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Effect of Seaweed Extract and Gibberellic Acid on Growth and Productivity of Globe Artichoke

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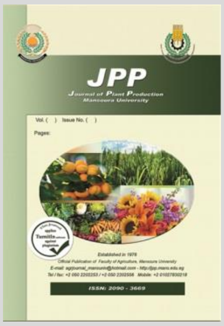

ABSTRACT

This research was conducted in the two successive seasons of 2019-2020 and 2020-2021 in a private farm at Abu Al- Matamir city, Al-Behiera Governorate, Egypt, under open field condition, with surface irrigation system. The aim was to study the influence of seaweed extract levels and gibberellic acid levels as well as their interactions on globe artichoke plants performance, cultivar 'Balady' such as vegetative growth traits, yield and head chemical elements. The experiment was carried out in a split plot system in a Randomized Complete Blocks Design (RCBD) with three replicates. The experiment contained 16 treatments as combinations between seaweed extract with 4 concentrations (0, 1000, 2000 and 3000 mg/l) as main plots, and GA_3 with 4 concentrations (0, 35, 75 and 105 mg/l) as the sub- plots. Explants were soaked in each solution for 10 min. The obtained results indicated that soaking explants in seaweed extract singly or GA_3 singly recorded the highest values of survival rate%, number of leaves/plant and number off-shoots/plant, early and total yield expressed in average weight of fruit g/plant and number of fruit/plant as well as N, P and K of head at 3000 and 105 mg l^{-1}, respectively. Also, the combined treatment between 3000 mg l^{-1} seaweed and 105 mg l^{-1} GA^3 brought about the highest average values of the examined traits and might be regarded as the recommended treatment for growing globe artichoke plants with a high yield and good quality under the similar conditions of the study.

Keywords: Globe artichoke, gibberellic acid, seaweed extract, soaking, yield.

INTRODUCTION

The Asteraceae family's globe artichoke (*Cynara scolymus* L.) is a popular vegetable crop. The globe artichoke is regarded as one of the most important vegetable crops in Mediterranean countries. In Egypt, more emphasis is being placed on promoting globe artichoke production to meet increased demand from local and international markets. Artichoke fields are usually established in Egypt by employing the vegetative parts of plants that have been cut down from older fields, such as offshoots and stump sections. Globe artichoke is mostly grown in the governorates of El-Behira, Alexandria, and Giza, as well as freshly reclaimed ground (Ezzo *et al*., 2019). The total area grown in Egypt with artichoke was 17287 ha, which produced about 323866 tons (FAO, 2018). It is well known that artichoke cultivars require verbalization to transition from the vegetative to the generative stage, which begins quite early in the cooler climates (during the autumn) only in the spring does the stem lengthen (Bucan *et al*., 2000; Mauromicale and Lerna, 2000). Because out-of-season production occurs during the warm part of the year, plants do not always have enough periods of low temperature to induce flowering; therefore, foliar application of gibberellic acid (GA_3) could be an alternative way to solve this problem and extend both the harvest period and the production season.

Plant growth regulator gibberellic acid (GA_3) is widely utilized in agriculture in many countries, including Egypt. Gibberellic acid (GA_3) is one of gibberellins' most active hormones. It's a growth hormone (endogenously and naturally) for growth and development, and it's supplied exogenously as a plant growth regulator to quicken or accelerate flowering (earliness), which leads to head formation in globe artichokes, especially between December and February (Gabr *et al*., 2021). During this time, the local market is in desperate need of a certain type of vegetable at a high price with the potential to be sent abroad. Furthermore, because most European countries do not produce during these months, this period is economically advantageous for export (Abd El Hameid *et al*., 2008). Using of exogenous gibberellic acid (GA_3) is advocated to speed up early head formation and gain more benefits from higher pricing. The use of GA_3 to achieve earliness in globe artichoke heads is a common practice (Abd El-Hameid *et al*., 2008). It influences a variety of plant growth mechanisms, including stem elongation through cell division and elongation, flowering, fruit development, and dormancy breaking (Neil and Reece, 2002). In this approach, GA_3 can act as a substitute for cold in the early stages of the flowering process. Furthermore, the optimum quality is obtained prior to the summer months (Sałata *et al*., 2013).

Seaweed extracts are used to increase nutritional status, vegetative development, yield, and fruit quality in some plants. They contain a wide range of macronutrient and micronutrient nutrients as well as organic components such as growth hormones, amino acids, vitamins, betaines, cytokinins, and sterols (Abd El-Moniem and Abd-Allah, 2008; Khan *et al*., 2009; Spinelli *et al*., 2010 and El-Sherpiny *et al*.,2022). In general, Calvo *et al*. (2014) in agriculture, reported that seaweed extracts can cause changes in physiological/biochemical processes related to nutrient intake and plant growth. Seaweed extracts, for

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example, aided seed germination and establishment as well as root growth and increased leaf chlorophyll (Jannin *et al*., 2013) enhanced crop performance and yield (Zodape *et al*., 2011) and elevated resistance to biotic/abiotic stress. Richardson *et al*. (2009) also noted that a seaweed extract originated from *Ascophyllum nodosum* could replace EDTA to chelate trace elements. Noteworthily, Halpern *et al.* (2015) the benefits of seaweed extracts are mostly linked to their ability to stimulate plant development rather than their ability to provide nutrients. Thus, Calvo *et al*. (2014) observed that Seaweed extracts may serve as a link between crops and fertilizers, balancing agricultural input markets and economic benefit. Seaweed extracts have recently been used as foliar sprays to boost plant growth and productivity. Plants treated with seaweed extracts had physiological responses that were similar to those treated with plant growth regulators. However, data on the effects of these hormones, as well as seaweed extracts, on artichokes is limited (Gabr *et al.*, 2021).

As a result, the purpose of this investigation was to study the influence of soaking Artichoke explant cv. 'Balady' in gibberellic acid and seaweed extract at various concentrations to produce early, high production, and best growth, yield, and head quality under Al-Behiera Governorate conditions.

MATERIALS AND METHODS

This research was conducted in the two successive seasons of 2019-2020 and 2020-2021 in a private Farm at Abu Al- Matamir city, in Al-Behiera Governorate, Egypt, under open field condition, with surface irrigation system, to study the influence of soaking globe artichoke explants 'Balady cv.' in seaweed extract and gibberellic acid concentration singly or mixed in vegetative growth traits, yield and head chemical elements.

During both seasons, before planting soil samples of 30 cm depth were taken and examined for some physical and chemical parameters of the soil at the experimental site. Soil chemical analysis was measured using the methods described by Black (1965) as indicated in Table (1).

Table 1. The physical and chemical properties of the soil (average of two seasons)

Soil properties	Average two seasons
Particle size distribution (%)	
Clay	7.32
Silt	20.16
Sand	72.52
Texture class	Sandy loam
pH (1:2.5 soil suspension)	8.03
EC dS/m (soil paste)	1.74
Soluble cations	
Ca^{++}	1.75
Mg^{++}	2.06
K^{+}	1.67
Na^{+}	7.03
Soluble anions	
CO_3^{--}	-
HCO_3^{-}	3.49
Cl^{-}	7.31
SO_4^{--}	1.71
Available N (mg/kg soil)	23.21
Available P (mg/kg soil)	14.84
Available K (mg/kg soil)	78.64

The analyses were carried out at soil, water, plant and fertilizers analyses section, The faculty of Agriculture (Saba Basha), Alexandria University, Egypt.

The experiment was carried out in a split plot system in a Randomized Complete Blocks Design (RCBD) with three replicates. The experiment contained 16 treatments as combinations between seaweed attraction with 4 concentrations (0, 1000, 2000 and 3000 mg/l) as main plots, and GA_3 with 4 concentrations (0, 35, 75 and 105 mg/l) as the sub- plots. Explants were soaked in each solution for 10 min.

The area of the experimental unit is 14 m^2 contain two ridges; each ridge was 7.00 m length and 1.00 m width, spacing between plants within ridges were 75 cm. To protect against side effects, two guard rows were left between each two adjacent major plots and one guard row was left between each two adjacent sub-plots.

Explants were created using the old crowns of earlier globe artichoke plants of the 'Balady' variety. Plant materials (explants) were soaked in each concentration of GA_3 and seaweed extract for 10 min and then air dried, followed that fogging with the fungicide Topsin M-70 before to planting in all experiments. During both seasons of the study, planting took place on August 15th.

Organic chicken manure (20 m^3/fed.) and identical levels of nitrogen, phosphorous, and potassium fertilizers were applied to all experimental units. 300 kg of ammonium sulphate (20.5% N) was equally divided and side dressed after 8, 12, and 16 weeks after planting. Before planting, 250 kg of calcium super phosphate (15.5% P_2O_5) was base dressed, and 100 kg of potassium sulphate was evenly divided and side dressed after 8 and 12 weeks of planting. All other agricultural practices were used as they were essential and as usually advised for globe artichoke commercial production.

- Survival rate (%): after 45 days, the survival rate (live plants) was estimated as a percentage of the total number of live plants divided by the total number of farmed plants at planting.
- Number of leaves plant^{-1}: It was calculated as the average of the five previously tagged plants after 115 days from planting.
- Number of offshoots plant^{-1}: It was collected by digging out the crowns of five randomly selected and tagged plants from the soil at the end of the growth season.

Harvesting started in the first season on 2nd day of December, 2019 and continued at seven days intervals until 1st March, 2020. Meanwhile, in the second season, the harvesting period extended from 29th November, 2020 and continued to 29th April, 2021.

- Early yield g/plant: It was calculated from the number of head/plant and average head weight/plant harvested every seven days during both seasons during the first 12 pickings across 88 days (from December 2nd to February 28th).
- Total yield g/plant: Total yield consisting of the marketable yield from the terminal and lateral buds. A single terminal bud (main capitum) is produced by each plant, however multiple lateral buds may be produced (secondary captia). It was calculated for both seasons and all pickings from the number of head/plant and average head weight/plant.
- Head mineral contents were determined by the modified Micro-kjeldahl apparatus according to Jones *et al.* (1991), spectrophotometrically and Flame photometerically as described by Peters *et al.* (2003), respectively for N, P and K%

The least significant difference (L.S.D) test at 0.05 and Duncan's approach were carried out using CoSTATE Computer Software and the analysis of variance technique.

RESULTS AND DISCUSSION

Vegetative growth parameters:

Vegetative growth parameters expressed in survival rate%, number of leaves/plant and number off-shoots/plant as affected by soaking in seaweed extract and gibberellic acid different concentrations for 10 min and their interaction during the seasons of 2019/2020 and 2020/2021 are presented at Table (2).

It could be observed that plants product from explants of globe artichoke soaked in seaweed extract at (1000, 2000 and 3000 mg l^{-1}) gained a greater survival rate%, number of leaves/plant and number off-shoots/plant compared to the untreated plants. The statical analysis of the obtained data revealed significant differences between treatments at ($p \leq 0.05$). The highest survival rate%, number of leaves/plant and number off-shoots/plant scored with plants soaked at 3000 mg l^{-1}, while the lowest values recorded with the control treatments. The same trend was true during both seasons.

Regarding the effect of gibberellic acid at different concentrations, data in Table (2) revealed that plants soaked of globe artichoke in (35, 70 and 105 mg l^{-1}) increased the mean value of survival rate%, number of leaves/plant and number off-shoots/plant than those obtained for the untreated, the concentration of 35, 70 and 105 mg l^{-1} had no significant effect with number of leaves and number of off-shoots per plant. In addition, the highest values recorded with 105 mg l^{-1} level, while the lowest one recorded with the control treatment.

Table 2. Averages values of some vegetative growth-related characters of globe artichoke plants as affected by soaking in seaweed extract and gibberellic acid for 10 min and their interaction during the seasons of 2019/2020 and 2020/2021.

Treatments		Survival rate (%)		No. leaves/plant		No. off-shoots/plant	
		2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Seaweed main effects (mg l^{-1})							
Control		50.05d	54.27d	15.17c	16.08c	4.67d	5.42d
1000		57.13c	61.71c	16.83bc	18.25b	5.50c	6.33c
2000		62.69b	68.22b	18.17ab	20.08ab	6.25b	7.17b
3000		68.32a	74.22a	19.83a	21.75a	7.08a	8.00a
Gibberellic acid (GA_3) main effects (mg l^{-1})							
Control		48.59d	52.51d	14.83b	15.92b	4.50b	5.25c
35		60.65c	65.82c	17.75a	19.25a	6.08a	6.83b
70		63.27b	68.69b	18.42a	20.17a	6.33a	7.25ab
105		65.67a	71.40a	19.00a	20.83a	6.58a	7.58a
Interaction effects							
Seaweed (mg l^{-1})	GA_3 (mg l^{-1})						
Control	Control	42.51p	46.57p	13.00h	13.33i	3.67h	4.00j
	35	48.69n	51.75n	15.00gh	16.00ghi	4.67fgh	5.33hi
	70	52.67l	57.24l	16.00e-h	17.00f-i	5.00efg	6.00f-i
	105	56.32j	61.53j	16.67d-g	18.00d-h	5.33efg	6.33e-h
1000	Control	46.60o	49.15o	14.67gh	15.33hi	4.33gh	5.00ij
	35	58.55i	63.87i	17.00c-g	18.67c-h	5.67def	6.67d-g
	70	60.68h	65.77h	17.67b-g	19.33c-g	6.00cde	6.67d-g
	105	62.67g	68.06g	18.00b-g	19.67b-g	6.00cde	7.00c-f
2000	Control	50.67m	54.98m	15.33fgh	17.33e-h	4.67fgh	5.67ghi
	35	64.63f	70.62f	18.67a-f	20.33a-f	6.67bcd	7.33cde
	70	66.79e	72.66e	19.00a-e	21.00a-e	6.67bcd	7.67bcd
	105	68.69d	74.63d	19.67a-d	21.67a-d	7.00abc	8.00abc
3000	Control	54.58k	59.36k	16.33d-h	17.67e-h	5.33efg	6.33e-h
	35	70.74c	77.04c	20.33abc	22.00abc	7.33ab	8.00abc
	70	72.94b	79.10b	21.00ab	23.33ab	7.67ab	8.67ab
	105	75.00a	81.37a	21.67a	24.00a	8.00a	9.00a

- Values having the same alphabetical letter (s) in common, within each group column, do not significantly differ, using the L.S.D. test at 0.05 level of probability.

As for the effect of interaction between seaweed extract and gibberellic acid at different concentrations, the same table revealed that both seaweed and gibberellic acid significantly increased the mean value of survival rate%, number of leaves/plant and number off-shoots/plant compared to the control. In this respect, the treatment of 3000 mg l^{-1} seaweed and 105 mg l^{-1} gibberellic acid was the best treatments and recorded the highest value of survival rate%, number of leaves/plant and number off-shoots/plant during both seasons.

The increment in points for vegetative growth parameters investigated due to soaking explants of globe artichoke in different concentrations and found a significant increase in all vegetative growth as mentioned before. The increment may be due to its ability to promote plant growth through the use of molecules including cytokines, auxins, gibberellins, amino acids, and vitamins may account for this improvement in growth characteristics. These substances also alter the activity of several enzymes, leaf growth, and photosynthetic capability (Abdel-Aziz *et al.*, 2011). This observation is in line with the findings of Madian *et al.* (2020) who studied the influence of foliar seaweed extract application and chilling times of crown parts on globe artichoke vegetative growth. The gained results indicated that the greatest vegetative growth characteristics values of globe artichoke, *i.e.* survival rate, plant height, leaf fresh weight, leaf dry weight, and dry matter %, were achieved by foliar application of seaweed extract at 750 mg/l as compared with the control treatment. Additionally, Ghazi (2020) revealed that sprayed hot pepper plant with seaweed extract at 0.5 g l^{-1} increased growth parameters *i.e.* plant height (cm), No. of leaves $plant^{-1}$, leaf area (cm^2 $plant^{-1}$), fresh and dry weights (g $plant^{-1}$).

One of the most significant gibberellins (GAs), which are a class of endogenous or exogenous plant hormones or plant growth regulators, is gibberellic acid (George *et al.*, 2008). The stimulating significantly diligence effect of gibberellic acid on vegetative growth parameters under investigated may be connected to how it affects cell growth and division. Positive effects of GA_3 have previously been noted by Gabr *et al*. (2021) revealed that foliar application with gibberellic acid at 60 ppm on globe artichoke French cultivar showed higher mean values of plant height, leaf area, number of leaves, number of branches, fresh and dry weight. Additionally, GA_3's method of action (positive effects) may be explained by an increase in auxin biosynthesis as reported by Sastry and Muir (1965), or IAA- oxidase activity is decreased to delay the breakdown of auxin as mentioned by Kogl and Elema (1960). Its foliar-applied plants led to an increase in the number and size of leaves because of a greater concentration (105 mg l^{-1}), and it may have also enhanced photosynthetic translocation, which in turn encouraged overall vegetative growth characteristics. Additionally, the interaction between the fresh and dry weights is likely to grow as a result of GA_3's effect on plant height. In this approach, the GA3 foliar spray improved growth stimulation of the shoots while indirectly reducing the plants' need for absorbed carbs due to its mechanism of action. As a result, the plants' fresh and subsequently dry weights are increased as available carbohydrates are digested and allocated to the development of vegetative features as reported by (Soliman *et al.*, 2019). These results are in accordance with those obtained by Elsharkawy and Ghoneim (2019) who showed that plants sprayed once or twice with GA_3 gave the highest values of vegetative growth (leaf length and width, plant height, and leaf dry matter) comparing to the untreated plants. Also, Ezzo *et al*. (2019) studied the effect of GA_3 on globe artichoke and reported that foliar application at 50 ppm significantly increased vegetative growth characters such as number of leaves per plant, plant height, leaf fresh weight, leaf area, and leaf dry weight as well as chlorophyll content compared with untreated control at 70 and 110 days after transplanting.

Early and total yield:

Data in Table (3) indicate the effect of soaking globe artichoke explants in seaweed extract and gibberellic acid at different concentrations as well as their interactions on early and total yield expressed in average weight of head g/plant and number of heads/plant comparing with the control treatment.

Statistical analysis of the data presented in Table (3) indicated that treatments of seaweed extract under study affected on the average head weight g/plant and number of head /plant for early and total yield. It is evident that the highest values of early and total yield are associated with explants soaked in 3000 mg l^{-1}. The increase in concentrations of seaweed extracts significantly increased the early and total yield expressed at average weight of head/plant and number of heads/plant during both seasons.

Concerning the effect of gibberellic acid at different concentrations, data in the same table illustrated that, soaking the explants of globe artichoke in gibberellic acid before planting significantly increased the mean values of average head weight and head number for early and total yield than those obtained for the untreated plants except number of head/plant for both early and total in the second season. Using 3000 mg l^{-1} was superior for increasing the aforementioned traits in two seasons.

It is clear from the data presented in Table (3) that interaction effect between seaweed extract and gibberellic acid significantly increased early and total yield than those obtained for the untreated plants. The highest mean values were obtained with the treatment of 3000 mg l^{-1} seaweed extract and 105 mg l^{-1} gibberellic acid. The same trend was realized for early and total yield of globe artichoke in the second seasons expressed in average weight of head g/plant and number of head /plant.

The increase in early and total yield due to soaking plantlets in seaweed extract for 10 min before planting at different concentrations agree, with Saif-Eldeen *et al*. (2014) found that rising seaweed extract levels were associated with a significant yield distribution (early, medium, and late yields) comparing to the control. Abd El-Hady *et al*. (2016) showed that soaking potato tubers in seaweed extracts at 3 ml L^{-1} pre planting plus spraying after emergence enhanced potato yield Also, Madian *et al*. (2020) reported that foliar application of seaweed extract at 750 mg/l on globe artichoke; recorded the maximum yield (early yield/plant, and total yield/plant), as compared with the control treatment. Additionally, Gabr *et al*. (2021) indicated an increase in average values of number of early heads/plant, number of early heads/feddan and total number of heads/plant, of artichoke plants as well as number and weight of total heads as a result to foliar application with 2 g/l seaweed extract. Such outcomes may be attributable to the function of seaweed extract, which served a variety of regulatory and defense functions by invoking and signaling a variety of physiological and metabolic processes.

During the study found that soaking explants in gibberellic acid improved early and total yield expressed in (number of head and average head weight) especially at 105 mg l^{-1}. This finding is in agreement with Ezzo *et al*. (2019) resulted that foliar application with 50 ppm of GA_3 significantly increased in early and total yield of two cultivars of globe artichoke (Imperial Star and Romanesco) comparing to the untreated plants. Moreover, Soliman *et al.* (2019) resulted that comparing to the control, globe artichoke recorded the highest early yield, total yield/plant (kg), total yield/feddan (ton), average head fresh weight (g) when plants sprayed with the highest concentration of GA_3 (75 mg/l). Also, Gabr *et al*. (2021) observed that foliar application with 60 ppm GA_3 on globe artichoke Balady cultivar showed high values of number of early head for (plant & feddan) and total head for (plant and feddan). Increased GA_3 concentrations, particularly at 105 mg l^{-1}, could be the cause of an increase in the number of globe artichoke heads per plant by promoting the creation of floral primordia (George *et al.* 2008). Gibberellic acid is known to have a significant role in this regard. It is well recognized that the number of heads per plant is an important factor, and that this attribute is strongly correlated with the number of heads per feddan, number of early yields per plant (kg), and number of heads per feddan (kg). The early harvest of globe artichoke plants may have been made possible by GA_3 treatments, which, as previously reported, increase the number of leaves and encourage vegetative growth. As a result, the synthesized assimilates are transferred to other plant parts and may have facilitated early flowering (produced heads). Notably, the majority of globe artichoke growers frequently use GA_3 as a vernalizing agent on the leaves to hasten the start of the heads (early yield) and increase financial returns for higher pricing. From December through February, Egypt's market prices are at their highest. However, this additional treatment (250 hours at a temperature of 7°C) is necessary for earlier planting of globe artichoke flowers. Therefore, globe artichoke growers turn to use GA_3 to overcame the higher temperature during the early time-course of plantation.

Table 3. Averages values of early and total yield characters of globe artichoke plants as affected by soaking in seaweed and gibberellic acid for 10 min and their interaction during the seasons of 2019/2020and 2020/2021.

Treatments		Early yield/plant (g/plant)				Total yield/plant (g/plant)			
		Average weight of head g/plant		Number of heads/plant		Average weight of head g/plant		Number of heads/plant	
		2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Seaweed main effects (mg l^{-1})									
Control		158.49d	178.51d	4.83d	6.08c	328.65d	390.44d	8.83d	11.75c
1000		173.72c	190.32c	5.67c	7.25bc	371.59c	419.96c	10.25c	12.92bc
2000		185.80b	198.90b	6.58b	8.25ab	405.09b	434.98b	11.33b	13.83ab
3000		197.51a	207.85a	7.58a	9.00a	430.90a	457.38a	12.83a	15.00a
Gibberellic acid (GA_3) main effects (mg l^{-1})									
Control		155.35d	176.63d	4.67c	5.75b	319.24d	384.37d	8.58c	11.42b
35		181.34c	195.66c	6.33b	7.83a	390.27c	430.21c	11.08b	13.58a
70		186.79b	199.54b	6.58ab	8.33a	405.83b	439.12b	11.67ab	14.08a
105		192.03a	203.74a	7.08a	8.67a	420.88a	449.07a	11.92a	14.42a
Interaction effects									
Seaweed (mg l^{-1})	GA_3 (mg l^{-1})								
Control	Control	141.58p	166.72k	4.00j	4.67g	280.35o	361.36l	7.33k	10.00f
	35	155.80n	176.08j	4.67hij	5.67efg	321.05m	383.72k	8.67ij	11.67def
	70	164.28l	182.36i	5.00g-j	6.67d-g	345.10k	397.91j	9.33g-j	12.33c-f
	105	172.30j	188.87h	5.67e-h	7.33b-f	368.10k	418.78h	10.00fgh	13.00b-f
1000	Control	151.51o	173.27j	4.33ij	5.33fg	308.64n	377.36k	8.33jk	11.00ef
	35	176.68i	193.01g	6.00d-g	7.67a-f	380.45h	426.73g	10.33efg	13.33a-e
	70	181.25h	196.21fg	6.00d-g	8.00a-e	391.99g	435.66f	11.00def	13.67a-e
	105	185.43g	198.77ef	6.33def	8.00a-e	405.26f	440.07ef	11.33cde	13.67a-e
2000	Control	160.11m	179.91i	5.00g-j	6.00efg	332.11l	391.32j	9.00hij	12.00c-f
	35	189.89f	201.79de	6.67cde	8.67a-d	416.54e	443.87de	12.00cd	14.00a-e
	70	194.30e	204.87d	7.00bcd	9.00a-d	429.84d	449.90cd	12.33bc	14.67a-d
	105	198.87c	209.03c	7.67abc	9.33abc	441.87c	454.85c	12.00cd	14.67a-d
3000	Control	168.19k	186.62h	5.33f-i	7.00c-g	355.85j	407.43i	9.67ghi	12.67b-f
	35	202.99c	211.74bc	8.00ab	9.33abc	443.06c	466.53b	13.33ab	15.33abc
	70	207.34b	214.72b	8.33a	9.67ab	456.40b	473.00b	14.00a	15.67ab
	105	211.52a	218.30a	8.67a	10.00a	468.27a	482.57a	14.33a	16.33a

- Values having the same alphabetical letter (s) in common, within each group column, do not significantly differ, using the L.S.D. test at 0.05 level of probability.

Nutrition values of heads:

The comparison between the means of the various combined treatments of seaweed extract, gibberellic acid and their interaction as shown in Table (4) has been reflected a significant difference between the average values of N, P and K concentration in the head of globe artichoke during both seasons.

The effect of seaweed extract treatment (1000, 2000 and 3000 mg L^{-1}) on head of artichoke N, P and K % content are shows in Table (4) explants soaked in different concentration of seaweed extract significantly affected in mentioned parameters of globe artichoke head. Comparing to the untreated plant which recorded the lowest mean values (2.07-2.36%) for N, (0.314-0.342%) for P and (1.50-1.66%) for K, the highest mean values realized with the highest concentration of seaweed extract 3000 mg l^{-1} (2.99-3.09%) for N, (0.402-0.416 %) for P and (2.31-2.54%) for K respectively in the two seasons.

Regarding the effect of gibberellic acid at different concentration 35, 75 and 105 mg L^{-1}, data at the same table found a significant increase in N, P and K% with increasing gibberellic acid concentration from 35 to 105 mg l^{-1}. The highest significant increase was realized in plants treated with 105 mg l^{-1} during both seasons.

It is clear from the data in Table (4), the effect of interaction between treatments under investigation on N, P and K% of globe artichoke head. From the data found a significant differences effect between different concentrations of seaweed extract and gibberellic acid on head N, P and K % content. In this regard, found the highest mean values of N, P and K % content was realized with 3000 mg l^{-1} seaweed extract combined with 105 mg l^{-1} gibberellic acid for both seasons.

As for the effect of seaweed extract on nutrient status content. This result was similarly with the results were obtained by Saif Eldeen *et al.* (2014) in globe artichoke stated that the contents of dry receptacle N, P, K% all responded positively and considerably to seaweed extract application. Shehata *et al.* (2019) resulted an increase in chemical analyses of cucumber plants (N, P and K %) with foliar application of 1000 mg/l seaweed extract. Madian *et al.* (2020) observed that seaweed extract up to 750 mg/l on globe artichoke; gave the highest average values of all chemical compositions such as N, P, K, Fe, Zn, Mn and Cu in head as compared with control treatment. Besides, Ghazi, (2020) indicated an increase with foliar application by seaweed extract at 0.5 gl^{-1} increased fruit chemical parameters i.e. N, P, K (%) of hot pepper plants.

The beneficial effect of gibberellic acid on nutrient status of head as may be due to the given that phytochrome influences chlorophyll, it is possible that this impact resulted through an interaction between GA_3 and phytochrome (Mathis *et al.* 1989). Along with some other nutrients (such as Mg) that could indirectly improve the function of the supplied molecule, this discovery could also be explained by the role of GA_3, which increases N content in leaves and contributes to the production of chlorophyll molecules. Additionally, GA_3 may prevent senescence (delay ageing) by delaying the loss of protein, RNA, and chlorophyll as a result of the gradual destruction of these substances and increasing composition (Alwan, 2014). In this respect, Ezzo *et al*. (2019) observed an increase in contents of N, P, K, Ca, Fe and Zn of globe artichoke as a result to foliar application with GA_3 at the rate of 50 ppm comparing to the control plant. Similar results were recorded by Soliman *et al.* (2019) found that the highest values of head nutrient contents of globe artichoke plants cv. 'Balady' found an increase with increasing GA_3 concentration up to 75 mg/l which increased the values of N, P and K. Additionally, Gabr *et al*. (2021) revealed that foliar application with gibberellic acid at 60 ppm on globe artichoke French cultivar leaf showed higher mean of N, P, K%.

Table 4. Averages values of head nutrient content of globe artichoke plants as affected soaking in seaweed and gibberellic acid for 10 min and their interaction during the seasons of 2019/2020and 2020/2021.

Treatments		Nutrient contents of heads (% d.w.)					
		N%		P%		K%	
		2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
Seaweed main effects (mg l^{-1})							
Control		2.07d	2.36d	0.314d	0.342d	1.50d	1.66d
1000		2.43c	2.65c	0.350c	0.371c	1.81c	1.99c
2000		2.73b	2.88b	0.375b	0.393b	2.06b	2.27b
3000		2.99a	3.09a	0.402a	0.416a	2.31a	2.54a
Gibberellic acid (GA_3) main effects (mg l^{-1})							
Control		1.99d	2.30d	0.308d	0.334d	1.42d	1.59d
35		2.62c	2.79c	0.366c	0.386c	1.98c	2.17c
70		2.74b	2.89b	0.378b	0.396b	2.08b	2.29b
105		2.87a	3.01a	0.390a	0.405a	2.20a	2.42a
Interaction effects							
Seaweed (mg L^{-1})	GA_3 (mg L^{-1})						
Control	Control	1.70p	2.05p	0.279i	0.307p	1.14n	1.30p
	35	1.99n	2.31n	0.307hi	0.336n	1.41l	1.60n
	70	2.18l	2.46l	0.324f-i	0.354l	1.61j	1.78l
	105	2.39j	2.63j	0.347d-h	0.369j	1.81h	1.97j
1000	Control	1.89o	2.23o	0.299hi	0.325o	1.32m	1.48o
	35	2.50i	2.71i	0.355c-h	0.379i	1.91g	2.05i
	70	2.61h	2.78h	0.369b-g	0.387h	1.96g	2.16h
	105	2.72g	2.90g	0.375b-f	0.393g	2.06f	2.26g
2000	Control	2.08m	2.38m	0.316ghi	0.344m	1.51k	1.70m
	35	2.83f	2.96f	0.38a-e5	0.401f	2.17e	2.36f
	70	2.95e	3.04e	0.394a-d	0.410e	2.23e	2.46e
	105	3.05d	3.14d	0.406abc	0.416d	2.34d	2.57d
3000	Control	2.28k	2.55k	0.337e-h	0.361k	1.71i	1.87k
	35	3.14c	3.19c	0.415ab	0.426c	2.44c	2.68c
	70	3.22b	3.26b	0.424ab	0.434b	2.51b	2.76b
	105	3.32a	3.37a	0.431a	0.444a	2.60a	2.87a

- Values having the same alphabetical letter (s) in common, within each group column, do not significantly differ, using the L.S.D. test at 0.05 level of probability.

CONCLUSION

In general, the results would contribute to knowledge on the ability of soaking globe artichoke explants for 10 min before planting in seaweed extract and gibberellic acid to stimulate flowering and increase earliness in globe artichoke. Finally, to obtained the best growth and high yield with good quality without any risk of globe artichoke crop, explants should soaking for 10 min in 3000 mg l^{-1} seaweed extract mixed with 105 mg l^{-1} gibberellic acid

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تأثير مستخلص الطحالب وحامض الجبريلليك على نمو وإنتاجية الخرشوف البلدي

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الملخص

أجريت تجربتان حقليتان خلال الموسمين ٢٠١٩-٢٠٢٠ و ٢٠٢٠-٢٠٢١ في مزرعة خاصة تقع في منطقة أبو المطامير- محافظة البحيرة – مصر، تحت ظروف الحقل المفتوح و الري السطحي. الهدف الرئيسي هو دراسة مستخلص الطحالب البحرية وتأثير حمض الجبريلليك بالإضافة للتفاعل المشترك بينهم على النمو الخضري و المحصول المبكر و الكلى و محتوى للثمار من النيتروجين والفوسفور والبوتاسيوم لنبات الخرشوف صنف "بلدى". صممت التجربة في عاملين متغيرين مستقلين في تصميم القطاعات العشوائية الكاملة بنظام القطع المنشقة لمرة واحدة بثلاث مكررات. تحتوي التجربة على ١٦ معاملة كانت نتيجة التفاعل بين ٤ معاملات من مستخلص الطحالب البحرية بمعدل (٠، ١٠٠٠، ٢٠٠٠، ٣٠٠٠ مجم/لتر) وزعت في القطع الرئيسية، و ٤ تركيزات من حمض الجبريلليك (٠، ٣٥، ٧٥ و ١٠٥ ملجم/لتر) وزعت في القطع المنشقة من خلال نقع قطع تقاوى الخرشوف في التركيزات المختلفة لمدة عشر دقائق قبل الزراعة. أظهرت النتائج أن النقع بصوره فرديه في كل من مستخلص الطحالب البحرية و حمض الجبريلليك أدى إلى زياده في كل من معدل نجاح القطع النباتية، عدد الاوراق / نبات، عدد الخلفات / نبات، المحصول (مبكر و كلى متمثل في عدد الرؤوس و متوسط وزن الرأس لكل منهما) و محتوى الثمار من النيتروجين و الفوسفور و البوتاسيوم بمعدل ٣٠٠٠ و ١٠٥ ملجم/لتر لكل منهم منهما على التوالي. أما بالنسبة للتفاعل المشترك بينهم وجد ان النقع في كل من٣٠٠٠ ملجم/لتر مستخلص طحالب بحريه مخلوطة مع ١٠٥ ملجم/لتر حمض جبريلليك سجل أعلى القيم للصفات المدروسة و بالتالي يمكن اعتبارها المعاملة المثلى للحصول على أعلى عائد و أفضل جوده من ثمار الخرشوف تحت ظروف محافظة البحيرة والظروف المشابهة لها.