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The Role of Nano Silver with Sucrose on Longevity of Cut Flowers of Zinnia in Vase

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ABSTRACT

This study was conducted in the Postharvest Lab of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., Giza, Egypt in May of 2018 and 2019 seasons, aiming to assess the efficiency of silver nanoparticles (AgNPs) to improve the quality of *Zinnia elegans* cut flowers. From the results of the present study, it can be concluded that, silver nano particles at 15 mg /l + sucrose at 15 g /l treatment had strong impact in improving zinnia cut flower quality by increasing the shelf life, absorbed solutions, relative fresh weight and water balance, in addition to reducing the amount of water loss and microbial count in vase solutions of cut flowers. Moreover, this holding solution retarded the chlorophyll degradation as well as anthocyanins concentrations as well as phenolic content was increased by combination treatments between silver nanoparticles and sucrose or treatments silver nanoparticles alone during the postharvest life.

***Keywords*: *Zinnia elegans*, silver nanoparticles, quality, cut flower**

Introduction

Zinnia elegans, Jacq. is native to Mexico and Central America. Zinnia is belonging to Family *Asteraceae* and is half-hardy summer annual available from spring to fall. The majority of its cultivars are derived from *Zinnia elegans* having brightly coloured and variously shaped ray florets in single or multiple whorls. It is used on a large scale in borders beds, edges and as planter the cut flowers can be a good source of foreign exchange. The need has been felt with an increased demand of cut flowers particularly in summer when a few summer annuals bloom (Saleem *et al*., 2003). Zinnia is a commercially important species in the cut flower industry, but little work has been done to determine the postharvest handling procedures for increasing shelf life.

One of the greatest problems in postharvest flower physiology is reducing of uptake solution resulting from blockage of vascular system, due to air or bacterial growth, leading to water stress in cut flowers. Adding preservatives to the pulsing or holding solutions is recommended to extend shelf life of the cut flowers. All holding solutions must contain essentially two components, sugar and germicides (Elhindi, 2012).

Keeping cut flowers in vase solutions containing sucrose has been shown to prolong their vase-life. Sucrose act as a source of nutrition for tissues approaching carbohydrate starvation, it has a role in subsequent water relations, Amin (2017a) reported that, the carbohydrates are the main substrate for respiration, which is essential for all living cells, they are also a major structural material used in cell growth, enlargement , a soluble component in petal tissues and hence an important osmotic regulator of water potential (Mayak *et al.,*2001) .Sucrose as a sugar in holding solutions is a usual practice to extend the vase life of cut flowers (De la Riva *et al.,* 2009).The beneficial effect of sugars on flower senescence was attributed to the supply of substrates for respiration, structural and osmotic materials (Pun and Ichimura, 2003). Jamil *et al.* (2016) on cut hippeastrum flowers declared that, sugars play an important role in flower development, either as an energy source for respiration or as osmotically active substance, which aids in maintaining the turgidity of the expanding corollas. Khandaker *et al.* (2017) showed that, 6% sucrose was the best treatment for maintaining the post-harvest quality as well as vase life of cut Mokara Chark Kuan orchid flowers.

Using nano materials including nanosilver has recently increased in the world. Use of NS is becoming increasingly widespread in medicine and various other industrial purposes. Usage of nano-silver compounds (NS) in pulse and vase solution treatment for cut flowers is relatively new and has demonstrated its importance as an antibacterial agent but mobility of silver ion in stem of flowers is very slow. Therefore, application of nano particle with antimicrobial effects can improve speed of that

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mobility and could prolong cut flower longevity It has been widely used due to its anti bacterial property (Amin, 2017b).Nanometer sized silver (Ag+) particles (NS) are considered to be more strongly inhibit bacteria and other micro organisms than Ag in various oxidation states; Ag^0 , Ag^{+1}, Ag^{+2}, Ag^{+3} ,NS releases Ag+ , which has been reported to interact with cytoplasmic components and nucleic acids, to inhibit respiratory chain enzymes and to interfere with membrane permeability . The positive effect of a NS (silver nanoparticles) pulse treatment was attributed to inhibition of bacterial growth in the vase solution and at the cut stem ends during the postharvest period (Mohammadiju *et al.,* 2014). Bahrehmand *et al*. (2014) suggested that, NS has the following effects; reduces transpiration in association with reducing stomata aperture (stomata closure), increases hydraulic conductance, inhibits bacterial growth in the vase solution and at the cut stem end, prevents ethylene-mediated processes which causes flower senescence.

Materials and Methods

Cut zinnia flowers were obtained from a well-known commercial farm in Al-Qanater Alkhayriuh, Egypt. They were wrapped in groups inside carton boxes then immediately transported within 1h. to the Postharvest Laboratory of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt in two successive seasons,2018and 2019. Stem bases were re cut under water by using sharp knife on the bottom of cut flower stems to uniform lengths and to ensure no air blocky of the stem end.

The upper two leaves were kept on each stem. The experiments were carried out at 25±3°C, 70±2 RH and $20 \mu molm^{-2}s^{-1}$, light intensity under a daily light period of 12 h. After pre cooled stems by placing them in cold water , they were placed individually in glass bottles (500 ml) with 300 ml of the experiment solutions with different levels viz:-

1- Distilled water as control.
2- Sucrose (suc) at 15 g/l.
3- Silver nanoparticles (AgNPs) at 5 mg/l.
4- Silver nanoparticles (AgNPs) at 5 mg/l with sucrose (suc) at 15 g/l.
5- Silver nanoparticles (AgNPs) at 10 mg/l.
6- Silver nanoparticles (AgNPs) at 10mg/l with sucrose (suc) at 15 g/l.
7- Silver nanoparticles (AgNPs) at 15 mg/l.
8- Silver nanoparticles (AgNPs) at 15mg/l with sucrose (suc) at 15 g/l.

Silver nanoparticles (AgNPs) a diameter of 8-20 nm was prepared according to Hebeish *et al*., (2013). Flowers glasses were covered with aluminum foil paper (silver ions destroy in light). Vases were arranged on benches with 3 replications. All solutions were freshly prepared at the beginning of the experiments.

1. Collected data were

- Shelf life (days): Number of days from the beginning of the treatment till the end of longevity of the flowers when petals wilt (50%) or when flower stems lose 10% of its fresh weight, whatever took place first.
- Water loss (g/flower): Daily water loss was calculated as difference between fresh weight of cut flowers with weight of solution at the end of experiment from the initial weight.
- Solution uptake (g/flower): Solution uptake of vase solution was measured daily by weighing the vase solution.
- Relative Fresh weight (%): Relative fresh weight (RFW) was estimated as a percentage in relation to the initial weight .
- Water balance (g/flower): Water balance = water uptake - water loss.
- Microbial count $log^{10}(CFU\ ml^{-1})$: Microbial count was determined by taking one ml vase solution samples during the first 6 days of the experiment, at 2 days intervals with 3 replications. One ml. from each sample was diluted in 10 fold serial dilution. 0.1 ml from each concentration of diluted samples was plated on nutrient agar and all were incubated at 35 ºC for 48 hours. Microorganisms were counted by standard plate counting method (by counting the number of colonies formed after incubation) to generate the number of colony forming units log^{10} $(CFU\ ml^{-1})$.

2. Chemical analyses:

- Chlorophyll a and b (mg/g f.w.) in leaves was recorded alorimetrically as described by Moran (1982).
- Total phenolic content: percentage according to Singleton *et al*. (1999).
- Total carbohydrates percentage: according to Dubois *et al*. (1956).
- Anthocyanins (mg/g d.w): in flowers were determined colorimetrically according to Fuleki and Francis (1968).

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

The purpose of this study was to evaluate the efficacy of silver nanoparticles solution as an antimicrobial agent in the holding solution on bacterial growth, water relations, vase life and keeping quality of cut zinnia flowers.

Results and Discussion

1. Shelf life

Zinnias are timeless and classic cut flowers, holding prestigious position in the cut flower industry for their versatility, numerous colors and low maintenance. Vase life of the cut flower is very important, which can be significantly increased by proper harvesting, handling and post harvest management. The longevity of vase life is an important factor in consumer preference (Kader, 2003 and Da Silva, 2003).

Results cleared that the application of different holding preservative solutions was effective on extending shelf life period of cut zinnia flowers in comparison to the control as documented in Table (1). The best result was obtained from the treatment of silver nanoparticles (AgNPs) at 15 mg/l combined with sucrose (suc) at 15 g/l that gave 21 days in the first season and 22 days in the second one as it seems to control senescence, whilst the control treatment gave 13 days in the first season and 12 days in the second one.

Table 1: Effect of holding solution treatments on shelf life of *Zinnia elegans* cut flowers (days) during the vase life period of 2018 and 2019 seasons.

Treatments	Vase life (days)	
	1st Season	2nd Season
Distilled water (control)	13.00G	12.00G
Suc (15g l^{-1})	15.00E	16.00E
AgNPs (5mg l^{-1})	16.00D	16.00E
AgNPs (5mg l^{-1}) + suc (15g l^{-1})	18.00C	19.00C
AgNPs (10mg l^{-1})	14.00F	15.00F
AgNPs (10mg l^{-1}) + suc (15g l^{-1})	19.00B	20.00B
AgNPs (15 mg l^{-1})	16.00D	17.00D
AgNPs (15 mg l^{-1}) + suc (15g l^{-1})	21.00A	22.00A

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

A similar effect was a result of using silver nanoparticles (AgNPs) for enhancing shelf life of some cut flowers and inflorescence as Kim *et al*. (2005) on lilium 'Dream Land' and 'Siberya'; Liu *et al.(* 2009a) on gerbera cv. Ruikou ; Solgi *et al.*(2009) on *Gerbera jamesonii* cv. 'Dune ; Lu *et al.* (2010) on rose cv. Movie Starflowers; Hatami *et al.* (2011) on rose ; Safa *et al.*(2012) on *Gerbera jamesonii L.* cv 'Balance ; Alimoradi *et al.(* 2013) on alstroemeria; Amin (2017b) on *Anthurium andraeanum* as all of them found nanosilver led to prolong shelf life of cut flowers. This may be to the positive effect of silver nanoparticles (AgNPs) treatments to reducing bacterial growth in the vase solution and at the cut surface stems during shelf life period. Silver ions are used as an antiseptic compound to inhibit microorganism's growth which ultimately increases vase life (Jiang *et al.,* 2004) however, sugar alone in vase solution increases shelf life of cut flowers but it tends to promote microbial growth. Hence, the combination of sugar and biocides might have extended the shelf life of cut flowers. In the present study, vase life enhancement can be described with antimicrobial properties of the mentioned compounds that led to water absorption improvement with vascular blockage prevention so it delays water deficiency related wilting. These results are also found in previous studies, Hatefi *et al*. (2014) conclude that, nanosilver as an antimicrobial material in accordance with sucrose increased the quality and cut flowers' vase life of alstroemeria cv. Isola. The effect has been suggested by many authors as Mortazavi *et al*. (2011) and Moradi *et al*. (2012). Also Asgari *et al.* (2013) showed that, application of nano-silver had no effect on quality and vase life of tuberose cut flowers, but that application of sucrose (1%) increased evaluations for these traits. It can be concluded that, the microbial factor has a major role on reducing the cut flowers vase life. In fact, the effect of silver compounds on longevity of cut flowers is because of reduction in bacterial growth and vessel blockage, increase in the solutions water uptake, impeding the water loss in plant (Mori *et al.,* 2001) and reducing the transpiration rate (Mei-hua *et al.,* 2008).

2. Water loss

The quality of post harvest of cut flowers is commonly quantified as the vase performance in terms of their ability to maintain a high capacity of water transport combined with their ability to overcome embolism. This means removal of embolism in the xylem conduits that might have occurred during transport or by excessive transpiration (van Ieperen *et al.,* 2002). Data presented in Table (2) showed that the effects of all holding solutions on water loss were significant in the cut flowers of zinnia. The highest record in this concern belonged to cut flowers kept in used solutions as silver nanoparticles (AgNPs) at 15 mg l^{-1} + sucrose (suc) at 15g l^{-1}) (15.54,62.53 and 108.44) after 3, 7 and 10 days respectively, in vase solution in the first season as it happened in the second season where recorded 19.11, 71.19 and 110.57 in the order after 3, 7 and 10 days respectively, in vase solution. However the results showed that the lowest water loss was obtained by holding cut flowers of zinnia in suc (15g l^{-1}) solution that achiev75.50 in the first season and 77.92 in the second one. The major effect of sucrose on the cut flowers is probably due to the increase in osmotic concentration of the flowers and by this improved water uptake, but the sucrose may also affect the nutrition or energy supply of the flowers. Sucrose may have, also, a beneficial effect on maintaining higher fresh weights in cut flowering stems by inducing stomatal closure in the leaves and thus, reducing water loss (Asrar, 2011) so, the effect of sugar in reducing water loss is by help reduce moisture stress affecting stomatal closure and transpiration rate, thereby reducing the water loss of the cut rose flowers (Jamil *et al.,*2016 on cut hippeastrum flowers and Rafi and Ramezanian, (2013) on cut rose cultivars 'Avalanche' and 'Fiesta').

Table 2: Effect of holding solution treatments on water loss of *Zinnia elegans* cut flowers (g/flower) during the vase life period of 2018 and 2019 seasons.

Treatments	Water loss					
	1st Season			2nd Season		
	After 3 days	After 7 days	After 10 days	After 3 days	After 7 days	After 10 days
Distilled water (control)	14.58B	47.02G	96.6B	18.92A	51.20G	98.93B
Suc (15g l^{-1})	10.01E	38.50H	75.50G	17.41C	42.03H	77.92G
AgNPs (5mg l^{-1})	12.00D	54.95C	83.16F	16.82D	57.30D	86.60F
AgNPs (5mg l^{-1}) + suc (15g l^{-1})	9.31F	47.81F	87.41D	15.84E	54.17F	89.79D
AgNPs (10mg l^{-1})	9.79E	52.77D	87.56D	14.55F	63.10C	89.90D
AgNPs (10mg l^{-1}) + suc (15g l^{-1})	11.98D	50.53E	88.24C	17.34C	54.61E	94.69C
AgNPs (15 mg l^{-1})	13.92C	50.34B	83.70E	18.10B	66.07B	88.02E
AgNPs (15 mg l^{-1}) + suc (15g l^{-1})	15.54A	62.53A	108.44A	19.11A	71.19A	110.57A

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

3. Water uptake

From data averaged in Table (3) it is clear that all used holding solutions raised the amount of water uptaken by flowering stems throughout the various stages of vase period with various significant differences as compared to the amount uptaken by flowering stems pulsed in suc (15g l^{-1}) in the two seasons. The prevalence however was for silver nanoparticles (AgNPs) at15 mg l^{-1} + sucrose (suc) at 15g l^{-1} solution that recorded the utmost high amount of water uptake in both seasons. This may indicated that the role of silver nanoparticles in raising water content in flowers and stems, hence maintaining flower turgidity. These results are in accordance with other researches related to silver nanoparticles and its role on cut flowers. Liu *et al.*(2009)found that, enhanced solution uptake in gerberas treated with nano-silver, also Basiri *et al*. (2011) recognized that adding the 5 mg l^{-1} SNP into vase solution increased water uptake in carnation (*Dianthus caryophyllus*) more than the control. The increase in water uptake may be because of preventing microorganism growth and vessel block which lead to greater life after harvesting of cut flowers.

Similar observations were also attained by Nair *et al.* (2010) that the silver nanoparticles increases total water uptake due to Ag nanoparticles well before the penetration and colonization microbes within the plant tissues, can improve their effectiveness. Kazemi and Ameri (2012) in cut gerbera; mentioned that application of nano-silver increased water uptake. Increased in water uptake could be attributed to inhibition of microbial growth in vase solution by silver nanoparticles (AgNPs). Hatefi *et al.* (2014) found that nanosilver as an antimicrobial material in accordance with sucrose that increased water uptake of alstroemeria cv. Isola. Moreover Park *et al.* (2005) stated that, NS releases Ag+, which has been reported to interact with cytoplasmic components and nucleic acids, to inhibit respiratory chain enzymes and to interfere with membrane permeability.

Table 3: Effect of holding solution treatments on water uptake of *Zinnia elegans* cut flowers (g/flower) during the vase life period of 2018 and 2019 seasons.

Treatments	Water uptake					
	1st Season			2nd Season		
	After 3 days	After 7 days	After 10 days	After 3 days	After 7 days	After 10 days
Distilled water (control)	15.02C	44.97F	94.00B	17.46D	47.15G	95.82B
Suc (15g l^{-1})	12.18F	40.32G	74.77G	16.02E	40.12H	76.05H
AgNPs (5mg l^{-1})	13.63E	56.23D	84.11F	16.09E	57.22D	84.65G
AgNPs (5mg l^{-1}) + suc (15g l^{-1})	12.65F	50.85E	87.10D	15.10F	53.09F	89.96D
AgNPs (10mg l^{-1})	16.00B	66.90B	84.75E	20.36A	58.52C	85.95F
AgNPs (10mg l^{-1}) + suc (15g l^{-1})	13.46E	51.34E	88.77C	15.90E	55.54E	90.94C
AgNPs (15 mg l^{-1})	14.37D	62.01C	85.21E	18.19C	64.22B	87.82E
AgNPs (15 mg l^{-1}) + suc (15g l^{-1})	17.12A	68.45A	110.14A	19.56B	70.85A	113.31A

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

4. Relative fresh weight:

With observance to holding solution effect on maximum increase of fresh weight of zinnia cut flowers, data presented in Table (4) showed positive increment in fresh weight and maintained cut flowers in all preservation solutions used in the experiment as a result than those of control. Relevant values for the maximum increase in fresh weight were in treatment with silver nanoparticles (AgNPs) at 15 mg l^{-1}) + sucrose (suc) at 15g l^{-1} and achieved 109.27and 113.50 at the beginning of vase period (after 3 days in vase solution); keep going up at the second phase (after 7 days in vase solution) was 118.63 and 124.34 until the end (after 10 days in vase solution) was 106.45and112.69 in the first and second seasons, respectively. However, the lowest values of this parameter accompanied the control, which were 88.19and 94.83 at the beginning of vase period (after 3 days in vase solution) then turn to the next one phase (after 7 days in vase solution) were 93.94,and 98.23 then finally after 10 days in vase solution reached106.45 and112.69. Treatments were significantly positively affected by silver nanoparticles (AgNPs) whereas researchers confirm that as Lǚ *et al.* (2010) who reported that, pulse treatment for 1h with 50and100 mg/l NS (silver nanoparticles) solutions suppressed reduction in fresh weight during the vase period of cut rose. Hatami *et al.* (2011) showed that pulse treatment with SNP (silver nanoparticles) prevented fresh weight loss during the vase life of cut rose cv. Red Bion. Different silver nanoparticles (AgNPs) concentration’s had effects on the maintenance time and their simultaneous effect with sucrose of 5% were significant differences. Nanosilver as an antimicrobial material in accordance with sucrose that increased the relative fresh weight of alstroemeria cv. Isola (Hatefi *et al.*, 2014).

The increment in fresh weight influenced by water uptake and transpiration between these two processes (Jowkar and Salehi, 2006). In this connection, Kiamohammadi *et al*. (2011) on lisianthus and, Mortazavi *et al.* (2010) on cut rose (cv. 'Varlon') stated that, sucrose treatment increased relative water content (RWC). Moreover, sucrose was found more effective when combining it with AgNPs that clear from results in this study by increasing water content, relative fresh weight increased. In line with our results, Asgari *et al*. (2013) pointed out that application of silver nanoparticles (AgNPs) had no effect while sucrose or sucrose application with silver nanoparticles increased RWC (relative water content) in cut tuberose flowers.

Table 4: Effect of holding solution treatments on relative fresh weight of *Zinnia elegans* cut flowers (%) during the vase life period of 2018 and 2019 seasons.

Treatments	Relative fresh weight					
	1st Season			2nd Season		
	After 3 days	After 7 days	After 10 days	After 3 days	After 7 days	After 10 days
Distilled water (control)	88.19H	93.94H	64.51F	94.83G	98.23H	68.93H
Suc (15g l^{-1})	106.22C	105.61F	81.22D	109.10D	109.85F	85.37E
AgNPs (5mg l^{-1})	104.93E	99.92G	68.93E	109.21D	105.34G	70.79G
AgNPs (5mg l^{-1}) + suc (15g l^{-1})	103.53F	106.11E	84.13C	107.74E	110.67E	88.46D
AgNPs (10mg l^{-1})	106.02D	111.40D	69.44E	110.39C	115.68D	73.82F
AgNPs (10mg l^{-1}) + suc (15g l^{-1})	101.07G	116.15B	97.69B	103.46F	120.44B	101.55B
AgNPs (15 mg l^{-1})	107.98B	111.82C	84.00C	112.72B	116.92C	89.18C
AgNPs (15 mg l^{-1}) + suc (15g l^{-1})	109.27A	118.63A	106.45A	113.50A	124.34A	112.69A

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

5. Water balance

The best treatment was silver nanoparticles (AgNPs) at 15 mgl^{-1} + sucrose (suc) at 15g l^{-1} as cleared from results illustrated in Figs (1) and (2) and that means silver nanoparticles and sucrose improve water balance in cut flowers of zinnia and its role in improving the water balance of cut flowers by preventing the growth of microorganisms in xylem and thus maintained water uptake by flower stems. *Zinnia elegans* is an important field grown cut flower crop, produces flowers that have water balance related vase life problems, where transpiration exceeds uptake causing tissue wilt and desiccation (Twumasi *et al.,* 2005) that may be influenced by bacteria.

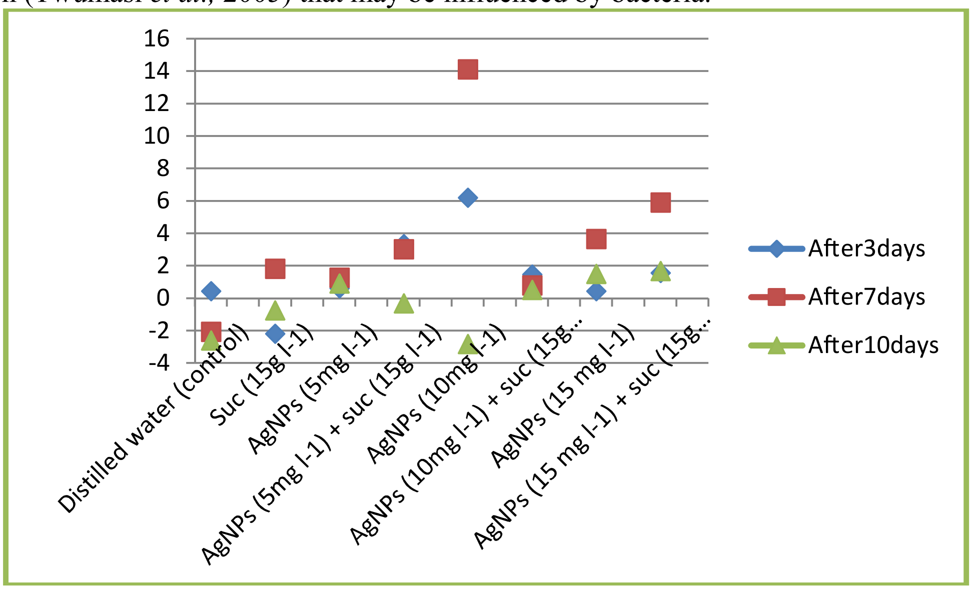

Fig. 1: Effect of holding solution treatments on water balance of *Zinnia elegans* flowers (g/flower) during the vase life period of the first season.

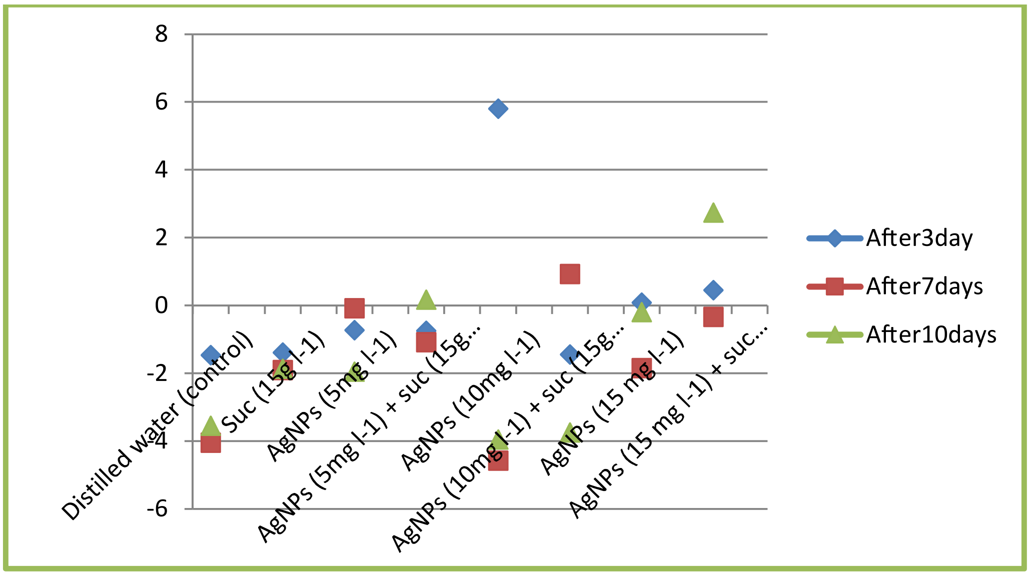

Fig. 2: Effect of holding solution treatments on water balance of *Zinnia elegans* flowers (g/flower) during the vase life period of the second season.

Mobility of silver ion in stem of rose flowers is very slow. Therefore, application of nano particle with antimicrobial effects can improve speed of that mobility and could prolong cut flower longevity. In addition, sucrose mainly acts as a food source or for water balance maintenance, and prevents the blockage of xylem vessels (Hatami *et al.,* 2013).Sucrose is widely used as a floral preservative, which acts as a food source or respiratory substrate and delays the degradation of proteins and improves the water balance of cut flowers (Vaidya and Collis,2013). In addition to that sucrose acts as a food source in the preservative solutions, also it maintains water balance (Solgi *et al.,* 2009on *Gerbera jamesonii*; Patel *et al.,* 2016 on *Tithonia rotundifolia*).

6. Microbial count

It can be seen from data averaged in Table (5) that the lowest microbial count was recorded in the preservative solutions containing silver nanoparticles (AgNPs) at15 mg l^{-1} compared to other treatments include control . Sugar of preservative solutions, provides a good environment for microorganisms growth and that sucrose increases the bacterial growth. By comparing the different concentrations of silver nanoparticles (AgNPs) with the average amount of bacteria in preservative solutions, silver nanoparticles (AgNPs) treated ones had lower amount of bacteria than the control. Jiang *et al.*(2004) found that, silver ions have been used for ages to reduce the contamination and growth and development of microorganisms after harvesting the cut flowers and most studies conducted on silver nano-particle in vase solution were focused on its anti-bacterial characteristics resulted in preventing vascular blockage (Koohkan, *et al.*, 2014)**.** In this respect, Li *et al.* (2017) found that the 25 mg l^{-1} NS pulse treatment effectively inhibited bacterial colonization and bio film formation on the stem-end cut surface and in the xylem vessels of cut gladiolus spikes.

One of the main factors affecting the fresh weight loss is blockage in the xylem vessels of stem due to microorganism's proliferation such as fungi and bacteria. Due to high surface area to volume ratio of silver nano-particles and strong antibacterial activity, it could suppress the growth of bacterial population in vase solution and in the xylem vessels as well.

Sucrose is used in preservative solutions of flowers, it acts as respiratory substrate and delays the degradation of proteins and improves the water balance of cut flowers in vases, while the germicides used to harm bacteria and prevent plugging of the conducting cells. The effect of silver on microorganisms has been related to the inactivation of enzymes due to the formation of silver complexes with electron donors containing sulfur, oxygen and nitrogen, such as thiols, carboxylates, amides, imidazols, indoles, and hydroxyls (Niemietz and Tyermann, 2002). Large surface to volume ratio of NS particles is increasing their contact with fungi or bacteria and vastly improving their antifungal and antibacterial efficiencies (Shah and Belozerova, 2009). Nanosilver is a germicide that changes the cell membrane and reduces the amplification of DNA in preservative solutions and as it has a big surface which leads to a better contact to bacteria and therefore, is more efficient that other components (Rai *et al.,* 2009). Morones *et al.*(2005) reported that, SNPs (Nanosilver) got into the bacterial cell, it forms a low molecular weight region in the center of the bacteria to which the bacteria conglomerates, thus, protecting the DNA from the silver ions. The SNPs (Nanosilver) attack the respiratory chain, cell division and finally leading to cell death.

Table 5: Effect of holding solution treatments on microbial count of *Zinnia elegans* cut flowers (log^{10} CFU ml^{-1}) during the vase life period of 2018 and 2019 seasons.

Treatments	**1st Season**	**2nd Season**
Distilled water (control)	8.0	8.5
Suc (15g l^{-1})	4.7	4.6
AgNPs (5mg l^{-1})	2.4	2.3
AgNPs (5mg l^{-1}) + suc (15g l^{-1})	2.3	2.1
AgNPs (10mg l^{-1})	2.0	1.9
AgNPs (10mg l^{-1}) + suc (15g l^{-1})	2.1	1.7
AgNPs (15 mg l^{-1})	1.7	1.5
AgNPs (15 mg l^{-1}) + suc (15g l^{-1})	1.8	1.6

7. Chemical composition

7.1. Chlorophyll a, Chlorophyll b and Chlorophyll a+b:

Relevant data in Table (6) showed that, the content of chlorophyll a, chlorophyll b and chlorophyll a+b in zinnia were affected by the different treatments in this experiment. A holding treatment silver nanoparticles (AgNPs) at 15 mg per liter + sucrose at 15 g per liter had strong impact in retarding chlorophyll degradation compared to control that, intensity of chlorophyll a was higher and attained 0.77 and 0.79 mg/g in the first and second season, respectively while treatment by distilled water (control) had 0.58 and 0.56 mg/g fw in the first and second seasons, respectively.

Table 6: Effect of holding solution treatments on Chlorophyll a and b (mg/g f.w.) and Chlorophyll a+b (mg/g f.w.) of *Zinnia elegans* flowers during the vase life period of 2018 and 2019 seasons.

Treatments	**Chlorophyll (mg/g f.w.) (a)**		**Chlorophyll (mg/g f.w.) (b)**		**Chlorophyll a+b (mg/g f.w.)**	
	1st Season	**2nd Season**	**1st Season**	**2nd Season**	**1st Season**	**2nd Season**
Distilled water (control)	0.58	0.56	0.16	0.17	0.74	0.73
Suc (15g l^{-1})	0.64	0.65	0.20	0.22	0.84	0.87
AgNPs (5mg l^{-1})	0.66	0.66	0.21	0.22	0.87	0.88
AgNPs (5mg l^{-1}) + suc (15g l^{-1})	0.68	0.69	0.25	0.26	0.93	0.95
AgNPs (10mg l^{-1})	0.70	0.69	0.24	0.24	0.94	0.93
AgNPs (10mg l^{-1}) + suc (15g l^{-1})	0.72	0.73	0.25	0.26	0.97	0.99
AgNPs (15 mg l^{-1})	0.73	0.74	0.26	0.27	0.99	1.01
AgNPs (15 mg l^{-1}) + suc (15g l^{-1})	0.77	0.79	0.27	0.28	1.04	1.07

This applies to both measurements, chlorophyll b and chlorophyll a+b where chlorophyll b recorded 0.27 and 0.28 mg/g fw at leaves which treated with a silver nanoparticles (AgNPs) 15 mg/l with sucrose at 15 g/l in the first and second seasons, respectively compared to control which had 0.16 and 0.17 mg/g in the first and second season, respectively and Chlorophyll a+b (1.04 and 1.07mg/g fw). This is due to the combined effect of sucrose and particals of nanosilver on plant chlorophyll content. This is in agreement with earlier reports of Elgimabi and Ahmed (2009) who found that, adding sucrose at 3% treatment increased chlorophyll content of cut rose flowers, however Alkasir *et al.* (2017) noticed that, pulse treatments with silver nanoparticles on cut rose flower 'High & Magic' at all concentrations maintenance of the relative fresh weight and chlorophyll fluorescence ratio (Fv/Fm) as compared to control.

7.2. Phenolic components

As shown in Table (7) there was a difference between treatments and the proportions of total phenolics values differed according to the silver nanoparticles concentrations, they responded to the treatment with silver nanoparticles (AgNPs) and sucrose, that phenolic accumulation gradually increased with increasing silver nanoparticles level, the highest total phenolic content obtained from the treatment with NS (15 mg l^{-1}) + suc (15g l^{-1}). Silver nanoparticles increased the production of phenolic content, which might act as antioxidants to scavenge the ROS, the results are in similar to those obtained by Franklin *et al*. (2009), Comotto *et al*. (2014) and Karakas (2020).

7.3. Total Carbohydrates content

Also, it is quite clear from data presented in Table (7) that there were obvious positive effects of silver nanoparticles (AgNPs)on total carbohydrates percentage in zinnia leaves, The highest value was obtained from the treatment with silver nanoparticles (AgNPs) at 15 mg l^{-1} + sucrose (suc) at15g l^{-1} compared to the other treatments and control .

7.4. Anthocyanin content

Data recorded in Table (7) indicated that, anthocyanin concentrations of cut flowers of zinnia treated with silver nanoparticles at15 mg l^{-1} with sucrose at 15g l^{-1} was the greatest, followed by the silver nanoparticles alone at15 mg l^{-1} treatment in both seasons , this may be due to presence of sucrose which promotes pigmentation of petal colors in some cut flowers such as eustoma (Ichimura and Korenaga, 1998) and sweet pea (Ichimura and Hiraya, 1999) whereas on *Dianthus caryophyllus* nanosilver in different concentrations showed increasing in content of petal anthocyanin (Sedaghathoor, 2015).

Table 7: Effect of holding solution treatments on total phenols and carbohydrates (%) and anthocyanin (mg/g f.w.)of *Zinnia elegans* cut flower during the vase life period of 2018 and 2019 seasons

Treatments	**Phenols (%)**		**Carbohydrates (%)**		**Anthocyanin (mg/g f.w.)**	
	1st Season	**2nd Season**	**1st Season**	**2nd Season**	**1st Season**	**2nd Season**
Distilled water (control)	0.515	0.520	8.07	8.08	244.2	243.4
Suc (15g l^{-1})	0.615	0.617	8.29	8.38	248.5	249.0
AgNPs (5mg l^{-1})	0.740	0.745	8.47	8.52	247.6	248.1
AgNPs (5mg l^{-1}) + suc (15g l^{-1})	0.769	0.773	9.11	9.17	251.7	252.6
AgNPs (10mg l^{-1})	0.852	0.861	9.21	9.29	250.4	251.3
AgNPs (10mg l^{-1}) + suc (15g l^{-1})	0.911	0.920	10.5	10.8	254.3	254.9
AgNPs (15 mg l^{-1})	0.909	0.916	10.8	10.9	253.8	254.7
AgNPs (15 mg l^{-1}) + suc (15g l^{-1})	0.944	0.946	12,3	12.5	255.9	256.3

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