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EFFECT OF PRE AND POST-HARVEST TREATMENTS ON THE POSTHARVEST KEEPING QUALITY OF SUNFLOWER CV. SUN RICH ORANGE CUT FLOWERS

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ABSTRACT: Two experiments were consummated in a saran's greenhouse at the Ornamental Nursery and the Ornamental Laboratory of Fac. Agric., Zagazig Univ., Egypt to study the effect of two factors (NPK fertilization at different rates of 0, 1.5, 3.0 and 4.5 g/l (pre-harvest) and some pulsing solutions i.e. distilled water (D.W.) for 16 h, sucrose (S) at 20% for 16 h, S (20%) for 16 h + silver thiosulfate (STS) at 1:4 mM for 18 min and S (20%) + 8-hydroxyquinoline sulfate (8-HQS) at 200 ppm for 16 h) to enhance sunflower (*Helianthus annuus* L.) cv. Sun Rich Orange growth and keeping quality of cut flowers after harvesting during 2019 and 2020 summer seasons. Also, the interactions between these two factors were assessed. Using any NPK fertilizer rate significantly enhanced plant height, total fresh and dry weights of plant and flower diameter as well as total chlorophyll content in the leaves, total carbohydrates percentage in leaves and anthocyanin content in flower petals of sunflower compared to control. Moreover, the rate of 3 g/l of NPK gave the highest values of water uptake and water balance in comparison with the other rates. The longevity of the cut flower was gradually increased with increasing NPK fertilizer rate up to 3 g/l then it decreased. Using S + STS or S + 8-HQS as a pulsing solution recorded the highest values in water uptake and water balance at 2, 4 and 6 days of shelf life periods of cut flower as well as increased longevity and fresh weight change (%) of cut sunflower compared to the other ones under study. In general, the interaction between S + STS or S + 8-HQS and 3 g/l of NPK gave the highest values of water balance and longevity compared to the other interaction treatments. It could be concluded that S + STS as well as S + 8-HQS, showed a uniform influence in keeping quality of sunflower cut flowers under 3 g/l of NPK fertilizer with increasing longevity and total sugars content in the flowers.

Key words: Sunflower, NPK fertilizer, pulsing solutions, growth, quality, cut flowers, sucrose, 8-HQS.

INTRODUCTION

Sunflower plants can become oddly large comparative to their container size, especially when grown in a greenhouse and can be complicated to hold adequately-watered in the post-harvest climate (Whipker and Dasoju, 1998). Cut flowers not only prettify our circumference but also express our emotions. Utilizing of cut flowers for several social events viz. birthday parties, weddings, visiting the patients and decorating buildings have been utilized in Egypt. Sunflower (*Helianthus annuus* L.) has potential as a potted flowering plant due to ease of propagation, short crop time, attractive flowers but postharvest life is short (Pallez *et al*., 2002). Sunflower is a serious cut flower and can be used both for bedding or bordering through gardens and cut flower purposes. Sunflower plant is a species belonging to the Asteraceae family and is described by a great ornamentally, as the production of cut flowers (head flowers) varying in the various cultivars by color of the flower, from cream to yellow as far as heavy brown and various flower size (Devecchi, 2005).

Post–harvest life of various cut flowers is affected by pre-harvest factors like fertilization, irrigation and some growth regulators, which can be determined as water uptake, water loss and water balance as well as sugars level of flowers; harvest factors including time and stage of harvest and post-harvest factors viz. pre-cooling, pulsing solutions, preservatives, packaging and storage (De *et al*., 2015). Using NPK fertilization rates as well as using nutrient management at the appropriate rate significantly increased the yield of flowers (Gurav *et al*., 2004; Singh and Jauhari, 2005). In addition, Elbohy (2017) pointed out that the maximum values of sunflower growth traits and flower characters were achieved by treating plants with nitrogen + potassium fertilization rates at 5 g/pot. Also, Neima *et al*. (2020) indicated that fertilization rate of 1 or 1.5 g/l significantly improved the flower yield and enhanced quality of rose flower.

Moreover, pulsing solutions seemed to prolong cut flower vase life. In this connection, some chemical preservatives, i.e. sucrose, silver thiosulphate, 8-hydroxy quinoline sulfate as pulsing solutions were utilized in prolonging flowers vase life. Moreover, sucrose decreases ethylene production and improves bud opening and inhibits senescence of flowers through enhancing sugars content (Ichimura and Hisamatsu, 1999). However, silver thiosulphate was extremely operative as an inhibitor to ethylene realization and action and a bactericide (Nowak and Rudnicki, 1990). However, the treatment of silver thiosulphate + S + 8-HQS recorded a significant increase in gerbera cut flowers vase life and water balance compared to control (Helaly, 2019). Furthermore, pulsing solution treatments of (sucrose + silver thiosulphate) increased the longevity and decreased fresh weight loss of *Lilium pumilum* cut flowers compared to non-treated as a control (Krause *et al*., 2021).

The main objective of the current study was to investigate the effect of pre-harvest treatments (NPK fertilizer rate) on growth and flowering as well as post-harvest treatments (pulsing solutions) for keeping quality of sunflower cv. Sun Rich Orange cut flowers.

MATERIALS AND METHODS

This study was carried out at a black net house (saran's greenhouse) of Ornamental Nursery, Faculty of Agriculture, Zagazig University, Egypt, during two consecutive seasons of 2019 and 2020.

Plant materials and cultivation:

Sunflower seeds of cv. Sun Rich Orange were obtained from the Ornamental Nursery, Fac. Agric., Zagazig Univ., Egypt and were sown in 30-cm-pots filled with 12 kg of mixture medium of clay + sand (1:1, v:v) on April 10^{th} and 16^{th} during the 1^{st} and 2^{nd} seasons, respectively. The physical and chemical analyses of the utilized medium mixture (average of the two seasons) are shown in Table (1) according to Chapman and Pratt (1978).

The present study had two main factors as follows:

1. NPK fertilizer rate as a pre-harvest treatments:

Four NPK fertilizer rates (0.0, 1.5, 3.0 and 4.5 g/l) as powder commercially known as Agro Kristalon Plus, which consists of the following minerals: N (19%), P_2O_5 (19%), K_2O (19%), Magnesium (1%) and Sulphur (3.7%) was obtained from Agro Egypt International Company (AEIC). The different NPK rates were applied to pots as soil application every two weeks (starting after 25 days from the sowing date) during the two growing seasons (2019 and 2020).

Table 1. Physical and chemical analyses of experimental growing mixture media (average of two seasons).

Physical analysis			
Clay (%)	**Silt (%)**	**Sand (%)**	**Soil texture**
21.37	7.83	70.80	Sandy

Chemical analysis													
Time	**pH**	**E.C. (dsm^{-1})**	**Soluble cations (mmol/l)**					**Soluble anions (mmol/l)**			**Available (ppm)**		
			Ca^{++}	Mg^{++}	Na^{+}	Zn^{++}	Mo^{++}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
Before sowing	7.82	0.59	1.81	0.97	0.32	1.09	1.29	3.03	1.13	0.83	117	54	58

2. Pulsing solution as a post-harvest treatments:

The sunflower flowers were harvested when the ray florets were completely opened and placed in the refrigerator at 4 °C for 3 h as a pre-cooling treatment. Immediately the end of flower stems was recut to 80 cm with keeping 3-4 leaves and removing the upper leaves. The cut sunflowers were kept at a temperature of 22-25 °C and 64-72% relative humidity, light was about 520 lux for imposing the pulsing treatments. Distilled water (D.W.), sucrose (S) at 20%, S + silver thiosulfate (STS) and S + 8-hydroxy-quinoline sulfate (8-HQS) as post-harvest treatments were used.

Two flowers were placed in a glass jar of 1000 ml capacity and covered with impermeable plastic and a plastic tie. All flowers were divided into equal and similar four groups which were treated with various chemical solutions as follows:

1. The first group was pulsed in distilled water (D.W) for 16 hours (control treatment).
2. The second group was pulsed in sucrose at 20% [S (20%)] for 16 hours.
3. The third group was placed in sucrose at 20% [S (20%)] for 16 hours + silver thiosulfate (STS) (1:4 mM) for 18 minutes.
4. The fourth group was pulsed in sucrose at 20% + 8-hydroxyquinoline sulfate (8-HQS) at 200 ppm for 16 hours.

The combination treatments between NPK fertilizer and pulsing solution:

Each treatment of NPK fertilizer rate was combined with each treatment of pulsing solution. The combination treatments between NPK fertilizer rate and pulsing solutions consisted of 16 treatments.

Experimental design:

The sixteen treatments were arranged in a factorial design with three replicates, where NPK fertilizer rate treatments were utilized as factor A, while pulsing solutions were randomly used as factor B.

Data recorded:

Pre- harvest characters:
1. Growth parameters:

After 70 days from the sowing date, the following parameters were recorded: plant height (cm), total fresh weights/plant (g), dry weights /plant (g) and flower diameter (cm).

2. Chemical constituents:

After 50 days from sowing, total chlorophyll content (SPAD unit) was determined in sunflower fresh leaves by using SPAD-502 meter (Markwell *et al.*, 1995). Also, total carbohydrates percentage in the dried leaves was determined according to the method described by Dubois *et al.* (1956). Moreover, at the harvesting stage, sunflower petals were dried at 65 °C till a constant weight and anthocyanin pigment content (mg/100 g) was assessed according to Francis (2000).

Post-harvest characters:
1. Water relations:

- Water uptake (g/flower) was determined after 2, 4 and 6 days from the treatment.
- Water loss (g/flower) was calculated as the difference between the beginning fresh weight of cut flower plus the beginning

weight of the solution and fresh weight of cut flowers besides the weight of solution after 2, 4 and 6 days from the treatments.

- Water balance (g/flower) was calculated as the difference between water uptake and water loss after 2, 4 and 6 days from the treatment.

2. The longevity of sunflower cut flowers (days):

was determined when the number of wilted flowers reached 75% of the total number of flowers.

3. Flower weight change (%):

Was determined by the following equation:

$$\text{Flower weight change (\%)} = \frac{\text{Flower weight at 2, 4 or 6 days of shelf life period (g)}}{\text{Flower weight at 0 day of shelf life period (g)}} \times 100$$

4. Sugars contents (mg/g dry weight):

Reducing and non-reducing sugars contents then total sugars (reducing + non-reducing sugars) were calculated according to Smith *et al*. (1956).

Statistical analysis:

The complete randomized block design (CRBD) in factorial design was utilized in this experiment with three replicates. The obtained data were statistically analyzed and the means were compared utilizing the least significant difference (L.S.D) at 5% level as reported by Gomez and Gomez (1984). The means were compared utilizing the computer program of Statistix version 9 (Analytical software, 2008).

RESULTS AND DISCUSSION

Effect of NPK fertilizer treatments (pre-harvest treatment):

Data presented in Table (2) show that using NPK fertilizer rates significantly increased sunflower height, total fresh and dry weights per plant as well as flower diameter compared to control in both seasons. Increasing NPK fertilizer rates gradually increased sunflower growth parameters. Generally, the highest values in this regard were obtained when sunflower plants fertilized with the highest rate under study in the two seasons. The increases in total plant dry weight were 38.82 and 42.81% compared to control in the 1st and 2nd seasons, respectively. The increase in sunflower growth due to the application of complete fertilizer (NPK) might be attributed to its importance to consist the amino acids to form the protein which participates in cell enlargement and cell division as explained by Devlin (1975). It is well known that NPK fertilizers could enhance plant growth due to the role of nitrogen in nucleic acids and protein synthesis and phosphorous as an essential component of energy compounds (ATP and ADP) and phosphor-protein as well as the role of potassium as an activator of many enzymes (Helgi and Rolfe, 2005). Furthermore, fertilization allows the plant roots to absorb an adequate quantity of the applied nutrients to meet their necessary nutritional requirements, actual for the appropriate plant growth and flowering throughout the growing stage (Elbohy, 2017 and Manimaran *et al*., 2017).

In addition, total chlorophyll content in sunflower leaves which were determined as SPAD units was significantly raised by using NPK fertilizer rates when compared with the control (Table, 2). In the same line, all rates of NPK increased each of total carbohydrates percentage in leaves and anthocyanin content in flower petals compared to control in both seasons. Nitrogen, phosphorus and potassium as main nutrients improved sunflower chemical analyses because the major roles of these elements might contribute in the improving of plant growth that reflected on chemical analyses. Moreover, NPK fertilizer plays an important role in a different physiological process of the plant which was described by Lambers *et al*. (2000). In the same trend, Treder (2005) reported that NPK fertilized lilies plants contained higher chlorophyll than that of

Table 2. Effect of pre-harvest (NPK rates) on vegetative growth parameters as well as some chemical constituents of sunflower (*Helianthus annuus* L.) plant during 2019 and 2020 seasons.

NPK fertilization rate (g/l)	Plant growth parameters							
	Plant height (cm)		Total plant fresh weight (g)		Total plant dry weight (g)		Flower diameter (cm)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	90.33	94.00	57.70	60.57	12.70	14.37	10.60	11.57
1.5	95.33	96.67	67.43	72.43	15.67	16.90	12.50	13.17
3.0	102.00	105.00	74.50	80.97	16.73	18.03	12.63	13.43
4.5	108.00	110.00	78.70	86.50	17.63	21.37	13.50	13.73
LSD at 5%	1.85	1.53	3.08	2.10	1.01	1.21	0.28	0.27

NPK fertilization rate (g/l)	Chemical constituents					
	Total chlorophyll content (SPAD)		Total carbohydrates percentage in leaves		Anthocyanin content in flower petals (mg/100 g)	
	2019	2020	2019	2020	2019	2020
Control	36.33	37.17	32.30	34.40	2.350	2.440
1.5	36.90	38.70	33.47	34.57	2.353	2.597
3.0	38.70	39.20	35.07	35.13	2.433	2.590
4.5	39.83	40.23	35.27	35.60	2.563	2.763
LSD at 5%	0.69	0.29	0.70	0.56	0.097	0.074

non-fertilized plants. Also, Bi *et al*. (2008) pointed out that florist's hydrangeas plants treated with 210 and 280 mg/l N during the first season had more leaf chlorophyll content than the forcing in the second one. These results are in harmony with the previous researches which stated that the growth promotion was gained through adding NPK fertilizers. This was reflected in enhancing plant growth and improving flower size due to the rise of chemical constituents of plants (Parveen *et al*., 2015 and Neima *et al*., 2020).

Effect of NPK fertilizer, pulsing solutions and their combination treatments (post-harvest treatment):

Water relations:

As shown in Table (3) the comparison between NPK treatments indicated that there was a significantly higher water uptake of flowers (63.95, 40.98 and 33.40 g/flower in the first season and 66.97, 42.45 and 31.53 in the second one at 2, 4 and 6 days of shelf life periods during both seasons, respectively) in the treatment with NPK at 3 g/l fertilization (once/two weeks). It was also recorded that the start plants (control) showed the minimum value of water uptake in this regard (24.43 and 23.82 g/flower at 6 days of shelf life periods during both seasons, respectively) compared to the other ones under study. In most cases, the highest water loss (g/flower) values were obtained for sunflower plants grown without fertilization (control) at 2, 4 and 6 days of shelf life periods in both seasons. However, the lowest values in this concern at any days of shelf life periods were achieved with a 3 g/l NPK fertilizer rate compared to the other rates in both seasons (Table, 4). Water balance was enhanced under any NPK fertilizer rates (except at 2 days of shelf life period at the first season only with 4.5 g/l NPK rate) compared to control. The highest values of water balance (29.30 and -6.51 g/flower as well as 34.71 and -0.52 at 2 and 4 days of shelf life periods during both seasons, respectively) were recorded when sunflower was fertilized with a 3 g/l rate in comparison with the other rates under study (Table, 5).

Table 3. Effect of pre-harvest (NPK rate) and postharvest pulsing solution treatments on water uptake (g/flower) of sunflower (*Helianthus annuus* L.) cut flowers during 2019 and 2020 seasons.

NPK fertilization rate (g/l)	Pulsing solutions	2019			2020		
		Shelf life period (days)					
		2	4	6	2	4	6
Control		58.74	37.15	24.43	60.89	34.71	23.82
1.5		54.32	40.43	28.40	61.30	35.10	30.13
3.0		63.95	40.98	33.40	66.97	42.45	31.53
4.5		58.98	37.32	32.05	58.59	44.75	30.04
LSD at 5%		0.05	0.07	0.08	0.03	0.07	0.09
	D.W.	47.58	29.60	23.05	51.15	32.18	24.10
	S	58.79	37.53	26.43	61.43	36.22	27.65
	S + STS	62.74	43.32	33.39	66.16	41.95	30.05
	S + 8-HQS	66.89	45.43	35.41	69.01	46.68	33.71
LSD at 5%		0.05	0.06	0.06	0.05	0.03	0.05
Control	**D.W.**	42.27	24.26	20.63	43.85	30.90	20.58
	S	60.33	38.50	21.55	63.92	30.35	22.58
	S + STS	64.35	40.10	25.69	65.95	38.92	24.08
	S + 8-HQS	68.02	45.75	29.87	69.83	38.68	28.02
1.5	**D.W.**	45.65	30.25	22.08	50.42	31.03	23.32
	S	54.80	40.82	25.03	61.58	34.98	30.92
	S + STS	56.42	45.17	30.55	68.32	35.05	32.77
	S + 8-HQS	60.43	45.48	35.95	64.88	39.35	33.50
3.0	**D.W.**	51.05	32.60	24.45	55.00	33.27	26.50
	S	65.04	35.13	29.82	68.20	39.03	28.77
	S + STS	68.67	48.00	38.50	70.17	43.83	32.50
	S + 8-HQS	71.05	48.17	40.83	74.50	53.67	38.33
4.5	**D.W.**	51.35	31.29	25.03	55.33	33.50	26.00
	S	55.00	35.67	29.33	52.00	40.50	28.33
	S + STS	61.50	40.00	38.83	60.18	50.00	30.83
	S + 8-HQS	68.07	42.33	35.00	66.83	55.00	35.00
LSD at 5%		0.09	0.13	0.13	0.09	0.08	0.13

*** D.W.: distilled water as control, S: sucrose 20%, STS: silver thiosulfate and 8-HQS: 8-hydroxyquroline sulfate.**

Table 4. Effect of pre-harvest (NPK rate) and postharvest pulsing solution treatments on water loss (g/flower) of sunflower (*Helianthus annuus* L.) cut flowers during 2019 and 2020 seasons.

NPK fertilization rate (g/l)	Pulsing solutions	2019			2020		
		Shelf life period (days)					
		2	4	6	2	4	6
Control		37.03	56.93	49.33	39.23	51.40	44.88
1.5		36.07	51.76	46.54	36.02	47.90	46.17
3.0		34.65	47.49	43.77	32.26	42.97	39.90
4.5		37.53	50.07	50.66	33.55	48.36	37.31
LSD at 5%		0.06	0.10	0.03	0.16	0.08	0.27
	D.W.	41.89	56.33	53.18	40.97	52.66	47.56
	S	41.23	53.93	49.37	38.30	49.43	44.38
	S + STS	28.14	46.06	42.09	28.44	41.05	35.69
	S + 8-HQS	34.03	49.92	45.66	33.35	47.49	40.63
LSD at 5%		0.08	0.08	0.02	0.12	0.09	0.22
Control	**D.W.**	41.74	60.33	60.80	45.52	59.27	50.09
	S	42.00	60.03	49.15	42.48	55.55	50.03
	S + STS	29.00	52.13	40.05	31.85	40.22	38.42
	S + 8-HQS	35.40	55.22	47.33	37.07	50.55	41.00
1.5	**D.W.**	42.92	57.00	51.03	40.73	55.45	48.98
	S	40.93	55.60	50.57	38.70	45.62	47.95
	S + STS	27.48	45.77	40.42	28.91	40.70	40.67
	S + 8-HQS	32.97	48.65	44.13	35.73	49.82	47.08
3.0	**D.W.**	40.92	53.95	48.73	38.13	45.22	45.45
	S	40.67	50.10	47.25	35.00	45.91	40.28
	S + STS	25.60	40.67	38.57	25.67	38.48	35.00
	S + 8-HQS	31.42	45.22	40.53	30.25	42.25	38.88
4.5	**D.W.**	41.97	54.02	52.17	39.50	50.70	45.73
	S	41.33	50.00	50.50	37.03	50.63	39.27
	S + STS	30.50	45.67	49.33	27.33	44.78	28.68
	S + 8-HQS	36.33	50.60	50.64	30.33	47.33	35.57
LSD at 5%		0.16	0.17	0.05	0.26	0.18	0.46

*** D.W.: distilled water as control, S: sucrose 20%, STS: silver thiosulfate and 8-HQS: 8-hydroxyquroline sulfate.**

Table 5. Effect of pre-harvest (NPK rate) and postharvest pulsing solution treatments on water balance (g/flower) of sunflower (*Helianthus annuus* L.) cut flowers during 2019 and 2020 seasons.

NPK fertilization rate (g/l)	Pulsing solutions	2019			2020		
		Shelf life period (days)					
		2	4	6	2	4	6
Control		21.71	-19.78	-24.90	21.66	-16.69	-21.07
1.5		18.25	-11.33	-18.13	25.28	-12.80	-16.04
3.0		29.30	- 6.51	-10.37	34.71	- 0.52	- 8.38
4.5		21.45	-12.75	-18.61	25.04	- 3.61	- 7.27
LSD at 5%		0.06	0.15	0.07	0.18	0.10	0.32
	D.W.	5.69	-26.73	-30.14	10.18	-20.49	-23.46
	S	18.33	-16.40	-22.93	23.12	-13.21	-16.73
	S + STS	35.35	- 2.74	- 8.70	37.71	0.91	- 5.65
	S + 8-HQS	32.62	- 4.49	-10.24	35.67	- 0.81	- 6.92
LSD at 5%		0.08	0.09	0.06	0.11	0.10	0.22
Control	**D.W.**	0.53	-36.07	-40.17	-1.67	-28.37	-29.51
	S	18.33	-21.53	-27.60	21.44	-25.20	-27.45
	S + STS	35.35	-12.03	-14.36	34.10	- 1.30	-14.34
	S + 8-HQS	32.62	- 9.47	-17.46	32.76	-11.87	-12.98
1.5	**D.W.**	2.73	-26.75	-28.95	9.69	-24.42	-25.66
	S	13.87	-14.78	-25.54	22.88	-10.64	-17.03
	S + STS	28.94	- 0.60	-9.87	39.41	- 5.65	- 7.90
	S + 8-HQS	27.46	- 3.17	-8.18	29.15	-10.47	-13.58
3.0	**D.W.**	10.13	-21.35	-24.28	16.87	-11.95	-18.95
	S	24.37	-14.97	-17.43	33.20	- 6.88	-11.51
	S + STS	43.07	7.33	-0.07	44.50	5.35	- 2.50
	S + 8-HQS	39.63	2.95	0.30	44.25	11.42	- 0.55
4.5	**D.W.**	9.38	-22.73	-27.14	15.83	-17.20	-19.73
	S	13.67	-14.33	-21.17	14.97	-10.13	-10.94
	S + STS	31.00	- 5.67	-10.50	32.85	5.22	2.15
	S + 8-HQS	31.74	- 8.27	-15.64	36.50	7.67	- 0.57
LSD at 5%		0.14	0.22	0.13	0.26	0.20	0.50

*** D.W.: distilled water as control, S: sucrose 20%, STS: silver thiosulfate and 8-HQS: 8-hydroxyquroline sulfate.**

In general, using pulsing solutions significantly increased water uptake of sunflower cut flower compared to control (distilled water). The best results in this connection were obtained with S + 8-HQS at 2, 4 and 6 days of shelf life periods in 1st and 2nd seasons compared to the other ones under study (Table, 3). Using 8-HQS was an effective factor as a participating agent for enhancing water uptake through inhibiting microorganisms blockage of cut flower vessels, also utilization of sucrose as an improving agent of water balance and osmotic in addition to its role as needed respiratory material for metabolic processes took place which reflected on increasing of flower longevity.

Furthermore, a comparison between the pulsing solution treatments indicated that there was a significantly higher water loss of flowers (41.89, 56.18 and 53.18 as well as 40.97, 52.66 and 47.56 g/flower at 2, 4 and 6 days of shelf life periods during both seasons, respectively) in the treatment of distilled water (Table, 4). Also, the lower values of water loss of cut flowers were noticed in the treatments of S + STS as well as S + 8-HQS as pulsing solutions, during both seasons, respectively. The highest values in water balance (35.35, -2.74 and -8.70 as well as 37.71, 0.91 and -5.65 g/ flower, in the two seasons, respectively) were recorded when the cut flower sunflower pulsed with S + STS at 2, 4 and 6 days of shelf life periods compared to the other ones (Table, 5).

In general, there was a significantly higher water uptake of sunflower cut flowers (71.05, 48.17 and 40.83 g/flower as well as 74.50, 53.67 and 38.33 at 2, 4 and 6 days of shelf life periods during both seasons, respectively) in the treatment of 3 g/l NPK fertilizer rate interacted with sucrose only as well as S + 8-HQS compared to the other interactions under study. It was also recorded that fertilizing sunflower plants with 3 g/l NPK combined with S + STS showed the highest value in this regard compared to the other ones (Table, 3). At the same time, the highest values of water loss of cut flowers (41.74, 60.33 and 60.80 g/flower as well as 45.52, 59.27 and 50.09 at 2, 4 and 6 days of shelf life periods during both seasons, respectively) were noticed in the treatment of distilled water pulsing solution without NPK fertilization (Table, 4). The combination between S + STS as well as S + 8-HQS and 3 g/l of NPK gave the highest values of water balance (g/flower) compared to the other combination treatments (Table, 5). In this respect, Verma *et al.* (2007) on *Dendranthema grandiflora* found that the maximum amount of solution consumed was noticed with the combined treatment of 0 g N and 20 g K/m^2 in 2% sucrose in interaction with 200 ppm 8-HQC, whereas, the lowest values were noticed with the interaction treatment of 60 g N and 0 g K/m^2 treatment in distilled water (control).

Longevity and flower weight change (%):

Data in Table (6) show that the means of longevity and flower weight change percentages were significantly increased with all NPK fertilizer rates to reach the maximum values with the high rates (3.0 and 4.5 g/l) compared to control during the two consecutive seasons. Also supplying plants with the rates of 3.0 g/l NPK significantly increased flower longevity (9.38 and 9.54 days) compared to control. In addition, the highest flower weight change % values (10.99 and 11.97, 10.24 and 12.09 as well as 4.66 and 1.48 % at 2, 4 and 6 days of shelf life periods during both seasons, respectively) were obtained with the same NPK rate (3.0 g/l) compared to the other ones under study. Chemical fertilization treatments have also proved to enhance the longevity of zinnia cut flowers, probably by increasing the sap movement in the xylem by enhancing plant growth (Abbasi *et al.*, 2004).

Data presented in Table (6) show that longevity of *Helianthus annuus* L. cut flowers recorded significant increases (10.83 and 11.13 days) as a result of exposing the cut flowers to the pulsing solution containing S + STS compared to the control treatment.

Table 6. Effect of pre-harvest (NPK rate) and postharvest pulsing solution treatments on flower weight change percentage and longevity (days) of sunflower (*Helianthus annuus* L.) cut flowers during 2019 and 2020 seasons.

NPK fertilization rate (g/l)	Pulsing solutions	Flower weight change (%) Shelf life period (days) 2		4		6		Longevity (days)	
		2019	2020	2019	2020	2019	2020	2019	2020
Control		4.87	6.97	9.86	8.00	0.92	-2.37	7.88	8.29
1.5		8.37	10.09	9.98	10.32	2.52	0.79	8.46	8.83
3.0		10.99	11.97	10.24	12.09	4.66	1.48	9.38	9.54
4.5		11.10	11.78	10.61	12.11	4.19	1.40	9.08	9.38
LSD at 5%		1.09	0.99	N.S.	0.89	0.60	0.59	0.70	0.54
	D.W.	5.73	7.50	8.28	8.10	1.17	-0.72	6.50	6.79
	S	7.90	9.59	9.48	9.91	3.00	0.10	7.95	8.17
	S + STS	10.53	11.74	10.92	12.24	4.65	1.05	10.83	11.13
	S + 8-HQS	11.18	11.98	12.00	12.27	3.48	0.87	9.50	9.96
LSD at 5%		0.87	0.81	0.77	0.71	0.44	0.41	0.51	0.41
Control	**D.W.**	3.69	6.45	6.65	7.29	-1.43	-4.11	6.00	6.33
	S	4.50	6.46	9.02	7.30	0.60	-2.78	7.00	7.50
	S + STS	4.69	6.66	10.97	8.26	2.03	-1.49	10.00	10.33
	S + 8-HQS	6.59	8.30	12.77	9.14	2.49	-1.09	8.50	9.00
1.5	**D.W.**	4.21	6.45	8.17	8.41	0.90	-0.28	6.33	6.50
	S	7.97	9.40	10.91	9.97	1.82	0.56	8.00	8.33
	S + STS	10.58	12.16	10.07	11.78	4.08	1.62	10.50	11.00
	S + 8-HQS	10.77	12.36	10.77	11.11	3.28	1.42	9.00	9.50
3.0	**D.W.**	7.33	9.16	9.09	7.04	2.28	-0.68	7.00	7.33
	S	8.60	10.34	8.18	11.30	4.87	1.37	8.50	8.5
	S + STS	14.21	14.03	10.84	15.10	6.63	2.08	11.50	11.67
	S + 8-HQS	13.80	14.34	12.86	14.92	4.84	1.78	10.50	10.67
4.5	**D.W.**	7.67	7.95	9.21	9.64	2.94	0.85	6.76	7.00
	S	10.54	12.14	9.83	11.09	4.71	1.26	8.33	8.33
	S + STS	12.62	14.11	11.79	13.82	5.84	1.97	11.33	11.50
	S + 8-HQS	13.56	12.94	11.60	13.89	3.28	1.53	10.00	10.67
LSD at 5%		1.85	1.72	1.55	1.52	0.97	0.92	1.13	0.89

*** D.W.: distilled water as control, S: sucrose 20%, STS: silver thiosulfate and 8-HQS: 8-hydroxyquroline sulfate.**

However, placing cut flower bases in S + STS as well as S + 8-HQS significantly increased the flower weight percentage (10.92 and 12.24 as well as 12.00 and 12.27%, respectively) at 4 days of shelf life periods as compared to control and other treatments under study. STS pulsing solution increased fresh weight change % might be due to that STS inhibited the action of ethylene. Mayak *et al.* (1982) found that STS inhibited the ACC to ethylene conversion activity. Pulsing solutions with 8-HQS were used to prolong the vase life of cut flowers. 8-HQS contains bacteriocide materials that improve water uptake and sugars as an osmoticum and respiratory substrate. Dias-Tagliacozzo *et al*. (2005) reported that the decrease of flower fresh weight happens due to transpiration processes and the lowering of water conductivity through the cut flowers senescence. Also, Hayat *et al*. (2012) on rose using a combination of STS with sucrose regarding longevity found similar results.

The interaction between S + STS or S + 8-HQS and 3 g/l of NPK gave the highest values of longevity (11.50 and 11.67 as well as 10.50 and 10.67 days, in 1st and 2nd seasons respectively) compared to the other interaction treatments (Table, 6). On the other hand, the highest values of weight change of cut flowers (6.63 and 2.08% at 6 days of shelf life periods during both seasons, respectively) were noticed in the treatment of S + STS pulsing solution with 3 g/l NPK fertilizer rate in both seasons (Table, 6). The existence of sucrose (S) in the pulsing solution causes this difference in flower weight loss (Nascimento *et al*., 2019) possibly to the role of sugar which decreases the osmotic potential and maintains cell turgor.

Sugars content (mg/g dry weight):

Table (7) pointed out that NPK fertilizer rates as pre-harvest treatments recorded significant increases in non-reducing and reducing as well as total sugars contents in sunflower flower petals (mg/g d.w.) compared to control (unfertilized plant). Utilizing NPK fertilizer rate at 3.0 g/l recorded the highest values of total sugars content (52.31 and 51.48 mg/g d.w.) compared to the other rates in both seasons. Furthermore, Castro *et al.* (2011) stated that potassium fertilizer deficiency resulted in decreasing values of carbohydrates accumulation in the leaves of *Heliconia psittacorum*. The data illustrated in Table (7) indicated that the treatment of S + STS as well as S + 8-HQS as pulsing solutions recorded significant increases in non-reducing and reducing as well as total sugars contents of sunflower cut flower compared to distilled water (control). On the other hand, the lowest values in this regard were obtained with control compared to any pulsing solutions type in the two seasons. The results also revealed a positive effect of STS on increasing the flower sugar contents. Silver (Ag) has been noticed to decrease the bacterial infection and plugging in the xylem vessels of cut flowers. It enhances the water movement in the vessels and inhibits the production of ethylene, hence enhancing the quality of cut flowers (Abbasi *et al*., 2004).

The interaction between S + STS or S + 8-HQS and 3.0 g/l gave the highest values of total sugars contents of sunflower flower petals (56.10 and 53.80 as well as 55.63 and 56.93 mg/g d.w., in the 1st and 2nd seasons, respectively) compared to the other interaction treatments (Table, 7). All interaction treatments between NPK fertilizer rates and pulsing solutions significantly increased the contents of non-reducing, reducing sugars as well as total sugars compared to control (without NPK fertilization combined with distilled water) in both seasons. In the same trend, Helaly (2019) reported that the highest values of total sugars percentage of gerbera flowers were obtained with pulsing solutions of S + STS. Also, Krause *et al.* (2021) on *Lilium pumilum* found similar results.

CONCLUSION

The above-mentioned results, showed that it is favorable to fertilize *Helianthus annuus*, L. cv. Sun Rich Orange plants with 3.0 or 4.5 g/l of NPK fertilizer rates every

Table 7. Effect of pre-harvest (NPK rate) and postharvest pulsing solution treatments on reducing and non-reducing sugars as well as total sugars contents (mg/g d.w.) of sunflower (*Helianthus annuus* L.) cut flowers during 2019 and 2020 seasons.

NPK fertilization rate (g/l)	Pulsing solutions	2019 Reducing sugars	2019 Non-reducing sugars	2019 Total sugars	2020 Reducing sugars	2020 Non-reducing sugars	2020 Total sugars
Control		4.24	40.27	44.52	4.63	40.73	45.36
1.5		6.03	42.48	48.50	6.64	41.73	48.38
3.0		7.26	45.05	52.31	6.83	44.65	51.48
4.5		6.98	42.93	49.92	6.98	44.10	51.08
LSD at 5%		0.70	0.60	0.48	0.21	0.57	0.52
	D.W.	4.68	39.62	44.29	4.75	40.15	44.90
	S	6.12	42.47	48.58	6.21	41.41	47.62
	S + STS	6.58	44.76	51.34	6.66	44.63	51.29
	S + 8-HQS	7.13	43.89	51.03	7.47	45.02	52.48
LSD at 5%		0.42	0.51	0.74	0.18	0.40	0.45
Control	**D.W.**	3.40	38.37	41.77	3.23	38.50	41.73
	S	4.53	40.67	45.20	5.13	39.10	44.23
	S + STS	4.40	40.80	45.20	5.33	41.70	47.03
	S + 8-HQS	4.63	41.27	45.90	4.83	43.60	48.43
1.5	**D.W.**	4.80	40.30	45.10	5.43	39.43	44.87
	S	5.87	42.47	48.33	6.60	40.97	47.57
	S + STS	6.03	44.43	50.47	6.27	44.03	50.30
	S + 8-HQS	7.40	42.70	50.10	8.27	42.50	50.77
3.0	**D.W.**	5.30	40.50	45.80	4.70	41.70	46.40
	S	7.07	44.63	51.70	6.60	42.20	48.80
	S + STS	8.30	47.80	56.10	7.67	46.13	53.80
	S + 8-HQS	8.37	47.26	55.63	8.37	48.67	56.93
4.5	**D.W.**	5.20	39.30	44.50	5.63	40.97	46.60
	S	7.00	42.10	49.10	6.50	43.37	49.87
	S + STS	7.60	46.00	53.60	7.37	46.67	54.03
	S + 8-HQS	8.13	44.33	52.47	8.40	45.40	53.80
LSD at 5%		1.01	1.06	1.37	0.37	0.91	0.93

*** D.W.: distilled water as control, S: sucrose 20%, STS: silver thiosulfate and 8-HQS: 8-hydroxyquroline sulfate.**

two weeks to enhance the growth parameters, total chlorophyll content as well as anthocyanin content and using sucrose (20%) for 16 h + silver thiosulfate (1:4 mM) for 18 min as a pulsing solution to keep quality of cut sunflower with increasing flowers longevity.

REFERENCES

Abbasi, N.A.; Zahoor, S. and Nazir, K. (2004). Effect of preharvest phosphorus and potassium fertilizers and postharvest $AgNO_3$ pulsing on the postharvest quality and shelf life of zinnia (*Zinnia elegans* cv. Blue Point) cut flowers. International Journal of Agriculture and Biology, 6(1):129-131.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

Bi, G.; Scagel, C.F. and Harkess, R. (2008). Rate of nitrogen fertigation during vegetative growth and spray application of urea in the fall alter growth and flowering of florist's hydrangeas. Hort. Science, 43(2):472-477.

Castro, A.C.R.; Aragão, F.A.S.; Loges, V.; Costa, A.S.; Willadino, L.G. and Castro, M.F.A. (2011). Macronutrients contents in two development phases of *Heliconia psittacorum*. Acta Horticulturae, 886:285-288.

Chapman, D.H. and Pratt, R.F. (1978). Methods Analysis for Soil, Plant and Water. Univ. California Div. Agric. Sci., USA, 309 p.

De, L.C.; Chhetri, P.G. and Rai, D. (2015). Pre-and post-harvest physiology of cymbidium orchids. International Journal of Horticulture, 5(6):1-5.

Devecchi, M. (2005). Post-harvest physiology of cut flowers of sunflowers 'Sun Rich Orange' (*Helianthus annuus*): first experimental results. Acta Hort., 669:381-388.

Devlin, P.M. (1975). Plant Physiology, 3rd Ed. Van Nostrand, New York, USA, 600 p.

Dias-Tagliacozzo, G.M.; Gonçalvez, C. and Castro, C.E.F. (2005). Manutenção da qualidade pós-colheita de lírio. Ornamental Horticulture, 11(1):29-34.

Dubois, M.; Gilles, K.A.; Robers, J.H. and Smith, F. (1956). Colorimetric methods for determination of sugars and related substances. Anal. Chem., 28(3):350-356.

Elbohy, N.F.S.I. (2017). Impact of pre-harvest nitrogen and potassium fertilizers rate on growth and longevity and some chemical constituents of sunflower (*Helianthus annuus* L.) cut flowers. Middle East Journal of Agriculture Research, 6(4):1536-1544.

Francis, F.J. (2000). Anthocyanins and betalains composition: composition and applications. Cereal Foods World, 45:208-213.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons Inc., Singapore, 680 p.

Gurav, S.B.; Singh, B.R.; Katwate, S.M.; Sabale, R.N.; Kakade, D.S.and Dhane, A.V. (2004). Influence of NPK nutrients on yield and quality in rose under protected conditions. Journal of Ornamental Horticulture, 7(3-4):239-242.

Harborne, J.B. (1973). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. Champman & Hall, London, UK, 278 p.

Hayat, S.; Amin, N.U.; khan, A.M.; Soliman, T.M.A.; Nan, M.; Hayat, K.; Ahmad, I.; Kabir, M.R. and Zhao, L. (2012). Impact of silver thiosulfate and sucrose solution on the vase life of rose cut flower cv. Cardinal. Advances in Environmental Biology, 6(5):1643-1649.

Helaly, A.A.E. (2019). Improving gerbera cut flowers by using pulsing and holding solutions under cold storage periods treatments J. Plant Production, Mansoura Univ., 10(3):241-246.

Helgi, O. and Rolfe, S.A. (2005). The Physiology of Flowering Plants, 4th Ed. Cambridge University Press, Cambridge, UK, 402 p.

Ichimura, K. and Hisamatsu, T. (1999). Effect of continuous treatment with sucrose on the vase life, soluble carbohydrates concentration, and ethylene production of cut snapdragon flowers. Journal of the Japanese Society for Horticulture Science, 68(1):61-66.

Krause, M.R.; Santos, N.; Moreira, K.F.; Tolentino, M.M. and Mapeli, A.M. (2021). Extension of the vase life of *Lilium pumilum* cut flowers by pulsing solution containing sucrose, citric acid and silver thiosulfate. Ornamental Horticulture, 27(3):344-350.

Lambers, H.; Chapin, F.S. and Pons, T.L. (2000). Plant Physiological Ecology. Springer-Verleg, New York. Inc., USA, 540 p.

Manimaran, P.; Rajasekar, P.; Rameshkumar, D. and Jaison, M. (2017). Role of nutrients in plant growth and flower quality of rose: A review. Intl. J. Chem. Stud., 5(6):1734-1737.

Markwell, J.; Osterman, J.C. and Mitchell, J.L. (1995). Calibration of the Minolta SPAD-502 leaf chlorophyll meter. Photosynthesis Res., 46:467-472.

Mayak, S; Legge, R.L. and Thompson, J.E. (1982). Ethylene formation from 1-aminocyclopropance -1-carboxylic acid by microsomal membranes from senescing carnation flower. Planta.,15(1):49-55.

Nascimento, Â.M.P.D.; Paiva, P.D.D.O.; Manfredini, G.M. and Sales, T.S. (2019). Harvest stages and pulsing in ornamental sunflower 'Sunbright Supreme'. Ornamental Horticulture, 25(2):149-157.

Neima, H.A.; Ahmad, F.K.; Ahmed, T.A. and Amen, T.A. (2020). Effect of fertigation on the cut rose growth and yield under semi-controlled conditions in Sulaymaniyah city. Journal of Applied Horticulture, 22(1):8-11.

Nowak, J. and Rudnicki, R.M. (1990). Postharvest Handling and Storage of Cut Flowers, Florist Greens and Potted Plants, Timber Press, Incorporated, USA, 208 p.

Pallez, L.C.; Dole, J.M. and Whipker, B.E. (2002). Production and postproduction studies with potted sunflowers. Hort. Technol., 12(2):206-210.

Parveen, S.; Alizai, N.A.; Shah, R.; Ali, M. and Kakar, H. (2015). Evaluation of different doses of NPK for cut flower production. Life Sci. Int. J., 9(1:4):3270-3273.

Singh, A.K. and Jauhari, S. (2005). Growth and flowering in rose as influenced by nitrogen, azotobacter and farmyard manure. Progressive Horticulture, 37(2):444-447.

Smith, F.; Gilles, M.A.; Hamilton, D.K. and Geeds, P.A. (1956). Colorimetric method for determination of sugar and related substances. Anal. Chem., 28:350.

Treder, J. (2005). Growth and quality of oriental lilies at different fertilization levels. Acta Hort., 673:297-302.

Verma, A.K.; Gupta, Y.C.; Dhiman, S.R. and Thakur, K.S. (2007). Influence of nitrogen and potassium levels and holding solutions on postharvest quality of chrysanthemum (*Dendranthema grandiflora* Tzvelev.) cut flowers. Journal of Ornamental Horticulture, 10(4):222-228.

Whipker, B. and Dasoju, S. (1998). Potted sunflower growth and flowering responses to foliar applications of daminozide, paclobutrazol and uniconazole. Hort. Tecnol., 8:86-88.

تأثير معاملات ما قبل وبعد الحصاد على جودة حفظ أزهار عباد الشمس صنف Sun Rich Orange بعد الحصاد

راندا إبراهيم دياب، أسامة أحمد عبد الصادق، نجلاء فتحي صلاح الدين إبراهيم البوهي
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تم إختبار تأثير عاملين رئيسيين وهما معدلات السماد النيتروجيني والفوسفاتي والبوتاسي (صفر، ١,٥، ٣,٠، ٤,٥ جم/لتر) كمعاملات ما قبل الحصاد ومحاليل الحفظ المؤقتة (الماء المقطر لمدة ١٦ ساعة ، السكروز ٢٠٪ لمدة ١٦ ساعة، السكروز ٢٠٪ لمدة ١٦ ساعه + ثيوسلفات الفضة ٤:١ مليمول لمدة ١٨ دقيقه و السكروز ٢٠٪ + ٨-هيدروكسي كينولين سلفات٢٠٠ جزء فى المليون لمدة ١٦ ساعة) كمعاملات ما بعد الحصاد ومعاملات التفاعل بينهما على عباد الشمس صنف Sun Rich Orange لتحسين نمو النبات والحفاظ على جودة أزهاره المقطوفة وذلك خلال موسمي الصيف لعامى ٢٠١٩ و ٢٠٢٠ في مشتل الزينة ومعمل نباتات الزينة بكلية الزراعة، جامعة الزقازيق، مصر. أدى استخدام أي معدل من المعدلات السمادية من النيتروجين والفسفور والبوتاسيوم إلى تحسين ارتفاع النبات، الوزن الطازج والجاف الكلي للنبات وقطر الزهرة بالإضافة إلى محتوى الكلوروفيل الكلي ونسبة الكربوهيدرات الكلية في الأوراق ومحتوى الأنثوسيانين في بتلات زهرة عباد الشمس مقارنةً بالكنترول. علاوة على ذلك، فإن استخدام ٣ جم / لتر من سماد النيتروجين والفسفور والبوتاسيوم أعطى أعلى القيم في امتصاص الماء والاتزان المائي مقارنة بالمعدلات الأخرى. تم زيادة عمر الأزهار المقطوفة تدريجياً مع زيادة معدل التسميد. سجل استخدام السكروز + ٨-هيدروكسي كينولين سلفات وكذلك السكروز + ثيوسلفات الفضه (السكروز٢٠٪ + ثيوسلفات الفضة ٤:١ مليمول) لمدة ١٨ دقيقه كمحاليل حفظ مؤقتة أعلى القيم في امتصاص الماء والتوازن المائي عند ٢، ٤ و ٦ أيام من فترات عمر الأزهار المقطوفة وكذلك سجلت تلك المعاملة زياده عمر الأزهار و زياده النسبه المئوية للتغير فى وزن الازهار (٪) مقارنةً بالمعاملات الأخرى قيد الدراسة. بشكل عام، أعطت معاملة التفاعل بين السكروز + ثيوسلفات الفضة أو السكروز + ٨-هيدروكسي كينولين سلفات ، ٣,٠ جم/لتر من سماد النيتروجين والفسفور والبوتاسيوم قيمًا مرتفعة للتوازن المائي وطول عمر الأزهار المقطوفة مقارنة بمعاملات التفاعل الأخرى. يمكن أن نستنتج أن السكروز٢٠٪ + ثيوسلفات الفضة ٤:١ مليمول لمدة ١٨ دقيقه وكذلك السكروز٢٠٪ + ٨-هيدروكسي كينولين سلفات ٢٠٠ جزء فى المليون لمدة ١٦ ساعة أظهر تأثيراً معنوياً في الحفاظ على جودة أزهار عباد الشمس المقطوفة تحت التسميد بالنيتروجين والفسفور والبوتاسيوم بمعدلات ٣,٠ جم/لتر مع زيادة طول عمر الأزهار وارتفاع محتواها من السكريات الكلية.