

Use of Some Essential Oils and Plant Extracts as GA₃ Alternatives on Globe Artichoke Flower Heads Earliness and Productivity.

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THIS STUDY was conducted during two seasons of 2012/2013 and 2013/2014 at Vegetables Research Farm in Kaha, Qualiobia Governorate, Horticulture Research Institute, Agriculture Research Centre to study the effect of some essential oils (*citronella* and *lemon grass*) and plant extracts of (aloe and garlic) compared to GA₃ on vegetative growth, earliness, yield and its quality of globe artichoke cv. Hyriuswas. Planting dates was on September 1st in both seasons. The essential oils of *citronella grass* and *lemon grass*, plant extracts of aloe and garlic, GA₃ at 25 ppm and the control were sprayed in different concentrations two times in each season after 60 and 75 day from planting.

Results revealed considerable improvements in earliness, the early yield as well as head length (cm), head diameter (cm), edible part fresh weight (g) and edible part dry weight (g) by the tested materials. Spraying with aloe extract 50 ml/l or citronella grass oil 0.5 ml/l gave the best results in this concern.

Globe artichoke (*Cynara scolymus L.*) is considered one of the most important vegetable crops in the countries of the Mediterranean basin. These days, in Egypt more attention is given to promoting globe artichoke production to satisfy the increased demands of local and international consumption markets. According to statistics of FAO (2011) Egypt occupies the third rank in world artichoke exporters by quantity of 5945 tones. In (2012) FAO Statistics reported that, the Egyptian planted area was 17,895 ha with production of 387,704 tones. Artichoke flower heads (the edible part of the plant) appear in Egyptian markets at the end of February, the most production was harvested during March and April. This relatively short season provides little opportunity for growers to export their product, so, the early crop was found to have a great importance in exportation. To accelerate and enhance the early production of heads obtaining significant benefits from higher prices the vernalization, low level of GA₃ and / or their interaction can be used. Since the use of growth substances for fresh market vegetable production may have some residual effects, the though to use other alternatives that can replace and reduce the harmful effect of growth regulators (Salisbury and Ross, 1999).The early harvest period from December to February for globe artichoke in Egypt is economically interesting because there is no production in most European countries during these window.

Mansour (1983) stated that, all concentrations of gibberellic acid (25, 50 and 75 ppm) gave highly significant increase in earliness and early yield (number of heads per plant and weight of heads per plant) as compared with control. However, the difference between 25 and 75 ppm concentrations was not significant. Abd El-Hameid *et al.* (2008) mentioned that, spraying globe artichoke plants with GA₃ resulted in significant increase in plant height, number of early heads /plant, early yield /plant and early yield ton/fed. This promotion effect was significantly increased with increasing GA₃ concentrations from 0 up to 40 ppm. In this regard, application of

A GA₃ at 20 ppm reflected the highest early yield and its components during both seasons of study.

Many higher plants produce economically important active organic compounds such as essential oils, resins, tannins, glycosides, alkaloids, flavonoids and antioxidants which have pharmaceutical effects as well allopathic effects. Also, Balandrin *et al.* (1985) emphasized that, it is expected to play an increasingly significant role in the commercial development of new products for regulating plant growth and for insect and weed control.

Gibberellic acid (GA₃) is a plant growth regulator used all over the world to improve production of fruits and vegetables and naturally occurring in all plants since it plays an essential role in plant growth and development (Giancaspero, 1998).

Krogmann (1979) mentioned that gibberellic acid among abundant class of compounds are arises from mevalonic acid via geranyl geranyl pyrophosphate. Haridy (1986) indicated that, sprayed geraniol on periwinkle plants increased GA₃ and IAA while ABA was decreased. Evans (1989) mentioned that IAA and several acids are all derived, in the plants, from tryptophan. In this way, Haridy *et al.* (2008) indicated that, growth of geranium plants showed a stimulation effect due to spraying with ATP, geraniol and tryptophan in different concentrations, it could be concluded that, geranium plants may be have the ability to recycle geraniol and tryptophan with the help of the co-enzyme ATP to produce the active phyto-hormones such as Gibberellin (GA) and Auxin (IAA) in the optimum concentrations that stimulates its growth. Hamouda *et al.* (2009) showed that, all materials used in the tested treatments (GA₃, geranium and lemon grass oils) comprise geraniol (the precursor of gibberellins), which is the main effective compound in improving grape bunches and berries.

The essential oil of citronella consists of citronellal (32-45%), geraniol (20-22%), geranyl acetate (8-12%), limonene (9-11%) also, the essential oil of lemon grass is consists of alcohols (20 to 30% citronellol, geraniol) and aldehydes (15% geraniol, 10% neral, 5% citronellal) Webb, (1984).

Aloe vera contains all the essential amino acids i.e. isoleucine, leucine, lysine, methionine, phenylalanine, threonine, valine and tryptophan. It also contains few other non-essential amino acids i.e. alanine, arginine, asparagine, cysteine, glutamic acid, glycine, histidine, proline, serine, tyrosine, glutamine, and aspartic acid. Moreover, aloe extract contains mono polysaccharides (cellulose, glucose, mannose and aldopentose), lignin, macro nutrients (N,P,K), secondary nutrients (Mg, Ca), trace elements (Zn, Fe, Mn, Cu), vitamins (B1, B2, B6, C, niacin, collin, enzymes, inositol, aloin, isobarbaloin, aloe emodin, natural hormones (auxins, gibberellins and salicylic acid) Gertrude (2010). These active chemical compounds presented in aloe extract were used to improve the germination, vegetative growth and flowering as described by (Youssef, 1997) on *Delphinium majacis* L., *Antirrhinum majus* L. and *Callistephus chinensis* L. plants. Hamouda *et al.* (2012) indicated that, foliar spraying with aloe extract and active dry yeast influenced the vegetative growth and oil content of sweet basil (*Ocimum basilicum*, L.)

Garlic contains 0.1-0.36% of a volatile oil these volatile compounds are generally considered to be responsible for most of the pharmacological properties.

Garlic contains at least 33 sulfur compounds like aliin, allicin, ajoene, allylpropl, diallyl, trisulfide, sallylcysteine, vinylidithiines, S-allylmercaptocystein, and others. In addition, garlic contains 17 amino acids and their glycosides, arginine and others, minerals such as selenium, enzymes i.e. allinase, peroxidases, myrosinase, and natural hormones such as gibberellins Tammy (2010). This active and fresh extracts of garlic can be used to improve the vegetative growth of many plants such as squash Abou-Hussein, *et al.* (1975) and El-Desouky *et al.* (1998).

The objective of this investigation was to study the possibility of using some essential oils (citronella and lemon grass oils) and plant extracts of (aloe, garlic) which related directly or indirectly with plant growth regulator gibberellins to early produce and improve the yield and quality of globe artichokes instead of synthetic GA₃.

Material and Methods

This investigation was carried out in Vegetable Research Farm in Kaha Qualiobia Governorate, Horticultural Research Institute, Agricultural Research Center, during the two successive seasons of 2012/2013 and 2013/2014 to investigate the effect of some essential oils (citronella grass and lemon grass) and plant extracts (aloe and garlic) compared to synthetic GA₃ on vegetative growth, earliness, yield and quality of globe artichoke plants.

The propagated parts of globe artichoke plants cv. Hyrius was prepared by dividing the old crown into pieces with at least two basal buds/ piece after detaching the old leaves and pruning the roots.

Propagation parts were, then, planted in the field on 1st of September in each seasons of the study. The recommended agricultural practices of globe artichoke including fertilization, irrigation and pests managements were done according to the Egyptian Ministry of Agriculture. The plot area was 20 m², consists of 4 ridges one meter width and 5 meters long. Each ridge contained 5 plants spaced at one meter apart.

The essential oils of citronella grass and lemon grass (which containing geraniol- precursor of gibberellins- and other active compounds as describe in Table A), plant extracts of aloe and garlic (which containing gibberellins and other active constituents as mentioned previously in the introduction), 25 ppm GA₃ (recommended concentration) and control were sprayed twice in each season, *i.e.* after 60 and 75 days from planting.

Essential oils extraction

The essential oils were distilled from the fresh herbs on the first of April 2013 in the Laboratory according to the method described in British Pharmacopoeia (1963).

The volatile oil was analyzed using Ds-Chrome 6200 Gas Chromatograph equipped with a flame ionization detector for the separation of volatile oil constituents. The analysis conditions were as follows: The chromatograph apparatus was fitted capillary column BPX-5, 5% phenyl (equiv.) polysilphenylene-siloxane 30m x 0.25mm ID x 0.25µm film. Temperature program ramp increases with a rate of 8^oC/min from 70^oC to 200^oC. Flow rates of gases were nitrogen at 1 ml/min, hydrogen at 30 ml/min and 330 ml/min for air. Detector and injector temperatures were 300^oC and 250^oC, respectively. The obtained chromatogram and report of GC analysis for each sample were analyzed to calculate the percentage of main components of volatile oil. The main constituents are shown in Table (A).

TABLE A. Main constituents of citronella grass and lemon grass essential oils.

Type of oil	Main components	%
Citronella grass oil (CO)	Geraniol	35.00
	Citronellal	30.00
	Limonene	10.00
	Geranyl acetate	11.00
Lemon grass oil (LO)	Geraniol	7.20
	Citronellol	5.60
	Geranial	15.00
	Citral	65.00
	Geranyl acetate	2.60

*Preparation of plant extracts**Aloe extract*

Leaves of *Aloe vera* were cold pressing by using a stainless steel drums to obtain the extracted solution gel of aloe leaves the obtained extract was filtrated and used as foliar spray at different concentration of 5% and 10% using distilled water for dilution. In Table (B) some constituents of aloe extract have been known by GLC according to waters HPLC by two pumps 510 waters with water autometed controller injector 746 waters column μ pandapach CL8 (3.9X300 mm) according to Shyamal *et al.* (1990).

TABLE B. Determination of phytohormons (GA₃, IAA and ABA) in *Aloe vera* extract according to Arid Land Agric. Res. Unit, Fac. of Agric. Ain Shams Univ.

Sample	Result (mg/100gm F.W)
GA ₃	16.00
IAA	0.63
ABA	3.06
Total carbohydrate (%)	10.10

Garlic extract

The Garlic extract was prepared as follows, fresh mature garlic cloves were blended in distilled water 1Kg cloves/1liter distilled water, then filtered. The filtrate was use for the preparation of different garlic extract concentrations. The obtained extracts were used for foliar spray at 50 and 100 m/l water, respectively) using distilled water. Some constituents of garlic extract have been analyzed by Arid Land Agric. Res. Unit Fac. of Agric. Ain Shams Univ. and shown in Table (C).

TABLE C. Some chemical constituents of garlic cloves extract according to Arid Land Agricultural Research Unit.

Components	Concentration
GA ₃	16.33 mg/100gm F.W
IAA	*
ABA	*

*Trace amount

The essential oils were emulsified by Tween 20 (1.0 ml/l) and sprayed using a manual sprayer. Ten foliar spraying treatments were used as follows:

- Control (using water + Tween 20 (1.0 ml/l)).
- GA₃ (25 ppm recommended application) + Tween 20 (1.0 ml/l).
- 3-Citronella oil 0.5 ml/l.
- Citronella oil 1.0 ml/l.
- Lemon grass oil 0.5 ml/l.
- Lemon grass oil 1.0 ml/l.
- Aloe extract 50 ml / l + Tween 20 (1.0 ml/l).
- Aloe extract 100 ml / l + Tween 20 (1.0 ml/l).
- Garlic extract 50 ml/l + Tween 20 (1.0 ml/l).

- Garlic extract 100 ml/l + Tween 20 (1.0 ml/l).

Data recorded

A random sample of six plants was taken from each experimental plot at 90 days after transplanting (1st December) in both seasons for measuring the growth characters of globe artichoke expressed as follows:

Vegetative growth characteristics

Plant height (cm). Plant height was measured from soil surface to the tip of the plant largest linear blade .

Number of leaves / plant.

Early head yield parameters

The early yield expressed as the number of heads produced from first of December till the end of February. A random sample of six heads from each experimental plot was taken from the early yield. The artichoke heads were harvested by cutting with part of stem (about 10 cm) for determining the following parameters.

- Average flower head length (cm).
- Average flower head diameter (cm)
- Number of early flower heads /plant.
- Number of early flower heads /fed.
- Average flower head weight (g).
- Average flower head with 10 cm neck weight (g).
- Average edible part fresh weight (g).
- Early flower head yield /plant (kg).
- Early flower head yield ton /fed.

Total yield parameters

Total yield expressed as the number of all heads produced throughout the entire harvesting season from the first of December till the end of May (the end of the production season of artichoke).

- Number of late flower heads /plant.
- Number of late flower heads /fed.
- Late flower head yield /plant (kg).
- Late flower head yield ton /fed.

Samples of edible part heads were dried in an electric oven to constant weight at 70°C for dry weight determination.

The statistical analysis

The obtained data were statistically analyzed using the complete randomized blocks design (Simple experiment) with three replicates; separation between means was performed by the L.S.D at 5 % level (Snedecor and Cochran, 1980).

Results and Discussion

Effect of some essential oils and plant extracts as GA₃ alternatives on plant height (cm) and number of leaves/plant of artichoke plants:

Vegetative growth

Data in Table 1 illustrated the effect of citronella, lemon grass oils, aloe and garlic extracts compared with GA₃ on plant height (cm) and number of leaves/plant in the two experimental seasons (2013&2014). Regarding plant height, the differences between each of the two oils (Citronella and lemon grass) and (aloe, garlic) extracts as well as the control and GA₃ treatments were significant in both seasons.

TABLE 1. Effect of some essential oils and plant extracts as GA₃ alternatives on plant height (cm) and number of leaves/plant on artichoke plants

Characters Treatments	Plant height(cm)		Number of leaves/plant.	
	1 st season	2 nd season	1 st season	2 nd season
Control	48.3	48.0	27.3	26.3
GA ₃ 25 ppm	55.6	54.8	31.3	29.3
Citronella oil 0.5 ml/l	50.4	50.9	38.3	37.3
Citronella oil 1.0 ml/l	51.9	52.9	31.7	30.0
Lemon grass oil 0.5 ml/l	49.8	50.7	35.0	34.0
Lemon grass oil 1.0 ml/l	50.9	52.0	29.7	28.3
Aloe extract 50 ml / l	49.6	50.4	40.0	38.3
Aloe extract 100 ml / l	51.8	52.8	31.7	33.7
Garlic extract 50 ml/l	48.9	49.6	28.0	27.3
Garlic extract 100 ml/l	50.7	51.1	37.3	35.3
L.S.D. at 5%	3.0	3.7	1.4	1.4

The treatment of spraying with 25 ppm GA₃ gave the longest plants compared to control and the rest of the treatments.

The highest values of plant height recorded were (55.6 & 54.8 cm) with GA₃ application while, the lowest values were (48.3 & 48.0 cm) with control treatment in the two seasons, respectively.

On the other hand, data in Table 1 also revealed that, significant differences between the tested treatments and GA₃ treatments in number of leaves per plant were recorded. Thus, the highest number of leaves /plant was recorded with 50 ml /l aloe extract (40.0 & 38.3) followed by 0.5 ml/l citronella oil (38.3 & 37.3), 100 ml /l garlic extract (37.3 & 35.3) and 0.5 ml/l lemon grass oil (35.0 & 34.0) meanwhile, GA₃ at the recommended dose recorded (31.1 & 29.3) in both seasons, respectively. These results are in accordance with those obtained by Abd El-Hameid *et al.* (2008) who stated that spraying globe artichoke plants with GA₃ resulted in significant increase in plant height while leaves number was significantly decreased with increasing gibberellic acid concentrations from 0 up to 40 ppm. Furthermore Sařata *et al.* (2013) indicated that, plants treated with

GA₃ were shorter, formed less leaves in comparison to control plants. On the contrary, Baixauli *et al.* (2013) reported that, the highest plant was noticed in plants sprayed with 30 ppm GA₃.

In general, it could be concluded that, elongation of globe artichoke plants was obtained with the highest dose in all tested GA alternatives (citronella, lemongrass oils and aloe, garlic extracts). This means that, the optimum dose for cell elongation was the highest dose in all tested GA alternatives. Also, it was clearly observed that, the highest effect in cell division was obtained by using the lowest dose of GA alternatives, so the highest number of leaves was generally obtained by the lowest dose of GA alternatives of the tested materials.

Early flower heads

Effect of some essential oils and plant extracts as GA₃ alternatives on heads with 10 cm neck weight (g) and head weight without neck (g) on artichoke plants:

Data in Table 2 emphasized the effect of citronella, lemon grass oils and aloe, garlic extracts compared with GA₃ and control on artichoke head with 10 cm neck and head weight without neck (g) all of the tested treatments showed significantly increase in head with neck weight and head weight (g) compared with GA₃ treatment. The heaviest head with neck weight (g) were recorded (286.0 & 353.3 g) with the use of 50 ml/ l aloe extract followed by (280.0 & 350.3 g) with 50 ml /l garlic extract , (278.0 & 337.1 g) with 0.5 ml/l citronella oil and (265.0 & 335.3 g) with 1.0 ml/l lemon grass oil in both season, respectively. The lowest values of head weight were recorded (238.0 & 307.0 g) with control treatment in both seasons.

The same trend was obtained for head weight (g). The heaviest head weight (g) was recorded with 50 ml / l aloe extract followed by spraying with 50 ml /l garlic extract, with 0.5 ml/l citronella oil and with 1.0 ml/l lemon grass oil in 1st and 2nd seasons, respectively. The lowest values of head weight were recorded with control treatment.

This growth stimulation may be explained on the concept of that aloe extract contains several physiologically active constituents such as tryptophan which is the precursor of auxin, zinc also help in this way and the endogenous gibberellins as well as other active compounds, all of these compounds in the low concentration 50 ml/l of aloe extract stimulating cell division. So, the number of leaves is increased, consequently provide the artichoke plant organs with more photosynthate allowing head weights to increase. In this respect, Sałata *et al.* (2013) stated that plants sprayed with GA₃ formed floral heads with higher average weight in comparison with plants not treated with the gibberellic acid. Also, Hamouda *et al.* (2009) showed that, all materials used in the tested treatments (GA₃, geranium and lemon grass oils) comprise the compound of geraniol which the precursor of gibberellins which is the main effective compound in improving grape bunches and berries. Hamouda *et al.* (2012) indicated that, foliar spraying with *Aloe vera* extract and active dry yeast influenced the vegetative growth and oil content of sweet basil (*Ocimum*

basilicum, L.). The fresh extracts of *Allium sativum* (garlic) can be used to improve the vegetative growth of many plants such as squash Abou-Hussein *et al.* (1975) and El-Desouky *et al.* (1998). On the other hand, Abd El-Hameid *et al.* (2008) reported that head weight was significantly decreased with increasing the concentration of GA₃.

TABLE 2. Effect of some essential oils and plant extracts as GA₃ alternatives on head with 10 cm neck weight (g) and head weight (g) of artichoke plants

Characters Treatments	1 st season 2013		2 nd season 2014			
	Head (with 10 cm neck) weight		Head weight(g)	Head (with 10 cm neck) weight		Head weight (g)
	(g)	± %		(g)	± %	
Control	238.0	- 4.8	208.2	307.0	- 65	269.3
GA ₃ 25 ppm	250.0	--	218.7	309.0	--	281.7
Citronella oil 0.5 ml/l	278.0	11.2	246.3	337.1	9.1	308.7
Citronella oil 1.0 ml/l	262.0	4.8	225.7	318.0	3.6	288.7
Lemon grass oil 0.5 ml/l	264.0	5.6	234.3	322.3	5.1	291.7
Lemon grass oil 1.0 ml/l	265.0	6.0	237.8	335.3	8.5	303.7
Aloe extract 50 ml / l	286.0	14.4	251.7	353.3	14.3	320.7
Aloe extract 100 ml / l	240.0	- 4	215.3	309.0	--	278.3
Garlic extract 50 m/l	280.0	12	250.7	350.3	13.4	318.7
Garlic extract 100 m/l	256.0	2.4	219.6	316.0	2.9	285.3
L.S.D. at 5%	5.8		7.6	8.0		11.6

±% in relation to GA₃ treatments.

Effect of some essential oils and plant extracts as GA₃ alternatives on head length and diameter (cm) & edible part fresh and dry weight (g) on artichoke plants:

Data in Table 3 indicated that, all tested treatments were increased in head length and head diameter (cm) compared with untreated plants, these increments were significant in the second season only. The longest head length was recorded the use of 50 ml / l aloe extract followed by 1.0 ml/l citronella oil, 0.5 ml/l citronella oil and GA₃ at 25 ppm treatments in 1st and 2nd seasons, respectively. The shortest head length was recorded with control treatment.

In case of head diameter, the longest head diameter was recorded with 50 ml / l aloe extract followed by 1.0 cm/l lemon grass oil and 50 ml / l garlic extract treatments.

Data in Table 3 also demonstrated that, in both seasons, all tested alternatives of GA₃ produced significantly heavier edible head fresh weights than the GA₃ at the recommended application and control. Thus, the heaviest edible part fresh weight of artichoke plants were recorded (146.0 & 130.8 g) with 50 ml/l aloe extract which promoted the edible part by (22.5 - 18.6 % compared with GA₃) in the two seasons respectively, followed by (139.5 & 124.6 g) with 0.5 ml/l citronella oil, (135.5 & 122.1 g) with 50 ml / l garlic extract and (127.8 & 118.6 g) with 0.5 ml/l lemon grass oil in the two seasons, respectively. Meanwhile, the GA₃ at 25 ppm (recommended application) recorded (119.2 & 110.3 g) in 1st and 2nd seasons, respectively. The lowest fresh weight of edible part was recorded

(115.0 & 96.6 g) with untreated plants in 1st and 2nd seasons, respectively. In this concern, Hamouda *et al.* (2009) showed that, all materials used in the tested treatments (GA₃, geranium and lemon grass oils) comprise the compound of geraniol which the precursor of gibberellins, *i.e.* is the main effective compound in improving grape bunches and berries. Hamouda *et al.* (2012) indicated that, foliar spraying with *Aloe vera* extract and active dry yeast influenced the vegetative growth and oil content of sweet basil (*Ocimum basilicum*, L.). The fresh extracts of *Allium sativum* (garlic) can be used to improve the vegetative growth of many plants such as squash Abou-Hussein *et al.* (1975) and El-Desouky *et al.* (1998). Also, Abd El-Hameid *et al.* (2008) mentioned that, head length, head diameter and edible part fresh weight were significantly decreased with increasing the concentration of GA₃.

The same trend was obtained on edible part dry weight (g), which showed an increase by (44.4 – 25.9 %) at 50 ml /l garlic extract followed by (33.3 – 20.3 %) 50 ml/l aloe extract and (31.7-15.7%) from 0.5 ml/l citronella oil in comparison with GA₃ treatment in 1st and 2nd seasons, respectively.

TABLE 3. Effect of some essential oils and plant extracts as GA₃ alternatives on head length and (cm) & edible part fresh and dry weight (g) on artichoke plants.

Characters Treatments	1 st season (2013)						2 nd season (2014)					
	Head length (cm)	Head diameter (cm)	Edible part fresh weight		Edible dry weight		Head length (cm)	Head diameter (cm)	Edible part fresh weight		Edible dry weight	
			(g)	±%	(g)	±%			(g)	±%	(g)	±%
Control	10.2	9.0	115.0	- 3.5	12.3	- 2.4	10.0	9.0	96.6	- 12.4	18.4	- 6.6
GA ₃ 25 ppm	10.6	9.3	119.2	--	12.6	--	10.6	9.2	110.3	--	19.7	--
Citronella oil 0.5 ml/l	10.6	9.3	139.5	17.0	16.6	31.7	10.6	9.2	124.6	13.0	22.8	15.7
Citronella oil 1.0 ml/l	10.7	9.2	124.7	4.6	15.8	25.4	10.7	9.1	114.6	3.9	20.7	5.1
Lemon grass oil 0.5 ml/l	10.4	9.3	116.6	- 2.2	14.4	14.3	10.5	9.1	105.8	- 4.1	20.2	2.5
Lemon grass oil 1.0 ml/l	10.4	9.4	127.8	7.2	14.5	15.1	10.6	9.3	118.6	7.5	22.1	12.2
Aloe extract 50 ml / l	10.9	9.5	146.0	22.5	16.8	33.3	10.8	9.4	130.8	18.6	23.7	20.3
Aloe extract 100 ml / l	10.6	9.3	125.1	5.0	14.5	15.1	10.3	9.2	116.2	5.4	20.3	3.1
Garlic extract 50 ml/l	10.4	9.4	135.5	13.7	18.2	44.4	10.2	9.3	122.1	10.7	24.8	25.9
Garlic extract 100 ml/l	10.3	9.3	116.1	-2.6	15.0	19.1	10.3	9.2	100.1	-9.3	19.6	-0.5
L.S.D. at 5%	N.S	N.S	5.7		3.5		0.5	0.4	2.1		5.8	

±% in relation to GA₃

Early and late yield

Effect of some essential oils and plant extracts as GA₃ alternatives on early yield /plant, early yield /fed., early yield /plant (g) and early yield /fed. (ton) on artichoke plants

With regard to the effect of citronella, lemongrass oil, aloe and garlic extracts compared with GA₃ the number of early flower heads per plant, per feddan and weight of early flower head /plant (g) and early flower yield /fed. (ton) of artichoke plants, data in Table 4 showed that, all tested treatments significantly affect the earliness of artichoke plants.

The numbers of flower heads per plant (early yield), generally ranged from 2.0 to 2.4 in the first season and from 1.9 to 2.4 in the second season. The highest values (2.4 – 2.3) came from citronella oil at 0.5 ml/l, (2.4 – 2.2) for aloe extract at 50 ml/l and (2.3 – 2.4) for garlic extract at 50g/l. in 1st and 2nd seasons, respectively. The least values resulted from untreated plants and 0.5 ml/l lemon grass oil. The same trend was obtained for early yield /fed.

Data in Table 4 generally showed that early yield /plant (g), ranged from (724.3 to 896.3 g) in the first season and from (693.7 to 880.0 g) in the second season. The highest values came from garlic extract at 50 g/l which promoted early yield /plant (g) by 17.4 – 14.8 % compared with GA₃ treatment followed by citronella oil at 0.5 ml/l and aloe extract at 50 ml/l in 1st and 2nd seasons, respectively. The least values resulted from untreated plants.

The same trend was obtained for early yield /fed. (ton), which showed an increase by (17.3 – 14.6 %) came from garlic extract at 50 g/l, followed by (14.0 – 11.7 %) from citronella oil at 0.5 ml/l in both seasons, respectively. In this respect, Abd El-Hameid *et al.* (2008) illustrated that, number of early heads /plant, early yield /plant and early yield ton/fed. were significantly increased with increasing GA₃ concentrations from 0 up to 40 ppm. In this regard, application of GA₃ at 20 ppm reflected on the highest early yield and its components during both seasons of the study. Also, Sałata *et al.* (2013) stated that plants sprayed with GA₃ formed less floral heads on inflorescence shoots in comparison to plants not treated with the gibberellic acid. Also, the obtained results agreed with those obtained by Hamouda *et al.* (2009) in grape and Hamouda *et al.* (2012) on sweet basil (*Ocimum basilicum* L.).

Abou-Hussein *et al.* (1975) and El-Desouky *et al.* (1998) concluded that, fresh extracts of *Allium sativum* (garlic) can be used to improve the vegetative growth of many plants such as squash.

TABLE 4. Effect of some essential oils and plant extracts as GA₃ alternatives on early yield /plant, early yield /fed, early yield /plant (g) and early yield /fed. (ton) on artichoke plants .

Characters	1 st season (2013)						2 nd season (2014)					
	Early yield /plant (number)	Early yield /fed. (number)	Early yield /plant (g)	Early yield /fed. (ton)	±% (ton)	±% (number)	Early yield /plant (number)	Early yield /fed. (number)	Early yield /plant (g)	Early yield /fed. (ton)	±% (ton)	±% (number)
Control	2.0	7833.3	724.3	2.90	-5.2	1.9	7500.0	693.7	-9.5	2.77	-9.8	
GA ₃ 25 ppm	2.3	8666.7	763.7	3.06	-	2.0	7833.3	766.7	-	3.07	-	
Citronella oil 0.5 ml/l	2.4	9333.3	872.0	3.49	14.0	2.3	9333.3	857.0	11.8	3.43	11.7	
Citronella oil 1.0 ml/l	2.2	8833.3	835.0	3.34	9.1	2.2	8666.7	848.7	10.6	3.40	10.7	
Lemon grass oil 0.5 ml/l	2.0	8000.0	729.7	2.92	-4.5	1.9	7666.7	699.3	-8.8	2.80	-8.8	
Lemon grass oil 1.0 ml/l	2.1	8333.3	815.7	3.26	6.5	2.2	8666.7	831.3	8.4	3.20	4.2	
Aloe extract 50 ml/l	2.4	9666.7	848.3	3.39	10.8	2.2	8833.3	842.7	9.9	3.27	6.5	
Aloe extract 100 ml/l	2.2	9000.0	777.7	3.11	1.6	2.0	8166.7	763.3	-0.44	3.05	-0.6	
Garlic extract 50 ml/l	2.3	9166.7	896.3	3.59	17.3	2.4	9500.0	880.0	14.8	3.52	14.6	
Garlic extract 100 ml/l	2.2	8666.7	848.3	3.39	10.8	2.3	9000.0	763.7	-0.4	3.06	-0.3	
L.S.D. at 5%	0.28	1142.4	51.2	0.43		0.19	676.6	29.0		0.24		

±% in relation to GA₃

Effect of some essential oils and plant extracts as GA₃ alternatives on total yield/plant, total late yield/fed., total late yield/plant (kg) and total yield/fed. (ton) on artichoke plants

Data in Table 5 indicated that, all tested treatments had a significant effect on the mentioned parameters.

Generally, total yield /plant expressed as number of flower heads ranged from 13.4 to 15.4 in the first season and from 13.3 to 16.3 in the second season. The highest values resulted from the use of aloe extract at 50 ml/l, citronella oil at 0.5 ml/l, garlic extract at 50g/l. followed by lemon grass oil at 1.0 ml/l in both season, respectively. The least values resulted from untreated plants (control). The same trend was obtained for total yield /fed.

With regard to the effect of citronella, lemongrass oil, aloe and garlic extracts compared with GA₃ on total yield /plant (kg) and total yield /fed. (ton) of artichoke plants data in Table 5 illustrated that, total yield /plant (kg), ranged from (3.5 to 4.4 kg/plant) in the first season and from (4.1 to 5.7 kg/plant) in the second season. The highest values obtained from the use of aloe extract at 50 ml/l which promoted total yield /plant 25.7 – 32.6 % compared with GA₃, followed by citronella oil at 0.5 ml/l which promoted total yield /plant 14.3 – 25.6 % compared with GA₃, followed by garlic extract at 50 g/l also lemon grass oil 1.0 ml/l in both season, respectively. The least values (3.5 & 3.5 kg/plant) and (4.1 & 4.3 kg/plant) resulted from untreated plants (control) and GA₃ at 25 ppm treatments in both seasons, respectively.

The same trend was obtained for total yield /fed. (ton), which promoted the total yield/fed. (ton) by (24.5 – 34.9 %) in case of aloe extract at 50 ml/l, followed by (14.1 – 27.5 %) for citronella oil at 0.5 ml/l in both seasons, respectively. Abd El-Hameid *et al.* (2008) recorded the number of late heads /plant, late yield /plant and late yield ton /fed. were gradually decreased with increasing GA₃ concentrations from 0 up to 40 ppm, Baixauli *et al.* (2013) the greatest final yield was achieved by the control and the highest concentrations of GA₃ (90 ppm) induced to a lowering final yield. The improving effect of essential oil due to geraniol as mentioned by Hamouda *et al.* (2009). Also, Hamouda *et al.* (2012) stated that *Aloe vera* extract influenced the vegetative growth of sweet basil. The fresh extracts of *Allium sativum* (garlic) can be used to improve the vegetative growth of many plants such as squash Abou-Hussein *et al.* (1975) and El-Desouky *et al.* (1998).

Conclusion and Discussion

The use of natural alternatives of GA₃ as citronella, lemongrass oil, aloe and garlic extracts compared with GA₃ in artichoke production or other fruit plants was not available in previous literature reports.

TABLE 5. Effect of some essential oils and plant extracts as GA₃ alternatives on total yield/plant, total yield/Fed., total yield/plant (kg) and total yield/fed. (ton) on artichoke plants .

Characters	1 st season (2013)				2 nd season (2014)			
	Total yield/plant (number)	Total yield/Fed (number)	Total yield/plant (kg)	Total yield/Fed (ton)	Total yield/plant (number)	Total yield/Fed (number)	Total yield/plant (kg)	Total yield/Fed (ton)
Control	13.4	53500	3.5	13.96	13.3	53000	4.1	16.37
GA ₃ 25 ppm	14.2	56667	3.5	14.12	13.8	55167	4.3	17.03
Citronella oil 0.5 ml/l	15.4	61444	4.0	16.11	16.1	64444	5.4	21.72
Citronella oil 1.0 ml/l	14.7	58667	3.8	15.01	14.3	57167	4.5	18.16
Lemon grass oil 0.5 ml/l	14.1	59476	3.8	15.21	13.6	54300	4.5	18.20
Lemon grass oil 1.0 ml/l	14.9	56300	3.9	15.64	14.9	59476	4.8	19.16
Aloe extract 50 ml/l	15.4	61500	4.4	17.58	16.3	65000	5.7	22.97
Aloe extract 100 ml/l	14.7	58833	3.5	14.12	14.5	57833	4.4	17.75
Garlic extract 50 ml/l	15.0	59833	3.9	15.54	15.2	60833	4.8	19.21
Garlic extract 100 ml/l	13.9	55500	3.7	14.96	13.4	53500	4.7	18.73
L.S.D. at 5%	0.85	3388.5	0.22	0.858	0.28	1132.8	0.12	0.501

± % in relation to GA₃.

Results of the present investigation revealed considerable improvements in early artichoke plants as well as head length (cm), head diameter (cm), edible part fresh weight (g) and edible part dry weight (g) by the tested natural substitutes of GA₃, especially spraying with aloe extract 50 ml/l, or citronella oil 0.5 ml/l, or garlic extract 50g/l, or lemon grass oil 1.0 ml/l.

The promoted effect of the natural alternatives of GA₃ as citronella and lemongrass oils in earliness of artichoke plants might be attributed to their chemical composition as comprise geraniol and its derivatives (which is a precursor of gibberellins) in citronella, lemongrass oil as demonstrated before

In addition, aloe and garlic extract contain natural GA₃. This growth stimulation may be explained on the concept of that aloe extract contains several physiologically active constituents such as tryptophan which is the precursor of auxin, zinc also, help in this way and the endogenous gibberellins as well as other active compounds, all of these compounds in the low concentration 50 ml/l of aloe extract are going to stimulate cell division increasing the leaves number and, consequently provide plant organs with more photosynthates and allowing head weights to increase.

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إستخدام بعض الزيوت العطرية والمستخلصات النباتية كبدايل للجبريللين على التذكير والإنتاجية لنورات الخرشوف

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أجرى هذا البحث خلال موسمي ٢٠١٢/٢٠١٣ و ٢٠١٣/٢٠١٤ في المزرعة التجريبية للخضر بقها محافظة القليوبية - معهد بحوث البساتين - مركز البحوث الزراعية لدراسة تأثير إستخدام بعض الزيوت العطرية) حشيشة الليمون والسترونيلا (وبعض المستخلصات النباتية الصبار والثوم (بالمقارنة بالجبريللين على النمو الخضرى والتذكير وجودة المحصول في نباتات الخرشوف.

تم زراعة الخرشوف صنف فرنساوى) هيريوس (في أول سبتمبر لكلا الموسمين بتجزئة التاج طوليا إلى جزئين تم رش الزيوت الطبيعية) حشيشة الليمون والسترونيلا كبدايل لتكوين الجبريللين (ومستخلصى الصبار والثوم) كمصدر للجبريللين مقارنة بالجبريللين مرتين بعد ٦٠ و ٧٥ يوم من الزراعة.

أظهرت النتائج أن رش البدائل الطبيعية للجبريللين المختبرة وخاصة الرش بمستخلص الصبار ٥٠ سم /لتر و زيت السترونيلا بمعدل ٥٠ سم/لتر و مستخلص الثوم بمعدل ٥٠ جرام /لتر أدت إلى تحسين التذكير في نباتات الخرشوف بالإضافة إلى تحسين مواصفات طول وعرض النورات الزهرية والوزن الطازج والجاف للجزء الصالح للأكل.

أوضحت الدراسة الاقتصادية أن رش نباتات الخرشوف بزيت السترونيلا بمعدل ٥٠ سم / لتر ومستخلص الصبار بمعدل ٥٠ سم / لتر ومستخلص الثوم بمعدل ٥٠ جرام /لتر أعطت أقصى صافي ربح مقارنة بGA₃ في الموسمين.