EFFECT OF POTASSIUM NITRATE AND ADENOSINE TRIPHOSPHATE ON PRE- AND POST-HARVEST GERBERA (GERBERA JAMESONII L.) PLANTS

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ABSTRACT: The pot experiment was conducted during the two consecutive seasons of 2016 and 2017 in plastic house at Horticulture Research Station, Mansoura, Dakahlia Governorate, Egypt as pre-harvest treatments. The main objective of the first experiment was to study the effect of two rates of adenosine triphosphate (0.0 and 7.0 g/l) alone or combined with potassium nitrate at the dose of 2.5, 5.0, 7.5 and 10.0 g/pot, on vegetative growth, flowering and chemical constituents of gerbera (Gerbera jamesonii). The highest values of plant height, number of leaves per plant, leaf area, number of flowers per plant, flower diameter, stalk length as well as the contents of total chlorophyll, carbohydrates, N, P, and K in plants were achieved with adenosine triphosphate (ATP) at 7 g/l as weekly foliar spray with significant difference compared to control. Also, increasing potassium nitrate from 2.5 up to 10.0 g/pot gradually increased the above mentioned parameters during both seasons. Furthermore, using the highest doses of potassium (7.5 and 10.0 g/pot) in interaction with ATP at 7 g/l significantly increased gerbera growth, flowering and chemical constituents compared to untreated plants and the other interaction treatments. From the first experiment the best interaction treatments were 7.5 and 10.0 g potassium nitrate/pot plus1 7 g ATP/l, these treatments were in the second experiment to study the effect of different pulsing solutions on flower vase life, solution uptake and flower fresh weight of gerbera. The obtained results revealed that, the longest vase life of gerbera and the highest quality cut flowers were obtained by using the combination treatments between (7.5 g potassium nitrate/pot + 7 g ATP/l) combined with 3% sucrose + 8-HQS at 200 ppm as holding solution. By studying simple correlation coefficients, gerbera cut flowers vase life exhibited strong positive relationship with each of water uptake and flower fresh weight which, indicated that the increase in these parameters was accompanied by increasing vase life of gerbera cut flowers under the effect of interaction treatments of pre and postharvest.

Key words: Gerbera, ATP, potassium nitrate, growth, cut flowers, chemical constituents, vase life, solution uptake.

INTRODUCTION

For the time being, cut flowers take up a remarkable position in the regional and foreign markets in order to their value as a source of national income of Egypt. Gerbera (Gerbera jamesonii L.) Fam. Asteraceae is an important decorative flower and is ordinarily utilized as a flowering pot plant and is one of 10 widespread cut flowers in the world which takes the 4th place according to the global orientation in floriculture (Choudhary and Prasad, 2000).
Adenosine triphosphate (ATP) is an all-over energy source, but acts as a neurotransmitter extracellular. ATP and else nucleoside triphosphates not only push energy-subordinate reactions into cells, but can also work outside the plasma membrane in the extracellular model, where they job as agonists that can encourage varied physiological replies without being hydrolyzed. This exterior function of ATP is well determined in animal cells but only lately has turn onto visible that extracellular ATP (eATP) can also job as a signaling factor in plants (Roux and Steinebrunner, 2007).

The application of potassium nitrates fertilizer may increase growth and flowering quality of cut flower plants. However, the application of KNO₃ significantly increased leaf area and its fresh and dry weight per plant irrespective to the growth of sunflower and safflower plants (Jabeen and Ahmad, 2011). Also, various concentrations potassium nitrate had significant effects on water uptake of chrysanthemum flower shelf life compared to control (Souri et al., 2018). Furthermore, nitrogen rates have positive correlations with total chlorophyll content and photosynthesis efficiency of plant leaves, which reflected in enhancing plant growth and flowering (Marschner, 2011). This can raise production of carbohydrate and sugar in plant tissues. On the other hand, nitrogenous compounds can influence ethylene production, chlorophyll declination and ion leakage in plant tissues (Druge, 2000). In fact, any internal or external factors that inhibit ethylene production can also increase cut flower vase life.

In addition, Halevy and Mayak (1979) found that sucrose irritates the influence of ABA, which encourages senescence. Usage of 8-hydroxy quinolone sulfate (8-HQS) reduced vascular blockages in rose cut flowers (Marousky, 1971). As well, sucrose lonely has not been ordinarily applied, because sugar treatment without disinfectant elevates bacterial reproduction, leading to shortening vase life. The use of 8-HQS increased vase life, wet weight, dry weight, flower diameter and mean absorbed preservative solution, it reduced the stem drooping in gerbera cut flowers (Banaee et al., 2013).

Therefore, the main purpose of the current study was to evaluate the effectiveness of pre-harvest treatments (potassium nitrate and adenosine triphosphate) on growth, flowering and chemical constituents as well as the effect of postharvest treatments (sucrose and 8-HQS as holding solutions) in combination with KNO₃ and ATP on prolonging vase life and keeping quality of Gerbera jamesonii L. cut flowers.

**MATERIALS AND METHODS**

This work was conducted in Horticulture Research Station at Mansoura, Dakahlia Governorate, Egypt, during the two consecutive seasons of 2016 and 2017 in plastic house. The first aim of the study was to investigate the effect of different pre-harvest treatments of adenosine triphosphate (0.0 and 7.0 g/l) and potassium nitrate concentrations (2.5, 5.0, 7.5 and 10.0 g/pot at 25 cm diameter) on growth, flowering and chemical constituents of Gerbera jamesonii (yellow color). A split plot design based on completely randomized design was utilized in this experiment. The ATP treatments was designated as the main plot whereas potassium nitrate at different concentrations were designed as sub plots.

Gerbera transplants obtained from private nursery (Abo-Shaish’s sons) at Mansoura, Dakahlia Governorate, Egypt, during the first of February. All seedlings were similar in growth and 10 cm in length. Transplants were planted in pots 25 cm diameter filled with 6 kg of sand:peat moss (1:1 v/v) with adding individual calcium super phosphate (15.5% P₂O₅) at 5 g/pot during the mixing on 10th February in the two seasons. After a month from planting, the plants were weekly sprayed with ATP from the beginning of 10th March until the end of each season (10 times). Adenosine-5-
triphosphoric acid disodium salt 95% (ATP) as almost white crystalline powder with 2.5-3.5 pH (1% in water) were obtained from Oxford Lab Fine Chem Company, India. Commercial potassium nitrate (46.2% K2O + 13.7 %N) product is produced by Kemapco Arab Fertilizers and Chemical Industry, Jordan.

Data recorded:

- Growth parameters: after 100 days from planting date, plant height (cm), number of leaves/plant and leaf area (cm²) were recorded.
- Flowering parameters: number of days to flowering, number of flowers/plant, flower diameter (cm) and inflorescence spike length (cm) were listed recorded.
- Chemical constituents: total chlorophyll content mg/g f.w. as fresh weight of leaves were analyses according to A.O.A.C. (1990). Also, total carbohydrates percentage was determined in the dried leaves samples, colorimetrically according to the method described by Jackson (1973). Moreover, total nitrogen, total phosphorus and potassium percentages in dried leaves of gerbera plant were determined according to Chapman and Pratt (1978).

The second part of the study aimed to investigate the response of postharvest parameters of gerbera flowers and correlation between them to the best pre-harvest treatments of 7.0 g ATP/l + 7.5 KNO3 g/pot as well as 7.0 g ATP/l +10.0 g KNO3/pot combined with holding solutions using sucrose (S) at 1, 3 and 5% and 8-hydroxy quinolene sulphate (8-HQS) at 100 and 200 ppm as follows;

1. Distilled water (D.W.) as control;
2. 1% S+ 100 ppm 8-HQS;
3. 3% S+ 100 ppm 8-HQS;
4. 5% S+ 100 ppm 8-HQS;
5. 1% S+ 200 ppm 8-HQS;
6. 3% S+ 200 ppm 8-HQS and 7. 5% S+ 200 ppm 8-HQS.

The desired flowers of uniform size 8 cm diameter, 25 cm flower stalk length with yellow colure, free from diseases and pests were chosen and harvested using sideward push near the base of the flower stem, by holding the clump. The flowers were harvested when the ray florets are perfectly outspread. Promptly after harvest the gerbera flowers were brought to the laboratory (light fluorescent about 450 lux, temperature 23-25 °C and 60-70% relative humidity) for imposing the treatments. Gerbera cut flowers were held in glass containers with seven different vase solutions.

A split plot design based on completely randomized design was utilized in this experiment. The main plot was the pre-harvest treatments. Each plot was divided into seven flower groups, using holding solution treatments were applied in each group.

Data recorded:

- Post-harvest parameters: vase life (days), flower diameter (cm), solution uptake (ml) and flower fresh weight (g) were recorded.
- Correlation coefficient: simple correlation coefficients between post-harvest parameters of gerbera cut flowers under the effects of combinations between pre-harvest treatments (7.0 g ATP/l + 7.5 KNO3 g/pot as well as 7.0 g ATP/l +10.0 g KNO3/pot) and holding solutions were prepared according to Guler et al. (2001).

Experimental design and statistical analysis:

The complete randomized block design (CRBD) in a split-plot design was used in the two experiments with three replicates. The obtained data were statistically analyzed and the means were compared using least significant difference (L.S.D) at 5% level as reported by Gomez and Gomez (1984). The means were compared using computer program of Statistix version 9 (Analytical software, 2008).
1. Effect of pre-harvest treatments:

Growth parameters:

Data tabulated in Table (1) show that, gerbera plants treated with adenosine triphosphate (ATP) showed significant different performances compared to control. Plants treated with the ATP at a concentration of 7 g/l showed the tallest plants (20.16 and 21.98 cm), the highest number of leaves per plant (27.79 and 29.81) and largest leaves (49.15 and 50.79 cm²) in the first and second seasons, respectively. Moreover, gerbera plant growth parameters gradually increased with increasing potassium nitrate rate from 2.5 to 10 g/pot, in both seasons. The best significant treatments in increasing plant height, number of leaves per plant and leaf area were that 7.5 and 10 g/pot with no significant difference between them in the first and second seasons.

Generally, increasing potassium nitrate rates under each ATP application increased gerbera growth parameters. These results hold true during the first and second seasons. The best interaction treatment in increasing plant height, leaf number per plant and leaf area was that application of ATP at 7 g/l + 7.5 g KNO₃ compared to the other interaction treatments under study.

Furthermore, adenosine triphosphate (ATP) is a life's form of energy. The ATP molecule has 3 phosphates jointed with an adenosine molecule. The latest phosphate bond withholds a lot of energy. As energy is wanted for cell division, the ATP is utilized to carry out cell division. If the plant cells hold a great supply of ATP, cell division is able to occur rapidly and more often (Merrett and Handoll, 1967). This means that with greater amount of ATP, gerbera plant is capable to grow to a greater height as well as more leaves number and its area.

### Table 1. Effect of adenosine triphosphate (ATP), potassium nitrate and their interactions on plant height, leaf number per plant and leaf area of gerbera during the two seasons of 2016 and 2017.

| Treatments | Plant height (cm) | Number of leaves/plant | Leaf area (cm²) |
|------------|-------------------|------------------------|-----------------|
|            | 2016   | 2017   | 2016   | 2017   | 2016   | 2017   |
| Without    | 19.17  | 20.47  | 24.89  | 26.48  | 43.44  | 44.59  |
| With       | 20.16  | 21.98  | 27.79  | 29.81  | 49.15  | 50.79  |
| LSD at 5%  | 0.36   | 0.97   | 1.22   | 1.11   | 1.07   | 0.62   |
| Adenosine triphosphate application (7 g/l) |   |   |   |   |   |
| Potassium nitrate rate (g/pot) |   |   |   |   |   |
| 2.5        | 18.23  | 19.69  | 21.93  | 23.68  | 39.04  | 40.99  |
| 5.0        | 18.63  | 19.91  | 25.39  | 26.26  | 43.46  | 43.97  |
| 7.5        | 20.94  | 22.71  | 28.77  | 30.89  | 50.89  | 52.31  |
| 10.0       | 20.87  | 22.60  | 29.25  | 31.74  | 51.77  | 53.48  |
| LSD at 5%  | 0.80   | 1.17   | 1.31   | 1.50   | 1.85   | 1.29   |
| Interaction effect between adenosine triphosphate and potassium nitrate |   |   |   |   |   |
| Without ATP | 17.95  | 19.25  | 20.01  | 21.92  | 37.05  | 38.86  |
| 5.0        | 18.57  | 19.52  | 24.87  | 25.52  | 40.50  | 40.96  |
| 7.5        | 19.63  | 21.03  | 26.75  | 27.98  | 45.42  | 46.48  |
| 10.0       | 20.54  | 22.08  | 27.91  | 30.49  | 50.76  | 52.04  |
| 2.5        | 18.51  | 20.13  | 23.86  | 25.45  | 41.03  | 43.12  |
| With ATP   | 18.68  | 20.29  | 25.92  | 26.99  | 46.42  | 46.98  |
| 5.0        | 18.25  | 19.49  | 24.39  | 25.79  | 50.36  | 51.14  |
| 7.5        | 21.19  | 23.11  | 30.58  | 33.00  | 52.79  | 54.91  |
| LSD at 5%  | 0.95   | 1.80   | 2.16   | 2.17   | 2.39   | 1.56   |
application of KNO₃ significantly increased leaf area, its fresh and dry weight per plant for the growth of sunflower and safflower plants (Jabeen and Ahmad, 2011). Also, the tested parameters (plant height, number of leaves/plant as well as fresh and dry weight) of coriander plants were generally positively influenced by potassium nitrate application (Elhindi et al., 2016). In addition, as mentioned just before, both ATP application and potassium nitrate fertilization rates (each alone) increased growth parameters of gerbera plant, in turn; they together might maximize their effects leading to taller, more leaves and larger leaves area.

**Flowering parameters:**

As shown in Table (2), the longest period required to flowering (122.92 and 122.42 days) was recorded without ATP application, while the shortest one (118.92 and 117.25 days) was observed with ATP application in the first and second seasons, respectively. No significant difference was noticed between the two treatments of ATP for the number of flowers per gerbera plant in both seasons. However, flower diameter and stalk length of gerbera plant were significantly increased by using ATP at 7 g/l compared to control in the two seasons (Tables 2 and 3). All treatments of potassium nitrate resulted a remarkable increase over control for the early flowering (days), number of flowers per plant, flower diameter (cm) and stalk length (cm). The best treatment in this connection was that 7.5 and 10 g/pot of potassium nitrate compared to the other ones under study during 2016 and 2017 seasons. In general, increasing KNO₃ rates under each ATP application increased gerbera flowering parameters (number of days to flowering, number of flowers/plant, flower diameter and inflorescences pike length). The best interaction treatment in this

| Treatments | Number of days to flowering (2016) | Number of days to flowering (2017) | Number of flowers/plant (2016) | Number of flowers/plant (2017) | Flower diameter (cm) (2016) | Flower diameter (cm) (2017) |
|------------|----------------------------------|-----------------------------------|-------------------------------|-------------------------------|--------------------------|--------------------------|
| Without ATP | 122.92                           | 122.42                           | 3.83                          | 4.08                          | 5.93                     | 6.74                     |
| With ATP   | 118.92                           | 117.25                           | 4.00                          | 4.42                          | 6.99                     | 7.55                     |
| LSD at 5%  | 1.36                             | 1.12                             | N.S.                          | N.S.                          | 0.46                     | 0.61                     |
| Adenosine triphosphate application (7g/l) | | | | | |
| Without ATP | 129.83                           | 128.67                           | 3.33                          | 3.50                          | 5.13                     | 5.59                     |
| With ATP   | 123.17                           | 122.17                           | 3.33                          | 3.83                          | 5.43                     | 6.19                     |
| LSD at 5%  | 2.12                             | 1.99                             | 0.93                          | 0.99                          | 0.81                     | 0.99                     |
| Potassium nitrate rate (g/pot) | | | | | |
| 2.5        | 131.33                           | 130.00                           | 3.33                          | 3.33                          | 5.16                     | 5.19                     |
| 5.0        | 125.67                           | 125.00                           | 3.33                          | 4.00                          | 5.27                     | 6.06                     |
| 7.5        | 120.00                           | 120.33                           | 4.00                          | 4.33                          | 5.79                     | 7.34                     |
| 10.0       | 114.67                           | 114.33                           | 4.67                          | 4.67                          | 7.51                     | 8.36                     |
| LSD at 5%  | 0.94                             | 0.81                             | 0.93                          | 0.99                          | 0.81                     | 0.99                     |
| Interaction effect between adenosine triphosphate and potassium nitrate | | | | | |
| Without ATP | 112.33                           | 108.67                           | 5.00                          | 5.67                          | 9.00                     | 9.13                     |
| With ATP   | 114.33                           | 113.67                           | 4.33                          | 4.67                          | 8.28                     | 8.74                     |
| LSD at 5%  | 2.12                             | 1.99                             | 1.17                          | 1.28                          | 1.04                     | 1.31                     |
regard was that application of ATP + 7.5 and 10 g/pot compared to the other interaction treatments under study.

ATP and other nucleotides can stimulate a raise in the cytosolic Ca\(^{2+}\) concentration and varied downstream changes that effect plant growth and blossom (Demidchik et al., 2003). Also, flowering time decreased with an increase in benzyl adenine (BA) and potassium nitrate rates, while there were no significant influence of BA and potassium nitrate interaction on floret numbers of narcissus plants (Matin et al., 2015). Furthermore, Thaneshwari (2014) indicated that the highest dose of potassium and nitrogen achieving good flowering attributes of hydrangea for commercialization purposes. Applying potassium to soil as dressing gave the highest significant values of number of florets per spike, floret diameter and spike length of gladiolus plant (El-Naggar and El-Nasharty, 2016). In addition, the lowest flower appearing rate of saffron plant was recorded in control, compared with treatments, and the application of 1000 ppm KNO\(_3\) treatment was useful. The results indicated an increasing trend of this variable as KNO\(_3\) levels increased (Khayyat et al., 2018).

**Chemical constituents:**

The obtained data in Tables (3 and 4) showed that, spraying gerbera plants with adenosine triphosphate at 7 g/l recorded the highest values of total chlorophyll content and total carbohydrates percentage as well as total nitrogen, total phosphorus and potassium percentages in leaves compared to untreated plants during the two consecutive seasons. Furthermore, the high levels of

| Treatments | Stalk length (cm)  | Total chlorophyll content (mg/g f.w.) | Total carbohydrates (% d.w.) |
|------------|--------------------|--------------------------------------|-----------------------------|
|            | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| Without ATP | 20.10 | 21.76 | 1.15 | 1.20 | 30.98 | 32.11 |
| With ATP | 22.43 | 24.03 | 1.31 | 1.44 | 34.91 | 36.66 |
| LSD at 5% | 0.63 | 0.90 | 0.04 | 0.04 | 0.74 | 0.74 |

| Potassium nitrate rate (g/pot) | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 2.5 | 15.58 | 17.11 | 1.10 | 1.13 | 27.34 | 28.88 |
| 5.0 | 20.57 | 21.98 | 1.14 | 1.22 | 31.13 | 32.20 |
| 7.5 | 23.80 | 25.92 | 1.37 | 1.57 | 36.54 | 37.78 |
| 10.0 | 25.10 | 26.57 | 1.29 | 1.36 | 36.76 | 38.67 |
| LSD at 5% | 0.57 | 1.00 | 0.07 | 0.04 | 0.85 | 1.29 |

| Interaction effect between adenosine triphosphate and potassium nitrate | 2016 | 2017 | 2016 | 2017 | 2016 | 2017 |
| 2.5 | 15.53 | 17.45 | 1.08 | 1.10 | 24.71 | 26.42 |
| 5.0 | 19.09 | 20.54 | 1.12 | 1.15 | 28.40 | 29.57 |
| 7.5 | 20.71 | 22.99 | 1.13 | 1.23 | 33.90 | 34.57 |
| 10.0 | 25.06 | 26.05 | 1.26 | 1.31 | 36.90 | 37.87 |
| 2.5 | 15.62 | 16.77 | 1.12 | 1.15 | 29.96 | 31.34 |
| 5.0 | 22.06 | 23.42 | 1.17 | 1.28 | 33.87 | 34.83 |
| 7.5 | 26.88 | 28.85 | 1.61 | 1.91 | 39.19 | 41.00 |
| 10.0 | 25.14 | 27.09 | 1.32 | 1.42 | 36.61 | 39.47 |
| LSD at 5% | 1.06 | 1.62 | 0.09 | 0.07 | 1.35 | 1.67 |
Table 4. Effect of adenosine triphosphate (ATP), potassium nitrate rate and their interactions on total nitrogen, total phosphorus and potassium percentages in leaves of gerbera during the two seasons of 2016 and 2017.

| Treatments | Nitrogen (% d.w.) | Phosphorus (% d.w.) | Potassium (% d.w.) |
|------------|------------------|---------------------|-------------------|
|            | 2016             | 2017                | 2016              | 2017                | 2016              | 2017                |
| Adenosine triphosphate application (7g/l) | | | | | | |
| Without ATP | 2.562            | 2.718               | 0.298             | 0.310               | 3.514             | 3.635               |
| With ATP    | 2.847            | 3.001               | 0.323             | 0.340               | 3.874             | 3.993               |
| LSD at 5%   | 0.081            | 0.188               | 0.005             | 0.015               | 0.091             | 0.061               |
| Potassium nitrate rate (g/pot) | | | | | | |
| 2.5         | 2.428            | 2.707               | 0.285             | 0.296               | 3.185             | 3.277               |
| 5.0         | 2.593            | 2.712               | 0.303             | 0.313               | 3.633             | 3.685               |
| 7.5         | 2.875            | 2.997               | 0.326             | 0.356               | 3.933             | 4.133               |
| 10.0        | 2.920            | 3.022               | 0.327             | 0.334               | 4.025             | 4.160               |
| LSD at 5%   | 0.038            | N.S.                | 0.008             | 0.026               | 0.063             | 0.133               |
| Interaction effect between adenosine triphosphate and potassium nitrate | | | | | | |
| Without ATP | 2.277            | 2.680               | 0.263             | 0.282               | 2.957             | 3.090               |
| With ATP    | 2.420            | 2.547               | 0.286             | 0.303               | 3.400             | 3.463               |
| 7.5         | 2.667            | 2.710               | 0.316             | 0.323               | 3.753             | 3.883               |
| 10.0        | 2.883            | 2.933               | 0.326             | 0.330               | 3.947             | 4.103               |
| 2.5         | 2.580            | 2.733               | 0.308             | 0.310               | 3.413             | 3.463               |
| With ATP    | 2.767            | 2.877               | 0.321             | 0.323               | 3.867             | 3.907               |
| 7.5         | 3.083            | 3.283               | 0.335             | 0.390               | 4.113             | 4.383               |
| 10.0        | 2.957            | 3.110               | 0.327             | 0.337               | 4.103             | 4.217               |
| LSD at 5%   | 0.121            | 0.427               | 0.011             | 0.033               | 0.143             | 0.158               |

Potassium nitrate rates significantly increased most of chemical constituents of leaves compared to the lowest rate (2.5 g/l), in both seasons. Generally, the effects of KNO₃ at 7.5 and 10 g/pot were significant on total chlorophyll content as well as the treatments of carbohydrates, phosphorus and potassium percentages, whenever, total nitrogen percentage in gerbera leaves was not significant, as compared with the control in the second season only. The best interaction treatment for increasing total chlorophyll content as well as total carbohydrate, N, P and K percentages was that 7 g/l ATP + 7.5 g/pot KNO₃ compared to the other interaction treatments under study in both seasons.

In addition, as mentioned just before, both ATP application and potassium nitrate rate (each alone) increased growth and flowering parameters of gerbera plant, in turn, they together might maximize their effects leading to more chlorophyll content, total carbohydrates and NPK percentages. Moreover, plants which were foliar sprayed by ATP in low and high concentrations enhanced the chemical composition (nitrogen, phosphorus, potassium and total carbohydrates percentages) of fresh and/or dry plants and green pods of snap bean plant (Abdel-Hakim et al., 2012). Potassium elevates the development of meristematic tissue, reactive some enzymatic reactions, aids in nitrogen metabolism, and the synthesis of proteins, some mineral elements catalyzes activities and aid in metabolism and translocation of carbohydrates (Zörb et al., 2014). Also, increasing nitrogen fertilization rates in combination with different potassium fertilization rates increased chemical constituents of hydrangea (Chhune, 2015). However, Elbohy (2017) pointed out that the maximum values of total chlorophyll (SPAD unit) and total carbohydrates (%) in the sunflower leaves...
were obtained by treating plants with N + K fertilization rates at 5 + 7.5 g/pot, respectively.

2. Effect of the best pre-harvest × holding solutions treatments:

Postharvest parameters:

Data presented in Table (5) show that, gerbera plants treated with potassium nitrate at 7.5 g/pot + adenosine triphosphate (ATP) at 7 g/l showed significant increases in gerbera flowers vase life, flower diameter, solution uptake and flower fresh weight compared to the highest rate (10 g KNO₃/pot + 7 g/l ATP) without significant differences between them in both seasons. Moreover, all holding solutions under study significantly increased abovementioned parameters of gerbera flowers compared to control (distilled water) during the two seasons, in most cases. Furthermore, the highest values in flower vase life, flower diameter, solution uptake and flower fresh weight of gerbera were obtained by the treatment of 3% sucrose (S) + 200 ppm of 8-hydroxy quinolenesulphate (8-HQS) compared to the other holding solutions under study in both seasons. In general, increasing holding solutions concentrations up to 3% (S) + 200 ppm (8-HQS) under the two rates of KNO₃ + ATP increased gerbera postharvest parameters. The best combination treatment in this concern was that (7.5 g KNO₃/pot + 7 g/l ATP) interacted with holding solution at 3% (S) + 200 ppm (8-HQS) compared to the other interaction treatments under study.

It was found through previous results that ATP + potassium nitrate led to improved vegetative growth, flowering parameters and chemical constituents of gerbera plants as pre-harvest treatments. This was reflected in the post-harvest parameters of gerbera cut flowers. In this regard, the size and shelf life of zinnia cut flowers significantly increased with the highest rates of pre-harvest P and K fertilizers application (Abbası et al., 2004). In addition, pre-treatment of chrysanthemum with potassium nitrate could significantly enhance shelf life and postharvest flower qualities. There was constant increase in water solution uptake by increasing the levels of potassium nitrate (Souri et al., 2018).

Correlation coefficients:

Data presented in Table (6) reveal that, the results of simple correlation coefficients between some characters of vase life and solution uptake, flower fresh weight as well as flower diameter of gerbera cut flowers under the effects of the interaction treatments between the best pre-harvest treatments (7.5 or 10 g KNO₃/pot + 7 g ATP/l) and holding solution treatments. Gerbera cut flowers vase life exhibited strong positive relationship with each of solution uptake, flower fresh weight and flower diameter, which, indicated that the increase in solution uptake was accompanied by increasing vase life of gerbera cut flowers under the effect of interaction treatments of pre-harvest treatments and holding solution. These results are in accordance with those stated by Diab et al. (2015) on sweet pea and El-Ghazouly et al. (2016) on gerbera cut flowers.

CONCLUSION

From the above mentioned results, it is preferable to fertilize Gerbera jamesonii L. plants with 7.5 g/pot in two doses of potassium nitrate with 7 g/l of ATP sprayed 10 times to improve the growth parameters, flowering characters and chemical constituents of the plant under Dakahlia Governorate conditions. Also, using pre-harvest treatments especially above rate (7.5 KNO₃/pot + 7 g ATP/l) and holding solution (3% sucrose + 200 ppm of 8-hydroxy quinolenesulphate) was the best treatment for enhancing vase life and gerbera cut flowers quality.

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Table 5. Effect of potassium nitrate rate, adenosine triphosphate (ATP) and pulsing solution treatments as well as their interactions on vase life, flower diameter, solution uptake and flower fresh weight of gerbera during the two seasons of 2016 and 2017.

| Treatments                  | Vase life (days)  | Flower diameter (cm) | Solution uptake (ml) | Flower fresh weight (g) |
|-----------------------------|-------------------|----------------------|----------------------|------------------------|
|                             | 2016          | 2017                 | 2016          | 2017                 | 2016          | 2017                 |
| KNO₃ at 7.5 g + ATP         | 10.52          | 11.24                | 9.03           | 9.23                 | 16.04         | 16.60                | 47.49          | 49.13                |
| KNO₃ at 10 g + ATP          | 10.38          | 11.19                | 8.80           | 9.06                 | 15.51         | 15.99                | 46.80          | 47.75                |
| LSD at 5%                   | N.S.            | N.S.                 | 0.13           | N.S.                 | 0.18          | N.S.                 | 0.95           |                      |

### Potassium nitrate (g/pot) + adenosine triphosphate (7 g/l)

| Treatments                  | 2016          | 2017                 | 2016          | 2017                 |
|-----------------------------|---------------|----------------------|---------------|----------------------|
| Distilled water             | 7.17          | 7.83                 | 8.19          | 8.34                 |
| 1% S + 100 ppm 8-HQS        | 8.00          | 8.50                 | 8.68          | 8.79                 |
| 3% S + 100 ppm 8-HQS        | 10.00         | 11.00                | 8.90          | 9.07                 |
| 5% S + 100 ppm 8-HQS        | 11.00         | 11.83                | 8.88          | 8.96                 |
| 1% S + 200 ppm 8-HQS        | 12.50         | 13.17                | 8.96          | 9.18                 |
| 3% S + 200 ppm 8-HQS        | 13.33         | 14.00                | 9.58          | 9.90                 |
| 5% S + 200 ppm 8-HQS        | 11.17         | 12.17                | 9.22          | 9.78                 |
| LSD at 5%                   | 1.04          | 1.24                 | 0.36          | 0.24                 |

### Pulsing solution treatments

| Treatments                  | 2016          | 2017                 | 2016          | 2017                 |
|-----------------------------|---------------|----------------------|---------------|----------------------|
| Distilled water             | 7.33          | 7.67                 | 8.17          | 8.22                 |
| 1% S + 100 ppm 8-HQS        | 7.67          | 8.33                 | 8.85          | 9.10                 |
| 3% S + 100 ppm 8-HQS        | 9.67          | 10.67                | 8.98          | 9.06                 |
| 5% S + 100 ppm 8-HQS        | 11.00         | 12.00                | 8.92          | 9.02                 |
| 1% S + 200 ppm 8-HQS        | 12.67         | 13.00                | 9.06          | 9.22                 |
| 3% S + 200 ppm 8-HQS        | 14.00         | 14.67                | 9.92          | 10.17                |
| 5% S + 200 ppm 8-HQS        | 11.33         | 12.33                | 9.32          | 9.80                 |
| Distilled water             | 7.00          | 8.00                 | 8.22          | 8.45                 |
| 1% S + 100 ppm 8-HQS        | 8.33          | 8.67                 | 8.51          | 8.47                 |
| 3% S + 100 ppm 8-HQS        | 10.33         | 11.33                | 8.81          | 9.07                 |
| 5% S + 100 ppm 8-HQS        | 11.00         | 11.67                | 8.83          | 8.90                 |
| 1% S + 200 ppm 8-HQS        | 12.33         | 13.33                | 8.86          | 9.13                 |
| 3% S + 200 ppm 8-HQS        | 12.67         | 13.33                | 9.24          | 9.62                 |
| 5% S + 200 ppm 8-HQS        | 11.00         | 12.00                | 9.11          | 9.76                 |
| LSD at 5%                   | 1.46          | 1.69                 | 0.61          | 0.33                 |

**Interaction effect between ATP and KNO₃ and pulsing solutions**

| Treatments                  | 2016          | 2017                 | 2016          | 2017                 | 2016          | 2017                 |
|-----------------------------|---------------|----------------------|---------------|----------------------|---------------|----------------------|
| Distilled water             | 7.33          | 7.67                 | 8.17          | 8.22                 | 11.97         | 12.31                | 34.75          | 35.83                |
| 1% S + 100 ppm 8-HQS        | 7.67          | 8.33                 | 8.85          | 9.10                 | 12.72         | 13.11                | 46.46          | 46.91                |
| 3% S + 100 ppm 8-HQS        | 9.67          | 10.67                | 8.98          | 9.06                 | 13.88         | 13.90                | 49.93          | 51.16                |
| 5% S + 100 ppm 8-HQS        | 11.00         | 12.00                | 8.92          | 9.02                 | 13.55         | 13.46                | 49.85          | 50.34                |
| 1% S + 200 ppm 8-HQS        | 12.67         | 13.00                | 9.06          | 9.22                 | 18.76         | 19.37                | 47.73          | 48.53                |
| 3% S + 200 ppm 8-HQS        | 14.00         | 14.67                | 9.92          | 10.17                | 21.33         | 22.56                | 52.16          | 56.73                |
| 5% S + 200 ppm 8-HQS        | 11.33         | 12.33                | 9.32          | 9.80                 | 20.11         | 21.49                | 51.56          | 54.43                |
| Distilled water             | 7.00          | 8.00                 | 8.22          | 8.45                 | 11.46         | 12.08                | 34.72          | 35.37                |
| 1% S + 100 ppm 8-HQS        | 8.33          | 8.67                 | 8.51          | 8.47                 | 12.57         | 12.95                | 45.77          | 45.84                |
| 3% S + 100 ppm 8-HQS        | 10.33         | 11.33                | 8.81          | 9.07                 | 13.69         | 13.64                | 49.32          | 50.34                |
| 5% S + 100 ppm 8-HQS        | 11.00         | 11.67                | 8.83          | 8.90                 | 13.54         | 13.40                | 48.58          | 49.34                |
| 1% S + 200 ppm 8-HQS        | 12.33         | 13.33                | 8.86          | 9.13                 | 16.36         | 17.31                | 47.26          | 48.35                |
| 3% S + 200 ppm 8-HQS        | 12.67         | 13.33                | 9.24          | 9.62                 | 20.67         | 21.84                | 51.23          | 52.87                |
| 5% S + 200 ppm 8-HQS        | 11.00         | 12.00                | 9.11          | 9.76                 | 20.28         | 20.74                | 50.75          | 52.14                |
| LSD at 5%                   | 1.46          | 1.69                 | 0.61          | 0.33                 | 0.84          | 0.73                 | 1.32           | 1.36                 |

S = sucrose, 8-HQS = 8-hydroxy quinolenesulphate.
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Table 6. Simple correlation coefficients between vase life and solution uptake, flower fresh weight and flower diameter during 2016 and 2017 seasons.

| Characters | 2016          | 2017          |
|-----------|---------------|---------------|
|           | 1  | 2  | 3  | 1  | 2  | 3  |
| Y. Vase life (day) | 0.716** | 0.740** | 0.707** | 0.770** | 0.703** | 0.731** |
| 1. Solution uptake | 0.630** | 0.726** | 0.684** | 0.828** |
| 2. Flower fresh weight | 0.709** | 0.842** |
| 3. Flower diameter |               |               |

The *P* values were highly significant (0.000).

Table 6. Simple correlation coefficients between vase life and solution uptake, flower fresh weight and flower diameter during 2016 and 2017 seasons.
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مساحة الورقة، عند الأزهار لكل نبات، قطر الزهرة، طول الساق الزهرية، بالإضافة إلى المحتوى الكلي من الكولورفين والنسب المولوية للكربوهيدرات، النتروجين، الفسفور والبوتاسيوم بأوراق الجرذانى باستخدام الري الأتموسفي من ثلاثي فوسفات الأدينوزين (ATP) بمعادل 7 جم/لتر مع وجود فرق معنوي مع الكندرول كما أدت زيادة تركيزات نترات البوتاسيوم من 2.5 إلى 100 جم/أصيص إلى زيادة تدريجية للصفات السابقة خلال المسمى. علاوة على ذلك، فإن استخدام أعلى تركيزات من نترات البوتاسيوم (7.5 و 100 جم/أصيص) بالداخل مع ATP بمعادل 7 جم/لتر أدى إلى زيادة معنوية في النمو الخضري للجرذانى والصفات الزهرية والكيميائية مقارنة بالنباتات غير المعاملة ومعاملات التفاعل الأخرى. تم اختيار أفضل معاملات التداخل السابقة (7/5 و 100 جم من نترات البوتاسيوم/أصيص + 7 جم/لتر) من التجربة الأولى لدراسة تأثير محايل الحفظ الدائمة على طول عمر الأزهار في الفازة، ومقدار إمتصاص محلول الحفظ وزن الأزهار الطازج في معدل ما بعد الحصاد. مع استخدام محايل الحفظ الدائم كندرول في صورة ماء مقطر، السكروز بتركيز 1% + 8-هيدروكسي الكينولين سلفيت + 100 جزء في المليون 3% سكروز + 100 جزء في المليون 8-هيدروكسي الكينولين سلفيت، 1% سكروز + 200 جزء في المليون 8-هيدروكسي الكينولين سلفيت، 3% سكروز + 200 جزء في المليون 8-هيدروكسي الكينولين سلفيت، ونأطول طول عمر الأزهار الطازج في الفازة كان له علاقة إيجابية قوية مع كل من امتصاص الماء والوزن الطازج للأزهار، مما يشير إلى أن زيادة في هذه الصفات كان مصحوبةً بزيادة عمر الأزهار المعطوفة في الفازة تحت تأثير معاملة التداخل بين معاملات ما قبل وبعد الحصاد.