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Effect of nano silver and silver nitrate on vase life of gerbera (*Gerbera jamesonii*) cv. Madagascar

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Abstract
A study was conducted to find out the effect of nano silver particles (NSPs) on vase life of gerbera cut flower at Post harvest laboratory, College of Horticulture, Dr. YSRHU, Anantharajupeta. The treatment T_{11}- Nano silver @ 10 ppm + sucrose @ 2% is found be significantly superior over other treatments and control. It recorded maximum cumulative water uptake (96.60 g), transpirational loss of water (95.06 g), water balance (1.54 g), fresh weight of flower (15.77 g), vase life (19.77 days) and the lowest bacterial count in vase solution (1.03 X 10^6 CFU ml^{-1}) was observed at the end of the vase life in 10 ppm nano silver whereas the flowers held in distilled water (control) recorded minimum water uptake (21.93 g), transpirational loss of water (28.23 g), water balance (-6.30 g), fresh weight of flower (10.80 g), vase life (19.77 days) and highest bacterial count (9.18 X 10^6 CFU ml^{-1}).

Keywords: Gerbera, vase life, iron and zinc

Introduction
Due to changes in social and cultural life style of people, cut flowers have found an important place in various social functions and daily activities. Different cut flowers like roses, carnations, gladioli, gerberas, anthuriums etc., are being used for decoration purpose and in making flower vases and boquets. Among cut flowers, Gerbera (*Gerbera jamesonii Bolus ex. Hook*.) belonging to Asteraceae family, is one of the most popular flower and ranks fifth position in the world after the roses, carnations, chrysanthemums and tulip. Gerbera can contribute largely to floriculture industry by virtue of its yield potential, colour variation and long vase life. In recent years, the cut flowers trade increased many folds in domestic as well as in the international markets. The beauty of the flower lies on the freshness of the flowers for longer time without losing its aesthetic value. Flower quality and freshness is one of the most important characters in the cut flower industry and this is influenced by several factors. Nearly 20-40 per cent of the cut flowers are lost due to improper post- harvest handling. This is because of the fact that vase life of cut flowers is one of the most important post-harvest issues in flower industry. Longer vase life of cut flowers is preferred in flower cultivation and in marketing as a good quality trait for retailers and consumers of domestic and export markets. The postharvest life of cut gerbera is very short due to its hollow flower stalk and bigger sized capitulum. The weight of the capitulum and disturbed water relations due to vascular occlusions results in scape bending (Prashanth *et al.*, 2007) [28]. The cut gerberas are sensitive to microbial contamination at the stem end that shortens their vase life (Balestra *et al.*, 2005) [4]. It is well established that one of the main causes for vase life reduction is the bacterial blockage of xylem vessel (Marandi *et al.* 2011) [22] and microorganisms that grow in a solution vase and their residue. Zagory and Reid (1986) [35] also found that some bacteria from vase water produced ethylene that causes senescense of flowers. Proper harvesting, postharvest handling and use of suitable floral preservatives improve keeping quality of cut gerberas by maintaining the turgidity of scapes. The use of anti-microbial compounds such as silver nitrate, aluminum sulphate, and 8 hydroxy quinoline sulphate in the vase solution is one of the common methods to extend the vase life of cut flowers (Basiri *et al.*, 2011) [5]. Recently, the broad antimicrobial effect of Nano-Silver is well-known and it has been used in different fields in medicine (healing wounds and anti-inflammatory) and water purgation (Chen and Schluesener, 2008) [6].
Nanometer sized silver particles (NS) have a high surface area to volume ratio and because of that, they are considered to prevent bacteria and other microorganisms more intensely than the components of oxidation states of silver (Furno *et al.*, 2004) [9].

Material and Methods

The vase life study in gerbera cv. Madagascar was carried out in Post harvest laboratory, College of Horticulture, Anantharajupeta. The experiment was carried out in a Completely Randomized Design (CRD) with three replications and 12 treatments (T_1- Distilled water, T_2- Sucrose @ 2%, T_3- Sucrose @ 4%, T_4- Silver nitrate @ 20 ppm, T_5- Silver nitrate @ 20 ppm + Sucrose @ 2%, T_6- Silver nitrate @ 20 ppm + Sucrose @ 4%, T_7- Nano silver particles @ 5 ppm, T_8- Nano silver particles @ 10 ppm, T_9- Nano silver particles @ 5 ppm + Sucrose @ 2%, T_{10}- Nano silver particles @ 5 ppm + Sucrose @ 4%, T_{11}- Nano silver particles @ 10 ppm + Sucrose @ 2%, T_{12}- Nano silver particles @ 10 ppm + Sucrose @ 4%).

Gerbera flowers were harvested from plants treated with foliar application of nano zinc oxide @ 300 ppm + nano iron oxide @ 200 ppm that are grown under naturally ventilated polyhouse located at College of Horticulture, Anantharajupeta. The flowers were harvested during morning hours between 7 and 8 am when the ray florets at 3/4th opened stage and were perpendicular to the flower stalk. Immediately after harvest 5-10 cm of basal portion was cut under deionized water for pre-cooling and were taken to the laboratory. The cut flowers were sorted to uniform length (35 cm) prior to placing them in holding solution in order to maintain uniformity within the replications. Graduated glass bottles were used to hold freshly prepared floral preservatives that are used in the study and a uniform volume of holding solution was dispensed into the bottles. The flowers having uniform stalk were place in each glass bottle and were kept at room temperature (28 °C) and RH of 75%. Observations like fresh weight of flower, water uptake (WU), transpirational loss of water (TLW), water balance (WB), microbial count and vase life were recorded.

Results and Discussion

Significantly highest cumulative water uptake (96.60 g) was recorded in (T_{11}) 10 ppm nano silver + sucrose 2% followed by (T_9) 5 ppm nano silver + sucrose 2% (83.27 g) and (T_{12}) 10 ppm nano silver + sucrose 4% (72.07 g) which was statistically on par with (T_{10}) 5 ppm nano silver + sucrose 4% (68.67 g) while, (T_1) distilled water recorded minimum cumulative uptake of water (21.93 g). Positive influence of nano silver particles on water uptake might be due to antibacterial effect of Ag^+ ions that may affect the regulation of water channel activity through inhibition of sulfhydryl-containing proteins and improve solution uptake (Hatami *et al.*, 2013) [12]. These results are in conformity with that of Vinodh *et al*. (2013) [34], Nemati *et al.* (2014) [25] in lilium and Bahrehmand *et al.* (2014) [3] in tuberose who reported that nano silver induced the highest amount of water uptake which might be due to the antibacterial effect which inhibited vascular blockage and increased absorption process in flowers.

The treatments excerted significant influence on TLW of gerbera cut flowers. Maximum cumulative transpirational loss of water (95.06 g) was recorded in (T_{11}) 10 ppm nano silver + sucrose 2% followed by (T_9) 5 ppm nano silver + sucrose 2% (82.90 g) and (T_{12}) 10 ppm nano silver + sucrose 4% (71.95 g) which was statistically on par with (T_{10}) 5 ppm nano silver + sucrose 4% (69.06 g) and (T_8) nano silver 10 ppm (63.53 g) while, (T_1) distilled water recorded minimum cumulative transpirational loss of water (28.23 g). Nano silver treatments decreased transpiration rate and stomatal conductance of the cut flower probably due to stomatal closure induced by nano silver ions (Lu *et al*., 2010a) [20]. The above results are in well agreement with findings of Lu *et al*. (2010b) [21] in cut rose, Rafi and Ramezanian (2013) [29] in rose and Amin (2017) [1] in anthurium.

The water balance (1.54 g) was found be highest in (T_{11}) 10 ppm nano silver + sucrose 2% which was statistically on par with (T_9) 5 ppm nano silver + sucrose 2% (0.37 g), (T_{12}) 10 ppm nano silver + sucrose 4% (0.12 g) and (T_{10}) 5 ppm nano silver + sucrose 4% (-0.40 g) while, (T_1) distilled water recorded lowest water balance (-6.03 g) followed by (T_2) sucrose 2% (-5.38 g) and (T_3) sucrose 4% (-4.45 g). Lu *et al.* (2010a) [20] stated that nano silver + sucrose solution not only delayed vascular blockage caused by microbial contaminations, but also reduced stomatal conductance so that the water balance in flowers was significantly improved.

At the time of wilting, maximum fresh weight of gerbera stem (15.77 g) was recorded in (T_{11}) 10 ppm nano silver + sucrose 2% which was statistically on par with (T_{10}) 5 ppm nano silver + sucrose 4% (14.77 g), (T_9) 5 ppm nano silver + sucrose 2% (14.30 g) and (T_{12}) 10 ppm nano silver + sucrose 4% (14.12 g) while, (T_1) distilled water recorded minimum final weight of flower stem (12.60 g).

At the end of vase life, the lowest colony forming units (1.03 X 10^6 CFU ml^{-1}) was observed in vase solution containing 10 ppm nano silver (T_8) followed by (T_{11}) 10 ppm nano silver + sucrose 2%, (T_7) 5 ppm nano silver, (T_{12}) 10 ppm nano silver + sucrose 4%, (T_9) 5 ppm nano silver + sucrose 2% and (T_{10}) 5 ppm nano silver + sucrose 4% (1.69 X 10^6 CFU ml^{-1}, 1.73 X 10^6 CFU ml^{-1}, 1.93 X 10^6 CFU ml^{-1}, 2.09 X 10^6 CFU ml^{-1} and 2.35 X 10^6 CFU ml^{-1} respectively) which were statistically on par with each other whereas T_1 (Distilled water) recorded significantly maximum microbial count (9.18 X 10^6 CFU ml^{-1}).

When SNPs entered into the bacterial cell, it forms a region of low molecular weight in the center of the bacteria to which the bacteria conglomerates, thus, protecting the DNA from the silver ions (Lopez *et al.*, 2016) [19]. Morones *et al.* 2005 [24] reported that silver ions strongly interact with vital thiol groups in enzymes and bases containing phosphorus. Thus, the damage is caused by interactions of silver nanoparticles with DNA; thus prevent cell division and DNA replication and finally leading to microbe cell death. Oraee *et al.* (2011) [27] affirmed that nano-silver can be used to decrease bacteria in stem end of cut gerbera and in solution. Furno *et al.* (2004) [9] reported that flowers treated with silver nano particles has demonstrated importance of nano silver as an anti bactericidal agent that could kill 650 species of bacteria in water. Li *et al.* (2017) [17] also noticed that treating the gladiolus spikes with nano silver @ 25 mg l^{-1} effectively inhibited bacterial colonization and biofilm formation on the stem end surface, xylem vessels of gladiolus spikes and also in vase solution. These results are in good agreement with the results obtained by Kazemi and Ameri (2012) [15] and Kader (2012) [14] in rose, Hatami *et al.* (2013) [12] in carnation and Nemati *et al.* (2013) [26] in lilium.

It is obvious from the results that, the treatment (T_{11}) 10 ppm nano silver + sucrose 2% has recorded the highest vase life after harvest (19.77 days) followed by (T_9) 5 ppm nano silver + sucrose 2% (18.40 days) and (T_{12}) 10 ppm nano silver + sucrose 4% (16.83 days) whereas (T_{12}) is statistically at par with (T_{10}) 5 ppm nano silver + sucrose 4% (16.47 days). Flowers held in deionized water (T_1) has the lowest vase life (8.70 days). (T_9) 5 ppm nano silver + sucrose 2% increased the vase life of gerbera flowers by 4.8 days when compared to (T_5) Silver nitrate @ 20 ppm + sucrose 2%. With respect to

the results, flowers treated with nano silver significantly extended the vase life of gerbera flowers, as compared to normal silver nitrate and control. These results are in harmony with those of Solgi *et al*. (2009) [32] on gerbera cv. Dune who reported that 2 mg l^{-1} SNP + 6% sucrose extended vase life of gerbera from (control) 8.3 to 16 days.

The effect of silver nano particles in extending the vase life of flowers might be due to reduced bacterial growth and vascular blockage (Morones *et al.*, 2005) [24], higher water uptake, decrease in transpiration rate and inhibiting ethylene action (Mohammadiju *et al.*, 2014) [23].

Application of silver ions can displace copper ions from the receptor proteins (ETR) for ethylene and consequently block the ethylene perception, since copper ions have a critical role in ethylene binding upon receptors (Khan, 2006) [16]. This effect of silver ion on ethylene was reported by Strader *et al.* 2009 [33].

Besides nano silver, sucrose act as a food source, reduces the protein degradation, improves the water balance of flowers and antagonizes the effect of ABA mediated senescence (Awad *et al.*, 1986) [2] which are required for the continuation of the vase life of the flowers (Halevy and mayak, 1981) [10], and may also act as osmotically active molecule, thus lead to the promoting of subsequent water relations and lengthening their vase life (Elgimabi and Sliai, 2013) [7]. In addition to sucrose, the presence of strong antimicrobial agent (silver) would increase water uptake and improve water relations, thereby increase fresh weight and the vase life of the flower. Similar results were reported by (Lu *et al.*, 2010a) [20] and (Kader, 2012) [14] in cut roses.

Safa *et al.* (2012) [31] also reported that gerbera flowers treated with 10 mg l^{-1} silver nanoparticles had maximum vase life as compared to the control (14.22 and 10.83 days respectively). Similar results were also obtained by Liu *et al.* (2009) in gerbera, Kader (2012) [14] in rose, Jowkar *et al.* (2014) [13] in rose and Roshani *et al.* (2016) [30] in cut carnation. Nanometer sized silver (Ag^{+}) particles used in vase solutions are considered to more strongly inhibit bacteria and other microorganisms than mass salts (silver nitrate in various oxidation states) because of having greater surface area that provides more contact with the microorganisms (Furno *et al*., 2004) [9]. NS releases Ag^{+} ions which are known to be effective in reducing the cytoplasmic membrane thickness, loosen the cell wall, and condense DNA molecules to inhibit respiratory chain enzymes and to interfere with membrane permeability. (Feng *et al.*, 2000) [8].

Table 1: Effect of nano silver and silver nitrate on water relations, Fresh weight of flower, microbial count (CFU ml^{-1}) and vase life of gerbera flowers

Treatments	Cummulative water uptake (CWU) (g $flower^{-1}$)	Cummulative Transpirational loss of water (CWU) (g $flower^{-1}$)	Water balance (g $flower^{-1}$)	Fresh weight of flower (g $flower^{-1}$)	Microbial count (CFU ml^{-1})	Vase life (days)
T_1- Distilled water	21.93	28.23	-6.30	10.80	9.18 X 10^6	8.70
T_2- Sucrose @ 2%	28.27	33.65	-5.38	11.85	7.05 X 10^6	9.80
T_3- Sucrose @ 4%	30.61	35.06	-4.45	12.82	7.82 X 10^6	10.57
T_4- Silver nitrate @ 20 ppm	39.03	43.07	-4.03	12.73	4.32 X 10^6	13.50
T_5- Silver nitrate @ 20 ppm + sucrose 2%	47.47	51.17	-3.70	13.10	5.67 X 10^6	14.97
T_6- Silver nitrate @ 20 ppm + sucrose 4%	40.01	43.96	-3.95	13.54	6.03 X 10^6	14.27
T_7- NSP @ 5 ppm	54.37	56.46	-2.09	13.90	1.73 X 10^6	15.10
T_8- NSP @ 10 ppm	61.05	63.53	-2.48	13.71	1.03 X 10^6	15.27
T_9- NSP @ 5 ppm + sucrose 2%	83.27	82.90	0.37	14.30	2.09 X 10^6	18.40
T_{10}- NSP @ 5 ppm + sucrose 4%	68.67	69.06	-0.40	14.77	2.35 X 10^6	16.47
T_{11}- NSP @ 10 ppm + sucrose 2%	96.60	95.06	1.54	15.77	1.69 X 10^6	19.77
T_{12}- NSP @ 10 ppm + sucrose 4%	72.07	71.95	0.12	14.12	1.93 X 10^6	16.83
Mean	53.61	56.18	-2.56	13.45	4.24 X 10^6	14.47
S.Em±	1.74	1.95	0.41	0.38	0.21 X 10^6	0.36
C.D (P=0.05)	5.07	5.69	1.21	1.11	0.63 X 10^6	1.04

Conclusion

For a good cut flower, vase life is an important character and among all the treatments of study, (T_{11}) 10 ppm nano silver + sucrose 2% recorded maximum fresh weight of flower, water uptake, TLW, water balance and vase life.

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