EFFECT OF NPK AND HUMIC ACID ON GROWTH, FLOWERING AND CHEMICAL COMPOSITION OF (BLUE SAKE) *ERANTHEUMUM PULCHELLUM* ANDREWS PLANT

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Abstract. In this study the treatments were carried out as follows: Control; Full dose of NPK containing 6 g ammonium sulphate (20.5%N) + 4 g calcium super phosphate(15.5%P_2O_5) + 3 g potassium sulphate (48.5%K_2O) to 8 kg soil in the pot; Half NPK dose; Half NPK dose + 50 ppm (HA); Half NPK dose + 100 ppm(H.A.); Half NPK dose + 150 ppm (H.A.); as well as (H.A.) at 50,100 and 150 ppm. The obtained results showed that most treatments resulted significantly taller plants, higher branch and leaf plural, wider leaf area compared to control with $^1/_2$ NPK + 150 ppm (H.A.) treatment providing the best results as this treatment gave also the high significant. Additionally, this treatment caused significantly the earliest flowering with the longest flower stem, widest flower diameter, number of flowers per plant as well as the heaviest fresh and dry weight of flowers. Most treatments gave significantly higher total chlorophyll in the leaves than the control with the superiority of the treatment of $^1/_2$ NPK + 150 ppm (H.A.) followed by the treatment of NPK alone with non-significant differences in between. N ratio in the leaves significantly increased over control in most treatments and especially for the treatment of $^1/_2$ NPK + 150 ppm (H.A.). P ratio in the leaves were significantly the highest as a result of the NPK treatment with no other additives. While the highest K ratio resulted from the treatment of either 100 or150 ppm (H.A.) without significant differences in between. However, the treatment of ½ NPK + 150 ppm (H.A.) is recommended to obtain high quality plants.
Keywords: *potassium humate; N, P and K fertilization; chemical fertilization; Erantheumum pulchellum*

Introduction

Chemical fertilization provides nutrients optimal for plant growth and development. The essential nutrients in the fertilizers are nitrogen, phosphorous and potassium (NPK). The most important major nutrient is nitrogen (N) which partakes in many compounds in the plant such as amino acids, proteins, chlorophylls, hormones, alkaloids and enzymes. Phosphorus (P) partakes in phospholipids, DNA, RNA and metabolism of fats. Potassium (K) regulates water condition within the plant cell and water loss by transpiration as a catalyst and condensing agent of complex substances through its active properties (Devlin, 1975) and potassium has a main role in plant metabolism such as photosynthesis, translocation of photosynthates, water relation as well as enzyme activation. Although, potassium is not a constituent of any plant structures or compounds, but it plays a part in many important regulatory roles in the plant, i.e. osmo-regulation process, regulation of plant stomata and water use, translocation of sugars and formation of carbohydrates, energy status of the plant, the regulation of enzyme activities, protein synthesis and many other processes needed to sustain plant growth and reproduction (Hasio and Lauchli, 1986).

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Humic acid (HA), called humin materials widely consists of a part of soil organic matter (65-70%) (Stott and Martin, 1990). It is a potential natural resource that can be utilized to increase growth, nutrient availability and yield (Sharif et al., 2002). It has direct and indirect effects on plant growth due to roles of humic acid (Pal and Biswas, 2005). Humic acid treatments improve soil aggregation, structure, water permeability, air conditioning, fertility, moisture-holding capacity. It constitutes a stable fraction of carbon (C), thus regulating the carbon cycle and releasing of nutrients, including N, P and S (Stevenson,1994) and improving nutrients uptake and hormonal effects (Nikbakht et al., 2008).

Erantheumum pulchellum Andrews (syn Daedalacanthus nervosum R) blue sake

The 7.5 to 15.3 cm-long flower spikes are borne above the large, rounded and prominently veined leaves. Leaves are large, dark green, simple, opposite and leaf blade length arrives 5 to 10 cm. Fruit shape is oval and its length is less than 12.5 cm. It is used in flower beds. It is popular with gardeners because of the spikes of flowers that are bright gentian blue - an unusual color in the tropics (Edward, 1999) as illustrated in *Figure 1*.

Figure 1. *Erantheumum pulchellum Andrews plant*

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The aim of this work was to study the effect of (NPK) nitrogen, phosphorus and potassium and humic acid (HA) on the growth, flowering and chemical composition of the plant and try to obtain the synergistic effect of HA to partly replace the risk of pollution to environments by chemical fertilization. Hence there was no need for the treatment of NPK (full dose) + HA.

Martials and methods

A series of pot experiments in the open field were conducted during 2014/2015 and 2015/2016 seasons in Hort. Dept., Agric. Fac., Kafr El-Sheik Univ. Egypt. The site is located at 31°07 N latitude and 30°57 E longitude with an elevation of about 6 m above mean sea level. The climatic conditions of the study area are provided in *Table 1*.

Table 1. *Monthly air temperature (Max., Min. and Mean °C), relative humidity (RH %), at the experimental site during the two growing seasons of 2014/2015 and 2015/2016. (Source Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt)*

Season	**2014/2015**				**2015/2016**			
Month	**Air Temp**			**RH%**	**Air Temp**			**RH%**
	Max	**Min**	**Mean**		**Max**	**Min**	**Mean**	
September	32.49	20.76	26.58	69.89	34.6	22.8	28.7	64.6
October	29.75	18.75	24.25	67.16	22.9	20.06	21.75	67.1
November	24.3	13.79	19.04	74.15	24.4	14.42	19.41	75.6
December	22.27	9.72	16.00	76.05	19.7	8.36	14.03	77.9
January	18.79	6.46	12.63	74.6	18.4	6.35	12.38	74.05
February	19.01	7.69	13.35	74.8	22.58	9.35	15.96	69.05
Mars	22.69	11.69	17.19	70.6	25.5	11.6	18.55	69.9
April	25.64	13.7	19.67	63.4	30.03	18.62	24.33	61.7
May	30.19	18.79	24.49	61.7	30.04	22.8	26.42	58.4
June	30.85	21.4	26.13	65	33.6	26.3	29.95	61.15
July	33.0	22.4	27.7	70.0	33.7	26.1	29.9	69.75
Augustus	35.1	25.0	30.05	67.8	33.6	26.0	29.8	70.3

The aim was to study the effect of N, P and K fertilization and humic acid foliar spray on the growth, flowering and chemical composition of a local variety of *Eranthemum pullchellum* Vahl R.BR. The cuttings of one-year-old plants of 10 cm length were planted in 20 cm diameter clay pots filled with about 8 kg clayey soil as one plant/pot commencing on the 1st September till September of the next year. The plants were treated as follows: 1-Control, 2-Full dose of NPK containiing 6 g ammonium sulphate (20.5% N) + 4g calcium super phosphate (15.5%P2O5) + 3 g potassium sulphate (48.5% K2O), 3-Half NPK dose, 4- Half NPK dose + 50 ppm humic acid (HA), 5- Half NPK dose + 100 ppm humic acid (HA), 6- Half NPK dose + 150 ppm humic acid (HA), 7- 50 ppm humic acid (HA), 8- 100 ppm humic acid (HA) and 9- 150 ppm humic acid (HA). The treatments were replicated three times involving 9 plants in a complete randomized design. NPK fertilizer was drench-applied as calcium super phosphate at preparing the soil, while N and K were monthly applied after one month from planting. HA was foliar applied monthly after one month from planting as the

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plants were run-off sprayed. The watering was every three days at summer and weekly in winter. The following data were recorded after one year, plant height (cm), number of branches, number of leaves/plant, leaf area as mean of 3 leaves in the middle part of the plant (cm^2) by using CI-202 portable laser leaf area meter (cidb10-science) made in USA, WWW.CID-INC.COM, fresh and dry weights of vegetative parts per plant (g), root length of the longest root (cm), fresh and dry weight of the roots per plant (g) after removing soil by water, flowering date (days) as the first flower showed color on the plant, number of flowers per plant, diameters of flower (cm), fresh and dry weights of flowers/plant (g) and flower stem length (cm). As for chemical composition total chlorophyll in leaf of the middle part of the plant was carried out according to Minolta chlorophyll method SPAD-SO (Yadava, 1986). Nitrogen% was determined by modified micro Kjeldahle method as described by Black (1983)

Phosphorus was determined colorimetrically as the method described by King (1951) while, potassium was estimated using the flame photometer according to Jackson (1967). Means of treatments were compared by Duncan' s multiple range test (Duncan, 1955) at a level of 5% probability according to Sendecor and Cochran (1980).

Results

Effect of treatments of NPK and humic acid on vegetative growth, flowering and chemical composition parameters of the plants

A. Vegetative growth, plant height, No. branches, No. leaves and leaf area

Data presented in *Table 2* showed that in most cases treatments of NPK and humic acid significantly increased plant height and gave more branches than the control in both seasons. The significantly tallest plants and highest number of branches in the first season resulted from the treatment of $^1/_2$ NPK + 150 ppm humic acid. In the second season, this treatment extended the simulative effect in addition to the treatment of NPK alone without significant differences in between.

The same table revealed that most treatments gave significantly more leaf number and widest leaf area per plant compared to control in the two seasons with the superiority of treatment of $^1/_2$ NPK + 150 ppm humic acid in both seasons. In the second season, this treatment was partaken with the treatment of $^1/_2$ NPK + 100 ppm humic acid (HA) and NPK alone without significant differences.

B. Fresh and dry weight of vegetative parts

Data presented in *Table 3* revealed that most treatments gave significantly heavier fresh and dry weights than control in the two seasons. The significantly heaviest fresh and dry weight in the first season resulted from the treatment of $^1/_2$ NPK + 150 ppm humic acid (HA). In the second season, this resulted from the treatment of NPK and the treatment of $^1/_2$ NPK + 150 ppm humic acid (HA) without significant differences.

C. Root parameters

Data of the root length No. roots/plant fresh and dry weight of roots are presented in *Table 4*. Data exhibited that most treatments significantly increased root length over control in the first season as the significantly longest roots and highest roots number/plant resulted from the treatment of $^1/_2$ NPK + 150 ppm humic acid (HA)

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followed by the treatments of $^1/_2$ NPK + 50 ppm humic acid (HA), treatment of $^1/_2$ NPK + 100 ppm humic acid (HA) without significant differences. In the second season, all treatments significantly increased root length when compared to the control and the significantly longest roots resulted from the treatment of $^1/_2$ NPK + 150 ppm humic acid (HA) followed by the treatment of NPK alone without significant differences.

Table 2. *Effect of NPK and humic acid treatments on some vegetative growth characters of Erantheumum pulchellum Andrews in two seasons*

Treatments	Plant height (cm)	No. of branches/plant	No. of leaves/plant	Leaf area (cm^2)
1st season				
Control	65.00 e	1.00 b	27.00 d	53.30 d
NPK	119.67 c	2.00 a	68.00 b	70.00 c
$^1/_2$ NPK	104.00 d	1.67 ab	58.00 b	51.73 d
$^1/_2$ NPK + 50 ppm humic acid (HA)	109.00 d	1.67 ab	62.00 b	55.70 d
$^1/_2$ NPK + 100 ppm humic acid (HA)	131.67 b	2.00 a	68.00 b	90.30 b
$^1/_2$ NPK + 150 ppm humic acid (HA)	159.00 a	2.00 a	89.00 a	120.70 a
50 ppm humic acid (HA)	68.33 e	1.00 b	47.00 c	41.93 d
100 ppm humic acid (HA)	70.33 e	1.33 ab	42.67 c	48.06 d
150 ppm humic acid (HA)	73.67 e	1.67 ab	29.33 d	44.80 d
Mean	100.07	1.60	54.62	64.09
2nd season				
Control	68.00 d	1.33 b	17.00 d	63.83 cd
NPK	103.67 a	2.00 ab	95.00 a	112.63 a
$^1/_2$ NPK	88.00 c	1.67 b	54.67 b	84.16 b
$^1/_2$ NPK + 50 ppm humic acid (HA)	94.00 bc	3.00 a	62.33 b	107.26 a
$^1/_2$ NPK + 100 ppm humic acid (HA)	99.00 ab	3.00 a	95.00 a	98.63 a
$^1/_2$ NPK + 150 ppm humic acid (HA)	107.33 a	1.67 b	108.67 a	108.57 a
50 ppm humic acid (HA)	73.33 d	1.00 b	35.00 c	77.70 bc
100 ppm humic acid (HA)	71.33 d	1.67 b	26.67 cd	59.40 d
150 ppm humic acid (HA)	67.00 d	1.67 b	16.67 d	74.70 bc
Mean	85.74	1. 88	56.77	87.43

Means within a column having the same letters are not significantly different according to Duncan's multiple range test

Data showed clearly that most treatments gave significantly heavier fresh and dry weight of roots than the control in both seasons. The significantly heaviest value of roots weight resulted from the treatment of $^1/_2$ NPK + 150 ppm humic acid (HA), followed with non- significant differences by the treatment of NPK alone. The results were similar in the second season but the significantly highest value resulted from the treatment of NPK alone followed with non-significant differences by the treatment of ½ NPK + 150 ppm humic acid (HA).

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Table 3. *Effect of NPK and humic acid (HA) treatments on fresh and dry weights of vegetative parts of Erantheumum pulchellum Andrews in two seasons*

Treatments	**Fresh weight of vegetative plant parts (g)**	**Dry weight of vegetative plant parts (g)**
1st season		
Control	36.00 f	24.83 d
NPK	99.33 bc	51.50 a
½ NPK	86.33 cd	42.67 b
½ NPK + 50 ppm humic acid	88.00 cd	43.30 b
½ NPK + 100 ppm humic acid	115.67 b	43.70 b
½ NPK + 150 ppm humic acid	244.67 a	56.50 a
50 ppm humic acid	67.33 de	36.23 bc
100 ppm humic acid	56.00 ef	31.40 cd
150 ppm humic acid	35.67 f	26.50 d
Mean	92.11	39.62
2nd season		
Control	25.77 d	16.13 f
NPK	130.93 a	48.23 c
½ NPK	60.63 c	38.30 d
½ NPK + 50 ppm humic acid	64.93 c	29.00 e
½ NPK + 100 ppm humic acid	100.00 b	60.83 b
½ NPK + 150 ppm humic acid	126.40 a	74.17 a
50 ppm humic acid	26.73 d	15.87 f
100 ppm humic acid	22.67 de	13.00 f
150 ppm humic acid	16.47 e	8.00 g
Mean	63.83	33.72

Means within a column having the same letters are not significantly different according to Duncan's multiple range test

D. Flowering characters

Data presented in *Table 5* showed that the precocity of flowering in both seasons was for the treatment of ½ NPK + 150 ppm humic acid (HA) followed by NPK alone with non-significant differences. The previous promotive effect of these treatments was extended to the other flowering parameters. The stimulatory effect of NPK on flowering is well known as nitrogen is a main constituent of chlorophyll leading to effective characteristic as flower stem length, flower diameter, number of flowers per plant and fresh and dry weights of flower registering the significantly highest values when compared to control and other treatments. A few exceptions were gained for the treatment of ½ NPK + 100 ppm humic acid giving values close to the previous treatments in the criteria of fresh and dry weights of flower.

E. Chemical composition of plants

Data of the effect of NPK treatment and humic acid on total chlorophyll, nitrogen, phosphorus and potassium ratio are presented in *Table 6,* as revealed the significantly highest values of total chlorophyll resulted from the treatment of ½ NPK + 150 ppm

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humic acid (HA) followed by the treatment of NPK alone. with non- significant differences. It is apparent that most treatments of either NPK + humic acid or NPK alone increased total chlorophyll in the leaves of plant over control in both seasons. The superiority was for the treatments of 1/2 NPK + 150 ppm humic acid followed by the other treatments of NPK alone or with humic acid with non-significant differences in most cases.

Table 4. *Effect of NPK and humic acid treatments on some rooting characters and fresh and dry weight roots of Erantheumum pulchellum Andrews in two seasons*

Treatments	**Root length (cm)**	**No. of roots plant**	**Fresh weight of roots (g)**	**Dry weight of roots (g)**
1st season				
Control	20.67 c	16.33 e	14.33 cd	3.83 c
NPK	22.00 bc	22.33 cd	22.33 ab	5.03 b
$^{1}/_{2}$ NPK	21.33 c	19.00 de	12.00 de	3.00 d
$^{1}/_{2}$ NPK + 50 ppm humic acid (HA)	28.67 ab	24.67 c	18.33 bc	4.60 b
$^{1}/_{2}$ NPK + 100 ppm humic acid (HA)	26.67 ab	29.33 b	19.00 bc	5.03 b
$^{1}/_{2}$ NPK + 150 ppm humic acid (HA)	32.67 a	40.00 a	24.67 a	6.17 a
50 ppm humic acid (HA)	26.67 ab	17.00 e	11.16 de	3.06 d
100 ppm humic acid (HA)	25.00 bc	17.00 e	8.47 e	3.16 cd
150 ppm humic acid (HA)	25.00 bc	15.33 e	10.16 de	2.80 d
Mean	25.40	22.33	15.60	4.07
2nd season				
Control	17.33 f	15.67 c	13.27 d	3.04 c
NPK	44.67 a	35.33 a	34.30 a	7.83 a
$^{1}/_{2}$ NPK	33.33 bc	29.67 b	24.33 c	5.60 b
$^{1}/_{2}$ NPK + 50 ppm humic acid (HA)	35.00 bc	33.33 b	27.83 b	6.17 b
$^{1}/_{2}$ NPK + 100 ppm humic acid (HA)	35.67 b	32.67 b	25.60 bc	5.23 b
$^{1}/_{2}$ NPK + 150 ppm humic acid (HA)	45.00 a	32.00 b	32.73 a	7.80 a
50 ppm humic acid (HA)	29.67 cd	14.33 c	11.33 d	2.60 c
100 ppm humic acid (HA)	26.33 de	13.33 c	10.33 d	2.77 c
150 ppm humic acid (HA)	24.00 e	15.00 c	10.17 d	2.57 c
Mean	32.33	27.93	21.09	4.89

Means within a column having the same letters are not significantly different according to Duncan's multiple range test

The results presented in *Table 6* showed that most treatments gave significantly higher N percentage than control in both seasons. The utmost highest values resulted from the treatments of NPK alone and $^{1}/_{2}$ NPK + 150 ppm humic acid (HA) with non-significant differences in between. A somewhat similar trend was obtained for phosphorus percentage (P%) with an exception for the treatment of $^{1}/_{2}$ NPK + 100 ppm humic acid giving values which non- significantly differ from the treatment of either NPK alone or $^{1}/_{2}$ NPK + 150 ppm humic acid.

For potassium percentage (K %) a similar trend was obtained. but the treatment of $^{1}/_{2}$ NPK + 100 ppm humic acid gave a value which did not differ from the treatments of NPK alone and $^{1}/_{2}$ NPK + 150 ppm humic acid.

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Table 5. *Effect of NPK and humic acid treatments on some flowering characters and their fresh and dry weights of Erantheumum pulchellum Andrews in two seasons*

Treatments	No of days to first flower	Flower stem length (cm)	Flower diameter (cm)	No. of flowers/plant	Fresh weight of flowers (g)	Dry weight of flowers (g)
Control	311.00 a	4.03 e	4.07 ef	10.00 d	1.61 d	1.10 e
NPK	258.33 d	5.90 b	6.57 a	13. 67 c	2.20 c	1.46 c
1/2 NPK	272.67 c	4.87 d	5.13 c	11. 67 cd	1.87 cd	1.21 de
1/2 NPK + 50 ppm humic acid (HA)	274.66 c	5.00 d	5.43 bc	13.33 c	2.14 c	1.40 cd
1/2 NPK + 100 ppm humic acid (HA)	268.67 c	5.23 c	5.73 b	17.00 b	2.74 b	1.72 b
1/2 NPK + 150 ppm humic acid (HA)	249.33 d	6.53 a	6.53 a	22. 00 a	3.54 a	2.24 a
50 ppm humic acid (HA)	294.00 b	3.90 e	4.63 d	12.33 cd	1.99 cd	1.06 e
100 ppm humic acid (HA)	277.00 c	3.87 e	4.20 e	11.33 cd	1.82 cd	1.01 e
150 ppm humic acid (HA)	273.67 c	3.80 e	3.80 f	10.00 d	1.61 d	1.03 e
Mean	275.48	4.79	5.12	13.48	2.17	1.36
2nd season						
Control	292.3 a	4.50 e	4.33 e	10.33 ef	1.56 fg	1.34 d
NPK	264.3 c	6.10 b	7.07 a	22.33 ab	3.43 b	2.59 a
1/2 NPK	258.7 cd	4.77 de	5.73 c	22.33 ab	2.38 d	1.99 c
1/2 NPK + 50 ppm humic acid (HA)	257.0 cd	5.07 cd	6.03 bc	18.00 c	2.70 c	2.14 bc
1/2 NPK + 100 ppm humic acid (HA)	255.3 d	5.30 c	6.27 b	20. 67 b	3.42 b	2.10 bc
1/2 NPK + 150 ppm humic acid (HA)	244.7 e	6.70 a	7.17 a	23.33 a	3.72 a	2.37 ab
50 ppm humic acid	275.3 b	4.33 ef	4.80 d	12.67 e	1.96 e	1.04 d
100 ppm humic acid	290.6 a	4.03 f	4.60 de	11.00 ef	1.71 f	1.04 d
150 ppm humic acid	280.3 b	3.93 f	4.50 de	9.33 f	1.45 g	1.07 d
Mean	268.7	5.00	5.61	15.89	2.48	1.74

Means within a column having the same letters are not significantly different according to Duncan's multiple range test

Discussion

The aforementioned results showed that the treatment of 1/2 NPK + 150 ppm humic acid gave the best vegetative growth characters in both seasons followed by the treatment of NPK alone in a few cases. This may be due to the synergistic effect of NPK and humic acid. Nitrogen stimulates stronger green growth, which provides healthy stems and leaves. Phosphorus is a vital nutrient involved in stimulating and enhancing bud development. Potassium plays a main role in plant metabolism as well as enzymes activation for formation of carbohydrate, energy status of the plants, which strengthen the stem. This coincides with the results of El Sallami (2002) on *Chorisia speciosa*, *Leucaena leucocephala* and *Prosopis juliflora*, and El-Naggar and El-Nasharty (2009) on amaryllis and Dubey et al. (2017) who mentioned that NPK fertilization treatments significantly increased plant height, number of leaves and suckers per plant. For humic acid, it helps in improving respiration in the growing medium and increasing the water holding capacity (Dorer and Paecock, 1997) in addition to the production of hormone-like activities that improved photosynthesis, phosphorylation, protein synthesis and various enzymatic reactions. However, it reduces inputs of chemical fertilization and minimizes environmental risks (Koreish et al., 2004). It supplies soil with carbon, microbes, increases cell membrane permeability, respiration, photosynthesis, oxygen and phosphorus uptake and helps chelation, and

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improves the effects of mineral fertilizers (Henry, 2011). Atiyeh et al. (2002) reported that the combined application of humic acid and macronutrients helps to transport vital sugars through plant membranes, promotes cell division, cell wall formation, and acts as an enzyme activation in protein.

Table 6. *Effect of NPK and humic acid treatments on chemical composition of Erantheumum pulchellum Andrews leaves in two seasons*

Treatments	Total chlorophyll (SPAD)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
		1st season		
Control	31.50 c	3.68 c	0.48 d	1.29 c
NPK	50.67 ab	6.01 a	0.77 ab	1.96 a
1/2 NPK	45.83 b	4.67 b	0.45 d	1.64 b
1/2 NPK + 50 ppm humic acid (HA)	51.33 ab	4.78 b	0.50 cd	1.72 ab
1/2 NPK + 100 ppm humic acid (HA)	51.63 ab	5.13 ab	0.66 bc	1.88 ab
1/2 NPK + 150 ppm humic acid (HA)	56.83 a	5.90 a	0.92 a	1.93 a
50 ppm humic acid (HA)	33.50 c	3.67 c	0.35 d	1.19 cd
100 ppm humic acid (HA)	26.10 c	3.44 c	0.45 d	1.27 c
150 ppm humic acid (HA)	26.53 c	3.26 c	0.53 cd	0.99 d
Mean	41.54	4.50	0.57	1.54
		2nd season		
Control	32.30 c	4.02 de	0.41 f	1.05 c
NPK	52.60 a	5.89 ab	0.91 ab	1.38 b
1/2 NPK	47.17 b	4.38 de	0.54 e	1.17 bc
1/2 NPK + 50 ppm humic acid (HA)	46.97 b	4.78 cd	0.73 c	1.30 b
1/2 NPK + 100 ppm humic acid (HA)	48.87 b	5.48 bc	0.83 b	1.87 a
1/2 NPK + 150 ppm humic acid (HA)	53.20 a	6.30 a	1.00 a	1.93 a
50 ppm humic acid (HA)	33.87 c	3.68 e	0.65 cd	1.14 bc
100 ppm humic acid (HA)	32.87 c	2.86 f	0.55 de	1.10 c
150 ppm humic acid (HA)	26.80 d	1.40 g	0.47 ef	1.08 c
Mean	41.63	4.31	0.68	1.22

Means within a column having the same letters are not significantly different according to Duncan's multiple range test

Stimulatory effect of the treatment 1/2 NPK + 150 ppm humic acid followed in some cases by NPK alone on the fresh and dry weight of the plant is a reflection of the better growth attributes mentioned before. It is well known that nitrogen forms about 40-50% of dry matter of the plant. Phosphorus has a vital role in photosynthesis and respiration while potassium plays a very important role in regulation of photosynthesis, respiratory rate and increases protein synthesis (Csirzinsky, 1999). This coincides with the results of Hendawy (2008) on *Plantago arenaria* and Sakr et al. (2018) on *Pelargonium graveolens.*

Regarding the promotive effect of humic acid, it affects growth through producing hormone analogues or growth regulators (Albayrak and Camas, 2005). Moreover, Sathiyabama and Selvakumari (2001) mentioned that application of 10 kg/ha humic acid, along with 75% of the recommended NPK dose was found to significantly influence production of green matter of Amaranthus.

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The mentioned results, concluded that the rooting parameters (root length, root number and fresh and dry weighs of roots) significantly responded to the treatment of $^{1}/_{2}$ NPK + 100 ppm humic acid and then in a few cases to the treatment NPK alone. This is explained in the view that nitrogen stimulates vegetative growth, which reflects on better root growth. Root stimulating fertilizers are often higher in phosphorus as it helps strengthen young roots and give them a strong start (Ayemi et al., 2017). As for humic acid which includes microorganisms capable of producing plant growth regulators such as auxins, gibberellins, cytokinins, etc. and also buffers the hydrogen ion (pH) concentration of the soil as attained by several workers as Mohammad Ipour et al. (2013) on pot marigold and Boogar et al. (2014) on *Petunia hybrida.*

The stimulatory effect of NPK on flowering was well known as nitrogen is a main constituent of chlorophyll leading to effective photosynthesis process with more carbohydrates necessary for flowering. Phosphorus is the element most responsible for stimulating stronger bud and flower development (Ayemi et al., 2017) and potassium is vital to several areas of plant growth as photosynthesis and metabolism, etc. including drought tolerance, disease resistance, stem strength, improved texture, colour and photosynthesis. Ahmed et al. (2010) reported that NPK treatments increased number of flowers per plant, fresh and dry weights of flower reached maximum with 15:20:10 NPK application in African marigold and 15:10:10 in French marigold. Similarly, were the results of EL-Naggar et al. (2016) on *Anthurium andreanum* and Ayemi et al. (2017) who demonstrated that Gerbera cv Ruby Red responded to NPK fertilization treatments in terms of number of flowers per plant, days to first flower appearance, flower diameter, stalk length and diameter and vase life of flowers.

The simulative effects of humic acid on plant growth was previously discussed and are supported by the findings of Dudley et al. (2004) on *Zinnia elegans* (Memon et al., 2014) on *Petunia multiflora*. As for the synergistic effect of humic acid due to partitioning of NPK with it, Ibrahim et al. (2014) mentioned that the significantly highest values of enhanced growth, flowering and quality of wild garlic plants, resulted from the treatment of 2 ml humic acid + 1 g/pot NPK (10:10:10).

Briefly it is a must to maximize from the synergistic effect of humic acid to reduce the risk of chemical minerals on environment as well as their high costs from the economical point of view as the treatment of $^{1}/_{2}$ NPK + 150 ppm humic acid seems to be the best in this concern. Moreover, the application of humic acid alone gave close values or even less than control in all studied characters as failed to compensate the effect of NPK at anyhow.

This is logical since nitrogen is a main constituent of chlorophyll molecule and has a great role to form protein, which affects forming of chlorophyll. Also, phosphorus is vital in photosynthesis and respiration. Potassium affects many functions in plant like regulating photosynthesis, respiratory rate and increases protein synthesis by Hasio and Lauchi (1986).

The data in *Table 6* were in agreement with the findings of the synergistic effects of humic acid due to its beneficial effects associated with elevated tissue concentration of macronutrients. This was attained by Boogar et al. (2014) on *Petunia hybrida L* and Ibrahim et al. (2014) on *Tulbaghiavi oleracea* L and Sakr et al. (2018) on *Pelargonium graveolens*.

The results were a reflection of the promotive effect of NPK and humic acid on the various vegetative, rooting and chlorophyll characters leading to more accumulation of dry matter in the leaves. These results were confirmed by the findings of Darwish

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(2008) on *Casuarina glauca* and Sayed et al. (2010) on *Vinca rosea* c.v Major who indicated that all NPK treatments increased the leaf content of chlorophyll a and b and N, P and K %.

Humic acid helps the soil to retain the nutrients making plants healthier and less susceptible to insect and disease problems (Henry, 2011). These results were supported by those of Ibrahim et al. (2014) on *Tulbaghiavi oleracea* L. who mentioned that application of humic acid at 9 cm/l as soil drench increased chlorophyll (a) and (b), content, N, P and K% in the leaves compared to untreated plants.

Conclusion

From the aforementioned results, it is recommended to fertilize the *Erantheumum pulchellum* plant with half dose of NPK (3 g ammonium sulphat 2 g calcium super phosphate + 1.5 g potassium sulphat) plus spraying plants with 150 ppm humic acid for each/pot to minimize the risk of the pollution due to chemical fertilization. Calcium super phosphate should be applied at preparing of the soil while N and K as well as spraying humic acid should be applied monthly during the growing season to obtain the high quality vegetative, rooting and flowering characteristics of the plants.

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