Globe Artichoke Yield and Quality as Affected by Foliar Application of Seaweed Extract and Cooling Periods of Crown Pieces

[(1)]G. K. I. Madian, [(2)]Aly I. A. Abido [(2)]M. M. Yousry [(3)]N. I. Abou El Fadl
[(1)]Postgraduate student
[(2)] Plant Production Dept. Faculty of Agriculture (Saba Basha) Alexandria University
[(3)] Hort. Res. Institute, Agric. Res. Center, Alex., Egypt

ABSTRACT: This study was carried out at private farm located at Shubrakhet City, in Behiera Governorate during the two successive seasons of 2017/2018 and 2018/2019, to evaluate the effect of foliar application with seaweed extract and cooling periods of crown pieces on vegetative growth, yield and quality of Globe Artichoke. The experiments were carried out in a split plot design with three replicates. Each experiment included three cooling periods (0, 15 and 30 days) at 5°C were arranged in the main plots, then the four seaweed extract (control, 250, 500 and 750 mg/l) were arranged in the sub plots. The collected data were analyzed using analysis of variance (ANOVA) with the aid GENSTAT 5 package, and significant means were separated and announced using the Least Significant Difference (LSD) at 5%, probability level. The gained results indicated that cooling period at 30 days and foliar application of seaweed extract at 750 mg/l; brought about the maximum vegetative growth characters values of Globe Artichoke, i.e. survival rate, plant height, leaf fresh weight, leaf dry weight and dry matter percentage, also, yield and yield components (early yield/plant, total yield/plant, head length, head diameter, neck diameter, head fresh weight, head dry weight and head dry matter percentage), as compared with the control treatment during both seasons. Likewise, increasing cooling periods up to 30 days and seaweed extract up to750 mg/l; gave the highest average values of all chemical compositions such as total sugars, reducing sugars and total soluble solids but inulin, recorded the highest percentage at 15 days cooling and foliar application of seaweed extract at 750 mg/l, as compared with control treatment.

Keywords: Globe Artichoke, cooling period, seaweed extracts, vegetative growth, yield and yield components chemical composition

INTRODUCTION

Artichoke (*Cynara scolymus* L.) is a perennial plant from Asteraceae family that used for various purposes such as human food (Gouveia and Castilho, 2012), animal feeding and medicinal plant in pharmaceutical industry (Sallam *et al.* 2008).

Artichoke is widely used in human diet, characterized by low protein and fat, high content of minerals, fibers, vitamins, inulin, carbohydrates and polyphenolic compounds. The edible flower buds and other artichoke plant extracts are rich in polyphenols and have high levels of antioxidant activity (Liorach *et al.*, 2002).

Globe artichoke is considered as one of the most important vegetable crops in the countries bordering the Mediterranean basin including Egypt, whereas the total area grown with artichoke in Egypt was 29726 fed., which produced about 236314 tons with an average yield of 7.95 ton/fed (FAO, 2016). In Egypt, the conventional method for globe artichoke propagation is based on the use of offshoots, ovoli (underground dried shoots with apical and lateral buds) and portion of stump [crown pieces] (Sharaf-Eldin, 2002).

Vernalization is the process of chilling seeds, crowns and transplants at temperatures between 4 - 5 ^{o}C which causes plants to flower earlier and enhance annual production of globe artichokes (Ierna and Mauromicale, 2004). Growing artichoke from plantlets obtained by cold stored cuttings is a valid alternative to micro propagation method. Cardarelli *et al.* (2005) and Mauromicale *et al.* (2005) reported that it could be very useful to develop nurseries for producing artichoke plantlets in the mountain areas and cold treatment of artichoke seedlings at the two expanded leaf stages may have the potential to enhance yield.

Seaweed contains all the trace elements and growth hormones required by plants and there is a growing concern over the use of seaweed extracts as a liquid fertilizer (SLF) (Abd El-Migeed *et al.* 2004). Today, there is a high demand for environment friendly agriculture for production of quality and healthy food to nourish the increasing population (Jayasinghe *et al.,* 2016).

Seaweed liquid extract (SLE) which contains macro nutrients, trace elements, organic substances like amino acids and plant growth regulators such as auxin, cytokinin and gibberellins are applied to improve nutritional status, vegetative growth, yield and fruit quality in some plants (Abd El-Moniem and Abd-Allah 2008 and Spinelli *et al.,* 2009).

The main objective of this investigation is to evaluate the effect of cooling periods, seaweed extract and their interaction on the productivity and quality of the Artichoke.

MATERIALS AND METHODS

Field experiments were carried out at private farm located at Shubrakhet City, in Behiera Governorate, Egypt, during the two successive seasons of 2017/ 2018 and 2018-2019.

A surface soil sample (0-30cm) was collected before planting to identify some physical and chemical properties of the experimental site and the collected data are listed in Table (1).

Table (1). Some physical and chemical properties of the experimental soil in 2017/2018 and 2018/2019 seasons

Parameter	Sample	Unit
Mechanical Analysis		
Sand	31.12	%
Silt	20	%
Clay	48.88	%
Textural class	Clay	
pH (1:2, water suspension)	8.2	-
EC(1:2, water extract)	0.44	dS/m
O.M,	1.5	%
$CaCO_3$	1.75	%
Soluble cations		
Ca^{2+}	1.2	meq/l
Mg^{2+}	2.1	meq/l
Na^{+}	2.4	meq/l
K^{+}	0.13	meq/l
Soluble cations		
HCO_3^{-}	1.2	meq/l
Cl^{-}	2.4	meq/l
SO_4^{2-}	1.31	meq/l
Available nutrients		
Nitrogen (N)	8.7	mg/kg
Phosphorus (P)	16.25	mg/kg
Potassium (K)	700	mg/kg

The experiments were carried out in a split- plot design with three replicates, where the three cooling periods (0, 15 and 30 days) were arranged in the main plots, then the four seaweed extract (control, 250, 500 and 750 mg/l) were arranged in the sub plots. Spraying treatments were applied four times started after 60 days from planting date and repeated every 15 days through the growth season. Each replicate contained 5 rows. Globe artichoke (*Cynara scolymus* L.), French variety was planted on 15th and 21th of August and harvest was done on 27th November in the first season and 5th of December in the second season. Seaweeds extract contains oligosaccharide (3%), K_2O (11%), Mn (0.1%), Zn (0.3%), Fe (0.2%), alganic acid (5%) and plant hormones: Cytokinin (0.001 %:) and IAA (0.02%). The vegetative growth characters, yield and yield components were measured as follows:

- Survival rate (%): was calculated when more than 50% of the plants developed additional two new leaves, i.e., at 45 days after planting in the field.

Five plants from each plot were chosen randomly from each treatment at 120 days after planting for measuring the following vegetative growth characters of Globe Artichoke plants expressed as follows:

- Average plant height (cm) was measured from soil surface to the terminal bud
- Average leaves fresh weight (g).
- Average leaves dry weight (g).
- Average leaves dry matter (%).

- Average head length (cm).
- Average head weight (g)
- Average head diameter (cm).
- Average neck diameter (cm).
- Average head fresh weight (g).
- Average head dry weight (g).
- Average head dry matter (%).

The early yield was considered as flower heads by weight (g) and number which were harvested from the first ten pickings, ended at the end of February. It was calculated as average head weight/ plant in (g), average number of heads /plant and early yield weight/plant (g). For the total yield, all flower heads harvested all over the season were calculated by average head weight/ plant (g), average number of heads /plants.

The total soluble solids of head juice (TSS %) was determined using Hand refractometer according to Chen and Mellenthin (1981). Also, total sugars (%) and reducing sugars%:

Total sugars were determined in fresh fruit samples according to Malik and Singh (1980). Sugars were extracted from 5 gram fresh weight and determined by phenol sulfuric and Nelson arsenate –molybadate colorimetric methods for total and reducing sugars, respectively. The non-reducing sugars were calculated by difference between total sugars and reducing sugars.

The inulin contents were determined in heads of early and total yield according to the method of Araya and Suporn (2011).

The obtained data were subjected to the proper method of statistical analysis of variance as described by Gomez and Gomez (1984). The treatment means were compared using the least significant differences (L.S.D.) test at 0.05 level of probability.

RESULTS AND DISCUSSIONS

Vegetative growth characteristics

Results in Table (2) showed maximum values for survival rate percentage, plant height, leaves fresh weight, leaves dry weight and leaves dry matter percentage under cooling period for (30 days) treatment, as compared with control treatment during both seasons.

The increment percentage points for survival rate percentage, plant height, leaves fresh weight, leaves dry weight and leaves dry matter percentage as compared with the control treatment (as an average of both seasons) were (23.56 and 25.96%), (31.45 and 31.44%), (10.52 and 19.22%), (35.18 and 20.14%) and (2.64 and 2.63%), during both seasons, respectively. These results could be due to the high number of growing buds on the crown pieces and more rhizome adventitious root primordial as a result of vernalization as mentioned by (Cardarelli *et al.,* 2005).

Cold storage of plant materials of globe artichoke for one month at 5^{o}C before planting in field enhanced the plant survival, yield and quality (Abd El-latif *et al.,* 2015). These results are in harmony with those obtained by (El-Abagy, 1993).

Concerning to foliar spraying application with seaweed extract, the results showed that there were significant($p \leq 0.05$) effect on vegetative growth i.e. plant height, leaves fresh weight, leaves dry weight and leaves dry matter (%). Data in (Table 2) showed that foliar application of 750 mg/l of seaweed extract gave the higher mean values of survival rate, plant height, leaves fresh weight, leaves dry weight and leaves dry matter, as compared with control which gave the lower mean values. The increment percentage points for survival rate, plant height, leaves fresh weight, leaves dry weight and leaves dry matter percentage as compared with the control treatment (as an average of both seasons) were (37.17 and 37.17 %), (37.18 and 37.18%), (22.78 and 37.21%), (23.99 and 36.51%) and (34.64 and 37.03%), respectively.

These results may be due to that seaweed extract contain more amino acids, vitamins as well as some trace elements. However, the previous studies have been proved that seaweed can, directly or indirectly, influence the physiological activities of the plants (Kamal and Ghanem, 2011 and Shehata *et al.,* 2012).

The results are in harmony with those reported by Shahira *et al.* (2015) who indicated that foliar application of algae extract on fenugreek plants significantly increased plant height, number of leaves, number of branches, fresh and dry weights of plant at vegetative growth and flowering stages.

The interaction among cooling periods treatments and seaweed extract treatments were highly significant ($p \leq 0.05$) on survival rate (%) and plant height during both seasons. Also, this interaction was significant on leaves fresh weight and leaves dry weight, during the second season.

Table (2). Average values of some vegetative growth characters as affected by cooling periods and seaweed extract of crown pieces Globe Artichok during both seasons 20172018 and 2018/2019

Treatments		Survival rate (%)		Plant height (cm)		Leaves fresh weight (g)		Leaves dry weight (g)		Leaves dry matter (%)	
		2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019	2017/2018	2018/2019
(A) Cooling period(days)											
Control		59.21c	62.24c	75.32c	79.29c	91.07c	95.86c	17.72b	19.02c	19.47b	19.84b
15		67.71b	71.27b	91.03b	95.56b	100.65b	105.95b	20.29a	21.24b	20.16a	20.04a
30		73.16a	78.40a	99.01a	104.22a	107.80a	114.29a	21.71a	22.85a	20.14a	19.99a
LSD (0.05)		**3.59**	**4.98**	**4.99**	**2.79**	**1.41**	**0.66**	**0.35**	**0.52**	**0.42**	**0.16**
(B) Seaweed extract (mg/l)											
Control		56.55d	59.92d	74.93d	78.87d	84.89d	89.34d	16.88b	17.86d	19.87a	19.99a
250		62.83c	66.46c	83.26c	87.64c	94.32c	99.26c	18.75ab	19.85c	19.87a	20.00a
500		69.81b	73.97b	92.84b	97.38b	104.80b	110.29b	20.84a	22.06b	19.87a	20.00a
750		77.57a	82.19a	102.79a	108.20a	115.34a	122.58a	23.16a	24.38a	20.08a	19.87a
LSD (0.05)		**0.31**	**0.32**	**0.60**	**0.41**	**1.57**	**0.50**	**0.14**	**0.19**	**4.06**	**0.15**
Interaction effect (AXB)											
Cooling	**Seaweed**										
Control	Control	50.21	52.85	67.23	63.87	77.22	81.28	15.03	16.25	19.47	20
	250	55.78	58.39	74.70	70.97	85.80	90.31	16.70	18.06	19.47	20
	500	61.98	65.25	83.00	78.85	95.33	100.35	18.55	20.07	19.47	20
	750	68.87	72.50	92.22	87.61	105.92	111.50	20.61	21.70	19.47	19.47
15	Control	57.41	60.43	81.03	76.97	85.34	89.84	17.21	17.97	20.16	20
	250	63.79	67.15	90.03	85.53	94.83	99.82	19.12	19.96	20.16	20
	500	70.87	74.61	100.03	96.03	105.36	110.91	21.24	22.18	20.16	20
	750	78.75	82.89	111.15	105.59	117.07	123.23	23.60	24.85	19.98	20.16
30	Control	62.04	66.47	88.37	83.95	92.11	96.90	18.41	19.37	19.98	19.99
	250	68.93	73.86	98.19	93.28	102.34	107.66	20.45	21.53	19.98	20
	500	76.59	82.07	109.10	103.65	113.71	119.62	22.73	23.92	19.98	20
	750	85.10	91.19	121.22	115.16	123.02	133.00	25.25	26.58	20.55	19.98
LSD (0.05)		**0.31**	**0.32**	**0.60**	**0.41**	**18.03**	**0.36**	**3.32**	**0.19**	**0.48**	**0.05**
Interaction (AXB)		**	**	**	**	**ns**	**	**ns**	**	ns	**ns**

Yield and yield components

Early yield/plant

Results in Table (3) illustrated that the highest early head weight was obtained from planting vernalized crown pieces in both seasons. In addition, there were significant ($p \leq 0.05$) differences, in the value of head weight, number of heads per plant. The obtained results declear that maximum head weight, number of heads/plant, and early yield/plant under cooling for (30 days), as compared with control treatment which recorded the minimum values during both seasons.

The increment percentage points for head weight, number of heads/plant, and early yield/plant, as compared with the control treatment (as an average of both seasons) were (10.45 and 14.93%), (17.50 and 17.84%) and (30.05 and 35.18%), respectively. These results are similar, more or less, to those of Salisbury and Ross (1999) and Stella and Cointry(2010) who reported that vernalization or cooling the plant stumps before planting increased earliness in globe artichoke plants. Such increment in early yield by number of heads may be due to vernalization enhanced the plant growth and initiation as well as the differentiation of flower buds as found by Pesti *et al* (2004), Stella and Cointry(2010) and Morteza *et al* (2013).

Growing artichoke from plantlets obtained by cold stored cuttings is a valid alternative to micro propagation method. Cardarelli *et al.* (2005) and Mauromicale *et al.,* 2005) reported that it could be very useful to develop nurseries for producing artichoke plantlets in the mountain areas and cold treatment of artichoke seedlings at the two expanded leaf stages may have the potential to enhance yield. However, plants received vernalization for 30 days and planted on Sept.1st gave the highest number of total yield / plant and / feddan in the two tested years as found by Anusury *et al* (2000). In addition, to those vernalized for 45 days then planted on Augu.15th recorded the highest yield as reported by Pesti *et al* (2004) and Morteza *et al* (2013).

Vernalized for 45 days then planted in Aug. 15th produced the highest significant total yield /plants in the two tested years in addition to those vernalized for 30 days and planted in Aug. 15th or Sept.1st. The results are in agreement with those of Abd El-Hamid *et al* (2008) and Chun *et al* (2013).

The previous results in respect to vernalized or non -vernalized planting materials are in harmony with those obtained by (El-Abagy, 1993 and Abd El-latif *et al.,* 2015), they mentioned that vernalized crown pieces produced high quality globe artichoke flower heads. As respect with the receptacle weight and diameter, the superior values were achieved by using vernalized crown pieces in both seasons. These results are in agreement with those obtained by (Abd El-latif *et al.,* 2015). Regarding to the results in Table (3) showed that foliar application of different concentrations of seaweed extract have significant ($p \leq 0.05$) on head weight, number of heads/plant, and early yield/plant. Data showed that foliar application of 750 mg/l of seaweed extract; gave rise to the higher average values of head weight, number of heads/plant, and early

yield/plant, as compared with control which gave the lower mean values during both seasons .

The increment percentage points for head weight, number of heads/plant, and early yield/plant, as compared with the control treatment (as an average of both seasons) were (37.17 and 37.17 %), (25.16 and 25.69%) and (71.63 and 72.48%), respectively. The interaction between cooling periods treatments and seaweed extract treatments was highly significant ($p \leq 0.05$) on head weight (g) in the first season and not significant in the second season while, highly significant ($p \leq 0.05$) on number of heads/plant and early yield/plant, during both seasons, respectively.

Total yield/plant

Results recorded in Table (4) showed that, maximum head weight, number of heads/plant, total yield/plant under cooling for (30 days), as compared with control which recorded the minimum values during both seasons.

The increment percentage points for head weight, number of heads/plant, total yield/plant, as compared with the control treatment (as an average of both seasons) were (8.00 and 13.82%), (37.78 and 45.89%), (48.74 and 66.33%) and (35.13 and 35.04%) respectively.

Results agree with those of Anusuya *et al* (2000), Pesti *et al* (2004), Abd El-Hamid *et al* (2008) and Chun *et al* (2013) who reported that vernalization enhanced early and total yield.

These results in contrast with those obtained by (Lovre *et al.,* 2005), they found that transplant type and transplant age did not influence yield or artichoke head weight. The previous results in respect to vernalized or non -vernalized planting materials are in harmony with those obtained by El-Abagy, (1993) and Abd El-latif *et al.* (2015). They mentioned that vernalized crown pieces produced high quality of globe artichoke flower heads.

In this respect, results in Table (4) showed that foliar application of different concentrations of seaweed extract have significantly ($p \leq 0.05$) effective on head weight, number of heads/plant and total yield/plant. Data showed that foliar application of 750mg/l of seaweed extract gave the higher mean values of head weight, number of heads/plant and total yield/plant, as compared with control which gave the lower mean values during both seasons.

The increment percentage points for head weight, number of heads/plant and total yield/plant, as compared with the control treatment (as an average of both seasons) were (37.18 and 37.18 %), (37.14 and 37.18%), (88.17 and 88.22 %) and, respectively.

The interaction between cooling and seaweed extract treatments was highly significant ($p \leq 0.05$) on head weight, number of heads/plant, and total yield/plant during both seasons.

Table (3). Average values of early yield/plant of globe artichoke 'as affected by cooling periods of crown pieces, foliar spray seaweed extract and their interactions during both seasons 2017/2018 and2018/2019

Treatments		Head weight (g)		Number of heads/plant		Early yield/plant (g)	
		2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019
(A) Cooling period(days)							
Control		259.00c	266.40c	3.20c	3.42c	835.94c	918.93c
15		272.40b	290.11b	3.33b	3.57b	917.03b	1046.14b
30		286.06a	305.01a	3.76a	4.03a	1087.17a	1242.18a
LSD (0.05)		**4.44**	**12.88**	**0.10**	**0.10**	**21.07**	**21.49**
(B) Seaweed extract (mg/l)							
Control		231.05d	244.19d	3.06d	3.27d	709.09d	800.18d
250		256.72c	271.32c	3.29c	3.52c	846.61c	957.82c
500		285.24b	298.24b	3.54b	3.80b	1014.16b	1138.18b
750		316.94a	334.96a	3.83a	4.11a	1216.99a	1380.14a
LSD (0.05)		**0.44**	**4.76**	**0.01**	**0.01**	**4.07**	**17.11**
Interaction effect (AXB)							
Cooling	**Seaweed**						
Control	Control	219.61	227.94	2.86	3.05	628.90	694.32
	250	244.02	253.27	3.07	3.28	748.41	829.71
	500	271.13	271.74	3.30	3.53	894.84	959.61
	750	301.26	312.67	3.56	3.81	1071.60	1192.07
15	Control	230.97	245.99	2.98	3.18	688.30	782.16
	250	256.64	273.32	3.20	3.42	820.38	934.66
	500	285.15	303.70	3.44	3.69	981.87	1121.52
	750	316.84	337.44	3.72	3.99	1177.59	1346.2
30	Control	242.56	258.62	3.34	3.57	810.08	924.07
	250	269.51	287.36	3.60	3.86	971.05	1109.10
	500	299.45	319.28	3.89	4.18	1165.76	1333.41
	750	332.73	354.76	4.21	4.52	1401.78	1602.13
LSD (0.05)		**0.44**	**4.76**	**0.01**	**0.01**	**4.07**	**17.11**
Interaction		**	**ns**	**	**	**	**

Table (4).Average values of total yield/plant of globe artichoke 'as affected by cooling periods of crown pieces, foliar spray seaweed extract and their interactions during 2017/2018 and2018/2019 seasons

Treatments		Head weight (g)		Number of heads/plant		Total yield/plant (g)	
		2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019
(A) Cooling period (days)							
Control		239.50b	239.09c	7.12c	7.91c	1728.99c	1913.67c
15		252.52a	258.47b	8.78b	9.76b	2248.30b	2559.10b
30		258.66a	272.13a	9.81a	11.54a	2571.75a	3183.07a
LSD (0.05)		**7.33**	**9.89**	**0.62**	**0.71**	**135.23**	**146.6**
(B) Seaweed extract (mg/l)							
Control		212.17d	217.66d	7.27d	8.26d	1548.25d	1811.21d
250		235.75c	241.85c	8.07c	9.17c	1911.69c	2236.18c
500		261.94b	268.17b	8.77b	10.19b	2359.31b	2751.38b
750		291.05a	298.58a	9.97a	11.33a	2913.32a	3409.03a
LSD (0.05)		**0.46**	**0.94**	**0.04**	**0.04**	**15.69**	**27.54**
Interaction effect (AXB)							
Cooling	**Seaweed**						
Control	Control	203.08	203.08	6.04	6.71	1225.89	1362.51
	250	25.64	225.65	6.71	7.45	1514.02	1681.60
	500	250.71	249.05	7.45	8.28	1868.59	2047.09
	750	278.57	278.58	8.28	9.20	2307.45	2563.49
15	Control	214.11	219.17	7.45	8.28	1594.48	1814.56
	250	237.90	243.52	8.28	9.20	1968.23	2240.27
	500	264.34	270.58	9.20	10.22	2430.01	2766.19
	750	293.71	300.64	10.22	11.36	3000.48	3415.37
30	Control	219.32	230.75	8.32	9.78	1824.39	2256.56
	250	243.69	256.39	9.24	10.87	2251.25	2786.65
	500	270.77	284.87	10.27	12.08	2779.32	3440.84
	750	300.86	316.53	11.41	13.43	3432.05	4248.23
LSD (0.05)		**0.46**	**0.94**	**0.04**	**0.04**	**15.69**	**27.54**
Interaction (AXB)		**	**	**	**	**	**

Physical characteristics of heads:

Regarding the effect of cooling periods of crown pieces treatments, foliar application of seaweed extract and their interactions on physical characteristics of globe artichoke heads, the data presented in Table (5) reveled that, cooling treatments and the all of foliar application treatments caused a significant increase in the all physical characters i.e., head length, head diameter, neck diameter, head fresh weight, head dry weight and head dry matter percentage in the two successive seasons, as compared with control plants.

Data showed maximum values of head length, head diameter, neck diameter, head fresh weight, head dry weight and head dry matter percentage under cooling period treatments for (30 days), as compared with control treatment which recorded the minimum values during both seasons.

The increment percentage points for head length, head diameter, neck diameter, head fresh weight, head dry weight and head dry matter percentage, as compared with the control treatment (as an average of both seasons) were (8.00 and 13.82%), (37.78 and 45.89%), (48.74 and 66.33%), (20.80 and 11.98%), (28.62 and 26.94%) and (6.45 and 6.92%),respectively.

In addition, results in Table (5) showed that foliar application of different concentrations of seaweed extract were significantly ($p \leq 0.05$) effective on head length, head diameter and neck diameter. Data showed that foliar application of 750 mg/l of seaweed extract gave the higher mean values during both seasons.

The increment percentage points for head length, head diameter, neck diameter, head fresh weight, head dry weight and head dry matter percentage, as compared with the control treatment (as an average of both seasons) were (37.18 and 37.18 %), (37.14 and 37.18%) and (88.17 and 88.22 %), (37.18 and 37.18 %), (37.16 and 45.56%) and (0.15 and 6.19 %), respectively.

Such results are in harmony with those of Pesti *et al.* (2004) and Morteza *et al.* (2013) who found that increase head diameter of globe artichoke.

The interaction between cooling periods treatments and seaweed extract treatments was not significant ($p > 0.05$) on head length in the first season and highly significant ($p \leq 0.05$) in the second season, while, highly significant ($p \leq 0.05$) on head diameter and neck diameter during both seasons.

The interaction between cooling and seaweed extract treatments affected significantly only the head fresh weight, while not significant on head fresh weight and head dry matter percentage and highly significant on head dry weight, during both seasons.

Table (5). Averages values of head morpho-physical characters of globe artichoke plants as affected by cooling periods of crown pieces, foliar spraying by seaweed extract during both seasons of 20172018 and 2018/2019

Treatments		Head length (cm)		Head diameter (cm)		Neck diameter (cm)		Head fresh weight (g)		Head dry weight (g)		Head dry matter (%)	
(A) Cooling period(days)													
Control		8.79c	9.25c	6.61c	6.96c	1.71c	1.62b	94.20c	99.16b	18.10c	18.24c	19.22b	18.35a
15		9.50b	10.00b	7.32b	7.71b	2.03	1.93b	103.45b	108.90b	20.14b	21.18b	19.49	19.45a
30		9.94a	10.37a	8.00a	8.42a	2.49a	2.37a	113.80a	119.79a	23.28a	23.51a	20.46a	19.62a
LSD (0.05)		**0.34**	**0.28**	**0.34**	**0.36**	**0.37**	**0.35**	**2.07**	**15.58**	**1.58**	**0.92**	**47.74**	**1.60**
(B) Seaweed extract (mg/l)													
Control		7.95d	8.37d	6.20d	6.53d	1.76d	1.67d	88.03d	92.66b	17.39d	17.25d	19.72a	18.57c
250		8.84c	9.30c	6.89c	7.25c	1.96c	1.86c	97.81c	102.96b	19.32c	19.71c	19.75a	19.12b
500		9.93b	10.34b	7.65b	8.06b	2.18b	2.07b	108.68b	103.29b	21.47b	21.84b	19.75a	19.05bc
750		10.91a	11.49a	8.50a	8.95a	2.42a	2.30a	120.76a	127.11a	23.85a	25.11a	19.75a	19.72a
LSD (0.05)		**0.61**	**0.02**	**0.03**	**0.03**	**0.02**	0.02	**0.19**	**19.18**	**0.10**	**0.60**	**40.09**	**0.54**
Interaction effect (AXB)													
Cooling	**Seaweed**												
Control	Control	7.45	7.85	5.61	5.90	1.45	1.38	79.87	84.08	15.35	15.15	19.22	18.02
	250	8.28	8.72	6.23	6.56	1.61	1.53	88.75	93.42	17.05	16.90	19.22	18.08
	500	9.20	9.69	6.93	7.29	1.79	1.70	98.61	103.80	18.95	18.76	19.22	18.07
	750	10.23	10.77	7.69	8.10	1.99	1.89	109.57	115.33	21.06	22.17	19.22	19.22
15	Control	8.05	8.48	6.21	6.53	1.72	1.64	87.72	92.34	17.08	17.14	19.49	18.56
	250	8.95	9.42	6.90	7.26	1.91	1.82	97.47	102.60	18.98	20.67	19.49	20.16
	500	9.95	10.47	7.67	8.07	2.13	2.02	108.30	114.00	21.09	22.24	19.49	19.53
	750	11.05	11.63	8.52	8.97	2.37	2.25	120.33	126.67	23.43	24.67	19.49	19.49
30	Control	8.36	8.80	6.79	7.14	2.11	2.01	96.49	101.57	19.74	19.46	20.46	19.14
	250	9.28	9.77	7.54	7.93	2.35	2.23	107.22	112.86	21.93	21.57	20.46	19.11
	500	10.65	10.86	8.38	8.82	2.61	2.48	119.13	125.40	24.37	24.53	20.46	19.56
	750	11.46	12.07	9.31	9.80	2.90	2.75	132.37	139.33	27.07	28.50	20.46	20.46
LSD (0.05)		**0.16**	**0.02**	**0.03**	**0.03**	**0.02**	**0.02**	**25.04**	**16.54**	**0.10**	**0.60**	**0.26**	**0.54**
Interaction		**ns**	**	**	**	**	**	**ns**	**ns**	**	**	**ns**	**ns**

Chemical composition of heads

Results of Table (6) clearly indicate that the increment percentage points for total sugar, reducing sugars, TSS and inulin, as compared with the control treatment (as an average of both seasons) were (20.26 and 28.26%), (26.61 and 28.37 %), (12.84 and 7.53%) and (7.81 and 6.46%), respectively.

Carbohydrates stored in roots and stems are the "savings account" of many perennial forage plants. They are energy stores used for survival during dormancy and to start growth following dormancy. The depletion of soluble sugars and a fructan-containing substance during the low–temperature storage of chrysanthemum cuttings were observed by (Rajapakse *et al.,* 1996). A significantly greater amount of all sugars in potato tubers during cold storage and starch is remobilized and converted to sugars was found by (Jacob *et al.,* 2006).

In this respect, results in the same table showed direct proportionate relationship with respect to the sub-main effect of seaweed extract treatments. The increment percentage points for total sugar, reducing sugars, TSS and inulin, as compared with the control treatment (as an average of both seasons) were (54.02 and 37.21 %), (36.44 and 37.25%), (37.13 and 37.20 %) and (38.01 and 37.14%),, respectively.

The value of seaweeds as well as algae extracts applications were due to the presence of trace elements (N, P, Fe, Cu, Zn, Co, Mo, Mn, Ni) and metabolites. The extract also contains hormones (IAA and IBA), cytokinins, vitamins, enzymes and amino acids. These extracts enhance seed germination, growth, yield, improved quality and longer shelf life of fruits, uptake of nutrients by the plants and more resistance to biotic and abiotic stresses (fungal diseases, insect attack and frost) (Booth, 1969 and Blunden, 1991).

The interaction among cooling periods treatments and foliar spraying of seaweed extract treatments was highly significant on reducing sugars and total soluble solids (TSS), during both seasons.

Table (6). Average values of chemical composition of globe artichoke heads 'as affected by cooling periods of crown pieces, foliar spray seaweed extract and their interactions during 2017/2018 and2018/2019 seasons

Treatments		Total sugars (%)		Reducing sugars (%)		TSS (%)		Inulin (%)	
		2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019	2017/ 2018	2018/ 2019
(A) Cooling period (days)									
Control		11.50b	12.10c	6.99c	7.26c	5.53b	6.11c	10.75c	11.46c
15		13.32ab	14.02b	7.99b	8.41b	5.83b	6.24b	12.27a	12.91a
30		13.83a	15.52a	8.85a	9.32a	6.24a	6.57a	11.59b	12.20b
LSD (0.05)		**2.21**	**0.50**	**0.33**	**0.30**	**0.23**	**0.10**	**0.19**	**2.78**
(B) Seaweed extract (mg/l)									
Control		9.96c	11.77d	6.75d	7.06d	5.09d	5.35d	9.76d	10.34d
250		12.43b	13.08c	7.49c	7.85c	5.65c	5.94c	10.85c	11.49c
500		13.81ab	14.53b	8.33b	8.72b	6.28b	6.60b	12.06b	12.76b
750		15.34a	16.15a	9.21a	9.69a	6.98a	7.34a	13.47a	14.18a
LSD (0.05)		**1.82**	0.03	**0.06**	**0.02**	**0.02**	**0.01**	**0.10**	**0.02**
Interaction effect (AXB)									
Cooling	**Seaweed**								
Control	Control	9.75	10.27	5.96	6.15	5.03	5.18	9.06	9.72
	250	10.83	11.40	6.62	6.84	5.58	5.76	10.07	10.80
	500	12.04	12.67	7.36	7.60	6.21	6.40	11.19	12.00
	750	13.38	14.08	8.02	8.45	6.90	7.11	12.67	13.33
15	Control	11.30	11.89	6.78	7.13	4.94	5.29	10.40	10.95
	250	12.55	13.21	7.53	7.93	5.49	5.88	11.56	12.17
	500	13.95	14.68	8.37	8.80	6.10	6.54	12.85	13.52
	750	15.50	16.31	9.30	9.79	6.78	7.26	14.27	15.03
30	Control	8.84	13.16	7.51	7.90	5.30	5.57	9.83	10.35
	250	13.90	14.62	8.34	8.78	5.88	6.19	10.92	11.49
	500	15.44	16.25	9.27	9.75	6.54	6.88	12.13	12.77
	750	17.15	18.06	10.30	10.84	7.26	7.65	13.48	14.19
LSD (0.05)		**1.82**	**0.03**	**0.06**	**0.02**	**0.02**	**0.01**	**0.10**	**0.02**
Interaction		**ns**	**ns**	**	**	**	**	**	**Ns**

CONCLUSION

Generally, it could be concluded that cooling periods of crown pieces at 30 days before planting and foliar application of seaweed extract at 750 mg/l recorded the maximum vegetative growth characters also, yield and yield components and gave the highest mean values of all chemical compositions such as, total sugars and reducing sugars .

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الملخص العربي

تأثر إنتاجية وجودة محصول الخرشوف بالرش بمستخلص الأعشاب البحرية وفترات تبريد التقاوي

[١]غادة كمال إبراهيم [٢]على ابراهيم على عبيدو [٢]منى محمد يسرى جابر [٣]نشوة إبراهيم أبو الفضل

[١]طالبة دراسات عليا

[٢]قسم الإنتاج النباتي- كلية الزراعة (سابا باشا)- جامعة الأسكندرية

[٣]باحث أول- مركز البحوث الزراعية- الصبحية

أجريت تجربتان حقليتان في مزرعة خاصة بمنطقة شبراخيت بمحافظة البحيرة خلال موسمي ٢٠١٧/٢٠١٨، ٢٠١٨/٢٠١٩ وذلك لتقييم تأثير الرش بمستخلص الأعشاب البحرية وفترات التبريد للتقاوي علي النمو الخضري والمحصول وجودة محصول الخرشوف. وكان تصميم التجربة قطع منشقة مرة واحدة مع ثلاث مكررات. تضمنت التجربة ثلاث فترا ت تبريد (كنترول، ١٥، ٣٠ يوم) كعامل رئيسي، وأربع مستويات من مستخلص الأعشاب البحرية (كنترول، ٢٥٠، ٥٠٠، ٧٥٠ مجم/لتر) كعامل تحت رئيسي.

وقد أوضحت النتائج مايلي:

١. أدت فترة التبريد لمدة (٣٠ يوم) إلي الحصول علي أفضل القيم لصفات النمو الخضري (نسبة الإنبات، إرتفاع النبات، الوزن الطازج للأوراق، الوزن الجاف للأوراق، % للمادة الجافة للأوراق، كما سجلت أفضل القيم لصفات المحصول ومكونات المحصول (المحصول المبكر/نبات، المحصول الكلي/نبات، طول وقطر النورة، قطر العنق، الوزن الطازج للنورة، الوزن الجاف للنورة، % للمادة الجافة للنورة)، مقارنة بمعاملة الكنترول خلال كلا الموسمين. أيضاً أعلي القيم للمكونات الكيماوية (السكريات الكلية، السكريات المختزلة، نسبة المواد الصلبة الكلية) ومن ناحية آخرى سجلت نسبة الأنيولين أعلي القيم مع فترة التبريد ١٥ يوم، مقارنة مع معاملة الكنترول خلال كلا الموسمين.

٢. الرش بمستخلص الأعشاب البحرية بمعدل ٧٥٠ مجم/لتر أعطي أفضل القيم لصفات النمو الخضري، المحصول ومكونات المحصول كذلك أعلي القيم للمكونات الكيماوية مقارنة بالمعاملات الآخري والكنترول في كلا الموسمين.