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Research Article

Effects of Preservatives on the Vase Life of Two Rose Cultivars

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Abstract

An experiment was carried out at the laboratory, Department of Horticulture, Hajee Mohammad Danesh Science and Technology University, Dinajpur during 1st to 17th December, 2017. The main objective of this research was to increase the vase life of two cut rose cultivars using different preservative solutions. The two factor experiment was laid out in the completely randomized design with three replications. There were two cultivars: Lincoln (V_1) and Tajmahal (V_2), and these flowers were kept in six preservative solutions *viz.,* T_1= water (control), T_2= 2% sucrose + 50 ppm $AgNO_3$, T_3= 2% sucrose + 100 ppm $AgNO_3$, T_4= 2% sucrose + 150 ppm $AgNO_3$, T_5= 2% sucrose + 150 ppm 8-HQS, and T_6= 2% sucrose + 200 ppm 8-HQS. Flowers were monitored for 1, 3, 5, 7, 9, 11, 13, 15 and 17 DAS of storage. Parameters studied in the experiment were: flower head diameter (cm), petal wilting (1-7 scale), petal discolouration (1-8 scale), petal blackening (1-8 scale), bent neck (1-8 scale), flower opening (1-4 scale), total soluble solids (TSS),% dry weight (g), solution uptake (g/flower), transpiration loss (g), water balance (g) and vase life (days). Lincoln performed better than Tajmahal. Among the preservatives, T_2 (2% sucrose + 50 ppm $AgNO_3$) gave the best results in respect of all parameters whereas T_1 gave the lowest results in different DAS. The combinations of cultivars and preservatives demonstrated a significant variation (1%) in vase life and most of the others (1% or 5%). The highest vase life (16.67 days) of Lincoln and Tajmahal were recorded when those were kept in T_2 and T_3, respectively whereas it was only 6.67 days in control. The highest solution uptake rate was recorded in V_1T_2 (14.50 g). At the end of the storage, the highest water balance rate was with V_1T_2 (0.33 g). The lowest number of petal discolouration was noted in V_1T_2 (5.17) than other treatment combinations. Again, at the end of storage, the minimum bent neck was observed in the combination V_1T_2 (3.50) than the others. In term of transpiration loss,% dry weight, total soluble solids, the best results were in V_1T_2 than the rest combinations. At the end of storage, the maximum flower head diameter was observed in V_2T_3. Different quality parameters like petal wilting and petal blackening were also significantly minimum in Lincoln preserved in T_2 than the other preservatives. Overall, 2% sucrose with 50 ppm $AgNO_3$ solution extended the vase life and improved the quality parameters in rose cv. Lincoln than other preservatives.

Keywords: Preservative; Wilting, Discoloration; Vase Life; Rose

Abbreviations

FHD: Flower Head Diameter; TSS: Total Soluble Solids; STS: Silver Thiosulphate; HQS: Hydroxy Quinolone Sulphate; CA: Citric Acid; NAA: Naphthalene Acetic Acid; SADH: Succinic Acid 2, 2-Dimethylhydrazide; RFW: Relative Fresh Weight; PDW: Petal Dry Weight

Introduction

Rose (*Rosa hybrida* L.) is one of the nature's most beautiful creations and is universally extolled as the "Queen of Flowers". It belongs to family Rosaceae and genus Rosa, which contains 200 species and with more than 20,000 cultivars [1]. Most species are native to Asia, with smaller number native to Europe, North America, and Northwestern Africa. It is widely grown as ornamental shrub for its attractive flowers. It is a symbol of love, adoration, innocence and other virtues and most popular of all garden flowers globally and sometimes indoor too. It is recognized for its high economical value as it provides the best raw material for agro-based industry *viz.,* cosmetics and perfumery, and also has important role in medicine and nutrition [2]. Rose hips are occasionally made into jam, jelly, marmalade, syrup and soup or are brewed for tea, primarily for their high vitamin C content. Rose petals or flower buds are sometimes used to flavour ordinary tea, or combined with other herbs to make herbal teas. But the rose is mainly cultivated for the commercial production of its cut flowers, which constitutes a considerable portion in the floriculture business. Typical, uses are in vase displays, wreaths and garlands. In some cultures, a major use of cut roses is for worship; this can be seen especially in south and Southeast Asia.

Cut roses can also be grown for export, to make bouquets, in flower arrangement, vase decorations and for dry flower making. The large-scale commercial production of cut roses started from mid 80's in Jhikargacha upazila of Jessore district. Since it was profitable, many farmers became interested in this business and Jessore, Savar, Chuadanga, Mymensingh and Gazipur are the major cut roses production belts of Bangladesh. At present, 10,000 hectares of land covers cut roses cultivation taking the lead by Jessore district. Bangladesh exports a large number of cut flowers and ornamental foliage to foreign countries. Rose is the major flower that makes up Bangladesh's floral basket for exports. In 2013-14 fiscal years, flower export generated $39.34 million of foreign earnings for the country, which is slightly lower than $42.88 million in 2010-11 fiscal years [3].

Rose is always regarded as the queen of flower. But its vase-life is usually short, i.e. about 7 days. Bangladeshi rose producers are facing problems due to high postharvest losses during both transportation and marketing. There are three parameters which affect its senescence: water balance, supply of carbohydrates and susceptibility towards the release of ethylene [4]. In the earlier times, most of the cut flowers were kept in water but now-a-days, scientists have introduced many floral preservatives to improve the vase life of cut flowers. Investigations pertaining to extend the vase life of cut flowers by chemical treatments after harvest have been made with varying success. Sugars play an important role in keeping the quality of cut flowers because it is the main source of food for flower and required for energy out all biological and physiological process after detachment from the mother plant. It also helps in flower development and opening either as energy source for respiration or as osmotically active substance, which aid in maintaining turgidity of the expanding corolla. The optimum concentration of sugar varies with the treatment and the flowers. The sugars provide a respiratory substrate, while the germicides control harmful bacteria and prevent plugging of the conducting tissues. Silver nitrate ($AgNO_3$) is a well-known germicide which generally used to control of germs that present in xylem of the plants, so after $AgNO_3$ application in holding solutions block then result xylem vessels will be clean and then plants easily uptake the solution.

Several studies showed that different germicides effectively control pathogen that present in xylem and phloem. These germicides also delay senescence by controlling ethylene synthesis and extend the vase live of cut roses viz., silver nitrate [5] and 8-hydroxiquinoline [6]. However, in Bangladesh, there is no accessible published information regarding the extension of vase-life of cut roses using different preservative solutions. This constitutes a major research gap since the vase-life of cut roses should be given priority in floriculture industry in Bangladesh. The aim of this study was:

- To find out the most effective preservative solutions on the vase-life of roses.

Materials and Methods

An experiment was carried out in the laboratory of the department of Horticulture, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from 1st to 17th December, 2017 at room condition to study the postharvest physiology of roses cvs. Lincoln and Tajmahal and to find out the effective treatment that can increase their vase life.

Experimental material

Cut flower of roses cvs. Lincoln and Tajmahal were used as experimental materials. The flowers were collected from the nursery

of Bangladesh Rural Advancement Committee (BRAC), Basherhat, Dinajpur. The desired flowers of uniform size and colour, free from pests and diseases were selected and harvested. The flowers were harvested when the ray florets were completely elongated. Immediately, after harvest the cut ends of the stalk were placed in clean water and brought to the laboratory for the vase life study.

Lincoln

Lincoln has long-pointed buds open into large, well-formed, long stemmed, fully double, 4" blooms of deep red. It has outstanding strong damask fragnance that seduces the senses. A vigorous, tall, upright continual blooming bush with dark green foliage. Makes a good cut flower.

Tajmahal

Tajmahal has large, well-formed, pointed bloom flowers. Its colour is very attractive and has no thorns which makes it easy to hold and make arrangements. Its stems are long which make them an extremely popular cut flower.

Treatments of the experiment

The two factors experiment consisted of the following treatments:

Factor (A) Variety: There were two cultivars of roses

- V_1 = Lincoln and
- V_2 = Tajmahal

Factor (B) Preservative solutions

The following 6 preservative solutions were used in the experiment :

- T_1 = tap water as control,
- T_2 = 2% sucrose + 50 ppm silver nitrate,
- T_3 = 2% sucrose + 100 ppm silver nitrate,
- T_4 = 2% sucrose + 150 ppm silver nitrate,
- T_5 = 2% sucrose + 150 ppm 8-hydroxyquinoline and
- T_6 = 2% sucrose + 200 ppm 8-hydroxyquinoli

Design of the experiment

The two factors experiment was arranged in the complete randomized design (CRD) with three replications.

Preparation of cut flower

Cut flower of roses cvs. Lincoln and Tajmahal were collected early in the morning from the nursery of Bangladesh Rural Advancement Committee (BRAC), Nashipur, Dinajpur when the buds were tight and the sepals were enclosed in the floral bud. Immediately, after detaching the flowers, the cut flowers were taken in the laboratory, Department of Horticulture. The cut flowers were placed in the upright position in the conical flasks partially filled-in with the preservative solution. The conical flasks with the cut flowers were kept under the room temperature. The cut flowers were monitored daily till the senescence of petals.

Preparation of vase solutions

Different preservatives were used to prepare vase solutions in this experiment. The vase solutions were made up with tube-well water and they were as follows:

- **2% sucrose solution:** Thirty gram (30 g) of sucrose was dissolved in 1.5 liter of water to make 2% sucrose solution.
- **50 ppm $AgNO_3$ solution:** Seventy five milligram (0.075 g) of $AgNO_3$ was dissolved in 1.5 liter of water to make 50 ppm $AgNO_3$ solution.
- **100 ppm $AgNO_3$ solution:** One hundred fifty milligram (0.15 g) of $AgNO_3$ was dissolved in 1.5 liter of water to make 100 ppm $AgNO_3$ solution.
- **150 ppm $AgNO_3$ solution:** Two hundred twenty-five milligram (0.225 g) of $AgNO_3$ was dissolved in 1.5 liter of water to make 150 ppm $AgNO_3$ solution.
- **150 ppm 8-HQS solution:** Two hundred twenty-five milligram (0.225 g) of 8-HQS was dissolved in 1.5 liter of water to make 150 ppm 8-HQS solution.
- **200 ppm 8-HQS solution:** Three hundred milligram (0.3 g) of 8-HQS was dissolved in 1.5 liter of water to make 200 ppm 8-HQS solution.
- **Control solution:** No preservative was added here. Only tap water was used.

The flower vase

Conical flask (500 ml) was used as flower vase in this experiment. After preparing the solutions each conical flask was filled in

with 300 ml of desired solution. Each flask was marked for easy identification. Water level was marked with a permanent marker after placing flower spike. The mouth of the conical flask were open.

Placement of flowers on the vase

Stems were cut at a length of 15 cm both in case of Lincoln and Tajmahal and placed in 5 cm under the vase solutions after removing the lower leaves and allowing no leaf in the vase solutions. Slanting cut (5 cm) was made at proximal end to create a wider surface area for increased water absorption.

Parameter studied

In this experiment, cut roses cvs. Lincoln and Tajmahal were monitored every day during the preservation period. Data were collected over a period of 1, 3, 5, 7, 9, 11, 13, 15 and 17 days of storage. However, the following parameters were studied:

Flower head diameter (FHD)

Flower head diameter was measured with an electrical digital caliper (Guanglu, China) and expressed in cm. The FHD of cut flowers were recorded using the procedure of Van Doorn., *et al* [7].

Petal wilting

Petal wilting is measured on 1-7 scale according to Locke (2010):

Scale		Description/decision/assumption
1	=	Completely firm
2	=	Petals are slightly soft or velvety to touch but don't really wilt
3	=	Petals are very soft or velvety but still don't show wilting visibly
4	=	Tips of some of the petals are slightly limp
5	=	Wilting is prominent on most of the petals
6	=	Wilting is prominent; oxidative browning and softening are visible on a good deal of the flower
7	=	Nearly all petals are very wilted, oxidative browning is severe

Table A

Petal discolouration

Petal discolouration is measured on 1-8 scale according to Locke (2010):

Scale		Description/decision/assumption
1	=	No brown spots
2	=	1-4 brown spots
3	=	More than 4 brown spots or one entire petal brown and crispy
4	=	40% of flower has brown spots
5	=	50% of flower has brown spots
6	=	60-70% of flower has brown spots
7	=	80-90% of flower has brown spots
8	=	100% of flower has brown spots

Table B

Petal blackening

Petal blackening measured on 1-8 scale according to Locke (2010):

Scale		Description/decision/assumption
1	=	No black tips
2	=	1-4 black tips
3	=	More than 4 black tips or one entire petal is black and crispy
4	=	40% of flower has black tips
5	=	50% of flower has black tips
6	=	60-70% of flower has black tips
7	=	80-90% of flower has black tips
8	=	100% of flower has black tips

Table C

Bent neck

Bent neck is measured on 1-8 scale according to Locke (2010):

Scale		Description/decision/assumption
1	=	Neck tissue is hard
2	=	Neck tissue beginning to soften
3	=	Slightly 10-20° nod
4	=	40-80° nod
5	=	90° nod
6	=	100-120° nod
7	=	150° nod
8	=	Head of flower touching stem

Table D

Openness stages

Openness stage was measured on 1-4 scale according to Locke (2010):

Scale		Description/decision/assumption
1	=	Tight (petals upright, some outer petals may be slightly reflexed)
2	=	Medium (all whorls beginning to reflex)
3	=	Open (outer whorls completely reflexed)
4	=	Stamen visible

Table E

Total soluble solids (TSS)

Tissue sap extracted from 8 petals and TSS was determined by using a refractometer (Erma, 0-32%, Tokyo, Japan) by placing two drops of clear juice on the prism surface and reading was taken as described by Lacey., *et al* [8]. Data were taken at two days interval and expressed in% Brix.

Petal dry weight

A dry weight of six outer petals was recorded using balance (KERN and Sohn GmbH, Germany) after drying the petals to constant weight in an oven (Memmert, UK) at 60°C for 3 days and expressed in gram.

Solution uptake

For determining solution uptake, flasks were weight with solution, without flower and the consecutive difference in weight signifies the solution uptake by flowers, expressed in grams per flower.

Transpiration loss

Flowers were weighted daily along with solution and flowers, and the consecutive difference in weights represents the transpiration loss, expressed in grams per flower. Difference between consecutive weights of conical flask plus solution plus cut roses gives transpiration loss of water of cut flower and expressed in ml [9].

Water balance

Water balance was calculated by deducting the total transpiration loss from water uptake and expressed in gram.

Vase life evaluation

Vase life can be defined as the number of days from the moment of placing the flowers in the vase (day 0) until the moment when their condition was considered unacceptable. It was determined on the percentage of wilting. When the percentage of wilting crosses 50%, there is discoloration and loss of petals then the vase life of flower is said to be terminated.

Statistical analyses

Analysis of variance (ANOVA) was performed using the Stat graphics Plus Version 2.1 statistical program (STSC, 1987). The means was compared using Fisher's Least Significant Difference (LSD) test.

Results and Discussion

This chapter consists of the results and discussion obtained from the experiment. These results and discussion have been presented in various tables, graphs and different headings. It is notable that the data were recorded on 1, 3, 5, 7, 9, 11, 13, 15 and 17 days on different parameters. It is noted that V_1T_1, V_1T_5, V_1T_6, V_2T_1, V_2T_5, and V_2T_6 treatment combinations were discontinued after 7 DAS but V_1T_4 and V_2T_4, were discontinued after 11 DAS of preservations. On the other hand, V_1T_2, V_1T_3, V_2T_2 and V_2T_3 were continued at the end of preservations (17 DAS). The possible interpretation of the results has been given under the following headings.

Flower head diameter (cm)

The data pertaining to flower head diameter (cm) in different days after storage are presented in table 1. It was observed that flower head diameter of roses cvs. Lincoln and Tajmahal were increased significantly in different days after treating among the preservative solutions. Maximum flower head diameter was 62.04 cm and 65.79 cm at 17 days recorded in V_1 (Lincoln) and V_2 (Tajmahal), respectively (Table 1). The effect of preservative solutions on flower head diameter was statistically significant. The maximum flower head diameter was 66.06 cm at 17 days recorded in T_3 (2% Sucrose + 100 ppm $AgNO_3$) which was statistically superior to all other treatments (Table 1). While the smallest flower head diameter was 42.96 cm at 7 DAS recorded in T_2 (2% Sucrose + 50 ppm $AgNO_3$) among the preservative solutions.

The interaction between cultivars and treatments (preservative solutions) was found to be significant for maximum flower head diameters at different DAS. In the bigenning of storage (3 DAS), the maximum FHD was recorded in V_1T_5 but at the end of storage (17 DAS) the maximum FHD was recorded in Tajmahal kept in 2% Sucrose with 100 ppm $AgNO_3$, which was statistical identical with

V_1T_2 and V_2T_2, respectively. In all cases, minimum FHD was recorded in V_1 preserved in T_1 solution. Butt (2005) found that silver in the form of $AgNO_3$ had shown a positive impact on flower head diameter and vase life of roses. In another study, Sarkka [10] suggested that carbohydrates are necessary for turgor pressure maintenance and important energy sources facilitating flower opening. In harmony to the present results Ichimura., *et al* [11] showed an increased flower diameter with 20 g/L of sucrose +200 mg/L of HQS. Van Doorn., *et al* [7] also observed that FHD increased during preservation and interaction of sucrose with $AgNO_3$ also contributes significantly.

Treatment	Flower head diameter (cm)								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	21.03^{NS}	33.53^{NS}	41.42^{NS}	47.70 b	52.54^{NS}	58.79^{NS}	59.20^{NS}	61.13^{NS}	62.04 b
V_2	21.04	29.33 b	40.25	49.82 a	52.81	57.18	61.83	65.17	65.79 a
LSD	1.05	1.19	1.62	1.71	3.17	2.92	4.55	4.25	3.65
CV %	7.22	5.48	5.72	5.07	5.72	4.80	5.32	4.76	4.04
Factor B									
T_1	21.28^{NS}	29.88 b	44.80 a	49.70 b	W	W	W	W	W
T_2	21.17	29.51 b	38.42 bc	42.96 c	47.15 c	50.73 c	57.75 b	60.57 b	61.77 b
T_3	21.29	31.65 ab	36.96 c	43.51 C	51.58 b	59.08 b	63.28 a	65.74 a	66.06 a
T_4	20.93	32.28 a	44.66 a	54.90 a	59.29 a	64.14 a	W	W	W
T_5	21.05	32.11 a	40.24 b	53.87 a	W	W	W	W	W
T_6	20.49	33.17 a	39.91 b	47.60 b	W	W	W	W	W
LSD	1.82	2.06	2.80	2.97	3.88	3.58	3.26	4.25	3.65
CV %	7.22	5.48	5.72	5.07	5.72	4.80	5.32	4.76	4.04
A×B									
V_1T_1	21.52^{NS}	32.68 c	36.04 ef	40.02 fg	W	W	W	W	W
V_1T_2	21.33	36.03 ab	41.84 cd	47.43 de	52.83 bc	61.81 a	63.57 a	64.16 ab	64.00 ab
V_1T_3	21.27	31.36 c	39.38 de	43.63 ef	48.09 cd	51.24 c	54.82 b	58.10 b	60.07 b
V_1T_4	20.43	31.35 c	38.64 de	48.43 cd	56.68 ab	63.32 a	W	W	W
V_1T_5	21.48	36.70 a	48.88 b	54.59 b	W	W	W	W	W
V_1T_6	20.17	33.09 bc	43.71 c	52.09 bc	W	W	W	W	W
V_2T_1	21.05	27.07 d	53.55 a	59.38 a	W	W	W	W	W
V_2T_2	21.07	27.67 d	37.45 e	43.39 ef	46.21 d	50.21 c	60.67 ab	63.03 ab	63.47 ab
V_2T_3	21.25	27.27 d	32.09 fg	38.48 g	50.33 cd	56.36 b	62.98 a	67.31 a	68.12 a
V_2T_4	21.43	33.22 bc	50.68 ab	61.37 a	61.89 a	64.96 a	W	W	W
V_2T_5	20.63	27.53 d	31.61 g	53.15 b	W	W	W	W	W
V_2T_6	20.80	33.24 bc	36.11 ef	43.12 ef	W	W	W	W	W
LSD	2.57	2.92	3.96	4.19	5.49	5.06	6.43	6.01	5.16
CV %	7.22	5.48	5.72	5.07	5.72	4.80	5.32	4.76	4.04

Table 1: Effect of preservatives on flower head diameter (cm) of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Petal wilting

The beginning of storage (1 DAS) petal wilting was not visible but from 3 DAS petal wilting was gradually increased up to end days (17 DAS) of preservation of both cut roses cvs. Lincoln and Tajmahal. Both the cultivars showed the same result (5.75) of petal wilting at 17 days after preservation. Regarding preservative solutions, significant differences were recorded among the solutions in DAS. From the table-2, it is found that T_1 always had maximum number petal wilting where minimum number petal wilting was recorded in T_3. However, at the end of storage no significant difference was observed between T_2 and T_3.

Treatment	Petal wilting								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	1.00^{NS}	1.97 a	3.22 a	4.81a	3.78 a	4.72 a	5.00 a	5.25^{NS}	5.75^{NS}
V_2	1.00	1.28 b	2.08 b	2.67 b	2.83 b	3.61 b	4.08 b	5.33	5.75
LSD	0.00	0.38	0.30	0.36	0.38	0.42	0.49	0.49	0.59
CV %	0.00	33.98	16.21	14.06	10.93	9.55	7.57	6.49	7.25
Factor B									
T_1	1.00^{NS}	2.08 a	3.50 a	5.33 a	W	W	W	W	W
T_2	1.00	1.58 ab	2.33 bc	2.67 c	3.08 b	3.50 b	4.17 b	4.92 b	5.50^{NS}
T_3	1.00	1.17 b	1.92 c	2.58 c	2.92 b	4.00 b	4.92 a	5.67 a	6.00
T_4	1.00	1.50 ab	2.42 bc	3.00 c	3.92 a	5.00 a	W	W	W
T_5	1.00	1.67 ab	3.25 a	4.33 b	W	W	W	W	W
T_6	1.00	1.75 ab	2.50 b	4.50 b	W	W	W	W	W
LSD	0.00	0.66	0.52	0.63	0.47	0.51	0.49	0.49	0.59
CV %	0.00	33.98	16.21	14.06	10.93	9.55	7.57	6.49	7.25
A×B									
V_1T_1	1.00^{NS}	2.83 a	3.83 b	6.83 a	W	W	W	W	W
V_1T_2	1.00	1.50 bc	2.33 de	2.67 cde	3.00 bc	3.33 cd	3.67 c	3.67 c	4.33 b
V_1T_3	1.00	1.33 bc	2.17 de	3.17 bcd	3.33 b	4.83 b	6.33 a	6.83 a	7.17 a
V_1T_4	1.00	1.67 bc	2.83 cd	3.50 bc	5.00 a	6.00 a	W	W	W
V_1T_5	1.00	2.33 ab	4.83 a	6.50 a	W	W	W	W	W
V_1T_6	1.00	2.17 ab	3.33 bc	6.17 a	W	W	W	W	W
V_2T_1	1.00	1.33 bc	3.17 bc	3.83 b	W	W	W	W	W
V_2T_2	1.00	1.67 bc	2.33 de	2.67 cde	3.17 bc	3.67 cd	4.67 b	6.17 a	6.67 a
V_2T_3	1.00	1.00 c	1.67 e	2.00 e	2.50 c	3.17 d	3.50 c	4.50 b	4.83 b
V_2T_4	1.00	1.33 bc	2.00 e	2.50 de	2.83 bc	4.00 c	W	W	W
V_2T_5	1.00	1.00 c	1.67 e	2.17 e	W	W	W	W	W
V_2T_6	1.00	1.33 bc	1.67 e	2.83 cde	W	W	W	W	W
LSD	0.00	0.94	0.73	0.89	0.66	0.72	0.69	0.69	0.83
CV %	0.00	33.98	16.21	14.06	10.93	9.55	7.57	6.49	7.25

Table 2: Effect of preservatives on petal wilting of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Considering, the interaction between cultivars and preservative solutions with respect to petal wilting was found to be significant. The highest petal wilting was observed in the combination of V_1T_1 (6.83) up to 7 DAS but at the end of storage V_1T_3 had the maximum petal wilting. On the other hand, at the end of storage minimum petal wilting was detected in V_1T_2 which was statistically similar with V_2T_3 (Table 2). The result indicates that 2% sucrose with 50 and 100 ppm $AgNO_3$ performed better in Lincoln and Tajmahal, respectively. Wilting is the most common reason for the termination of vase life, not their natural senescence. The present result showed that petal wilting of cut roses cvs. Lincoln and Tajmahal depend on the type of preservative solutions. Similar variation in petal wilting among different cultivars of rose was also reported by Locke [12]. Ferriera and Swardt, [13] also suggested that flower senescence during vase life is correlated with reduction in sugar content of the flower which resulted in wilting.

Petal discolouration

The effect of cultivars on petal discolouration of flowers in different DAS was statistically significant except in 1, 13, 15, and 17 DAS. At the end of storage (17 DAS), highest discolouration of petal was recorded in Tajmahal (T_2), however the difference with Lincoln was statistically insignificant. Regarding preservative solutions, significant differences were recorded among the solutions in different DAS except in 13 and 15 DAS. At 7 DAS, the highest number of petal discolouration was recorded in T_1 (6.00) where the minimum number of petal discolouration was recorded in T_2 (2.50) which was statistically similar with T_3 (Table 3). However, at the end of storage (17 DAS), the minimum number of petal discolouration was recorded in T_2 (6.00) than other preservatives (Table 3).

Treatment	Petal discolouration								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	1.00^{NS}	2.49 a	3.28 a	4.22 a	5.22 a	5.33 a	5.34^{NS}	5.67^{NS}	6.25^{NS}
V_2	1.08	1.50 b	2.25 b	2.61 b	2.94 b	3.94 b	4.58	5.33	6.58
LSD	0.085	0.25	0.25	0.34	0.53	0.65	0.81	0.86	0.62
CV %	11.82	17.80	12.95	12.42	13.95	13.30	11.82	11.03	6.75
Factor B									
T_1	1.17 a	2.42 a	3.33 a	6.00 a	W	W	W	W	W
T_2	1.00 a	1.79 b	2.00 d	2.50 d	3.33 b	4.08 b	4.67^{NS}	5.33^{NS}	6.00 b
T_3	1.09 ab	1.92 b	2.50 c	2.83 d	3.33 b	4.08 b	5.00	5.67	6.83 a
T_4	1.00 b	1.92 b	2.83 bc	3.42 c	4.08 a	5.75 a	W	W	W
T_5	1.00 b	2.17 ab	3.00 ab	4.42 b	W	W	W	W	W
T_6	1.00 b	1.75 b	2.92 abc	4.33 b	W	W	W	W	W
LSD	0.15	0.43	0.43	0.59	0.65	0.794	0.81	0.86	0.61
CV %	11.82	17.80	12.95	12.42	13.95	13.30	11.82	11.03	6.75
A×B									
V_1T_1	1.00 b	2.83 a	3.67 ab	7.83 a	W	W	W	W	W
V_1T_2	1.00 b	1.75 cde	1.83 c	2.67 de	3.33 b	3.50 cd	3.83 b	4.50 b	5.17 c
V_1T_3	1.00 b	2.67 a	3.33 ab	3.83 c	4.33 a	5.17 b	6.33 a	6.83 a	7.33 a
V_1T_4	1.00 b	2.50 ab	3.33 ab	4.00 c	5.00 a	7.33 a	W	W	W
V_1T_5	1.00 b	2.67 a	3.83 a	6.50 b	W	W	W	W	W
V_1T_6	1.00 b	2.50 ab	3.67 ab	6.50 b	W	W	W	W	W
V_2T_1	1.33 a	2.00 bc	3.00 b	4.17 c	W	W	W	W	W

V_2T_2	1.00 b	1.83 cd	2.17 c	2.33 de	3.33 b	4.67 bc	5.50 a	6.17 a	6.83 ab
V_2T_3	1.17 ab	1.17 ef	1.67 c	1.83 e	2.33 c	3.00 d	3.67 b	4.50 b	6.33 b
V_2T_4	1.00 b	1.33 def	2.33 c	2.83 d	3.17 bc	4.17 bcd	W	W	W
V_2T_5	1.00 b	1.67 cde	2.17 c	2.33 de	W	W	W	W	W
V_2T_6	1.00 b	1.00 f	2.17 c	2.17 de	W	W	W	W	W
LSD	0.21	0.60	0.61	0.82	0.91	1.12	1.14	1.21	0.87
CV %	11.82	17.80	12.95	12.42	13.95	13.30	11.82	11.03	6.75

Table 3: Effect of preservatives on petal discolouration of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Considering the interaction effect with respect to petal discolouration significant differences among the treatment combinations were observed in different DAS. Generally petal discolouration was increased with advancement of vase life and at 7 DAS the highest petal discolouration was recorded in V_1T_1 (7.83) and the lowest was found in V_2T_3 (1.83) than other treatment combinations (Table 3). At the end of storage (17 DAS), the lowest number of petal discolouration was recorded in Lincoln preserved in 2% sucrose with 50 ppm $AgNO_3$ while the highest number of petal discolouration was observed in Lincoln kept in 2% sucrose with 100 ppm $AgNO_3$. Petal discolouration was increased with increasing the vase life of cut roses.

Petal discolouration can be described either by petal browning of entire petals developing from the distal region and Friedman., *et al* [14] found that Botrytis infection was responsible for varieties of rose and they also observed that discolouration had strong positive correlations with vase life of rose. From the present experiment, it was observed that petal discolouration increased with vase life of cut roses and similar positive relationships between long vase life and petal discolouration in rose were reported by Regan [15] and Locke [12]. However, Locke [12] also concluded that increased petal discolouration would not be indicated of treatment effect. In all cases, from the present result it is evident that Lincoln when bored in 2% sucrose with 50 ppm $AgNO_3$ had the lowest discolouration of petals than other treatments.

Petal blackening

The data pertaining to petal blackening were presented in Table 4 and it was observed that the cultivars of roses varied significantly in respect of petal blackening except in 1, 13 and 17 DAS. However, at the end of storage (17 DAS), there was no significant difference between Lincoln and Tajmahal. Considering, the effects of preservatives on petal blackening, significant differences were noted among the solutions in DAS except at 1 DAS. From the table 4, at 7 DAS the highest number of petal blackening was recorded in T_1 (5.25) where the minimum number of petal blackening was recorded in T_2 (2.17). However, at the end of storage (17 DAS), the minimum number of petal blackening was recorded in T_2 (5.92) which was statistically superior than T_3 (7.50).

The interaction between cultivars and treatments with respect to petal blackening was found to be significant. In general petal blackening was increased with advancement of shelf life and at 7 DAS the highest petal blackening was recorded in V_1T_1 (7.83) and the lowest was found in V_2T_2 and V_2T_3 which were statistically identical to V_1T_2, V_2T_1, V_2T_4, V_2T_5, and V_2T_6, respectively (Table 4). At the end of storage, the lowest number of petal blackening was recorded in Lincoln preserved in 2% sucrose with 50 ppm $AgNO_3$ while the highest number of petal blackening was observed in Lincoln kept in 2% sucrose with 100 ppm $AgNO_3$. In general number of petal blackening symptoms was increased with storage time and a lower number of petal blackening symptom is desirable in cut roses. The present study indicated that 2% sucrose with 50 ppm $AgNO_3$ solution performed better than other preservatives and the best result was observed when Lincoln preserved in this solution. Locke [12] observed that petal blackening was positively correlated with vase life and it tended to entire petals around the outer whorl of rose.

Treatment	Petal blackening								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	1.00^{NS}	1.83 a	3.11 a	5.00 a	3.56 a	4.61 a	4.92^{NS}	5.50 b	6.42^{NS}
V_2	1.03	1.27 b	1.70 b	2.22 b	2.39 b	3.56 b	4.42	6.00 a	7.00
LSD	0.058	0.18	0.28	0.25	0.33	0.35	0.64	0.39	0.64
CV %	8.22	17.17	16.76	9.91	10.49	8.06	9.62	4.81	6.69
Factor B									
T_1	1.08^{NS}	1.58 ab	2.92 a	5.25 a	W	W	W	W	W
T_2	1.00	1.33 b	1.83 b	2.17 d	2.75 b	3.58 b	4.08 b	5.33 b	5.92 b
T_3	1.00	1.33 b	1.92 b	2.67 c	2.83 b	3.50 b	5.25 a	6.17 a	7.50 a
T_4	1.00	1.33 b	2.08 b	2.75 c	3.33 a	5.17 a	W	W	W
T_5	1.00	1.83 a	2.67 a	4.42 b	W	W	W	W	W
T_6	1.00	1.92 a	3.00 a	4.42 b	W	W	W	W	W
LSD	0.10	0.32	0.48	0.43	0.40	0.42	0.64	0.39	0.64
CV %	8.22	17.17	16.76	9.91	10.49	8.06	9.62	4.81	6.69
A×B									
V_1T_1	1.00 b	1.67 b	4.00 a	7.83 a	W	W	W	W	W
V_1T_2	1.00 b	1.67 b	2.00 bcd	2.33 d	2.83 b	3.00 c	3.17 c	4.00 c	5.00 c
V_1T_3	1.00 b	1.67 b	2.33 bc	3.33 c	3.67 a	4.33 b	6.67 a	7.00 a	7.83 a
V_1T_4	1.00 b	1.67 b	2.67 b	3.33 c	4.17 a	6.50 a	W	W	W
V_1T_5	1.00 b	2.17 a	3.50 a	6.50 b	W	W	W	W	W
V_1T_6	1.00 b	2.17 a	4.17 a	6.67 b	W	W	W	W	W
V_2T_1	1.17 a	1.50 b	1.83 cd	2.67 d	W	W	W	W	W
V_2T_2	1.00 b	1.00 c	1.67 cd	2.00 d	2.67 b	4.17 b	5.00 b	6.67 a	7.17 ab
V_2T_3	1.00 b	1.00 c	1.50 d	2.00 d	2.00 c	2.67 c	3.83 c	5.33 b	6.83 b
V_2T_4	1.00 b	1.00 c	1.50 d	2.17 d	2.50 bc	3.83 b	W	W	W
V_2T_5	1.00 b	1.50 b	1.83 cd	2.33 d	W	W	W	W	W
V_2T_6	1.00 b	1.67 b	1.83 cd	2.17 d	W	W	W	W	W
LSD	0.14	0.45	0.68	0.60	0.57	0.60	0.90	0.55	0.90
CV %	8.22	17.17	16.76	9.91	10.49	8.06	9.62	4.81	6.69

Table 4: Effect of preservatives on petal blackening of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Bent neck

The changes of bent neck found significant between Lincoln and Tajmahal in different DAS except in 1, 3, and 5 DAS. The data presented in Table-5 showed that at the end of storage (17 DAS), minimum bent neck was recorded in Lincoln (3.83) where the maximum bent neck was found in Tajmahal (6.17) which was nearly 2 times higher than superiors. The effect of preservative solutions on bent neck in different DAS was statistically significant except in 1, 13, and 15 DAS. It is observed that T_1 always had maximum bent neck while the minimum number of bent neck in T_2 up to 7 DAS which was statistically similar with T_3 and T_4. But at the end of storage (17 DAS), the minimum number of bent neck was recorded in T_2 (4.58) which was statistically superior to T_3 (5.42).

There was a significant interaction effect between the treatments and cultivars on bent neck recorded in different DAS except initial DAS i. e., 1 DAS. The symptom of bent neck was increased with vase life and up to 7 DAS the higher bent neck was noted in V_1T_1 and minimum was recorded in V_1T_2, V_1T_3, V_2T_3 and V_1T_4 (Table 5). However, at the end of storage minimum bent neck was detected in the combination of V_1T_2 (3.50) than other treatment combinations (Table 5). In general bent neck symptoms were increased with storage time and the cut flower with bent neck symptom is discarded in cut flower marketing. From the present study, it is evident that 2% sucrose with 50 and 100 ppm $AgNO_3$ effectively control the bent neck symptom in Lincoln compared to other treatment combinations. It was also observed that in all cases incidence of bent neck tended to be the highest in the water (control) which possibly indicating the need for an antimicrobial or indicating that addition of carbohydrates may improve water status in receptacle and stem tissue. In general cut flower exhibited bent neck symptom which possibly due to water shortage as a result of vessel blocking due to attack by microorganisms. The present result is in accordance with the findings of Steinitz (1984) who reported that inclusion of cut gerbera often bended and broke when they were placed in water, but inclusion of antibacterial compounds such as $AgNO_3$ in the vase water decreased the number of bent symptoms.

Treatment	Bent neck								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	1.00^{NS}	1.44^{NS}	2.39^{NS}	3.94 a	2.56 b	3.06 b	3.42 b	3.75 b	3.83 b
V_2	1.00	1.33	2.31	3.00 b	3.39 a	4.28 a	4.83 a	5.17 a	6.17 a
LSD	0.00	0.22	0.32	0.41	0.35	0.50	0.58	0.61	0.26
CV %	0.00	22.52	19.59	16.99	11.35	12.94	9.90	9.71	3.73
Factor B									
T_1	1.00^{NS}	1.50 ab	3.17 a	5.42 a	W	W	W	W	W
T_2	1.00	1.25 bc	1.75 b	2.25 c	2.42 b	3.33 a	4.08^{NS}	4.42^{NS}	4.58 b
T_3	1.00	1.25 bc	2.17 b	2.83 c	3.33 a	3.83 a	4.17	4.50	5.42 a
T_4	1.00	1.09 c	1.92 b	2.58 c	3.17 a	3.83 a	W	W	W
T_5	1.00	1.42 bc	2.25 b	3.67 b	W	W	W	W	W
T_6	1.00	1.83 a	2.83 a	4.01 b	W	W	W	W	W
LSD	0.00	0.37	0.55	0.70	0.43	0.61	0.57	0.61	0.26
CV %	0.00	22.52	19.59	16.99	11.35	12.94	9.90	9.71	3.73
A×B									
V_1T_1	1.00^{NS}	1.83 ab	4.50 a	7.83 a	W	W	W	W	W
V_1T_2	1.00	1.50 bcd	1.50 c	2.00 d	2.33 d	2.50 b	3.00 c	3.33 c	3.50 d
V_1T_3	1.00	1.17 cd	1.83 c	2.17 d	2.33 d	3.33 b	3.83 b	4.17 bc	4.17 c
V_1T_4	1.00	1.00 d	1.50 c	2.50 d	3.00 bc	3.33 b	W	W	W
V_1T_5	1.00	1.67 abc	2.17 bc	4.67 b	W	W	W	W	W

V_1T_6	1.00	1.50 bcd	2.83 b	4.50 b	W	W	W	W	W
V_2T_1	1.00	1.17 cd	1.83 c	3.00 cd	W	W	W	W	W
V_2T_2	1.00	1.00 d	2.83 b	3.67 bc	4.33 a	5.17 a	5.33 a	5.67 a	7.33 a
V_2T_3	1.00	1.33 bcd	1.67 c	2.33 d	2.50 cd	3.33 b	4.33 b	4.67 b	5.00 b
V_2T_4	1.00	1.17 cd	2.33 bc	2.67 cd	3.33 b	4.33 a	W	W	W
V_2T_5	1.00	1.17 cd	2.33 bc	2.67 cd	W	W	W	W	W
V_2T_6	1.00	2.17 a	2.83 b	3.67 bc	W	W	W	W	W
LSD	0.00	0.53	0.78	0.10	0.61	0.86	0.82	0.87	0.37
CV %	0.00	22.52	19.59	16.99	11.35	12.94	9.90	9.71	3.73

Table 5: Effect of preservatives on bent neck of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Flower opening

The data presented in Table 6 indicated that flower opening of rose cvs. Lincoln and Tajmahal were increased significantly in different DAS that the opening of Lincoln was comparatively slower than Tajmahal in different DAS. However, at 17 DAS no significant difference was observed between these two cultivars on flower opening (Table 6). Regarding preservatives, the result showed that minimum opening of flower was detected when the flower kept in 2% sucrose with 50 ppm $AgNO_3$ solution compared to other preservatives in different DAS. But at 17 DAS the difference in respect of flower opening found to be insignificant (Table 6).

Treatment	Flower opening								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	1.08^{NS}	1.50 b	2.19 b	2.61 b	2.67 b	3.00 b	3.00 b	3.08 b	3.50^{NS}
V_2	1.00	2.33 a	3.11 a	3.36 a	3.39 a	3.44 a	3.67 a	3.67 a	3.75
LSD	0.10	0.27	0.28	0.21	0.30	0.12	0.20	0.33	0.33
CV %	13.86	20.18	15.36	9.96	9.37	3.66	4.33	6.98	6.50
Factor B									
T_1	1.08^{NS}	2.00^{NS}	3.17 a	3.58 a	W	W	W	W	W
T_2	1.08	1.75	2.17 c	2.17 d	2.92 b	3.00 c	3.25^{NS}	3.25^{NS}	3.58^{NS}
T_3	1.00	2.00	2.25 c	2.67 c	2.67 b	3.17 b	3.42	3.50	3.67
T_4	1.00	2.17	3.08 ab	3.17 b	3.50 a	3.50 a	W	W	W
T_5	1.00	1.92	2.67 abc	3.33 ab	W	W	W	W	W
T_6	1.08	1.67	2.58 bc	3.00 bc	W	W	W	W	W
LSD	0.17	0.47	0.49	0.36	0.37	0.15	0.20	0.33	0.33
CV %	13.86	20.18	15.36	9.96	9.37	3.66	4.33	6.98	6.50
A×B									
V_1T_1	1.00^{NS}	2.33 ab	4.00 a	4.00 a	W	W	W	W	W
V_1T_2	1.00	2.17 abc	2.17 de	2.17 e	3.17 b	3.00 c	3.50 b	3.50 ab	3.50 bc

V_1T_3	1.00	2.50 a	2.67 bcd	3.00 c	3.00 b	3.33 b	3.83 a	3.83 a	4.00 a
V_1T_4	1.00	2.33 ab	3.17 b	3.33 bc	4.00 a	4.00 a	W	W	W
V_1T_5	1.00	2.67 a	3.33 ab	3.83 ab	W	W	W	W	W
V_1T_6	1.00	2.00 abcd	3.33 ab	3.83 ab	W	W	W	W	W
V_2T_1	1.17	1.67 bcde	2.33 cde	3.17 c	W	W	W	W	W
V_2T_2	1.00	1.50 cde	1.83 e	2.33 de	2.33 c	3.00 c	3.00 c	3.17 bc	3.83 ab
V_2T_3	1.17	1.33 de	2.17 de	2.17 e	2.67 bc	3.00 c	3.00 c	3.00 c	3.17 c
V_2T_4	1.00	2.00 abcd	3.00 bc	3.00 c	3.00 b	3.00 c	W	W	W
V_2T_5	1.00	1.17 e	2.00 de	2.83 cd	W	W	W	W	W
V_2T_6	1.17	1.33 de	1.83 e	2.17 e	W	W	W	W	W
LSD	0.25	0.66	0.69	0.50	0.52	0.22	0.29	0.47	0.47
CV %	13.86	20.18	15.36	9.96	9.37	3.66	4.33	6.98	6.50

Table 6: Effect of preservatives on flower opening of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

The interaction between cultivars and treatments with respect to flower opening was found to be significant in different DAS except in 1 DAS. At 7 DAS, the lowest flower opening was recorded in V_1T_2, V_2T_3, and V_2T_6 where the highest flower opening was recorded in V_1T_1 (Table 6). At the end of storage, the minimum flower opening was detected in the combination of V_2T_3 than other treatment combinations (Table 6). The present results showed that in all cases both V_1T_2 and V_2T_3 had the minimum opening of petals which indicated better keeping quality of these treatments. It was also observed that sucrose in combination of antimicrobial agent ($AgNO_3$) helped in slower opening of petal irrespective of rose cultivar. Furthermore, the present result is accordance with Sarkka [10] who reported that sugars are essential precursors for cut flower respiration and sucrose is the main transporting form of sugar to flower bud. He also found that carbohydrates are necessary for turgor pressure maintenance and also they are important energy sources for facilitating flower opening.

In another study, Farnham., *et al.* [16] also reported that sucrose solution accelerated the opening of carnation. Considering antibiotic, Ferreira and Swardt [13] has been reported that $AgNO_3$ has beneficial effects on the vase life of cut rose blooms which support the present findings.

Total soluble solids (TSS)

The data pertaining to TSS were presented in Table 7 and it was observed that the cultivars of roses varied significantly in respect of TSS at different DAS. From the result, it was noticed that Tajmahal had comparatively more TSS than Lincoln in different DAS (Table 7). Regarding preservative solutions, significant differences were recorded among the preservatives in different DAS except in 13, 15 and 17 DAS respectively and it was observed that both T_1 and T_6 had maximum TSS both up to 7 DAS (Table 7). However, at the end of storage (17 DAS) the highest TSS of petal was observed in T_3 (13.49) which was statistically identical with T_2 (Table 7).

Interaction effect of preservatives and cultivars on TSS of rose cvs. Lincoln and Tajmahal found significant in different DAS. At 7 DAS, the lowest TSS was recorded in V_2T_5, which was statistical identical with V_1T_2, and V_1T_3. Where the highest TSS was recorded in V_1T_1 (Table 6). At the end of storage, the minimum TSS was detected in the combination of V_1T_2 which was statistically similar with V_1T_3 (Table 6). The present result also showed that TSS of petals was increased gradually in all the treatment combinations with the advancement of vase life. These might be due to high water loss from the petals of rose flowers. In this investigation, Lincoln had comparatively lower accumulation of TSS than Tajmahal. Fur-

thermore, the lowest TSS was found in Lincoln when kept in 2% sucrose with 50 ppm $AgNO_3$ indicating that this combination decreased the transpiration loss in cut flower. The results of present study also indicated that the changes of TSS during initial period of preservation among all the treatment was very slow which was also observed by Elgimabi and Sliai [17].

Treatment	Total soluble solids (TSS)								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	5.58 b	6.22 b	6.99 b	7.69 b	9.58 b	10.43 b	10.93 d	11.99 b	12.24 b
V_2	7.44 a	9.20 a	10.58 a	11.67 a	11.57 a	12.56 a	13.13 a	13.88 a	14.52 a
LSD	0.68	0.60	0.49	0.56	0.51	0.56	0.82	0.88	0.78
CV %	14.99	11.17	8.12	8.42	4.59	4.68	4.85	4.83	4.15
Factor B									
T_1	7.44 a	9.25 a	10.32 a	10.95 a	W	W	W	W	W
T_2	5.52 c	6.74 c	7.60 c	8.03 c	10.07 b	10.82 b	11.57^{NS}	12.89^{NS}	13.27^{NS}
T_3	5.99 bc	7.25 bc	8.45 bc	9.42 b	10.47 b	11.45 b	12.50	12.99	13.49
T_4	6.31 abc	7.55 bc	8.68 b	9.80 b	11.18 a	12.20 a	W	W	W
T_5	6.82 ab	7.61 bc	8.53 b	9.09 b	W	W	W	W	W
T_6	6.98 ab	7.875 b	9.13 b	10.80 a	W	W	W	W	W
LSD	1.168	1.03	0.85	0.98	0.62	0.69	0.82	0.88	0.78
CV %	14.99	11.17	8.12	8.42	4.59	4.68	4.85	4.83	4.15
A×B									
V_1T_1	8.83 a	12.20 a	13.57 a	14.37 a	W	W	W	W	W
V_1T_2	5.30 c	5.97 d	6.40 d	7.27 e	8.68 c	9.643 c	10.76 c	11.61 c	12.05 b
V_1T_3	5.22 c	6.02 d	6.90 d	7.26 e	10.30 b	10.62 bc	11.10 bc	12.38 bc	12.43 b
V_1T_4	6.90 bc	8.60 bc	10.37 b	12.17 b	12.60 a	13.37 a	W	W	W
V_1T_5	7.75 ab	8.80 bc	10.13 b	10.97 b	W	W	W	W	W
V_1T_6	8.67 a	9.63 b	10.63 b	12.17 b	W	W	W	W	W
V_2T_1	6.04 bc	6.31 d	7.08 cd	7.53 de	W	W	W	W	W
V_2T_2	6.67 bc	8.53 bc	10.50 b	11.57 b	12.27 a	13.27 a	14.23 a	14.37 a	14.93 a
V_2T_3	5.82 c	7.45 cd	8.30 c	8.81 cd	9.83 b	11.03 b	12.03 b	13.40 ab	14.10 a
V_2T_4	5.72 c	6.49 d	6.93 d	7.43 de	9.75 b	11.04 b	W	W	W
V_2T_5	5.88 c	6.42 d	6.93 d	7.21 e	W	W	W	W	W
V_2T_6	5.30 c	6.12 d	7.62 cd	9.43 c	W	W	W	W	W
LSD	1.65	1.46	1.21	1.38	0.88	0.98	1.17	1.25	1.11
CV %	14.99	11.17	8.12	8.42	4.59	4.68	4.85	4.83	4.15

Table 7: Effect of preservatives on Total soluble solids (TSS) of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Percent dry weight

The effect of cultivars on percent dry weight of flowers in different DAS was statistically significant except in 9 and 11 DAS. The result indicated that rose cv. Tajmahal accumulated maximum dry matter (%) compared to Lincoln (Table 8). The effect of preservative solutions on dry weight (%) of petal was statistically significant except 1 DAS. Among the preservative solutions the maximum dry weight (%) of petal was recorded in T_1 and T_6 until 7 DAS however, at the end of storage (15 and 17 DAS) the difference between T_2 and T_3 was insignificant.

The interaction between cultivars and preservatives with respect to percent dry weight was found to be significant in different DAS. In the beginning of storage (1 DAS), Lincoln accumulated the maximum percent dry weight irrespective of preservatives than Tajmahal (Table 8). But at the end of storage (17 DAS), the maximum percent dry weight was recorded in V_2T_2 (30.07) which was statistically identical to V_1T_3. The result of the experiment showed that the percent dry matter increased gradually in all the treatment combinations with the advancement of vase life. It might be due to the less water uptake or higher transpiration rate. It is evident from the experiment that Lincoln had comparatively lower accumulation of dry matter than Tajmahal indicating that Lincoln had higher water uptake. Furthermore, lowest percent of dry matter was found in Lincoln when kept in 2% sucrose with 50 ppm $AgNO_3$ indicating that this combination increased water uptake in cut flower. Rogers [18] fresh weight of flower can increase if the absorption of water more than the transpiration rate. Similar finding also reported earlier by Dinesh., *et al* [19]. Where they found that $AgNO_3$ controlled the rate of respiration during storage of cut flower. In another studies, Bhattacharjee [20] and Ichimura [21] also reported that sucrose is the most widely used floral preservative that maintains the pool of dry matter and respirable substrates in flower petals.

Treatment	Percent dry weight								
	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A									
V_1	19.26 a	21.95 a	24.68 a	25.97 a	24.71^{NS}	26.19^{NS}	26.92 b	27.78 b	28.28 b
V_2	14.98 b	18.06 b	20.34 b	22.77 b	24.2	25.70	27.94 a	29.08 a	29.50 a
LSD	0.56	0.36	0.36	0.47	0.55	0.50	1.02	0.76	0.68
CV %	4.73	2.63	2.28	2.81	2.16	1.83	2.62	1.88	1.67
Factor B									
T_1	17.00^{NS}	23.01 a	24.51 a	26.33 a	W	W	W	W	W
T_2	17.38	18.97 cd	21.10 c	22.33 d	23.58 b	24.93 c	26.69 b	28.50^{NS}	28.75^{NS}
T_3	17.18	18.81 d	20.96 c	23.22 c	25.05 a	26.86 a	28.16 a	28.37	29.03
T_4	16.65	18.73 d	21.32 c	23.77 bc	24.78 a	26.03 b	W	W	W
T_5	17.08	19.52 c	22.40 b	24.48 b	W	W	W	W	W
T_6	17.43	20.99 b	24.77 a	26.10 a	W	W	W	W	W
LSD	0.97	0.63	0.62	0.82	0.68	0.61	1.02	0.76	0.68
CV %	4.73	2.63	2.28	2.81	2.16	1.83	2.62	1.88	1.67
A×B									
V_1T_1	18.86 a	26.60 a	27.89 a	29.23 a	W	W	W	W	W
V_1T_2	19.42 a	20.83 c	21.90 d	23.07 c	24.10 b	25.37 bc	26.80 b	27.20 c	27.43 c
V_1T_3	18.93 a	20.17 cd	21.50 d	22.80 cd	23.87 bc	26.17 b	27.03 b	28.37 b	29.13 ab
V_1T_4	19.18 a	20.43 c	23.83 c	25.17 b	26.17 a	27.03 a	W	W	W
V_1T_5	19.81a	21.83 b	24.80 b	26.23 b	W	W	W	W	W
V_1T_6	19.34 a	21.81 b	28.15 a	29.33 a	W	W	W	W	W

V_2T_1	15.14 b	19.42 d	21.13 de	23.43 c	W	W	W	W	W
V_2T_2	15.43 b	17.44 e	20.43 ef	23.63 c	26.23 a	27.56 a	29.29 a	29.53 a	30.07 a
V_2T_3	15.34 b	17.11 e	20.29 ef	21.60 d	23.07 c	24.50 c	26.59 b	28.63 ab	28.93 b
V_2T_4	14.12 b	17.03 e	18.81 g	22.37 cd	23.40 bc	25.03 c	W	W	W
V_2T_5	14.35 b	17.20 e	20.00 f	22.72 cd	W	W	W	W	W
V_2T_6	15.53 b	20.17 cd	21.40 d	22.87 cd	W	W	W	W	W
LSD	1.371	0.89	0.87	1.16	0.96	0.86	1.44	1.07	0.97
CV %	4.73	2.63	2.28	2.81	2.16	1.83	2.62	1.88	1.67

Table 8: Effect of preservatives on percent dry weight (g) of rose cvs. Lincoln and Tajmahal at different days after storage (DAS) V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Solution uptake (g)

The data pertaining to solution uptake were presented in Table 9 and it was observed that solution uptake was decreased with vase life regarded of cultivars, preservatives, and combination of both factors (Table 9). The result showed the cultivars of roses varied significantly in different DAS except in 1, 11, and 13 DAS. At the end of storage (17 DAS), solution uptake was higher in Lincoln (13.23 g) than Tajmahal (12.30 g). Considering the effect of preservative solutions, it was observed that T_2 always had maximum solution uptake where minimum was recorded in T_1 (Table 9). At 17 DAS, the maximum solution uptake was recorded in T_2 (13.60 g) which was statistically higher than all other preservatives (Table 9).

Treatment	Solution uptake (g)							
	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A								
V_1	32.00^{NS}	23.21 b	19.61 b	18.20 b	16.50^{NS}	15.45^{NS}	14.13 a	13.23 a
V_2	30.94	26.51 a	21.87 a	19.81 a	16.17	14.98	13.23 b	12.30 b
LSD	3.15	1.99	1.83	1.42	0.92	0.62	0.78	0.74
CV %	5.92	4.72	5.22	7.13	5.37	2.88	4.04	4.08
Factor B								
T_1	30.00 c	21.45 d	17.27 d	W	W	W	W	W
T_2	31.00 bc	26.00 b	23.47 a	20.58 a	18.20 a	16.03 a	14.47 a	13.60 a
T_3	31.00 bc	25.25 b	21.02 bc	17.22 b	15.47 b	14.40 b	12.90 b	11.93 b
T_4	33.67 a	28.42 a	22.08 b	19.22 a	15.33 b	W	W	W
T_5	30.67 bc	23.37 c	20.03 c	W	W	W	W	W
T_6	32.50 ab	24.67 bc	20.55 c	W	W	W	W	W
LSD	2.23	1.41	1.30	1.74	1.13	0.62	0.78	0.74
CV %	5.92	4.72	5.22	7.13	5.37	2.88	4.04	4.08
A×B								
V_1T_1	30.33 bc	20.17 e	17.50 e	W	W	W	W	W
V_1T_2	32.00 abc	26.33 bc	24.27 b	22.17 a	19.40 a	16.73 a	15.27 a	14.50 a

V_1T_3	31.00 abc	25.00 c	20.70 cd	16.00 c	14.77 c	14.17 c	13.00 b	11.97 b
V_1T_4	34.00 a	26.17 bc	17.50 e	16.43 bc	15.33 c	W	W	W
V_1T_5	31.67 abc	20.40 e	18.90 de	W	W	W	W	W
V_1T_6	33.00 abc	21.17 de	18.77 e	W	W	W	W	W
V_2T_1	29.67 c	22.73 d	17.03 e	W	W	W	W	W
V_2T_2	31.00 abc	25.50 c	21.33 c	18.43 bc	16.17 bc	14.63 bc	12.80 b	11.90 b
V_2T_3	30.00 bc	25.67 c	22.67 bc	19.00 b	17.00 b	15.33 b	13.67 b	12.70 b
V_2T_4	33.33 ab	30.67 a	26.67 a	22.00 a	15.33 c	W	W	W
V_2T_5	29.67 c	26.33 bc	21.17 c	W	W	W	W	W
V_2T_6	32.00 abc	28.17 b	22.33 c	W	W	W	W	W
LSD	3.15	1.99	1.83	2.47	1.60	0.88	1.10	1.04
CV %	5.92	4.72	5.22	7.13	5.37	2.88	4.04	4.08

Table 9: Effect of preservatives on solution uptake (g) of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Interaction effect of preservatives and cultivars on solution uptake of rose cvs. Lincoln and Tajmahal were significant at different DAS. In the beginning of storage (3 DAS), the maximum solution uptake was recorded in V_1T_4 but at the end of storage (17 DAS) the maximum solution uptake was recorded in Lincoln preserved in 2% sucrose with 50 ppm $AgNO_3$ (Table 9). While the lowest solution uptake was recorded in V_2T_2 (11.90 g) at 17 DAS which was statistical identical with V_1T_3, and V_2T_3, respectively. In the present study, it was observed that Lincoln kept in 2% sucrose with 50 ppm $AgNO_3$ performed better in maintaining solution uptake and prolonging the vase life of cut roses. Generally, solution uptake decreased with increasing the storage time. This could be due to air embolism of cut stem, proliferation of microbes, and plant reaction to wounding as described by Tsegaw., *et al* [22]. On the other hand, the ending vase life of cut roses treated with water at 7 DAS could be due to microbial development in the vase solution which might have clogged the xylem tube making the cut rose stems unable to uptake solution from the vase. Silver ions have a positive influence on the water uptake because of antibacterial effects and improve solution uptake [23,24]. In another study, Nijsse., *et al* [25] reported that variability among cultivars as to water uptake may be due to differences in xylem anatomy, which has been shown to greatly influence hydraulic conductivity.

Transpiration loss (g)

The data from Table-10 indicated that transpiration loss decreased with vase-life irrespective of cultivar and preservatives. In most cases no significant difference in transpiration loss was observed between two cultivars in different DAS except in 11 and 13 DAS. Regarding preservatives, significant differences were noted among the different preservatives for transpiration loss in different DAS. The data showed that 2% sucrose with 50 ppm $AgNO_3$ continuously had minimum transpiration loss in different DAS (Table 10). At 17 DAS, T_2 had significantly lower transpiration loss than T_3 (Table 10).

There was a significant interaction effect among the preservation solutions and cultivars on transpiration loss was recorded. At the end of storage (17 DAS), the maximum transpiration loss was recorded in V_1T_2 (16.70 g) while the lowest was recorded in V_2T_3 (Table 10). Transpiration loss is an important factor and higher transpiration rate over water uptake causes wilting of cut flowers. However, normal rate of transpiration is essential for extending the vase life of cut flowers and any process that hinders the normal transpiration will decrease the keeping quality of cut flowers. Wilting is the most common reason for the termination of vase life, not their natural senescence [26].

Treatment	Transpiration loss (g)							
	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A								
V_1	25.86^{NS}	20.90^{NS}	19.44^{NS}	17.02^{NS}	16.94 a	15.80 a	14.92^{NS}	14.05^{NS}
V_2	24.92	22.38	19.31	17.07	14.80 b	14.55 b	14.55	14.47
LSD	2.10	1.52	1.71	1.33	0.72	0.63	0.66	0.72
CV %	15.05	4.89	4.14	7.45	4.30	2.93	3.17	3.59
Factor B								
T_1	24.83 bc	20.58 c	18.90 bc	W	W	W	W	W
T_2	24.92 bc	20.53 c	18.15 c	15.15 b	14.78 b	14.62 b	13.70 b	13.42 b
T_3	24.42 c	20.97 bc	19.55 ab	17.92 a	16.73 a	15.73 a	15.77 a	15.10 a
T_4	26.83 a	24.18 a	19.42 abc	18.07 a	16.10 a	W	W	W
T_5	25.08 bc	21.58 bc	20.25 a	W	W	W	W	W
T_6	26.25 ab	22.00 b	19.98 ab	W	W	W	W	W
LSD	1.49	1.07	1.21	1.63	0.88	0.63	0.66	0.72
CV %	15.05	4.89	4.14	7.45	4.30	2.93	3.17	3.59
A×B								
V_1T_1	25.00 abc	20.00 d	20.27 bc	W	W	W	W	W
V_1T_2	25.33 abc	20.97 d	19.67 bc	18.97 a	17.47 a	15.10 b	14.37 c	13.50 c
V_1T_3	25.50 abc	20.97 d	18.90 cd	15.10 b	15.93 b	16.50 a	15.47 b	14.60 b
V_1T_4	27.00 a	22.90 b	16.37 e	17.00 ab	17.43 a	W	W	W
V_1T_5	25.83 abc	20.60 d	21.13 ab	W	W	W	W	W
V_1T_6	26.50 ab	19.97 d	20.30 bc	W	W	W	W	W
V_2T_1	24.67 abc	21.17 cd	17.53 de	W	W	W	W	W
V_2T_2	23.50 c	20.97 d	19.43 bc	16.87 ab	16.00 b	16.37 a	17.17 a	16.70 a
V_2T_3	24.33 bc	20.10 d	17.40 de	15.20 b	13.63 c	12.73 c	11.93 d	12.23 d
V_2T_4	26.67 ab	25.47 a	22.47 a	19.13 a	14.77 bc	W	W	W
V_2T_5	24.33 bc	22.57 bc	19.37 bc	W	W	W	W	W
V_2T_6	26.00 ab	24.03 ab	19.67 bc	W	W	W	W	W
LSD	2.10	1.52	1.71	2.31	1.24	0.89	0.93	1.02
CV %	15.05	4.89	4.14	7.45	4.30	2.93	3.17	3.59

Table 10: Effect of preservatives on transpiration loss (g) of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

Water balance (g)

The effect of cultivars on water balance in different DAS was statistically significant except in initial days of storage i. e., 1 DAS. The result of the study showed that water balance was decreased with vase life irrespective of cultivars and preservatives (Table 11). At the end of storage (17 DAS), the highest water balance recorded

in Lincoln than Tajmahal (Table 11). The effect of preservative solutions on water balance was also statistically significant except 17 DAS. Although no significant difference was marked in preservatives at 17 DAS in term of water balance but most cases comparatively higher water balance was recorded in T_2 compared to other preservatives (Table 11).

Treatment	Water balance (g)							
	3 DAS	5 DAS	7 DAS	9 DAS	11 DAS	13 DAS	15 DAS	17 DAS
Factor A								
V_1	6.14^{NS}	2.35 b	0.17 b	1.19 b	-0.34 b	-0.35 b	-0.78 a	-1.15 a
V_2	6.09	4.13 a	2.56 a	2.74 a	1.6 a	0.43 a	-1.32 b	-2.13 b
LSD	1.56	0.82	0.63	0.29	0.39	0.31	0.46	0.41
CV %	5.21	15.04	27.51	14.20	58.72	526.12	-31.31	-17.55
Factor B								
T_1	5.33 c	0.867 e	-1.63 e	W	W	W	W	W
T_2	6.08 abc	4.65 ab	2.87 b	2.07 b	0.68 b	-0.22 b	-0.80 a	-1.45^{NS}
T_3	6.58 ab	5.03 a	3.92 a	2.68 a	1.47 a	0.30 a	-1.30 b	-1.83
T_4	6.83 a	4.23 b	2.67 b	1.15 c	-0.267 c	W	W	W
T_5	5.58 bc	1.98 d	-0.22 d	W	W	W	W	W
T_6	6.25 abc	2.67 c	0.567 c	W	W	W	W	W
LSD	1.10	0.58	0.45	0.36	0.47	0.31	0.46	0.41
CV %	5.21	15.04	27.51	14.20	58.72	526.12	-31.31	-17.55
A×B								
V_1T_1	5.33^{NS}	0.17 e	-2.77 h	W	W	W	W	W
V_1T_2	6.67	5.37 a	4.60 a	3.23 a	1.93 ab	1.63 a	0.90 a	0.33 a
V_1T_3	5.50	3.90 bc	1.80 d	0.900 c	-1.17 d	-2.33 c	-2.47 b	-2.63 c
V_1T_4	7.00	3.27 c	1.13 e	-0.567 d	-1.80 d	W	W	W
V_1T_5	5.83	0.20 e	-2.23 h	W	W	W	W	W
V_1T_6	6.50	1.20 d	-1.53 g	W	W	W	W	W
V_2T_1	5.33	1.57 d	-0.50 f	W	W	W	W	W
V_2T_2	6.50	4.70 ab	3.23 c	2.13 b	1.00 c	-1.03 b	-3.50 c	-4.00 d
V_2T_3	6.67	5.40 a	3.93 b	3.23 a	2.53 a	1.90 a	0.87 a	-0.27 b
V_2T_4	6.67	5.20 a	4.20 ab	2.87 a	1.27 bc	W	W	W
V_2T_5	5.33	3.77 c	1.80 d	W	W	W	W	W
V_2T_6	6.00	4.13 bc	2.67 c	W	W	W	W	W
LSD	1.56	0.82	0.63	0.51	0.67	0.44	0.66	0.58
CV %	5.21	15.04	27.51	14.20	58.72	526.12	-31.31	-17.55

Table 11: Effect of preservatives on water balance (g) of rose cvs. Lincoln and Tajmahal at different days after storage (DAS)

V1: Lincoln, V2: Tajmahal, T1: Water (Control), T2: 2% Sucrose + 50 ppm AgNO3, T3: 2% Sucrose + 100 ppm AgNO3, T4: 2% Sucrose + 150 ppm AgNO3, T5: 2% Sucrose + 150 ppm 8-HQS, T6: 2% Sucrose + 200 ppm 8-HQS, W = Wilted and NS means Non-Significant. In each column, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

There was a significant interaction effect between the cultivars and the preservative solutions on water balance was noted except initial DAS of storage (1 DAS). The results indicated that V_1T_1 constantly had minimum water balance up to 7 DAS where the highest water balance was observed in V_1T_2 (4.60 g). However, at the end of storage (17 DAS), the maximum water balance was detected in V_1T_2 than other preservatives. The result of the study showed that 2% sucrose with 50 ppm $AgNO_3$ performed better in Lincoln. Water balance determined by the difference between water uptake and water loss [27]. Generally, the water balance rate was decreased with increasing the storage time. Lower water uptake is commonly caused by microbes when they block the xylem vessels resulting blockage of water to the upper part [7,28]. For determining the quality and longevity of cut flower, water balance is considered as the determining factor which is influenced by water uptake and transpiration rate. Moon-Soo., *et al* [29] observed that sucrose is widely used in floral preservatives, which acts as a food source or respiratory substrate and delays the degradation of proteins and improves the water balance of cut flowers.

Vase life

Figure 1 showed no significant difference between Lincoln and Tajmahal on vase life (Appendix V). However, the effect of preservative solutions on flower longevity found to be statistically significant (Appendix V). It was observed that the flower kept in 2%sugar with 50 ppm or 100 ppm $AgNO_3$ had higher vase life compared to other preservatives.

Figure 1: Interaction effect on vase life of rose cvs. Lincoln and Tajmahal. In each bar, means followed by the same letters are not significantly different according to Fisher's least different test ($P \leq 0.05$).

The interaction between cultivars and preservatives with respect to vase life was found to be significant (Appendix V). The highest vase life was recorded in the combination of V_1T_2 which was statistical identical with V_1T_3, V_2T_2, and V_2T_3. While the lowest vase life was observed in V_1T_1 (6.67 days) which was statistical identically to V_1T_5, V_1T_6, V_2T_1, V_2T_5, and, V_2T_6.

Vase life of cut rose was determined by the number of days in which flowers get wilted. In the present study, cut rose cv. Lincoln kept in 2% sucrose with 50 or 100 ppm $AgNO_3$ solution showed the highest vase life (16.67 days) via improving solution uptake, reducing RFW loss, reducing PFW loss, and enhancing TSS. Similar findings were also reported by Hajizadeh., *et al.* [30] on rose cultivar Black Magic. The extended vase life might be due to water balance in cut rose flowers as affected by sucrose in vase solution. Butt [31] suggested that variation of vase life depends on different responses to chemical compounds as well as genetic variability of flowers. It was also observed that $AgNO_3$ solutions showed minimum percentage of wilting and better physiological characteristics compared to other treatments (Figure 1). In another study, Singh., *et al*. [32] reported that the vase life or longevity of cut flowers depends on its water relations and the rate of senescence. According to Paulin [33], sucrose in the vase solution is found to increase the vase life of roses. Durkin and Kuc [34] also suggested that vascular blockage was the result of oxidative processes induced from harvesting injury. A major factor contributing to the rapid senescence of the cut rose flower is vascular blockage, which begins at the cut ends and move up into the stem with time. This was supported by the fact, that an increase in cellulose activity parallel the decline in conductivity of cut roses and application of cellulose decreased water uptake [35].

Summary and Conclusion

An experiment was conducted during 1st to 17th December, 2017 in the laboratory of Horticulture, HSTU, Dinajpur. The experiment was carried out to increase the vase life and postharvest quality of cut rose cvs. Lincoln and Tajmahal by using different preservative solutions. In the present experiment, different preservative solutions *viz.,* 2% sucrose + 50 ppm $AgNO_3$, 2% sucrose + 100 ppm $AgNO_3$, 2% sucrose + 150 ppm $AgNO_3$, 2% sucrose + 150 ppm 8-HQS, 2% sucrose + 200 ppm 8-HQS were used and flowers were kept at room temperature. The experiment consisting of 12 treatment combinations was laid out in the completely randomized design (CRD) with three replications. Observations were made on

flower head diameter (cm), petal wilting, petal discolouration, petal blackening, bent neck, flower opening, Total soluble solids (TSS), percent dry weight (g), solution uptake (g), transpiration loss (g), water balance (g) and vase life. Data were recorded carefully and statistically analyzed and interpreted. It is noted that the cut roses kept in control solution (water) could not continue after 7 DAS due to excessive water loss and wilting.

In the present study, changes in flower head diameter in rose cvs. Lincoln and Tajmahal showed a significant difference over the preservation period irrespective to different treatment. Considering preservative solutions, at the end of storage (17 DAS) the maximum flower head was observed in T_3 than T_2. Regarding treatment combinations, at the end of storage (17 DAS), the maximum FHD was recorded in Tajmahal kept in 2% Sucrose with 100 ppm $AgNO_3$, which was statistical identical with V_1T_2 and V_2T_2, respectively. On the other hand, minimum FHD was recorded in V_1 preserved in T_1 solution.

No significant variation in petal wilting of roses was identified among the treatments at 17 DAS. T_1 always had maximum number of petal wilting where minimum number petal wilting was recorded in T_3. On the other hand, the highest petal wilting was observed in the combination of V_1T_1 (6.83) up to 7 DAS but at the end of storage V_1T_3 had the maximum petal wilting. At 17 DAS, minimum petal wilting was detected in V_1T_2 which was statistically similar with V_2T_3.

It was observed from the present study that at 7 DAS the highest number of petal discolouration was recorded in T_1 (6.00) where the minimum number was recorded in both T_2 and T_3. However, at 17 DAS, the minimum number of petal discoloration was recorded in T_2 (6.00) than other preservatives. Regarding treatment combinations, in the beginning of storage petal discolouration was observed in V_2T_3 but at the end of storage (17 DAS) the lowest number of petal discolouration was observed in Lincoln preserved in 2% sucrose with 50 ppm $AgNO_3$ while the highest number of petal discoloration was observed in Lincoln kept in 2% sucrose with 100 ppm $AgNO_3$.

In preservative solutions, at 7 DAS the highest number of petal blackening was detected in T_1 (5.25) and at 17 DAS, the minimum number of petal blackening was recorded in T_2 (5.92). Although, at 7 DAS the highest petal blackening was recorded in the combination of V_1T_1 (7.83) but at 17 DAS the highest number of petal blackening was observed in V_1T_3 and lowest was in V_1T_2.

The result further revealed that T_1 (5.42) always had maximum bent neck while the minimum number of bent neck was recorded in T_2 (2.25) up to 7 DAS which was statistically similar with T_3 and T_4. But at 17 DAS, the minimum number of bent neck was detected in T_2 (4.58) which was statistically superior to T_3 (5.42). In treatment combinations, at the end of storage minimum bent neck was detected in the combination of V_1T_2 (3.50) than other treatment combinations. However, 2% sucrose with 50 and 100 ppm $AgNO_3$ effectively control the bent neck symptom in Lincoln compared to other treatment combinations.

It was observed from the present study that the minimum opening of flower was detected when the flower kept in 2% sucrose with 50 ppm $AgNO_3$ solution compared to other preservatives in different DAS. But in treatment combinations, at 7 DAS the lowest flower opening was recorded in V_1T_2, V_2T_3, and V_2T_6 where the highest flower opening was recorded in V_1T_1. At the end of storage, the minimum flower opening was detected in the combination of V_2T_3 than other treatment combinations. Both V_1T_2 and V_2T_3 had the minimum opening of petals.

Wide variation was found among the different treatments in case of TSS. The maximum TSS was found in T_1 (10.95) that was statistically similar with T_6 (10.80) up to7 DAS. However, at 17 DAS the highest TSS of flower petals was observed in T_3 (13.49) which was statistically identical to T_2. In treatment combinations, the minimum TSS was detected in V_1T_2 which was statistically similar with V_1T_3. Lower accumulation of TSS was observed in Lincoln than Tajmahal. Among the preservative solutions, the percent dry weight was insignificant at 17 DAS. But considering the interaction effect, the maximum percent dry weight was recorded in V_2T_2 (30.07) which was statistically identical to V_1T_3 due to the less water uptake or higher transpiration rate. But the lowest percent of dry matter was found in Lincoln when kept in 2% sucrose with 50 ppm $AgNO_3$ at the end of storage period.

Results of the experiment showed that, T_2 always had maximum solution uptake where minimum was recorded in T_1. At 17 DAS the maximum solution uptake was recorded in T_2 (13.60) than other treatments. However, at 3 DAS the maximum solution uptake was recorded in the combination of V_1T_4 but at 17 DAS the maximum

solution uptake was recorded in V_1T_2. While the lowest solution uptake was recorded in V_2T_2 (11.90 g) which was statistically identical to V_1T_3, and V_2T_3, respectively. However, solution uptake was higher in Lincoln than Tajmahal.

In transpiration loss, it is found that T_2 continuously had minimum transpiration loss in different DAS. However, at the end of storage the maximum transpiration loss was recorded in the combination of V_2T_2 (16.70 g) and the lowest was recorded in V_2T_3. It was observed from the present experiment that water balance was decreased with vase life irrespective of cultivars and preservatives. However, at the end of storage there was no significant difference was recorded among the preservatives. The result indicated that 2% sucrose with 50 ppm $AgNO_3$ performed better in Lincoln than Tajmahal.

In the present study, the maximum vase life was observed in both T_2 and T3 (16.67 days). Regarding treatment combinations, the highest vase life was observed in V_1T_2 which was statistically identical to V_1T_3, V_2T_2, and V_2T_3, respectively. On the other hand, the lowest vase life was observed in V_1T_1 (6.67 days) which was statistically similar with V_1T_5, V_1T_6, V_2T_1, V_2T_5, and, V_2T_6, respectively. However, Lincoln kept in 2% sucrose with 50 or 100 ppm $AgNO_3$ solution showed the highest vase life.

Based on the results of this study, it could be concluded that vase life of cut rose flowers influenced by the preservative solutions. In the present study, the cultivar Lincoln was observed to be superior to Tajmahal in terms of vase life and most of the quality parameters. Again, T_2 (2% Sucrose + 50 ppm $AgNO_3$) found to be best in Lincoln in terms of vase life and most of the quality parameters where T_3 (2% Sucrose + 100 ppm $AgNO_3$) performed best in Tajmahal. It is evident from the experiment that Lincoln had performed better than Tajmahal.

Based on the results obtained in the present investigation, the following future line of work is suggested:

1. For validation of the findings future study may be conducted with other cultivars of cut flowers.
2. Effect of natural preservatives (vinegar, lemon-lime soda,bleach etc.) may be tested on vase life, quality and biochemical parameters of the flowers.

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