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Influence of Magnetic Technology On Quality and Vase Life of Tulip Cut Flowers

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Future Science Association

Available online free at
www.futurejournals.org

Print ISSN: 2692-5826

Online ISSN: 2692-5834

DOI:
10.37229/fsa.fjh.2023.03.23

Received: 5 February 2023
Accepted: 7 March 2023
Published: 23 March 2023

Abstract: Global climate changes led to water scarcity all over the world, which increased the demand for fresh water resources. Water is an essential factor in floral vase solutions to extend the lifespan of cut flowers. It may be either tap water or distilled water and more recently, magnetized water can be used as a holding solution for cut flowers' absorption ability. The present study aimed to assess the efficiency of some treatments under the magnetization process to improve the quality of *Tulipa gesneriana*. Three different water types: tap water, distilled water and magnetized water were used as well as salicylic acid at 150 and 200 ppm plus sucrose at 25g/l in addition to magnetize cut flowers for 15 and 30 minutes. Data revealed that magnetized tap and distilled water with salicylic acid at 200 ppm and sucrose prolonged vase life, maintained the relative fresh weight and increased the flower diameter. Also, magnetized tap water with salicylic acid at 150 ppm achieved tremendous results in increasing the amount of absorbed solution. The results of the current study demonstrate some significant effects of magnetically treated water on chlorophyll (a + b), carotenoids and anthocyanin contents as well as total phenols. Utilization of magnetized water for cut flowers must occupy a foremost rank in the list of non-chemical and environmentally spotless or green manners.

Keywords: Tulip cut flowers - salicylic acid- magnetized water-vase life.

INTRODUCTION

The life span of cut flowers after harvest has a great importance in estimating their economic value. Cut flowers are very sensitive and easily affected by many factors such as pre-harvest factors, cultivars, carbohydrate levels in tissue, light and water quality. Cut flowers are affected in the post-harvest period as they begin to lose quality causing post-harvest deterioration and post-harvest damage manifestations in cut flowers and foliage. A wide range of techniques have a beneficial effect on extending the shelf life of cut flowers, including using flower preservative solutions, the flower solution component at least, carbohydrates, and biocides in good and clean water.

Tulips are a genus of spring-blooming perennial bulbiferous geophytes (having bulbs as storage organs), 10 to 70 cm (high), and stems have few leaves (2 to 6 leaves). The flowers are usually large, showy, and brightly colored, generally red, pink, yellow, or white (usually in warm colors). The tulip plant is a member of the lily Family (Liliaceae). The name "Tulip" is thought to be derived from a Persian word for turban who discovered it. Tulips are popular with consumers and used as cut flowers and as potted plants, it stands at the fourth position among the top ten cut flowers in the global floriculture trade **(Jhon and Neelofar, 2006).**

Sucrose act as a source of nutrition for tissues approaching carbohydrate starvation, it has a role in subsequent water relations, carbohydrates are the main substrate for respiration, which is essential for all living cells and the presence of it in holding solutions is a usual practice for prolonging the longevity of cut flowers **(Amin *et al.*, 2020).**

Salicylic acid (SA) is an endogenous growth regulator of phenolic nature, naturally produced by plants as a secondary metabolite and it is a hormone-like substance that plays an important role in regulating several physiological processes and providing protection against biotic and abiotic stresses in the plant. SA plays various important roles in plant growth and development such as ethylene biosynthesis and respiration **(Amin, 2017).** SA has a vital role in plant defense and is implicated in the activation of defense systems against different pathogens **(Grant and Lamb, 2006; Miura *et al.*, 2010).** SA is synthesized in plants via the shikimate pathway by two metabolic routes viz, phenylalanine route and isochorismate route. The phenylalanine pathway operates in the cytoplasm while as isochorismate pathway operates in the chloroplast **(Sharma *et al.*, 2020).** Furthermore, SA could improve the longevity of flowers with economic values like Rosa **(Gerailoo and Ghasemnezhad, 2011)**, Dianthus **(Roodbaraky *et al*., 2012)**, Lilium **(Santos *et al*., 2018)** and Chrysanthemum **(Phi *et al.*, 2021).**

Water is the most important factor in extending the life span of flowers after they are picked. Magnetized water may be used as a useful holding solution for cut flowers this may be due to that the magnetic treatment of water can improve water productivity **(Duarte *et al.*, 1997)** and the water treated by a magnetic field can cause changes in the physical, chemical and biophysical properties of the exposed water **(Pang and Deng, 2008; Othman *et al.*, 2019)**, this has enhanced the post-harvest properties of the cut flowers. The differences between magnetized and non-magnetized water have been mentioned regarding hydrogen bond formation, water molecule size, conductivity, evaporation, activation energy, salt mobility, dissolved oxygen surface tension, viscosity, as well as uniformity of their structure **(Inaba *et al.*, 2004).** Magnetized water is less viscous to be able to absorb, as the magnetization process breaks hydrogen bonds, which minimizes intermolecular interactions that lead to enhanced water absorption **(Abdul- Qados and Hozayn, 2010; Ali *et al.*, 2014).** To explain the mechanism of action of magnetized water, it is obtained when water passes through a permanent magnetic field with some specific changes in its molecular properties. Regular tap water molecules are not separated from each other due to the presence of hydrogen bonds. They tend to relate to each other, forming clusters. When tap water passes through a permanent magnetic field, the size of these clusters and the number of aggregated particles decreased Thus, the activity of water molecules increases. Magnetic fields have weakened the hydrogen bonds within the clusters, breaking larger clusters, and forming smaller clusters with stronger hydrogen bonds within the cluster **(Esmaeilnezhad *et al.*, 2017).** The magnetic water treatment works by positively controlling the negative-negative charges to strengthen the water properties which is useful in improving industrial cooling and the performance of power generation **(Wang *et al.*, 2018)**. Magnetic field treatment could enhance plants' drought tolerance by stimulating water and Ca^2 uptake, cell membrane permeability, pigment synthesis, stomatal conductance, protecting the plants against salinity by increasing water uptake, stomatal conductance, sugar and protein synthesis, and also by regulating the antioxidants and defense metabolites

(Radhakrishnan 2019). In general, the literature review reveals that there are some serviceable effects of magnetization treatment on plants and other related parameters.

The present study was designed mainly to evaluate the magnetized water as a suitable vase solution for cut flowers of tulip and to leverage the advantage of some chemical preservatives as a holding solution to extend the vase life.

MATERIALS AND METHODS

The present trial was undertaken at the Lab of Sandy and Calcareous Soil Lands Dept., Water and Environment Res. Inst., ARC, Giza, Egypt in two successive seasons 2021 and 2022. *Tulipa gesneriana.* cv. Ile de France cut flowers were obtained from the local commercial greenhouses of Floramix Farm (El-Mansouria, Giza) in each season. The stems were picked in the early morning at the standard stage for export and wrapped in Kraft paper. The cut flowers were transported to the laboratory within 2 hours under dry conditions and rapidly precooled by cold water for one hour to remove the heat of the field from the cut flowers. Thereafter, the end of the flowering stem was recut to 2cm nearly to adjust to 40 cm for the stem. The cut flowers were placed in glass bottles (500 ml) containing 400 ml of holding solutions, each treatment consisted of 3 replicates and each bottle contained 3 stems of cut flowers and placed in ambient conditions at 24±2 °C, the light level was about15 µmol $m^{-2}S^{-1}$ partially from natural light and partially from fluorescent cool light for 12 h/day. The holding solutions consisted of two groups each one containing eight treatments. Magnetic device 1.5 tesla from Delta Water.

In the first group, the cut flowers were placed in the following solutions:

- Tap water (control) (TW).
- Magnetized tap water (MTW).
- Tap water (TW)+ salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su).
- Tap water (TW)+ salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su).
- Magnetized tap water (MTW)+ salicylic acid at 150 ppm + sucrose at 25 g/l(Su).
- Magnetized tap water (MTW)+ salicylic acid at 200 ppm+ sucrose at 25 g/l(Su).
- Magnetized the cut flowers for 15 minutes (min) then held them in tap water (MFTW1) + sucrose at 25 g/l.
- Magnetized the cut flowers for 30 minutes then held them in tap water (MFTW2) + sucrose at 25 g/l.

In the second group, the cut flowers were placed in the following solutions:

- Distilled water (control) (DW).
- Magnetized distilled water (MDW).
- Distilled water (DW)+ salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su).
- Distilled water (DW)+ salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su).
- Magnetized distilled water (MDW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su).
- Magnetized distilled water (MDW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su).
- Magnetized the cut flowers for 15 minutes then held them in distilled water (MFDW1) + sucrose at 25 g/l(Su).
- Magnetized the cut flowers for30minutes then holding them in distilled water (MFDW2) + sucrose at 25 g/l(Su).

Table (A). Properties of tap water and magnetized water according to Bharath *et al.* (2016)

Test parameter	Test Results	
	Tap water	Magnetized water
Surface tension (N/m)	0.07275	0.06750
Viscosity (m^2 /s)	7.65 x 10^{-6}	7.13 x 10^{-6}
Electrical conductivity (µs/cm)	343.20	353.30
pH	8.10	8.15

The measurements evaluated in the experiment were as follows:

Vase life: The time from the start of treatment until the senescence of flowers (days).

Total water uptake: Cumulative water uptake was recorded after 2 days (first stage) and at the end (second stage) of vase life (g/flower stem).

Relative fresh weight recorded daily during the experiment according to **He *et al*. (2006)** and calculated as $\mathbf{RFW\%} = \frac{\text{Fresh weight of stem on mentioned day}}{\text{Fresh weight of stem in zero−day}} \times 100$

Flower head diameter (cm) measurement was recorded after 2 days (first stage) and at the end of the vase period (second stage).

Chemical analyses:

- **Chlorophyll (a + b) and carotenoids (mg/100g f.w.) in leaves** were determined according to **Moran (1982).**
- **Anthocyanins (mg/100g) in flowers** were determined according to **Fuleki and Francis (1968).**
- **Reducing and total sugars (%)** were determined according to **Dubois *et al.* (1956).**
- **Total phenols (%)** were determined according to **Singleton *et al.* (1999).**
- **Anatomical study:** A cross-section taken from the end of the stem of cut flowers.

Statistical analysis: Data were tabulated and subjected to analysis of variance as a factorial completely randomized design **(Snedecor and Cochran ,1980).**

RESULTS AND DISCUSSION

The effect of magnetic technique and salicylic acid on:

The vase life of cut flowers

According to data presented in Table (1), it is clear that the vase life was markedly extended in response to using the magnetization types and salicylic acid treatment with the superiority of magnetized water (whether tap or distilled) + SA at 200 ppm +sucrose at 25g/l which recorded the highest number of days as the shelf life of cut flowers with significant differences in both seasons. Cut flowers were treated with SA as a protease inhibitor to relieve protein degradation and conserve a higher concentration of proteins (which activates stress-related defense mechanisms by enlarging antioxidant enzymes activity) in petal tissues which are correlated with a prolonged vase life of cut flowers. In addition, salicylic acid may increase the life span by maintaining the membrane integrity like rose, lisianthus and chrysanthemum **(Gerailoo and Ghasemnezhad, 2011; Bahrami *et al.*, 2013; Balieiro *et al.*, 2018),** respectively**.** SA also suppresses 1-amino cyclopropane 1-carboxylate synthase (ACC synthase) and 1-aminocyclopropane-1-carboxylate oxidase (ACC oxidase) activities and controlled the biosynthesis of ethylene which could be an important factor in reducing longevity and enhancing the senescence rate of cut flowers. Treated cut flowers with tap water+ sucrose at 25g/l as a holding solution and magnetized cut flowers for 15 min were more efficient than those treated for 30 min. The first exposure period gave 6.67 and 7.33 days compared to 5.67 and 6.67 days from the second one, in the first and second seasons, respectively. In the same manner, the magnetized cut flowers for 15 min (short exposure) was more preferable compared to 30 min and then held in a vas solution containing distilled water + sucrose at 25 g/l. and that may be attributed to the influence of the magnetic field being influenced by the exposure duration, field intensity and sensitivity of different species **(Tang *et al.*, 2015).** Previous studies revealed that the exposure of plants to continuous electromagnetic fields induced different biological responses such as cellular, molecular and whole plant scales **(Vian *et al.*, 2016).** The importance of magnetized water appeared as an effective tool in increasing the period of survival of flowers in the vase solution. These gains are supported by **Abdel-Kader *et al.* (2015)** who recommended magnetized distilled water to utilize the preservatives solution for cut flowers to extend the life span of gladiolus spikes. It may be attributed to that magnetized water that having various mechanical, thermodynamic and electromagnetic properties compared to tap water and that may increase the ability of cut flowers to absorption.

Table (1). Effect of magnetized (tap and distilled) water and salicylic acid on vase life (days) of tulips during the two seasons

Treatments	Vase life (days)		Treatments	Vase life (days)	
	First season	Second season		First season	Second season
TWO	4.33	4.33	**DW**	4.67	4.33
MTW	5.00	5.00	**MDW**	6.00	5.67
TW+SA1+Su	5.67	5.00	**DW + SA1+Su**	6.67	6.33
TW+SA2+Su	6.00	6.00	**DW+ SA2+Su**	7.33	6.33
MTW+SA1+Su	7.00	6.67	**MDW+SA1+Su**	8.00	7.67
MTW+SA2+Su	8.33	8.33	**MDW+SA2+Su**	9.00	8.33
MFTW1+Su	6.67	7.33	**MFDW1+Su**	8.00	7.67
MFTW2+Su	5.67	6.67	**MFDW2+Su**	6.67	6.33
L.S.D. at 5 %	0.30	0.31	**L.S.D. at 5 %**	0.28	0.27

Tap water (TW) - Magnetized tap water (MTW) - Tap water (TW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Tap water (TW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for15minutes (min) then held them in tap water (MFTW1) + sucrose at 25 g/l - Magnetized the cut flowers for 30 minutes then held them in tap water (MFTW2) + sucrose at 25 g/l - Distilled water (DW) - Magnetized distilled water (MDW) - Distilled water (DW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Distilled water (DW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 15 minutes then held them in distilled water (MFDW1) + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 30 minutes then holding them in distilled water (MFDW2) + sucrose at 25 g/l(Su).

Water uptake

As shown in Table (2), data indicated that almost all holding solutions raised the amount of water uptake throughout the two stages of life span with different significant differences compared to the amount of water up taken by cut flowers held in control. The supremacy was for the vase solution containing magnetized tap water and salicylic acid at 150 ppm with sucrose at 25 g/l at the two stages of the life span in cut flowers. Magnetized cut flowers for 30 minutes and held them in tap water (MFTW2) + sucrose at 25g/l increased the amount of absorption in the first season at the two stages of life span compared to that magnetized for 15 min. The explanation for these results is that magnetized water causes a reduction in the pH of the solution and improves the water uptake also, which may be due to the state of the water molecules within the magnetic field changes or breaks the hydrogen bonds between the molecules leading to changes in the properties of water, such as electrical systems, an increase in the percentage of dissolved oxygen in water, elasticity, electrical insulation and an increase in permeability, giving energy and vitality to the water **(Aly *et al.*, 2015)** and lead to reduction in water pH which makes the preservation solution more convenient in preserving the cut flowers. Data in Table (2) indicated the effect of the vase solution containing distilled water and salicylic acid at 150ppm with sucrose at 25g/l on water uptake. The salicylic acid as a holding solution plus sucrose enhanced absorption and gave the maximum values compared to other treatments including the control. This result may be due to the effect of salicylic acid as an antimicrobial in inhibiting vascular blockage, thereafter increasing the water uptake due to its acidifying and stress alleviating properties **(Amin, 2017).** Moreover, SA reduced respiratory activity and improved water balance by enhancing absorption. Furthermore, water and solute (sucrose) as factors to modify enlargement, push plant cell expansion and contribute to the design of the plant and the function involved in stomata movements. The sucrose involved in the stomatic closure led to reducing water loss, and acts directly in the water balance maintenance with less loss of turgidity, thus allowing considerable water uptake and accreted osmotic concentration.

Therefore, the least amount of water uptake was noticed with distilled water because it does not contain biocides, which leads to the proliferation of microorganisms and reduces the absorption process. Magnetized the cut flowers for 15 min. and held them in (DW) water (MFDW1) + sucrose at 25g/l gave a higher amount of absorption in the second season at the two stages of life span compared to the one that magnetized for 30 min. The above-mentioned results showed the important role of the magnetization process in improving water quality and increasing the plant's ability to absorb water, according to many studies, magnetic water treatment is a technique that gains a high water use efficiency due to its effect on some chemical and physical parameters of water, these results are supported by **Al-Mana *et al.* (2021).**

Table (2). Effect of magnetized (tap and distilled) water and salicylic acid on total water uptake (g) of tulips during the two seasons

Treatments	Water uptake (g/flower)								
	Stage one		Stage two		Treatments	Stage one		Stage two	
	First season	Second season	First season	Second season		First season	Second season	First season	Second season
TW	13.15	13.68	61.08	59.91	**DW**	13.75	14.07	76.22	74.51
MTW	14.92	15.45	63.44	61.60	**MDW**	17.30	17.20	80.80	80.23
TW+SA1+Su	18.75	18.71	65.72	64.09	**DW+ SA1+Su**	20.02	19.26	85.24	83.77
TW+SA2+Su	20.05	20.17	71.21	70.42	**DW+ SA2+Su**	18.18	17.56	83.65	81.16
MTW+SA1+Su	20.27	20.39	71.62	72.01	**MDW+SA1+Su**	19.14	18.16	78.86	76.82
MTW+SA2+Su	19.30	19.34	70.29	71.61	**MDW+SA2+Su**	18.40	17.60	79.47	77.55
MFTW1+Su	14.12	14.69	64.35	62.89	**MFDW1+Su**	15.88	14.29	78.02	76.12
MFTW2+Su	15.03	13.80	69.14	58.62	**MFDW2+Su**	16.86	13.33	76.16	75.39
L.S.D. at 5 %	0.69	0.67	0.84	0.88	**L.S.D. at 5 %**	0.71	0.67	1.00	0.97

Tap water (TW) - Magnetized tap water (MTW) - Tap water (TW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Tap water (TW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 15 minutes (min) then held them in tap water (MFTW1) + sucrose at 25 g/l - Magnetized the cut flowers for 30 minutes then held them in tap water (MFTW2) + sucrose at 25 g/l - Distilled water (DW) - Magnetized distilled water (MDW) - Distilled water (DW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Distilled water (DW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 15 minutes then held them in distilled water (MFDW1) + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 30 minutes then holding them in distilled water (MFDW2) + sucrose at 25 g/l(Su).

Relative fresh weight

The weight loss may be due to water imbalance since the treatments caused lower water absorption. In addition, the tissues continued the respiratory process, releasing energy (ATP) for flower opening as well as heat production, which must be wasted by transpiration, causing insufficient water.

A positive increment in the fresh weight and maintenance in the cut flowers was noticed in all treatments that were used in this experiment compared to those in control (Table,3). The values related to the maximum increase in fresh weight were recorded in the treatment with magnetized tap water in addition to salicylic at 150 or 200 ppm + sucrose at 25g/l greatly through the whole life of the cut flower. It was also found that magnetizing the cut flowers for 15 min increased the fresh weight of the cut flowers compared to those treated for a period of 30min in the last period of the life of the cut flower vase. The increased solution uptake may be due to the germicidal activity of SA in preventing vascular blockage by suppressing bacterial proliferation thereby, enhance continuous flux through xylem vessels **(Singh *et al*., 2018)** which increased fresh weight, SA also fosters stomata closure to slow down the respiratory rate which prevents water loss through transpiration **(Hatamzadeh *et al*., 2012).** Thus, increasing water uptake with decreased water loss could improve the fresh weight of cut flowers. Data illustrated in Table (3) declared also that MDW+SA2+Su significantly increased the percentage of relative fresh weight of cut flowers tremendously exceeding the rest of the other treatments. This may be due to the effect of SA besides the positive effect of magnetized water on increasing the water uptake, reducing water loss led to improving water balance within tissues during the vase life period thereby, the fresh weight of cut flowers increased. The previous benefits of magnetized water on maintence the fresh weight were documented before by **Hegazy *et al*. (2019)** on cut rose flowers. Furthermore, magnetic water treatment probably also affects plant hormone production resulting in improved cell activity and furtherance of the fresh weight of cut flowers.

Table (3). Effect of magnetized (tap and distilled) water and salicylic acid on relative fresh weight (%) of tulips during the two seasons

Treatments	Fresh weight (g)								
	Stage one		Stage two		Treatments	Stage one		Stage two	
	First season	Second season	First season	Second season		First season	Second season	First season	Second season
TW	106.1	105.0	64.56	65.41	**DW**	107.0	106.0	72.75	71.15
MTW	107.4	106.2	71.90	70.66	**MDW**	110.8	109.3	75.73	74.51
TW+SA1+Su	111.7	110.2	72.03	70.82	**DW+ SA1+Su**	112.9	111.3	79.59	78.40
TW+SA2+Su	113.8	112.5	73.86	72.36	**DW+ SA2+Su**	112.9	111.3	80.98	80.13
MTW+SA1+Su	115.3	114.0	81.22	80.34	**MDW+SA1+Su**	114.7	112.1	84.35	83.65
MTW+SA2+Su	116.4	116.1	86.91	84.64	**MDW+SA2+Su**	115.1	112.8	88.18	85.57
MFTW1+Su	100.8	101.0	71.05	70.56	**MFDW1+Su**	112.2	109.7	79.64	78.15
MFTW2+Su	101.0	100.0	71.19	70.11	**MFDW2+Su**	110.3	109.0	78.46	77.22
L.S.D. at 5 %	1.33	1.31	1.51	1.49	**L.S.D. at 5 %**	1.35	1.32	0.73	0.69

Tap water (TW) - Magnetized tap water (MTW) - Tap water (TW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Tap water (TW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for15minutes (min) then held them in tap water (MFTW1) + sucrose at 25 g/l - Magnetized the cut flowers for 30 minutes then held them in tap water (MFTW2) + sucrose at 25 g/l - Distilled water (DW) - Magnetized distilled water (MDW) - Distilled water (DW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Distilled water (DW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 15 minutes then held them in distilled water (MFDW1) + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 30 minutes then holding them in distilled water (MFDW2) + sucrose at 25 g/l(Su).

Flower head diameter

Data listed in Table (4) suggested that the use of magnetic tap water was efficacious in a marginal boost of the cut flower head diameter by using it alone as a flower-preserving solution compared to the control. It was also clear that using it in conjunction with salicylic acid at a higher concentration (200 ppm) increased this efficiency. The usefulness of SA application may be due to raised absorption of the solution and swelling of the petal tissues maintaining the stiffness **(Bayat and Aminifard, 2017).** In addition, the plant hormones (SA) involved in the regulation of senescence in cut flowers, changes in the levels of these compounds serve as signals for a particular organization or interrupt specific reactions. The functional impact is completed by using sucrose which promoted bud opening, similarly, Pun and **Ichimura (2003)** reported that, supplying sucrose (in several cut flowers) gives energy and carbon skeleton required for floral structure and is necessary for petal expansion.

Likewise, using the technique of magnetizing cut flowers for 15 min was better than 30 min in this regard during the cut flower's lifespan. The data shown in the same table confirmed the superiority of magnetized distilled water in maximizing the diameter of the cut flowers, whether it used alone or with salicylic acid and sugar in the preservative solution, while the SA application was more functional in magnetized water compared to distilled water, SA at 150 ppm in the first stage gave 5.90 and 5.80 cm compared to 6.03 and 6.00 cm from the same concentration of SA, whilst, in the second stage, it recorded 6.00 and 5.91 cm compared to 6.60 and 6.30 cm in the first and second seasons, respectively. The treatment of magnetization with a period of 15 min achieved the highest rate of increasing the head diameter of the flowers as compared to the exposure period of 30 min, and it also outperformed all the treatments used in addition to the control.

Anatomical study

Since water is desirable for almost all morphological, physiological and biochemical processes of cut flowers, its deficiency is detrimental to their life span and general appearance of them, magnetized water is advantageous because it minimizes the surface tension of water, which ameliorates the ability of cut flowers to uptake solutions, thus improving various biosynthesis processes. As, **Reina and Pascual (2001)** emphasized that the magnetic field alters the water transport mechanism across the cellular membrane and this effect may be due to alterations in ionic fluxes across the membrane. Furthermore, the magnetic field could influence pathogens such as the biomagnetic effect, which pointed to cell membrane permeability, biomass metabolism and enzyme activity **(Liu *et al*., 2008).** As shown in Figure (1), by increasing the life span of the flower, microorganisms aggregate and cause damage to the vascular bundles, and morphological and physiological effects will also occur due to the lack of water.

Treatments that included magnetized water with salicylic acid and sucrose were among the best treatments, besides, SA could lower the pH of the water and reduce the proliferation of bacteria thereby, maintaining continuous flux through xylem vessels. It is evident from the illustration shown in Figure (1) that, treating cut flowers with MDW+SA2+Su (1) gave the best result compared to the control treatment. The effect of the transactions is arranged gradually in descending order as in the following MTW+SA1+Su (3)> MDW+SA1+Su (4) > MFTW1+Su (5) and ultimately by MFDW1+Su (6). On the contrary, using tap and distilled water (control) did not inhibit the growth of microorganisms in the solution, which led to blockage of the conductivity vessels.

Table (4). Effect of magnetized (tap and distilled) water and salicylic acid on flower diameters (cm)of tulips during the two seasons

Treatments	Flower head diameter (cm)				Treatments				
	Stage one		Stage two			Stage one		Stage two	
	First season	Second season	First season	Second season		First season	Second season	First season	Second season
TW	4.80	4.70	4.90	4.70	**DW**	5.03	5.00	5.20	5.20
MTW	5.00	4.97	5.22	5.00	**MDW**	5.22	5.19	5.40	5.45
TW+SA1+Su	5.13	5.10	5.34	5.30	**DW + SA1+Su**	5.90	5.80	6.00	5.91
TW+SA2+Su	5.17	5.14	5.39	5.32	**DW+ SA2+Su**	5.80	5.73	6.30	6.00
MTW+SA1+Su	5.22	5.20	5.64	5.60	**MDW+SA1+Su**	6.03	6.00	6.60	6.30
MTW+SA2+Su	5.77	5.71	6.05	6.00	**MDW+SA2+Su**	6.86	6.60	7.00	6.80
MFTW1+Su	5.53	5.50	5.97	5.90	**MFDW1+Su**	6.90	6.75	7.00	6.70
MFTW2+Su	5.41	5.30	5.89	5.87	**MFDW2+Su**	6.84	6.62	6.85	6.61
L.S.D. at 5 %	0.08	0.93	0.12	0.11	**L.S.D. at 5 %**	0.05	0.65	0.04	0.05

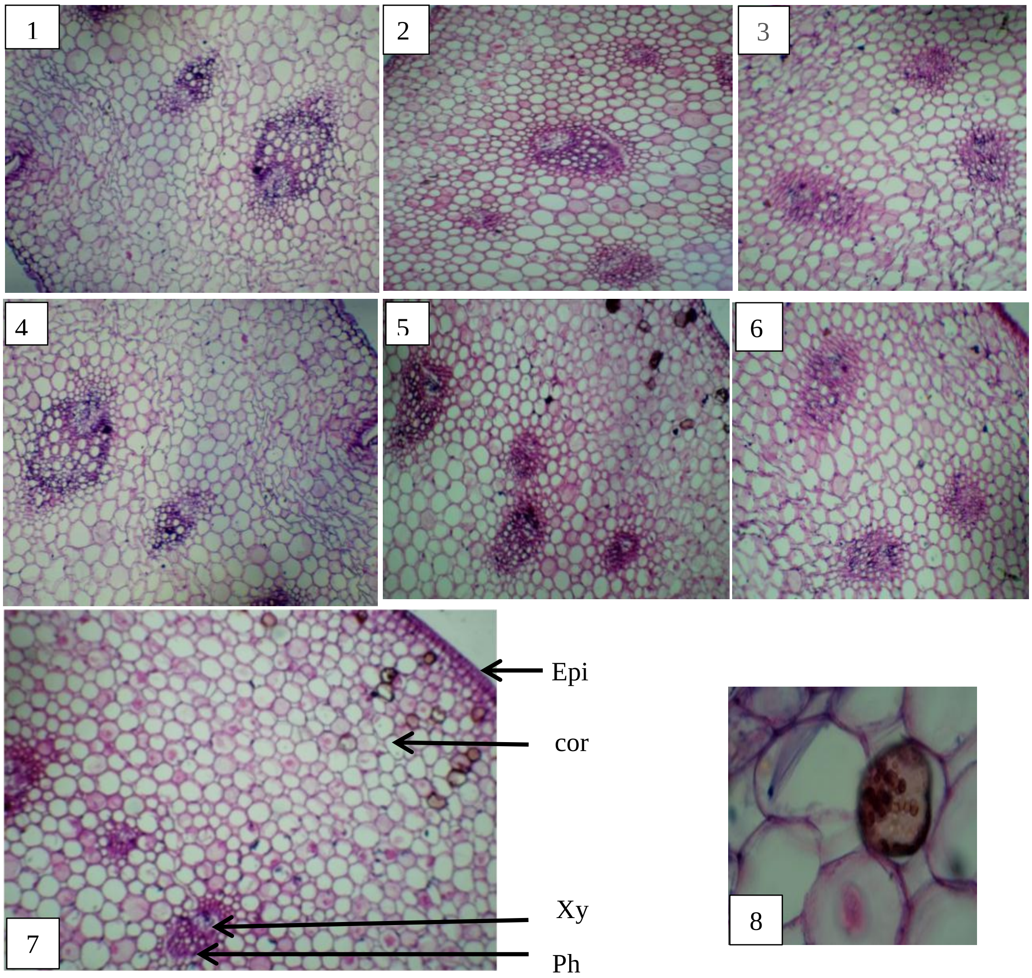
Tap water (TW) - Magnetized tap water (MTW) - Tap water (TW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Tap water (TW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized tap water (MTW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for15minutes (min) then held them in tap water (MFTW1) + sucrose at 25 g/l - Magnetized the cut flowers for 30 minutes then held them in tap water (MFTW2) + sucrose at 25 g/l - Distilled water (DW) - Magnetized distilled water (MDW) - Distilled water (DW) + salicylic acid at 150 ppm (SA1) + sucrose at 25 g/l (Su) - Distilled water (DW) + salicylic acid at 200 ppm (SA2) + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 150 ppm + sucrose at 25 g/l(Su) - Magnetized distilled water (MDW) + salicylic acid at 200 ppm + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 15 minutes then held them in distilled water (MFDW1) + sucrose at 25 g/l(Su) - Magnetized the cut flowers for 30 minutes then holding them in distilled water (MFDW2) + sucrose at 25 g/l(Su).

Fig (1). Cross (Transverse) section of the stem of cut tulip flowers cleared treatments with a control

1-MDW+SA2+Su 4- MDW+SA1+Su 7- control

2-MTW+SA2+Su 5- MFTW1+Su 8- zoom of section from control

3- MTW+SA1+Su 6- MFDW1+Su Epi- epidermis xy-xylem ph- phloem cor- cortex



The chemical analyses

Chlorophyll (a + b) and carotenoids (mg/100g f.w.

Chlorophyll is a photosynthetic pigment, a gauge of plant health and responsible for stress response mechanisms. Using the different magnetic treatments significantly alleviated the adverse effects of drought at the beginning of the degradation stage by improving the chlorophyll content. The results in Fig (2) specify the influence of magnetic treatments on chlorophyll concentration in the leaves. The chlorophyll content in the treatment of MTW + SA1 + Su and MDW + SA1 + Su groups which gave a high value but less than the MFTW1 + Su and MFDW1 + Su groups which, had the highest value of chlorophyll content compared to the control group. Obviously, the ability of magnetized distilled and tap water with salicylic acid in addition to magnetized flowers to increase the content of photosynthetic pigments is considered beneficial for flowers. **Pietruszewski and Martínez (2015)** recognized the increase of photosynthetic pigments chlorophylls (a+b) in cut flowers of tulips that were treated with magnetization compared to the ones that non-magnetized. These results may be attributed to that the magnetic field stimulated lipid synthesis in chloroplast, mitochondria and other cell membranes **(Novitskii *et al.*, 2014).** The application of magnetized water to plants could increase chlorophyll levels due to the paramagnetic properties of chloroplasts which can be affected by magnetization by increasing ion mobility and ion absorption and increases photostimulation **(Sutiyanti and Rachmawati, 2021).**

The carotenoids are among the most important pigment take part in antioxidative defense in higher plants. According data in Fig (3) it is evident that the most significant effects on carotenoids content were obtained from the flowers treated with magnetized distilled and tap water in combination with salicylic acid, these results are in agreement with the results obtained by the after mentioned scholar **Sutiyanti and Rachmawati (2021)** who found that magnetized water treatments could increase levels of carotenoids.

Reducing and total sugars (%)

From the data described in Fig (4 and 5) it is clear that, using the combined treatment between magnetized tap water, salicylic acid and sucrose increased the content of reducing sugars in cut flowers and produced the highest percentage in the first and second seasons. On the other hand, using the combined treatment of magnetized distilled water plus sucrose increased the reducing sugars content in cut flowers and gave the highest percentage in the first and second seasons.

Among the individual treatments, the obtained data in Fig (5) demonstrated that, the combined treatment between magnetized tap and distilled water and sucrose with or without salicylic acid increased the percentage of sugars and the maximum percent was in cut flowers treated by magnetized water, salicylic acid and sucrose and minimum recorded in control flowers in both seasons.

Anthocyanins (m/100gm) and total phenols (%)

Anthocyanins are a class of naturally occurring antioxidants that belongs to the group of polyphenols and it's known as pigments plentiful in highly colored plants.

The highest anthocyanin content was found at flower treated with magnetized tap water, salicylic acid at 150 ppm and sucrose at 25g/l compared to other treatments including control. (Fig,6). Furthermore, the flowers that were treated with magnetization for 15 and 30 min gave close percentages of anthocyanin content and achieved high results compared to the rest of the treatments. It might be attributed to the magnetization process's delayed senescence which caused the degradation of the pigment, in addition, the effect of salicylic acid in maintains the flower content of anthocyanins by reducing malondialdehyde (MDA) content by lowering cell membrane permeability, membrane lipid peroxidation thereby maintaining membrane integrity and accordingly adjourning the senescence of cut flowers **(Singh *et al.*, 2018).**

Phenolic compounds are important plant constituents with redox properties responsible for antioxidant and gave a strong correlation with antioxidant activity. The increased synthesis of phenol due to the effect of magnetization could be the reason for minimizing ROS production. Data presented in Fig (7) show that using salicylic acid at 200 ppm in magnetized tap water mixed with sucrose at 25 g/l achieved the highest value of phenols content in cut tulips in the first and second seasons. Phenaolic molecules are responsible for deactivating free radicals based on their ability to donate hydrogen atoms to free radicals. The magnetization procedure prevents oxidative stress damage by reducing H_2O_2, SOD, POD and CAT activities and the metabolic energy used for scavenging the free radicals **(Radhakrishnan,2019)** which extends vase life of cut flowers.

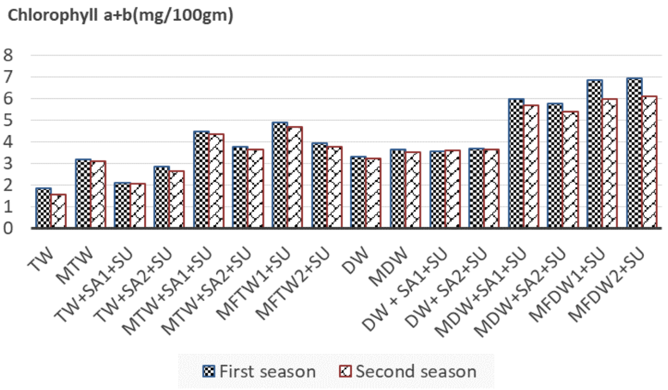


Fig.2 Effect of magnetized (tap and distilled) water and salicylic acid on chlorophyll (a + b) content (mg/100gm f.w.) of tulips during the two seasons.

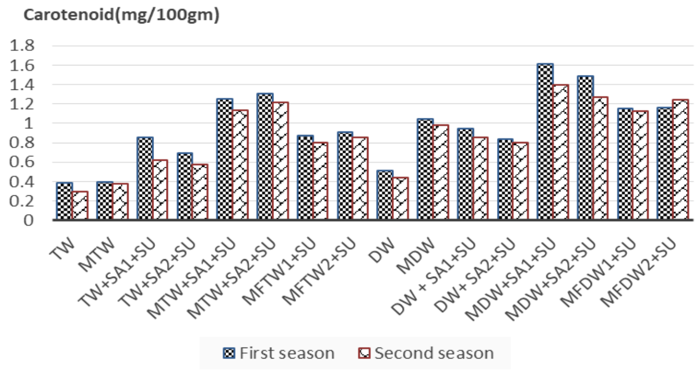


Fig.3 Effect of magnetized (tap and distilled)water and salicylic acid on carotenoids content (mg/100gm f.w.) of tulips during the two seasons.

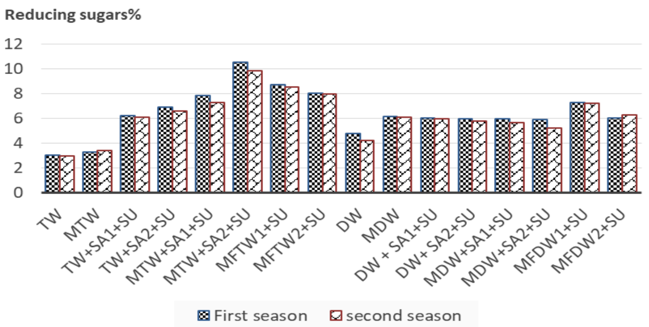


Fig.4 Effect of magnetized (tap and distilled) water and salicylic acid on reducing sugars (%) of tulips during the two seasons.

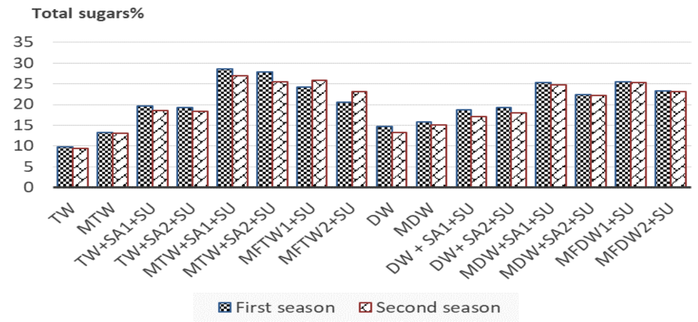


Fig.5 Effect of magnetized (tap and distilled) water and salicylic acid on total sugars (%)of tulips during the two seasons.

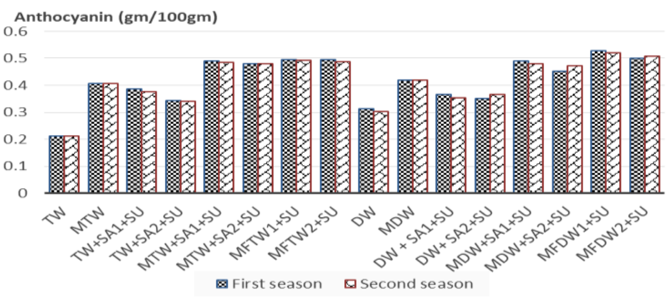


Fig.6 Effect of magnetized (tap and distilled)water and salicylic acid on anthocyanins content (m/100gm)of tulips during the two seasons.

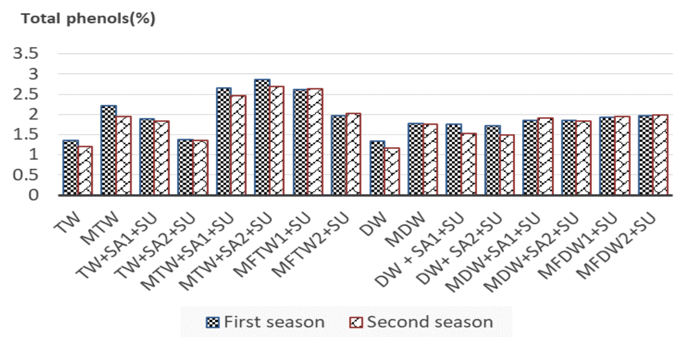


Fig.7 Effect of magnetized (tap and distilled) water and salicylic acid on total phenols (%)of tulips during the two seasons.

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