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RESPONSE OF GROWTH, FLOWERING, OIL YIELD AND CHEMICAL COMPOSITION OF *MATRICARIA CHAMOMILLA* L. PLANTS TO SOME MICRONUTRIENT FOLIAR APPLICATIONS

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ABSTRACT

The present work was carried out in the Experimental area, Faculty of Agriculture, Fayoum University in two successive seasons; 2004/2005and 2005/2006. This work aimed to investigate the effect of iron (Fe), zinc (Zn) and manganese (Mn) as a foliar spray on some growth and floral traits, oil yield and some chemical constituents of chamomile (*Matricaria chamomilla* L.) plants. Significant influences of micronutrient treatments in single (Fe, Zn and Mn), double (Fe+Zn, Fe+Mn and Zn+Mn) and/or triple (Fe+Zn+Mn) combinations were observed on all studied parameters during the two growing seasons. Spraying plants with micronutrients in all applied treatments increased growth characters (fresh and dry weights of herb plant^{-1}, percentage of dry weight of herb plant^{-1} and number of branches on main stem plant^{-1}), floral traits (number of flowers plant^{-1} and fresh and dry weights of flowers plant^{-1}) and determined chemical constituents [concentrations of chlorophylls (a & b), carotenoids and total free amino acids in fresh herb, percentages of N, P, K, total carbohydrates and protein, and concentrations of Fe, Mn, and Zn in dry matter of herb]. The triple combination treatment was appeared to be the super since, it recorded the best results.

***In view of the obtained results*, growth, flowering and chemical composition especially, oil content of chamomile plants could be improved by the foliar application of Fe, Zn and Mn in triple combination at the rate of 2% for each.**

Key words: Growth, Flowering, Oil yield, Chemical composition, Micronutrients, Chamomile (*Matricaria chamomilla* L.).

INTRODUCTION

Chamomile (*Matricaria chamomilla* L.) is an annual herb belongs to Family Asteraceae. It is an important medicinal plant, it has been reported to be used in domestic and pharmaceutical industries. Mild infusion and teas made from chamomile flowers as a remedy against fever, stomach trouble, digestion, intestinal pain, as a mild tonic and antispasmodic.

Externally, the flowers are applied in the form of fomentations against inflammations irritation (**Guenther, 1960**). Thus, chamomile could be considered as a source of hard currency.

Micronutrients play an important role in improving the vegetative growth and flowering of plants. Iron, zinc and manganese are some of these elements which had a stimulative effect on growth of several plants. In this connection, **Girwani *et al.* (1990)** on marigold, **Selim and El-Tantawy (1993)** on gerbera, **El-Fadaly (1994)** on *Jasminum sambac*, **Chio *et al.* (1996)** on *Tagetes patula*, **Mostafa *et al.* (1997)** on chrysanthemum plants, **El-Deeb (1999)** on *Philodendron scandens*, **Selim *et al.* (2001)** on *Calendula officinalis*, **Refaat and Balbaa (2001)** on lemongrass plants, and **Gadallah and El-Sawah (2004)** on potato plants. concluded that, spraying plants with Fe, Zn and/or Mn increased all vegetative growth characters and floral traits. On the other side, the effect of Fe, Zn and/or Mn on chemical composition of plants reported by many investigators such as **El-Deeb (1999)** on *Philodendron scandens* who found that, Zn and Mn increased the content of chlorophyll a, **Selim *et al.* (2001)** on *Calendula officinalis* who mentioned that, Zn and Mn increased the content of chlorophylls (a & b) and carotenoids, and **Refaat and Balbaa (2001)** on lemongrass who indicated that, Fe, Zn and Mn increased chlorophylls (a & b), carotenoids, N, P, K, Fe, Mn and Zn, while carbohydrates were decreased. On the other wise, the application of microelements (Fe, Zn and Mn) was reported to affect the quality and quantity of many essential oils. **El-Ghadban, (1994)** on spearmint and **Gamal El-Din *et al.*, (1997), Tarraf *et al.*, (1999)** and **Refaat and Balbaa (2001)** on lemongrass, obtained positive effects on the quality of the oil due to the foliar application of the mentioned micronutrients.

Therefore, this study aimed to investigate the effect of Fe, Zn and Mn treatments in single, double and/or triple combinations on the growth, flowering and some chemical constituents as well as oil content of flowers of *Matricaria chamomilla* L. plants.

MATERIALS AND METHODS

This investigation was carried out in the Experimental Area, Faculty of Agriculture, Fayoum University during the two successive seasons of 2002/2003 and 2003/2004 to study the effects of iron (Fe), zinc (Zn) and manganese (Mn) and their double (Fe+Zn, Fe+Mn and Zn+Mn) and/or triple (Fe+Zn+Mn) combinations applied as a foliar spray on vegetative growth, flowering and chemical composition of chamomile (*Matricaria chamomilla* L.).

The seeds of chamomile were obtained from the Research Center of Medicinal and Aromatic plants, Giza, Egypt. Seeds were sown in the nursery on 15^{th} September in both seasons. All Agricultural practices necessary for seedlings production were achieved. Uniform seedlings of 45 days old were transplanted into clay pots of 30cm diameter. Each of them was filled with equal amounts of air dried clay soil mixed with sand at a ratio 1: 1 by weight. Samples of the used soil were analyzed according to **Black (1965**). Results of analysis are given in Table (1).

A basic mixed uniform dose of NPK fertilizers (4g pot^{-1}) at a ratio of 5: 1: 1 in the form of ammonium nitrate (33.5% N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O), respectively, was applied to each pot at 2 equal portions; 30 and 45 days after transplanting. The treatments comprised spraying the of plants two times; 30 and 45 days after transplanting with the studied micronutrient (each at a concentration of 2%) in above mentioned treatments. Few drops of Triton B were added to the spray solution to serve as a wetting agent. The respective source of Fe, Zn and Mn was the commercial fertilizer namely Prosol containing Fe, Zn or Mn at 20, 25 or 20%, respectively in a chelated form where the chelating agent was citric acid. The control plants were sprayed with distilled water.

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Table 1. Some physical and chemical properties of the experimental soil.

Properties	2002/2003	2003/2004
Particle size distribution:		
Sand%	32.100	32.270
Silt%	32.070	31.410
Clay%	35.830	36.320
Texture grade	Sandy clay	Sandy clay
Hydraulic conductivity (cm^3/hr)	00.027	00.029
Chemical properties:		
Calcium carbonate%	4.800	4.600
Organic matter%	1.250	1.280
Total nitrogen%	0.062	0.066
EC_e (dS/m)	2.900	2.600
PH of paste extract	7.500	7.300
Available nutrients (mg/kg soil):		
P	23.00	22.00
K	96.80	99.26
Zn	00.81	00.80
Fe	03.64	03.71
Mn	08.03	07.89

The experimental layout was a randomized complete block design with eight replications. Each experimental unit contained 3 pots. All agricultural practices necessary for growth and development as cultivation, irrigation and pest control were followed whenever it was necessary and as recommended in the commercial production.

Data recorded:

1. Growth characters; at full blooming, number of branches on main stem plant^{-1} were counted, and the fresh and dry weights of herb plant^{-1} were weighted, as well as the percentage of dry weight of herb plant^{-1} was calculated.
2. Floral traits; during the entire flowering period, number of flowers plant^{-1} was counted, and the fresh and dry weights of flowers plant^{-1} were weighted.

3. Essential oil%; a random sample of inflorescences from each treatment was selected and subjected to hydrodistillation according to the **Egyptian Pharmacopoeia (1984)**.
4. Components of essential oil; the extracted essential oil was dehydrated using anhydrous sodium sulphate and then subjected to analysis using GLC (Hewlett pckard 5890 series II) to identify its components as outlined by **Hoftman (1967)** and **Hethelyi et al. (1992)**.
5. Chemical constituents; a random sample of fresh herb of each treatment was taken for determination of the following parameters: leaf pigments; chlorophylls (a & b) and carotenoids. Samples were extracted by acetone (80%) then, their concentrations (mg g^{-1} fresh herb) were determined using colorimetric method as described by **Arnon (1949)**. Total free amino acids% were extracted by using ethanol 80% then, determined using ninhydrin reagent method as outlined by **Jayarman (1981)**. Dry matter of herb of each treatment was used for determination of the following parameters: total carbohydrates% were colorimetrically determined using phenol-sulphoric acid reagent method as outlined by **Dubois *et al.* (1956)**. Nitrogen% was colorimetrically determined by using the Orange G dye according to the method of **Hafez and Mikkelsen (1981)** and a factor of 6.25 was used for the conversion of N% to protein% (**Kelley and Bliss, 1975**). For P, K, Fe, Mn and Zn determination, the wet digestion of 0.1g of fine dry material of herb of each treatment was done with sulphuric and perchloric acids as described by **Piper (1947)**. Phosphorus% was colorimetrically estimated by using chlorostannous molebdophosphoric blue colour method in sulphuric acid system as described by **Jackson (1967)**. Potassium% was determined using a Perkin-Elmer, Flame Photometer (**Page *et al.*, 1982**). Iron, manganese, and zinc concentrations (ppm) were determined by using a Perkin-Elmer, model 3300, Atomic Absorption Spectrophotometer according to the method described by **Chapman and Pratt (1961)**.
6. Statistical analysis; the means of data recorded in the two successive seasons were subjected to the analysis of variance

according to **Snedecor and Cochran (1980)**. The Least Significant Differences (LSD) at *P*=0.05 level was used to verify the differences between means of the treatments.

RESULTS AND DISCUSSION

I. Vegetative growth and floral traits:

Data presented in Tables (2 & 3) show that all applied treatments of Fe, Zn and Mn singly, in double or in triple combinations had significant increments in both vegetative growth characters; fresh and dry weights of herb plant^{-1} and number of branches on main stem plant^{-1}, and floral traits; number of flowers plant^{-1} and fresh and dry weights of flowers plant^{-1} in comparison with the control. This trend was similar in both seasons. The differences in fresh and dry weights of herb plant^{-1}, number of branches on main stem plant^{-1} and number of flowers plant^{-1} were nonsignificant among the individual Fe, Zn and Mn treatments, and among the double combination treatments; Fe+Zn, Fe+Mn and Zn+Mn. Otherwise, they were significant among other applied treatments in addition to the control, with stable trend in both studied seasons. On the other hand, fresh and dry weights of flowers plant^{-1} represented significant differences among all applied treatments in addition to the control except, between Fe+Mn and Zn+Mn treatments in the first season and between Fe+Zn and Fe+Mn treatments in the second one since, the differences were nonsignificant. The triple combination treatment; Fe+Zn+Mn was the best one which surpassed the control by 26.04%, 57.24%, 24.74%, 26.36%, 71.43%, 68.87% and 72.51% for fresh weight of herb plant^{-1}, dry weight of herb plant^{-1}, the percentage of herb dry weight plant^{-1}, number of branches on main stem plant^{-1}, number of flowers plant^{-1}, fresh weight of flowers plant^{-1} and dry weight of flowers plant^{-1}, respectively, as well as by 28.19%, 58.75%, 23.80%, 35.06%, 84.66%, 75.05% and 82.67% for the same traits in the first and second seasons, respectively.

The distinct improvement of growth and floral traits of chamomile plants obtained from foliar application with micronutrients; Fe, Zn and Mn singly, in double or in triple combinations was mainly due to that these elements had an important physiological and biochemical functions on the structure of photosynthetic pigments, metabolism of carbohydrates and protein. These distinctive findings are, apparently, due to an enzyme activiation induced by micronutrients during cell division and cell elongation in plants (**El-Sayed, 1982**). In this connection, the enhancement of growth as a result of Zn spray may be explained by the fact that it plays a role in tryptophan acid synthesis which is the precursor of endogenous natural hormone (IAA) which is necessary for cell division and cell enlargement (**Smith, 1957; Antonov, 1976; Singh, 1981; Abed *et al.*, 1987 and Singh and Singh, 1995**). Zinc is recognized as an essential component of a lot of enzymes as dehydrogenases, proteinases and peptidases. It has an effect on electron transfer reactions including those in the kreb`s cycle and subsequently an energy production in the plant thus, encourages growth characters of plants (**Rains, 1976 and Gomaa *et al.*, 1986**) which reflect on floral traits. The noticed effect of Zn on growth characters may be related to its effect on carbohydrates and RNA synthesis and consequently protein formation (**Amberger, 1974**). Concerning the effect of Fe, **Donnini *et al.* (2003)** indicated that Fe plays a main role in the photosynthetic process in plant and cell metabolism leading to get a better growth and flowering, and/or to its role in the formation of chlorophyll molecule which leads to a high growth (**Machold and Stephan, 1969; Farag *et al.*, 1989 and Dahdoh and Moussa, 2000**). Regarding the effect of Mn, **Mengle and Kirkby (1982)** pointed out that the most important function of manganese is related to the oxidation-reduction processes. It can be used as a cofactor of many enzymes that act on phosphorylated substrates, also it plays a role in regulating the level of auxins in plant tissues by activating the auxin oxidase system (**Russell, 1989**). The favourable effect of the interaction between micronutrients on plant growth and flowering may be attributed to their effects on physiological processes such as chlorophyll content and activation as well as micronutrients uptake (**Amberger, 1979 and Nour *et al.*, 1984**). In addition, **Fawzi and El-Fouly (1998)** mentioned that the specific plant demand and soil properties influences the proportion of Fe, Zn and Mn need for correction of micronutrient deficiencies leading to a quality of plant growth and subsequently flowering. The results in this investigation are in accordance with those obtained by **Girwani *et al.* (1990)** on marigold, **Selim and El-Tantawy (1993)** on gerbera**, El-Fadaly (1994) on** *Gasminum sambac,* **Chio *et al.* (1996)** on marigold, **Mostafa *et al.* (1997)** on chrysanthemum, **El-Deeb (1999)** on some foliage plants**, Selim *et al.* (2001)** on *Calendula officinalis* and **Gadallah and El-Sawah (2004)** on potato.

Table (2). Response of vegetative growth characters of chamomile plants to foliar application by some micronutrients in the two successive seasons of 2002/2003 and 2003/2004.

Character / Treatment	Fresh weight of herb plant^{-1} (g)	Dry weight of herb plant^{-1} (g)	Dry weight of herb plant^{-1} (%)	No. Branches on main stem plant^{-1}
		2002/2003		
Control	106.14	21.28	20.05	14.91
Fe	112.99	23.96	21.21	15.86
Zn	113.64	24.82	21.84	16.50
Mn	115.08	24.74	21.50	15.97
Fe+Zn	121.62	27.84	22.89	17.62
Fe+Mn	123.18	28.88	23.44	17.48
Zn+Mn	126.45	29.08	23.00	17.90
Fe+Zn+Mn	133.78	33.46	25.01	18.84
L.S.D.$_{(0.05)}$	5.96	2.27	1.04	0.87
		2003/2004		
Control	102.19	20.22	19.79	12.38
Fe	109.67	22.86	20.84	14.12
Zn	111.25	23.15	20.81	14.16
Mn	110.88	23.41	21.11	14.08
Fe+Zn	119.64	26.56	22.20	15.21
Fe+Mn	123.56	27.78	22.48	15.20
Zn+Mn	123.69	28.64	23.15	15.69
Fe+Zn+Mn	131.00	32.10	24.50	16.72
L.S.D.$_{(0.05)}$	6.05	2.34	1.02	0.68

II. Some chemical constituents:

1. Leaf pigments:

From data presented in Table (4), it appears that all applied treatments revealed significant increases in chlorophylls (a & b) and total carotenoids by comparison with the control in both studied seasons. Nonsignificant differences were obtained among the results of individual Fe, Zn and Mn treatments, as well as among the results of double combinations treatments; Fe+Zn, Fe+Mn and Zn+Mn in

Table (3). Response of floral traits of chamomile plants to foliar application by some micronutrients in the two successive seasons of 2002/2003 and 2003/2004.

Character / Treatment	No. of flowers $plant^{-1}$	Fresh weight of flowers $plant^{-1}$ (g)	Dry weight of flowers $plant^{-1}$ (g)
2002/2003			
Control	290.5	30.61	5.02
Fe	351.2	33.94	5.58
Zn	362.0	36.49	6.02
Mn	356.7	39.06	6.47
Fe+Zn	416.1	42.61	7.08
Fe+Mn	420.6	45.00	7.52
Zn+Mn	421.9	44.62	7.56
Fe+Zn+Mn	498.0	51.69	8.66
$L.S.D._{(0.05)}$	51.2	2.27	0.41
2003/2004			
Control	248.4	26.29	4.27
Fe	306.0	29.21	4.79
Zn	310.9	31.36	5.17
Mn	321.5	33.60	5.56
Fe+Zn	389.3	37.18	6.18
Fe+Mn	380.8	37.20	6.26
Zn+Mn	394.6	39.48	6.64
Fe+Zn+Mn	458.7	46.02	7.80
$L.S.D._{(0.05)}$	53.0	2.05	0.34

relation to chlorophyll a and total carotenoids in the two growing seasons. While, chlorophyll b represented nonsignificant differences among only the individual Fe, Zn and Mn treatments in both seasons. On the other side, the differences among the findings of other applied treatments in addition to the control were significant with stable trend in both seasons. The superiority was detected when plants received the triple combination treatment; Fe+Zn+Mn which exerted chlorophyll a, chlorophyll b and total carotenoids increments exceeded the control by 37.14%, 40.82% and 45.16%, respectively in the first season. While, in the second one, 42.03%, 54.35% and 42.42% for the same parameters, respectively were the best over the control. The positive effect of foliar application of Fe, Zn and/or Mn on the concentration of leaf pigments may be due to its role in chlorophyll synthesis. In this respect, Fe is essential for chlorophyll synthesis in that it is necessary for the synthesis of δ-aminolevulinic acid; a precursor of chlorophyll (**Bogorad, 1966**). Iron played a somewhat similar role to Mg in the porphyrin structure of chlorophyll. According to **Machold and Stephan (1969)**, Fe is necessary in the oxidation step from coproporphyrinogen to protoporphyrinogen in chlorophyll synthesis. With regard to the effect of Zn, **Chanturiya and Mikaberidze (1977)** reported that Zn deficiency symptoms started as chlorosis accompanied with the advanced stages by necrosis. **Foy *et al.* (1978)** hypothesized that Zn interfers with Fe utilization in the leaves for chlorophyll synthesis. Moreover, **Farag *et al.* (1989)** concluded that the enhancing effect of micronutrients on chlorophyll content may be due to their essential role in chlorophyll assimilation by plants. The results in this research are in conformity with those obtained by **Amberger (1974); *Farag et al.* (1989)** *Pisum sativum*; **Singh and Singh (1995)**on soybean; **El-Deeb (1999); Dahdoh and Moussa (2000)** on peanut and broad bean; **Refaat and Balbaa (2001)** on lemongrass and **Gadallah and El-Sawah (2004)** on potato.

2. **Macro- and micronutrients:**

As for the results shown in Table (5), it is clear that results of the control revealed significant decrements by comparison to those of all applied treatments in all tested elements; N, P, K, Fe, Mn and Zn, and the trend was consistent in both seasons. As for N, the differences among the results appeared to be nonsignificant when plant foliage received micronutrients; Fe, Zn and Mn individually and/or in double combinations treatments. While, other applied treatments in addition to the control represented significant differences in both two growing seasons. Concerning other investigated elements, the differences among their results appeared to be significant when plants foliage was fertilized with all applied treatments in addition to the control in both seasons. Regarding previous studied parameters, the triple combination treatment; Fe+Zn+Mn recorded the highest significant increments for all tested elements in comparison with the control, and this trend was recorded in both seasons. This super treatment granted increases surpassed the control by 24.24%, 55.10%, 44.55%, 36.56%, 40.82% and 51.59% for N, P, K, Fe, Mn and Zn, respectively in the first season, while in the second one exceeded the control by 22.40%, 46.81%, 34.60%, 35.41%, 35.00% and 41.54% for the same parameters, respectively. In this connection, **Farag *et al.* (1989)** concluded that micronutrients have an essential role in absorption of macronutrients such as N, P and K by plant. The favourable effect of Fe on macronutrients may be due to its effect on the chlorophyll content of the grown plants and hence the increase of their growth which leads to more absorption of these elements (**Dahdoh and Moussa, 2000**) on peanut and board bean they concluded that , Zinc participates in the different physiological functions or processes inside the plant including the process of mineral uptake by plant roots and translocation inside the plant, and the absence of zinc may bring about a depressive effect on plant growth partially due to its effect on biosynthesis of auxin (IAA) which promote rooting process and consequently reduces the amounts of mineral elements absorbed and translocated into the different parts of the plant Similar results go in line with the findings of **Baza *et al.* (1989)** on clover; **Moussa *et al.* (1996)** on peanut**; Refaat and Balbaa (2001) on** lemongrass**; Khalifa *et al.* (2003)** and **Gadallah and El-Sawah (2004)** on potato.

3. Total carbohydrates, protein and total free amino acids:

Data shown in Table (6) revealed significant increases in total carbohydrates, protein and total free amino acids in favor of all applied treatments as compared to the control in both two growing seasons. The differences in all mentioned parameters were nonsignificant among the individual Fe, Zn and Mn treatments, as well as among the double combinations treatments; Fe+ZN, Fe+Mn and Zn+Mn, Otherwise, they were significant among other applied treatments in addition to the control, and the trend was consistent in both two growing seasons. The super treatment was the triple combination; Fe+Zn+Mn which exerted increases over the control by 26.28%, 24.23% and 26.38% for total carbohydrates, protein and total free amino acids, respectively in the first season, while in the second one, it hiccupped the control by 21.74%, 22.42% and 41.15% for the same parameters, respectively. It seems from the previous results that when foliar micronutrients application was used, it resulting in increasing the content of total carbohydrates and protein in the herb of plants. The micronutrients of foliar feeding might be mediated via the

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Table (4). Response of photosynthetic pigments of chamomile herb to foliar application by some micronutrients in the two successive seasons of 2002/2003 and 2003/2004.

Character / Treatment	Chlorophyll a (mg g^{-1} F.W.)	Chlorophyll b (mg g^{-1} F.W.)	Total carotenoids (mg g^{-1} F.W.)
2002/2003			
Control	0.70	0.49	0.31
Fe	0.76	0.52	0.35
Zn	0.77	0.54	0.36
Mn	0.79	0.52	0.36
Fe+Zn	0.87	0.58	0.41
Fe+Mn	0.86	0.61	0.40
Zn+Mn	0.89	0.65	0.41
Fe+Zn+Mn	0.96	0.69	0.45
L.S.D.$_{(0.05)}$	0.06	0.03	0.02
2003/2004			
Control	0.69	0.46	0.33
Fe	0.77	0.54	0.36
Zn	0.77	0.54	0.38
Mn	0.80	0.56	0.36
Fe+Zn	0.88	0.66	0.42
Fe+Mn	0.90	0.59	0.42
Zn+Mn	0.89	0.62	0.43
Fe+Zn+Mn	0.98	0.71	0.47
L.S.D.$_{(0.05)}$	0.07	0.03	0.03

Table (5). Response of some macro- and microelements of chamomile herb to foliar application by some micronutrients in the two successive seasons of 2002/2003 and 2003/2004.

Character / Treatment	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)
2002/2003						
Control	1.98	0.49	2.02	331	196	126
Fe	2.08	0.52	2.14	389	205	135
Zn	2.09	0.56	2.24	346	216	160
Mn	2.11	0.59	2.35	360	240	143
Fe+Zn	2.25	0.63	2.51	421	226	169
Fe+Mn	2.27	0.67	2.63	403	251	152
Zn+Mn	2.28	0.70	2.74	375	260	178
Fe+Zn+Mn	2.46	0.76	2.92	452	276	191
L.S.D.$_{(0.05)}$	0.09	0.03	0.10	13	9	8
2003/2004						
Control	1.92	0.47	2.11	305	200	130
Fe	2.05	0.50	2.20	360	211	137
Zn	2.05	0.52	2.28	318	214	159
Mn	2.08	0.55	2.35	333	241	145
Fe+Zn	2.20	0.59	2.45	387	226	167
Fe+Mn	2.19	0.61	2.54	374	256	152
Zn+Mn	2.21	0.64	2.62	345	267	175
Fe+Zn+Mn	2.35	0.69	2.84	413	270	184
L.S.D.$_{(0.05)}$	0.11	0.02	0.07	12	10	7

Table (6). Response of some photosynthates of chamomile herb to foliar application by some micronutrients in the two successive seasons of 2002/2003 and 2003/2004.

Character / Treatment	Total carbohydrates (%)	Protein (%)	Total free amino acids (%)
2002/2003			
Control	13.05	12.38	0.235
Fe	13.78	13.00	0.251
Zn	13.89	13.06	0.254
Mn	13.74	13.19	0.256
Fe+Zn	14.88	14.06	0.272
Fe+Mn	14.91	14.19	0.274
Zn+Mn	15.12	14.25	0.278
Fe+Zn+Mn	16.48	15.38	0.297
L.S.D.$_{(0.05)}$	0.66	0.56	0.15
2003/2004			
Control	12.28	12.00	0.209
Fe	12.97	12.81	0.225
Zn	13.15	12.81	0.230
Mn	13.21	13.00	0.228
Fe+Zn	14.16	13.75	0.244
Fe+Mn	14.10	13.69	0.256
Zn+Mn	14.28	13.81	0.270
Fe+Zn+Mn	14.95	14.69	0.295
L.S.D.$_{(0.05)}$	0.60	0.69	0.12

Table (7). Response of constituents of inflorescences essential oil of chamomile to foliar application by some micronutrients in the season of 2003/2004.

Character / Treatment	Cineol (%)	Chamazulene (%)	Farnesol (%)
2003/2004			
Control	5.910	11.853	56.842
Fe	5.830	13.011	78.430
Zn	4.647	0.479	58.828
Mn	2.496	6.965	84.502
Fe+Zn	2.790	0.912	84.469
Fe+Mn	0.970	13.762	80.284
Zn+Mn	4.208	11.141	46.205
Fe+Zn+Mn	2.505	5.989	66.573

enzymatic system responsible for biosynthetic apparatus and thus raising the metabolic products of plants such as carbohydrates and protein (**Abou-Zied, 1979**) on *Ocimum gratissimum*. In this respect, **Ashour and Hegazy (1972)** reported that Zn sprays increased protein content of wheat grains. Also Zn has a possible role in plant metabolism involved in carbohydrates and protein metabolism (**Marschner, 1997**). The possible involvement of Fe in protein metabolism has been suspected from the results of a number of authors who have observed that in case of Fe deficiency, the protein fraction decreased simultaneously with an increase in the level of soluble organic N compounds (**Perur *et al.*, 1961 and Kashirad *et al.*, 1978**). Moreover, **Price *et al*. (1972) and Bidwell (1980)** reported that Fe, Zn and Mn stimulate the growth of various plants due to their enhancement effect on most metabolic processes such as carbohydrates, protein, phosphate RNA and ribosome formation. These results are in conformity with those of **Gadallah and El-Sawah (2004)** on potato.

4. **Components of essential oil:**

Data presented in Table (7) and Figs.(1-8) showed that comparison among the different constituents of essential oil of the heads clearly indicated that application of Fe alone decreased cineol percentage in the volatile oil than control. On the other hand, both of farnisol and chamazulene increased by 37% and 9% compared to the control, respectively. Zinc alone decreased both of cineol and chamazulene to the lowest level in the essential oil but increased farnisol by 2.6%. The reduction of chamazulene was very sharp (about 95%). Treating chamomile plants with single application from micronutrients (Mn only) decreased both of cineol and chamazeulene by 50% for each and increased farnisol content. Application of Fe and Zn together resulted in reducing of cineol and chamazeulene by about 50% and 97%, respectively compared to the control while, increased the content of farnisol by about 48%. Spraying chamomile plants with Fe companied with Mn resulted in sharp decrease in cineol percentage in the essential oil (about 83%) and produced the highest increment in chamazeulene (10.3%) and increased farnisol percentage by about 41% compared to the control. Application of Zn and Mn reduced both of cineol, chamazeulene and farnisol by about 28%, 5.9% and 18%, orderly compared to the control. When chamomile plant sprayed by the three nutrients (Fe, Zn and Mn), both of cineol and chamazeulene decreased than control by 57% and 50.4%, respectively. On contrary, the farnisol increased by about 17% than the control.

Collectively, it could be concluded under the conditions of this study that the effects of Fe, Zn and/or Mn on growth and floral traits and chemical constituents especially, oil content of chamomile (*Matricaria chamomilla* L.) are valid and considered as important findings.

In view of the aforementioned results, growth, flowering and chemical composition particularly, oil content could be improved by foliar application with Fe, Zn and Mn in triple combination at the level of 2% for each.

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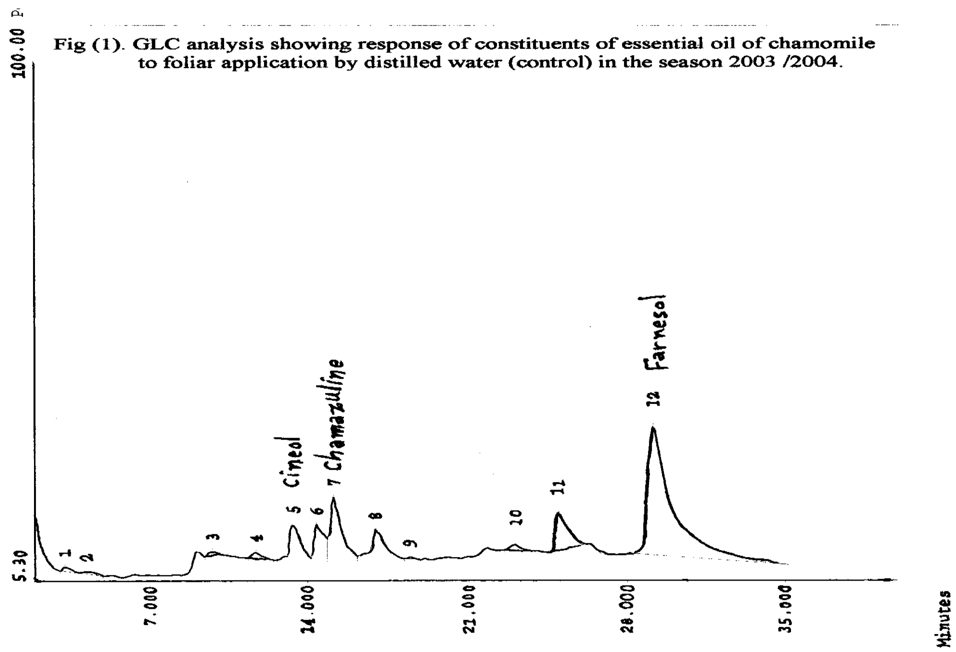


Fig (1). GLC analysis showing response of constituents of essential oil of chamomile to foliar application by distilled water (control) in the season 2003 /2004.

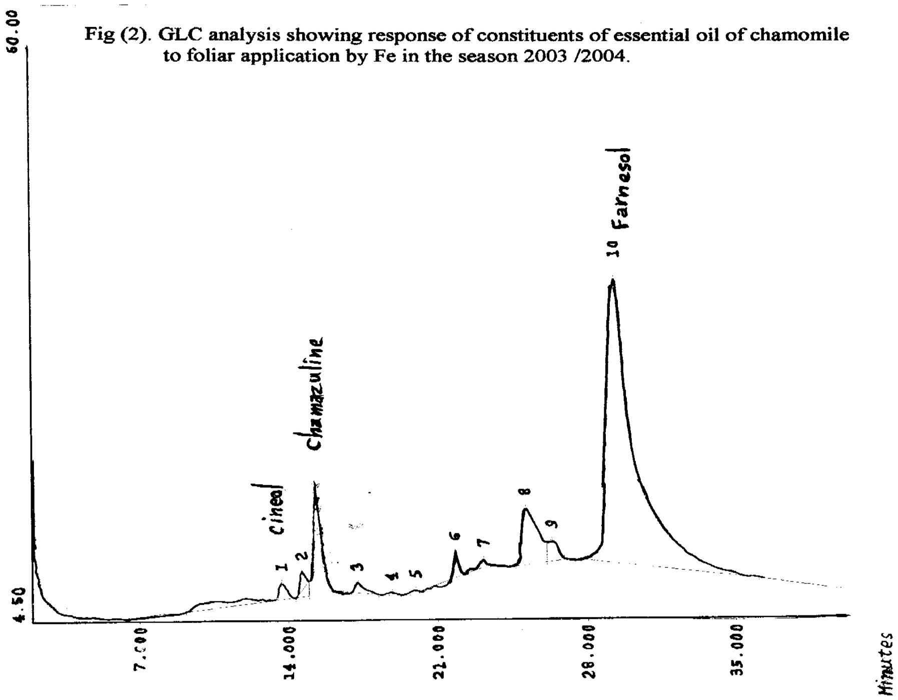


Fig (2). GLC analysis showing response of constituents of essential oil of chamomile to foliar application by Fe in the season 2003 /2004.

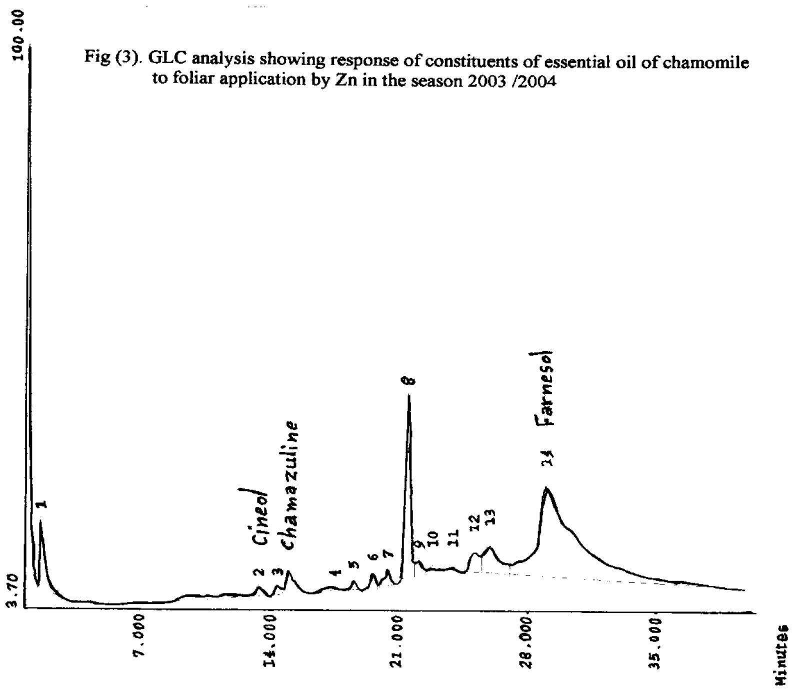


Fig (3). GLC analysis showing response of constituents of essential oil of chamomile to foliar application by Zn in the season 2003 /2004

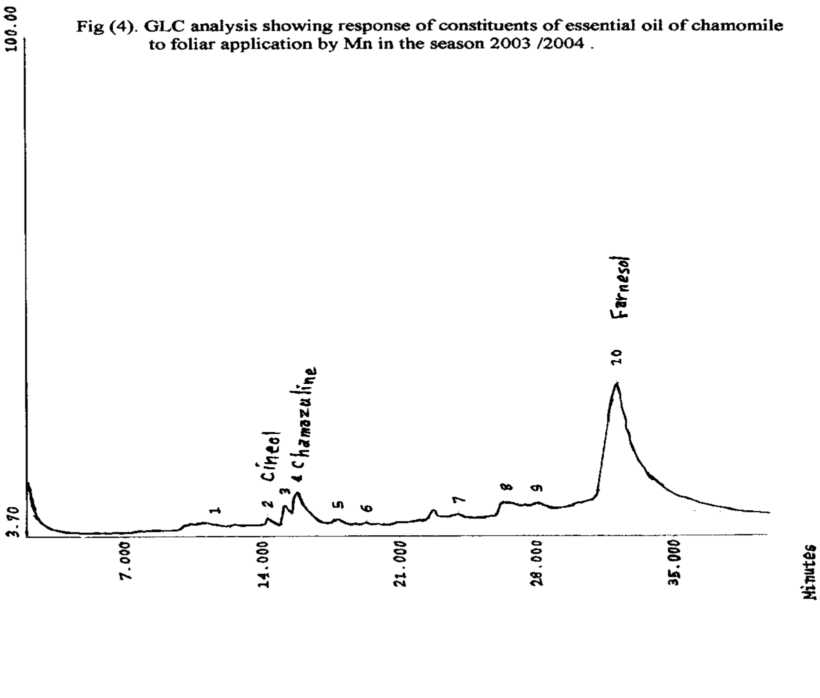


Fig (4). GLC analysis showing response of constituents of essential oil of chamomile to foliar application by Mn in the season 2003 /2004 .

Fig (5). GLC analysis showing response of constituents of essential oil of chamomile to foliar application by Fe + Zn in the season 2003 /2004 .

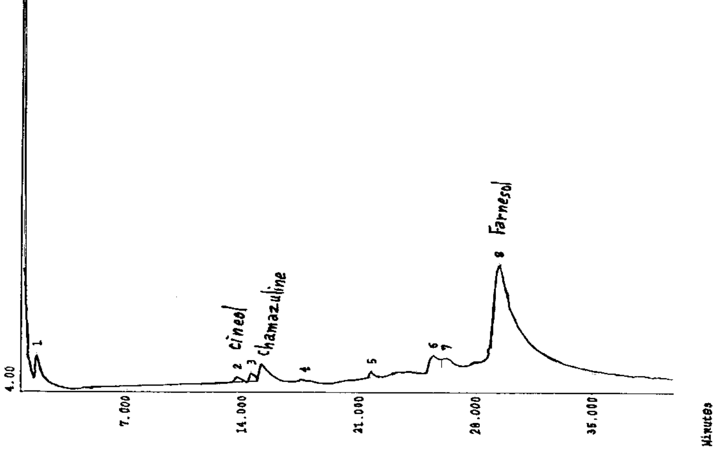


Fig (6). GLC analysis showing response of constituents of essential oil of chamomile to foliar application by Fe + Mn in the season 2003 /2004 .

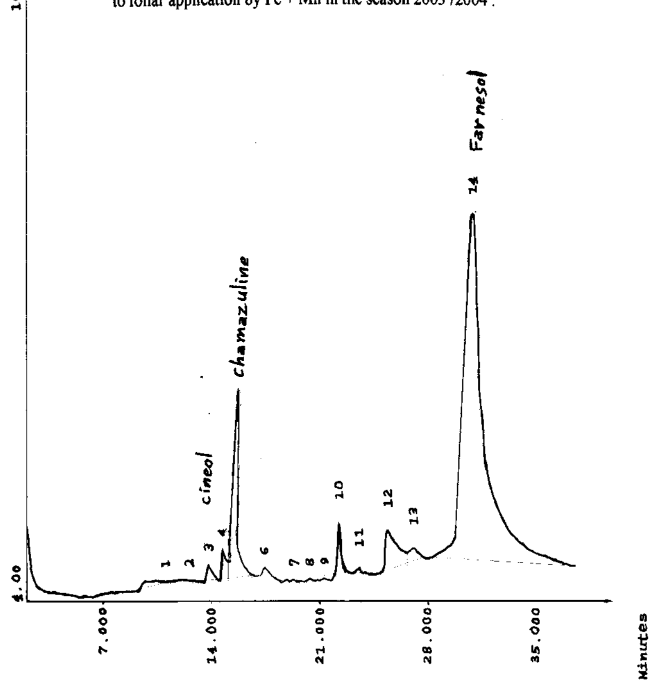


Fig (7). GLC analysis showing response of constituents of essential oil of chamomile to foliar application by Zn + Mn in the season 2003 /2004 .

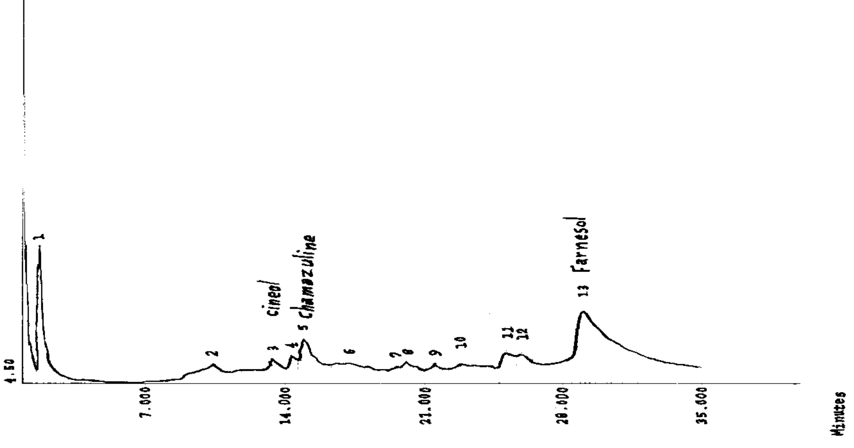
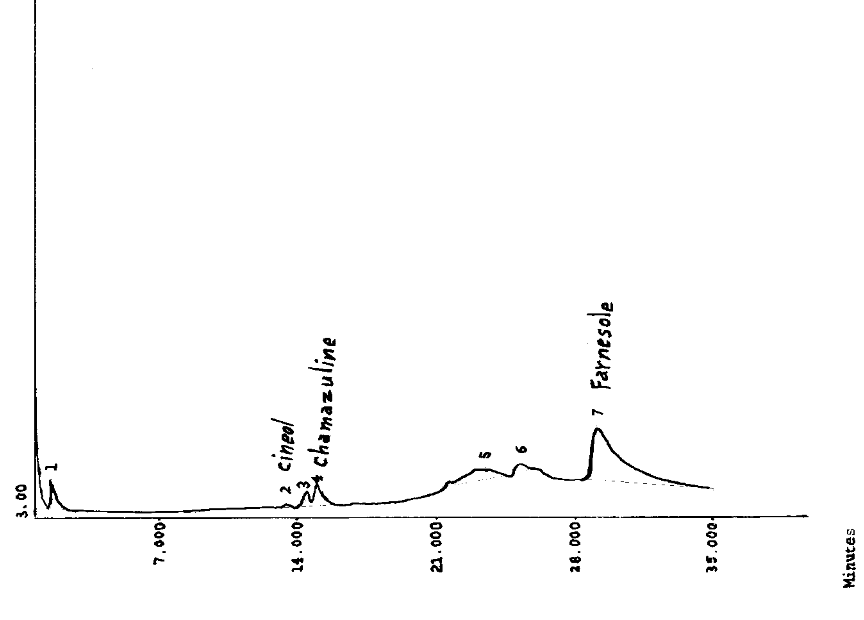


Fig (8). GLC analysis showing response of constituents of essential oil of chamomile to foliar application Fe + Zn + Mn in the season 2003 /2004 .



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الملخص العربي

استجابة النمو، الإزهار، محتوى الزيت والتركيب الكيماوي لنباتات الشيح للرش الورقي ببعض العناصر الصغرى

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أجري هذا البحث في المساحة التجريبية، كلية الزراعة جامعة الفيوم خلال موسمي 2003/2002 و2004/2003. يهدف هذا البحث إلى دراسة تأثير الرش الورقي ببعض العناصر الصغرى مثل الحديد والزنك والمنجنيز على صفات النمو والتزهير ومحتوى الزيت وبعض المكونات الكيماوية لنباتات الشيح. أظهرت جميع معاملات الرش الورقي لتلك العناصر سواء منفردة أو في مخاليط من كل عنصرين (الحديد+الزنك، الحديد+المنجنيز والزنك+المنجنيز) أو في مخلوط من العناصر الثلاثة (الحديد+الزنك+المنجنيز) تأثيرات إيجابية معنوية على جميع الصفات المدروسة في موسمي التجربة. أظهرت جميع المعاملات زيادات معنوية في بعض صفات النمو تحت الدراسة (الأوزان الطازجة والجافة للعشب/نبات، نسبة الوزن الجاف للعشب نبات وعدد الأفرع على الساق الرئيسي/نبات)، الصفات الزهرية (عدد الأزهار/نبات والأوزان الطازجة والجافة للأزهار/نبات) وبعض المكونات الكيماوية (تركيزات الكلوروفيلات: أ وب والأحماض الأمينية الحرة الكلية في العشب الطازج، والنسبة المئوية لكل من النيتروجين، الفوسفور، البوتاسيوم، الكربوهيدرات الكلية والبروتين، وكذلك تركيز كل من الحديد، المنجنيز، والزنك في العشب الجاف). تم الحصول على أفضل النتائج من معاملة المخلوط من العناصر الثلاثة (الحديد+الزنك+المنجنيز). في ضوء تلك النتائج، يمكن تحسين صفات النمو والتزهير والتركيب الكيماوي خاصةً محتوى الزيت لنباتات الشيح من خلال الرش الورقي بعناصر الحديد والزنك والمنجنيز خاصةً في مخلوط من العناصر الثلاثة بتركيز 2% لكل منهم.