4 and minimum vase life (4.67 days) was recorded in the flowers that served as control (A_{13}). Use of antitranspirants have been found to increase the vase life of the flowers as compared to control and the probable reason for this might be due to the decrease in stomatal conductance and decrease in water loss during transpiration due to the spray of antitranspirants which might have maintained the integrity of cell membranes and thus prolong the vase life of cut roses. Similar increase in vase life of cut roses was observed by Song *et al*., 2011 [15]. Thus it can be concluded that out of the various antitranspirants used, foliar application of 8% glycerol increased the vase life accompanied by minimum water uptake and water loss and appearance was improved as they form a layer over the flowers which help in retaining maximum freshness and colour. Stomata opening which serve as portals for both loss of water vapour and for the intake of CO_2, was decreased by the application of 8% glycerol and this is correlated with minimum transpiration rate recorded in those flowers.

References

1. Asrar AA. Effect of glycerol on water relations and keeping quality of two cut rose cultivars. Annals of Agricultural Sciences. 2000; 45(2):679-688.
2. Davenport DC, Hagan RM, Martin PE. Antitranspirants: Uses and effects on plant life. California Turf grass Culture. 1969; 19:25-27.
3. Durkin DJ. Effect of millipore filtration, citric acid and sucrose on peduncle water potential of cut rose flower Journal of the American Society for Horticultural Science. 1979; 104:860-863.
4. Gale J, Hagan RM. Plant antitranspirants. Annual Review of Plant Physiology. 1966; 17:269-282.
5. Gomez LA, Gomez AA. Statistical procedures for Agricultural research John Wiley and Sons, 1983, 680.
6. Goreta S, Leskovar DI, Jifon JL. Gas exchange, water status, and growth of pepper seedlings exposed to transient water deficit stress are differentially altered by antitranspirants. Journal of the American Society for Horticultural Science. 2007; 132:603-610.
7. Javan M, Tajbakhsh M, Mandoulakani BA. Effect of antitranspirants application on yield and yield

components in soyabean (Glycine max L.) under limited irrigation. Journal of Applied Biological Sciences. 2013; 7(1):70-74.

8. Kim J, Van Iersel MW. ABA drenches induce stomatal closure and prolong shelf life of Salvia splendens. Southern Nursery Association Research Conference. 2008; 53:107-111.
9. Liang Z, Zhang F, Shao M, Zhang J. The relations of stomata conductance, water consumption, growth rate to leaf water potential during soil drying and rewatering cycle of wheat (Tricitum aestivum). Botanical Bulletin of Academia Sinica. 2002; 43:187-192.
10. Moftah AE, Al-Humaid AI. Response of vegetative and reproductive parameters of water stressed Tuberose plants to vaporgrad and Kaolin Antitranspirants. Journal of King Saud University of Agricultural Sciences. 2006; 18(2):127-139.
11. Osswald WM, Neihuss M, Huber W, Elstner EF. Support of nonhost resistance by artificial leaf coating. Z. Krankh plants. The Journal of Plant protection Sciences. 1984; 91:337-341.
12. Prakash M, Ramachandran K. Effect of chemical Ameliorants in Brinjal (*Solanum melongena* L.) under moisture strees conditions. Journal of Agronomy and Crop Science. 2000; 185:237-239.
13. Shanan NT, Shalaby EA. Influence of some chemical compounds as antitranspirant agents on vase life of Monstera deliciosa leaves. African Journal of Agricultural Research, 2011, 132-139.
14. Shen B, Hohmann S, Jensen RG, Bohnert HJ. Roles of sugar alcohols in osmotic stress adaptation: Replacement of glycerol by mannitol and sorbitol in yeast. Plant Physiology. 1999; 121:45-52.
15. Song X, Wang W, Zhang C, Ma Q, Li Y. Postharvest physiochemical responses of cut rose (*Rosa hybrida* L.) to antitranspirant and vacuum cooling. Philippine Agricultural Scientist. 2011; 94(4):368-374.
16. Wang YT and Blessington TM. Growth of Four Tropical Foliage Species Treated with Paclobutrazol or Uniconazole. HortScience. 1990; 25(2):202-204.