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Effect Of Some Mineral Nutrients Treatments On Growth And Productivity Of Geranium Plant (*Pelargonium Graveolens, L.*)

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Abstract

A two- year field trial was carried out during 2009/2010 and 2010/2011 seasons at the Experimental Farm, Horticulture Dept., of Agric Fac., Benha Univ., to study the effect of some mineral nutrients i. e., Fe (50, 100 and 150ppm), Zn (75, 100 and 125ppm) and Mn (75, 100 and 125ppm) as well as their combination (Fe + Zn + Mn at 100ppm) on vegetative growth, essential oil and its main components as well as chemical constituents of geranium plants. Results showed that, different applied treatments of mineral nutrients led to significant increase of growth parameters such as plant height, number of branches, fresh and dry weights of plant. However, the highest values of these parameters were recorded by the treatment of F11 (Fe + Zn + Mn at 100ppm) and F7 (Zn at 125ppm). Also, all tested mineral nutrients obviously increased leaves total carbohydrates, N, P, and Kcontents of treated plants, with superiority for the treatments of F11 and F7 in both seasons. In addition, the obtained vigrous growth of geranium plants with different treatments was accompanied by pronounced increase in leaves volatile oil content. Moreover, volatile oil % was increased by spraying with all application of mineral nutrients in both seasons. Moreover, all tested treatments increased the total components of volatile oil, especially the treatment of (Fe + Zn + Mn at 100ppm) followed in descending order by the treatment of Zn at 125ppm. Anyway, the major constituents of leaves volatile oil of geranium were Citronelol and Geraniol, respectively. The highest value of Citronelol, and Geraniol were observed in the treatment of (Fe + Zn + Mn at 100ppm) and Zn at 125ppm .

Consequently, it is preferable spray geranium plants with the treatment of (Fe + Zn + Mn at 100ppm) for enhancing growth and oil productivity.

Key words: Pelargonium grveolens, L. mineral nutrients, vegetative growth, oil productivity.

Introduction

Nowadays, the extension of aromatic and medicinal plants cultivation to face the current demands of the foreign markets has become urgent. This makes medicinal and aromatic plants of great importance as exportable crops and source of hard currency. Moreover, they offer the raw materials for some of our important industries such as; pharmaceutical, perfume and cosmetics, soap and food industries, (**Mostafa, 2006**). *Pelargonium graveolens*, L. (Rose - scented geranium) belongs to Family Geraniaceae. It is not to be confused with the household variety of geranium, which is a completely different species. There are over 700 varieties of cultivated geranium; however, most are grown for ornamental purposes. The plants of Pelargonium are native to South Africa, (**Shawi *et aL*, 2006).** Geranium *(P. graveolens,* L.) is one of the most important medicinal and aromatic plants. The importance of geranium and its essential oil arises from their uses in the manufacture of soaps, creams, cosmetics and flavouring and perfumes... etc. The Encyclopedia of essential oils mentioned that geranium herb and oil are also used as an antidepressant, antihaemorrhagic, anti-inflammatory, antiseptic, astringent, cicatrisant, deodorant, diuretic, fungicid, heamostatic, stimulant, styptic, tonic, vermifuge and vuhnerary **(Lawless, 1992).**

The role of iron is incorporated directly into the cytochromes, into compounds necessary to the electron transport system in mitochondria and into ferredaxin **(Nason and Mc-Elory, 1963).** Concerning iron, **Mousa and El-Lakany (1984)** indicated that, foliar application of iron to *Tagetes erecta* increased flower yield, weight and length of flower stalk Mohamed **(1992)** found that, foliar spray with iron increased vegetative growth, flowering and carbohydrates content of *Dahlia pinnata* plants.

Zinc is one of the essential microelements for growth and flowering of plants (**Chandler, 1982; Gomaa, 1997 and Youssef, 2000).** Many investigatores reported the stimulating effect of applied micronutrients as soaking or foliar spray on growth and flowering of different ornamental plants; **Mohamed (1985)** found that Mn at 75 or 375 ppm. and Zn at 45 or 225 ppm. increased the vegetative growth, flowering and tuberous roots production of *Dahlia hybrida* cv. "Moon Light Sonata". **Andon (1973)** concluded that foliar application of Mn and Zn to tobacoo and to hybrid petunia stimulated flower formation and seed production. **Savva (1977)** revealed that foliar application of Mn to *Dianthus chinensis* improved yields quality and seed yield. **Mousa and El-Lakany (1984)** indicated that foliar application of Fe, Zn and Mn to *Tageates erecta* increased flower yield, weight and length of flower stalk.

Maharana and Pradhan (1980) stated that the application of Mn to hybrid rose improved the number of leaves, shoots and flowers. **Mohamed (1985)** found that zinc at (30 or 150 ppm) increased the vegetative growth, flowering, tuberous roots production of *Dahlia hybrida* cv. Moon Light Sonata.

The aim of the study is to evaluate the effect of foliar spray with some mineral nutrients treatments on growth, volatile oil content and its main components as will as chemical composition of geranium (*Pelargonium graveolens, L.*) plants.

Materials and methods

Two field experiments were conducted at the Experimental Farm and in the Laboratory of Horticulture Department, Faculty of Agriculture at Moshtohor, Benha Univ., during 2009/2010 and 2010/2011 seasons to study the influence of some mineral nutrients i.e., Fe, Zn and Mn on vegetative growth, essential oil and its main components as well as chemical constituents of geranium plants.

Geranium well rooted stem cuttings were obtained from Floriculture Farm, Horticulture Department, Faculty of Agriculture, Benha Univ., The uniform terminal cuttings with length (20 cm long) with 4 – 6 leaves were translanted in clay loam soils on mid March in both seasons in plots (1x1 m) containing two rows (50 cm. in-between), each row contained two hills (50 cm. apart). Soil was directly irrigated to provide suitable moisture for growth. All the normal cultural practices for growing geranium plants were followed as recommended in the experimental soil region.

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

Table a. Mechanical properties of the experimental soil.

Texture	Sand %		Clay %	Silt %
	Fine	Coarse		
Clay	**5.09**	**7.43**	**54.0 7**	**33.41**

Chemical properties of experimental soil soluble actions and anions m mol/L Available (ppm).

Table b. Chemical properties of the soil.

pH	E.C ds/m	SO_4^{--} meq./L	Cl^- meq./L	HCO_3^- meq./L	Mg^{++} meq./L	Ca^{++} meq./L	K^+ meq./L	Na^+ meq./L	N ppm	P ppm	K ppm	Fe ppm	Mn ppm	Zn ppm
7.34	0.62	0.80	3.4	2.00	1.20	2.50	1.23	1.27	918.7	17.9	431.7	9411.1	450.1	72.43

Experimental layout.

This experiment included 11 treatments were set up in a simple experiment with complete randomized blocks, design as follows:
(1)Control (without any fertilization). (2) Fe at 50 ppm. (3) Fe at 100 ppm. (4) Fe at 150 ppm. (5) Zn at 75 ppm. (6) Zn at 100 ppm (7) Zn at 125 ppm. (8) Mn at 75 ppm. (9) Mn at 100 ppm (10) Mn at 125 ppm. (11) Fe + Zn + Mn (100 ppm). The plants were received the micro nutrients at tested concentration as foliar spray four times in each season. The first and second ones were sprayed at three weeks interval, starting March 10th, while the third and fourth ones were also, sprayed at three weeks interval, 20th of May. The experiment design followed was complete randomized blocks design with four replications, Each replicate contained four plants.

Treated plants were sprayed till run off, whereas control plants were sprayed with tap water.

Data recorded

In both seasons, two cuts were taken viz., the first cut was taken in mid-May, whereas the second one was performed in mid-September. The following measurements were calculated in each cut as follows; plant height (cm.) number of leaves/plant, number of branches/plant, fresh and dry weights of herb/plant (g). The percentage of N,P,K, and total carbohydrates was determined in the dry matter leaves, Total nitrogen was determined using the modified MicroKieldahl method according to **A.O.A.C. (1980).** While, total phosphorus percentage was determined according to **Murphy an Rily (1962),** Potassium percentage was determined by Flame-photometer as described by **Brown and Lilleland (1964),** total carbohydrates percentage was determined according to **Dubois et al., (1956).** Leaves volatile oil percentage. The essential oil of each treatment was extracted by hydro-distillation according to **Guenther (1961).**

The GLC analysis of the leaves volatile oil (second cut) was carried out using Gas chromatograph, (Hewlett packard GC. Model 5890) equipped with a flame ionization detector (FID). A fused silica capillary (HP-5), (30 m length x 0.53 mm internal diameter (i.d.) x 0.88 um film thickness) , was used for the separation in the GC. The identification of the different constituents was achieved by comparing their retention times with those of the authentic samples.

Statistical analysis.

The obtained data in both seasons of study were subjected to analysis of variance as a factorial experiment. LSD method was used to compare the means according to **Snedecor and Cochran (1989).**

Results and discussion

1-Effect of some micro-nutrients fertilizer treatments on vegetative growth of *Pelargonium graveolens* plant.

1-1 Plant height (cm):

Data presented in Table (1) on plant height as affected by some micro-nutrients treatments, reveal that all studied fertilization treatments progressively increased the plant height of *Pelargonium graveolens* L. plant when compared with control (F1) in both seasons of this study. However, the treatment of Fe+Zn+Mn at 100ppm (F11) is being the most effective one for producing the tallest plants, followed in descending order by using the treatment of Zn at 125ppm (F7) when compared with control (F1) . On contrary, the lowest value of this parameter was gained by using the treatment of control (F1) in both seasons. The other treatments occupied an intermediate position between the aforementioned treatments in both seasons of this study..

Regardless the effect of micro-nutrients fertilization, the tallest plants of *Pelargonium graveolens* was scored in the second cut of this study in both seasons in most cases. As for the interaction effect between micro-nutrients fertilization treatments and cuts, it was observed that the greatest values of this parameter were recorded by using the treatment of F11 at the second season, followed by using the same treatment in the second season, at the first cut and the treatment of F7 in the second one. The lowest value of this parameter was scored by using the treatment of control (F1) at the first and second cuts of this study in both seasons.

1-2- Number of leaves/plant:

Data presented in Table (1) show that all tested applications of micro-nutrients fertilizer treatments resulted in significant increments in leaves number of *Pelargonium graveolens* plants as compared with control, particularly the treatment of F11 which induced the highest leaves number/plant followed by using F7 when compared with control in both seasons. Additionally, the second cut (regardless the effect of fertilizations) was more effective in inducing the highest number of leaves/plant as compared with the first cut. This trend was true in both seasons. As for the interactions effect between fertilization and cuts, it was concluded that all resulted interactions increased leaves number of this plant, particularly the treatment of F11 at the first and second cut, followed by using the treatment of F7 at the two cuts in both seasons of this study. On the reverse, the lowest leaves number was scored by using F1 under the first and second cut in both seasons.

1-3- Number of branches/plant:

Data tabulated in Table (2) show that the number of branches/plant was progressively increased by using all studied micro-nutrients application fertilizer treatments, especially the treatment of F11 which induced the highest value in this concern, followed by using the treatment of F7 as compared with control and the other treatments in both seasons. Irrespective control, the lowest branches number/plant was recorded by using the treatment (F5) as an average in both seasons.

Furthermore, (regardless the effect of fertilization treatments) the highest number of branches was gained at the second cut as compared with the first cut in both seasons. However, all resulted combinations between micro-nutrients fertilizer treatments and cuts succeeded in increasing the number of branches, particularly the treatment of F11 at the two cuts, followed by using the treatment of F7 under the two cuts in both seasons. On the reverse, the lowest value of this parameter (regardless control) was recorded by using Mn at 75ppm (F8) in the first season either under the first cut or under the second cut and the treatments of F5 and F8 in the second one. in both seasons. The remained treatments occupied an intermediate position between the aforementioned treatments in both seasons.

1-4- Total fresh and dry weights of leaves/ plant (g):

It is clear from data in Table (3) that all studied treatments of micro-nutrients fertilizer statistically increased the total fresh and dry weights of plants at the two seasons as compared with control. However, the heaviest total fresh and dry weights of plant was recorded by using the treatment of F11, followed by using the treatment of F7. Moreover, F4-treated plants induced highly significant increments in this concern. This trend was true in both seasons of this study. Whereas, the lowest value of this parameter "irrespective control" was gained by using the treatment of F8 in both seasons. The remained treatments occupied an intermediate position between the aforementioned treatments in both seasons. Irrespective the effect of fertilization treatments, it was observed that the highest values of this parameter were recorded at the second cut as compared with those obtained in the first cut. This trend was true on both seasons. The differences between cuts were non-significant in the first season, and significant in the second one. Generally, the treatment of F11 at the two cuts in the both seasons showed to be the most effective for producing the heaviest total fresh and dry weights of plant as compared with the other treatments in both seasons. Also, applying the treatments of F7 and F4 at the two cuts induced highly significant increases in this respect at the two seasons.

Such increase in plant height and the fresh and dry weights of herb could be attributed to that the used of micro-nutrients fertilizers might enhance cell division and/or cell enlargement as well as the anabolic processes resulting in tallest plant and higher weight of herb .Besides, they might play a direct or indirect role in plant anabolism through activating photosynthetic processes as well as the accumulation of their products in plant organs resulting in more herb fresh and dry weights. The abovementioned results of mineral nutrients are in conformity with those obtained by **Gomaa (2008)** indicated that foliar application of Fe, Zn and Mn to *Hibiscus sabdariffa,* L plant increased vegetative growth parameters such as plant height, stem diameter, number, fresh and dry weights of branches and leaves/ plant. **Youssef (2009)** reported that spraying rosemary plants with Fe, Zn or Mn each at 150 ppm succeeded in increasing vegetative growth parameters such as plant height, stem diameter, number, fresh and dry weights of branches and leaves/ plant.

2-Effect of some micro-nutrients fertilizer treatments on oil production of *Pelargonium graveolens* plant.

2-1- Essential oil percentage (%):

Data in Table (4) clearly show that the essential oil percentage of *Pelargonium graveolens* plants was progressively increased as a result of applying all micro-nutrients fertilization treatments as compared with untreated control in both seasons. The highest values in this concern were obtained by applying F11 treatment, followed in descending order by using F7 treatment in both seasons. Moreover, F4-treated plants resulted highly significant increases in this respect in both seasons. Whereas, the lowest values were recorded for untreated control, followed in ascending order by using F8 treatments in both seasons. The best treatments occupied an intermediate position between the aforementioned treatments in both seasons. Regardless fertilizer treatments, the highest essential oil percentage (%) was scored in the first cut as compared with the second cut in both seasons. Generally, the greatest leaves essential oil content (%) was recorded by using F11 treatment at the first cut, followed descendingly by using F7 treatment at first cut. Also, F7-treated plants at the first cut gave highly significant increments in this concern. This trend was true in both seasons. On contrary, (irrespective control) the lowest values of this parameter were recorded by applying F8 at the second cut in both seasons.

The aforementioned results of mineral nutrients are in parallel with those obtained by **Gomaa (2008)** indicated that foliar application of Fe, Zn and Mn to *Hibiscus sabdariffa,* L plant increased leaves oil percentage. **Youssef (2009)** reported that spraying rosemary plants with Fe, Zn or Mn each at 150 ppm succeeded in increasing oil % and oil yield/plant.

2-2- Gas chromatograms of geranium leaves volatile oil distilled as affected by different mineral nutrients treatments.

Data in Table (5) as illustrated in Figs (1 to 6) clearly indicate that GLC analysis of the volatile oil of geranium revealed the presence of α- Pinene, Myrcene, P-cymene, Limonene, Linalool, Citronelol, and Geraniol in all treatments. However, as shown in Table (5) all treatments increased the total components of volatile oil, especially the treatment of F7 followed in descending order by the treatment of F11. Anyway, the highest main components of geranium leave volatile oil were Citronelol, and Geraniol respectively. The highest values of Citronelol, and Geraniol were observed in the treatments of F7 and F11 in the first and second cuts

3-Effect of some micro-nutrients fertilizer treatments on chemical composition of *Pelargonium graveolens* plant.

3- Chemical composition determinations:

3-1- Leaf carbohydrates content (%):

Data presented in Table (6) show that all studied micro-nutrients fertilizer applications statistically increased leaf carbohydrates content, especially the treatment of F11which induced the highest value in this regrad as compared with untreated plants "control" in both seasons. Moreover, using the treatment of F7 and F4 resulted in highly significant increments in this concern in both seasons. In addition, leaf total carbohydrates content in the first cut was more than in those obtained in the second cut in both seasons.

Generally, the greatest leaf total carbohydrates content was scored in the two cuts by using F11-treated plants, followed in descending order by using the treatment of F7 in the first cut. On contrary, the lowest value of this parameter was scored by using the untreated plants "control". The remained treatments occupied on intermediate position between the aforementioned treatments. This trend was true in both seasons of this study.

3-2- Leaf nitrogen content (%):

Data presented in Table (6) clear that all studied micro-nutrients fertilizer applications progressively increased leaf total nitrogen content, especially the treatment of F11 which induced the greatest value in this concern as compared with untreated plants "control" in both seasons. Moreover, using the treatment of F7 and F10 induced highly significant increments in this concern in both seasons. On the opposite, the lowest values of this parameter were gained by using F8 (irrespective control). The rest treatments occupied an intermediate position between the aforementioned treatments. In addition, leaf total nitrogen content in the second cut was more than in those obtained in the first cut in both seasons.

In general, the richest leaf total nitrogen content was recorded by using F11- treated plants at the two cuts, followed in descending order by using the treatment of F7 at the two cuts in both seasons. On contrary, the lowest value of this parameter was scored by using the untreated plants "control". This trend was true in both seasons of this study.

3-3-Leaf phosphorus content (%):

Data presented in Table (7) reveal that all tested micro-nutrients fertilizer applications succeeded in increasing leaf total nitrogen content, with superior for the treatment of F11 in both seasons. Moreover, using the treatments of F7 and F4 induced highly significant increases in this respect in both seasons. Additionally, leaf total nitrogen content in the second cut was more than in those obtained in the first cut in both seasons.

Generally, the highest leaf total nitrogen content was obtained by using F11- treated plants at the two cuts, followed by applying the treatments of F7 at the two cuts in both seasons. Furthermore, F4-treated plants at the two cuts gave highly increments in this concern in both seasons. On contrary, the lowest value of this parameter was scored by using the untreated plants "control". The rest treatments occupied an intermediate position between the aforementioned treatments. This trend hold true in both seasons of this study.

3-4- Leaf potassium content (%):

Data in Table (7) declare that all examined micro-nutrients fertilizer applications progressively increased leaf potassium content, especially the treatment of F11 which induced the highest value in this connection as compared with untreated plants "control" in both seasons. Moreover, using the treatment of F7 and F4 induced highly significant increases in this respect in both seasons. On the reverse, the F1-treated plants scored the lowest value of this parameter in both seasons. In addition, leaf potassium content in the second cut was more than in those obtained in the first cut in both seasons.

In general, the highest leaf potassium content was recorded by using F11- treated plants at the two cuts, followed in descending order by using the treatment of F7 in the two cuts. On contrary, the lowest value of this parameter was scored by using the untreated plants "control". The remained treatments occupied an intermediate position between the aforementioned treatments. This trend was recorded in both seasons of this study.

The effects of the studied mineral nutrients may be due to the role of iron as it incorporated directly into the cytochromes, into compounds necessary to the electron transport system in mitochondria and into ferredaxin. Ferredaxin is indispensable to the light reactions of photosynthesis. Iron is essential for the synthesis of chlorophyll and it plays an essential chemical role in both the synthesis and degradation of chlorophyll, **(Nason and Mc-Elory, 1963).** Iron is required in the synthesis of chloroplast proteins. Protoporphyrinin-9 is one of the intermediates in chlorophyll biosynthesis and may represent a branch point in the biosynthesis of either cytochromes or chlorophyll. The synthetic path is dependent on which metal, magnesium or iron, is incorporated into the porphyrin structure **(Granick, 1950).**

Moreover, Zinc is one of the essential microelements for growth and flowering of plants **(Chandler, 1982).** It is recorded that zinc is essential at a specific concentration for sucrose synthesis **(Takaki and Kusizaki, 1987)** and production of auxin in plants. Zinc also is a part of enzymes participate in starch and protein synthesis **(Amberger, 1974).**

The aforementioned results of mineral nutrients are in conformity with those obtained by **Gomaa (2008)** indicated that foliar application of Fe, Zn and Mn to *Hibiscus sabdariffa*, L plant increased leaves N, P, K and total carbohydrates contents. **Youssef (2009)** mentioned that spraying rosemary plants with Fe, Zn and Mn at 150 ppm increased leaves total chlorophylls, N, P and K contents.

Generally, it could be recommended from the previous results, that foliar application with mineral nutrients especially Fe, Zn and Mn as well as their combination could play an important role in improving growth, yield and volatile oil content of geranium plants. Therefore, the present study strongly admit the use of such treatments to provide good and high exportation characteristics due to its safety role on human health.

Table 1. Plant height and number of leaves per plant of *Pelargonium graveolens* as affected by some micro-nutrient treatments during the two successive seasons of 2010 and 2011.

Parameters	Plant height (cm)						Number of leaves / plant					
Treatments	First season		Mean	Second season		Mean	First season		Mean	Second season		Mean
	1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut	
Control (F1)	43.000	40.250	41.625	48.333	68.253	58.293	98.250	109.750	104.000	58.500	85.250	71.875
Fe at 50 ppm (F2)	52.500	54.500	53.500	65.095	85.157	75.126	111.250	124.250	117.750	105.000	141.500	123.250
Fe at 100 ppm (F3)	59.750	56.500	58.125	68.330	88.415	78.373	112.250	125.000	118.625	155.000	190.750	172.875
Fe at 150 ppm (F4)	62.500	64.500	63.500	71.557	91.600	81.579	119.000	131.250	125.125	207.500	241.000	224.250
Zn at 75 ppm (F5)	52.750	54.250	53.500	60.350	80.315	70.333	106.000	116.750	111.375	89.500	121.500	105.500
Zn at 100 ppm (F6)	49.750	67.500	58.625	75.715	95.578	85.646	222.250	235.000	228.625	226.750	261.250	244.000
Zn at 125 ppm (F7)	67.250	71.000	69.125	78.880	99.005	88.943	232.500	245.250	238.875	244.750	279.500	262.125
Mn at 75 ppm (F8)	50.750	53.750	52.250	66.645	86.730	76.688	108.500	120.250	114.375	88.500	119.750	104.125
Mn at 100 ppm (F9)	54.000	55.500	54.750	67.475	87.550	77.513	111.750	124.750	118.250	133.500	166.750	150.125
Mn 125 ppm (F10)	61.250	57.500	59.375	68.613	88.702	78.658	115.750	128.500	122.125	175.750	209.750	192.750
Fe+Zn+Mn at 100 ppm (F11)	71.750	73.000	72.375	95.550	115.50	105.53	233.750	246.250	240.000	345.750	372.500	359.125
Mean	56.841	58.932	57.886	69.686	89.710	79.698	142.841	155.182	149.011	166.409	199.045	182.727
L.S.D. at 5% for Cuts		N.S.			0.728			2.221			5.168	
L.S.D. at 5% for Treatments		7.542			5.630			5.210			12.119	
L.S.D. at 5% for Interactions		9.250			2.220			8.350			16.870	

Table 2. Branches numbers per plant of *Pelargonium graveolens* as affected by some micro-nutrient treatments during the two successive seasons of 2010 and 2011.

Parameters	Number of braches / plant					
Treatments	First season		Means	Second season		Means
	1 Cut	2 Cut		1 Cut	2 Cut	
Control (F1)	16.250	20.500	18.375	11.750	20.000	15.875
Fe at 50 ppm (F2)	23.000	25.250	24.125	26.750	36.250	31.500
Fe at 100 ppm (F3)	28.500	28.000	28.250	38.000	49.500	43.750
Fe at 150 ppm (F4)	30.000	31.250	30.625	69.750	79.500	74.625
Zn at 75 ppm (F5)	25.000	23.250	24.125	21.750	28.250	25.000
Zn at 100 ppm (F6)	29.500	31.000	30.250	62.750	73.500	68.125
Zn at 125 ppm (F7)	32.000	34.000	33.000	80.500	89.500	85.000
Mn at 75 ppm (F8)	23.750	24.250	24.000	23.250	30.250	26.750
Mn at 100 ppm (F9)	26.500	27.250	26.875	35.750	43.250	39.500
Mn 125 ppm (F10)	28.750	32.250	30.500	54.000	62.000	58.000
Fe+Zn+Mn at 100 ppm (F11)	32.500	33.750	33.125	107.250	114.250	110.750
Mean	26.886	28.240	27.591	48.318	56.932	52.625
L.S.D. at 5% for Cuts		1.144			1.294	
L.S.D. at 5% for Treatments		2.682			3.035	
L.S.D. at 5% for Interactions		3.960			4.580	

Table 3. Fresh and dry weight of leaves per plant of *Pelargonium graveolens* as affected by some micro-nutrient treatments during the two successive seasons of 2010 and 2011.

Parameters	Fresh weight of leaves / plant (g)						Dry weight of leaves / plant (g)					
	First season		Mean	Second season		Mean	First season		Mean	Second season		Mean
Treatments	1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut	
Control (F1)	326.500	333.750	330.125	489.325	134.055	311.690	53.200	57.252	55.226	92.668	127.748	110.208
Fe at 50 ppm (F2)	373.000	390.250	381.625	1102.500	1324.030	1213.270	61.787	60.757	61.272	228.258	269.268	248.763
Fe at 100 ppm (F3)	424.000	426.750	425.375	1338.500	1474.440	1406.470	64.050	68.312	66.181	254.985	295.405	275.195
Fe at 150 ppm (F4)	459.650	463.250	461.450	1454.250	1636.390	1545.320	64.840	69.457	67.149	284.930	324.115	304.522
Zn at 75 ppm (F5)	387.250	391.750	389.500	1126.750	1324.150	1225.450	58.563	62.948	60.755	229.797	269.872	249.834
Zn at 100 ppm (F6)	453.750	456.750	455.250	1346.250	1468.460	1407.360	63.890	68.557	66.224	255.425	295.848	275.636
Zn at 125 ppm (F7)	501.500	505.000	503.250	1593.750	1618.880	1606.320	65.635	70.367	68.001	291.990	332.622	312.306
Mn at 75 ppm (F8)	338.500	375.250	356.875	1018.250	1240.320	1129.290	56.287	62.290	59.289	214.718	254.395	234.556
Mn at 100 ppm (F9)	422.000	424.500	423.250	1269.500	1342.960	1306.230	61.300	66.485	63.892	234.278	275.452	254.865
Mn 125 ppm (F10)	494.000	497.000	495.500	1522.250	1640.300	1581.280	72.063	76.625	74.344	290.977	328.055	309.516
Fe+Zn+Mn at 100 ppm (F11)	626.750	627.500	627.125	1678.050	1650.070	1664.060	84.917	89.700	87.309	303.083	337.365	320.224
Mean	436.991	444.705	440.848	1267.220	1350.370	1308.790	64.230	68.432	66.331	243.737	282.740	263.239
L.S.D. at 5% for Cuts		N.S.			21.478			2.220			3.169	
L.S.D. at 5% for Treatments		41.131			50.370			5.207			7.432	
L.S.D. at 5% for Interactions		58.343			71.122			8.643			9.325	

Table 4. Essential oil percentage and oil yield per plant of *Pelargonium graveolens* as affected by some micro-nutrient treatments during the two successive seasons of 2010 and 2011.

Parameters / Treatments	Essential oil percentage (%)					
	First season		Means	Second season		Means
	1 Cut	2 Cut		1 Cut	2 Cut	
Control (F1)	0.215	0.203	0.209	0.207	0.198	0.203
Fe at 50 ppm (F2)	0.298	0.288	0.293	0.295	0.287	0.291
Fe at 100 ppm (F3)	0.344	0.302	0.323	0.335	0.295	0.315
Fe at 150 ppm (F4)	0.387	0.313	0.350	0.380	0.308	0.344
Zn at 75 ppm (F5)	0.329	0.299	0.314	0.321	0.292	0.307
Zn at 100 ppm (F6)	0.379	0.305	0.342	0.368	0.300	0.334
Zn at 125 ppm (F7)	0.383	0.328	0.356	0.380	0.323	0.351
Mn at 75 ppm (F8)	0.312	0.263	0.288	0.308	0.260	0.284
Mn at 100 ppm (F9)	0.329	0.300	0.314	0.321	0.295	0.308
Mn 125 ppm (F10)	0.383	0.311	0.347	0.376	0.308	0.342
Fe+Zn+Mn at 100 ppm (F11)	0.395	0.348	0.371	0.388	0.345	0.367
Mean	0.341	0.296	0.319	0.334	0.292	0.313
L.S.D. at 5% for Cuts		0.006			0.006	
L.S.D. at 5% for Treatments		0.015			0.015	
L.S.D. at 5% for Interactions		0.021			0.021	

Table 5. Effect of Fe, Zn and Mn on the identified constituents of leaves volatile oil of Geranium plant (*Pelargonium graveolens*, L.) obtained from GLC analysis and calculated as relative percentages.

Components / Treatments	U.K	U.K	α- Pinene	U.K	Myrcene	P-cymene	U.K	Limonene	U.K	U.K	Linalool	U.K	Citronelol	Geraniol	Citronelly Formate	U.K	U.K	Eugenol	β-Caryophyllene	U.K	U.K	U.K	U.K	U.K	U.K	U.K	U.K	U.K	Total
	Area %																												
First cut																													
Control (F1)	0.59490	0.59700	0.02366	0.24864	0.08687	0.51873	0.08317	7.08712	0.32328	5.53607	0.61947	0.88964	36.6479	21.5768	0.56700	1.40896	0.26903	1.33772	0.84998	2.74768	0.84597	0.27402	1.89890	0.38172	9.29259	4.66172	0.63150	-----	100.000
Zn at 125 PPm (F7)	0.42100	0.26597	0.15719	0.17603	0.26739	0.20304	0.05281	5.00281	0.91324	0.27499	4.62072	1.00013	37.4226	23.2656	2.70622	0.54324	1.59769	1.59901	1.15329	0.79809	0.71954	1.41852	0.75162	0.02889	1.51679	13.0836	0.03962	-----	100.000
Fe+Zn+Mn at 100 PPm (F11)	0.14895	0.68930	0.02481	0.32547	0.67422	0.10659	6.8008	0.81888	0.27145	4.34634	0.68622	3.81449	34.7154	23.8307	1.64635	1.08466	0.42952	0.91096	1.69544	1.13150	0.85775	0.12886	1.74316	0.31676	8.38417	1.78934	2.62957	-----	100.000
Second cut																													
Control (F1)	0.43344	0.13953	0.36213	0.17794	8.61830	0.24648	4.55201	0.42829	0.56477	0.3365	0.23175	2.13729	40.6251	21.1499	1.69615	0.51613	1.19809	1.22630	0.82995	1.35233	0.35047	0.35281	1.58001	0.20699	8.06473	1.23727	1.51862	0.16947	100.000
Zn at 125 PPm (F7)	0.2075	0.2843	0.1853	0.0148	0.2843	0.4193	0.0552	5.8557	0.5763	0.1672	4.5294	0.2671	44.068	25.108	3.8098	0.3585	1.0384	0.5867	0.3676	1.4398	0.4898	0.0789	1.1527	0.2125	5.5914	1.2081	1.6430	-----	100.00
Fe+Zn+Mn at 100 PPm (F11)	0.1948	0.2876	0.2498	0.1024	0.2647	0.2374	4.9821	0.6926	4.1093	0.3964	3.4988	0.0682	36.292	24.452	1.4812	0.1666	0.4504	0.1256	0.7788	0.7466	1.0979	0.8857	2.4771	0.2973	10.196	2.0331	3.4354	-----	100.00

Fig (1-6): Gas chromatograms of Geranium leaves distilled volatile oil as influenced by Fe, Zn and Mn on the identified constituents of leaves volatile oil .

First cut

1- U.K 2- U.K 3- α- Pinene 4- U.K 5- Myrcene 6- P-cymene 7- U.K 8- Limonene 9- U.K 10- U.K

11- Linalool 1 2- U.K 13- Citronelol 1 4- Geraniol 15- Citronelly Formate 16- U.K 17- U.K 1 8- Eugenol

1 9- B- Caryophyllene 20- U.K 21- U.K 22- U.K 23- U.K 24- U.K 2 5- U.K 26- U.K 27- U.K 28- U.K

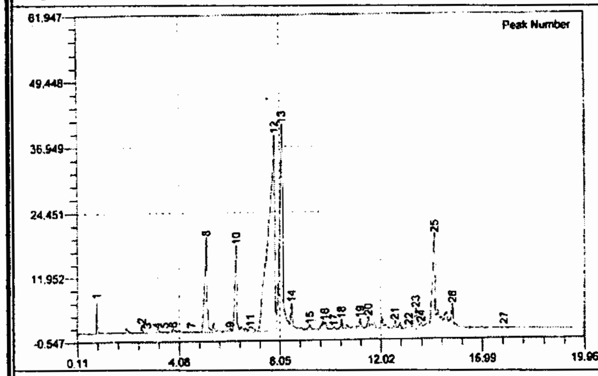

Fig (1): Gas chromatograms of Geranium leaves volatile distilled of untreated plants (First cut)

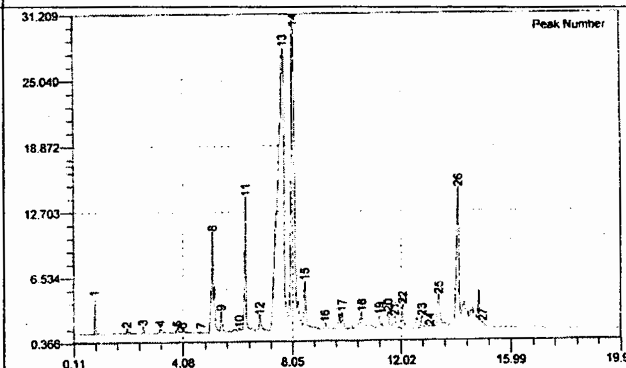

Fig (2): Gas chromatograms of Geranium leaves volatile distilled of Zn From 125 PPm (First cut)

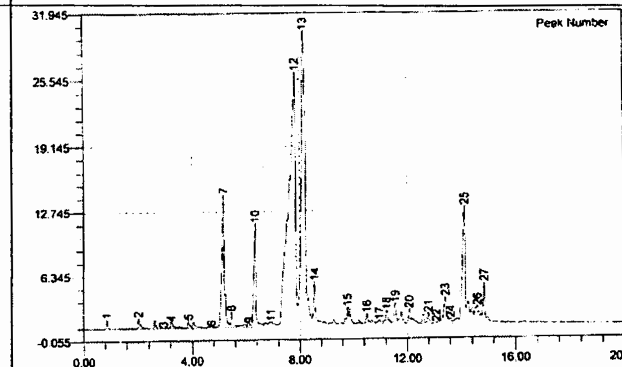

Fig (3): Gas chromatograms of Geranium leaves volatile distilled of Fe+Zn+MnFrom 100 PPm (First cut)

Second cut

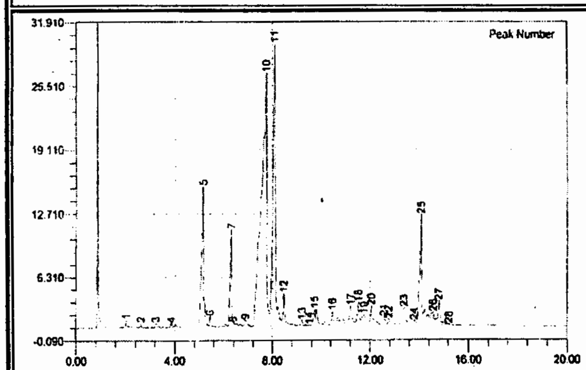

Fig (4): Gas chromatograms of Geranium leaves volatile distilled of untreated plants (Second cut)

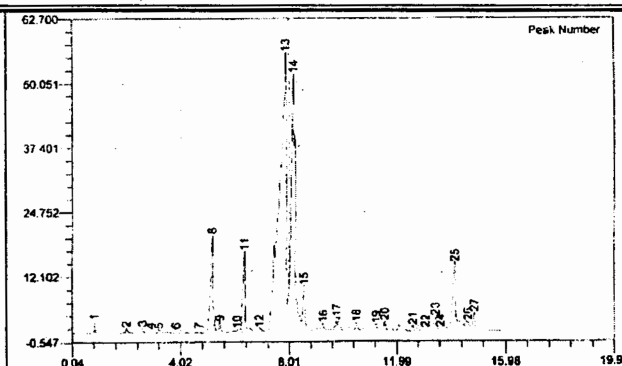

Fig (5): Gas chromatograms of Geranium leaves volatile distilled of Zn From 125 PPm (Second cut)

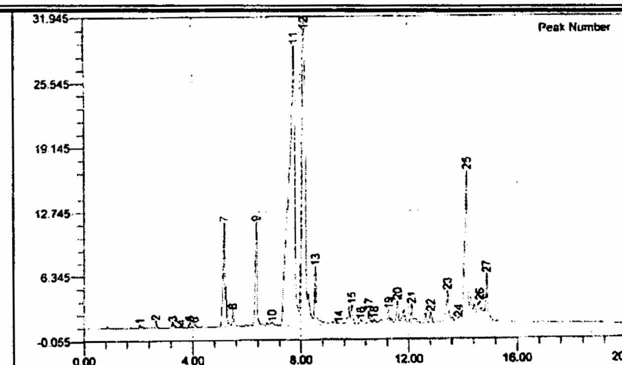

Fig (6): Gas chromatograms of Geranium leaves volatile distilled of Fe+Zn+MnFrom 100 PPm (Second cut)

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Table 6. Carbohydrates percentage and nitrogen in leaves of *Pelargonium graveolens* as affected by some micro-nutrient treatments during the two successive seasons of 2010 and 2011.

Parameters	Carbohydrates (%)						Nitrogen (%)					
	First season		Mean	Second season		Mean	First season		Mean	Second season		Mean
Treatments	1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut	
Control (F1)	33.535	26.277	29.906	26.705	25.898	26.301	2.058	2.123	2.091	1.964	2.072	2.018
Fe at 50 ppm (F2)	35.508	34.660	35.084	28.770	27.752	28.261	2.242	2.345	2.293	2.129	2.237	2.183
Fe at 100 ppm (F3)	38.838	38.073	38.455	38.443	37.407	37.925	2.543	2.650	2.597	2.425	2.538	2.481
Fe at 150 ppm (F4)	41.580	40.820	41.200	43.352	42.318	42.835	3.549	3.674	3.611	3.504	3.590	3.547
Zn at 75 ppm (F5)	36.617	35.087	35.852	34.833	34.050	34.441	2.316	2.424	2.370	2.221	2.334	2.278
Zn at 100 ppm (F6)	40.197	39.188	39.692	39.285	38.275	38.780	3.467	3.597	3.532	3.157	3.266	3.211
Zn at 125 ppm (F7)	42.825	41.810	42.318	44.305	43.302	43.804	3.852	3.942	3.897	3.841	3.927	3.884
Mn at 75 ppm (F8)	34.700	33.677	34.189	27.720	26.640	27.180	2.121	2.230	2.175	2.047	2.155	2.101
Mn at 100 ppm (F9)	36.423	35.415	35.919	30.082	28.943	29.513	2.238	2.347	2.292	2.159	2.237	2.198
Mn 125 ppm (F10)	40.878	39.860	40.369	41.307	40.275	40.791	3.646	3.762	3.704	3.629	3.735	3.682
Fe+Zn+Mn at 100 ppm (F11)	43.758	42.735	43.246	46.355	45.335	45.845	4.426	4.553	4.490	4.178	4.225	4.201
Mean	38.623	37.055	37.839	36.469	35.472	35.971	2.951	3.059	3.005	2.841	2.938	2.890
L.S.D. at 5% for Cuts		0.236			0.217			0.086			0.080	
L.S.D. at 5% for Treatments		0.553			0.509			0.201			0.187	
L.S.D. at 5% for Interactions		0.782			0.955			0.325			0.214	

Table 7. Phosphorus and potassium content in leaves of *Pelargonium graveolens* as affected by some micro-nutrient treatments during the two successive seasons of 2010 and 2011.

Parameters	Phosphorus content %						Potassium content %					
	First season		Mean	Second season		Mean	First season		Mean	Second season		Mean
Treatments	1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut		1 Cut	2 Cut	
Control (F1)	0.700	0.643	0.672	0.635	0.621	0.628	1.640	1.720	1.680	1.530	1.637	1.584
Fe 50 ppm (F2)	0.727	0.752	0.74	0.728	0.741	0.735	1.708	1.765	1.736	1.598	1.705	1.651
Fe 100 ppm (F3)	0.755	0.781	0.768	0.784	0.788	0.786	1.947	1.988	1.968	1.772	1.880	1.826
Fe 150 ppm (F4)	0.789	0.814	0.802	0.807	0.813	0.810	2.025	2.105	2.065	1.907	2.017	1.962
Zn 75 ppm (F5)	0.739	0.766	0.753	0.735	0.746	0.741	1.775	1.830	1.802	1.665	1.772	1.719
Zn 100 ppm (F6)	0.763	0.795	0.779	0.791	0.802	0.797	1.915	2.000	1.957	1.802	1.907	1.855
Zn 125 ppm (F7)	0.801	0.829	0.815	0.814	0.821	0.818	2.040	2.112	2.076	1.940	2.017	1.979
Mn 75 ppm (F8)	0.722	0.748	0.735	0.678	0.711	0.695	1.820	1.787	1.804	1.567	1.700	1.634
Mn 100 ppm (F9)	0.746	0.777	0.762	0.743	0.755	0.749	1.793	1.902	1.847	1.710	1.815	1.763
Mn 125 ppm (F10)	0.772	0.801	0.787	0.798	0.809	0.804	1.953	2.060	2.006	1.845	1.953	1.899
Fe+Zn+Mn 100 ppm (F11)	0.811	0.844	0.828	0.719	0.827	0.773	2.285	2.240	2.262	2.007	2.130	2.069
Mean	0.757	0.777	0.767	0.748	0.767	0.758	1.900	1.955	1.928	1.759	1.867	1.813
L.S.D. at 5% for Cuts		0.006			0.007			0.042			0.014	
L.S.D. at 5% for Treatments		0.014			0.015			0.099			0.034	
L.S.D. at 5% for Interactions		N.S.			N.S.			N.S.			N.S.	

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الملخص العربي

تأثير بعض معاملات العناصر المغذية على نمو وإنتاجية نبات العتر

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أجريت تجربه حقلية لمدة عامين خلال موسمي 2009/ 2010و 2010/ 2011وذلك بمزرعة الزينة بقسم البساتين – كلية الزراعة- جامعة بنها. وذلك لدراسة تأثير بعض معاملات العناصر المغذية (حديد بتركيز50، 100، 150 جزء في المليون - زنك بتركيز 75، 100، 125 جزء في المليون – منجنيز بتركيز 75، 100، 125 جزء في المليون - حديد+ زنك + منجنيز بتركيز 100 جزء في المليون) على النمو الخضري ومحتوى النبات من الزيت ومكوناته وكذلك على المحتوى الكيماوي لنبات العتر. أوضحت النتائج أن المعاملات المختلفة من العناصر الصغرى قد أدت إلي زيادة معنوية في قياسات النمو الخضري مثل طول النبات ، عدد الأفرع/ نبات، الوزن الطازج والجاف للنبات وخاصه المعامله (F11) حديد+ زنك + منجنيز بتركيز 100 جزء في المليون . كذلك أدت جميع معاملات العناصر المغذية إلي زيادة واضحة في محتوي الأوراق من الكربوهيدرات الكلية والنيتروجين والبوتاسيوم والفوسفور . كما وجد أن جميع المعاملات التي أعطت زيادة كبيرة في النمو قد صحبها أيضا زيادة في نسبة محتوى الأوراق من الزيوت الطيارة كما أعطت جميع معاملات العناصر المغذية زيادة في محتوي الأوراق من الزيوت الطيارة وخاصة المعاملة الزنك بتركيز 125 جزء في المليون يليها في ذلك المعاملة حديد+ زنك + منجنيز بتركيز 100 جزء في المليون. كما أوضح التحليل الكروماتوجرامى أن المكونات الرئيسية للزيت هي α- Pinene, Myrcene, P-cymene, Limonene, Linalool, Citronelol, and Geraniol على التوالي. وقد كان أكبر محتوى من الزيت قد تم الحصول عليه عن طريق المعاملة بالزنك بتركيز125 جزء في المليون و المعاملة بالحديد+ زنك + منجنيز بتركيز 100 جزء في المليون بينما أعطت المعاملة بالزنك بتركيز 125 جزء في المليون يليها في ذلك المعاملة حديد+ زنك + منجنيز بتركيز 100 جزء في المليون أعلي محتوي لمادة Citronelol, and Geraniol في الزيت.

وبناءا على النتائج المتحصل عليها فانه ينصح برش نباتات العتر بالمعاملات حديد+ زنك + منجنيز بتركيز 100 جزء في المليون أو الزنك بتركيز 125 جزء في المليون وذلك لتحسين نمو وإنتاجية النبات من الزيت .