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Influence of Mineral, Micro-nutrients and Lithovit on Growth, Oil Productivity and Volatile Oil Constituents of *Cymbopogon citruts* L. Plants

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ABSTRACT

Two year field trials were carried out during 2016 and 2017 seasons at the Experimental Farm, Horticulture Dept., of Agric Fac., Benha Univ., to evaluate the effect of some nutrient foliar spray treatments i.e. the combination of Ca +Mg at 50,100 and 150 ppm, beside the combination of micro-nutrients i.e. Fe +Mn +Zn at 50, 100 and 150ppm and Lithovit at 0.5 and 1g/L four times a year on vegetative growth, essential oil yield and constituents and some chemical constituents of *Cymbopogon citratus* plants. Results showed that different applied treatments of some nutrients treatments led to significant increase of the studied parameters i.e. plant height, fresh and dry weights of herb/(g/plant), and No. of tiller /plant. However, the tallest plant, was recorded by 150ppm Fe +Mn +Zn -sprayed plants, whereas the heaviest fresh and dry weights of herb/(g/plant) and the highest number of tiller /plant were scored by lithovit at 1g/L in both cuts and in the two seasons. Moreover, the highest values of N, P, K and total carbohydrates contents were registered by lithovit at 1g/L treatment in both seasons and in the two cuts. In addition, spraying *Cymbopogon citratus* plants with 150 ppm Fe +Mn +Zn treatments gave the highest leaf Fe, Zn and Mn content, while the richest leaf total chlorophylls, Ca and Mg contents were recorded by Ca +Mg at 150ppm treatment at the both cuts in the two seasons. Furthermore, leaf essential oil percentage scored the highest values when plants were sprayed with the high concentration of Fe +Mn +Zn (150ppm). Six compounds of volatile oil of *Cymbopogon citratus* plant were identified. The main component was the citral A (Geranial), that ranged from (46.05 to 50.22 %) followed by citral B (Neral) (30.35 to 32.30) and β-Myrcene (9.35 to 10.03%).

Consequently, it is preferable to spray *Cymbopgon citruts* plants with lithovit at 1g/L or 150ppm Fe +Mn +Zn four times a year to enhance the growth, essential oil yield and constituents and some chemical constituents of this plant.

Key words: *Cymbopgon citruts*, mineral,micro-nutrients, lithovit,, growth, chemical composition and oil productivity and constituents..

Introduction

Cymbopgon citruts "lemongrass" Family: Poaceae(Gramineae) is a perennial herbaceous plant in Egypt. It has an odor resemble the combine of ginger and lemon odors. It is also an important crop with high production and manifold applications since the plant is a good crop minimizing soil erosion and the oil of lemongrass is used in many purposes, such as perfumes, cosmetic industry, scenting soaps and in the manufacture of synthetic vitamin A, (Guenther, 1970). Lemongrass is notable for its lemon flavor and fragrance thereupon It is used in cooking as a major source of lemon flavoring. Medically, it is anti-inflammatory, antidiabetic, analgesic, anthelmintic, antibacterial, antifungal, anticancer, antioxidant, antiplatelet, hepatoprotective, sedative and vasorelaxant. Citral is the major constituent of its essential oil. The oil is carminative, depressant, analgesic, antipyretic, antibacterial and antifungal (Harborne and Baxter, 2001; Ling *et al.*, 2009; Balick , 2014 and Dubey, 2014).

Calcium is an element taken up from the soil by plants only in a relatively low pH, hence as Ca_2 is found in an insoluble form. Calcium regulates the activity of many enzymes, e.g. ATPase, amylase, phospholipase, and it easily connects with saccharides. (White and Broadley, 2003).

Magnesium is part of chlorophyll in green plants, and it helps in activation of many plant enzymes needed for growth (Jedrzejczak *et al.,* 1999). Moreover, activates micro-nutrients, especially Fe, Zn and Mn act either as metal components of various enzymes or as functional, structural, or regulatory

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cofactors. Thus, they are associated with saccharide metabolism, photo-synthesis and protein synthesis (Marschner, 1997).

Many investigators reported the stimulating effect of applied mineral and micronutrients as foliar spray on growth and flowering of different medicinal and aromatic plants. In this respect (El-Khyat, 2013) on *Rosmarinus officinalis* and (Amran, 2013) on *Pelargonium graveolens* illustrated that foliar application of Fe, Zn and Mn improved the growth and chemical composition of the plants. Moreover, (Youssef, 2014) on *Echinacea purpurea*, (Yadegari, 2015) on borago, thyme and marigold and (Abou-Shleell, 2017) on *moringa olifera.* who mentioned that foliar application of (Ca, Mg and Fe in chelated) form at 500 ppm significantly increased all the studied vegetative growth parameters and chemical composition of the plants.

Nano-particles are used to evaluate their effects on plant growth, yield and for the control of plant diseases (Nair *et al.,* 2010). Recent studies showed that nano-particles induce a beneficial effect on plant growth and development (Roghayyeh *et al.,* 2010). Nano-fertilizers are used recently as an alternative to conventional fertilizers due to slow release and efficient use by plants. Lithovit compound particles contain calcium carbonate (80%), magnesium carbonate (4.6%) and Fe (0.75%). The beneficial effect of this compound is being contains calcium carbonate ($CaCO_3$) decomposes to calcium oxide (CaO) and carbon dioxide (CO_2) in leaves stomato, and this Co_2 increases photosynthesis intensity, leading to increased carbon uptake and assimilation, thereby increasing plant growth (Carmen *et al.,* 2014). The positive effects of lithovit compound on plant growth and chemical constituents were reported by (Abd El Ghafar *et al.,* 2016) on onion plants, (Abo-Sedera *et al.,* 2016) on snap bean plants, (Abou-Shleell, 2017) on *moringa olifera.* They declared that foliar application with lithovit at 500 ppm significantly increased all the studied vegetative growth parameters and chemical composition of moringa plants.

Therefore, the objective of this study was to evaluate the effect of foliar spray with some nutrients on vegetative growth, essential oil yield and constituents and some chemical constituents of of *Cymbopogon citratus* plants.

Materials and Methods

This investigation was carried out during the two successive growing seasons 2016 and 2017 at the Experimental Farm of Horticulture Department, Faculty of Agriculture, Benha Univ., to study the influence of some macro and micro nutrients combinations and Lithovit on vegetative growth parameters, yield and constituents of essential oil and some chemical constituents of *Cymbopogon citratus* plants.

The treatments could be arranged as follow:

1. Control (tap water).
2. Ca +Mg at 50ppm for each as foliar spray.
3. Ca +Mg at 100 ppm for each as foliar spray
4. Ca +Mg at 150 ppm for each as foliar spray
5. Fe +Mn +Zn at 50 ppm for each as foliar spray
6. Fe +Mn +Zn at 100 ppm for each as foliar spray
7. Fe +Mn +Zn at 150ppm for each as foliar spray
8. Lithovit at 0.5 g/L for each as foliar spray
9. Lithovit at 1g/L for each as foliar spray

The uniform tillers of lemongrass plants (30 cm height) were obtained from Floriculture Farm, Horticulture Department, Faculty of Agriculture, Benha Univ., planted in mid-March in both seasons in beds (1x1 m) containing two rows (50 cm in-between) . All the traditional cultural practices for growing *Cymbopogon citratus* plants were followed as recommended in this region.

Mechanical and chemical analyses of the experimental soils are presented in Table, 1. Mechanical analysis was estimated according to Jackson, (1973), whereas chemical analysis was estimated according to Black *et al.* (1982).

Experimental layout.

The layout of the experiment was a complete randomized block design included six treatments with three replicates. Each replicate contained 3 plots (4 plants / plot), which represented all combinations between foliar application of mineral elements Ca and Mg was applied as foliar spray in chelated form : control, Ca +Mg at 50,100 and 150ppm. Also, micro-nutrients Fe, Mn and Zn was applied as foliar spray in the form of EDTA (13%) : control, Fe +Mn+Zn at 50,100 and150ppm. In addition Lithovit (micronized calcium carbonate) at Lithovit at 0.5 and 1g/L. Lithovit as Nano particales (Ca, Mg and Fe nano or micro particles) which was obtained from Agro Link Company , Egypt.

Treated plants were foliar sprayed four times a year. The first spray was applied after 30 days from transplanting, the second was applied 21 days later, the third spray took place one month after the first cut and the fourth spray was applied 21 days later the third spray.

Treated plants were sprayed till run off, whereas control plants were sprayed with tap water. The plants were sprayed with a hand pump mister to the point of runoff. A surfactant (Tween 20) at a concentration of 0.01% was added to all tested solutions including the control. Common agricultural practices (irrigation, fertilization, manual weed control, … etc.) were carried out when needed.

Table 1: Mechanical properties and chemical analysis of the experimental soil

Parameters	Values		Parameters	Values	
A. Mechanical properties			B. Chemical analysis		
	(2016)	(2017)		(2016)	(2017)
Coarse sand	6.22 %	6.33 %	Organic matter	1.36 %	1.44 %
Fine sand	13.40 %	14.34 %	$CaCO_3$	0.78 %	0.82 %
Silt	28.22 %	27.88 %	Available nitrogen	0.82 %	0.87 %
Clay	52.16 %	51.45 %	Available phosphorus	0.49 %	0.44 %
Textural class	Clay loam	Clay loam	Available potassium	0.66 %	0.71 %
			pH	7.44	7.55
			EC (dS/m)	0.82	0.78

Harvesting time

During the two seasons lemongrass plants were harvested through two cuts in each harvest. The first cut was done in mid-August. While, the second cut was done on in mid-November of both growing seasons 2016 and 2017.

Data recorded.

I-Vegetative growth:

Plant height (cm), leaves fresh weight / plant (g), Leaves dry weight / plant (g) and number of tillers bases was determined at the end of experiment

II-Chemical composition:

a. Photosynthetic pigments: total chlorophylls were calorimetrically determined in leaves of lemongrass according to the method described by (A.O.A.C, 1990).and calculated as mg/100g fresh weight.
b. Nitrogen, phosphorus, potassium and total carbohydrates were determined in lemongrass herbs according the methods described by (Horneck and Miller, 1998), (Hucker and Catroux, 1980), (Horneck and Hanson, 1998) and (Herbert *et al.,* 1971), respectively. Ca was measured by flame photometer according to the methods outlined by (Westerman, 1990). In addition, micronutrients Mg, Fe, Zn, and Mn (%) were determined in the digested samples by atomic absorption as described by (Chapman and Paratt, 1961).

III-Essential oil characters

1-Essential oil percentage (%);

2-GLC (analysis of the volatile oil constituents).

The percentage of volatile oil were determined in the fresh herb using 100 g samples for each cut per plant. Distillation of volatile oil for 3hr in order to extract the essential oils according to the method described by British Pharmacopeia (1963).

Gas liquid chromatography analysis of essential oil (GLC):

The gas liquid chromatography analysis was carried out at the medicinal and Aromatic plant laboratory. Dokki.

Essential oil samples were performed using Ds chrom 6200 gas chromatograph equipped with aflame ionization detector for separation of volatile oil constituents. The analysis conditions were as follows: The chromatograph apparatus was fitted with capillary column BPX-5.5% phenyl (eguiv.) polysillphenylene – siloxane 30m x 0.25mm ID x 0.25 µm film. Temperature program ramp increase with rate of 10°C/min from 70° to 200°C. Flow rates of gases were nitrogen at 1ml/min, hydrogenat 30ml/min and 330ml/min for air. Detector and injector temperatures were 300°C and 250°C respectively. The obtained chromatogram and report of GC analysis for each sample were analyzed to calculate the percentage of main components of volatile oil.

IV- Statistical analysis

The design of this experiment was a simple experiment in RCBD (Snedecor and Cochran, 1989) as 9 treatments, each treatment replicated three times and each replicate continued 3 plots (4 plants / plot). The differences between the mean values of various treatments were compared by Duncan's multiple range test (Duncan's, 1955).

Results and Discussion

I- Effect of some nutrient foliar spray treatments on vegetative growth of *Cymbopogon citratus* L plants during 2016 and 2017 seasons.

I- Vegetative growth characteristics:

I-1-Plant height (cm)

Table (2) declares that all tested nutrient treatments significantly increased the plant height of *Cymbopogon citratus* L when compared to control at the two cuts in both seasons. However, the tallest plants were produced by (Fe +Mn +Zn) treatment spraying the plants, especially high concentration (150 ppm) of Fe +Mn +Zn which recorded 109.2, 110.7,110.1 and 113.5 in the first and the second cuts of both seasons, respectively. Moreover Fe +Mn +Zn at 100 ppm treatment or lithovit treatment at (1g/L) of produced high increments of plant height in two cuts of both seasons. On the reverse, control gave the lowest values of this parameter regarding the two cuts in both seasons. Furthermore, the rest treatments came in-between the above-mentioned treatments at both cuts and in the two seasons.

Table 2: Effect of some nutrient foliar spray treatments on plant height of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Treatments \ Parameters	Plant height (cm)			
	1st season		2nd season	
	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	84.40 f	85.40 h	89.47 h	92.47 f
Ca +Mg at 50 ppm	90.97 e	91.40 g	91.23 g	93.60 f
Ca +Mg at 100 ppm	95.90 d	95.40 f	97.53 f	97.47 e
Ca +Mg at 150 ppm	101.3 c	99.00 e	100.4 e	102.9 d
Fe +Mn +Zn at 50 ppm	100.1 c	102.4 d	102.6 d	105.5 c
Fe +Mn +Zn at 100 ppm	105.4 c	106.8 b	107.4 b	108.9 b
Fe +Mn +Zn at 150 ppm	109.2 a	110.7 a	110.1 a	113.5 a
Lithovit at 0.5 g/L	101.1 c	102.2 d	101.6 de	104.3 cd
Lithovit at 1 g/L	106.5 b	105.4 c	105.2 c	105.5 c

I-2-Fresh and dry weights of herbs/plant (g)

Table (3) reveals that fresh and dry weights of herb per plant were positively affected by all different nutrients treatments in the two cuts of both seasons. However, lithovit treatments statistically increased the fresh and dry weights of herb per plant, with superiority for the high level (1g/L) of lithovit treatment in the two seasons at both cuts. Moreover, Fe +Mn +Zn at 150 ppm treatment gave the third values in this concern.

Table 3: Effect of some nutrient foliar spray treatments on fresh and dry weight of herbs/plant of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters / Treatments	Fresh weight of herbs (g/plant)				Dry weight of herbs (g/plant)			
	1st season		2nd season		1st season		2nd season	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	850.4i	881.2i	890.4i	911.4i	85.27g	89.27i	91.07h	96.37h
Ca +Mg at 50 ppm	961.0h	950.5h	976.6h	971.5h	98.27e	95.23h	106.2e	103.2g
Ca +Mg at 100 ppm	971.8f	975.4f	1011.6f	1021.2f	98.23e	103.0f	105.1f	107.2f
Ca +Mg at 150 ppm	1030.4e	981.3e	1043.4e	1061.4d	108.1d	107.7e	108.2d	115.4d
Fe +Mn +Zn at 50 ppm	965.4g	971.3g	986.3g	989.43g	97.17f	99.03g	101.0g	103.1g
Fe +Mn +Zn at 100 ppm	1041.6d	1050.4d	1051.4d	1055.6e	108.0d	110.7d	109.2c	113.1e
Fe +Mn +Zn at 150 ppm	1112.5c	1111.6c	1170.6c	1171.3c	129.9c	130.3c	139.7b	138.1c
Lithovit at 0.5 g/L	1176.3b	1181.2b	1190.5b	1195.0b	131.1b	135.4b	141.0a	144.5b
Lithovit at 1 g/L	1190.6a	1220.4a	1221.6a	1232.4a	135.6a	144.9a	141.2a	148.2a

I-3- Tiller numbers/plant.

Table (4) illustrates that, all tested nutrient sprays resulted in significant increments in No. of tillers /plant of *Cymbopogon citratus* L plant, with superiority for lithovit at 1g/L as compared with control in both cuts in the two seasons. Also, lithovit at 0.5 g/L and Fe +Mn +Zn at 150 ppm treatment statistically increased No. of tillers /plant in the first and second cuts of both seasons. On the other side, the control treatment gave the lowest values of this parameter in the two cuts of both seasons.

It is well known that the tested mineral and micro- nutrients supply the plant with the required necessary for the growth and development. Besides, nanoparticles improved the plant growth characteristics (Esitken and Turan, 2004 and Carbonell *et al.,* 2011).

Table 4: Effect of some nutrient foliar spray treatments on No. of tillers /plant of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters / Treatments	No. of tillers /plant			
	1st season		2nd season	
	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	35.7i	54.0h	41.5h	56.7g
Ca +Mg at 50 ppm	38.8h	59.7g	43.3g	61.3f
Ca +Mg at 100 ppm	41.6g	62.7f	45.4f	66.5e
Ca +Mg at 150 ppm	48.3e	68.4d	47.7e	69.7d
Fe +Mn +Zn at 50 ppm	43.7f	65.3e	46.6e	69.3d
Fe +Mn +Zn at 100 ppm	49.7d	69.4d	54.3d	71.3c
Fe +Mn +Zn at 150 ppm	52.3c	70.3c	56.0c	74.4b
Lithovit at 0.5 g/L	54.7b	71.6b	60.5b	71.8c
Lithovit at 1 g/L	58.0a	76.7a	63.4a	79.9a

The abovementioned results of mineral and micro- nutrients are nearly similar to those obtained by, (Youssef, 2009) on rosemary plant, (Nasiri *et al.,* 2010) on chamomile plant, (Ajay *et al.,* 2010) on *Mentha arvensis* L., (Said-Al Ahl and Mahmoud, 2010) on sweet basil, (Amuamuha *et al.,* 2012) on marigold plant., (Khalid, 2012) on anise plant, (Amran, 2013) on *Pelargonium graveolens* , (El-Khyat, 2013) on *Rosmarinus officinalis* and (Youssef, 2014) on *Echinacea purpurea*, (Yadegari, 2015) on borago, thyme and marigold and (Abou-Shleell, 2017) on *Moringa olifera.* that foliar application with mineral elements

(Ca, Mg and Fe chelated) at 500 ppm significantly increased all the studied vegetative growth parameters of this plant.

Also, the abovementioned results of lithovit are in harmony with those attained by, (Abd El Ghafar *et al*., 2016) on onion plants, (Abo-Sedera *et al*., 2016) on snap bean plant and (Abou-Shleell, 2017) on *Moringa olifera.* they mentioned that foliar application of lithovit at 500 ppm significantly increased all the studied vegetative growth parameters.

III. Effect of some nutrients on some chemical composition of *Cymbopogon citratus* L plants.

III - 1- Nitrogen, phosphorus, potassium and total carbohydrates percentage

Tables (5 and 6) reveal that all tested concentrations of Ca +Mg and micro-nutrients Fe +Mn +Zn and levels of lithovit statistically increased leaf N, P, K and total carbohydrate contents of *Cymbopogon citratus* L when compared to control at both cuts in the two seasons. Hence, 1g/L lithovit sprayed plants gave the highest values in this concern, followed in descendingly by lithovit at 0.5g/L in both cuts and seasons . Moreover, the high concentrations of Ca +Mg (150 ppm) gave the third values in this concern. On the contrary, the lowest values of these parameters were recorded by control in the first and second cuts and in both seasons.

Table 5: Effect of some nutrient foliar spray treatments on nitrogen and phosphorus percentage of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters / Treatments	Nitrogen percentage				Phosphorus percentage			
	1st season		2nd season		1st season		2nd season	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	2.32g	2.25h	2.51h	2.43g	0.229d	0.219e	0.230e	0.229e
Ca +Mg at 50 ppm	2.95d	2.91e	2.93f	2.91d	0.265bc	0.271c	0.273cd	0.271cd
Ca +Mg at 100 ppm	3.05c	3.11c	2.99e	3.12bc	0.263bc	0.261cd	0.271cd	0.265d
Ca +Mg at 150 ppm	2.98d	3.11c	3.16c	3.13b	0.267b	0.271c	0.280c	0.275c
Fe +Mn +Zn at 50 ppm	2.64f	2.71g	2.76g	2.74f	0.254c	0.250d	0.261d	0.265d
Fe +Mn +Zn at 100 ppm	2.86e	2.85f	2.90f	2.88e	0.259bc	0.255d	0.266d	0.269d
Fe +Mn +Zn at 150 ppm	2.98d	3.01d	3.04d	3.11c	0.262bc	0.256d	0.271cd	0.270cd
Lithovit at 0.5 g/L	3.17b	3.19b	3.25b	3.29a	0.291a	0.295b	0.294b	0.291b
Lithovit at 1 g/L	3.29a	3.32a	3.35a	3.31a	0.299a	0.310a	0.321a	0.317a

Table 6. Effect of some nutrient foliar spray treatments on potassium and total carbohydrate percentage of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters / Treatments	Potassium percentage				Total carbohydrates percentage			
	1st season		2nd season		1st season		2nd season	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	1.20i	1.16g	1.21h	1.21g	8.16i	8.10i	8.86h	9.11h
Ca +Mg at 50 ppm	1.65e	1.61d	1.69d	1.69d	11.19f	11.31e	11.41e	11.32e
Ca +Mg at 100 ppm	1.70d	1.69c	1.70d	1.69d	11.64d	11.69d	11.76d	11.69d
Ca +Mg at 150 ppm	1.84c	1.79b	1.78c	1.81c	12.14c	12.11c	12.21c	12.34c
Fe +Mn +Zn at 50 ppm	1.29h	1.30f	1.34g	1.37f	10.12h	10.30h	10.65g	10.50g
Fe +Mn +Zn at 100 ppm	1.34g	1.33f	1.40f	1.39f	10.64g	10.61g	10.80f	10.76f
Fe +Mn +Zn at 150 ppm	1.43f	1.46e	1.50e	1.55e	11.31e	11.11f	11.40e	11.31e
Lithovit at 0.5 g/L	1.88b	1.87a	1.87b	1.89b	12.69b	12.65b	12.75b	12.79b
Lithovit at 1 g/L	1.94a	1.91a	2.12a	1.96a	13.14a	13.20a	13.40a	13.36a

III-2. Leaf total chlorophylls, Fe, Zn and Mn contents

Tables (7 and 8) declare that all tested nutrients treatments increased leaf total chlorophylls, Fe, Zn and Mn content of *Cymbopogon citratus* L plant in both cuts and seasons. In this respect, the richest leaf total chlorophylls contents were recorded by Ca +Mg at 150ppm treatment in both seasons as compared with control and the rest treatments, followed in descendingly by Ca +Mg at 100ppm. Besides, spraying *Cymbopogon citratus* plants with Fe +Mn +Zn at 150 ppm treatments proved to be the most pronounced treatments for producing the highest leaf Fe, Zn and Mn content at the both cuts in the two seasons. Also, 1g/L lithovit or Fe +Mn +Zn at 100ppm sprayed plants recorded the highest values of Fe, Zn and Mn content in both cuts and seasons with none significant differences between them in most cases. On the reverse, control treatment gave the lowest values of the aforementioned traits in both cuts and seasons. In addition, the rest treatments came in-between the above-mentioned treatments at both cuts and in the two seasons.

Table 7: Effect of some nutrient foliar spray treatments on Leaf total chlorophylls and iron percentage of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters	Total chlorophylls (mg/100g F.W)				Fe%			
	1st season		2nd season		1st season		2nd season	
Treatments	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	150.9h	147.2g	156.5g	158.0g	0.046f	0.048d	0.051e	0.51d
Ca +Mg at 50 ppm	191.2c	189.2b	193.8b	189.8c	0.056e	0.059c	0.058de	0.057d
Ca +Mg at 100 ppm	195.7b	189.9b	197.5a	196.3ab	0.057de	0.059c	0.060cde	0.058cd
Ca +Mg at 150 ppm	198.9a	196.6a	198.1a	196.9a	0.061cde	0.060c	0.063bcd	0.060bcd
Fe +Mn +Zn at 50 ppm	170.4g	171.5f	174.5f	173.1f	0.065bcd	0.067bc	0.069abc	0.067abc
Fe +Mn +Zn at 100 ppm	176.9f	176.6e	181.4e	179.4e	0.070ab	0.067bc	0.071ab	0.070ab
Fe +Mn +Zn at 150 ppm	187.3d	186.3c	187.7c	189.3c	0.076a	0.076a	0.077a	0.074a
Lithovit at 0.5 g/L	185.3e	180.7d	184.6d	185.1d	0.067bc	0.069ab	0.067bcd	0.068ab
Lithovit at 1 g/L	190.0c	189.2b	193.0b	195.6b	0.070ab	0.070ab	00071ab	0.071a

Table 8. Effect of some nutrient foliar spray treatments on leaf Zn and Mn percentage of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters	Zn%				Mn%			
	1st season		2nd season		1st season		2nd season	
Treatments	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	0.020c	0.020f	0.022c	0.021c	0.012d	0.010d	0.012c	0.012d
Ca +Mg at 50 ppm	0.023bc	0.023e	0.022bc	0.023bc	0.014cd	0.014c	0.014bc	0.013cd
Ca +Mg at 100 ppm	0.023bc	0.024de	0.025abc	0.025abc	0.015bc	0.015bc	0.017a	0.016bc
Ca +Mg at 150 ppm	0.026ab	0.025cd	0.026abc	0.026abc	0.015bc	0.016bc	0.017a	0.015bc
Fe +Mn +Zn at 50 ppm	0.027ab	0.028ab	0.027abc	0.030a	0.015bc	0.014bc	0.018a	0.015bc
Fe +Mn +Zn at 100 ppm	0.030a	0.028ab	0.028ab	0.030a	0.016bc	0.015bc	0.018a	0.017ab
Fe +Mn +Zn at 150 ppm	0.032a	0.030a	0.030a	0.031a	0.019a	0.019a	0.018a	0.018a
Lithovit at 0.5 g/L	0.027ab	0.027bc	0.027abc	0.029ab	0.016abc	0.017ab	0.016ab	0.016bc
Lithovit at 1 g/L	0.029ab	0.027bc	0.029a	0.028ab	0.018ab	0.018a	0.018a	0.018a

III-3. Calcium and magnesium percentage:

Table (9) illustrates that, all tested nutrients treatments statistically affected leaf calcium and magnesium percentage of *Cymbopogon citratus* plants in both cuts and seasons. However, Ca +Mg foliar spray treatments showed to be most affective treatments for increasing leaf calcium and magnesium percentage in the two cuts and seasons, especially the high concentration 150ppm, followed by 100ppm of Ca +Mg treatments. Moreover, 50ppm Ca +Mg or 1g/L lithovit sprayed plants induced increments of these parameters in this respect in both cuts of both seasons.

Additionally, the untreated plants(control) showed the lowest percentages of these two studied parameters at both cuts in the two seasons.

The aforementioned obtained results of mineral and micro-nutrients are in conformity with those obtained by (Youssef, 2009) on rosemary plant, (Nasiri *et al.,* 2010) on chamomile plant, (Ajay *et al.,* 2010) on *Mentha arvensis* L., (Amran, 2013) on *Pelargonium graveolens* , (El-Khyat, 2013) on *Rosmarinus officinalis*, (Youssef, 2014) on *Echinacea purpurea*,. (Abou-Shleell , 2017) on *Moringa olifera.* they mentioned that foliar application with mineral elements (Ca, Mg and Fe chelated) at 500 ppm significantly increased photosynthetic pigments such as chlorophyll a ,b and carotenoids in the two seasons. The results of lithovit are in harmony with those attained by (Abou El-Nasr *et al*., 2015) and (Abo-Sedera *et al*., 2016). and (Abou-Shleell, 2017) on *Moringa olifera,* they reported that foliar with lithovit at 500 ppm increased photosynthetic pigments such as chlorophyll a ,b and carotenoids as compared with control in the two seasons.

Also, effects of lithovit application on photosynthetic pigments could be explained by (Abou El-Nasr *et al.,* 2015) who reported that an increase in leaf bio-chemicals showed a tremendous increase in total and refraction of chlorophyll and carotenoids content using magnetite treatments compared to traditional iron chelate treatment. Previous studies showed that nanoparticles can have a beneficial effect on plants chemical composition (Radhakrishnan and Kumari, 2012).

Table 9: Effect of some nutrient foliar spray treatments on calcium and magnesium percentage of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters / Treatments	Ca%				Mg%			
	1st season		2nd season		1st season		2nd season	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	0.99h	0.67h	1.11h	0.99g	0.19h	0.17i	0.19g	0.19g
Ca +Mg at 50 ppm	1.29c	1.30b	1.30c	1.26d	0.31c	0.29e	0.32cd	0.30d
Ca +Mg at 100 ppm	1.34b	1.30b	1.36b	1.33b	0.37b	0.35b	0.34b	0.35b
Ca +Mg at 150 ppm	1.45a	1.41a	1.46a	1.41a	0.39a	0.37a	0.37a	0.36a
Fe +Mn +Zn at 50 ppm	1.15g	1.11g	1.14g	1.11f	0.23g	0.22h	0.23f	0.22f
Fe +Mn +Zn at 100 ppm	1.17f	1.16f	1.21f	1.18e	0.26f	0.27f	0.26e	0.22ef
Fe +Mn +Zn at 150 ppm	1.21e	1.19e	1.23e	1.19e	0.28e	0.25g	0.25e	0.23e
Lithovit at 0.5 g/L	1.22e	1.21d	1.27d	1.32c	0.29d	0.31d	0.31d	0.31cd
Lithovit at 1 g/L	1.26d	1.25c	1.27d	1.26d	0.32c	0.32c	0.33bc	0.32c

IV. Effect of some nutrients foliar spray treatments on essential oil yield and composition

IV-1- Essential oil percentage

Table (10) indicates that, essential oil percentage of *Cymbopogon citratus* was more affected by all tested nutrient treatments as compared to control in both cuts and seasons. However, the highest values of essential oil percentage (1.32, 1.24, 1.36 and 1.33%) contents were scored by 150ppm Fe +Mn +Zn sprayed plants, in the first and second cuts and seasons, respectively. Also, 100ppm Fe +Mn +Zn or 1g/L lithovit sprayed plants recorded highly increments of this parameter at both cuts, in both seasons. The lowest value of essential oil percentage was produced by unfertilized plants (control) at both cuts and in the two seasons.

Table 10: Effect of some nutrient foliar spray treatments on essential oil percentage of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Parameters / Treatments	Essential oil %			
	1st season		2nd season	
	1st cut	2nd cut	1st cut	2nd cut
Control (tap water)	0.76g	0.73f	0.81g	0.79g
Ca +Mg at 50 ppm	0.87f	0.74f	0.90f	0.84f
Ca +Mg at 100 ppm	0.91e	0.91e	0.92f	0.91e
Ca +Mg at 150 ppm	0.95d	0.93e	0.96e	0.95e
Fe +Mn +Zn at 50 ppm	1.11c	0.96d	1.15c	1.05d
Fe +Mn +Zn at 100 ppm	1.24b	1.20b	1.31b	1.30a
Fe +Mn +Zn at 150 ppm	1.32a	1.24a	1.36a	1.33a
Lithovit at 0.5 g/L	1.12c	1.11c	1.10d	1.13c
Lithovit at 1 g/L	1.21b	1.21b	1.17c	1.20b

Similar enhancing effect to the obtained results in oil percentage with foliar application of micro-nutrients was reported by (Gamal El-Din *et al.,* 1997) on *Cymbopogon citratus*, (Youssef, 2009) on rosemary plant, (Ajay *et al.*, 2010) on Mentha arvensis L., (Nasiri *et al.,* 2010) on chamomile plant, (Amran, 2013) on Pelargonium graveolens and (El-Khyat, 2013) on *Rosmarinus officinalis*. (Yadegari, 2015) on borago, thyme and marigold, they found that the essential oils composition of lemongrass was significantly affected by foliar application of micronutrients.

IV -2- Essential oil constituents:

Table (11) and Figs. (1 to 4) show the effect of the assigned treatments of Ca +Mg at 150 ppm, Fe +Mn +Zn at 150 ppm, Lithovit at 1 g/L and the control on the constituents of essential oil distilled from *Cymbopogon citratus*. six compounds were identified in the volatile oil constituents of lemongrass, i.e. β-Myrcene, Limonene, Linalool, Citral B (Neral), Citral A (Geranial) and Geranyl acetate. The main component was the citral A (Geranial), that ranged from (46.05 to 50.22 %) followed by citral B (Neral) (30.35 to 32.30) and β-Myrcene (9.35 to 10.03%). In addition, unknown component with vales from (0.88 to 6.64%). However, 150ppm Fe +Mn +Zn gave the maximum values of citral A (50.22 %) and Citral B (32.30) followed by Lithovit at 1 g/L (48. 60) and (31.90) of citral A and citral B ,respectivally. Moreover, the lowest values of citral A(46.05) and citral B and (30.35%) was scored by control. Furthemore, 1 g/L Lithovit gave the highest value (10.03) of β-Myrcene as compared of control and the other one.
Similar results was reported by Hamed *et al*. (2017) who illustrated that, nine components were identified in volatile oil on *Cymbopogon citratus* i.e. citral a, citral b, d- limonene, beranyl acetate, borneol, linalool, nerol, methyl geranate and nhexadecane. Citral was the chief component of the oil.

Consequently, it is preferable to spray *Cymbopgon citruts* plants with lithovit at 1g/L or 150ppm Fe +Mn +Zn four times a year to enhance the growth, essential oil yield and constituents and some chemical constituents of this plant.

Table 11: Effect of some nutrient foliar spray treatments on essential oil constituents of *Cymbopogon citratus* L plants during 2016 and 2017 seasons

Peak No.	Component name	Area %			
		Control	Ca +Mg at 150 ppm	Fe +Mn +Zn at 150 ppm	Lithovit at 1 g/L
1	β-Myrcene	9.35	9.58	8.09	10.03
2	Limonene	-	1.99	1.96	2.56
3	Linalool	2.81	2.39	2.33	1.57
4	Citral B (Neral)	30.35	30.66	32.30	31.90
5	Citral A (Geranial)	46.05	46.77	50.22	48.60
6	Geranyl acetate	4.80	4.35	3.79	4.36
*	Unknown	6.64	4.26	1.31	0.88
Total		100.00	100.00	100.00	100.00

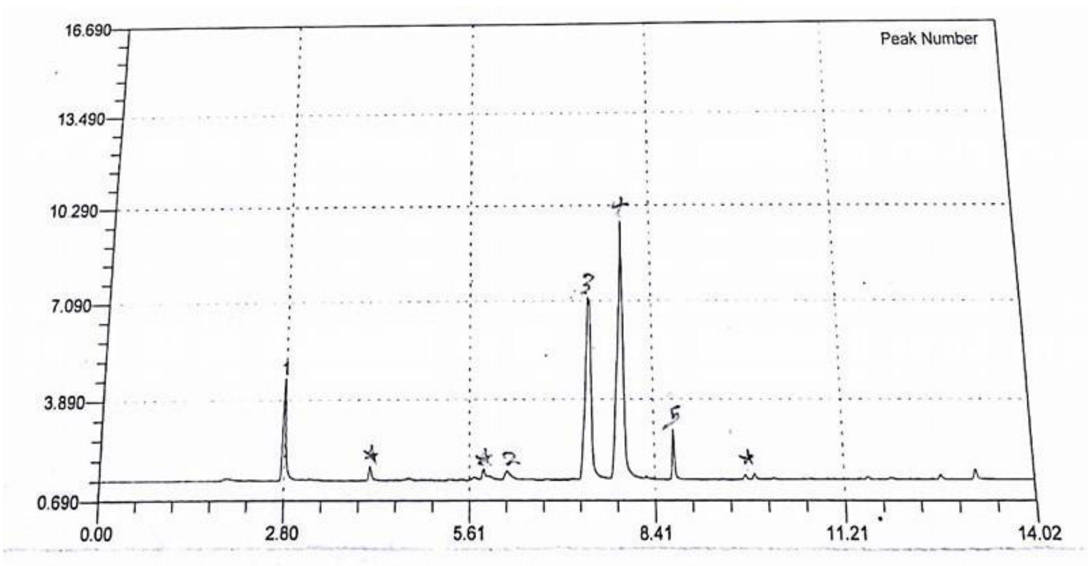

Fig.1: Effect of control treatment on essential oil constituents of *Cymbopogon citratus* plants.

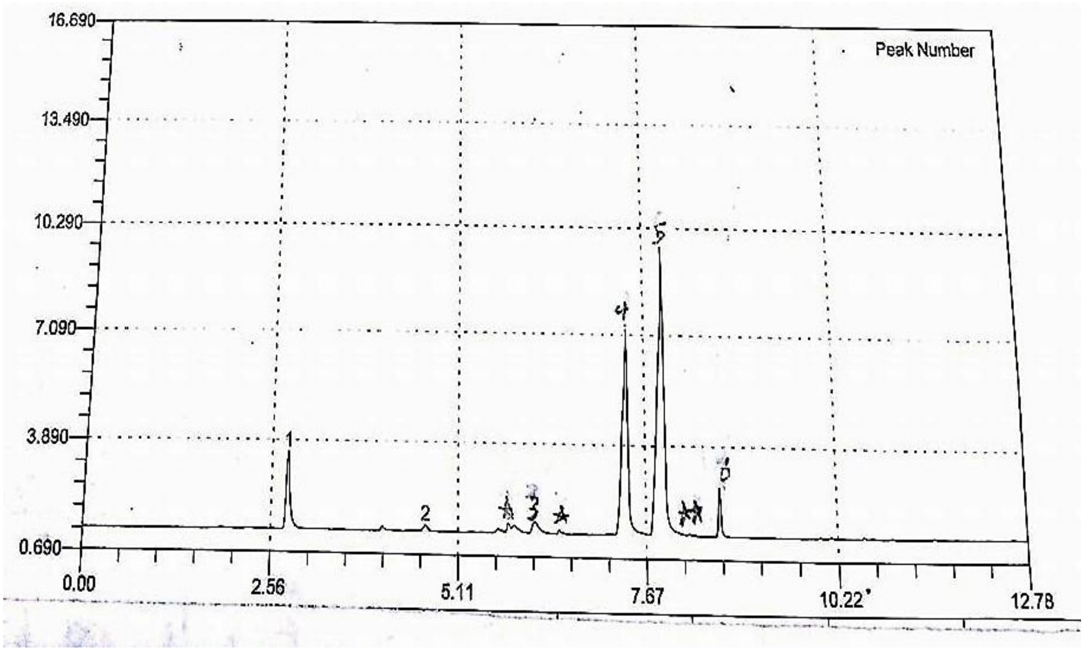

Fig. 2: Effect of Ca +Mg at 150 ppm treatment on essential oil constituents *Cymbopogon citratus* plants.

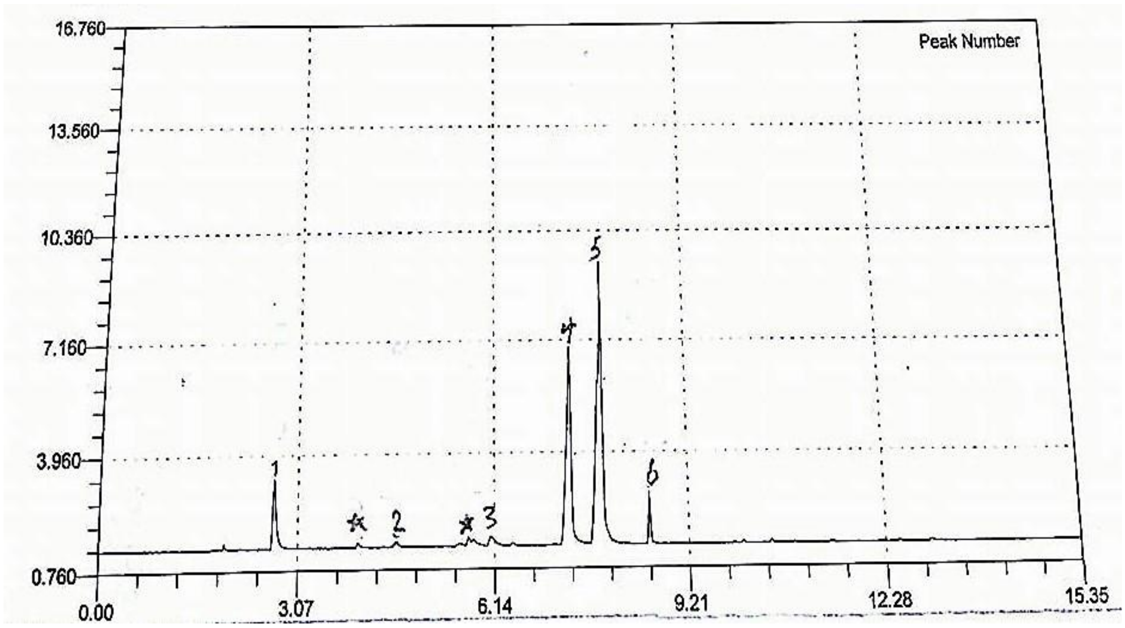

Fig. 3: Effect of Fe +Mn +Zn at 150 ppm treatment on essential oil constituents *Cymbopogon citratus* plants.

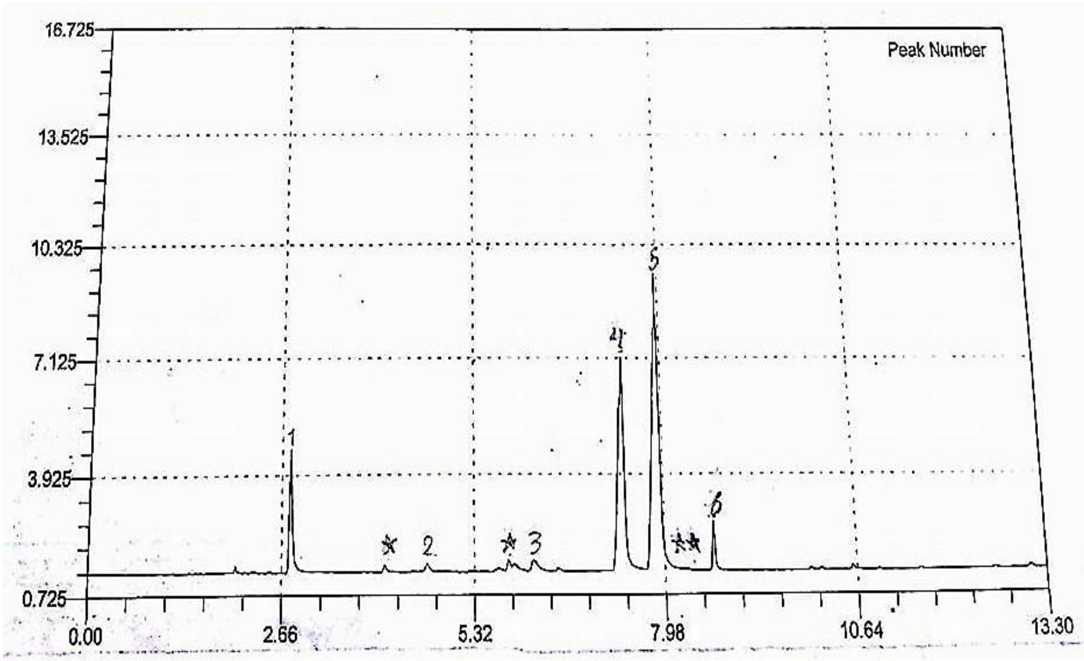

Fig. 4: Effect of Lithovit at 1 g/L treatment on essential oil constituents *Cymbopogon citratus* plants.

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