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Comparison of Silver Nanoparticles and Other Metal Nanoparticles on Postharvest Attributes and Bacterial Load in Cut Roses var. Taj Mahal

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ABSTRACT

Rose is one of the most sought after cut flowers globally. The naturally short vase life of cut roses is an impediment. Microbial contamination is one of the major reason for abbreviated vase life. In this study, effects of nanoparticle vase holding solutions on water relations and microbial load of rose var. Taj Mahal were evaluated. The present study was carried out at the Postharvest Technology Laboratory, College of Horticulture, Bengaluru. During vase period, water uptake, transpiration loss, water balance and microbial load were measured. Nanosilver solutions were the best in maintaining water relations and inhibiting bacterial proliferation. Flowers were held in 50 ppm nanosilver exhibited the best results. This study reveals the fact that, in the present context, silver nanoparticles are one of the best available technologies in delaying the postharvest associated degradation in rose cut flowers.

Key words: *Rose flower, Silver nanoparticles, Vase life, Water uptake, Relative fresh weight*

INTRODUCTION

Discoveries in the past decade have shown that once materials are prepared in the form of very small particles, they change significantly their physical and chemical properties, sometimes to the extent that completely new phenomenon is established[1]. There are some reliable reports in the literature that show encouraging reports about the activity of different drugs and anti-microbial formulations in the form of nanoparticles.

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Previous studies have shown that antimicrobial formulations in the form of nanoparticles could be used as effective bactericidal materials[2]. Due to the smaller size and larger surface area of metal nanoparticles, there is improved functionality of these metals along with the added benefit of getting easily absorbed and mobilized into the plant system. Rose (*Rosa* spp.) is one of the highest in demand cut flowers in the world and has a limited commercial value due to early dehydration[3].The length of vase life is one of the important factors for quality of cut flowers. The main cause of abbreviated vase life in cut flowers is failure in water relations. Blockage of water conducting xylem vessels contributes to the short postharvest life of many cut flowers[4]. Numerous investigations have demonstrated the helpful effects of various chemical additives on the postharvest water relations and extending the vase life of cut rose flowers[5]. Stem blockage might be microbial or physiological[6]. Silver nanoparticles have been effectively used as vase life enhancer and as a biocide in vase solutions[7]. Many metal nanoparticles too have shown some promise as anti-microbial agents[8]. Hence, a study was contemplated to compare these select metal nanoparticles with silver nanoparticles and explore possible positive influence on post-harvest factors in cut roses var. Taj Mahal.

MATERIAL AND METHODS

The cut rose flower (*Rosa* x *hybrida*), 'Taj Mahal' were obtained from a commercial greenhouse at the outskirts of the city of Bengaluru, Karnataka, India. They were immediately transferred to the postharvest laboratory of the College of Horticulture, Bengaluru, a sub-campus of University of Horticultural Sciences, Bagalkot, India. Cut flowers were harvested in the morning between 7 am-8 am. Immediately after harvest, cut ends of the flowers were kept in a bucket containing water. These flowers were pre cooled at 2°C for four hours. After pre-cooling flowers were bunched and trimmed to 50-60 cm. These flowers were transported with their cut ends immersed in water to the laboratory which had average temperature of 25+ 2°C and 55 to 65 per cent relative humidity. The experiments were carried out the same day. The flower stems were re-cut under deionized water to a uniform length of 45 cm. Recutting was to ensure no air blockage of the stem end. Flower stems were places in glass bottles containing 100 ml of preservative solutions. The mouths of the bottles were then stuffed with non-absorption cotton so as to minimize evaporation loss and prevent contamination. Experiments were carried out in a Completely Randomized Design.

Vase solutions were freshly prepared at the beginning of experiments. A solution contains the following treatments

T_1:5 ppm Silver nano particle	T_7: 20 ppm Zinc nano particle
T_2: 20 ppm Silver nano particle	T_8: 10 ppm Magnesium nano particle
T_3: 50 ppm Silver nano particle	T_9: 20 ppm Magnesium nano particle
T_4: 10 ppm Nano copper	T_{10}: 5 ppm Carbon nano tubes
T_5: 20 ppm Nano copper	T_{11}: 10 ppm Carbon nano tubes
T_6: 10 ppm Zinc nano particle	T_{12}: Control (De ionised water)

Preparation of nanoparticle solutions:

The nanoparticles were added to distilled water at desired concentrations and placed in Ultrasonic Cleaner so as to facilitate quick and uniform dissolution.

Measurements: The rose flowers were considered senescent when showing at least one of the following symptoms of senescence: wilting of leaves or flowers, neck bending and incomplete bud opening. Water uptake, transpiration loss and water balance were recorded daily by measuring weights of vases without flowers and of flowers separately.

a. Uptake of water (g/ cut flower)

Difference between consecutive weights of bottle plus solution gives uptake of water of cut flower and represented in grams.

b. Transpiration loss of water (g/ cut flower)
Difference between consecutive weights of bottle plus solution plus cut flower gives transpiration loss of water of cut flower and expressed in grams.

c. Water balance (g/ cut flower)
Water balance of cut flower was calculated by using the formula given below.

Water balance = Water uptake – Transpiration loss of water

d. Bacterial count: Bacterial count was carried out using dilution plate technique. The number of bacteria was counted by the standard plate counting method to determine the number of colony forming units per ml (CFU ml)[9].

RESULTS AND DISCUSSION

In the current study different metal nanoparticle solutions were compared with nano-silver (NS). Significant differences were found various treatments in extending the vase life of rose flowers.

3.1 Uptake of water (g/cut flower)

Significant differences were found among the treatments with respect to water uptake (table 2). Flowers held in solution containing SNP 20 ppm improved water uptake compared to others. The rate of decrease reflected the freshness retention of the cut flowers under each treatment. With progression of days, there was reduction in water uptake by the cut flowers. Silver nanoparticles, 50 ppm, effectively suppressed the reduction in fresh weight followed by treatment T_2 (SNP, 20 ppm). On the contrary, flowers held in deionized water (control) exhibited the sharpest decline in the water uptake values wilted earlier compared to the other treatments. Silver nanoparticles (SNP) may have had a positive influence on the water uptake because antibacterial effects of Ag+ ions in SNP may affect regulation of water channel activity via inhibition of sulfhydryl-containing proteins of bacteria and improve solution uptake[10]. Silver being a cation enhances solution and water flow through xylem vessels[11]. Better vase water uptake values were associated with suppression of bacterial growth in both vase water and stem-end delaying stem blockage of *Acacia holosericea* foliage[12].

3.2 Transpiration loss of water (g/cut flower)

The lowest transpirational loss in water (table 2) was seen in the flowers held in plain distilled water. Flowers held in the treatment T_3 (SNP, 50 ppm) exhibited the highest transpirational water loss in all the days, but the flowers lasted till the end of the study period. Water deficit has direct effect on turgor of cut flowers, which accelerates wilting and senescence. The higher transpiration loss of water reflected better water uptake status, hence better freshness and vitality. The higher water uptake might be due to higher TLW to avoid temporary water stress. Silver ions enhanced water uptake due to microbe free conducting tissues and also delaying senescence by inhibiting ethylene generation. Minimum TLW in control was due to reduced water uptake[13].

3.3 Water balance (g/cut flower)

Water balance in the cut flowers held in vase water is an indicator to decide about the longevity of the cut flowers in vase. Flowers held in distilled water (T_{12}) showed water balance values (0.50) of less than one on third day itself indicating that the flowers experienced higher water loss compared to the rest treatments (table 3). On the other hand, flowers held in silver nanoparticle solutions exhibited better water balance values. Treatments T_3 (SNP, 50 ppm) and T_2 (SNP, 20 ppm) were successful in maintaining water balance values (1.11 and 1.20 respectively) up to fourth day of vase period. Water deficit may develop only when the rate of water uptake is lower than the rate of transpiration, and a high rate of transpiration disrupts the water balance, which may then shorten the vase life of cut roses. Stomatal conductance and transpiration rate of the cut roses were found to be decreased by NS treatments, probably due to stomatal closure induced by NS (nano silver)[14].

4.1.8 Microbial load (CFU)

The lowest bacterial count (fig. 1) was recorded with vase solution containing 50 ppm SNP (T_3) followed by the treatment T_6 (ZnONPs, 10 ppm). Silver nanoparticles decreased the bacterial population of rose var. Taj Mahal cut flowers, as they are very effective antimicrobial agents and consequently prevented the occlusion of xylem vessels. Similar results were reported in rose[14,15 and 16]. Zinc nanoparticles too have been reported to have antibacterial effects on gram-negative bacteria *Escherichia coli*[17]. Vascular occlusion has been considered to be mainly due to microbial proliferation[18]. Efficacy of nanometer sized particles bearing Ag^+ as an antibactericidal agent (NS) is well established[19]. Antibacterial activity of NS is partly a function of particle size, with higher surface to volume ratio increasing the proportion of atoms at the grain boundary[20]. Nano silver pulse treatment inhibited bacterial growth for the first 2 days of vase life in stem ends of cut gerberas[7].

Table 1: Effect of nanoparticles holding solution on uptake of water (g) during vase period of cut flowers of rose var. Taj Mahal

	Uptake of Water						
	2 DAYS	**3 DAYS**	**4 DAYS**	**5 DAYS**	**6 DAYS**	**7 DAYS**	**CWU**
T1: Silver nanoparticles, 5 ppm	13.67	14.00	13.33	11.33	10.67	10.67	73.67
T2: Silver nanoparticles, 20 ppm	13.67	13.17	13.33	12.13	11.20	10.00	73.51
T3: Silver nanoparticles, 50 ppm	15.17	16.81	15.98	13.67	11.33	11.41	84.37
T4: Nano copper, 10 ppm	13.83	14.50	13.67	9.00	8.33	-	59.33
T5: Nano copper, 20 ppm	12.97	12.33	12.00	9.33	8.63	7.67	62.93
T6: Zinc nanoparticles, 10 ppm	15.07	17.33	14.67	12.00	11.67	9.00	79.73
T7: Zinc nanoparticles, 20 ppm	11.17	12.00	11.67	11.00	9.67	-	55.50
T8: MgO nanoparticles, 10 ppm	15.00	13.00	12.67	12.00	11.33	9.00	73.00
T9: MgO nanoparticles, 20 ppm	13.67	14.36	15.67	15.33	12.00	-	71.02
T10: Carbon nano tubes, 5 ppm	15.50	18.00	17.05	15.11	10.00	8.50	84.16
T11: Carbon nano tubes, 10 ppm	14.50	15.27	15.33	14.67	12.67	-	72.44
T12: Control	14.53	17.32	15.33	14.30	11.44	-	72.92
SEm	0.67	2.31	1.61	0.96	0.81	0.36	0.5270
CD 1%	2.94	10.15	7.06	4.22	3.57	1.58	2.31
Significance	**	NS	NS	**	*	**	**

Table 2: Effect of nanoparticles holding solution on transpiration loss of water (g) of flowers during vase period of cut flowers of rose var. Taj Mahal

	Transpiration Loss of Water						
	2 DAYS	**3 DAYS**	**4 DAYS**	**5 DAYS**	**6 DAYS**	**7 DAYS**	**CTL**
T1: Silver nanoparticles, 5 ppm	16.00	20.33	16.00	12.67	10.33	8.55	83.88
T2: Silver nanoparticles, 20 ppm	12.67	14.33	15.00	12.37	11.33	9.17	74.86
T3: Silver nanoparticles, 50 ppm	14.83	17.22	18.67	12.91	11.65	9.31	84.60
T4: Nano copper, 10 ppm	12.67	15.67	17.67	10.01	7.67	-	63.67
T5: Nano copper, 20 ppm	11.33	13.87	9.33	10.21	9.62	7.86	62.22
T6: Zinc nanoparticles, 10 ppm	10.83	12.34	11.00	11.60	10.70	8.83	65.31
T7: Zinc nanoparticles, 20 ppm	11.83	12.33	13.00	15.41	10.56	-	63.14
T8: MgO nanoparticles, 10 ppm	15.00	17.85	16.00	14.90	11.34	8.97	84.06
T9: MgO nanoparticles, 20 ppm	16.17	19.69	16.00	14.67	12.33	-	78.86
T10: Carbon nano tubes, 5 ppm	17.77	19.16	20.03	16.62	12.97	-	86.56
T11: Carbon nano tubes, 10 ppm	14.17	15.73	13.00	11.34	9.67	-	63.90
T12: Control	9.60	7.90	7.05	6.17	5.00	-	35.71
SEm	1.6600	1.6550	3.1806	0.46	2.1487	0.2194	12.96
CD 1%	7.29	7.27	13.97	2.04	9.44	0.96	56.93
Significance	*	**	NS	**	NS	**	NS

Table 3: Effect of nanoparticles holding solution on water balance (g) of flowers during vase period of cut flowers of rose var. Taj Mahal

	Water Balance (g)					
	2 DAYS	**3 DAYS**	**4 DAYS**	**5 DAYS**	**6 DAYS**	**7 DAYS**
T1: Silver nanoparticles, 5 ppm	1.57	1.32	1.00	-0.39	-0.82	-1.27
T2: Silver nanoparticles, 20 ppm	1.83	1.63	1.20	0.11	-0.57	-1.05
T3: Silver nanoparticles, 50 ppm	1.63	1.47	1.11	0.14	-0.40	-1.03
T4: Nano copper, 10 ppm	1.33	1.17	0.67	-1.33	-1.87	-2.23
T5: Nano copper, 20 ppm	1.33	1.20	0.75	-1.10	-1.77	-2.42
T6: Zinc nanoparticles, 10 ppm	1.67	1.20	0.86	-0.93	-1.21	-2.08
T7: Zinc nanoparticles, 20 ppm	1.83	1.27	0.95	-0.96	-1.20	-2.03
T8: MgO nanoparticles, 10 ppm	1.50	1.00	0.58	-1.50	-2.13	-2.62
T9: MgO nanoparticles, 20 ppm	1.77	1.12	0.65	-1.30	-2.27	-2.77
T10: Carbon nano tubes, 5 ppm	1.50	1.00	0.27	-1.98	-2.33	-2.92
T11: Carbon nano tubes, 10 ppm	1.67	1.00	0.17	-1.90	-2.70	-3.00
T12: Control	1.70	0.50	-1.13	-2.73	-3.10	-
SEm	0.31	0.09	0.06	0.06	0.16	0.07
CD 1%	1.34	0.40	0.27	0.24	0.69	0.29
Significance	NS	**	**	**	**	**

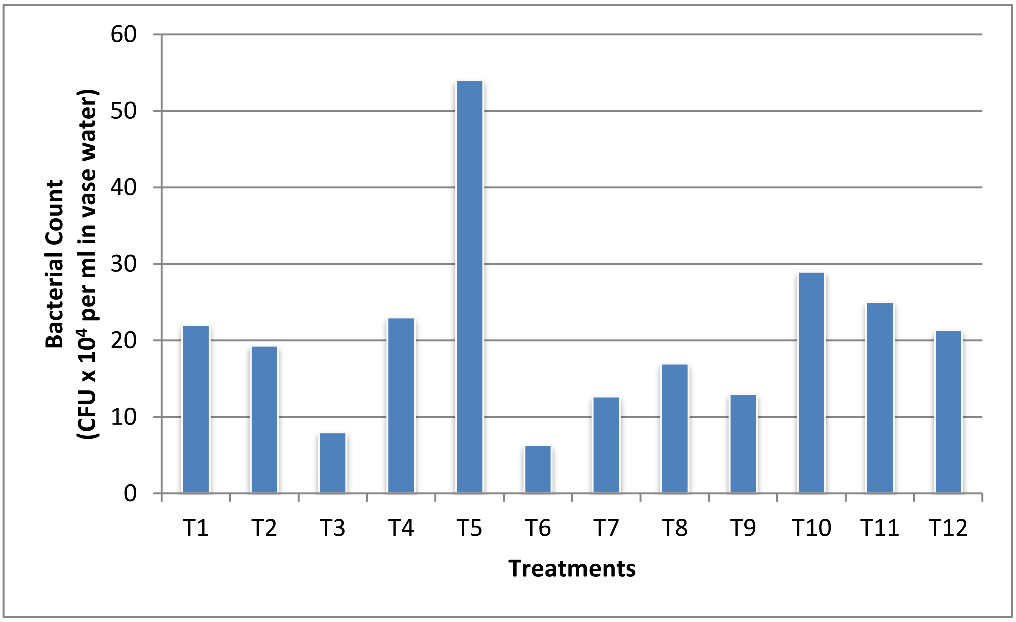

Fig. 1: Effect of nanoparticle vase solution on bacterial count in vase solution during the vase period of rose var. Taj Mahal cut flowers

CONCLUSION

In conclusion, in 'Taj Mahal' roses, using vase holding solution containing silver nanoparticles significantly extended vase life compared to the few other metal nanoparticles included in the study. Mobility of nanoparticles in the plant system is comparatively faster and easier compared to conventionally available metal powders. From the study, it is evident that silver nanoparticles are one of the best available chemicals to counter postharvest senescence in cut flowers. It can also be noted that zinc and copper nanoparticles too have shown considerable promise in maintaining postharvest attributes in roses. Concerted studies are further required to gain detailed insight into their probable roles.

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