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The influence of seaweed extract and irrigation interval on growth and quality production of *Hippeastrum hybridum, Hort*

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ABSTRACT

This study aimed to assess the effects of extract spray of *Ascophyllum nodosum* (0.0, 2.5, 5.0, 7.5 ml/l) on improving vegetative growth, flowering and chemical constituents of *Hippeastrum hybridum* during prolonged irrigation intervals (3, 7, 10-day interval). Spraying the plants irrigated every 3-days with seaweed extract had the most increment of the vegetative growth parameters (leaf length, number of leaves, dry matter and leaf area) and flowering (stalk length and diameter, flower diameter, earlier flowering, flower long duration and long vase life). Irrigated plants every 7 and 10-days and spraying with 5.0 ml/l seaweed extract gave the highest value of growth parameters, flowering characters, leaf chlorophyll (a) and (b) and total carbohydrate leaves and bulbs contents as compared with untreated plants under the same irrigation interval. It can be concluded that seaweed extracts application enhances plant tolerance against drought. The results indicated that application of seaweed extracts at 5.0 ml/l and irrigated every 7-days had a favorable effect on vegetative growth, flowering and chemicals constituents of *Hippeastrum hybridum* plants.

Keywords: *Ascophyllum nodosum, Hippeastrum hybridum,* irrigation intervals.

Introduction

The genus Hippeastrum in the family Amaryllidaceae includes 75 species from South America, except for one from the West African taxa (Bailey1960).It is classified as ornamental flowering bulbs, herbaceous plant. Hippeastrum is commercially used as large cut flowers and potted plant; it is suitable for landscaping, bed pot, borders and a greenhouse garden. This plant is particularly valued in worldwide markets.The height of ornamental plants is an invaluable property of its appearance that not only influences its physiological traits but also increases their resistance during transportation from farms to markets.(Azimi and Alavijeh, 2020).

Naturalistic nutrition plays an important role during the process of plant growth and development. In order to improve uptake fertilizer treatments through the leaves or root, seaweed extract is used. The brown algae with around 2000 species, is the most common type used in agriculture, and *Ascophyllum nodosum* among them (Khan *et al*., 2009). As mentioned by Van Oosten *et al.* (2017), nearly 47 companies worldwide are currently involved in manufacturing extracts from *A. nodosum* for agricultural and horticultural applications. The *Ascophyllum nodosum* is commonly known as rockweed. The extract of *Ascophyllum nodosum* have many components (protein/amino acids 3–6%, lipid 1%, alginic acid 12–18%, polymers 12–15%, mannitol 5–6%, other carbohydrates 10–20%). Ali *et al.*(2019). Seaweed extract stimulate the development of the plant yield, increase tolerance to abiotic stresses. Moreover, the *A. nodosum* extract action of mechanisms and clarification are little understood (Carvalho *et al*., 2018).*A. nodosum* extract influences drought stress tolerance of grasses and increases vegetables and ornamental crops (Timothy, 2011).

Many studies reported that the application of seaweed extract as a foliar spray enhanced growth and yield in agricultural and horticultural crops such as geranium (*Pelargonium spp)* (Krajnc *et al.* , 2012). Also, Sivasankari*et al*., 2006 and Spinelli *et al*., 2010, reported that the content of leaves chlorophyll was increased as a result of seaweed application. Seaweed concentrate triggers flowering early and fruit formation in a considerable number (Featonby-Smith and Van Staden, 1987 and Arthur *et al*., 2003).

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The probable *A. nodosum* extract mechanism of the advantageous on agriculture is enhanced photosynthetic efficiency and assimilation of carbon, delayed senescence, antimicrobial, insect antipathetic, decreasing transpiration, promote stomatal conductance, efficient water and nutrient uptake (Khan *et al.,* 2009).

Water stress (drought stress) considers one of the main environmental factors and abiotic stress which limit plant growth and biochemical development. Spann and Little (2011) reported that application of seaweed extract, as foliar spray, increased the drought tolerance of citrus stock plants under water deficit. Also, XU and Leskovar (2015) indicated that under mild drought stress *A. nodosum* (ANE) enhanced spinach growth by improving leaf water relations, and reducing stomatal limitation, which in turn led to a large leaf area and high photosynthetic rate.

The current study is to investigate the effect of *Ascophyllum nodosum* (L.) seaweed extract under drought stress condition on improve *Hippeastrum hybridum* vegetative growth, flowering quality and bulb growth.

Material and Methods

At the nursery of Antoniadis Research Gardens, Horticulture Research Institute, Alex., Egypt, experimental trial was carried out through the two successive seasons of (2017 - 2018 and 2018 – 2019) of *Hippeastrum hybridum.* Similar size of *Hippeastrum hybridum* (Baby star cultivar) bulbs were selected in 3 - 3.3 cm. diameter and 36 – 38 g. weight. Bulbs were grown in a grown in a mixture of clay and sand (1:1 v/ v) in 25 cm. diameter clay pots (one bulb/pot) under natural light in the plastic greenhouse condition. Some chemical and physical properties analysis of the used mixture soil as described by Chapman and Pratt (1961) are illustrated in Table (1).

Table 1: Some chemical properties of the used mixture soil

pH	EC, dS/m	Cations(meq/l)				Anions (meq/l)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO3^{--}$	$HCO3^{-}$	Cl^{-}	$SO4^{--}$
7.8	1.69	8.00	3.00	4.69	1.50	-	4.50	8.55	4.14

On 4th November 2017 and 7th November 2018 in both seasons respectively, 4 doses of *Ascophyllum nodosum* (ANE) extract (0.0, 2.0, 2.5, 5.0 and 7.5 ml/l) applied as a foliar spray repeated once every two weeks. For foliar spray, all rates were applied using a hand sprayer and the tween-20 as a wetting agent was added to each test solution .Each plant was sprayed individually till the point of run-off, under three irrigation intervals (3, 7 and 10 days) as well as their interactions on *Hippeastrum hybridum* bulbs. The complete mineral fertilizer N P K (19:19:19) was top-dressed (2.5 g/pot) every 30 days, throughout the period from November till June, in both seasons.

Data recorded

At the end of the experiment, on the 4th of June 2018 and 9th of June 2019 (in the first and second seasons; respectively) the experiments were terminated, and the following measurements and chemical analysis were determined.

1-Vegetative growth parameters:

Leaf length (cm), number of leaves per plant, leaf area (cm^2) and leaves dry matter content (LDM percentage) (%).

2-Flowering growth parameters:

Time to flowering (number of days from planting time to the shown color of the first flower), number of flowering stalk/plant, flower stalk length (cm), flower diameter (cm), stalk diameter (cm), stalk dry weight, flower duration in mother plant (expressed as the days elapsed between the appearance of inflorescence color and fading on mother plant) and flower vase life (determined after flower stalks cutting grown from mother plants with different treatments).

3-Bulbs growth parameters:

Bulbs diameter (cm) at the end of the experiment, dry weight (g), and number of new bulblets.

4- Chemical composition:

Leaf chlorophyll a and b contents (mg/100g L.F.W.) were determined according to the method described by Moran (1982). The total carbohydrate contents (%) in dried leaves and bulbs were determined according to Herbert *et al*., (1971). Proline (µg/g dry weight) content in leaves according to Bates *et al.*(1973).

Statistical analysis

This experiment was factorial (3 treatments irrigation intervals x 4 treatments *Ascophyllum nodosum* extract ANE, doses) , and conducted using a complete randomized block design which included three replicates, for each treatment, three pots were used as an experimental unit for each replication. The means of the individual variables and their interactions were
contrasted by Bayesian L.S.D. (B.L.S.D.) test at 5% level of probability, according to the method described by Snedecor and Cochran (1989).

Results

1-Vegetative growth parameters:

Data presented in Table (2) proved that the interaction between irrigation intervals and ANE levels in leaf length (cm) and Number of leaves was recorded. The main effect of the applied treatments showed that increased irrigation intervals decreased leaf length of *Hippeastrum hybridum* for both seasons in, Table (2). The differences between levels of ANE and others were significant. The period of irrigation interval 3-days has given the longest leaves (51.85 and 51.11 cm), while the third level of irrigation interval 10-days was given the shortest length of Hippeastrum (44.42 and 45.94 cm) in the two seasons, respectively. The irrigation interval 3-days combined with ANE at 5.0 ml/l produced the longest leaves (58.10 and 60.35 cm) for both seasons, respectively.

Table 2 :Means of a leaf length (cm), number of leaves/plant of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combinations between them, in the two seasons of (2017-2018) and (2018-2019).

Irrigation intervals (A) / ANE cons. ml/l(B)	Leaf length (cm.)							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7days	10days	Means	3 days	7 days	10days	Means
ANE 0.0 (ml/l)	44.69	42.23	37.10	41.34	42.00	40.57	36.10	36.56
ANE 2.5 (ml/l)	49.12	45.28	40.68	45.02	43.17	43.43	38.13	41.58
ANE 5.0 (ml/l)	58.10	55.58	51.70	55.13	60.35	59.20	49.17	56.24
ANE 7.5 (ml/l)	55.47	50.44	48.19	51.37	58.93	56.70	42.84	54.53
Means	51.85	48.38	44.42		51.11	49.98	45.94	
B.L.S.D. at 0.05 (A)		1.01				1.21		
B.L.S.D. at 0.05 (B)		1.17				1.39		
B.L.S.D. at 0.05 (AXB))		2.41				2.87		
	Number of leaves/plant							
ANE 0.0 (ml/l)	4.00	3.44	2.33	3.26	4.11	3.66	2.33	3.37
ANE 2.5 (ml/l)	4.22	3.66	2.78	3.55	4.33	3.77	3.00	3.70
ANE 5.0 (ml/l)	5.44	5.00	3.89	4.63	5.33	4.66	4.00	4.66
ANE 7.5 (ml/l)	5.33	4.22	3.33	4.29	5.33	5.22	3.44	4.33
Means	4.75	3.97	3.08		4.78	4.08	3.19	
B.L.S.D. at 0.05 (A)			0.25				0.21	
B.L.S.D. at 0.05 (B)			0.29				0.24	
B.L.S.D. at 0.05 (AxB) X B)			0.59				0.49	

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However, the shortest leaf length (37.10 and 36.10 cm) was due to 10-day irrigation intervals with (0.0 ml) ANE in both seasons, respectively.

The irrigation interval 3-days gave the highest number of leaves/plant (4.75 and 4.78) in both seasons, respectively. In the same Table, the ANE at 5.0 ml/l gave the largest number of leaves (4.63 and 4.66) compared with the control during the two seasons, respectively.

Applying the dose of 5.0 ml/l ANE within the irrigation interval of 3-day led to give the highest increment (5.44 and 5.33) in the number of leaves/plant in the two seasons, respectively, followed by the treatment of combinations between irrigation interval 3-days and 7.5 ml/l ANE level (5.33 and 5.33) and ANE at 5.0 ml/l combined with irrigation interval 7-days in the number of leaves/plant in the two seasons; respectively.

It was noticed that was positive effect between the application of ANE at the rate of 5.0 ml and leaf area, in both seasons. The same effect was noticed in irrigation interval every 3-days. (Table3).

Table 3: Means of a leaf area (cm2), LDM % of Hippeastrum hybridum as influenced by Ascophyllum nodosum and irrigation intervals levels and their combination between them, in the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A) / ANE cons. ml/ (B)	Leaf area (cm^2)							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7 days	10 days	Means	3 days	7days	10days	Means
ANE 0.0 (ml/l)	126.42	116.81	90.01	111.08	133.97	118.41	97.45	101.72
ANE 2.5 (ml/l)	172.67	156.77	132.07	153.84	179.59	143.27	135.50	152.79
ANE 5.0 (ml/l)	262.53	255.11	194.96	237.54	267.06	264.52	207.11	246.23
ANE 7.5 (ml/l)	229.45	219.41	174.00	207.62	231.16	259.44	200.18	230.26
Means	197.77	187.03	147.76		202.94	196.41	160.06	
B.L.S.D. at 0.05 (A)		2.59				2.38		
B.L.S.D. at 0.05 (B)		2.99				2.74		
B.L.S.D. at 0.05(AX B))		5.18				4.75		
	LDM (%)							
ANE 0.0 (ml/l)	9.66	9.42	8.83	9.31	10.00	9.53	9.07	9.54
ANE 2.5 (ml/l)	10.17	9.65	9.86	9.90	10.40	9.97	9.37	9.91
ANE 5.0 (ml/)	11.03	10.75	10.38	10.72	11.54	11.39	10.19	11.04
ANE 7.5 (ml/)	10.75	10.17	9.74	10.22	10.68	10.21	9.72	10.20
Means	10.41	10.00	9.70		10.65	10.28	9.59	
B.L.S.D. at 0.05 (A)		0.26				0.61		
B.L.S.D. at 0.05 (B)		0.30				0.70		
B.L.S.D. at 0.05 (AxB) X B)		0.62				1.44		

In general, all interaction between ANE doses and watering day's interval resulted In increment in plants leaf area as compared with untreated plants at the same irrigation interval. The results of the first season, the largest plant leaf area was recorded with the treatment of 5.0 ml/l ANE in plants irrigated every 3-days followed by the 5.0 ml/l ANE in plants irrigated every 10-day. The data of second season revealed that there was non-significant effect between the treatments of 5.0 ml/l ANE combined with 3 and 7-days irrigation intervals. Data are given in Table (3) show that the simple effect of irrigation intervals gave the heaviest leaf dry matter content (LDM) was noticed in plants irrigated every 3-day, in the two seasons. There was non-significant effect between the simple effect of irrigation every 3 and 7-days in the second season. The disturbing 5.0 ml/l ANE had an extreme increase in the LDM (7.68 and 7.63 %) on the plants during both seasons.

It is also indicating that the interaction between irrigation intervals at 3-days combined with applied ANE dose 5.0 ml/l record the highest LDM (11.03 and 11.54 %) in the two seasons; respectively, followed by treatment of 5.0 ml/l ANE combined with 7-days irrigation interval (10.75

and 11.39 %) in the two seasons, respectively. In the same table the lowest values in the LDM percentage (8.83 and 9.07 %) were obtained at treatment of 0.0 ml/l ANE combined with irrigation interval every 10-day in two seasons.

2-Flowering growth parameters:

The unique effect of applied treatments indicated that the principal effects of irrigation intervals and seaweed extract were calculated on Hippeastrum plants (Table 4). The treatments indicated that irrigated plants every 3-day interval caused earliness in flowering (218.28and 217.92 days) compared with the 10-day irrigation time (222.36 and 222.14 days) in both seasons; respectively. In the same table, the interaction between irrigation intervals (days) and ANE (ml/l) in flowering time (days) was recorded. The effect of the applied treatments indicated that the time of flowering was fewer days in treatment 5.0 ml/l ANE when plants irrigated every 3-days (214.87 and 215.55 days), in both seasons; respectively. Whoever, it was much more time 7-day irrigated time was 215.11 in the first season, which treated with 5.0 ml/l of *Ascophyllum nodosum* extract.

In Hippeastrum, seaweed extract at a concentration of 5.0 ml/l increased the inflorescence length (77.17 and 78.89 cm) whereas at a 3 days irrigation interval, it increased the inflorescence length (71.12 and 72.08 cm). Insignificant difference was recorded between 3 -days and 7 days irrigation intervals, also between the doses of 5.0 and 7.5 ANE, in both seasons.

The interaction treatments produced longer values of inflorescence length (85.83 and 82.67 cm) at 5.0 ml/l when irrigated every 3-days. Moreover, there were insignificant differences among the doses of 5.0 and 7.5 ml/l ANE in plants irrigated every 3-days and that treated with 5.0 ml/l ANE combined with irrigation every 7-days.

Table 4: Means of time to flowering (days) and stalk length (cm) of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, in the two seasons of (2017-2018) and (2018 – 2019).

Irrigation intervals (A) / ANE cons. ml/l (B)	Time to flowering (days)							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7 days	10 days	Means	3 days	7 days	10 days	Means
ANE 0.0 (ml/l)	220.78	223.44	224.33	222.85	220.34	225.05	224.78	223.39
ANE 2.5 (ml/l)	220.56	218.45	223.33	220.78	219.45	223.47	223.00	221.97
ANE 5.0 (ml/l)	214.78	215.11	219.89	216.59	215.55	217.33	219.89	217.59
ANE 7.5 (ml/l)	217.00	218.56	221.89	219.15	216.34	218.22	220.89	218.48
Means	218.28	218.89	222.36		217.92	221.02	222.14	
B.L.S.D. at 0.05 (A))			1.58				0.67	
B.L.S.D. at 0.05 (B))			1.82				0.77	
B.L.S.D.at0.05 (AXB) B))			3.76				1.59	
	Stalk length (cm)							
ANE 0.0 (ml/l)	54.50	54.67	45.67	51.61	61.33	60.33	42.17	54.61
ANE 2.5 (ml/l)	60.18	65.83	52.00	59.34	66.33	73.17	52.67	64.06
ANE 5.0 (ml/l)	85.83	82.00	63.67	77.17	82.67	80.00	74.00	78.89
ANE 7.5 (ml/)	83.95	78.33	58.33	73.54	78.00	77.00	68.17	74.39
Means	71.12	70.21	54.92		72.08	72.63	59.25	
B.L.S.D. at 0.05 (A)			1.68				2.08	
B.L.S.D. at 0.05 (B))			1.94				2.40	
B.L.S.D.at0.05 (AXB)			4.00				4.94	

In the two success seasons, the maximum number of flowers /stalk was (2.22 and 2.31) on the plants were grown under 3-days irrigation. Insignificant differences were detected among all irrigation intervals, in the first season and the same situation between the 3 and 7-days irrigation, in the second one. The results obtained for in Table (5) show that the treatment of 5.0 ml/l ANE doses recorded 2.37 resulted in a significant increase in number of flowers in the both seasons. While the treatment with the concentrations at 5.0 and 7.5 ml/l in plants irrigated every 3 and 7-days was the highest in terms of the number of flowers (2.45) in the first season and at the concentration of 5.0 ml/l ANE (2.56) in the second seasons; respectively.

Data in Table (5) showed that irrigated plant every 3-day increased flower diameter in two seasons recorded 19.89 and 19.66 cm; respectively. The plants treated with 5.0 ml/l ANE gave the largest mean on the flower diameter (21.13 and 21.03 cm) in both seasons, respectively. The maximum values of flower diameter (22.15 and 21.85 cm) were obtained in 3 days irrigation interval with application of (5.0 ml/l) of ANE in both seasons; respectively.

Table 5: Means of number of flowers / stalk and flower diameter (cm) of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals and their combination between them, in the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A) / ANE cons. ml/l(B)	Number of flowers / stalk							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7days	10days	Means	3 days	7days	10days	Means
ANE 0.0 (ml/l)	2.11	2.00	2.00	2.04	2.11	2.11	2.00	2.07
ANE 2.5 (ml/l)	2.11	2.22	2.00	2.11	2.33	2.33	2.00	2.22
ANE 5.0 (ml/l)	2.45	2.45	2.22	2.37	2.56	2.44	2.11	2.37
ANE 7.5 (ml/l)	2.22	2.22	2.11	2.18	2.22	2.33	2.11	2.22
Means	2.22	2.22	2.08		2.31	2.30	2.06	
BL.S.D. at 0.05 (A)			0.19				0.20	
B.L.S.D. at 0.05 (B)			0.22				0.23	
B.L.S.D. at 0.05(AXB)			0.45				0.47	
	Flower diameter (cm)							
ANE 0.0 (ml/l)	17.97	17.52	17.09	17.52	17.41	17.14	16.37	16.97
ANE 2.5 (ml/l)	18.30	18.23	17.72	18.08	18.55	18.00	17.57	18.04
ANE 5.0 (ml/l)	22.15	21.28	19.95	21.13	21.85	21.80	19.45	21.03
ANE 7.5 (ml/l)	21.13	20.09	19.28	20.17	20.84	20.84	19.34	20.32
Means	19.89	19.28	18.51		19.66	19.18	18.18	
B.L.S.D. at 0.05 (A)			0.47				0.32	
B.L.S.D. at 0.05 (B)			0.54				0.37	
B.L.S.D. at 0.05 (AxB) B)			1.11				0.77	

Stalk diameter was greatest in those plants which received ANE concentration at 5.0 ml/l (2.24 and 2.30 cm), compared to the other treatments of application in both seasons; respectively (Table 6). Table (6) be mentioned that the plants irrigated every 3-days were the largest plants on a stalk diameter (2.27 and 2.29 cm) over the controls of both seasons; respectively. The interaction between irrigation intervals (days) and ANE levels (ml/l) were recorded the greatest stack diameter (2.43 and 2.44 cm) in both seasons; respectively.

Data given in Table (6) showed that the main effect of irrigation intervals was significant in both seasons. The spike dry weight was differences between ANE doses and each other's. The highest spikes dry weight (3.47 and 3.58 g) was presented from 3-days in the two seasons, respectively. Plants which irrigated every 10-day were given the lowest spike dry weight (3.07 and 2.93 g) in the two seasons; respectively. The highest spike dry weight (3.44 and 3.47 g) was come from the treatment of 5.0 ml/ l ANE in the both seasons, respectively. Data presented in Table (6) reveal that the interaction between of 3-daysirrigation intervals and ANE level at 5.0 ml/l treatments led to significant increase in spikes dry weight (3.58 and 3.77 g) in the both seasons; respectively.

Table 6 : Means of stalk diameter (cm), stalk dry weight(g) of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, in the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A)	Stalk diameter (cm)							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
ANE cons. ml/l (B)	3 days	7days	10days	Means	3 days	7days	10days	Means
ANE 0.0 (ml/l)	2.08	2.04	1.99	2.04	2.13	2.07	2.04	2.08
ANE 2.5 (ml/l)	2.17	2.21	1.87	2.08	2.16	2.21	2.08	2.15
ANE 5.0 (ml/l)	2.43	2.34	1.95	2.24	2.44	2.33	2.13	2.30
ANE 7.5 (ml/l)	2.41	2.10	2.04	2.18	2.43	2.16	2.08	2.23
Means	2.27	2.17	1.96		2.29	2.19	2.08	
B.L.S.D. at 0.05 (A)			0.11				0.03	
B.L.S.D. at 0.05 (B)			0.13				0.04	
B.L.S.D. at 0.05(A X B)			0.27				0.08	
	Stalk dry weight (g)							
ANE 0.0 (ml/l)	3.36	3.16	2.70	3.07	3.38	3.18	2.55	3.04
ANE 2.5 (ml/l)	3.45	3.23	3.06	3.25	3.56	3.27	2.94	3.26
ANE 5.0 (ml/l)	3.58	3.44	3.28	3.44	3.77	3.50	3.14	3.47
ANE 7.5 (ml/l)	3.50	3.35	3.25	3.37	3.62	3.33	3.09	3.35
Means	3.47	3.30	3.07		3.58	3.32	2.93	
B.L.S.D. at 0.05 (A)			0.04				0.03	
B.L.S.D. at 0.05 (B)			0.04				0.03	
B.L.S.D. at 0.05(AxB) X B)			0.09				0.07	

From data in Table (7), it can be observed that in both seasons, the doses of 5.0 ml/l ANE significantly expanded the flowering duration in mother plant as compared with other doses. Regarding to irrigation intervals, the plants irrigated every 3-days recorded the longest flower duration in mother plant (2.11 and 12.25 days) in both seasons, respectively. The longest period of duration of flowering in mother plant (14.56 and 14.44 days) was recorded in plants irrigated every 3-days and sprayed with 5.0 ml/l ANE in the two seasons, respectively.

As for the effect of ANE on flower vase life, results in Table (7) revealed that the concentration of 5.0 ml/l of ANE led to a significant longevity in flower vase life of Hippeastrum flowers (12.30 and 12.00 days) in both seasons, as compared with all other tested treatments. On the other side, the irrigation every 3 days produces long flower vase life (11.39 and 11.69 days) in both seasons, as compared with other irrigation intervals. The plant was irrigated every 3 days and sprayed with 5.0 ml/l ANE had flowers with long flower vase life (13.56 and 13.67 days) increased by (4.89 and 4.55 days) when compared with un-treated plants under the same irrigation interval. This longevity of flower vase life followed by the (12.45 days) in the treatments of 5.0 ml/l ANE in plants irrigated every 7-day, in the first season, and in the second one followed by the treatment of 7.5 ml/l combined with irrigation every 3 days.

3-Bulbs growth parameters:

Table (8) reveals that the treatments of 5.0 ml/l ANE and irrigation plants every 3-days showed to be the most effective for producing highest values of bulb diameter, dry weight and number of bulblets/ plant as compared with un-treated plants. The largest bulb diameter (5.70 and 6.24 cm) was recorded at the 5.0 ml/l ANE in plants irrigated every 3-days followed by (5.33 and 5.67cm) in plants irrigated every 7-days, with non-significance effect between the two treatments in both seasons; respectively.

Table 7: Means of flower duration in mother plant and flower vase life (days) of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, in the two seasons of (2017-2018) and (2018- 2019).

Irrigation intervals (A) / ANE conc. ml/L (B)	2018 Irrigation intervals (A) 3 days	2018 7days	2018 10days	2018 Means	2019 Irrigation intervals (A) 3 days	2019 7days	2019 10days	2019 Means
	Flower duration in mother plant (days)							
ANE 0.0 (ml/l)	9.67	8.56	8.11	8.78	9.89	8.89	8.00	8.93
ANE 2.5 (ml/l)	11.00	10.22	9.78	10.33	11.22	10.44	9.89	10.52
ANE 5.0 (ml/l)	14.56	11.67	11.11	12.44	14.44	11.56	11.00	12.33
ANE 7.5 (ml/l)	13.22	10.22	10.11	11.19	13.44	10.44	10.22	11.37
Means	12.11	10.17	9.78		12.25	10.33	9.78	
B.L.S.D. at 0.05 (A)			0.31				0.21	
B.L.S.D. at 0.05 (B)			0.36				0.24	
B.L.S.D. at 0.05(AX B))			0.74				0.49	
	Vase life (days)							
ANE 0.0 (ml/l)	9.33	9.00	8.11	8.81	9.33	8.78	7.89	8.67
ANE 2.5 (ml/l)	11.22	10.56	9.89	10.56	11.33	10.44	10.00	10.59
ANE 5.0 (ml/l)	13.56	12.45	10.89	12.30	13.67	11.56	10.78	12.00
ANE 7.5 (ml/l)	11.44	11.22	10.22	10.96	12.44	10.89	9.89	11.07
Means	11.39	10.81	9.78		11.69	10.42	9.64	
B.L.S.D. at 0.05 (A)			0.27				0.30	
B.L.S.D. at 0.05 (B)			0.32				0.34	
B.L.S.D. at 0.05 (AxB) B)			0.65				0.71	

Table 8: Means of bulb diameter (cm) and bulb dry weight (g) of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, in the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A) / ANE cons. ml/L (B)	2018 Irrigation intervals (A) 3 days	2018 7days	2018 10days	2018 Means	2019 Irrigation intervals (A) 3 days	2019 7days	2019 10days	2019 Means
	Bulb diameter (cm)							
ANE 0.0 (ml/l)	3.88	3.65	2.82	3.45	3.73	3.42	2.78	3.31
ANE 2.5 (ml/l)	5.21	4.49	3.44	4.38	4.91	4.39	3.41	4.24
ANE 5.0 (ml/l)	5.70	5.33	4.33	5.12	6.24	5.76	4.10	5.37
ANE 7.5 (ml/l)	4.99	4.67	4.10	4.59	5.11	4.94	3.66	4.57
Means	4.95	4.53	3.67		5.00	4.63	3.49	
B.L.S.D. at 0.05 (A)			0.28				0.20	
B.L.S.D. at 0.05 (B)			0.32				0.23	
B.L.S.D. at 0.05 (AXB))			0.67				0.48	
	Bulb dry weight (g)							
ANE 0.0 (ml/l)	10.15	7.45	6.06	7.89	10.24	8.27	6.99	8.50
ANE 2.5 (ml/l)	12.96	10.03	11.41	11.46	13.02	10.88	10.96	11.62
ANE 5.0 (ml/l)	19.74	17.95	14.83	17.51	22.80	19.50	15.05	19.12
ANE 7.5 (ml/l)	16.49	16.31	12.24	15.01	20.89	18.69	13.98	17.86
Means	14.83	12.93	11.13		16.74	14.34	11.75	
B.L.S.D. at 0.05 (A)			0.65				0.83	
B.L.S.D. at 0.05 (B)			0.75				0.95	
B.L.S.D. at 0.05 (AxB) X B)			1.55				1.97	

The same effect was observed in bulb dry weight, the highest value of bulb dry weight was recorded at 5.0 ml/l ANE (19.74 and 22.80 g) in both seasons; respectively, while the lowest weight was recorded (0.0) ml/l ANE in plants irrigated every 7-days (7.45 and 8.27 g) and 10-days (6.06 and 6.99 g) in both seasons; respectively. Regarding the number of bulblets, non-significant variation was observed in interaction between the ANE levels and irrigation intervals (Table 9).

Table 9: Means of bulbuls number of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, during the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A) ANE cons. ml/l (B)	Bulbuls No.							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7days	10days	Means	3 days	7days	10days	Means
ANE 0.0 (ml/l)	0.78	0.67	0.33	0.59	0.89	0.56	0.33	0.59
ANE 2.5 (ml/l)	1.22	0.89	0.44	0.85	1.33	0.89	0.56	0.93
ANE 5.0 (ml/l)	2.11	1.89	0.89	1.63	2.33	2.11	1.11	1.89
ANE 7.5 (ml/l)	1.89	1.44	0.78	1.37	2.22	1.56	0.78	1.52
Means	1.50	1.22	0.61		1.69	1.28	0.69	
B.L.S.D. at 0.05 (A)			0.18				0.17	
B.L.S.D. at 0.05 (B)			0.21				0.20	
B.L.S.D. at 0.05 (AXB)			0.43				0.41	

4-Chemical composition

Table (10 and 11) indicates that both tested 7 and 10-days irrigation intervals decreased leaf total chlorophylls and total leaf and bulb carbohydrates contents as compared with plants irrigated every 3 days in both seasons.

Table 10: Means of chlorophyll a and chlorophyll b (mg/100g fresh weight) *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, in the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A) ANE cons. ml/ (B)	Chlorophyll a (mg/100g fresh weight)							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7days	10days	Means	3 days	7days	10days	Means
ANE 0.0 (ml/)	7.71	7.14	6.76	7.20	7.52	6.97	6.77	7.08
ANE 2.5 (ml/l)	8.27	8.09	7.89	8.08	8.30	8.19	8.29	8.26
ANE 5.0 (ml/l)	9.09	8.94	8.08	8.70	9.37	9.14	8.94	9.15
ANE 7.5 (ml/l)	8.93	8.55	7.80	8.43	9.20	9.02	8.44	8.89
Means	8.50	8.18	7.63		8.60	8.33	8.11	
B.L.S.D. at 0.05 (A)			0.18				0.08	
B.L.S.D. at 0.05 (B)			0.21				0.09	
B.L.S.D. at 0.05(A X B))			0.36				0.16`	
	Chlorophyll b (mg/100g fresh weight)							
ANE 0.0 (ml/l)	3.19	2.74	2.29	2.74	3.30	2.85	2.33	2.83
ANE 2.5 (ml/l)	3.43	3.20	3.29	3.31	3.64	3.32	3.20	3.39
ANE 5.0 (ml/l)	4.16	4.03	3.81	4.00	4.34	4.17	3.55	4.02
ANE 7.5 (ml/l)	3.71	3.42	3.26	3.46	3.69	3.72	3.20	3.54
Means	3.62	3.35	3.16		3.74	3.51	3.07	
B.L.S.D. at 0.05 (A)			0.30				0.18	
B.L.S.D. at 0.05 (B)			0.35				0.21	
B.L.S.D. at 0.05 (AxB) X B)			0.72				0.42	

Table 11: Means of total carbohydrate (%) in leaf and bulbs of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, during the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A) ANE cons. ml/l (B)	Total carbohydrate (%) in leaf							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7days	10days	Means	3 days	7days	10days	Means
ANE 0.0 (ml/l)	8.12	7.82	6.29	7.41	8.48	7.69	6.63	7.60
ANE 2.5 (ml/l)	8.29	7.98	6.79	7.69	9.29	8.23	6.83	8.12
ANE 5.0 (ml/l)	9.66	9.15	8.01	8.94	9.74	9.23	8.08	9.02
ANE 7.5 (ml/l)	8.87	8.61	7.91	8.46	9.45	8.99	8.01	8.82
Means	8.74	8.39	7.25		9.24	8.54	7.39	
B.L.S.D. at 0.05 (A)			0.29				0.18	
B.L.S.D. at 0.05 (B)			0.33				0.20	
B.L.S.D. at 0.05 (AXB))			0.68				0.42	
Total carbohydrate (%) in bulbs								
ANE 0.0 (ml/l)	16.41	15.52	13.47	15.13	17.99	16.81	16.80	17.20
ANE 2.5 (ml/l)	19.37	18.85	16.04	18.08	18.50	18.19	18.11	18.26
ANE 5.0 (ml/l)	22.87	20.47	18.86	20.73	22.37	20.99	18.54	20.63
ANE 7.5 (ml/l)	19.63	18.55	17.65	18.61	18.94	18.64	17.33	18.30
Means	19.57	18.35	16.50		19.45	18.66	17.70	
B.L.S.D. at 0.05 (A)			0.44				0.42	
B.L.S.D. at 0.05 (B)			0.50				0.48	
B.L.S.D. at 0.05 (AxB) X B)			1.04				0.99	

Also, the increments of leaf total chlorophylls and total leaf and bulb carbohydrates contents were in parallel to the increasing of ANE level to reach the maximum increasing at the high level in both seasons. In general, all resulted interactions between ANE and irrigation treatments statistically increased the values of these parameters as compared with un-treated plants in both seasons. However, the highest values of chlorophyll a (9.09 and 9.37 mg/100g F.W) and chlorophyll b (4.16 and 4.34 mg/100g F.W) contents were recorded by the treatments of 5.0 ml/l ANE in plants irrigated every 3 days followed by 5.0 mg/l in plants irrigated every 7-days, in the first and second seasons, respectively. On the other hand, the dose of 5.0 ml/l ANE combined with irrigation every 3 days followed by 5.0 ml/l ANE combined with irrigation every 7 days, recorded the highest mean of total carbohydrates at leaves and bulbs, in both seasons.

Regarding to the effect of treatments of ANE and irrigation regime on proline accumulation of Hippeastrum plants, the results in Table (12) indicated that the treatment of ANE at 5.0 ml/l followed by 7.5 ml/l ANE combined with 3 days irrigation regime showed the lowest content of proline in the first season, and in the second one, it was observed non-significant effect between 5.0 ml/l and 7.5 ml/l ANE.

Table 12: Means of Proline (µg·g /g dry weight)in leaves of *Hippeastrum hybridum* as influenced by *Ascophyllum nodosum* and irrigation intervals levels and their combination between them, in the two seasons of (2017-2018) and (2018 - 2019).

Irrigation intervals (A) ANE cons. ml/l (B)	Proline (µg·g /g dry weight)							
	2018				2019			
	Irrigation intervals (A)				Irrigation intervals (A)			
	3 days	7days	10days	Means	3 days	7days	10days	Means
ANE 0.0 (ml/l)	447	540	887	625	423	538	855	604
ANE 2.5 (ml/l)	433	499	808	580	414	515	835	588
ANE 5.0 (ml/)	325	408	689	474	333	428	737	499
ANE 7.5 (ml/)	334	439	715	496	338	434	727	500
Means	379	472	775		377	479	789	
B.L.S.D. at 0.05 (A)			5.38				3.15	
B.L.S.D. at 0.05 (B)			6.21				3.64	
B.L.S.D. at 0.05 (AXB))			12.79				7.49	

Discussion

In the present study, the results showed that foliar application of seaweed extract significantly enhanced different vegetative characters, i.e., leaf length, number of leaves, leaf area and leaf dry matter content. This increment in leaf length and leaf area could be ascribed to the role of seaweed enriched in auxins and cytokinins. These hormones affect metabolic activities predominantly through cell division and elongation. Several studies clearly demonstrated that the application of different ANEs alleviated drought stress on plants such as, sweet orange trees (*Citrus sinensis*) (Spann and Little, 2011); spinach (*Spinaceaoleracea*) by Xu and Leskovar, (2015)and bean (*Phaseolus vulgaris)* by Carvalho *et al*., (2018).

Seaweed products contain growth regulators (auxins, cytokinine and gibberellins), amino acids and mineral nutrients, that accordingly positively affect plant growth and division which can stimulate plant development and yield, also improving tolerance to abiotic stresses as reported by Carvalho *et al* (2018). Hormonal content of seaweed extracts, especially cytokines could be responsible for many factors, so cytokines may have some physiological regulatory role in nutrient mobilization in plants (Abdel Aziz *et. a.,* 2011). Seaweed extracts enhanced flowering and yield characters of cucumber. The increase in cucumber yield might be attributed to the increase of the distillate flowers number, which in turn enhances the number of fruits that reflected on yield/plant and total yield (Sarhan and Ismael, 2014). The beneficial effect of seaweed extracts on crop yield could be due to the stimulatory influence of seaweed concentrates on triggering early flowering. Aliko *et al* (2017) indicated that extract of seaweed (*Ascophyllum nodosum)* enhanced plant flowering, particularly number of days to flower initiation and 50% flowering. Crouch, (1990), reported that the tomato trials, seaweed treated plants were the first to flower. Associated with early flower set was early fruit ripening and increased yield. Also, Emam *et al*. (2016) applying seaweed liquid extract as foliar spray led to a significant increment in vase life of pot marigold flowers. Moreover, the present results also showed that each one concentrations of ANE exhibited higher bulb dry weight. This could be ascribed to the seaweed auxins supplied which in turn provides cell division, elongation, and differentiation in addition to increase uptake of higher proteins and nucleic acid reserves eventually ensuring higher bulb dry weight. Similar results were reported by Abbas *et al.* (2020). The favorable effect of seaweed may be due to it contain of a high cytokines activity, which could be responsible for the many effects such as plant growth, flowering and chemical constituents (Abdel Aziz *et al*, 2011).

Elansary*et al.*, (2017) found that SWE application at 7 ml/l was more effective in enhancing Salam turf grass the photochemical efficiency of the plants compared to 5 ml/l. Petunia chlorophyll content increased significantly with increasing ANE foliar spraying rate up to 5 ml/l (Li and Mattson, 2015). Seaweed extract treated plants showed increased chlorophyll content in a wide variety of crops including grapevine and strawberry (Fan *et al*., 2013). Also in Black gram which shows enhanced chlorophyll content in seaweed treated at lower concentration (Kalaivanan *et al.,* 2012). Similar observation were recorded in onion where highest chlorophyll at ANE (0.55%). These results may be related to that the seaweed contained higher amounts of cytokines, auxins, macro and micronutrients (Hidangmayum and Sharma, 2017). The data reported by Elansary *et al*. (2017) indicated that ANE treatments enhanced the total non-structural carbohydrates in turf grass exposed to prolonged salinity, by increasing photochemical efficiency. ANE regulated the expression of genes involved in the metabolism and transport of carbohydrates; thus, unspecified bioactive compounds present in ANE must supply enough carbon and energy to the plant during stressful conditions. An increasing in the concentrations of seaweed led to decrease the proline content in Amaranthus tricolor plants (Abdel Aziz *et al*., 2011). ANE was found to improve proline biosynthesis in *P. vulgaris* grown under drought stress (Carvalho *et al*., 2018).

More recent studies indicate that seaweed extracts can stimulate increases in endogenous phytohormones such as cytokinins, auxin, indole acetic acid, and gibberellic acid, which can improve growth and development, as well as protect plants from various stresses such as drought on petunia (Li and Mattson, 2015).

Conclusion

The study here with recommends using 5.0 ml/l of seaweed extract (*Ascophyllum nodosum* to) applied as foliar spray on *Hippeastrum hybridum*to increase the vegetative, flowering growth and produce flowers have long vase life. Whereas, under drought stress (irrigation every 7 or 10-days) the dose of 5.0 ml/l *Ascophyllum nodosum*can produce plants of *Hippeastrum hybridum* enhancing vegetative, flowering growth and long vase life flowers.

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