Scientific J. Flowers & Ornamental Plants
www.ssfop.com/journal
ISSN: 2356-7864
doi: 10.21608/sjfop.2022.248727

IMPROVING GROWTH CHARACTERISTICS AND VASE LIFE OF *DENDRANTHEMA GRANDIFLORUM* 'FLYER' USING HUMIC AND FULVIC ACIDS AS BIOSTIMULANTS SUBSTANCES

M. M. Abd El-Baset and M.M. Kasem
Vegetable and Floriculture Department, Faculty of Agriculture, Mansoura University, Egypt

ABSTRACT: A greenhouse experiment was conducted during two consecutive seasons of 2018/2019 and 2019/2020 at the Nursery of Ornamental plants, Faculty of Agriculture, Mansoura University, Egypt, to compare the ability of humic and fulvic acids solely at different concentrations (500,1000,1500 mg/l), besides the control on improving some vegetative, flowering parameters and chemical constituents of mums (*Dendranthema grandiflorum* 'Flyer'). The obtained results cleared that fulvic acid at concentrations of 1500 and 1000 mg/l or humic acid at 1500 mg/l were the most effective treatments for improving the vegetative parameters (plant height, branches number, plant spread, roots/shoots ratio, fresh and dry weights of plant, and leaf area), flowering parameters (days required period for appearing the first inflorescence and 50% of inflorescences, duration of flowering stage and the vase life, inflorescences number/plant, inflorescence diameter). Furthermore, drenching fulvic acid at 1500 and 1000 mg/l or humic acid at 1500 mg/l, promoted the photosynthesis pigments (total chlorophylls and carotenoids), in addition to the percentages of total carbohydrates, nitrogen, phosphorous and potassium in the leaves. Finally, it could be recommended to use fulvic acid at 1000 mg/l or humic acid at 1500 mg/l twice monthly (six times during the flowers production process) as a soil drench before the irrigation process for obtaining the ideal growth characteristics of this important pot and cut flower plant.

Key words: *Dendranthema*, *Chrysanthemum*, mums plant, humic acid and fulvic acid.

Scientific J. Flowers & Ornamental Plants, 9(2):87-102 (2022).

Received:
28/3/2022
Accepted:
13/5/2022

Corresponding author:
M.M. Kasem
mmk@mans.edu.eg

INTRODUCTION

Mums (*Dendranthema grandiflorum,* Ramat) are herbaceous perennial ornamental plants native to China. It belongs to the Asteraceae family, and numerous cultivars have been produced (Kim *et al.,* 2015). The mums consider one of the most popular plants for home use and widely grown in the Mediterranean areas and starts blooming in late summer until the autumn and calling the autumn queen, as it blooms at these times. Mums are ranked as the second most economically important cut flower in the world, after rose (Teixeira da Silva *et al*., 2013), pots or garden plants with various colors and shapes. Mum's pots are normally only temporary guests in our homes, as the duration of their bloom, is around 6 - 8 weeks.

Humic acid (HA) is a heterogeneous mixture of many compounds, with weak aliphatic and aromatic organic acids which are not soluble in water under acid conditions but are soluble in water under alkaline conditions (Mosa *et al*., 2020) that influences variously plant growth and soil traits (Tan, 2003). HA is produced commercially and intended in organic fertilization, and improves soil fertility and increases nutrients availability, enhancing plant growth, yield, and decrease the harmful effect of stresses through various mechanisms inside plants and soil (Moraditochaee, 2012). In addition, it is able for adding to the soil for improving the plants' yield through the actions of plant growth promoting hormones, including cytokinins, auxins, and gibberellins. Its promoting effect may be attributed to many factors, including the natural source and concentration of humic substances, soil pH, and plant species. The benefits of humic acid are attributed to its ability to form complex metal ions resulting an aqueous complex with micronutrients in addition to form an enzymatically active complex which can be carried on reactions that are usually assigned to the metabolic activity of living microorganisms. So, the use of these organic substances in such soil showed good means in that concern. The major functional groups of humic acid include carboxyl, phenolic hydroxyl, alcoholic hydroxyl, ketone and quinoid.

Fulvic acids that are always in solution, especially at the pH of productive agricultural soils, also contribute towards cation exchange capacity of the soil. Due to the solubility of fulvic acids in water and the fact that it can be easily leached out, it is usually only present in very low concentrations (0.2-1% w/v) in peat and compost etc. sources. Therefore, some companies will dry fulvic acids to a powder. Fulvic acid as an organic fertilizer is a non-toxic mineral chelating additive and water binder that maximizes uptake through leaves and stimulates plant productivity (Malan, 2015). It attracts water molecules, helping the soil to remain moist and aiding the movement of nutrients into plant roots. Fulvic acid easily binds or chelates minerals such as iron, calcium, copper, zinc and magnesium, as it can deliver these elements to plant directly (Lotfi *et al.*, 2015). Furthermore, fulvic acid is considered as a metabolic anti-transpiration organic acid, nontoxic, not expensive and did not cause pollution problems with of extensive use (Nardi *et al.,* 2002). Also, fulvic and humic acids have been used to regulate the plant growth under well-watered and drought conditions.

The present research aimed to evaluate the ability of humic and fulvic acids soil drench under different concentrations solely of each beside the control treatment on the vegetative, flowering, vase life and chemical compositions of mums' plant important pot and cut flower plants.

MATERIALS AND METHODS

The existing research was conducted through two successive seasons of 2018/2019 and 2019/2020 at the Floriculture Nursery and Laboratory of the Vegetable and Ornamental Plants Dept., Faculty of Agriculture, Mansoura Univ., Egypt.

Plant material:

Mums' plants (*Dendranthema grandiflorum*, Ramat 'Flyer') as shown in Fig. (a) were purchased from a commercial Nursery at El-Qanater Al-Khayriyah cultured in 5 cm plastic bags filled with a clay soil with a height of 10 cm, approximately. Transplants were planted on October 10th of each season under a plastic greenhouse condition in experimental plots (2.6 × 2.4 m, for each treatment) which consist of three ridges of 60 cm width and 50 cm space between plants. Foliar application by a commercial balanced NPK (Fert plus powder, 20:20:20) at 1.5 g/l was applied after three weeks from the planting date (all plants reached 15 to 20 cm height with 15 to

Fig. a. The plant material under study (*Dendranthema grandiflorum*, Ramat cv. Flyer).

20 leaves/plant) and repeated four times every 14-day intervals, then replaced by foliar application NPK (Gharsfert, 20:50:30 + TE) until 50% of the inflorescence appearing.

Experimental layout:

The treatments were arranged in a randomized complete block design (RCBD) with five replicates, each included three plants. The experiment design consisted of seven treatments as follows: control (without humic and fulvic acids addition), commercial humic acid (Force Humate, Life Force Company, potassium humate 10%) at three concentrations (500, 1000 and 1500 mg/l), and commercial fulvic acid (Pota fulvic, DAMAC for Agriculture Development Company, potassium fulvate 10%) at three concentrations (500, 1000 and 1500 mg/l). Stock solutions of humic and fulvic acids were prepared by dissolving 40 g/l, which led to obtaining a stock solution of 4000 mg/l after that dilutions of every concentration from humic and fulvic acids were prepared. Treatments of humic and fulvic acids were applied twice monthly (six times during the experiment) as a soil drench (each plant received exactly 350 ml) before the irrigation process. Moreover, the experimental soil samples were mechanically and chemically analyzed (Table, a).

Table a. Pre-chemical and physical analysis of the experimental soil before applying treatments.

Mechanical analysis		Soluble cations (meq/100 g soil)	
Coarse sand (%)	1.92	**Ca^{++}**	1.85
Fine sand (%)	28.37	**Mg^{++}**	1.29
Silt (%)	38.09	**Na^{+}**	0.98
Clay (%)	31.62	**K^{+}**	0.09
Texture	Clay loamy	**Soluble anions (meq/100 g soil)**	
pH*	8.10	**$CO_3^{=}$**	0.00
$CaCO_3$	1.90	**HCO_3^{-}**	2.50
Chemical analysis		**$SO_4^{=}$**	0.71
Available N (mg/l)	41	**Cl^{-}**	0.80
Available P (mg/l)	6.30		
Available K (mg/l)	335		
Organic matter (%)	2.14		
E.C.**	0.27		

*** 1:2.5 soil: water extraction**
**** 1:5 soil suspension**

Data recorded:

Collection of the experiment samples was done on 10th February during both seasons after about 15 days from the last fertilization treatment and included the following parameters:

1. Vegetative characteristics:

Which included the plant height (cm) from the soil surface to the highest growth point of branches, branch number/plant, plant fresh and dry weights (g) which drying was achieved under 78 ºC in an oven to a constant weight according to Khan *et al.* (2016), plant spread (cm) was calculated by taking the mean of two perpendicular measurements, roots/shoots ratio was estimated by dividing the root fresh weight on the same shoot fresh weight. In addition, the leaf area (cm^2) was measured according to Koller (1972).

2. Flowering characteristics:

Which contained the inflorescence number/plant, inflorescence diameter by taking the mean of two perpendicular measurements at the blossom period, inflorescence dry weight (g), number of days to the first inflorescence, number of days to 50% flowering and the flowering period (days). Moreover, the vase life was calculated once the fourth outer radial floret rows were fully expanded (Fig., a), since the inflorescence stems were precooled by holding in cold water for 30 minutes to remove the field heat. After that, the original fresh weights (g) were estimated and held in graduated glass cylinders containing 100 ml of fixed preservative solution which contained 10% sucrose + 150 ppm 8-HQS + 150 ppm citric acid. Inflorescences were considered dead when 50% or more of the inflorescences were deemed unattractive (Cho *et al.*, 2001). Ten selected inflorescences per each treatment were used for vase life calculation (days) under lab conditions (fluorescent light of about 950 lux, temperature of 25 °C ± 2 and relative humidity between 65-70%.).

3. Chemical estimations:

Were determined at the beginning of the flowering period, including the pigments content (mg/100 g f.w.) of total chlorophylls and carotenoids determined by a spectrophotometer in fresh leaf samples at 666, 653 and 470 nm for chlorophyll a, b for estimating the total chlorophyll and carotenoids, respectively according to Arnon, (1949). Also, nitrogen percentage was determined by the modified micro Kjeldahle method as described by Schuman *et al.* (1973). In addition, phosphorus percentage was estimated according to Jackson (1973) and potassium percentage was calculated according to Black (1965). Finally, total carbohydrates percentage was estimated in dried leaf samples according to Hodge and Hofreiter (1962).

Statistical analysis:

Data were subjected to analysis of variance by using the SAS V. 6.04, 4th ed. program (SAS Institute, 1994) and comparing between means was achieved using Duncan's multiple range test at 5% level, (Gomez and Gomez, 1984).

RESULTS

1. Vegetative characteristics:

Data presented in Table (1) cleared that all tested concentrations of humic and fulvic acids were effective in improving the height of mums' plant. Treating plants with humic acid at 1500 mg/l resulted in the highest significant increase in plant height in both seasons (60.00 and 48.33 cm., respectively). Followed by fulvic acid at 1500 mg/l resulted in an increase in plant height values (51.66 cm) with a significant difference comparing with humic acid at 1500 mg/l. In the second season, it was notable that the same treatments were superior, but there was an insignificant difference between them. On the other hand, the shortest plants were observed with the control or plants treated with the lowest humic acid concentration (500 mg/l). In general, applying either humic acid or fulvic acid at 1500 mg/l gained increase the percentage of 36.36, 17.41, 49.49 and 43.30% compared with the control group during both seasons, respectively.

In addition, a significant increase in number of branches by applying fulvic acid at 1500 mg/l (10.66) was observed in the first season when compared with all the other studied treatments (Table, 1). In this regard, adding humic acid at 1500 mg/l or fulvic acid at 1000 mg/l increased the number of branches (8.33 and 7.33, respectively) without significant differences between them but exceeded the other treatments. However, in the second season, fulvic acid at either 1000 or 1500 mg/l resulted in the highest branch number than the other treatments (12.00 and 13.66, respectively) without significant differences between them. Moreover, treating plants by either humic or fulvic acid at a concentration of 1500 mg/l, gained branch number increases of 78.75, 128.76, 141.50 and 241.50% compared with the control plants during both seasons, respectively.

Furthermore, the obtained results (Table, 1) cleared that applying fulvic acid at 1000 or 1500 mg/l improved the leaf area in both seasons (52.87, 53.58, 52.75 and 54.01 cm^2, respectively) than the other treatments, followed by the plants were treated by humic acid at the highest concentration (1500 mg/l), as the leaves were expanded to 50.70 and 50.14 cm^2, during both seasons. On the other side, the control plants or plants treated with the lowest and moderate concentrations of humic acid (500 and 1000 mg/l) produced smaller leaf area compared with the other treatments. In addition, the superior treatments (humic or fulvic at 1500 mg/l), gained increase percentages of leaf area by 16.15, 20.85, 14.21 and 24.17% compared with the control during both seasons, respectively. The greatest plant spread was found for mums' plants were treated with fulvic acid at 1500 mg/l in both seasons (29.29 and 29.37 cm, respectively) and significant differences were observed in both

Table 1. Impact of humic and fulvic acids on plant height (cm), branches number, leaf area (cm^2) and plant spread (cm) of mums' plant during 2018/2019 and 2019/2020 seasons.

Growth stimulant (mg/l)	Plant height (cm)		Branches number/plant		Leaf area (cm^2)		Plant spread (cm)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
T1	44.00±2.08 c	32.33±1.45 d	4.66±0.33 d	4.00±0.58 e	43.65±0.49 d	43.90±0.64 d	13.39±0.52 e	12.86±0.19 f
T2	45.66±1.76 c	38.33±0.67 c	6.33±0.32 cd	7.66±0.88 dc	44.41±0.33 d	44.91±0.43 d	16.28±0.78 d	16.65±1.01 de
T3	47.00±1.53 c	42.33±1.44 bc	6.00±1.00 cd	8.66±0.85 dc	46.32±0.29 c	46.66±0.37 c	18.58±1.28 c	18.12±1.13 cd
T4	60.00±1.15 a	48.33±2.48 a	8.33±0.33 b	9.66±1.86 bc	50.70±0.84 b	50.14±0.83 b	20.33±0.81 c	20.11±0.76 c
T5	43.66±1.86 c	41.33±0.31 bc	5.33±0.31 d	6.33±1.33 de	44.86±0.37 cd	44.30±0.42 d	14.76±0.17 de	15.07±0.13 e
T6	44.00±0.58 c	42.66±0.33 a-c	7.33±0.87 bc	12.00±0.57 ab	52.87±0.55 a	53.58±0.19 a	25.56±0.60 b	25.65±0.86 b
T7	51.66±1.67 b	46.33±2.03 ab	10.66±0.65 a	13.66±1.86 a	52.75±0.47 a	54.01±0.57 a	29.29±0.36 a	29.37±0.35 a

T1: control, T2: humic acid at 500 mg/l, T3: humic acid at 1000 mg/l, T4: humic acid at 1500 mg/l, T5: fulvic acid at 500 mg/l, T6: fulvic acid at 1000 mg/l, and T7: fulvic acid at 1500 mg/l.
Means in the same column and having the same letter (s) are not significantly different at 5% level.

seasons when compared with the other treatments with increasing percentages of 118.74 and 128.38% compared with the control, respectively.

Moreover, mums' plants treated with 1500 mg/l fulvic acid produced the highest ratio between roots and shoots in the first season, but in the second season one applying fulvic acid at either 1000 or 1500 mg/l recorded the superior values compared with the rest treatments (Fig., 1 A). In contrast, the control treatment recorded the lowest ratio of this parameter.

Also, it was notable that treating plants with fulvic acid at 1500 mg/l gave a significant increase of plant fresh weight (161.33 g/plant) in the first season, followed by fulvic acid at 1000 mg/l and humic acid at 1500 mg/l which produced 148.00 and 119.33 g/plant, respectively comparing with the other used treatments (Fig., 1 B). In the second season, applying fulvic acid at 1500 or 1000 mg/l gave a higher value of plants fresh weight without significant differences between them (189.33 and 166.66 g/plant), followed by humic acid at 1500 mg/l (129.33 g/plant). Most other treatments showed insignificant differences between themselves in this parameter. Furthermore, the superior treatments of fulvic and humic acid at concentrations of 1500 mg/l, gained increase percentages of plant fresh weight (210.25, 129.48, 268.85 and 151.96%) higher than the control treatment. Dry weight clearly indicated that it had almost the same trend which was observed in the fresh weight values (Fig., 1 C), since are treatments of fulvic and humic acids at 1500 mg/l produced the heaviest dry weight values (36.52, 24.72, 32.56 and 24.39 g/plant, respectively).

2. Flowering characteristics:

A pronounced increase in the number of inflorescences per plant was obtained with the application of fulvic acid at 1500 mg/l in both seasons (28.00 and 21.33 inflorescences, respectively), followed by applying humic acid at 1500 mg/l or fulvic acid at 1000 mg/l during both seasons (24.66, 22.66, 21.00 and 19.33 inflorescences/plant, respectively) without significant differences between them. It was obvious that those superior treatments still giving significant higher values than the other treatments (Table, 2). In a similar way, using any concentration from humic or fulvic acids led to an increase in the diameter of inflorescence compared with the control in both seasons, and the average largest inflorescence was observed when fulvic acid was applied at the concentration of 1500 mg/l, since it recorded 7.00 and 6.33 cm, respectively in both seasons. In addition, the heaviest inflorescence dry weight was obtained when mums plants were treated with fulvic acid at 1000 or 1500 mg/l (2.37 and 2.52 g/inflorescence, respectively) over the other treatments. Furthermore, using humic acid at 500 mg/l produced the shortest vase life as the control without significant differences between themselves and the extended vase life was obtained when fulvic acid at 1500 mg/l was used (23.40, 24.20 days) during both seasons, respectively (Table, 2). One of the most notable results is that using fulvic or humic acids at concentrations of 1500 mg/l, increased the percentages in the vase life parameter (39.29, 32.14, 47.56 and 39.02%, respectively) compared with the control treatment in both seasons. In addition, the shortest interval between the planting date and appearing of the first inflorescence was recorded for mums' plants treated with 1500 mg/l (Fig., 2 A), followed by applying fulvic acid at 1000 mg/l and humic acid at 1500 mg/l. Also, these superior treatments decreased the required time for obtaining 50% of inflorescences/plant (Fig., 2 B), compared with the control plants which prolonged the required days for this parameter. Moreover, the longest flowering periods were recorded for plants treated with fulvic acid at concentrations of 1000 or 1500 mg/l in both seasons (Fig., 2 C), followed by plants that received humic acid at the higher concentrations (1500 and 1000 mg/l).

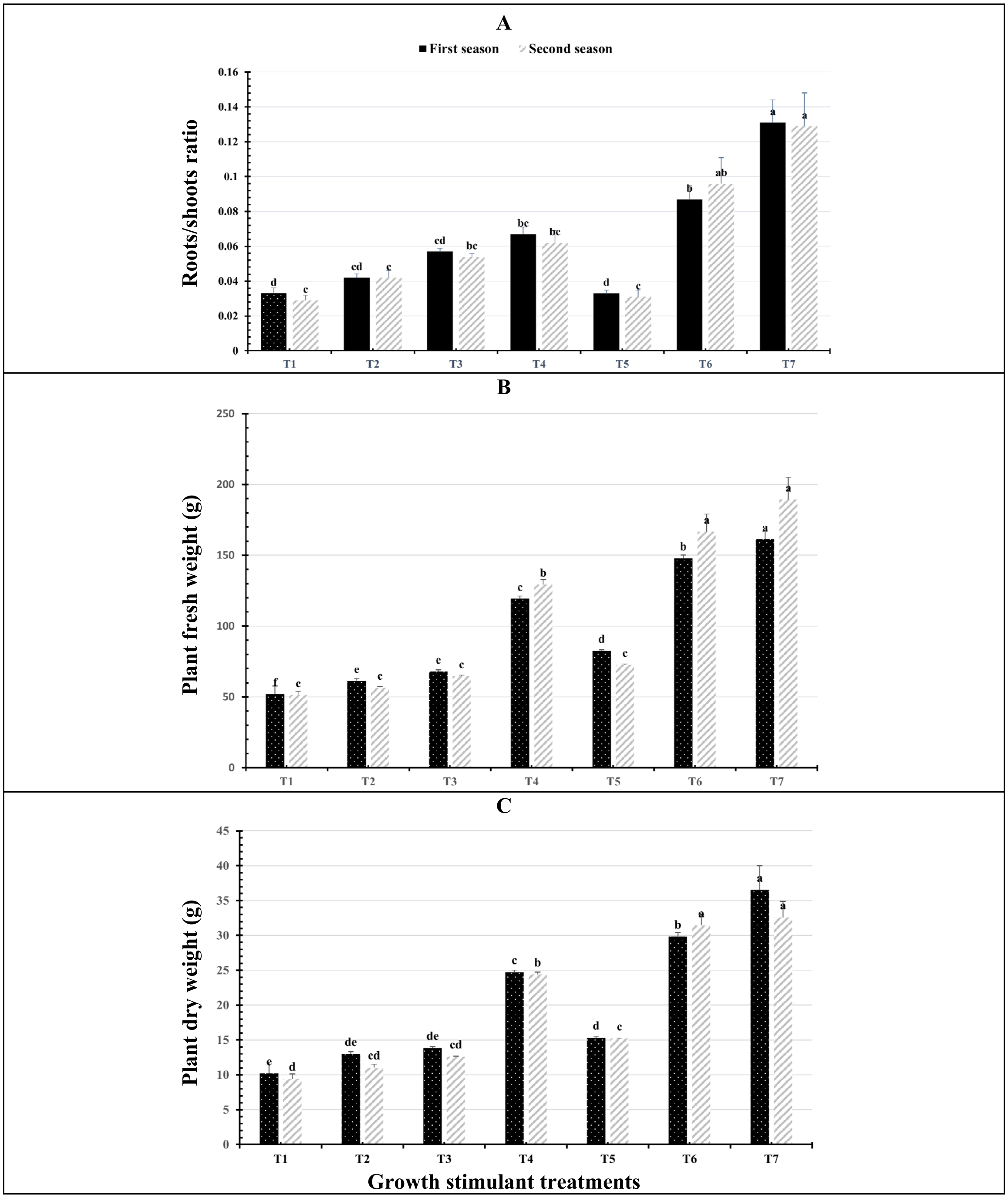

Fig. 1. Impact of humic and fulvic acids on (A) roots/shoots ratio, (B) plant fresh weight (g) and (C) plant dry weight (g) of mums' plant during 2018/2019 and 2019/2020 seasons.

T1: control, T2: humic acid at 500 mg/l, T3: humic acid at 1000 mg/l, T4: humic acid at 1500 mg/l, T5: fulvic acid at 500 mg/l, T6: fulvic acid at 1000 mg/l, and T7: fulvic acid at 1500 mg/l.
The same letter (s) above column of the same growing season are not significant by different at 5% level.

Table 2. Impact of humic and fulvic acids on inflorescences number/plant, inflorescence diameter (cm), inflorescence dry weight (g) and vase life (days) of mums' plant during 2018/2019 and 2019/2020 seasons.

Growth stimulant (mg/l)	Inflorescence number/plant		Inflorescence diameter (cm)		Inflorescence dry weight (g)		Vase life (days)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
T1	14.00±0.52 b	7.00±0.19 c	4.66±0.03 b	4.33±0.07 b	1.64±0.04 d	1.56±0.07 e	16.80±0.37 b	16.40±0.24 d
T2	16.66±0.78 b	10.66±1.01 bc	5.66±0.06 ab	5.00±0.08 ab	1.87±0.07 c	1.80±0.08 d	17.80±0.24 b	21.20±0.21 c
T3	15.66±1.28 b	11.00±1.29 bc	6.00±0.20 ab	5.33±0.12 ab	2.08±0.11 b	2.13±0.12 c	21.40±0.36 a	22.40±0.24 b
T4	24.66±0.80 ab	21.00±0.76 a	6.33±0.05 ab	5.33±0.06 ab	2.25±0.04 b	2.25±0.06 bc	22.20±0.21 a	22.80±0.20 b
T5	14.33±0.17 b	12.66±0.13 b	4.33±0.05 b	5.66±0.06 ab	1.79±0.05 cd	1.73±0.06 de	22.60±0.89 a	16.80±0.37 d
T6	22.66±0.60 ab	19.33±0.86 a	5.33±0.03 ab	5.66±0.02 ab	2.47±0.02 a	2.37±0.02 ab	22.00±0.92 a	22.80±0.49 b
T7	28.00±0.36 a	21.33±0.35 a	7.00±0.04 a	6.33±0.05 a	2.54±0.03 a	2.52±0.04 a	23.40±0.40 a	24.20±0.19 a

T1: control, T2: humic acid at 500 mg/l, T3: humic acid at 1000 mg/l, T4: humic acid at 1500 mg/l, T5: fulvic acid at 500 mg/l, T6: fulvic acid at 1000 mg/l, and T7: fulvic acid at 1500 mg/l.
Means in the same column and having the same letter (s) are not significantly different at 5% level.

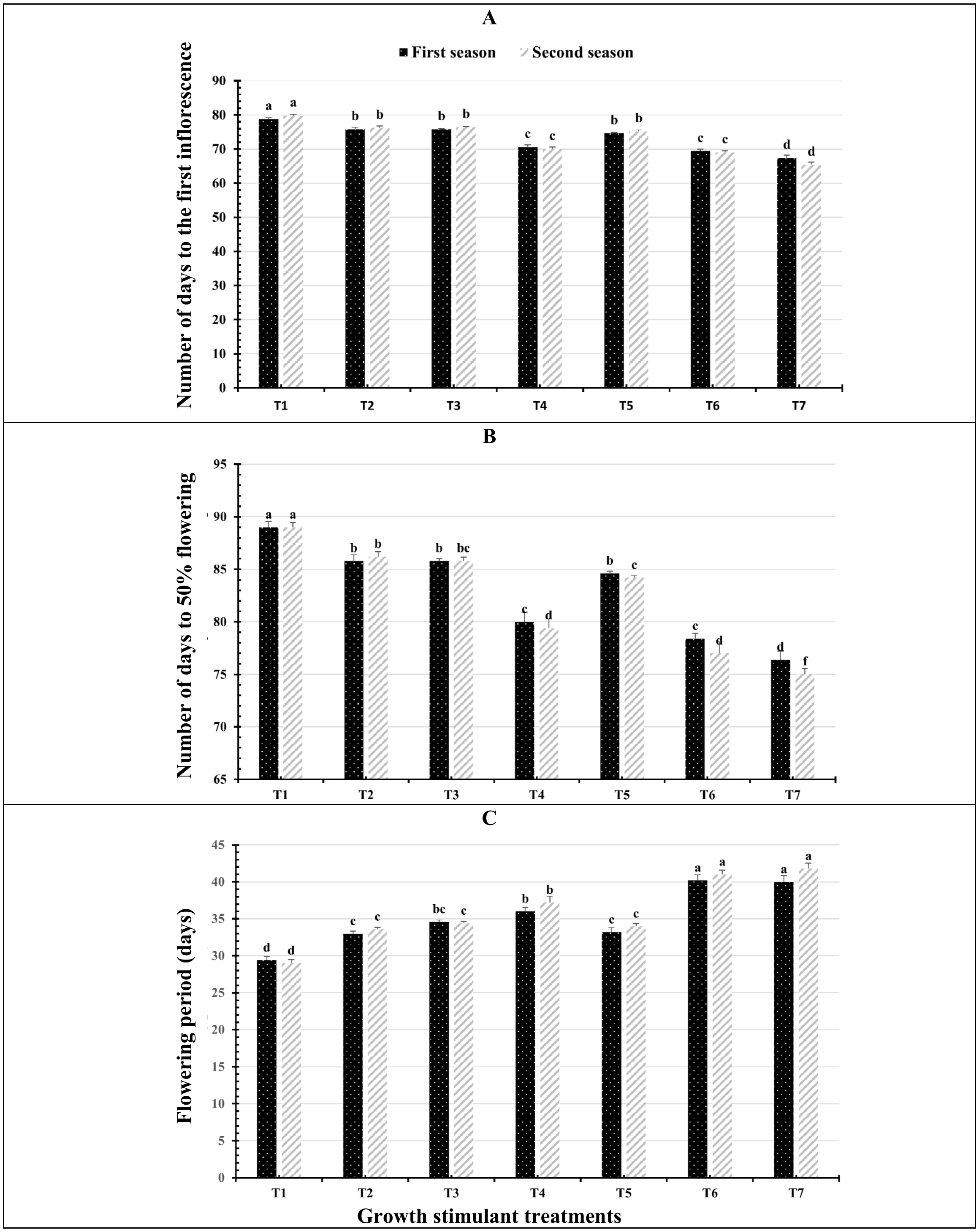

Fig. 2. Impact of humic and fulvic acids on (A) number of days to the first inflorescence, (B) number of days to 50% flowering and (C) flowering period (days) of mums' plant during 2018/2019 and 2019/2020 seasons.

T1: control, T2: humic acid at 500 mg/l, T3: humic acid at 1000 mg/l, T4: humic acid at 1500 mg/l, T5: fulvic acid at 500 mg/l, T6: fulvic acid at 1000 mg/l, and T7: fulvic acid at 1500 mg/l.
The same letter (s) above column of the same growing season are not significant by different at 5% level.

3. Chemical estimations:

It was obvious that mums' plants treated with the higher levels of fulvic acid at 1500 or 1000 mg/l significantly improved the total chlorophyll content (37.16 and 35.27 mg/100 g f.w., respectively) in the first season over the other treatments without significant difference among themselves (Fig., 3 A). The matter was quite similar in the second season, since plants treated with fulvic acid at 1500 gave a superior value of chlorophyll content compared with the other treated plants. In addition, carotenoids showed nearly about the same trend as shown in the total chlorophyll. In contrast, the lowest level of carotenoids resulted from plants treated with humic acid at a concentration of 500 mg/l and the control (10.12 and 7.75 mg/g f.w., respectively) (Fig., 3 B). In addition, plants treated with fulvic acid at 1500 mg/l gave the highest percentages of nitrogen, phosphorous, potassium and total carbohydrates on dry weight in both seasons (Table, 3), but there

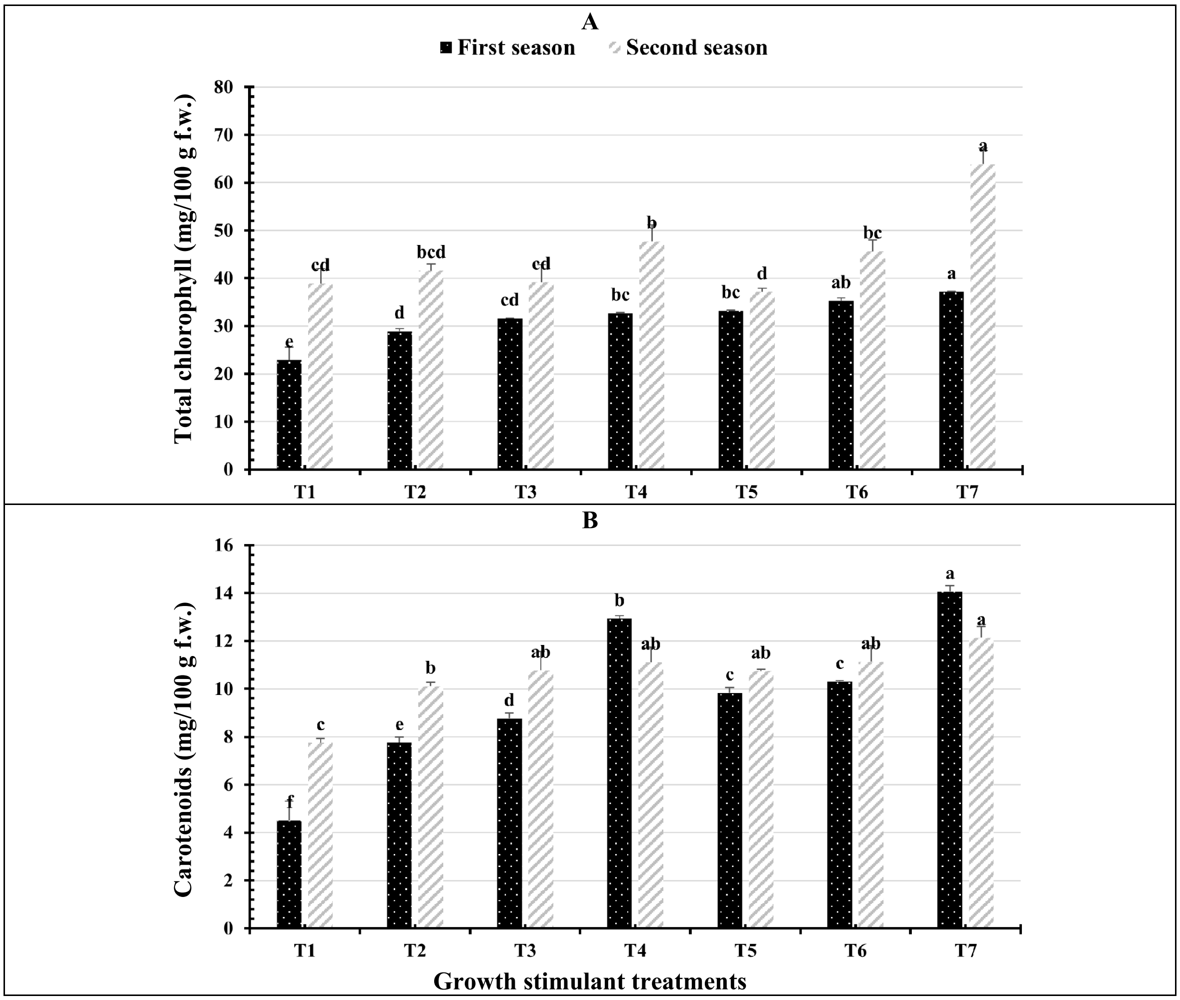

Fig. 3. Impact of humic and fulvic acids on (A) total chlorophyll (mg/100 g f.w.) and (B) carotenoids (mg/100 g f.w.) of mums' plant during 2018/2019 and 2019/2020 seasons.

T1: control, T2: humic acid at 500 mg/l, T3: humic acid at 1000 mg/l, T4: humic acid at 1500 mg/l, T5: fulvic acid at 500 mg/l, T6: fulvic acid at 1000 mg/l, and T7: fulvic acid at 1500 mg/l.

The same letter (s) above column of the same growing season are not significant by different at 5% level.

Table 3. Impact of humic and fulvic acids on nitrogen, phosphorus, potassium percentages and total carbohydrates of mums' plant during 2018/2019 and 2019/2020 seasons.

Growth stimulant (mg/l)	Nitrogen %		Phosphorus %		Potassium %		Total carbohydrates %	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
T1	2.34±0.020 e	2.36±0.015 c	0.47±0.001 e	0.50±0.002 c	1.70±0.021 g	1.93±0.018 c	22.74±0.38 g	23.28±0.23 g
T2	2.43±0.010 d	2.57±0.018 bc	0.48±0.003 d	0.51±0.001 bc	1.75±0.007 f	2.00±0.024 bc	24.22±0.17 f	24.39±0.10 f
T3	2.49±0.020 d	2.66±0.007 b	0.48±0.002 d	0.53±0.002 b	1.81±0.012 e	2.07±0.019 bc	25.18±0.21 e	25.24±0.27 e
T4	3.42±0.015 a	3.39±0.019 a	0.55±0.001 b	0.58±0.002 a	2.46±0.012 b	2.58±0.017 a	26.16±0.22 d	37.85±0.11 c
T5	2.63±0.020 c	2.82±0.018 b	0.50±0.003 c	0.53±0.003 b	1.94±0.013 d	2.15±0.015 b	26.96±0.20 c	27.52±0.23 d
T6	2.72±0.017 b	3.50±0.012 a	0.51±0.002 c	0.60±0.001 a	1.99±0.011 c	2.68±0.035 a	27.94±0.10 b	39.24±0.19 b
T7	3.44±0.014 a	3.58±0.233 a	0.58±0.005 a	0.61±0.025 a	2.57±0.012 a	2.73±0.167 a	29.15±0.09 a	40.38±0.48 a

T1: control, T2: humic acid at 500 mg/l, T3: humic acid at 1000 mg/l, T4: humic acid at 1500 mg/l, T5: fulvic acid at 500 mg/l, T6: fulvic acid at 1000 mg/l, and T7: fulvic acid at 1500 mg/l.
Means in the same column and having the same letter (s) are not significantly different at 5% level.

was a significant difference as compared with each other in the first season. In the second season, it was found that using fulvic acid at 1000 mg/l or humic acid at 1500 mg/l produced the highest nitrogen, phosphorous and potassium percentages, followed by applying fulvic acid at 1500 mg/l without any significant differences between themselves. In opposite, the moms of control plants were the lowest N, P, K and total carbohydrates percentages in both seasons.

DISCUSSION

Different humic and fulvic acids concentrations were used to increase *Dendranthema grandiflorum* plant growth parameters such as plant height, branch number/plant, leaf area, and plant spread in the current study (Table, 1). The capacity of fulvic and humic acids to stimulate growth has been found in a wide variety of plants, including lilium (Parandian and Samavat, 2012), chrysanthemum (Fan *et al.*, 2014), gerbera (Yazdani *et al.*, 2014), *Impatiens walleriana* (Esringü *et al.*, 2015) and in yarrow (Bayat *et al.*, 2021). The observed increase might be attributed to humic acid, which has been complexed with potassium, and has numerous activities linked to water relations, protein and fats synthesis and magnesium activation of many plant enzymes needed for vegetative growth. Humic acid also acts as a catalyst, boosting the activity of soil microbes (Sharif *et al.*, 2002). Furthermore, one of the most bioactive humate molecules increases potassium levels in leaves. These findings are like those reported by Ali *et al.* (2008) on gerbera. Increasing the number of branches involves getting a better and higher quality. One of the most notable effects of fulvic acid is that it promotes root development and respiration, which improves plant growth and yield; these findings are like those published by Rongting *et al.* (2017) on mums' plant. In addition, the presence of humic and fulvic acids, may impact cellular metabolism in treated plants, resulting to greater vigor and development, may be responsible for the increase in plant spread in mums plant direction. In addition, the rise in most vegetative parameters might be due to the use of humic fertilizers, which boost nitrogen content in the plant shoots. It has been discovered that nitrogen molecules included in humic acid play a vital role in plant development. Humic acid boosted shoot development by promoting calcium, nitrogen, phosphorus, manganese, potassium, iron, zinc and copper intake, as well as having hormone-like effects. Humic acid was also reported to improve plant development by raising the activity of the RuBisCO enzyme, which led to an increase in photosynthetic activity (Abaszadeh *et al.*, 2018). Likewise, humic acid lowers the pH of alkaline soils and improves plant development by influencing metabolic activity and improving nutrient uptake, particularly nitrogen absorption (Akladious and Mohamed, 2018). The usage of humic compounds enhanced leaf area and consequently photosynthesis, resulting in greater dry matter accumulation in plants. Humic compounds have a considerable impact on root development as well.

The availability of oxygen groups in humic acid was thought to boost lateral root development. Although humic acid promoted shoot and root growth, its impact on the plant root was more noticeable. The use of fulvic and humic acids boosted the development and blooming of mums' plants in the present research by increasing N, P, K absorption, and total carbohydrates percentages (Table, 3). Furthermore, the beneficial effects of humic acid on plant development and chemical constituents might be attributed to humic acid's hormonal activities, which include respiration, photosynthesis, antioxidant activity and protein synthesis (Fan *et al.*, 2014). In addition, fulvic acid was much more successful than humic acid in increasing growth characteristics in most cases, without no significant differences between them in most of the flowering growth parameters (Table, 2 and Fig., 2). Altogether, fulvic and humic acids enhanced plant growth and flowering productivity by promoting the absorption of nutrients such as Ca, N, K, P, Zn, Mn and Fe along with their hormonal actions (Olaetxea *et al.*, 2018). The findings of this study showed that increased levels of fulvic and humic acids (1500 mg/l) had a better impact on increasing the growth parameters of mums' plants than lower one (500 mg/l). This might be owing to a stronger stimulating function, which accelerates photosynthetic and enhances plant development. During both seasons, fulvic and humic acids had a favorable effect on total chlorophyll and carotenoids concentration in this study (Fig., 3). In general, fulvic and humic acids enhanced total chlorophyll and carotenoids synthesis by delivering additional nutrients to the plant, such as Mg, N, Mn, and Fe for the plant (Delfine *et al.*, 2005). Fulvic and humic acid's hormonal action can also cause an increase in chlorophyll pigments (Nardi *et al.*, 2002). Organic fertilizers enhance the number of photosynthetic activities in the plant, which are needed in the formation of secondary metabolites such phenolic compounds (Nguyen *et al.*, 2010). According to Schiavon *et al*. (2010) humic acid increases the shikimic pathway's components (phenols, alkaloids, and tocopherols) through enhancing phenylalanine ammonia-lyase enzyme activity. Furthermore, through increasing enzymatic and non-enzymatic antioxidant defense mechanisms, humic acid enhances crop tolerance to environmental stress. The application of fulvic and humic acids increased the levels of N, P, and K in leaves in the current research, which was consistent with earlier findings on gerbera (Yazdani *et al.*, 2014), and pepper (Akladious and Mohamed, 2018). Humic acid has been shown to improve nutrients absorption by increasing the activity of the plasma membrane H^+-ATPase (Khaled and Fawy, 2011) and indirectly increases P uptake by creating a compound with iron (David *et al.*, 1994). Furthermore, the enhanced phosphorus content in plants due to fulvic and humic acid treatments is mostly sufficient to increase phosphorus solubility in the soil (Verlinden *et al.*, 2009). Humic acid's chelating activity improves the accessibility of insoluble phosphorus compounds in soil (Wang *et al.*, 2003), and promoting the development of roots in the rhizosphere to improve the absorption of some elements such as N, P and K (Sanchez *et al.*, 2006). Another reason for the probable rise in leaf potassium concentration is the abundance of potassium in the fulvic matrix (Sanchez *et al.*, 2006). The leaf nitrogen levels in treated plants with fulvic acid were greater than those in plants treated with humic acid in this research, which might be owing to fulvic acid's lower molecular weight compared to, than of humic acid, which leads to enhance metal complexation (Tan, 2003).

CONCLUSION

From the abovementioned results it could be concluded that soil drenched with fulvic, or humic acid is considered as a useful agriculture practice and eco-friendly bio-stimulants for mums' production. The best values of vegetative growth (plant height, branch number, plant spread, roots/shoots ratio, fresh and dry weight of plants, and leaf area) under clay soil conditions were attained with soil drenched by either fulvic acid at rates of 1500, 1000 mg/l or humic acid at 1500 mg/l, respectively. In addition, these superior treatments enhanced the flowering parameters such as reducing the required interval for appearing the first inflorescence and 50% of flowering, with extending the flowering period and the vase life and increased inflorescence number/plant, inflorescence diameter. Furthermore, drenching fulvic acid at 1500 and 1000 mg/l or humic acid at 1500 mg/l, promoted the photosynthesis pigments such as total chlorophylls and carotenoids, in addition to the total carbohydrates, nitrogen, phosphorous and potassium percentages. Therefore, we could recommend the use of fulvic acid at 1500 or 1000 mg/l for reducing the economic cost or humic acid at 1500 mg/l under the conditions of the North

Egyptian Delta for improving the mums' production.

REFERENCES

Abaszadeh, F.R.; Shoor, M.; Tehranifar, A.; Abedi, B. and Safari, N. (2018). Effects of humic acid and fulvic acid on some morphological characteristics of geranium. Journal of Horticulture Science, 32(1):35-50.

Akladious, S.A. and Mohamed, H.I. (2018). Ameliorative effects of calcium nitrate and humic acid on the growth, yield component and biochemical attributes of pepper (*Capsicum annuum*) plants grown under salt stress. Sci. Hortic., 236:244–250.

Ali, N; Mohsen, K.; Mesbah, B. and Etemadi, M. (2008). Effect of humic acid on plant growth, nutrient uptake and postharvest life of gerbera. Journal of Plant Nutrition, 31(12):2155–2167.

Arnon, D.I. (1949). Copper enzymes in isolated chloroplasts. Polyphenoloxidase in *Beta vulgaris*. Plant Physiol., 24:1–15.

Bayat, H.; Shafie, F.; Aminifard, M.H. and Daghighi, S. (2021). Comparative effects of humic and fulvic acids as biostimulants on growth antioxidant activity and nutrient content of yarrow (*Achillea millefolium* L.). Scientia Horticulturae, 279:109912.

Black, C.A. (1965). Methods of Soil Analysis, Part 2. Amer. Soc. Agron., Madison, Wisconsin, U.S.A, 802 p.

Cho, M.S.; Çelikel, F.G.; Dodge, L. and Reid, M.S. (2001). Sucrose enhances the postharvest quality of cut flowers of *Eustoma grandiflorum*. ActaHort, 543: 304-315.

David, P.P.; Nelson, P.V. and Sandres, D.C. (1994). A humic acid improves growth of tomato seedling in solution culture. J. Plant Nutr, 17:173–184.

Delfine, S.; Tognetti, R.; Desiderio, E. and Alvino, A. (2005). Effect of foliar application of N and humic acids on growth and yield of durum wheat. Agron. Sustain. Dev., 25:183–191.

Esringü, A.; Sezen, I.; Aytatli, B. and Ercişli, S. (2015). Effect of humic and fulvic acids application on growth parameters in *Impatiens walleriana* L. Akademik Ziraat Dergisi, 4:37–42.

Fan, H.M.; Wanga, X.W.; Sun, X.; Li, Y.Y.; Sun, X.Z. and Zheng, C.S. (2014). Effects of humic acid derived from sediments on growth, photosynthesis and chloroplast ultrastructure in chrysanthemum. Sci. Hortic., 177:118–123.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley & Sons, New York, USA, 680 p.

Hodge, J.E. and Hofreiter, B.T. (1962). Determination of reducing sugars and carbohydrates. In: Whistler, R.L. and BeMiller, J.N. (eds.), Methods in Carbohydrate Chemistry, Academic Press, New York, USA, pp. 380-394.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of India Private Ltd. M-97, New Delhi, India, 498 p.

Khaled, H. and Fawy, H. (2011). Effect of different levels of humic acid on the nutrient content, plant growth and soil properties under conditions of salinity. Soil Water Res., 6: 21–29.

Khan, N.; Bano, A. and Babar, M.A. (2016). The root growth of wheat plants, the water conservation and fertility status of sandy soils influenced by plant growth promoting rhizobacteria. Symbiosis, 72:195–205.

Kim, Y.S.; Kim, S.H.; Sung, D.S.; Kim, J.B. and Kang, S.Y. (2015). Genetic relationships among diverse spray and standard-type chrysanthemum varieties and their derived radio-mutants determined using AFLPs. Hort. Environ. Biotechnol., 56: 498-550.

Koller, H.R. (1972). Leaf area - leaf weight relationship in soybean canopy. Crop Sci., 12:180-183.

Lotfi, R.; Pessarakli, M.; Gharavi-Kouchebagh, P. and Khoshvaghti, H. (2015). Physiological responses of *Brassica napus* to fulvic acid under water stress: chlorophyll a fluorescence and antioxidant enzyme activity. The Crop Journal, 3:434 - 439.

Malan, C. (2015). Humic and Fulvic Acids, A Practical Approach. Proc. the Sustainable Soil Management Symposium, Stellenbosch, South Africa, pp. 5-6.

Moraditochaee, M. (2012). Effects of humic acid foliar spraying and nitrogen fertilizer management on yield of peanut (*Arachis hypogaea* L.) in Iran. ARPN Journal of Agricultural and Biological Science, 7: 289–293.

Mosa, A.; Ahmed, A. and Elsaeid, M. (2020). Agro-environmental applications of humic substances: a critical review. Egypt. J. Soil. Sci., 60(3):211-229.

Nardi, S.; Pizzeghello, D.; Muscolo, A. and Vianello, A. (2002). Physiological effects of humic substances on higher plants. Soil Biology & Biochemistry, 34:1527–1536.

Nguyen, P.H.M.; Kwee, E.M. and Niemeyer, E.D. (2010). Potassium rate alters the antioxidant capacity and phenolic concentration of basil (*Ocimum basilicum* L.) leaves. Food Chem. 123:1235–1241.

Olaetxea, M.; De Hita, D.; Garcia, C.A.; Fuentes, M.; Baigorri, R.; Mora, V.; Garnica, M.; Urrutia, O.; Erro, J.; Zamarre˜no, A.M. and Berbara, R.L. (2018). Hypothetical framework integrating the main mechanisms involved in the promoting action of rhizospheric humic substances on plant root-and shoot-growth. Appl. Soil Ecol., 123:521–537.

Parandian, F. and Samavat, S. (2012). Effects of fulvic and humic acids on anthocyanin, soluble sugars, µ-amylase enzyme and some micronurient elements in lilium. International Research Journal of Applied and Basic Sciences, 3(5):924-929.

Rongting, J.; Gangqiang, D.; Weiming, S. and Ju, M. (2017). Effects of liquid organic fertilizers on plant growth and rhizosphere soil characteristics of chrysanthemum. Sustainability, 9:1-16.

Sanchez, S.A.; Sanchez, A.J.; Juarez, M.; Jorda, J. and Bermudez, D. (2006). Improvement of iron uptake in table grape by addition of humic substancecs. J. Plant Nutr., 29:259–272.

SAS Institute (1994). SAS/STAT User's Guide: Statistics, Vers. 6.04, 4th Ed. SAS Institute Inc., Cary, N.C., USA.

Schiavon, M.; Pizzeghello, D.; Muscolo, A.; Vaccaro, S.; Francioso, O. and Nardi, S. (2010). High molecular size humic substances enhance phenylpropanoid metabolismin maize (*Zea mays* L.). J. Chem. Ecol., 36:662–669.

Schuman, G.; Stanley, M. and Knudsen, D. (1973). Automated total nitrogen analysis of soil and plant samples. Soil Sci. Soc. Am. J., 37:480–481.

Sharif, M.; Khattak, R.A. and Sarir, M.S. (2002). Effect of different levels of lignitic coal derived humic acid on growth of maize plants. Commun. Soil Sci. Plant Anal., 33(19):3567-3580.

Tan, K.H. (2003). Humic Matter in Soil and the Environment, Principles and Controversies. Marcel Dekker, Inc., NY, USA, 408 p.

Teixeira da Silva, J.A.; Shinoyama, H.; Aida, R.; Matsushita, Y.; Raj, S.K. and Chen, F. (2013). Chrysanthemum Biotechnology: Quo vadis? Critical Reviews in Plant Sciences, 32: 21–52.

Verlinden, G.; Pycke, B.; Mertens, J.; Debersaques, F.; Verheyen, K.; Baert, G.;

Bries, J. and Haesaert, G. (2009). Application of humic substances results in consistent increases in crop yield and nutrient uptake. J. Plant Nutr., 32:1407–1426.

Wang, X.J.; Wang, Z.Q. and Li, S.G. (2003). The effect of humic acid on the availability of phosphorus fertilizers in alkaline soils. Soil Use Manage, 11: 99–102.

Yazdani, B.; Nikbakht, A. and Etemadi, N. (2014). Physiological effects of different combinations of humic and fulvic acid on gerbera. Commun. Soil Sci. Plant Anal., 45:1357–1368.

تحسين صفات النمو والبقاء بعد القطف لنبات الأراولا من خلال التحسين الحيوى لحامض الهيوميك والفولفيك

مهند محمد عبد الباسط علي جبر، محمود مكرم الرفاعى قاسم
قسم الخضر و الزينة، كلية الزراعة، جامعه المنصورة، مصر

أجريت تجربة في صوبة بلاستيكية خلال الموسمين المتتاليين ٢٠١٩/٢٠١٨ و ٢٠٢٠/٢٠١٩، بمشتل وحدة نباتات الزينة ، كلية الزراعة ، جامعة المنصورة ، مصر، وذلك لدراسة قدرة حامض الهيوميك والفولفيك كلا على حده كإضافة أرضية بثلاث تركيزات لكل منهما (٥٠٠ ، ١٠٠٠ ، ١٥٠٠ ملجم/لتر) بالإضافة لمعاملة الكنترول على بعض صفات النمو الخضري والزهري والمحتوى الكيميائي لنبات الأراولا صنف فلاير 'Flyer' *Dendranthema grandiflorum*. وقد أوضحت النتائج المتحصل عليها أن المعاملة بحمض الفولفيك بتركيزات ١٥٠٠ و ١٠٠٠ ملجم/لتر أو تركيز ١٥٠٠ ملجم/لتر من حمض الهيوميك كانا أكثر فاعلية بالمقارنة بمعظم المعاملات الأخرى لتحسين الصفات الخضرية (ارتفاع النبات ، عدد الفروع ، انتشار النبات ، نسبة الجذور/النموات الخضرية ، الوزن الطازج والجاف/النبات ، ومساحة الورقة)، معاملات التزهير (تقليل الفترة الزمنية المطلوبة لبداية التزهير و ٥٠٪ من النورات، إطالة فترة الإزهار وعمر الأزهار بعد القطف، عدد النورات/النبات، قطر النورة). علاوة على ذلك، فإن معاملات حمض الفولفيك بتركيز ١٥٠٠ و ١٠٠٠ ملجم/لتر أو حمض الهيوميك بتركيز ١٥٠٠ ملجم/لتر يعزز صبغات التمثيل الضوئي مثل الكلوروفيل الكلي والكاروتينويدات، بالإضافة إلى النسبة المئوية الكلية للكربوهيدرات والنيتروجين والفوسفور والبوتاسيوم. وبشكل عام، يمكن التوصية باستخدام حمض الفولفيك بتركيز (١٥٠٠ ملجم/لتر) أو حمض الهيوميك بمعدل ١٥٠٠ ملجم/لتر مرتين شهرياً (ست مرات أثناء عملية إنتاج الأزهار) كإضافة للتربة قبل عملية الري للحصول على أفضل صفات للنمو لهذا النبات الهام كنبات اصص أو كزهرة قطف.