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Using some antioxidants and natural extracts as a substitutes or supplement for gibberellin for earliness induction in Globe artichoke

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Abstract

Two field experiments were carried out during two successive winter seasons of (2018/2019-2019/2020). The purpose of these experiments was to investigate the response of Globe artichoke (French cultivar) plants to foliar spray with each of GA_3, chitosan, garlic extract, moringa leaf extract or salicylic acid or the combination of each material with GA_3. Plant parameters of vegetative growth, earliness, yield quantity and quality as well as some chemical composition were recorded. The results indicated that spraying plants with moringa leaf extract increased vegetative growth *i.e.,* plant height, number of shoots, leaf length and leaf width compared to control plants and other treatments in both the seasons. GA_3 + moringa leaf extract ranked second. The same results were obtained with yield parameters (early, middle, late and total) by moringa leaf extract. The lowest values were obtained from control plants treatments for all studied characters. The results indicated that there were significant effects of the interaction treatments *i.e.,* GA_3 + chitosan, GA_3 + garlic extract, GA_3 + moringa leaf extract or GA_3 + salicylic acid where the highest values were obtained from GA_3 + moringa leaf extract treatment compared with all other interaction treatments. It can be concluded that a foliar spray application of moringa leaf extract or the combination of GA_3 + moringa leaf extract is more suitable strategy for artichoke yield improvement under similar environmental conditions.

Key words: Artichoke, GA_3, chitosan, garlic extract, moringa leaf extract, salicylic acid

Introduction

The artichoke (*Cynara scolymus*) is a herbaceous perennial rosette plant grown throughout the world for its large, fleshy heads. Artichoke is widely used in human diet characterized by low protein and fat, high content of minerals, fibers, vitamins, inulin, carbohydrates and polyphenolic compounds (Awad, 2017). Egypt is ranked the second world producer of Globe artichoke with the highest productivity per unit area in the world. The total area grown with artichoke in Egypt was 41022 fed., which produced about 339197 tons with an average yield of 8.269 ton/fed (Department of agricultural Economic statistics, Ministry of Agriculture, Egypt, Anonymous, 2017).

Since ancient times, GA_3, antioxidant and natural extracts are used in many ways for improved production. At present, public health and environmental safety concerns encouraged the use of these natural products for improving growth, production, nutritional status and for management of insect pests. The higher content of certain metabolites and phenolic compounds seem to have synergistic effects on growth, yield and mortality of most fungus (Abd El–Hamied and El-Amary, 2015). Schrader (1994) used plant growth regulator GA_3 and cytokinin as a foliar application and results showed that using of GA_3 (400 ppm) increased the yield of artichoke plants. Hosseinzadeh *et al.* (2013) found that morphological, yield and quality of foliage of artichoke areimproved with salicylic acid foliar spray, the results revealed that that the number of leaves increased 18-26 % as compared to control.

Gibberellic acid (GA_3) is known as plant growth regulator (endogenously occurs as natural hormone) for growth and development and applied exogenously as plant growth regulator to hasten or accelerate flowering process and subsequently head production in Globe artichoke especially during the period from November to February which has a major importance for promoting the local market (with highest market prices) and export (Abd El-Hameid *et al.,* 2008).

Gehan and Ghoneim (2019) used different levels of GA_3 and chitosan, The results showed that plants sprayed once or twice with GA_3 gave the highest value of vegetative growth, early yield and edible part fresh weight. However, spraying artichoke plants three times with GA_3 resulted in the highest number of heads/plant, total yield, average head weight, head diameter and edible part diameter. Moreover, spraying chitosan at 300 ppm significantly increased plant growth characters, head yield and its components. In addition, the interaction treatments between spraying artichoke plants two times with GA_3 and chitosan at 150 ppm gave the highest values for early yield. However, total yield favored spraying plants three times with GA_3 and 300 ppm of chitosan.

Garlic extract effect on plant characters has been discussed by Sayeeda and Ahmad (2005) and El-Shayeb (2009). Their results showed that garlic extract had comparatively greater efficacy on promoting growth and nutrition status of groundnut and in many other crops. Abbas *et al.* (2007) demonstrated that the garlic extract improved the growth, sex expression and fruit yield and quality of cucumber. These extracts contain many growth promoting compounds and essential for vegetative and reproductive growth.

Research on the Globe artichoke indicated that garlic and moringa leaf extract (3 mL/L) significantly increased vegetative growth characteristics (plant height, leaf area, dry weight of leaves and number of shoots/plant) and yield distribution (early, middle, late yield and total yield/fed.) compared with control (Saif Eldeen, 2015). The spray also improved most head quality characteristics (head weight, length, and diameter, receptacle fresh and dry matter).

Fresh *Moringa oleifera* leaves have high zeatin which plays an important role in cell elongation and cell division that resulted promotion of the plant growth; hence, it is used as a natural plant growth enhancer also, has anti-aging potential and protective effects in plants. In addition, it contains proteins, vitamins, β carotene, amino acids, phenolic compounds, sugars, minerals and several flavonoid pigments (Jacob and Shenbagaraman, 2011).

Chitosan is a natural biodegradable compound derived from crustaceous shells such as crabs and shrimps, and its main attribute corresponds its polycationic nature (Bautista-Baños *et al.,* 2006). It has received much attention as a functional biopolymer with applications in agriculture, pharmaceuticals, food, cosmetics and medicines. Agricultural applications of chitosan can reduce environmental stress due to drought and soil deficiencies, increase yields, improve quality, and improve storability of postharvest fruits and vegetables (Linden and Stoner, 2007). Also, chitosan increases photosynthesis, promotes and enhances plant growth, stimulates nutrient uptake, increases germination (Kim *et al.,* 2005). Many investigators reported that chitosan, as foliar spray, increased vegetative growth, yield and quality of some vegetable crops (Abdel-Mawgoud *et al.,* 2010; Kamal and Ghanem, 2011; Fawzy *et al.,* 2012).

Therefore, this investigation aimed to study the effect of GA_3, salycilic acid, chitosan, garlic extract, moringa leaf extract, and their interaction with GA_3 as a foliar application on growth, yield and yield component, chemical composition and quality under Beni-suief governorate conditions.

Material and methods

Two field experiments were carried out at the Research Farm, Sids Horticulture Research Station for Agriculture Research Center, Beni-Suief Governorate, Egypt. The experiments were done during the two winter seasons of 2018/2019 and 2019/ 2020 in a clay loam soil.

Table 1 shows some physical and chemical properties of the experimental soil before planting, according to the methods described by Black (1982).

Experimental design was randomized complete block with three replicates. The planting dates were 17 and 21 of August in the 1st and 2nd seasons, respectively. Prior to planting, the old grown pieces (stumps) were treated with fungicides for 30 minutes. Planting was done by hand at 1 m apart between each two plants on one side of the row and each row was 1 m in length. Plot area was 12 m^2 (4 lines × 3 m long × 1 m width). Other cultural practices and pest control measures were applied as commonly recommended for commercial Globe artichoke production by Ministry of Agriculture.

The experiment included ten treatments as follows:
1-Control (distilled water), 2- GA_3 50 ppm, 3- Chitosan 100 ppm, 4- Garlic extract 10 %, 5- Moringa leaf extracts 10 %, 6- salicylic acid 100 ppm, 7- GA_3 50 ppm + chitosan 100ppm, 8- GA_3 50 ppm+ galic extract 10 %, 9- GA_3 50 ppm + moringa leaf extract 10 %, 10-GA_3 50 ppm + salicylic acid 100 ppm

Garlic extract: Garlic extract was prepared according to EL-Desouky *et al.* (1998) where the fresh mature garlic cloves were blended in distilled water (l00 g cloves/ L). Frozen and thawed two times then filtered. The final extract was collected separately in other dark glass bottles then stored in a refrigerator at 5 °C until needed. Main contents of garlic extract analyzed by Arid Land Agricultural Research Unit, Faculty of Agriculture, Ain Shams University is given in Table 2.

Table 2. Some chemical constituents of garlic cloves

Components	Concentration
GA_3	1.63 mg/100 g F.W.
IAA	Trace amount
ABA	Trace amount
Ca	1.36 %
Mg	1.23 %
SO_4	0.18 %
Zn	66.5 ppm
Mn	94.4 ppm

Moringa leaf extract: According to Culver *et al.* (2012), moringa leaf extract was prepared as follows: An amount of 20 g of young moringa leaves (shoots were harvested at 35 days after emergence) was mixed with 675 mL of 80 % ethanol. The suspension was stirred using a homogenizer to help maximize the amount of the extract. The solution was then filtered by wringing the solution using a mutton cloth. The solution was re-filtered using No. 2 Whatman filter paper. The extract was diluted with distilled water at a ratio 1:32 (v/v) and then sprayed directly on the plants. The extract was used within five hours from cutting and extracting (if not ready to be used, the extract or the solution prepared was stored at 0 °C and only taken out when needed for use).

Chitosan (2-amino-2-deoxy-beta-D-glucosasmine) solution was prepared by dissolving a proper amount of Chito–Care®, (an Egyptian commercial product of chitosan), in 1 % acetic acid solution.

Treatments with the mentioned substances were done by spraying three times; the first one was carried out after 70 days from planting (when the plants had approximately 13 leaves). The second application was 20 days after the first one (plants had approximately 18 leaves). The third application was 20 days

Table 1. Physical and chemical properties of the experimental soil

Mechanical analysis				Chemical analysis			Available nutrients					
Sand %	Silt (%)	Clay (%)	Texture	O.M	pH	E.C mmhos/cm	N (%)	P (ppm)	K (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
20	34	46	Clay loam	1.57	7.90	1.03	0.06	29.21	387.4	33.1	20.1	6.1
22	30	48	Clay loam	1.66	7.70	1.04	0.07	30.25	381.5	30.0	21.2	6.4

after the second spray (plants had approximately 23 leaves). The untreated control plants were sprayed with distilled water.

Plant growth parameters: Random samples of five plants/plot were picked up after 150 days of planting to determine plant height, number of shoots/plant and fresh weight of leaves and dry matter content of leaves (%) which was conducted in an electrical oven at 75 °C till obtaining a constant weight, then determined as (%).

Yield distribution: All flower heads of plants in each plot were harvested and counted during the periods from November-February and March-May, to study yield distribution and to determine early, medium and late yields. Yield was calculated as ton/fed.

Heads quality characteristics: At the peak of harvesting period (March), head quality characters were considered and the following measurements and determinations were undertaken: average head weight, length and diameter /head, receptacle fresh weight and dry weight of receptacle as well as total soluble solids (TSS) in the edible portions, using a hand refractrometer.

Chemical constituents: At 150 days after planting, dry receptacle, was finely ground and wet digested for N, P and K determination. Nitrogen concentration was determined in dry leaves using Kjeldahl method described by Jackson (1967). Phosphorus was estimated colorimetrically using the reduced molybdophosphoric blue color method according to Jackson (1970). Potassium percentage (%) was determined in digested plant material using the flame photometer (Black, 1965)

Statistical analysis: All recorded data were subjected to Analysis of Variance and DMRT (Duncan, 1955) at P=0.05 was used to compare treatment means.

Results and discussion

Vegetative growth characters: The results presented in Table 3 clearly show that, foliar spraying of moringa significantly influenced all growth characters (plant height, number of shoots/plant and dry weight of leaves, leaf length and leaf width) in both the seasons. In general, there were significant differences between the mean values of all treatments. The highest values of plant height were recorded from spraying with moringa extract (121.8 and 125.8 cm) in both the seasons followed by spraying with GA_3 + moringa extract (118.9 and 122.6). The lowest values of plant height occurred with control plants (97 and 100 cm). The highest values of number of shoots, leaf dry weight (%), leaf length and leaf width character were obtained from moringa leaf extract followed by GA_3 + moringa extract, in both the seasons. In the meantime, the lowest values of leaf dry weight (%), leaf length and leaf width were recorded with control plants, in both the seasons. Among the various treatments, the most significant increase on vegetative growth parameters was obtained from moringa extract treatment which may be due to its role as plant growth stimulator. Being a rich source of vitamins, essential macro and micro plant minerals, amino acids, natural antioxidants and plant growth regulators such as gibberellins and zeatin (cytokinins), it can be effectively exploited as plant growth enhancer (Makkar and Becker, 1996; Mahmood *et al.*, 2010). These results are in line to those obtained by earlier workers (Culver *et al.*, 2012; Muhamman *et al.,* 2013; Bashir *et al.*, 2014; Yasmeen *et al.*, 2014 on tomato, and Ndor *et al.*, 2012 on watermelon). Moreover, Hussain *et al.* (2013) reported that moringa extracts enhanced the plant growth and improved resistance against pests and diseases.

Yield distribution: Significant difference was recorded between the treatments and control plants in all the studied yield parameters, in both the seasons (Table 4). Among the various treatments, the highest value of yield was obtained from moringa leaf extract followed by GA_3+ moringa leaf extract, in both the seasons. Control treatment gave the lowest values for yield. The favorable effect of moringa leaf extract on yield might be due to its role as plant growth regulators in improving crop growth and hence yield (Muhamman *et al.,* 2013). It contains endogenous cytokinins (zeatin, dihydrozeatin and isopentyladenine) which affect assimilate mobilization and/or distribution (Emongor, 2015). Zeatin is a plant growth hormone from the cytokinines group, which plays an important role in cell division and cell elongation (Taiz and Zeiger, 2006) and involved in carbohydrate mobilization as well as distribution to the sink where more carbohydrates are needed to cater the needs of rapidly increasing growth (Iqbal, 2014). Also, obtained results are in agreement with those reported by Saif Eldeen (2015).

Head quality characteristics: Data recorded in Table 5 show that, foliar spray with GA_3, chitosan, garlic extract, moringa leaf extract and their interaction with GA_3were responsible for the significant improvement in head quality characteristics, expressed as head weight, length, diameter, and receptacle fresh weight, dry matter and total soluble solids (TSS) compared to the control. The highest head quality characteristics were recorded by foliar

Table 3. Plant height, number of shoots, leaf dry weight, leaf length and leaf width in artichoke plants as affected by foliar spraying with GA_3, chitosan, garlic extract, moringa extract, salicylic acid and their interaction with GA_3treatments during the two seasons

Treatments	Plant height (cm)		Number of shoots/ plant		Leaf dry weight (%)		Leaf length (cm)		Leaf width (cm)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control (distilled water)	97.8G	100.3G	2.1F	2.7G	11.8G	12.3E	67.33DE	101.3AB	32.00 E	37.30D
GA_3 50 ppm	110.8F	112.0F	4.5E	4.0F	14.0F	15.0D	68.34DE	102.0AB	39.00CD	40.00CD
Chitosan 100 ppm	113.5D	115.5DE	4.8DE	4.8CDE	14.5EF	15.5BC	70.08 D	105.0AB	35.67DE	48.67BC
Garlic extract 10 %	115.9C	121.7B	5.5AB	5.0C	16.1BC	18.0A	65.33 E	105.3AB	43.33ABC	45.33BCD
Moringa leaf extract 10 %	121.8A	125.8A	5.8A	5.7A	17.9A	18.2A	91.08 A	109.3A	47.67A	60.33A
Salicylic acid 100 ppm	111.7EF	114.5E	4.7DE	4.6DE	15.0DE	15.1CD	85.00B	94.08B	33.00E	51.33AB
GA_3 + chitosan 100 ppm	112.6DE	115.0E	4.8DE	4.5E	15.5CD	15.4BCD	71.67D	106.0AB	31.67E	47.33BC
GA_3+ garlic extract 10 %	116.7C	118.7C	5.0CD	4.8CDE	15.9C	17.8A	78.67C	95.0AB	33.67E	58.68AB
GA_3 + Moringa leaf extract 10 %	118.9B	122.6B	5.3BC	5.3B	16.8B	18.0A	88.67AB	111.3A	44.60AB	51.54AB
GA_3 + salicylic acid	111.5EF	116.7D	5.0CD	4.9CD	16.2BC	15.6B	84.67B	101.7AB	41.00BC	48.33BC

In each column mean of each treatment followed by the same letter(s) are not significant at P=0.05 by Duncan's Multiple Range Test (DMRT)

Table 4. Early, middle, late and total yields in artichoke plants as affected by foliar spraying with GA_3, chitosan, garlic extract, moringa extract, salicylic acid and their interactions with GA_3 treatments during the two seasons

Treatments	Early yield (ton/fed.)		Middle yield (ton/fed.)		Late yield (ton/fed.)		Total yield (ton/fed.)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control (tap water)	0.250G	0.311F	1.850G	2.100 g	3.150AE	3.400E	5.350H	5.811F
GA_3 50 ppm	0.550E	0.565E	2.800F	3.200E	4.500D	4.700D	7.850G	8.461E
Chitosan100 ppm	0.580C	0.600C	3.100D	3.450CD	4.650C	4.880BCD	8.330D	8.930C
Garlic extract 10 %	0.620B	0.655B	3.400B	3.520B	4.880B	5.000B	8.900B	9.175B
Moringia leaf extract 10 %	0.722A	0.758A	3.750A	4.000A	5.140A	5.500A	9.612A	10.258A
Salicylic acid 100 ppm	0.565D	0.570DE	3.000E	3.100F	4.610C	4.750CD	8.175F	8.420E
GA_3 + Chitosan100ppm	0.540F	0.595C	3.050DE	3.400D	4.600C	4.860BCD	8.190EF	8.855C
GA_3+ garlic extract 10 %	0.570D	0.752A	3.350B	3.500BC	4.850B	4.950BC	8.770C	9.092B
GA_3 + moringia leaf extract 10 %	0.715A	0.752A	3.700A	3.950A	5.100A	5.480A	9.515A	10.182A
GA_3 + salicylic acid	0.570D	0.575D	3.200C	3.250E	4.650C	4.800BCD	8.307DE	8.625D

In each column mean of each treatment followed by the same letter(s) are not significant at *P*=0.05 by Duncan's Multiple Range Test (DMRT)

spray with moringa leaf extract followed by GA_3+moringa leaf extract, in both the seasons.

There were significant differences between all treatments and control plants on head length and receptacle fresh weight, head diameter, and receptacle dry matter, and TSS. The highest values were obtained from moringa leaf extract on all quality characters.The obtained results are similar as reported by Saif Eldeen (2015) in artichoke, EL-Sayed *et al.* (2014) in sugar pea and Azra (2011) on wheat, peas and tomato. They found that spraying with moringa extract had increased productivity and crop quality characteristics.

Chemical composition: Foliar spray treatments showed a significant effect on nitrogen, phosphorus and potassium percentages in artichoke dry leaves in both the seasons (Table 6). Among the various treatments, the most significant increase in percentages of N, P, and K were produced from foliar spraying with moringa leaf extract in both seasons.. While, control treatment gave the lowest values. The increased percentages of nitrogen, phosphorus and potassium in artichoke leaves may be caused by enhanced ion uptake (Marschner, 2013). Moringa leaf extract foliar application was more effective as natural bio stimulant to improve fruit quality of tomato. It increased lycopene, total soluble solids, total sugar and vitamin C content in fruits (Yasmeen *et al.*, 2014; Saif Eldeen, 2015). .

It can be concluded that foliar spray with moringa leaf extract (10 %) three times after 70, 90 and 110 days from planting could be recommended for higher growth and yield (both early and total) with higher quality of artichoke plants under similar environmental conditions.

Table 5. Head weight, head length, head diameter, receptacle fresh weight, receptacle dry matter and receptacle T.SS in artichoke plants as affected by foliar spraying with GA_3, chitosan, garlic extract, moringa extract, salicylic acid and their interactions with GA_3treatments during the two seasons

Treatments	Head weight (g)		Head length (cm)		Head diameter (cm)		Receptacle fresh weight (g)		Receptacle dry matter (%)		Receptacle TSS (%)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control (distilled water)	142.0F	150.0G	6.8G	7.3G	5.6E	6.0G	47.3F	52.3E	13.8F	14.0F	8.5G	8.8F
GA_3 50 ppm	230.0E	240.0D	9.2F	9.8F	7.7D	7.8F	59.3E	67.0D	16.5E	17.5E	9.4F	9.0F
Chitosan 100 ppm	245.0C	252.0CD	9.7E	10.2E	8.1BC	8.2DE	71.0B	75.5BC	18.2D	19.2D	9.8E	10.0C
Garlic extract 10 %	251.0B	260.0B	11.2BC	11.5B	8.4A	8.6BC	90.9A	96.7A	20.7B	22.0BC	10.4C	10.7B
Moringa leaf extract 10 %	285.0A	281.0A	11.6A	11.8A	8.5A	9.0A	92.5A	98.7A	22.8A	23.2A	11.7A	12.0A
Salicylic acid 100 ppm	233.0DE	247.0E	9.5EF	9.9F	7.9CD	8.0EF	63.0D	70.9CD	19.5C	18.6D	9.5F	9.4E
GA_3 + chitosan 100 ppm	236.0D	250.0DE	9.5EF	10.8C	8.0C	8.1DEF	68.5C	73.7BC	18.1D	19.0D	9.7E	9.7D
GA_3+ garlic extract 10 %	246.0C	255.0C	11.0C	11.3B	8.3AB	8.4BCD	90.5A	95.5A	20.5B	21.2C	10.1D	10.5B
GA_3 + Moringa leaf extract 10 %	281.0A	279.0A	11.5AB	11.4B	8.4A	8.7AB	91.7A	96.3A	19.7C	22.8AB	11.5B	11.8A
GA_3 + salicylic acid	237.0D	255.0C	10.5D	10.5D	8.0C	8.3 CDE	66.5C	77.5B	17.9D	18.9D	9.5F	9.6DE

In each column mean of each treatment followed by the same letter(s) are not significant at *P*=0.05 by Duncan's Multiple Range Test (DMRT)

Table 6. Percentages of Nitrogen, Phosphorus and potassium in artichoke plants as affected by foliar spraying with GA_3, chitosan, garlic extract, moringa extract, salicylic acid and their interactions with GA_3 treatments during the two seasons

Treatments	N %		P %		K %	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control (distilled water)	1.920E	2.047 F	0.1810F	0.2030B	2.600E	2.580D
GA_3 50 ppm	2.167E	2.670CDE	0.1980E	0.2190B	3.300C	3.133C
Chitosan 100 ppm	2.027E	2.733CD	0.2150D	0.2600AB	3.400C	3.733B
Garlic extract 10 %	2.037 E	2.433DE	0.2550B	2.360AB	3.200C	3.600B
Moringa leaf extract 10 %	3.640A	3.980A	0.3530A	0.3270A	4.400A	4.368A
Salicylic acid 100 ppm	2.900C	2.350E	0.1920E	0.2300B	3.233C	3.567B
GA_3 + chitosan 100 ppm	2.433D	2.754CD	0.2530B	0.2570AB	2.933D	3.900B
GA_3+ garlic extract 10 %	2.500D	2.667CDE	0.2370C	0.2400AB	3.68B	2.960C
GA_3 + Moringa leaf extract 10 %	3.337B	3.268B	0.3540A	0.2730AB	2.64E	4.660A
GA_3 + salicylic acid	2.010E	2.767C	0.2500B	0.2600AB	2.64E	3.133C

In each column mean of each treatment followed by the same letter(s) are not significant at *P*=0.05 by Duncan's Multiple Range Test (DMRT)

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