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EVALUATION THE EFFECT OF PRESERVATIVE SOLUTIONS AND STORAGE CONDITIONS ON SHELF LIFE OF SUNFLOWER INFLORESCENCES

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ABSTRACT: Two separated experiments were conducted at the Postharvest Lab of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., Giza, Egypt during 2012 and 2013 seasons to study the response of the fresh inflorescences/heads of sunflower (*Helianthus annuus* L. cv. Sunrich Orange) either to some preservative solutions under the ambient conditions, viz. distilled water (control), sucrose at 10, 20 and 30 g/l levels, glucose at 3, 8 and 15 g/l levels, chelated calcium at 20, 30 and 50 g/l levels and glucerol at 20 and 50 g/l levels in the first experiment or to the main 3 important factors of transportation, storage system (wet or dry), cool storage temperature (0 or 5 °C) and storage period (5 or 7 days) in the second one. The previous 3 factors were combined factorially to obtain the different interactions among them. The flowering stalks after wet or dry storage were held in graduated cylinders filled with about 350 ml of deionized water under the room temperature till the end of shelf life.

The obtained results of the first experiment indicated that all preservative solutions improved the means of water uptake, the percent of change in flower head fresh weight, flower head diameter, vase life and total soluble sugars content in petals with various significant levels as compared to control means in both seasons. However, the superiority was for holding in 50 g/l chelated- Ca solution, that gave in the two seasons the utmost high values over the other solutions in most parameters mentioned before. The second position was occupied by preserving the flowering stems in 30 g/l sucrose solution, which improved means of some characters to values closely near to those of the super treatment. So, for elongating the vase life and keeping quality of sunflower cv. Sunrich Orange heads, it is recommended to holding them either in 50 g/l chelated Ca or in 30 g/l sucrose one.

In the second experiment, the results have shown that dry storage system recorded better results than wet storage one, especially in water uptake and flower head diameter traits. Storing the flowering stems at 0 °C raised water uptake and vase life means to be more than those of storage at 5 °C in the two seasons, while storage at 5 °C caused only a higher increment in flower head diameter. In general, storage for 7 days scored higher means of water uptake, the percent of change in flower head fresh weight, flower head diameter and vase life than storage for 5 days in both seasons. Regarding the total soluble sugars content in the petals, it was not affected markedly by storage system, temperature and period with few exceptions in the two seasons. On the other hand, effect of interaction treatments on the previous stated parameters was fluctuated, where dry storage at 0 °C for 7 days

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recorded the highest means of water uptake and vase life, while dry storage at 5 °C for 7 days gave only the widest diameter of flower head. The wet storage at either 0 or 5 °C for 7 days scored the highest content of total soluble sugars, while the wet storage at 0 °C for 5 days registered the highest percent of change in flower head fresh weight. Hence, it can be advice to store the cut heads of sunflower cv. Sunrich Orange, dry at 0 °C for 5 or 7 days at long-space transportation without noticeable reduction in their vase life and quality.

Key words: *Helianthus annuus*, sucrose, glucose, chelated calcium, glucerol, storage system, storage period.

INTRODUCTION

The sunflower (*Helianthus annuus* L.) is the herbaceous annual plant belongs to Fam. Compositae, mostly native to N. America, but it extensively cultivated in Russia, India and Egypt. It is used for various purposes, including decoration as ornamental, but recently it is used more as cut flower. Sunflower vase life is very variable, depending on the variety; it reportedly ranged from 4 to 13 days (Gast, 1995). So, heads of some cultivars may need to be treated with a suitable postharvest treatment to improve their vase life.

In this regard, Jones *et al*. (1993) found that a non-ionic detergent used as a pulse treatment for 1 h increased water uptake and the length of vase life in cut sunflower stored for 3 days at 8 °C prior to vase life. Celikel and Reid (2002) noticed that a lower storage temperature (0-1 °C) increased the length of vase life and reduced stem bending of sunflower heads. Moreover, Mensuali-Sodi and Ferrante (2005) reported that vase life of sunflowers was significantly increased by treatment with 150 mg/l citric acid, while 2 mM amino-oxyacetic acid (AOA), an ethylene inhibitor, reduced ethylene production, but did not increase vase life.

Today, several chemical materials are used in preservative solutions to increase cut flowers longevity. In this concern, Amiri *et al*. (2009) mentioned that vase life of gerbera cv. "Pags" flowers was significantly extended from 12 days (control) to 24.5 days by using a combination of aluminum sulphate (300 ppm) and sucrose (30 ppm), while 30 ppm sucrose + 250 ppm $AgNO_3$ + 250 ppm citric acid combination improved water uptake which led to prolonging vase life, delaying scape bending, wilting and the curvature of the stem at the end of vase life. Similar observations were also obtained by Mor *et al*. (1984) on *Agapanthus orientaslis* cvs. Mooreanus (blue) and Albidus (white), Abdel-Moniem *et al*. (2009) on gerbera cv. "Deliana", Mohammadi *et al*. (2011) on roses, Abdel-Moniem *et al*. (2012) on rose cvs. Anna, Gold Strike and Spot, and Khenizy *et al*. (2014) on *Gypsophila paniculata* "Perfecta".

It is well known that cold storage is essential to delay flower senescence and quality deterioration in postharvest chain and when it is needed to regulate the supply of flowers to the market. Thus, many efforts were done in this respect such as that of Cevallos (2001) who revealed that the vase life of carnation "Imperial White", daffodils "King Alfred", iris "Telstar", *Chrysanthemum maximum*, narcissus "Paperwhite", rose "Ambiance" and *Tulipa gesneriana* was decreased with increasing storage temperature from 0 °C to 20 °C, but after wet storage at 12 .5 °C or greater, it was significantly longer than that after dry storage at those temperatures. Further, Hettiarachchi and Balas (2004) stated that wet storage (4 °C for 7 days) of fully opened *Gloriosa superba* flowers markedly improved flowers keeping quality compared to dry stored flowers. Flowers kept at 4 °C (wet storage for 7 days maintained a higher

chlorophyll yield during vase period, but there was a significant decrement of chlorophyll yield with increasing storage temperature and vase period. On *Narcissus tazetta* cv. "Kashmir", Gul and Tahir (2012) affirmed that the scapes previously wet stored in distilled water for 72 h at 5 °C before transfer to holding solution exhibited a marked improvement in blooming, solution uptake, maintenance of membrane integrity, fresh or dry mass of flowers, sugars fractions and soluble proteins with a corresponding decrease in amino acids.

The synergistic effect of both storage and holding treatments was also documented by many workers, such as that of Shahri *et al*. (2011) whom declared that pulsing the spikes of *Consolida ajacis* cv. Violet Blue with 0.5 mM STS prior to 72 h wet storage at 5 °C and transferring them to holding solution containing sucrose + 100 mg/l 8-HQS can be used as a storage/chemical treatment to improve the postharvest performance of this cut flower. Like results were also explored by Gendy and Hamad (2011) on bird of Paradise, Bayleyegn *et al*., (2012) on rose cv. "red Calypso" and Abd-Allah *et al*., (2013) on *Lilium longiflorum* cv. "Orange tycoon".

However, the current work aims to investigate the effects of preservative solutions, as well as the wet and dry storage at two low temperatures for two shelf periods (alone or in combined treatments) on quality and vase life of sunflower cv. "Sunrich Orange" cut heads.

MATERIALS AND METHODS

The present trial was undertaken at the postharvest lab of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., Giza, Egypt in 2012 and 2013 seasons to find out the response of sunflower cut heads to some postharvest treatments.

Therefore, the fresh inflorescences (*Helianthus annuus* L. cv. Sunrich Orange) were brought from local commercial farm (Floramax, El-Mansouria, Giza) after picking up them in the early morning when the ray florets were completely expended and all the disc ones were visible and quickly transported to the lab. In the Lab, the cut heads were firstly precooled to remove the field heat, selected for uniformity and the stem bases were recut under water to a length of 60 cm. The prepared heads were divided to 3 groups, and then subjected to the following treatments in two independent experiments:

In the first experiment, the bases of flowering stems of the first group were hold in clear glass jars (3 heads/jar) under ambient temperature (20 ± 1 °C), normal day light and natural ventilation. The jars were filled with about 350 ml of one of the following preservative solutions:

1- Distilled water as control.
2- Sucrose solution at concentrations of 10, 20 and 30 g/l.
3- Glucose solution at concentrations of 3, 8 and 15 g/l.
4- Chelated-Ca solution at concentrations of 20, 30 and 50 g/l.
5- Glycerol solution at concentrations of 20 and 50 g/l.

A film of plastic was added on the surface of solutions mentioned above to prevent evaporation during the vase life period. The lay out of this experiment in the two seasons was a complete randomized design with 3 replicates as each one contained 3 flowering stems (Mead *et al*., 1993).

In the second experiment, the other two groups were subjected to either wet or dry storage as follows:

Wet storage treatments:

At the flowering stems were stored inside a fridge, vertically after wrapping then in kraft paper soaked in distilled water in plastic pots at 0 or 5 °C for 5 or 7 days.

Dry storage treatments:

As the flowering stems were stored just as the previous group, but without soaking in

any solution at the same two cool temperatures for the same two periods.

The previous treatments (wet and dry) were combined factorially to obtain the different interactions between the different factors employed in this experiment. The flowering stems after wet or dry cool storage were kept in graduated cylinders (3 flowering stems/cylinder) filled with about 350 ml deionized water under the same room conditions mentioned before in the first experiment till the end of the shelf life. A factorial in complete randomized design with 3 replicates each of 3 flowering stems was used for the experiment in both seasons (Mead *et al*., 1993).

During the shelf period of the two experiments, water uptake (g/flower head) was measured once every 3 days and recorded in the tables as general mean for the whole shelf period, while at the end of this period, the change in flower heads fresh weight as percentage was calculated mathematically. After 2 days in the preservative solutions, the flower head diameter (cm) was measured. The flower heads were also examined daily and their vase life (day) was recorded as the number of days to wilting, curling or dropping of the ray florets. In fresh ray florets samples, total soluble sugars content (%) was evaluated using the method of Dubois *et al*. (1956) in the second season only.

Data were then tabulated and statistically analyzed according to program of SAS Institute (2009), followed by Duncan`s New Multiple Range Test (Steel and Torrie, 1980) to verify the significancy among the means of different treatments.

RESULTS AND DISCUSSION

The first experiment: Effect of preservative solutions on some postharvest parameters of *H. annuus* L. cv. Sunrich Orange flower heads:

Data in Table (1) show that all preservative solutions used in this experiment greatly improved the means of water uptake (g/flower head), the percent of change in flower head fresh weight, flower head diameter (cm), vase life (day) and total soluble sugars content (%) with various significant levels when compared to the means of control in most cases of both seasons.

Table (1). Effect of preservative solutions on some postharvest parameters of *Helianthus annuus* L. cv. Sunrich Orange flower heads during 2012 and 2013 seasons.

Preservative solutions	Water uptake (g/flower head)		The change in flower head %		Flower head diameter (cm)		Vase life (day)		Total soluble sugar
	2012	2013	2012	2013	2012	2013	2012	2013	2013
D.W.	382.50h	361.7i	2.29c	1.97c	13.00h	12.00g	10.00e	9.00e	0.79
Suc. at 10 g/l	472.80f	466.2g	0.74e	0.62e	16.00d	15.00d	11.00d	10.00d	1.39
Suc. at 20 g/l	392.70g	378.3h	1.71d	1.15d	17.00b	17.00b	12.00c	11.00c	1.86
Suc. at 30 g/l	541.50a	532.2b	-9.23j	-7.68i	18.00a	18.00a	12.00c	11.00c	1.25
Glu. at 3 g/l	532.8b	522.5c	-7.51h	-5.83g	16.50c	16.00c	11.00d	10.00d	1.28
Glu. at 8 g/l	494.7d	481.2e	-6.30g	-5.05f	17.00b	16.00c	10.00e	10.00d	1.83
Glu. at 15 g/l	513.3c	510.5d	-5.70f	-4.87f	15.00e	14.00e	11.00d	10.00d	1.26
Che. Ca at 20 g/l	534.6b	530.6b	-8.07i	-6.61h	14.00f	14.00e	14.00a	13.00a	1.06
Che. Ca at 30 g/l	480.6e	473.2f	1.01e	0.64e	14.00f	13.00f	13.00b	12.00b	1.07
Che. Ca at 50 g/l	543.7a	540.9a	-10.31k	-8.28j	17.00b	17.00b	14.00a	13.00a	1.38
Gly. at 20 g/l	240.4j	255.9k	7.70a	6.33a	13.00h	12.00g	10.00e	9.00e	1.06
Gly. at 50 g/l	353.1i	354.0j	5.35b	4.89b	13.50g	12.00g	11.00d	10.00d	1.04

D.W. = Distilled water, Suc. = Sucrose, Glu. = Glucose, Che. Ca .= Chelated calcium and Gly. = Glycerol. Means followed by the same letter in a column do not differ significantly according to Duncan's New Multiple Range t- test at P = 0.05.

However, the best results were gained by soaking in 50 g/l chelated-Ca solution, which gave the highest records over the other solutions in most traits mentioned above in the two seasons. This may be attributed to the role of Ca in strengthening cell membranes and regulating Na, Mg/Ca, K ratio (Mengel and Kirlby, 1979). In this concern, Fenn and Taylor (1991) found that Ca stimulates NH4 band K absorption from nutritive solution by ornamental foliage plants. Besides, Khenizy *et al*. (2009) noticed that pulsing the spikes of *Maluccella laavis* in solutions containing 30 mM/l of chelated-Ca increased water uptake, flower weight and its vase life, while weight loss during storage period and degradation of chlorophylls and carotenoids were decreased.

At the second rank, came the soaking treatment in same solution at 30 g/l level that improved water uptake, the percent of change in flower head fresh weight and flower head diameter means to values closely near to those of 50 g/l chelated-Ca solution in both seasons. This may indicate the role of sucrose in reducing ethylene effects or acting as a source of energy (VanDoorn and Han, 2011). This result was documented by Gendy and Hamad (2011) whom observed that all pulsing solutions containing 20% sucrose significantly increased vase life and florets opening %, improved water balance for cut spikes and maintained of flower quality, i.e., anthocyanin content in petals of Bird-of-Paradise cut flowers.

The previous gains are in accordance with these detected by Jones *et al*. (1993) on sunflower, Amiri *et al*. (2009) on gerbera cv. "Pags", Mohammodi *et al*. (2011) on rose cvs. Grand Prix and Avallanche and Khenizy *et al*., (2014) on gypsophila cv. "perfecta". In this connection, Mor *et al*. (1984) reported that basal treatment of partially opened flowers of *Agapanthus orientalis* cvs. Haffmanns and Albidus with solutions containing 10-20% sucrose and bactericide improved bud opening, vase life and reduced floret abscission. Abdel-Moniem *et al*. (2012) declared that helding the cut flowers of rose cvs. Anna, Gold Strike and Spot in 20 g/l sucrose + STS (1:4) solution gave the best water relations, longer vase life and better colour of petals during the whole shelf period that reached 20 days against only 12 days for the other preservative solutions.

Hence, in order to elongate the vase life plus keeping quality of sunflower cv. "Sunrich Orange" heads, it can be advise to holding them either 50 g/l chelated-Ca solution or in 30 g/l sucrose one.

The second experiment: Effect of storage system, temperature, period and their interactions on some postharvest parameters of *H. annuus* L. cv. Sunrich Orange flower heads:

It is obvious from data averaged in Tables (2, 3 and 4) that dry storage system recorded better results than wet storage one, especially in characters of water uptake (g/flower head) and flower head diameter (cm) as this system gave higher means than the other one in both seasons, while the means of vase life (day) in the dry system gave higher records in the first season only. However, wet storage system scored a slight higher content of total soluble sugars than the dry one. This may be due to that dry storage controlled bacterial growth at the bases of flowering stems and prevented the xylem vessels from blockage, but the opposite is the right in case of wet storage that is needed only when the cut flowers are held at wormer storage temperature, above 10 °C (Cevallos, 2001).

It was also noticed that storage temperature at 0 °C raised the means of water uptake (g/flower head) and vase life (day) more than storage at 5 °C in the two seasons, while storage at 5 °C caused only a higher increment in flower head diameter (cm) than 0 °C storage temperature in both seasons. The percent of change in flower head fresh weight was unsteady, as it was better in the first season by storage at 0 °C temperatures, but in the second one, that was

Table 2. Effect of storage system, temperature, period and their interactions on water uptake and the change in fresh weight of *Helianthus annuus* L. cv. Sunrich Orange flower heads during 2012 and 2013 seasons.

Storage system	Storage temperature	Water uptake (g/flower head) Storage period 5 days	Storage period 7 days	Mean A x B	The change in flower head f.w. (%) Storage period 5 days	Storage period 7 days	Mean A x B
				First season: 2012			
Wet	**0 °C**	184.6bc	151.9e	168.3B	2.41f	5.77e	4.09C
	5 °C	130.6f	179.5c	155.1C	10.09a	9.25b	9.68A
	Mean A x C	157.6D	165.7A		6.26B	7.41A	
Dry	**0 °C**	191.0b	284.2a	237.6A	8.05c	7.11d	7.58B
	5 °C	165.9d	162.7d	164.3B	7.21d	7.51cd	7.36B
	Mean A x C	178.4B	223.4A		7.63A	7.31A	
	Mean (C)	168.0B	194.6A	**Mean (A)**	6.94B	7.41A	**Mean (A)**
	Mean (B)	202.9A	159.7B		5.84B	8.52A	
	Mean B x C	187.8B	218..0A	161.7B	5.23C	6.44B	6.88B
		148.2D	171.1C	200.9A	8.66A	8.38A	7.47A
				Second season: 2013			
Wet	**0 °C**	183.5bc	149.7e	166.6B	2.07f	5.40e	3.73D
	5 °C	128.8f	177.8c	153.3C	9.72a	8.64b	9.18A
	Mean A x C	156.2D	163.7C		5.90C	7.02A	
Dry	**0 °C**	185.2b	244.6a	214.9A	7.15c	6.37d	6.76B
	5 °C	151.3e	161.1d	156.2C	5.39e	6.36d	5.87C
	Mean A x C	168.3B	202.9A		6.27B	6.36B	
	Mean (C)	162.2B	183.3A	**Mean (A)**	6.08B	6.69A	**Mean (A)**
	Mean (B)	190.8A	154.8B		8.25B	7.53A	
	Mean B x C	184.4B	194.2A	160.0B	4.61C	5.88B	6.46A
		140.1D	169.5C	185.5A	7.55A	7.50A	6.32A

Means followed by the same letter in a column do not differ significantly according to Duncan's New Multiple Range t-test at P = 0.05.

achieved by storage at 5 °C temperature. The percent of total soluble sugars in the petals, however was unaffected by either of the used storage temperature, as both 0 and 5 °C temperatures gave content closely near together. Hence, storage at 0 °C according to these results may be to some extent better than storage at 5 °C.

This may be attributed to that storage at 0 °C reduces the flower respiration and internal breakdown of tissues by enzymes to the minimal level (Cevallos and Reid, 2000). In this regard, Reid (2001) pointed out that Narcissus flowers stored at 0 °C showed no effect of storage, whereas those stored at higher temperatures (up to 10 °C) showed progressively increased negatively geotropic bending. Further, Celikel and Reid (2002) indicated that maintaining temperatures close to the freezing point during commercial handling and transport of gerbera and sunflower is very important for maximum vase life. Analogous observations were also revealed by Cevallos (2001) on carnation, daffodils, iris, chrysauthemum, narcissus, rose and tulip, as well as Reid (2001) who stated that the proper handling temperature for flowers other than tropical is close to freezing point, 0 °C (32 °F).

In relation to the effect of storage period, data in Tables (2, 3 and 4) exhibit that storage for 7 days scored better results

Table 3. Effect of storage system, temperature, period and their interactions on diameter and vase life of *Helianthus annuus* L. cv. Sunrich Orange Flower heads during 2012 and 2013 seasons.

Storage system	Storage temperature	Flower head diameter (cm) Storage period 5 days	7 days	Mean A x B	Vase life (day) Storage period 5 days	7 days	Mean A x B
				First season: 2012			
Wet	**0 °C**	9.17e	8.50g	8.83D	6.00a	5.00b	5.50B
	5 °C	8.20h	12.30b	10.25B	4.00c	4.00c	4.00C
Mean A x C		8.68D	10.0B		5.00B	4.50C	
Dry	**0 °C**	9.00f	10.10c	9.55C	6.00a	6.00a	6.00A
	5 °C	9.43d	14.00a	11.72A	3.00d	5.00b	4.00C
Mean A x C		9.22C	12.05A		4.50C	5.50A	
Mean (C)		8.95B	11.23A	**Mean (A)**	4.75B	5.00A	**Mean (A)**
Mean (B)		9.19B	10.98A		5.75A	4.00B	
Mean B x C		9.08C	9.30B	9.54B	6.00A	5.50B	4.75B
		8.82D	13.15A	10.63A	3.50D	4.50C	5.00A
				Second season: 2013			
Wet	**0 °C**	8.00g	9.00d	8.50D	5.00a	4.00b	4.50A
	5 °C	8.10f	11.00b	9.55B	3.00c	4.00b	3.50C
Mean A x C		8.05D	10.00B		4.00B	4.00B	
Dry	**0 °C**	8.50e	10.00c	9.25C	3.00c	5.00a	4.00B
	5 °C	9.00d	13.00a	11.00A	3.00c	5.00a	4.00B
Mean A x C		8.75C	11.50A		3.00C	5.00A	
Mean (C)		8.40B	10.75A	**Mean (A)**	3.50B	4.50A	**Mean (A)**
Mean (B)		8.88B	10.28A		4.25A	3.75B	
Mean B x C		8.25D	9.50B	9.03B	4.00B	4.50A	4.00A
		8.55C	12.00A	10.13A	3.00C	4.50A	4.00A

Means followed by the same letter in a column do not differ significantly according to Duncan's New Multiple Range t-test at P = 0.05.

Table 4. Effect of storage system, temperature, period and their interactions on total soluble sugar content in *Helianthus annuus* L. cv. Sunrich Orange ray florets during 2013 season.

Storage system	Storage temperature	Storage period 5 days	7 days	Mean A x B
Wet	**0 °C**	0.89	0.93	0.91
	5 °C	0.89	0.90	0.90
Mean A x C		0.89	0.92	
Dry	**0 °C**	0.84	0.80	0.82
	5 °C	0.85	0.86	0.86
Mean A x C		0.85	0.83	
Mean (C)		0.87	0.87	**Mean (A)**
Mean (B)		0.87	0.88	
Mean B x C		0.87	0.87	0.90
		0.87	0.88	0.84

than storage for 5 days giving higher values for characters of water uptake (g/flower head), flower head diameter (cm) and vase life (day) in the two seasons. As for the total soluble sugars content (%) in the petals registered by the two storage periods, it was equal. Improving postharvest parameters by the longer cool storage period may be ascribed to its influence on reducing the respiration rate of flowers, moisture loss and physical damage for longer period. This fact was demonstrated by Hettiarachchi and Balas (2004) whom discovered that flowers of *Gloriosa superba* kept at 4 °C (wet storage) for 7 days maintained a higher chlorophyll yield than those for 3 days.

On the other hand, the effect of interactions between the 3 studied factors employed in such work on the various postharvest measurements was fluctuated (Tables 2, 3 and 4), as the dry storage at 0 °C for 7 days gave the highest means of water uptake (g/flower head) as vase life (day) over the other interactions in the first and second seasons, whereas the dry storage at 5 °C for 7 days recorded only the widest flower head diameter (cm) in both seasons. However, the wet storage at either 0 or 5 °C for 7 days scored the highest content of total soluble sugars (%), whilst the wet storage at 0 °C for 5 days achieved the highest percent of change in flower head fresh weight relative to the other interactions in both seasons.

These findings could be interpreted and discussed as done before in case of discussion of each factor individually.

Hence, from the aforementioned results, it can be recommend storing the heads of sunflower cv. "Sunrich Orange", dry at 0 °C for 5 or 7 days for long-term transportation without remarkable reduction in their vase life and quality.

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تقييم تأثير محاليل الخفظ وظروف التخزين على عمر نورات دوار الشمس

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أجريت تجربتين منفصلتين بمعمل معاملات ما بعد القطف، قسم بحوث الزينة، معهد بحوث البساتين، الجيزة، مصر خلال موسمي ٢٠١٢، ٢٠١٣ لدراسة استجابة النورات (أو الرؤوس) الزهرية لنبات دوار الشمس (*Helianthus annuus* L. cv Sunrich Orange) إما لبعض محاليل الحفظ،، وهى: الماء المقطر (كمقارنة)، محلول السكروز بتركيزات ١٠، ٢٠، ٣٠ جم/لتر، محلول الجلوكوز بتركيزات ٣، ٨، ١٥ جم/لتر، محلول الكالسيوم المخلبى بتركيزات ٢٠، ٣٠، ٥٠ جم/لتر والجليسرول بتركيزات ٢٠، ٥٠ جم/لتر وذلك فى التجربة الأولى ... أو دراسة استجابتها لأهم ثلاثة عوامل أساسية عند الشحن لمسافات بعيدة، وهى: طريقة التخزين (رطب أو جاف)، درجة حرارة التخزين البارد (صفر أو ٥ °م) وفترة التخزين (٥ أو ٧ أيام) وذلك فى التجربة الثانية. كما تم دراسة تأثير التفاعلات المشتركة بين العوامل الثلاثة سالفة الذكر على الصفات. ولقد حفظت السيقان الزهرية بعد التخزين الرطب والجاف فى مخابير مدرجة مملوءة بحوالي ٣٥٠ مل من الماء المقطر تحت ظروف حرارة الغرفة العادية حتى نهاية فترة الحياة.

أوضحت النتائج المتحصل عليها فى التجربة الأولى أن جميع محاليل الحفظ موضع الدراسة قد أحدثت تحسناً في جميع الصفات المقاسة (وهى كمية الماء الممتص، النسبة المئوية للتغير فى الوزن الطازج للرؤوس الزهرية، قطر الرأس الزهرية، عمر الرأس الزهرية فى الفازة ومحتوى البتلات من السكريات الكلية الذائبة) وبفروق معنوية متباينة عند مقارنتها بمتوسطات الكنترول فى كلا الموسمين. إلا أن السيادة والتفوق كانت لمعاملة الحفظ فى محلول الكالسيوم المخلبي بتركيز ٥٠ جم/لتر والتي أعطت أعلى القيم على الأطلاق فى معظم الصفات المذكورة آنفاً مقارنة بالمحاليل الأخرى فى كلا الموسمين. أما المرتبة الثانية، فقد أحتلتها معاملة الحفظ فى محلول السكروز بتركيز ٣٠ جم/لتر والتى حسنت متوسطات بعض الصفات المقاسة إلى قيم قريبة جداً من القيم التى حققتها المعاملة المتفوقة. وعليه، عندما يراد إطالة عمر النورات الزهرية لدوار الشمس (صنف Sunrich Orange) والحفاظ على جودتها خلال وجودها فى الفازة، فإنه يوصى بغمسها إما فى محلول كالسيوم مخلبى (٥٠ جم/لتر) أو محلول سكروز (٣٠ جم/لتر).

فى التجربة الثانية، أوضحت النتائج أن التخزين الجاف حقق نتائج أفضل من التخزين الرطب خاصة فى صفتي كمية الماء الممتص وقطر النورة الزهرية. كما أن معاملة التخزين على درجة الصفر المئوي أحدثت زيادة واضحة فى متوسطات كمية الماء الممتص وعمر الفازة لتكون أكبر من تلك التى حققتها معاملة التخزين على درجة ٥ °م بينما احدث التخزين على درجه ٥ °م تحسناً أفضل فى قطر النورة الزهرية فقط. وبصفة عامة، سجل التخزين لمدة (٧ ايام) متوسطات أعلى فيما يتعلق بكمية الماء الممتص، النسبة المئوية للتغير فى الوزن الرطب للنورة الزهرية، قطر النورة الزهرية وعمرها فى الفازة عند التخزين لمدة (٥ أيام) فى كلا الموسمين. أما بالنسبة لمحتوى البتلات من السكريات الكلية الذائبة، فإنه لم يتأثر بشكل ملحوظ بطريقة أو حرارة أو فترة التخزين مع بعض الاستثناءات البسيطة فى كلا الموسمين. على الجانب الأخر، فإن تأثير المعاملات المشتركة على الصفات المذكورة سابقاً كان متقلباً، حيث سجلت معاملة التخزين الجاف على درجة الصفر المئوى لمدة ٧ ايام اعلى متوسطات فى كمية الماء الممتص وعمر الفازة بينما سجلت معاملة التخزين الجاف (٥ °م) لمدة (٧ أيام) أكبر قطر للنورة الزهرية فقط. أما التخزين الرطب على درجة الصفر المئوي أو ٥ °م لمدة (٧أيام) فقد أحرز أعلى محتوى للسكريات الكلية الذائبة فى البتلات، بينما سجل التخزين الرطب على درجة (صفر °م) لمدة (٥ أيام) أعلى نسبة مئوية للتغير فى الوزن الرطب للنورة الزهرية.

وعليه، يمكن طبقًا لهذه النتائج النصح بتخزين نورات دوار الشمس (صنف Sunrich Orange) حديثة القطف تخزيناً جافاً على درجة الصفر المئوي لمدة (٥ أو ٧ أيام) عند الشحن لمسافات بعيدة دون أن يحدث إنخفا ضاً ملحوظ فى جودتها أو عمرها فى الفازة بعد ذلك.