Growth, Yield and Quality of Two Globe Artichoke Cultivars as Affected by Gibberellic Acid, Naphthalene Acetic Acid, Benzyle Amino Purine and Seaweed Extract

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ABSTRACT

Two field experiments were carried out during the two successive seasons (2016 - 2017 and 2017- 2018), in a private Farm, at Seedy Ghazi- Kafr El Dawar, Behiera Governorate, Egypt. The objectives of this work are to evaluate the outcomes of using gibberellic acid (30 and 60 ppm), naphthalene acetic acid (25 and 50 ppm),6-N benzyl adenine purine (20 and 30 ppm) and seaweed extract (1 and 2 g / L) on growth, yield and quality of globe artichoke cv. 'French' and 'Balady' under Behiera Governorate environment. The obtained results of the two seasons revealed that French cultivar showed higher mean values of plant height, number of leaves, leaf area, number of branches, fresh and dry weight, nitrogen and protein in leaves. However, Balady cultivar showed high values of number of early head / plant and number of early head /feddan, total head / plant, number of total head /feddan, weight of edible part/ plant and potassium in leaves. Spraying artichoke plant suing gibberellic acid, naphthalene acetic acid, N-6-benzyle amino purine and seaweed extract with all concentrations showed significant effect on the almost vegetative growth characteristics, yield and its components and chemical characteristics of leaves with different magnitude compared to control treatment. In this respect, gibberellic acid was superior in the case of vegetative growth and early yield characteristics. However, seaweed extract and 6-N benzyl adenine purine gave the highest mean values of total yield and chemical characteristics of leaves. The combined treatment of Balady cultivar and either seaweed extract at 2 g / L or N-6-benzyle amino purine at 30 ppm recorded the maximum mean values of the studied characters and might be considered as an optimal treatment for the production of high yield and good quality of globe artichoke plants.

Key words: Globe Artichoke, Gibberellic Acid, Naphthalene Acetic Acid, Seaweed Extract.

INTRODUCTION

Globe artichoke *(Cynara scolymus* L.*)* is an important vegetable crop, belongs to the *Asteraceae* family. It is a perennial rosette plant grown throughout the worldwide for its edible and fleshy heads. It is considered as one of the most significant medicinal plant, too. It has important nutritional status related to its high content of phenolic compounds as flavonoids, inulin, fibers and minerals. Phenolic compounds such as cynarin have effect on hepatitis diseases, hyperlipidemia, dropsy, rheumatism and cholesterol metabolism (Mauromicale *et a*l., 2003).

Artichoke is widely cultivated in the Mediterranean region, including Egypt. The total area grown with artichoke in Egypt was 17287 ha, which produced about 323866 tons (FAO, 2018). High yield and quality of artichoke flower heads during the period of December to February, has major encouragement for promoting artichoke plantation area in Egypt. It is known that artichoke cultivars demand to undergo verbalization to shift from vegetative to generative stage which in the cooler regions starts very early (during the autumn). Stem elongation occurs only in the spring (Bucan *et al*., 2000; Elia *et al.*, 1991; Mauromicale *and Lerna*, 2000). Probably out- of- season production occurs during warm part of the year; therefore, plants often do not have enough periods of low temperature to induce flowering; hence foliar application of gibberellic acid (GA_3) could be an alternative mean to solve this problem and extend both the harvest period and production season. Saber *et al.* (2003) mentioned GA_3 is used extensively in Egypt and other countries to increase the growth and yield of many vegetables such as tomatoes, globe artichoke, cabbages and cauliflower. Several reports stated the profound effects of GA_3 on globe artichoke, but outcome results are variable (De Malach *et al*., 1976; El-Baz *et al*., 1979 and Mauromicale *et al*., 2003).

Gibberellic acid is known as growth hormone (endogenously and occurs as natural hormone) for growth and development, and added exogenously as plant growth regulator to hasten or accelerate flowering process that subsequently head production in globe artichoke especially during the period from December to February period. Throughout this period, the local market is in need to kind of vegetable at high price and option for export abroad. Additionally, this period is economically interesting for export, because there is no production in most European countries during these months (Abd El-Hameid *et al*., 2008). In order to accelerate the early production of heads and obtain increased benefits from higher prices, hence exogenous gibberellic acid (GA_3) application is proposed. Application of GA_3 is a common practice to achieve earliness in globe artichoke heading (Abd El-Hameid *et al*., 2008). Numerous of articles concerning effect of GA_3 on flowering of globe artichoke exhibited inconsistent trend in annual artichokes production.

For instance, according to field observations, Schrader and Keith 1997 reported that foliar application of GA_3 for perennial artichoke production; increased earliness slightly but failed to achieve the level of uniformity and earliness. Define type of applied growth regulators, rates and application times are effective for accelerating maturity and increasing uniformity of flowering in artichokes grown as annuals from seed.

The use of other plant hormones such as cytokinins and auxins has an effective role in accelerating maturity and increasing yields of many vegetable crops. Flowering, fruit setting and inhibition of abscission are other plant responses under the direct or indirect control of auxins, while many effects on plant development are under the effect of cytokinins, either in conjunction with auxin or another hormone. Recently, Seaweed extracts are utilized as foliar sprays to improve plant growth and yield. Plants treated with *seaweed* extracts showed similar physiological responses to those treated with plant growth-regulatory substances. However, there is meager information on the effects of these hormones as well as seaweed extracts on artichokes.

Cultivar is another important factor in determining the quantity and quality of a crop. There are many studies showed high discrepancy between artichoke varieties in several characteristics such as early flowering, yield, and quality. Cultivation the local cultivar (Balady) produces heads with poor quality which are not suitable for exportation purposes. Therefore, more attention should be given to promote artichoke flower head production and its quality through choice suitable cultivars.

Therefore, the objectives of this study are to evaluate the using gibberellic acid, naphthalene acetic acid, 6-N benzyl adenine purine and seaweed extract on growth, yield and quality of globe artichoke cv. 'French' and cv. 'Balady' under Behiera Governorate environment.

MATERIAL AND METHODS

Two field experiments were carried out during the two successive seasons (2016 - 2017 and 2017-2018), in a private Farm at Seedy Ghazi- Kafr El Dawar, Behiera Governorate, Egypt, under open field condition, using surface irrigation system. Soil samples of 30 cm depth were collected and analyzed for some soil's physical and chemical properties for the experimental site during both seasons according to, Black (1965). Results of soil physio-chemical analyses are shown in Table 1.

The present experiment included 18 treatments which were the combination between the two cultivars (Balady and French) and spraying treatments: Gibberellic acid(GA_3) at 30 and 60 ppm, Naphthalene acetic acid (NNA) at 25 and 50 ppm, N-6-Benzyle amino purine (6BA) at 20 and 30 ppm and seaweed extract at 1 and 2 g / L and control (tap water). Stumps cuttings (crown pieces) as a propagation methods were produced from an old crown of a previous globe artichoke plant, cv. Balady and French in both experiments. The stumps were disinfected by the fungicide Topspin M-70 at the rate of 2 g/ l for 20 minutes, before planting, subsequently they were air dried. Planting took place on August 15th during both seasons of the study. Each stump has approximately constant weight, more or less, *ca*. 160 g / stump. Each experimental unit contained 3 rows, 14 m long, 1 m width and the intra-row spacing was 75 cm apart.

Table 1. Some physical and chemical properties of the experimental location during both seasons of experimentation (2016-2017 and 2017-2018).

Soil properties		Seasons	
		2016-2017	2017-2018
Particle Size Distribution (%)	sand*	29.5	28.9
	silt	27.6	28.8
	clay	42.9	42.3
Textural Class		Clay Loam	Clay Loam
Chemical	pH	8.55	8.39
	EC (dsm^{-1})	1.62	1.58
	O.M(%)	1.79	1.74
Soluble Ions (meq/L)	$CaCO_3$ (%)	21.4	22.6
	Na^+	5.3	5.24
	Ca^{++}	5	5.1
	Mg^{++}	4.8	4.9
	K^+	0.12	0.1
	Cl^-	8.8	8.7
	SO_4^{--}	3.4	3.5

*The analyses were carried out at the Agricultural Directorate Lab of Damanhur city, El-Behera governorate, Egypt.

The experimental unit area was 42 m^2. So, the total number of plants/ feddan were 5333 plants.

The suggested concentrations of spraying treatments were applied as a foliar spraying until run-off using a hand sprayer. All precautions and accuracy were followed during weighing, dissolving and spraying. Foliar application was done just before sunset during both seasons, to avoid deterioration caused by effect of high temperatures and other ambient atmosphere on the applied items. Each spraying treatment was applied three times after planting: 60, 80 and 100 days. The untreated control plants were sprayed with tap water similarly. All experimental units received identical levels of nitrogen, phosphorus and potassium fertilizers as well as organic manure (20 m^3 FYM/fed.). Ammonium sulphate (20.5% N) at the rate of 300 kg/fed. was equally divided and side dressed after 8, 12 and 16 weeks after planting, Calcium super phosphate (15.5 % P_2O_5) at the rate of 250 kg /fed. was base dressed before planting and potassium sulphate at the rate of 100 kg /fed. was equally divided and side dressed after 8 and 12 weeks of planting. All other agricultural practices were adopted whenever they were necessary and as commonly recommended for the commercial production of globe artichoke. Harvesting started in the first season on December 10th, 2016 and continued at seven days intervals until May 1st, 2017. Meanwhile, in the second season, the harvesting period extended from November 29th, 2017 and continued to April 30th, 2018.

The layout experiment was split plots system in a Randomized Complete Blocks Design (RCBD) with three replications. The two cultivars' French' and 'Balady' were arranged as the main plots, whereas, each of gibberellic acid, naphthalene acetic acid,6-N benzyl adenine purine and seaweed extract concentrations were considered as the sub- plots. Two guard rows were left between each two adjacent main plots and one guard row was left between each two adjacent sub-plots to protect against side effects. In each experimental unit, a representative sample of random five plants from each plot was randomly taken at 1110 and 115 days from planting in the first and second experiment, respectively. The following growth traits measurements were recorded.

Vegetative growth characteristics

Plant height (cm), number of leaves per plant, number of shoots per plant, plant fresh weight (gm), Plant dry weight(gm). Leaf area per plant (cm^2) was calculated using the weight method as used by Fayed (1997).

Head yield and its components

At the harvest, a random sample of five plant heads from each plot were randomly collected for measuring the following traits:

Early yield was calculated as the number of all harvested heads/plant and head/ feddan for the first 12 pickings. Total yield was calculated as the number of all harvested heads/ plant and head/feddan, and weight of edible from during the season.

Chemical constituents of leaves.

Total chlorophyll content was measured by a digital chlorophyll meter SPAD-502.Total nitrogen was determined calorimetrically according to Evenhuis and De Waard (1980). Phosphorus was determined using ammonium molybdate stannous chloride method (A.O.A.C, 1992). Potassium was measured using a flame photometer as described by Singh *et al*. (2005). Protein (%) was estimated according to A.O.A.C. (1975).

Statistical Analysis

All obtained data were subjected to analysis of variance according to the design used by the Costate software package (Costate, 2008). Comparisons among the means of different treatments were carried out using Revised Least Significant test at probability 0.05 to verify significant among treatments.

RESULTS AND DISCUSSION

Vegetative growth characters:

Data presented in Tables (2 and 3) indicated that the main effect of artichoke cultivars differed significantly in their vegetative growth in both seasons. French cultivar showed higher mean values of plant height, number of leaves, leaf area, number of branches, fresh and dry weight than those of balady cultivar. The detected differences between the two cultivars could be related to their genetic features. The present results are in agreement with those reported by Ibrahim (1980) who indicated that artichoke cultivars were significantly differed in their plant size, branching number and shape of leaves as well as varied in length. Also, Ibrahim (2009) reported that plant height, number of leave / plant and average leaf area obtained from French and Imperial Star cultivars, recorded the highest values compared to Balady cultivar.

Okasha *et al*. (1997) reported that significant diligence in plant growth, i.e., Plant height, number of leaves / plant and both leaf length and width were detected among some artichoke cultivars. Moreover, Hammouda *et al*. (1993) found that the highest number of leaves was obtained from the Romanian strain compared to Balady cultivar. The obtained results are in agreement with those of Gabr and Sarg (1998) and Gabr *et al*. (2002) on potatoes.

Regarding the main effect of the spraying treatments (gibberellic acid, naphthalene acetic acid, N-6-benzyle amino purine and seaweed extract) on vegetative growth parameters of artichoke plants, the showed results in Tables (2 and 3) illustrated that spraying gibberellic acid, naphthalene acetic acid,

Table 2: The main average values of some vegetative growth of artichoke plants as affected by cultivars, NNA, GA_3, 6BA and Seaweed Extract during the fall season of 2016 and 2017.

	Treatments	Plant height* (cm)		Number of leaves /plant		leaf area /plant (cm^2)		Number of branches /plant		Fresh weight/plant (gm)		Dry weight/plant (gm)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
treatment	French	115.62 A	117.13 A	24.17 A	24.70 A	3016.14 A	2837.83 A	8.92 A	8.92 A	3925.50A	3172.9A	1366.06 A	1264.85 A
	Balady	101.22 B	108.88 B	20.71 B	22.29 B	2598.26 B	2454.38 B	8.88 A	8.88 A	3378.97 B	3231.7B	1175.78 B	1096.75 B
Control	tap water	99.33 D	98.74 F	19.00 C	20.83 F	1716.03 D	1721.33 F	7.33 D	7.33 D	2015.37 E	2018.16 I	514.10 D	520.35 H
NAA	25 ppm	102.00 CD	105.84 E	20.00 BC	22.16 EF	2253.03 C	2308.49 E	7.33 D	7.33 D	3112.65D	3044.9 H	1151.68 C	1138.51 G
	50 ppm	101.66 CD	109.34 D	21.33ABC	22.33 DEF	2913.97 B	2732.20 C	8.50 C	8.50 C	3370.92 C	3296.84 F	1182.29 C	1167.60 F
GA_3	30 ppm	105.83BCD	114.15 C	20.17 BC	21.83 EF	2944.43 B	2683.93 D	8.83 BC	8.83 BC	3144.08D	3142.3 G	1168.31 C	1381.50 B
	60 ppm	121.50 A	121.12AB	24.50 AB	24.66 B	2717.73 B	2963.88 A	10.00 A	10.00 A	3553.94 C	3700.8 D	1304.19 B	1184.30 E
6BA	20 ppm	109.50 B	115.34 C	23.83 AB	23.00CDE	2859.32 B	2881.20 B	9.83 AB	9.83 AB	3455.70 C	3464.1 E	1189.98 C	1177.70EF
	30 ppm	109.16 B	123.60 A	25.33 A	27.33 A	3298.00 A	2947.96 A	10.33 A	10.33 A	4337.93A	4431.8 A	1415.85 A	1407.23 A
Seaweed	1g/L	107.83 BC	105.42DE	19.83 BC	23.83BCD	2718.25 B	2690.43 D	9.33 ABC	9.33 ABC	3895.79 B	3857.6 C	1393.33AB	1297.35 D
	2g/L	119.00 A	120.14 B	24.50 AB	24.16 BC	2752.86 B	2885.65 B	9.83 AB	9.83 AB	4346.86 A	4294.2B	1361.70AB	1407.23 A

* values having the same alphabetical letter (s) in common, do not significant different, using the revised L.S.D. test at 0.05 level of probability.

Table 3: The Interaction average values of some vegetative growth of artichoke plants as affected by cultivars, NNA, GA_3,6BA and Seaweed Extract during the fall seasons of 201 6and 2017.

Treatments		Plant height /plant * (cm)		Number of leaves/plant		leave area /plant (cm^2)		Number of branches/plant		Fresh weight /plant (gm)		Dry weight /plant (gm)	
		1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season	1^{st} season	2^{nd} season
French	Control	102.66 efgh	102.71 hi	20.33 bc	21.00 efg	1815.90 g	1822.36 j	7.33 gh	6.33 g	2132.67 k	3138.66m	591.11 i	589.97 j
	NAA 25 ppm	106.33 defg	111.48def	22.00 abc	24.33 bcd	3041.83 bc	3142.13 b	8.67 efgh	7.00 fg	3311.33 fgh	3229.71 j	1225.19 def	1186.36 f
	NAA50 ppm	107.66 def	109.59efg	22.33 abc	21.66efg	3067.33 bc	2866.88de	10.00 abcde	9.66 bc	3548.33 ef	3396.14 i	1244.52 def	1198.71 f
	$GA_3$30 ppm	111.66 de	112.74 de	26.66 ab	23.00 cde	2976.06 bcd	2607.87 g	10.33 abcde	8.00 def	3399.00 fg	3379.34 i	1409.93 abc	1488.18 a
	GA_3 60 ppm	131.66 a	120.23 b	21.67abc	25.00 bc	2906.67bcde	2961.14 c	10.67 abcd	8.66 bcde	3801.00 de	3892.38 f	1249.53 def	1279.16 d
	6BA 20 ppm	121.66 bc	120.08 bc	26.33 ab	25.00 bc	2503.36 f	2858.87 e	11.00 abc	10.00 ab	3839.66cde	3829.94 g	1322.2 cde	1295.03 d
	6BA 30 ppm	130.33 ab	133.62 a	27.33 a	30.33 a	3604.36 a	3229.50 a	11.66 a	11.33 a	4542.33 a	4880.40 a	1506.30 a	1471.96 a
	Seaweed1g/L	113.00 cd	111.46def	25.66 ab	24.00 bcd	2846.33 bcdef	2896.91e	11.33 ab	9.33 bcd	4211.66 b	4218.91 c	1482.56 ab	1395.33 b
	Seaweed 2g/L	115.66 cd	132.27 a	21.33 abc	25.33 b	3183.17 b	3154.82 b	11.66 a	10.00 ab	4750.66 a	4450.58 b	1488.2 a	1478.96 a
Balady	Control	96.00 h	94.77 j	17.67 c	20.66 fg	1616.15 g	1620.30 k	7.00 h	8.33 cdef	1898.07 k	1897.66 n	437.09 j	450.72 k
	NAA 25 ppm	97.66 gh	100.20 i	18.00 c	20.00 g	2676.81cdef	2620.28 g	8.00 fgh	7.66 efg	2913.97 ij	2860.27 I	1078.17gh	1090.65 h
	NAA 50 ppm	95.66 h	109.10 efg	20.33 bc	23.00 cde	2529.65 ef	2509.00 h	9.00 defg	8.00 def	3193.50 ghi	3197..53 j	1120.07 fgh	1136.50 g
	GA_3 30 ppm	100.00 fgh	115.55 cd	23.33 bc	24.33 bcd	2705.69cdef	2698.26 f	9.33 cdef	9.33 bcd	2889.15 j	2905.53 I	1235.206def	1274.82 d
	GA_3 60 ppm	102.66 efgh	113.58 de	18.67 c	24.00 bcd	2528.80 ef	2503.26 h	9.67 bcdef	9.00 bcde	3306.87fgh	3509.36 h	1087.09gh	1089.43 h
	6BA 20 ppm	97.33 gh	110.59 ef	18.33 c	21.00 efg	2002.69 g	2009.10 i	9.33 cdef	9.66 bc	3071.73hij	3098.33 k	1057.76 h	1060.38 i
	6BA 30 ppm	111.33 de	122.02 b	21.33 abc	24.33 bcd	2991.62 bc	2904.41 d	10.33 abcde	10.00 ab	4133.52 bc	4137.81 d	1349.13bc	1342.50 c
	Seaweed1g/L	102.66 efgh	105.39 gh	23.33 abc	20.66 fg	2590.16 def	2483.77 h	10.66 abcd	9.33 bcd	3579.91 ef	3496.43 h	1198.44 efg	1199.41 f
	Seaweed 2g/L	107.66 def	108.01 fg	22.33 abc	22.66 def	2760.60cdef	2741.09 f	10.00 abcde	8.66 bcde	3943.05bcd	3983.30 e	1280.35 cde	1226.40 e

* values having the same alphabetical letter (s) in common, do not significant different, using the revised L.S.D. test at 0.05 level of probability.

N-6-benzyle amino purine and seaweed extract with all concentrations showed significant effects on plant height, number of leaves, leaf area, number of branches, fresh and dry weight compared to the control treatment, in both seasons. It is obvious that N-6-benzyle amino purine at 30 ppm gave the highest mean values of all studied characters, followed by gibberellic acid at 60 ppm, seaweed extract at 2 g/l and naphthalene acetic acid at 50 ppm. However, plant height reached the maximum when plants sprayed with seaweed at 2 g/l, in the first season. This particular treatment (N-6-benzyle amino purine at 30 ppm), the estimated percentages increase in plant height, number of leaves, leaf area, number of branches, fresh and dry weight were (9.89 and 25.17 %), (33.31 and 31.20 %), (92.19 and 71.26 %), (55.79 and 40.92 %), (115.24 and 119.59 %), and (175.40 and 170.43 %), compared to the control treatment in the first and second season, respectively. The present results could be attributed to the role of each spraying material. Synthetic cytokinin such as benzyl amino purine (BAP), 2-chloro-4-pyridyl-Nphenylurea (CPPU) and 6-furfuryl-aminopurin (Kinetin) can improve plant growth by cell division, break bud dormancy and promotes the growth of the lateral bud (Hossain et al., 2006). Exogenous application of N-6-benzyle amino purine on Cowpea improved vegetative growth and that seemed to be due to increase greater chlorophyll synthesis as observed by Reddy *et al., (2009).* Application of the 6BA on okra plants increased significantly plant height, number of leaves, number of branches and leaf area plant^{-1} compared to the untreated control (Brengi ,2018). Using benzyl adenine at 100 – 200 ppm led to significant increases in branch, dry weight, period from showing color to full opening stage, flowering duration and inflorescence (Gabrelel *et al*., 2018). Cytokinin reduced heat stress effects and increased production of artichoke growing under hot fall conditions (Schrader, 2005). The endogenous cytokinin levels decreased under high temperature conditions (Hare *et al*., 1997; Banowetz *et al*., 1999).

The interaction effects between artichoke cultivars and the spraying treatments on vegetative growth parameters of artichoke plants, were significance during both seasons (Table, 3). The combined treatment of France cultivar and N-6-benzyle amino purine at 30 ppm, generally, recorded the highest mean values of plant height, number of leaves, leaf area, number of branches, fresh and dry weight compared to the control treatment, in both seasons.

Yield and its components:

Tables (4 and 5) show the main effects of the two studied factors of artichoke cultivars and the spraying treatments (gibberellic acid, naphthalene acetic acid, N-6-benzyle amino purine and seaweed extract) and their interactions on the yield and its components of artichoke plants in 2016-2017 and 2017-2018 seasons.

Results outlined in Table (4) exhibit the average values of number of early heads/plant, number of early heads/feddan, total number of heads/ plant, and weight of edible part of artichoke plants in 2016-2017 and 2017-2018 seasons. The results indicated that the main effect of artichoke cultivars differed significantly in their yield parameters in both seasons. Balady cultivar showed higher mean values of yield and its component than France cultivar, in both seasons. The noticed differences between the two cultivars could be attributed to their genetic features. This finding is in agreement with those of McErlich (1983), who compared three cultivar of globe artichoke in a three years' trial. He found that Tudella and E15 gave higher yield than Green Globe cv. which gave the highest average head weight. In another study, Rodrigo *et al.* (1979) evaluated five introduced artichoke cultivars in Spain (Murcia, Amposta, Tudela, San Juan de Enova and Tudela X Amposta). Early yield was about 15-25% of the total yield of artichoke harvested during November to early March.

Calabrese *et al*. (1994) showed significant difference among some tested cultivar in their number of heads and earliness. They added that 21 heads /m^2 were harvested 19 times between November and May. The greatest number of heads was 209000 heads /ha (on average) compared with only 143000 heads/ha for cultivars 137. Moreover, Basnitzki and Zohary (1987) revealed that Talpiot artichoke cultivar gives yield of 13-16 ton of fresh heads/hectare. Such results have been also obtained with colonel varieties Violet de Provence and Blanc de Hyeres cultivars. Pandita *et al*. (1988) evaluated exotic cultivars for yield characters of globe artichoke in Kashmir valley. They found that green globe (GG) and Fl Sasanqua gave the highest yields based on number of buds/plant (20.2 and 20.0, respectively) and bud weight kg /plant (6.1 and 5.3, respectively).

Miccolis *et al*. (1990) found that the peak yield of artichoke was seen from April to mid-May. The average harvesting period was 50 days, but it varied from only 7 days in Violet to Spinoso to 201 days in Blanco cultivar. They added that average yield/plant was 843.5g and ranged from 119g to 1832g. Recently, Soria *et al*. (2020) showed that the greatest final total yield was reached by the green head cultivars/lines 'Nun 4011' (3.73 kg m^{-2}) and 'Madrigal' (3.65 kg m^{-2}) and among purple color head cultivar 'Opal' (2.92 kg m^{-2}). Similar results were obtained with those of Gabr and Sarg (1998) and Gabr *et al.* (2002) on potatoes.

Table 4: The main average values of Yield and its components of artichoke plants as affected by cultivars, NAA, GA_3 6BA and Seaweed Extract during the fall season of 2016 - 2017 and 2017-2018.

Treatments		Early yield				Total yield					
		Number of heads /plant *		Number of heads / feddan		Total number of heads / plant		Total number of heads /feddan		Wight of edible part /plant (gm).	
		1st season	2 nd season	1st season	2 nd season	1st season	2 nd season	1st season	2 nd season	1st season	2 nd season
French		5.09 B	5.36 B	27145 B	28585 B	11.75 B	11.36 B	62653.86 B	60574.47 B	56.90 B	61.76 B
Balady		6.06 A	5.78 A	32318 A	30825 A	12.89 A	12.32 A	68729.04 A	65702.97 A	63.93 A	62.28 A
	Control(tap water)	4.30 D	4.74 E	22932 D	25278 E	9.87 G	11.12 F	52656.71 G	59295.49 F	59.93 CDE	61.95 CD
	NAA 25 ppm	5.01 C	5.02 DE	26718 C	26772 DE	11.25 F	10.65 G	59996.25 F	56777.52 G	58.63 E	57.32 E
	NAA 50 ppm	5.13 C	5.07 DE	27358 C	27038 DE	11.62 E	11.25 E	61976.13 E	60014.92 E	60.92 BCD	61.74 CD
	$GA_3$30 ppm	5.15 C	5.51 BCD	27465 C	29385 BCD	11.50 E	11.36 E	61336.17 E	60582.88 E	59.68 DE	61.78 CD
	GA_3 60 ppm	6.16 A	6.73 A	32851 A	35891 A	12.50 D	12.32 C	66655.83 D	65694.56 C	61.33 BC	62.50 BC
	6BA 20 ppm	5.24 C	5.21 CDE	27945 C	27785 CDE	12.87 C	12.23 C	68655.71 C	65240.19 C	58.50 E	62.14 CD
	6BA 30 ppm	5.68 B	6.03 B	30291 B	32158 B	14.00 B	12.66 B	74655.33 B	67512.05 B	63.51 A	65.90 A
	Seaweed 1g/L	5.87 B	5.82 BC	31305 B	31038 BC	12.75 CD	11.57 D	67975.75 CD	61708.68 D	58.97 E	60.70 D
	Seaweed 2g/L	6.38 A	6.02 B	34025 A	32105 B	14.50 A	13.39 A	77315.17 A	71422.2 A	62.25 AB	64.15 AB

* values having the same alphabetical letter (s) in common, do not significant different, using the revised L.S.D. test at 0.05 level of probability.

Concerning the main effects of the spraying treatments (gibberellic acid, naphthalene acetic acid, N-6-benzyle amino purine and seaweed extract) on yield parameters of artichoke plants, are presented in Tables (4). Spraying the aforementioned treatments showed significant effects of early yield (number of early heads / plant and number of early heads /feddan) and total yield (number of heads/ plant, number of heads /feddan and weight of edible part plant), compared to control treatment, in both seasons. Regarding early yield, it is clear that either gibberellic acid at 60 ppm in both seasons or seaweed extract at 2 g/l in the first season only, gave the highest mean values of number of head/plant and number of head /feddan compared to other treatments. The gibberellic acid at 60 ppm increased number of early head / plant and number of early head /feddan by 43.25 and 41.98%, respectively, compared to the control treatment) as an average of the two seasons. These results are in harmony with those of George *et al.* (2008) who reported that increasing number of globe artichoke heads/plant, with spraying GA_3 concentrations could be attributed to its mode of action in promotion of flowers primordia production. It is known that number of heads per plant is a vital factor, whereas this trait is directly in connection with the number of heads per feddan, number of early yield per plant and per feddan. It is concluded that gibberellic acid plays an important role in boosting the early yield. The earliness of globe artichoke plant yield may be taken place owing to GA_3 treatments which promote vegetative growth and thus there is a translocation of the synthesized assimilates to other plant parts and might have facilitate early flowering (produced heads). Conspicuously, most globe artichoke growers inclined to foliar application of GA_3 as a vernalized tool to enhance and accelerate heads initiation (early yield) and achieve high financial returns because of high prices. In Egypt, the highest market prices are recorded from December to February. Nonetheless, for earlier planting, globe artichoke floral induction requires such add GA_3 treatment (250 hours at temperature $\leq$ 7°C). Therefore, globe artichoke growers turn to use GA_3 to overcame the higher temperature during the early time-course of plantation. The results of the present study are in agreement with those of EL-Baz *et al.* (1979), who stated that foliar application of GA_3 at either 50 or 75 ppm, induced early yield in selected "French" cv., but did not exhibit such influence on the total yield. Also, Basnitzki and Zohary (1987) showed that foliar application of globe artichoke plants with GA_3 at 60 and 120 ppm can be used safely. Zaki *et al. (*1991) reported that foliar application of GA_3 at 50, 100 and 200 ppm on globe artichoke plants cv. 'Herious'; improved early and total yield of flower head, especially at 200 ppm. Likewise, Lin *et al.* (1991) in Taiwan, reported that foliar application of GA_3 at 45 ppm in February and March, enhanced positive effect on bolting earliness, bolting percentage and flower bud yield. Also, Schrader and keith (1997) found that application of 20 ppm GA_3 three times at 2 weeks' intervals increased significantly the percentage of early yield. Parallel reports about the effect of GA_3 on encouraging earliness of globe artichoke were, also, introduced by El-Gridly (1994), Schrader (1994) and Miguel *et al*. (2003).

The positive effect of seaweeds extract on early yield characters was reported by Saif- Eldeen *et al.* (2014) who showed that the high level of seaweeds extract were accompanied with significant yield distribution (early, medium and late yields) compared with control.

Concerning total yield, It is obvious that spraying seaweed extract at 2 g/l gave the highest mean values of number of total heads/plant and number of total head s/feddan, in both seasons, compared to the other treatments. However, the highest mean values of the weight of edible part/ head were achieved when plants sprayed with N-6-benzyle amino purine at 30 ppm, in both seasons, compared to the other treatments. At the favorite treatment (seaweed extract at 2 g/l), the estimated percentages increase in number of total heads/plant and number of total heads /feddan were (46.90 and 20.41%) and (46.82 and 50.45 %), respectively for the first and second seasons, respectively, compared to the control treatment. The positive effects of seaweed extract in yield parameters could be due to the fact that it contains macro, micronutrients and amino acids that improve nutritional status, vegetative growth and yield. These results are in harmony with Saif- Eldeen *et al.* (2014) who showed that the increasing seaweeds extract levels were accompanied with significant yield distribution (early, medium and late yields) compared with control. Also, Seaweed extract application for different crops has a great importance due to its content of organic matter, micro elements (Fe, Cu, Zn, Co, Mo, Mn and Ni), vitamins and amino acids. Additionally, it is also rich in growth regulators such as auxins, cytokinins and gibberellins (Khan *et al.*, 2009; Hamed 2012; El- Miniawy *et al*.2014). The interaction effects between artichoke cultivars and the spraying treatments on yield parameters of artichoke plants were significant during both seasons (Table 5). The combined treatment of Balady cultivar and either gibberellic acid at 60 ppm or seaweed extract at 2 g/L, generally, recorded the highest mean values of number of early yield (number of early heads/plant and number of early heads /feddan) compared to the other treatments, in both seasons.

Table 5: The interaction average values of yield and its components of artichoke plants as affected by cultivars, NAA, GA_3 6BA and Seaweed Extract during fall season of 2016-2017 and2017-2018.

	Treatments	Early yield				Total yield					
		Number of *heads / plant		Number of heads / feddan		Number of heads / plant		Number of heads / feddan		Wight of edible part /plant (gm)	
		1st season	2 nd season	1st season	2 nd season	1st season	2 nd season	1st season	2 nd season	1st season	2 nd season
French	Control(tap water)	3.93 i	4.43 h	20959 i	23625 h	9.00 q	10.41j	47997.00 q	55516.53 j	812.6 i	810.99 l
	NAA 25 ppm	4.75 h	4.90 fgh	25332 h	26132 fgh	10.50 p	10.17 k	55996.50 p	54236.61 k	759.49 i	917.12 j
	NAA 50 ppm	4.73 h	4.75 gh	25225 h	25332 gh	11.00 n	10.65 ij	58636.33 n	56796.45ij	887.55h	853.95 k
	$GA_3$30 ppm	4.61 h	5.21 defgh	24585 h	27785 defgh	11.25 m	11.13 gh	59996.25 m	59356.29 gh	807.3 i	913.35j
	$GA_3$60 ppm	4.70 h	4.85 gh	25065 h	25865 gh	11.75 l	12.07e	62636.08 l	64369.31 e	986 efg	1045.84 de
	6BA 20 ppm	5.11 g	5.66 bcdefg	27252g	30185 bcdefg	12.75 h	12.54d	67995.75 h	66875.82 d	956.8 g	1027.77ef
	6BA 30 ppm	5.60 ef	5.58 bcdefg	29865 ef	29758bcdefg	13.50 e	11.36 fg	71995.50 e	60582.88 fg	977.13 fg	1129.82c
	Seaweed 1g/L	5.17 g	5.24 cdefgh	27572 g	27945 cdefgh	11.75 l	13.25 b	62636.08 l	56796.45 ij	812.6 i	982.94 g
	Seaweed 2g/L	6.06 cd	5.93 bcde	32318 cd	31625 bccde	14.25 c	10.65 ij	75995.25 c	70662.25 b	1087.32 d	1123.87c
Balady	Control tap water	4.67 h	5.05 efgh	24905 h	26932 efgh	10.75 o	11.83 e	57316.42 o	63249.38 e	1073.57 d	962.95 h
	NAA 25 ppm	5.27 fg	5.14 efgh	28105 fg	27412efgh	12.00 k	11.12h	63996.00 k	59302.96 h	1006.47efg	955.26 h
	NAA 50 ppm	5.53 ef	5.38 cdefg	29491 ef	28692 cdefg	12.25 j	11.86 e	65315.92 j	63622.69 e	1079.82 d	1048.09 d
	$GA_3$30 ppm	5.69 e	5.81 bcdef	30345 e	30985bcdef	11.75 l	11.59 f	62676.08 l	61809.47 f	1021.44 ef	1023.24 f
	$GA_3$60 ppm	6.72 a	7.30 a	35838 a	38931 a	13.25 f	12.57d	70675.58 f	67035.81 d	1156.34 c	1050.14 d
	6BA 20 ppm	5.78 de	6.17 bc	30825 de	32905bc	13.00 g	11.93 e	69315.67 g	63089.39 e	1035.89de	1052.69 d
	6BA 30 ppm	6.25 bc	6.41 ab	33331 bc	34185ab	14.50 b	13.96 a	77315.17 b	74448.68 a	1321.55 a	1308.37 a
	Seaweed 1g/L	6.55 ab	6.13 bcd	34931ab	32691bcd	13.75 d	12.89c	73315.42 d	68742.37 c	1083.43 d	1133.37 c
	Seaweed 2g/L	6.69 a	6.38 ab	35678 a	34025 ab	14.75 a	13.13 bc	78635.08 a	70022.29 bc	1212.68 b	1208.61b

* values having the same alphabetical letter (s) in common, do not significant different, using the revised L.S.D. test at 0.05 level of probability.

Table 6: The main average values of some chemical analysis of artichoke leaf as affected by cultivars, NAA, GA_3 ,6BA and Seaweed Extract during the fall Season of 2016-2017 and 2017- 2018.

Treatments		Total chlorophyll *		N (%)		P (%)		K (%)		Protein (%)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
treatments	French	46.75 A	45.94 A	2.91 A	2.84 A	0.71 A	0.72 A	3.40 B	3.40 B	18.19 A	17.77 A
	Balady	46.75 A	46.38 A	2.88 B	2.86 A	0.74 A	0.76 A	3.58 A	3.64 A	17.97 B	17.85 A
Control	tap water	44.11D	47.47 E	2.56 C	2.48 F	0.64 F	0.65 E	3.27 E	3.26 DE	15.97 C	15.48 F
NAA	25 ppm	44.40 C	44.67 DE	2.78 B	2.70 E	0.71 BCD	0.71 D	3.37 D	3.32 CDE	17.40 B	16.90 E
	50 ppm	47.35 A	46.44 ABC	2.81 B	2.93 BC	0.73 SB	0.75ABCD	3.36 D	3.17 E	17.57 B	18.32 BC
GA_3	30 ppm	47.27 A	45.92 BC	2.92 A	2.96 AB	0.70 DE	0.76 ABC	3.42 D	3.43 BCD	18.26 A	18.48 AB
	60 ppm	46.35 AB	46.85 AB	2.92 A	2.89 BC	0.70 CDE	0.73 BCD	3.53 BC	3.63 AB	18.27 A	18.07 BC
6BA	20 ppm	47.23 A	45.57 CD	2.85 B	2.79 D	0.73 AB	0.72 CD	3.50 C	3.68 A	17.79 B	17.46 D
	30 ppm	46.28 AB	47.01 A	2.94 A	2.95 AB	0.75 A	0.79 A	3.52 BC	3.72 A	18.36 A	18.46 AB
Seaweed	1g/L	47.10 AB	46.85 AB	2.98 A	2.86 CD	0.72 BC	0.75 ABCD	3.58 AB	3.52 ABC	18.64 A	17.90 CD
	2g/L	48.02 A	47.49 A	2.94 A	3.02 A	0.73 AB	0.78 AB	3.62 A	3.66 A	18.36 A	18.88 A

* values having the same alphabetical letter (s) in common, do not significant different, using the revised L.S.D. test at 0.05 level of probability.

Table 7: The interaction average values of some chemical analysis of artichoke head plants as affected by cultivars, NAA, GA_3,6BA and seaweed extract during Fall season of 2016-2017 and 2017- 2018.

	Treatments	Total chlorophyll *		N (%)		P (%)		K (%)		Protein (%)	
		1st season	2nd season	1st season	2nd season	1st season	2 nd season	1st season	2 nd season	1st season	2 nd season
French	Control tap water	45.47 abcd	45.17 f	2.59 h	2.56 f	0.62 i	0.67 gh	3.18 j	3.43 de	16.17 h	16.03 f
	NAA 25 ppm	44.47 cd	44.87 ef	2.85 cdef	2.79 cd	0.67 h	0.69 fgh	3.24 ij	3.98 ab	17.79 def	17.43 cd
	NAA 50 ppm	47.37 ab	46.39 bcd	2.97 ab	2.92 ab	0.69 efgh	0.71 fgh	3.23 ij	3.51 cde	18.54 ab	18.26 ab
	$GA_3$30 ppm	47.20 ab	46.30 bcde	2.79 ab	2.96 ab	0.72 bcde	0.79 bcde	3.29 hi	3.68 bcd	17.44 fg	18.49 ab
	GA_3 60 ppm	46.37 abcd	45.39 def	2.96 ab	2.79 cd	0.72 bcde	0.74 cdef	3.47 def	3.65 cd	18.48 abc	17.43 cd
	6BA 20 ppm	46.23 abcd	45.63 bcdef	2.84 def	2.73 de	0.71 bcde	0.71 fgh	3.40 efg	3.63 cd	17.75 ef	17.09 de
	6BA 30 ppm	47.13 ab	46.70 bcd	2.96 ab	3.00 a	0.71 bcde	0.72 efg	3.39 fgh	3.52 cde	18.52 ab	18.74 a
	Seaweed 1g/L	47.20 ab	47.06 b	2.92 abcde	2.76 d	0.70 defg	0.74 cdef	3.56 abcd	3.76 bc	18.27 abcde	17.26 d
	Seaweed 2g/L	48.03 a	47.06 b	2.99 a	3.01 a	0.73 bc	0.69 fgh	3.57 abcd	4.15 a	18.70 a	18.84 a
Balady	Control tap water	45.33 bcd	44.78 f	2.52 h	2.51 f	0.66 h	0.64 h	3.35 gh	3.10 g	15.77 h	15.66 f
	NAA 25 ppm	44.33 d	44.48 f	2.72 g	2.62 ef	0.75 ab	0.73 defg	3.51 cde	3.12 fg	17.00 g	16.38 ef
	NAA 50 ppm	47.33 ab	46.50 bcd	2.88 bcdef	2.94 ab	0.73 bc	0.80 abcd	3.50 cdef	3.41 def	17.98 bcdef	18.38 ab
	$GA_3$30 ppm	47.33 ab	46.96 bc	2.83 ef	2.96 ab	0.68 fgh	0.74 cdef	3.55 bcd	3.38 defg	17.71 ef	18.48 ab
	GA_3 60 ppm	46.33 abcd	46.45 bcd	2.89 def	2.93 ab	0.68 fgh	0.73 defg	3.58 abc	3.30 efg	18.06abcdef	18.31 ab
	6BA 20 ppm	47.33 ab	45.51 cdef	2.85 cdef	2.85 bcd	0.74 ab	0.74 defg	3.59 abc	3.23 efg	17.83 cdef	17.83 bcd
	6BA 30 ppm	46.33 abcd	47.01 b	2.91abcde	2.91 abc	0.77 a	0.82 ab	3.64 ab	3.43 de	18.20 abcde	18.19 abc
	Seaweed 1g/L	47.00 abc	47.06 b	2.97 ab	3.03 a	0.74 ab	0.81 abc	3.59 abc	3.11 fg	18.56 ab	18.93 a
	Seaweed 2g/L	48.00 a	48.68 a	2.95 abc	2.96 ab	0.78 a	0.87 a	3.66 a	3.43 de	18.43 ab	18.53 ab

* values having the same alphabetical letter (s) in common, do not significant different, using the revised L.S.D. test at 0.05 level of probability.

At the positive combined treatment (Balady cultivar and gibberellic acid at 60 ppm), the estimated percentages increase in number of early head/plant and number of early head /feddan were 70.55 and 64.78 %, respectively as an average of the two seasons, compared to the control treatment. The present results are in agreement with those reported by Calabrese *et al*. (1994), Okasha *et al*. (1997), and Soria *et al*. (2020) who showed significant differences among some tested cultivar and different spraying materials in their number of heads and earliness.

Moreover, the combined treatment of Balady cultivar and N-6-benzyle amino purine at 30 ppm logged the highest mean values of total number of heads/plant and total number of head/feddan in the second season only and weight of edible part/ plant for both seasons. However, the combined treatment of Balady cultivar and seaweed extract at 2 g/ L recorded the highest mean values of total number of head /plant and total number of head /feddan in the first season only, compared to the other treatments. At the combined treatment (Balady cultivar and N-6-benzyle amino purine at 30 ppm), the estimated percentages increase in total edible weight /plant were 62.63 and 61.33 %, in comparison to the control treatment, in both seasons.

Leaf chemical characteristics

Data presented in Tables (6 and 7) indicated that the main effect of artichoke cultivars differed significantly in their leaf chemical characteristics. French cultivar showed higher mean values of nitrogen and protein in the first season. However, Balady cultivar exhibited higher mean values of potassium in both seasons. Meanwhile, the two cultivars are equal in total chlorophyll and phosphorus.

Regarding the main effect of the spraying treatments on leaf chemical characteristics of artichoke plants, the results reported in Tables (6 and 7) confirmed that spraying gibberellic acid, naphthalene acetic acid, N-6-benzyle amino purine and seaweed extract with all concentrations showed significant effects on total chlorophyll, nitrogen, phosphorus, potassium and protein contents, compared to control treatment, in both seasons. It is obvious that the best results were obtained from plants sprayed with seaweed extract at 2 g/l, followed by N-6-benzyle amino purine at 30 ppm and gibberellic acid at 30 ppm, respectively, compared to the other treatments, in both seasons. using seaweed extract at 2 g/l), caused percentages increase in total chlorophyll, nitrogen, phosphorus, potassium and protein contents of (5.77 and %), (14.84 and 21.77 %), (14.06 and 20.00%), (10.70 and 12.27 %) and (14.96 and 21.96 %), for the first and second seasons, respectively, compared to the control treatments.

The interaction effects between artichoke cultivars and the spraying treatments on leaf chemical characteristics of artichoke plants, are presented in (Table 6 & 7). The average values presented significant effects on the tested characteristics, during both seasons. The combined treatment of French cultivar and seaweed extract at 2 g/l, recorded the highest mean values of nitrogen and protein in both seasons, total chlorophyll in the first season and potassium in the second season. However, the combined treatment of Balady cultivar and seaweed extract at 2 g/l, reached the maximum for total chlorophyll and phosphorus in both seasons, potassium in the first season and protein, in the second season.

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الملخص العربى

نمو ومحصول وجودة صنفين من الخرشوف متآثراً بحمض الجبريلك، نفثالين حمض الخليك، البنزيل امينو بيرورين ومستخلص الاعشاب البحرية

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أجريت تجربتان حقليتان خلال موسمي ٢٠١٦–٢٠١٧ و٢٠١٧–٢٠١٨ م. في مزرعة خاصة بمنطقة سيدي غازي مركز كفر الدوار – محافظة البحيرة.

تهدف هذه الدراسة إلى اختبار استخدام الرش بحامض الجبرليك بتركيز (٣٠ و٦٠ جزء في المليون)، نفثالين حامض الخليك بتركيز (٢٥ و٥٠ جزء في المليون)، ٦– ن بنزيل أمينو بيورين بتركيز (٢٠ و٣٠ جزء في المليون) ومستخلص الأعشاب البحرية بتركيز (١و ٢ جرام / لتر).على نمو ومحصول وجودة صنفي الخرشوف (الفرنساوى والبلدي) تحت الظروف المصرية.

أوضحت النتائج من خلال موسمي الزراعة أن الصنف الفرنساوى أعطى اعلى القيم لكلآ من ارتفاع النبات، عدد الأوراق، المساحة الورقية، عدد الفروع، الوزن الطازج والجاف، محتوى الأوراق من النيتروجين والبروتين. بينما الصنف البلدي أعطى آعلى القيم لكلآ من عدد رؤوس الخرشوف المبكرة/ نبات وعدد الرؤوس المبكرة/ فدان، عدد الرؤوس الكلية للنبات والفدان، ووزن الجزء الذي يؤكل من الرآس/ نبات ومحتوى الأوراق من البوتاسيوم.

أفادت الدراسة أيضاً أن رش نبات الخرشوف بالمركبات السابقة وبكل التركيزات أعطت زيادة معنوية لمعظم صفات النمو الخضري والمحصول والمحتوى الكيماوي للأوراق مقارنة بمعاملة الكنترول وان كانت بدرجات مختلفة وفى هذا الصدد تفوق الرش بحامض الجبرليك في النمو الخضري والمحصول المبكر بينما تفوق الرش بمستخلص الأعشاب البحرية و٦–ن بنزيل آدينين في حالة المحصول الكلى والصفات الكيماوية للأوراق.

أشارت الدراسة أن أفضل معاملة تداخلية هي زراعة الصنف البلدي والرش بمستخلص الأعشاب بتركز ٢جرام / لتر أو الرش ن –٦ بنزيل أدينين بتركيز ٣٠ جزء في المليون حيث تعتبر المعاملة المثلى لإنتاج الخرشوف بكمية عالية وبجودة مرتفعة.