Journal of Horticultural Science & Ornamental Plants 11 (3): 289-298, 2019
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2019.289.298

Effect of Fertilization with Humic Acid and Ammonium Sulfate on the Quality of *Asparagus densiflorus* "Meyerii" Plants

Noor El-Deen T.M. and M.A. El-Ashwah

Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Egypt

Abstract: A trial was performed under open field conditions at the Experimental Farm of Ornamental Plants and Landscape Gardening, Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt through 2016/2017 and 2017/2018 seasons to study the effect of fertilization with humic acid at 0.0, 2.5 and 5.0 g/plant, ammonium sulfate at 0.0, 2.5, 5.0 and 10 g/plant and their interaction which were applied 10 times at monthly intervals on vegetative growth, chemical constituents as well as vase life of *Asparagus densiflorus* "Meyerii" cut foliage. Increasing humic acid rates gradually increased all studied characters in both seasons with little exceptions. On the other hand, increasing the rate of ammonium sulfate up to 5.0 g/plant produced the highest values in most cases. The interaction between humic acid (5.0 g/plant) and ammonium sulfate (5.0 g/plant) was the best combined treatment for enhancing the quality of plants in terms of height, fresh and dry weights of vegetative growth, branch length, number of branches, fresh and dry weights/branch as well as contents of chlorophyll a and b, N, P, K and total carbohydrates and recorded the longest vase life of cut foliage (13.50 and 14.67 days in the first and second seasons, respectively). It can be recommended the application of humic acid at 5.0 g/plant in addition to 5.0 g/plant ammonium sulfate at monthly intervals to obtain high quality *Asparagus densiflorus* "Meyerii" plants with extending vase life of cut foliage.

Key words: *Asparagus densiflorus* "Meyerii" · Fertilization · Humic acid · Ammonium sulfate · Cut foliage

INTRODUCTION

Asparagus densiflorus (Kunth) Jessop. "Meyerii" or Foxtail fern (Fam: Liliaceae) is an evergreen plant native to South Africa, has dense, arching, foxtail-like fronds, with 30-40 cm long of needle-like or leaf-like stems (2.0-2.5 cm long) the plant reaches to 40 cm height. In summer, bears axillary racemes of small white flowers, followed by bright red berries. The foliage is useful for floral arrangements [1]. Asparagus cut foliage "greens" are used in floristry as a filler material. The small needle-like structures (cladophylls) fill out bouquets giving an attractive form backdrop for flower arrangements [2].

Humic acid is one of the major acid extractable components of humic substances. Humic acid that available in liquid form, powder or granules are used on crops in the field and in the protected areas as growth biostimulators of plants and soil improvers [3]. The effects on intermediary metabolism are less understood, but it seems that humic substances may influence both respiration and photosynthesis [4]. Positive effects of humic acid were proved by many authors i.e. El-Sayed and El-Shal [5] on schefflera (*Brassaia actinophylla*), El-Sayed *et al.* [6] on *Cynodon dactylon*, Abdel-Fattah *et al.* [7] on dracaena and ruscus plants, El-Fouly *et al.* [8] on *Cordyline terminalis*, Fan *et al.* [9] on *Chrysanthemum*, Manda *et al.* [3] on *Spathiphyllum wallisii* Regel, El-Sayed *et al.* [10] on *Cycas revoluta*, Thunb., Abou Dahab *et al.* [11] on *Chamaedorea elegans*. and Abd-El-Hady *et al.* [12] on *Acalypha wilkesiana*.

Addition of chemical fertilization to the soil is very important factor in production of ornamental plants along with other production factors. Generally, in the soils, N element is very more deficient than any other elements. Because the nitrogen has presented in many essential compounds, the growth is very slow without nitrogen addition [13]. In this regard, fertilization with nitrogen alone or with other macronutrients (P and K) led to improve vegetative growth and chemical constituents of various foliage and ornamental plants as reported by Poole and Conover [14] on *Brassaia actinophylla*, *Calathea makoyana* and *Chrysalidocarpus lutescens* and Stamps [15] on *Aspidistra elatior* "Variegata".

Corresponding Author: Noor El-Deen T.M., Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Egypt

Ammonium sulfate provides critical plant nitrogen and sulfur nutrients. Compared with other N fertilizers, such as urea and ammonium nitrate, ammonium sulfate may have various potential agronomic and environmental benefits as its positive effects on soil acidification which led to increase the availability of soil phosphorus and micronutrients, less denitrification with ammonium sulfate than ammonium nitrate that may increase nitrogen efficiency and minimize greenhouse gases as NO and N_2O [16]. Also, ammonium sulfate is known to be more acidifying, because it produces twice as many H^+ ions from nitrification and it is less prone to leaching [17].

The objective of this study was to evaluate the effect of fertilization with humic acid and ammonium sulfate and their interactions on growth, plant chemical constituents and quality of *Asparagus densiflorus* "Meyerii" plants as a garden plant and as cut foliage "greens" production.

MATERIALS AND METHODS

A trial was performed under open field conditions at the Experimental Farm of Ornamental Plants and Landscape Gardening, Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt through 2016/2017 and 2017/2018 seasons to study the effect of humic acid, nitrogen fertilization with ammonium sulfate and their interaction on vegetative growth, chemical constituents as well as vase life of *Asparagus densiflorus* "Meyerii" cut foliage.

Transplants of *Asparagus densiflorus* "Meyerii" (15 cm height with 4 branches) were obtained in 12 cm bags from local nursery in Al-Qanatir Al-Khayriyyah, Qalyubia Governorate, on March, 15th in both seasons. The transplants were planted in 1.5 × 1.0 m beds (6 plants/bed); the distances between transplants were 50 cm, physical and chemical properties of the field soil are shown in Table 1.

Treatments: After one month from planting (at mid-April) both humic acid and ammonium sulfate fertilizers were dressed by hand around plants and gently were covered with the soil. This procedure was repeated at monthly intervals till the next mid-January for each season. So, each treatment was applied 10 times. The following treatments were applied:

- Three rates of humic acid (0.0, 2.5 and 5.0 g/plant) were applied, Hammer product (containing 85% humic acid + 10% potassium oxide) which manufacturing by UAD Company in Egypt was used as a source of humic acid.
- Four rates of ammonium sulfate $(NH_4)_2SO_4$ (0.0, 2.5, 5.0 and 10.0 g/plant) were applied. Ammonium sulfate fertilizer (containing 20.6% nitrogen and 23.8% sulfur).
- Interaction treatments between humic acid and ammonium sulfate were 3 × 4 = 12 treatments.

Experiment Layout: This experiment was arranged in a split-plot design according to Gomez and Gomez [18], humic acid levels represented main plots, while ammonium sulfate allocated for sub plots. Each plot contained 4 beds (1.5 × 1.0 m), so the main plot area was 6 m^2. Each treatment contained 3 replicates, each one involved 6 plants. Total area of the experiment was 54 m^2.

Data Recorded: After 15 days from the last application (at the beginning of February) the following data were recorded in both seasons:

Vegetative Growth Parameters: Plant height (cm) from ground level to the highest tip of the plants, total vegetative growth fresh and dry weights (g)/plant, branch length (average of the tallest 5 branches (cm)), branches number/plant, fresh and dry weights/branch (average of the tallest 5 branches (g)).

Vase Life of Cut Branches (Days): At the beginning of February, tallest three homogeneous branches from each replicate of each treatment were harvested at the same time in the morning and placed in vases containing only distilled water to count number of days from cutting till yellowing of half of the branch. These vases were kept under lab conditions at 1000 lux light intensity, 18±2°C of room temperature and 50-55% relative humidity.

Chemical Composition: At the beginning of February of the second season, chemical composition analysis was done as following:

- Photosynthetic pigments (mg/g f.w.): fresh branch tips were collected from all plots to determined chlorophyll a and b as well as carotenoids contents according to the method described by Wellburn and Lichtenthaler [19].
- The contents of N, P and K (%) in dry branches: nitrogen was determined using micro-Kjeldahle method as described by Jackson [20], phosphorus was colorimetrically measured by the method described by Cottenie *et al.* [21] and potassium was measured using flamephotometer set according to Jackson [20].

Table 1: Some physical and chemical properties of the used experiment soil

	Particle size distribution (%)						Cations (meq/l)				Anions (meq/l)		
Soil type	Sand	Silt	Clay	E.C. (dS/m)	pH	$CaCO_3$ (%)	Ca^{+2}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{-2}
Loamy sand	83.12	6.00	10.88	0.18	8.40	1.20	1.00	0.20	0.40	0.20	0.40	0.75	0.65

- Total carbohydrates (%) in dry branches was colorimetrically determined using the method described by Dubois *et al.* [22].

Statistical Analysis: All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-plot design as published by Gomez and Gomez [18] by using "MSTAT-C" computer software package [23]. Means of treatments were compared using Duncan's multiple range tests at 5% level of probability as described by Duncan [24].

RESULTS AND DISCUSSION

Vegetative Growth Parameters

Plant Height, Vegetative Growth Fresh and Dry Weights: Data in Table 2 showed that treating plants with humic acid at different rates had a significant effect on these three traits than untreated plants, in both seasons, however the highest values of abovementioned traits were obtained with the rate of 5.0 g/plant, in both seasons (22.80 and 23.27 cm for plant height, 28.19 and 31.60 g for fresh weight/plant and 8.38 and 10.04 g for dry weight/plant, in the first and second seasons, respectively). While, the lowest values were obtained by control plants (untreated plants) giving 16.30 and 17.42 cm for plant height, 12.02 and 13.85 g for fresh weight/plant and 4.91 and 4.84 g for dry weight/plant in the first and second seasons, respectively.

As for the treatment of ammonium sulfate, the same data in Table 2 indicated that, the moderate rate of ammonium sulfate (5.0 g/plant) was the best for increasing plant height (21.87 and 22.84 cm, in both seasons, respectively), as well as fresh weight/plant (27.74 and 30.96 g) and dry weight/plant (9.33 and 10.98 g) in both seasons, respectively. In this regard, untreated plants exhibited the lowest values which were 16.21 and 16.66 cm for plant height, 13.12 and 13.82 g for fresh weight/plant and 3.94 and 4.48 g for dry weight/plant in the first and second seasons, respectively.

Regarding the interaction between humic acid and ammonium sulfate, data in Table 2 showed that, fertilizing plants with humic acid at 5.0 g/plant in addition to 5.0 g ammonium sulfate significantly was the best interaction treatment for enhancing plant height, fresh and dry weights of vegetative growth in both seasons. The values were 26.23 and 27.37 cm for plant height, 40.99 and 45.34 g for fresh weight/plant and 12.58 and 15.35 g for dry weight/plant in the first and second seasons, respectively. Control treatment (untreated plants) recorded the lowest values (13.87 and 14.63 cm for plant height, 7.51 and 10.44 g for fresh weight/plant and 3.29 and 3.48 g for dry weight/plant in the first and second seasons, respectively).

Branch Characteristics: Data in Table 3 showed that treating plants with humic acid at different rates had significant effect on branch characteristics than untreated plants in both seasons, however the tallest branches (31.51 and 33.35 cm), as well as the highest number of branches (19.00 and 20.99) and the heaviest weights/branch (1.99 and 2.07 g for fresh weight and 0.67 and 0.69 g for dry weight) in the first and second seasons, respectively, were obtained with application of humic acid at 5.0 g/plant, but the differences between this treatment and the lower one (2.5 g/plant) were insignificant in case of branch length in both seasons and dry weight/branch in the first one. While there were insignificant differences among all humic acid rates in case of dry weight/branch in the second season. In most cases the untreated plants produced the lowest values, as recorded 20.38 and 19.02 cm for branch length, 10.86 and 11.61 for number of branches, 1.47 and 1.52 g for fresh weight of branch and 0.55 and 0.61 g for dry weight of branch in the first and second seasons, respectively.

As for ammonium sulfate treatments (Table 3), the obtained results indicated that, the moderate rate of ammonium sulfate (5.0 g/plant) were the best for increasing all studied branch characteristics. The values were (32.56 and 33.11 cm for branch length, 15.59 and 17.08 for number of branches, 2.19 and 2.32 g for fresh weight of branch and 0.75 and 0.79 g for dry weight of branch in the first and second seasons, respectively). Such increments were significant when compared with untreated plants (control) and were insignificant when compared with ammonium sulfate at 10.0 g/plant except for fresh weight of branch in both seasons. Untreated plants produced the lowest values as recorded 22.17 and 22.08 cm for branch length, 11.33 and 12.27 for number of branches, 1.39 and 1.51 g for fresh weight of branch and 0.45 and 0.51 g for dry weight of branch in the first and second seasons, respectively.

Table 2: Effect of fertilization with humic acid, ammonium sulfate and their interaction on plant height (cm) and fresh and dry weights (g) of *Asparagus densiflorus* "Meyerii" plants during 2016/2017 and 2017/2018 seasons

	Humic acid (g/plant) (A)							
	0.0	2.5	5.0	Mean (B)	0.0	2.5	5.0	Mean (B)
Ammonium sulfate (B)	2016/2017				2017/2018			
				Plant height (cm)				
Control	13.87 e	16.73 de	18.03 cd	16.21 c	14.63 h	16.87 g	18.47 fg	16.66 c
2.5 g/plant	16.23 de	18.70 cd	21.47 bc	18.80 b	17.17 g	19.60 ef	22.10 cd	19.62 b
5.0 g/plant	16.47 de	22.90 ab	26.23 a	21.87 a	17.20 g	23.97 bc	27.37 a	22.84 a
10.0 g/plant	18.63 cd	21.17 bc	25.47 a	21.76 a	20.70 de	22.77 c	25.17 b	22.88 a
Mean (A)	16.30 c	19.88 b	22.80 a		17.42 c	20.80 b	23.27 a	
				Vegetative growth fresh weight (g)				
Control	7.51 f	11.59 de	20.26 c	13.12 c	10.44 h	11.63 h	19.40 ef	13.82 c
2.5 g/plant	8.82 ef	12.71 d	29.78 b	17.11 b	10.91 h	16.14 fg	39.76 b	22.27 b
5.0 g/plant	19.45 c	22.77 c	40.99 a	27.74 a	18.76 efg	28.78 c	45.34 a	30.96 a
10.0 g/plant	12.29 d	22.25 c	21.73 c	18.76 b	15.29 g	24.51 d	21.91 de	20.57 b
Mean (A)	12.02 c	17.33 b	28.19 a		13.85 c	20.27 b	31.60 a	
				Vegetative growth dry weight (g)				
Control	3.29 h	3.82 gh	4.70 f-h	3.94 c	3.48 f	3.84 f	6.12 e	4.48 d
2.5 g/plant	4.10 f-h	5.19 e-g	8.83 b	6.04 b	3.61 f	6.30 e	12.64 b	7.52 b
5.0 g/plant	6.98 d	8.43 bc	12.58 a	9.33 a	7.98 d	9.63 c	15.35 a	10.98 a
10.0 g/plant	5.26 ef	6.53 de	7.41 cd	6.40 b	4.28 f	8.59 cd	6.06 e	6.310 c
Mean (A)	4.91 b	5.99 b	8.38 a		4.84 c	7.09 b	10.04 a	

Means having the same letter are not significantly differed at 0.05 level of probability according to Duncan's Multiple Range Test [24]

Table 3: Effect of fertilization with humic acid, ammonium sulfate and their interaction on branch characteristics of *Asparagus densiflorus* "Meyerii" plants during 2016/2017 and 2017/2018 seasons

	Humic acid (g/plant) (A)							
	0.0	2.5	5.0	Mean (B)	0.0	2.5	5.0	Mean (B)
Ammonium sulfate (B)	2016/2017				2017/2018			
				Branches number/plant				
Control	9.67 e	10.00 de	14.33 b	11.33 b	10.80 f	11.30 f	14.70 c	12.27 c
2.5 g/plant	10.33 c-e	12.33 b-e	19.67 a	14.11 a	10.57 f	12.43 d-f	22.47 b	15.16 b
5.0 g/plant	12.11 b-e	12.67 b-d	22.00 a	15.59 a	11.73 ef	14.67 c	24.83 a	17.08 a
10.0 g/plant	11.33 c-e	13.04 bc	20.00 a	14.79 a	13.33 c-e	14.17 cd	21.97 b	16.49 a
Mean (A)	10.86 b	12.01 b	19.00 a		11.61 c	13.14 b	20.99 a	
				Branch length (cm)				
Control	18.33 f	22.73 d-f	25.43 cd	22.17 b	16.13 g	22.70 f	27.40 de	22.08 c
2.5 g/plant	20.50 ef	23.70 c-e	27.60 c	23.93 b	18.33 g	24.77 ef	29.90 d	24.33 b
5.0 g/plant	21.27 d-f	37.40 ab	39.00 a	32.56 a	19.03 g	38.57 b	41.73 ab	33.11 a
10.0 g/plant	21.43 d-f	36.83 ab	34.00 b	30.76 a	22.60 f	41.83 a	34.37 c	32.93 a
Mean (A)	20.38 b	30.17 a	31.51 a		19.02 b	31.97 a	33.35 a	
				Branch fresh weight (g)				
Control	1.10 h	1.32 gh	1.76 de	1.39 c	1.20 fg	1.42 ef	1.89 cd	1.51 d
2.5 g/plant	1.28 gh	1.61 ef	2.19 b	1.69 b	1.15 g	1.59 e	2.33 ab	1.69 c
5.0 g/plant	1.87 cd	2.11 bc	2.60 a	2.19 a	2.07 bc	2.33 ab	2.56 a	2.32 a
10.0 g/plant	1.63 d-f	2.20 b	1.40 fg	1.74 b	1.66 de	2.51 a	1.52 e	1.90 b
Mean (A)	1.47 c	1.81 b	1.99 a		1.52 c	1.96 b	2.07 a	
				Branch dry weight (g)				
Control	0.36 e	0.44 de	0.54 cd	0.45 c	0.41 d	0.49 cd	0.63 bc	0.51 c
2.5 g/plant	0.43 de	0.52 cd	0.74 ab	0.56 b	0.50 cd	0.61 b-d	0.76 ab	0.62 bc
5.0 g/plant	0.64 bc	0.78 a	0.84 a	0.75 a	0.74 ab	0.79 ab	0.85 a	0.79 a
10.0 g/plant	0.76 a	0.86 a	0.54 cd	0.72 a	0.77 ab	0.82 ab	0.52 cd	0.70 ab
Mean (A)	0.55 b	0.65 a	0.67 a		0.61 a	0.68 a	0.69 a	

Means having the same letter are not significantly differed at 0.05 level of probability according to Duncan's Multiple Range Test [24]

Regarding interaction between humic acid and ammonium sulfate treatments, data in Table 3 showed that, the interaction treatment between humic acid at 5.0 g/plant and ammonium sulfate at 5.0 g/plant was significantly the best treatment for growth of branches in both seasons, as it recorded 39.00 cm for branch length in the first season, 22.00 and 24.83 for number of branches and 2.60 and 2.56 g for fresh weight/branch in both seasons, respectively and 0.85 g for dry weight/branch in the second season). The exception was for the combined treatment of humic acid at 2.5 g/plant and 10.0 g/plant ammonium sulfate which recorded the highest values in case of branch length in the second season (41.83 cm) and dry weight/branch in the first one (0.86 g). It can be indicated that in most cases untreated plants produced the lowest values for branch length (18.33 and 16.13 cm in both seasons, respectively), number of branches/plant (9.67) and fresh weight/branch (1.10 g) in the first season only and for dry weight/branch (0.36 and 0.41 g in both seasons, respectively).

Regarding the effect of humic acid on vegetative growth the above-mentioned results were in line with the resultes obtained by Fan *et al.* [9] who reported that the morphological indices (stem diameter, fresh and dry weights of shoots) of *Chrysanthemum* improved obviously after foliar application with humic acid. Manda *et al.* [3] on *Spathiphyllum wallisii* Regel. showed that humic acid treatment at 2.5% increased plant height, number of leaves/plant and the number of offsets/plant. While on *Cycas revoluta*, Thunb. El-Sayed *et al.* [10] showed that plant height as well as fresh and dry weights of leaves and stems were significantly improved over control in response to the treatment of humic acid at 5 ml/l. Abou Dahab *et al.* [11] on *Chamaedorea elegans* reported that application of humic acid at 6 ml/l increased plant height, fresh and dry weights of shoots to the highest values. Babar *et al.* [25] showed that maximum plant height of gladiolus was obtained with 350 ppm humic acid. Abd-El-Hady *et al.* [12] stated that application of HA at 2000 mg/l manifested the highest values of all studied growth parameters of *Acalypha wilkesiana*

To interpret the enhancement of plant growth achieved by using humic acid, it may be due to increasing nutrients uptake such as N, Ca, P, K, Mg, Fe, Zn and Cu [26]. Enhancement of photosynthesis, chlorophyll density and plant root respiration which resulted in greater plant growth with humate application [27].

Concerning the effect of nitrogen fertilization the obtained results were in parallel with the results obtained by Sodha and Dhaduk [28] on *Solidago canadensis* who showed that, the highest plant height, number of leaves, number of suckers, plant spread and fresh and dry weights of plant were recorded with treatment containing nitrogen rate at 150 kg N/ha. Similar results were obtained by Kolodziej [29] on *Solidago virgaurea* subsp. virgaurea, Nath *et al.* [30] on *Peperomia obtusifolia*, *Cordyline terminalis* and *Cholorophytum laxum*, Almeida *et al.* [31] on calla lily and Badole *et al.* [32] on China-aster.

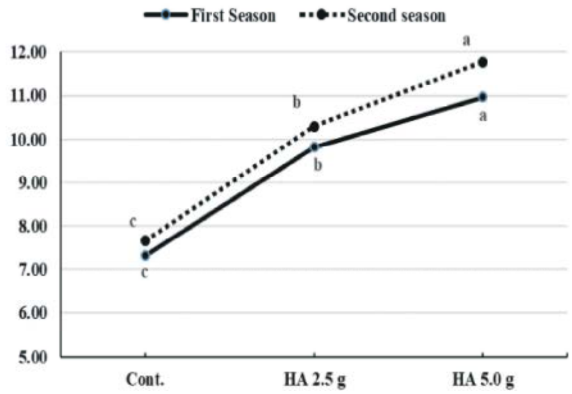
This increment in vegetative growth of asparagus plant may be attributed to the beneficial effects of nitrogen on stimulating the meristematic activity for producing more tissues and organs, since it plays major roles in the synthesis of structural proteins and other several macro molecules, in addition to its vital contribution in several biochemical processes that related to plant growth [33]. Opik and Rolfe [34] reported that nitrogen is a constituent of many cellular molecules, in particular proteins and nucleic acids, the key macromolecules of life. There are many lower molecular weight nitrogenous organic compounds vital to cell metabolism vitamins, cofactors, hormones, the chlorophyll pigments and the phytochrome photoreceptors.

Vase Life (Days): Regarding the effect of humic acid, treated *Asparagus* with humic acid at 5.0 g/plant gave the longest vase life (10.96 and 11.77 days) against (9.82 and 10.29 days) for 2.5 g humic acid and (7.32 and 7.65 days) for untreated plants in the 1st and 2nd seasons, respectively (Fig. 1).

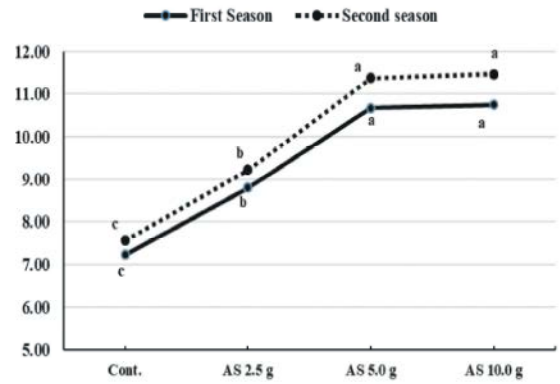
As for ammonium sulfate, data in Fig. 1 indicated that fertilizing plants with 5.0 g/plant extended vase life of *Asparagus* cut foliage and recorded the highest values (10.68 and 11.38 days) with no significant differences between 10.0 g/plant (10.76 and 11.48 days), while untreated plants recorded the shortest vase life (7.22 and 7.56 days) in the first and second seasons, respectively.

Concerning the interaction between humic acid and ammonium sulfate treatments (Fig. 1), the longest vase life of *Asparagus* cut foliage (13.50 and 14.67 days in both seasons, respectively) was recorded with the interaction between humic acid at 5.0 g/plant + ammonium sulfate at 5.0 g/plant. In this regard the shortest vase life of *Asparagus* cut branches was recorded by untreated plants as recorded 6.77 and 7.22 days in both seasons, respectively.

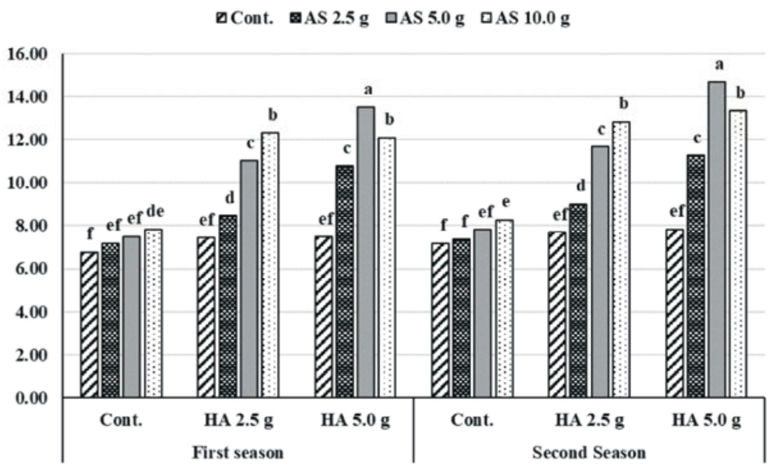
It can be observed that the vase life of asparagus cut foliage was extended up to 14.67 days by applying humic acid at 5.0 g + ammonium sulfate at 5.0 g/plant, this value was more supreme when compared with the values



Humic acid



Ammonium sulfate



Humic acid × ammonium sulfate

HA= humic acid at 2.5 or 5.0 g/plant; AS= ammonium sulfate at 2.5, 5.0 or 10.0 g/plant; Cont. = untreated plants (control). Means having the same letter are not significantly differed at 0.05 level of probability according to Duncan's Multiple Range Test [24].

Fig. 1: Effect of fertilization with humic acid, ammonium sulfate and their interaction on vase life (days) of *Asparagus densiflorus* "Meyerii" cut foliage during 2016/2017 and 2017/2018 seasons.

recorded by previous studies on the same plant cultivar i.e. Kayalvizhi *et al.* [35] who found that the longest vase life had been recorded was only 7.47 days. In addition, these results are in parallel with the results obtained on vase life of cut flowers, as Nikbakht *et al.* [36] who showed that higher humic acid levels (1000 mg/l) extended vase life of gerbera harvested flowers by 2-3.66 days. Ahmad *et al.* [37] revealed that treating gladiolus with three applications of HA and NPK, resulted in longer vase life of cut flowers. Ali *et al*. [38] found that humic acid at 1.25 ml/l + 10 g/m^2 NPK gave the inimitable outcomes concerning vase life of *Tulipa gesneriana* cut flowers. While, there was no obvious effect regarding the effect of fertilization on subsequence vase life of cut foliage as reported by Conover and Poole [39] on *Pittosporum tobira* and Stamps [15] on *Aspidistra elatior* "Variegata".

Chemical Composition

Pigments Content (mg/g f.w.): As for the effect of humic acid, the results in Table 4 showed that all photosynthetic pigments contents significantly increased by increasing humic acid rates, the highest increment was obtained in chlorophyll a, b and carotenoids in tissues (0.407, 0.217 and 0.102 mg/g f.w., respectively) when plants were treated with humic acid at 5.0 g/plant. While the lowest values were recorded in untreated plants giving 0.323, 0.128 and 0.070 mg/g f.w. for chlorophyll a, b and carotenoids, respectively.

Table 4: Effect of fertilization with humic acid, ammonium sulfate and their interaction on pigment contents (mg/g f.w.) of *Asparagus densiflorus* "Meyerii" plants during 2017/2018 season

	Humic acid (g/plant) (A)			
Ammonium sulfate (B)	0.0	2.5	5.0	Mean (B)
	Chlorophyll a (mg/g f.w.)			
Control	0.215 e	0.354 c	0.389 b	0.319 c
2.5 g/plant	0.318 d	0.402 ab	0.405 ab	0.375 b
5.0 g/plant	0.350 cd	0.407 ab	0.425 a	0.394 ab
10.0 g/plant	0.411 ab	0.418 ab	0.409 ab	0.413 a
Mean (A)	0.323 b	0.395 a	0.407 a	
	Chlorophyll b (mg/g f.w.)			
Control	0.081 e	0.095 e	0.154 d	0.110 c
2.5 g/plant	0.086 e	0.149 d	0.204 c	0.146 b
5.0 g/plant	0.113 e	0.154 d	0.217 c	0.161 b
10.0 g/plant	0.231 bc	0.263 ab	0.294 a	0.263 a
Mean (A)	0.128 c	0.165 b	0.217 a	
	Carotenoids (mg/g f.w.)			
Control	0.104 b-d	0.160 a	0.124 b	0.129 a
2.5 g/plant	0.075 d-g	0.091 b-e	0.109 bc	0.092 b
5.0 g/plant	0.055 fg	0.086 c-f	0.107 b-d	0.083 b
10.0 g/plant	0.047 g	0.045 g	0.067 e-g	0.053 c
Mean (A)	0.070 b	0.095 a	0.102 a	

Means having the same letter are not significantly differed at 0.05 level of probability according to Duncan's Multiple Range Test [24]

Table 5: Effect of fertilization with humic acid, ammonium sulfate and their interaction on total carbohydrates, N, P and K contents of *Asparagus densiflorus* "Meyerii" plants during 2017/2018 season

	Humic acid (g/plant) (A)			
Ammonium sulfate (B)	0.0	2.5	5.0	Mean (B)
	Total carbohydrates (%)			
Control	14.26 g	14.59 g	23.35 e	17.40 d
2.5 g/plant	15.31 g	17.93 f	27.53 c	20.26 c
5.0 g/plant	26.20 cd	27.06 c	37.80 a	30.35 a
10.0 g/plant	26.55 c	31.88 b	24.20 de	27.54 b
Mean (A)	20.58 c	22.86 b	28.22 a	
	N (%)			
Control	1.29 f	1.68 de	2.23 bc	1.73 c
2.5 g/plant	1.31 f	1.81 d	2.35 b	1.82 b
5.0 g/plant	1.57 e	2.13 c	2.52 a	2.07 a
10.0 g/plant	1.66 e	2.18 c	2.57 a	2.14 a
Mean (A)	1.46 c	1.95 b	2.42 a	
	P (%)			
Control	0.108 g	0.218 e	0.368 c	0.231 c
2.5 g/plant	0.140 f	0.239 e	0.402 b	0.261 b
5.0 g/plant	0.149 f	0.355 c	0.446 a	0.317 a
10.0 g/plant	0.168 f	0.293 d	0.442 a	0.301 a
Mean (A)	0.141 c	0.276 b	0.415 a	
	K (%)			
Control	1.03 f	1.05 f	1.64 c	1.24 d
2.5 g/plant	1.44 d	1.48 d	2.08 b	1.67 b
5.0 g/plant	1.31 e	2.24 a	2.27 a	1.94 a
10.0 g/plant	1.08 f	1.42 de	1.55 cd	1.35 c
Mean (A)	1.22 c	1.55 b	1.89 a	

Means having the same letter are not significantly differed at 0.05 level of probability according to Duncan's Multiple Range Test [24]

Respecting ammonium sulfate, it is evident from the data in Table 4 that ammonium sulfate rates had a significant effect on chlorophyll a, b and carotenoids contents in asparagus tissues. It is obvious that ammonium sulfate at 10.0 g/plant give the highest values for chlorophyll a (0.413 mg/g f.w.) and b (0.263 mg/g f.w.) when compared with other rates or control. In contrast, carotenoids were decreased with increasing ammonium sulfate rates and control plants produced the highest value (0.129 mg/g f.w.).

As for the interaction between humic acid and ammonium sulfate, it is clear from data presented in Table 4 that all interaction treatments showed a significant effect on chlorophyll a, b and carotenoids contents in tissues than the untreated plants. In general, treating plants with humic acid at 5.0 g/plant and fertilizing with 5.0 g/plant ammonium sulfate were the best interaction treatment for enhancing chlorophyll a content (0.425 mg/g f.w.), while treating plants with humic acid at 5.0 g/plant and ammonium sulfate at 10.0 g/plant recorded the highest value for chlorophyll b (0.294 mg/g f.w.). In this regard, treating plants with humic acid at 2.5 g/plant without ammonium sulfate recorded the highest value of carotenoids concentration in plant tissues (0.160 mg/g f.w.).

Total Carbohydrates, N, P and K (% d.w.): Concerning the effect of humic acid, data presented in Table 5 showed that the maximum values of total carbohydrates (28.22%), N (2.42%), P (0.415%) and K (1.89%) contents were recorded with the plants when treated with humic acid at 5.0 g/plant, while the minimum values were recorded with control treatment (20.58, 1.46, 0.141 and 1.22% for total carbohydrates, N, P and K, respectively).

As for ammonium sulfate, the same data in Table 5 indicated that, the moderate rate of ammonium sulfate (5.0 g/plant) was the best for increasing total carbohydrates (30.35%), N (2.07%), P (0.317%) and K (1.94%) in plant with no significant differences with 10.0 g/plant with respect to N and P contents in plant tissues (2.14 and 0.301%, respectively). The lowest values were recorded in untreated plants (control), the values were 17.40, 1.73, 0.231 and 1.24% for total carbohydrates, N, P and K, respectively.

Regarding the interaction between humic acid and ammonium sulfate, data in Table 5 showed that, humic acid at 5.0 g/plant in addition to fertilizing with 5.0 g/plant ammonium sulfate recorded the highest values of total carbohydrates (37.80%), P (0.446%) and K (2.27%) in plants. While, the interaction between humic acid at

5.0 g/plant and fertilizing with 10.0 g/plant ammonium sulfate recorded the highest values in case of nitrogen content (2.57%). The lowest values (14.26, 1.29, 0.108 and 1.03% for total carbohydrates, N, P and K, respectively) were recorded by untreated plants (control).

The previous mentioned results were similar to the results obtained by El-Attar [40] who found that using humic acid at 0.5 or 1.0 ml/l on *Ficus alii* cv. Green and cv. Variegata plants caused an increase in N and P and total carbohydrates contents. Abdel-Fattah *et al*. [7] on dracaena and ruscus plants reported that a combination of humic acid at 5 ml/l as a foliar spray and at 10 ml/l as a soil drench recorded a marked increment in the leaf content of chlorophyll a, b, carotenoids, total carbohydrates, N, P and K content. El-Sayed *et al.* [10] showed that on *Cycas revoluta*, Thunb. showed that humic acid at 5 ml/l produced the highest photosynthetic pigments (chlorophyll a, b and carotenoids), N, P, K and total carbohydrates. On *Chamaedorea elegans* Abou Dahab *et al.* [11] revealed that application of humic acid at 3 ml/l increased total chlorophylls and carotenoids contents while at 6 ml/l recorded the highest total carbohydrates, N, P and K contents. Abd-El-Hady *et al.* [12] on *Acalypha wilkesiana* reported that humic acid at 2000 mg/l recorded the highest total chlorophylls, N, P and K. While at 1000 mg/l was more effective for carotenoids content.

The Increments of N, P, K contents with the application of humic acid may be attributed to the improvement of plant growth. Moreover, such improvement reflects on the abundance of minerals in the soil solution which enhanced their uptake by plant roots [41].

It was observed that humic substances may affect both the level and percentage distribution of sugars of maize leaves; these effects seem to be mediated by changes in the activities of enzymes involved in carbohydrate metabolism [42]. Also, the stimulative effect of humic acid on chemical constituents may be due to that humic acid is one of the most active fractions of organic matter, it improves the absorption of nutrients by plants and soil microorganisms, have a positive effect on the dynamic of N and P in soil, stimulate plant respiration and the photosynthesis process [43]. Abd-El-Hady *et al.* [12] emphasized that application of humic acid principally associated to the enhancement of nutrients absorption. It enhances protein synthesis, improves photosynthesis products and macro-elements such as K^+, NH_4^+, or Ca_2^+ and forms aqueous complexes with micronutrients.

Ahmad *et al*. [37] showed that treating gladiolus plants with humic acid and NPK was the best for increasing total chlorophylls contents than treated plant with humic or NPK alone. Ali *et al*. [38] found that treating tulip plants with humic acid at 1.25 ml + 10 g/m^2 NPK increased nutrients contents.

It could be suggested that the enhancing effect of increasing ammonium sulfate rate on photosynthetic pigments might be due to that nitrogen is a main constituent molecule of chlorophyll. Moreover, nitrogen is the main constituent of all amino acids and hence of proteins and lipids as glactolipids, acting as a structural component of chloroplast. Correspondingly, an enhancement of protein synthesis and chloroplast formation leads to an increase in chlorophyll and carotene [33].

The increase in minerals concentration in tissues of *Asparagus* plant as a result of increasing the addition of nitrogen fertilizer might be attributed to the stimulating effect of absorbing efficiency of the plant. In addition, application of nitrogen fertilizer stimulates synthesis of carbohydrates to which the dry matter content is a reliable index. This might be due to increase in amount of carbohydrates in roots consequently the minerals uptake became greater [44]. Vargas and Bryla [17] reported that ammonium sulfate may increase N uptake relative to urea as a result of lower soil pH and increased availability of NH_4-N.

From the obtained results of this study, it is recommended to fertilize *Asparagus densiflorus* "Meyerii" grown in the open field with humic acid at 5.0 g/plant in addition to 5.0 g/plant ammonium sulfate at monthly intervals to obtain high quality plants with extending vase life of cut foliage.

REFERENCES

1. Brickell, C., 1997. The American Horticultural Society A-Z Encyclopedia of Garden Plants. DK Publishing, Inc., New York, USA, pp: 1092.
2. Skutnik, E., J. Rabiza-Swider and A.J. Lukaszewska, 2006. Evaluation of several chemical agents for prolonging vase life in cut asparagus greens. Journal of Fruit and Ornamental Plant Research, 14: 233-240.
3. Manda, M., M.G. Dumitru and C. Nicu, 2014. Effects of humic acid and grape seed extract on growth and development of *Spathiphyllum wallisii* Regel. South Western Journal of Horticulture, Biology and Environment, 5(2): 125-136.

4. Nardi, S., D. Pizzeghello, A. Muscolo and A. Vianello, 2002. Physiological effects of humic substances on higher plants. Soil Bio. and Biochemistry, 34: 1527-1536.
5. El-Sayed, B.A., G.H. Abedel–Fattah and S.A. El-Shal, 2008. Improvement of growth and quality of tifway sod by actosol and biofertilizers. J. Biol. Chem. Environ. Sci., 3(1): 91-102.
6. El-Sayed, B.A. and S.A. El-Shal, 2008. Effect of growing media and humic acid on schefflera (*Brassaia actinophylla*) quality. J. Agric. Sci., Mansoura Univ., 33(1): 371-381.
7. Abdel-Fattah, G.H., B.A. El-Sayed and S.A.M. Khenizy, 2009. Response of *Dracaena* and *Ruscus* to humic acid and biofertilizer supply. Annls. of Agric. Sci., Moshtohor, 47(1): 111-119.
8. El-Fouly, A.S., B.A. El-Sayed and S.M. Shahin, 2014. Effect of foliar spraying with humic acid and chelated microelements on growth and quality of goodluck (*Cordyline terminalis* (L.) Kunth.) plant. Minufiya J. Agric. Res., 39(1): 205-213.
9. Fan, H.M., X.W. Wang and X. Sun, 2014. Effects of humic acid derived from sediments on growth, photosynthesis and chloroplast ultrastructure in chrysanthemum. Scientia Horticulturae, 177: 118-123.
10. El-Sayed, B.A., T.M. Noor El-Deen, L. Abdel-Galeil and W. Aly, 2016. Effect of natural activator (Biohorm) and humic acid on growth and quality of Cycas Plant. Scientific Journal of Flowers and Ornamental Plants, 3(1): 79-86.
11. Abou Dahab, T.A.M., H.A. Ashour, E.E.A. El-Deeb and H.M.M. Saber, 2017. Response of *Chamaedorea elegans*, Mart. plants grown under different light intensity levels to chemical and organic fertilization treatments. Journal of Horticultural Science & Ornamental Plants, 9(2): 72-85.
12. Abd-El-Hady, W.M., E.M.M. Selim and N.I. El-Sayed, 2019. Influence of humic and ascorbic acids on growth parameters and anthocyanin content of *Acalypha wilkesiana* irrigated with seawater. Plant Archives, 19(1): 652-664.
13. Salisbury, F.B. and C.W. Ross, 1992. Mineral Nutrition: In: Plant Physiology 4th edition. Wadsworth Pub Co Belmont, California, USA.
14. Poole, R.T. and C.A. Conover, 1985. Nitrogen, phosphorus and potassium fertilization of *Brassaia actinophylla*, *Calathea makoyana* and *Chrysalidocarpus lutescens*. Journal of Environmental Horticulture, 3(1): 1-3.
14. Stamps, R.H., 1995. Effects of shade level and fertilizer rate on yield and vase life of *Aspidistra elatior* 'Variegata' leaves. Journal of Environmental Horticulture, 13(3): 137-139.
16. Chien, S.H., M.M. Gearhart and S. Villagarcía, 2011. Comparison of ammonium sulfate with other nitrogen and sulfur fertilizers in increasing crop production and minimizing environmental impact: A Review. Soil Science, 176(7): 327-335.
17. Vargas, O.L. and D.R. Bryla, 2015. Growth and fruit production of highbush blueberry fertilized with ammonium sulfate and urea applied by fertigation or as granular fertilizer. HortScience, 50(3): 479-485.
18. Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. John Wiley & Sons, New York, USA, pp: 680.
19. Wellburn, A.R. and H. Lichtenthaler, 1984. Formulae and program to determine total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Advanced Agricultural Biotechnology, 2(1): 9-12.
20. Jackson, M.L., 1973. Soil Chemical Analysis. Prentice-Hall of India Private Ltd. M-97, New Delhi, India, pp: 498.
21. Cottenie, A., M. Verloo, L. Kiekan, G. Velghe and R. Comerlynck, 1982. Chemical Analysis of Plants and Soils. Laboratory of Analytical and Agrochemistry, State Univ., Ghent-Belgium, pp: 44-45.
22. Dubois, M., K.A. Gilles, J.K. Hamilton, P.T. Rebers and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. Analytical Chemistry, 28(3): 350-356.
23. MSTAT Development Team, 1989. MSTAT User's Guide: A Microcomputer Program for The Design Management and Analysis of Agronomic Research Experiments. Michigan State University, East Lansing, USA.
24. Duncan, D.B., 1955. Multiple range and multiple F test. Journal of Biometrics, 11: 1-42.
25. Babar, A., A. Jawad, W.A.B. Sayyed, I. Muhammad and K. Waqas, 2017. Effect nitrogen and humic acid levels on plant height and number of florets per spike of Gladiolus Cultivars. Int. J. Environ. Sci. Nat. Res., 7(1): 1-4.
26. Adani, F., P. Genevini, P. Zaccheo and G. Zocchi, 1998. The effect of commercial humic acid on tomato plant growth and mineral nutrition. J. Plant Nutr., 21: 561-575.

27. Chen, Y. and T. Aviad, 1990. Effects of Humic Substances on Plant Growth 1. In: P. MacCarthy, C.E. Clapp, R.L. Malcolm and P.R. Bloom editors, Humic Substances in Soil and Crop Sciences: Selected Readings, SSSA, Madison, WI., pp: 161-186.
28. Sodha, B.P. and B.K. Dhaduk, 2002. Effect of spacing and nitrogen on solidago. J. Ornamental Hort. (New Series). Indian Soc. of Ornamental Hort., 5(1): 63-64.
29. Kolodziej, B., 2007. The effect of NPK fertilization on goldenrod (*Solidago virgaurea* subsp. virgaurea) yield and quality parameters. Herba Polonica, 53(3): 129-134.
30. Nath, M.R., A.K. Pal and J. Biswas, 2008. Effect of inorganic fertilisers on growth and development of three shade loving ornamental foliage plants. Orissa Journal of Horticulture, 36(1): 59-63.
31. Almeida, E.F.A., P.D.O. Paiva, J.E.M. Frazao, F.H.S. Santos, F.A. Resende and M.L. Campos, 2012. Growth and inflorescences production on calla lily plants in response a NPK and cattle manure fertilization. Revista Brasileira de Horticultura Ornamental, 18(2): 129-133.
32. Badole, W.P., P.B. Sanap, K. Vandana and P. Bhaisare, 2015. Effect of nitrogen and phosphorus on nutrient uptake, yield and quality of China-aster. Journal of Soils and Crops, 25(2): 397-401.
33. Marschner, H., 1995. Mineral Nutrition of Higher Plants. 2nd Ed. Academic. Press. London New York, pp: 889.
34. Opik, H. and A.S. Rolfe, 2005. The Physiology of Flowering Plants, 4th Ed. Cambridge University Press, New York, USA, pp: 404.
35. Kayalvizhi, K., R. Arulmozhiyan, A. Sankari and M. Anand, 2013. Influence of potting media on growth of *Asparagus densiflorus* “Meyersii”. Journal of Horticultural Sciences, 8(2): 278-281.
36. Nikbakht, A., K. Mohsen, B. Mesbah, X.Y. Ping, L. Ancheng and E. Nemat-Allah, 2008. Effect of humic acid on plant growth, nutrient uptake and postharvest life of Gerbera. J. Plant Nutr., 31: 2155-2167.
37. Ahmad, I., R.U. Saquib, M. Qasim, M. Saleem, A.S. Khan and M. Yaseen, 2013. Humic acid and cultivar effects on growth, yield, vase life and corm characteristics of gladiolus. Chilean J. Agric. Res. 73(4): 339-344.
38. Ali, A., S.U. Rehman and S. Raza, 2014. Combined effect of humic acid and NPK on growth and flower development of *Tulipa gesneriana* in Faislabad, Pakistan. Journal of Ornamental Plants, 4(4): 39-48.
39. Conover, C.A. and R.T. Poole, 1980. Effects of light and fertilizer levels on cut foliage production. In Proceedings of the Florida State Horticultural Society, 93: 210-212.
40. El-Attar, A.S., 2006. Physiological Studies on *Ficus alii* Plants. M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt, pp: 169.
41. Dorneanu, A.D., M.E. Dorneanu, C. Preda, L. Anton and L. Oprica, 2008. Fertilization with liquid humic fertilizers, procedure of high efficiency in improving plant nutrition along the growing season. In the Proceeding of the 17th International Sympodium of the International Scientific Centre for Fertilizers (CIEC), 24-27 Nov., Cairo, Egypt, pp: 259-264.
42. Merlo, L., R. Ghisi, C. Passera and N. Rascio, 1991. Effects of humic substances on carbohydrate metabolism of maize leaves. Canadian Journal of Plant Science, 71(2): 419-425.
43. Brunetti, G., C. Plaza, C.E. Clapp and N. Senesi, 2007. Compositional and functional features of humic acids from organic amendments and amended soils in Minnesota, USA. Soil Biol. Biochem., 39: 1355-1365.
44. Mengel, K. and E.A. Kirkby, 1978. Principles of plant nutrition. International Potash Institute, P.O. Box, CH. 3048, Worblaufen Bern, Switzerland.