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Effect of Chemical and Organic Fertilizers on Yield and Essential Oil of Chamomile Flower Heads

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ABSTRACT

Two experiments were carried out under sandy soil conditions at the experimental station of Sekem Company, Sharkiya region, Egypt during two successive seasons of 2008/2009 and 2009/2010 to study the productivity of chamomile (*Matricaria chamomilla* L.) flower heads as influenced by different chemical fertilizers, compost rates and liquid compost. All compost + liquid compost treatments overcame the chemical fertilizers or compost treatments and improved the flower heads growth characters [i.e. fresh or dry weights of flower heads (g plant^{-1}) and flower head diameter (cm)] and essential oil contents [% and g plant^{-1}]. For various essential oil constituents increased, decreased, or did not change in *M. chamomilla* L. flower heads under chemical and organic fertilizers as compared with unfertilized control plants.

Keywords: chamomile (*Matricaria chamomilla* L.), chemical fertilizers, compost, essential oil, flower heads, liquid compost
Abbreviations: DW, dry weight; **EO**, essential oil; **FW**, fresh weight

INTRODUCTION

Chamomile (*Matricaria chamomilla* L.) belongs to the *Asteraceae* (*Compositae*) family; it is an annual herb with short but widespread roots. It varies in size (from small to 60 cm) depending on the locality and the soil. The flowers are collected from May to July (Applequist 2002). Chamomile flower is an official drug in the pharmacopoeia of 26 countries. At present this plant is known as one of the main medicinal herbs and is listed in major pharmacopoeia such as United States Pharmacopoeia Convention (2004) and British Pharmacopoeia Commission (2002). Furthermore, chamomile is widely used as a medicinal herb in Europe. The European Scientific Cooperative for Phytotherapy (ESCOP) is producing comprehensive scientific reviews and suggested regulatory texts for herb use. One of the first herbs for which they produced such a document was chamomile (Blumenthal 2004). One of the main reasons for the pharmaceutical characters of chamomile is related to different classes of active constituents, including the essential oil (EO) (Szoke *et al*. 2004). The plant contains 0.24–1.9% EO, from which over 120 components have been identified. The major EO components include α-(-)-bisabolol and chamazulene which directly reduce inflammation and are both mild antibacterial. The EO also contains bisabolol oxides A and β-farnesene and abisabolonoxide A, which have anti-inflammatory and antispasmodic actions (Achterrath-Tuckermann *et al*. 1980; Jakolev *et al*. 1983).

Plant nutrition is one of the most important factors that increase plant production. Nitrogen (N) is most recognized in plants for its presence in the structure of the protein molecule. In addition, N is found in such important molecules as purines, pyrimidines, porphyrines, and coenzymes. Purines and pyrimidines are found in the nucleic acids RNA and DNA, which are essential for protein synthesis. The porphyrin structure is found in such metabolically important compounds as the chlorophyll pigments and the cytochromes, which are essential in photosynthesis and respiration. Coenzymes are essential to the function of many enzymes. Accordingly, N plays an important role in synthesis of the plant constituents through the action of different enzymes. N limiting conditions increase volatile oil production in annual herbal. N fertilization has been reported to reduce EO content in creeping juniper (*Juniperus horizontalis*) (Robert and Francis 1986), although it has been reported to increase total EO yield in thyme (*Thymus vulgaris* L.) (Baranauskienne *et al*. 2003). 40 kg N ha^{-1} resulted in the greatest response of geranial and citronellal contents in *Leptospermum petersonii* EO (Diatloff 1990). Increasing N application from 12 to 24 kg N ha^{-1} increased the *Agastache rugosa* EO yield by 95.8% (Ohk *et al*. 2000). N fertilizer of 0, 100 and 200 Kg ha^{-1} increased the anise (*Pimpinella anisum* L.) seed yield by 546, 794 and 897 Kg ha^{-1} and EO by 13.46, 21.16 and 24.88 L ha^{-1} respectively (Azizi 2000). Increasing N level at 30 kg N ha^{-1} had a positive effect on the major component (*p*-cymene) of black seed (*Nigella sativa* L.) EO, whereas no change in the levels of α-pinene or β-pinene was observed (Ashraf *et al*. 2006). Yield and EO of cumin (*Cuminum cyminun*) were significantly increased by adding N fertilizer (Azizi and kahrizi 2008). Various levels of N fertilization (0, 176, 264, 352, or 442 mg N pot^{-1}) decreased the EO content of *Nigella sativa* L. seeds (Shah 2008). Application of N at 200 kg ha^{-1} year^{-1} increased the total herbage yield by 104.5% and total EO yield by 102.6% over control (no application of N) (Singh 2008). Application of 75 kg N ha^{-1} significantly increased the total dry matter and EO yield in mint (*Mentha longifolia*) plant (Alsafar and Al-Hassan 2009). 1.2 g N pot^{-1} was effective in raising the productivity of herb and EO of oregano (*Origanum vulgare* L.) (Said-Al Ahl *et al*. 2009). N increased the seed yield of calendula (*Calendula officinalis* L.) (Rahmani *et al*. 2009). Phosphorous (P) plays an important role in various metabolic processes. It is a constituent of nucleic acid, phospholipids, the coenzymes, DNA and NADP, and most importantly ATP. It activates coenzymes for amino acid production used in protein synthesis, and it is decomposes carbohydrate production in photosynthesis; as well as involved many other metabolic processes required normal growth, such as photosynthesis, glycolysis, respiration, fatty acid synthesis. Moreover, P enhances seed

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germination and early growth, stimulates blooming, enhances bud set, aids in seed formation and hastens maturity (Espinnosa *et al*. 1993). High P rates (more than 7.47 kg P ha^{-1}) decreased chamomile EO yield (Emongor 1990). Within the sweet basil leaves EO, eugenol, linalool, 1,8-cineol, acetate-D-amyl and germacrene-D concentrations were affected (increased or decreased) by the amount of applied P, on the other hand, α-bergamotene, β-elemene concentration was not affected (Chimura *et al*. 1993). Application of 100 kg ha^{-1} P significantly increased the fresh and dry weights in feverfew (*Tanacetum parthenium* (L.) Schultz Bip) plant while All P levels (50, 100 and 150 Kg ha^{-1}) as compared with the control significantly enhanced the EO concentration (Saharkhiz and Omidbaigi 2008). Application of 50 kg P_2O_5 ha^{-1} significantly increased the total dry matter and EO yield in mint (*Mentha longifolia*) plant (Alsafar and Al-Hassan 2009). The leaf biomass of garden sage (*Salvia officinalis* L.) and EO content increased with adding P fertilizer (Nell *et al*. 2009). Potassium (K) is one of the most important elements for plant nutrition, which content occupies 1-5% of crops' dry matter, it plays a very important role in the growth, yield and quality of crops, K is involved in the activities of over 60 kinds of plant enzymes, potassium affects the metabolism of N and carbohydrates, and the synthesis of lipid, starch and protein. K also plays a very important role in substance transportation inside plants (Zahra *et al*. 1984). Adding K fertilizer increased herb, EO and its constituents in rue (*R. graveolens* L.) (Khalid *et al*. 2007). The highest peppermint (*Mentha piperita*) EO production was in K at 218 mg L^{-1} concentration (Mollafilabi *et al*. 2010). Addition of K at 123 kg ha^{-1} $year^{-1}$ enhanced the total EO yield of palmarosa (*Cymbopogon martinii* [Roxb.] Wats. var. Motia burk) plant by 23.7% in comparison to no K application (Munnu 2008). K fertilization increased EO and anethole content of anise (*pimpinella anisum* L.) plant (Al-Awak 2010). K increased fruit yield, EO content, linalool and limonene but no considerable differences were observed in carvone with different K rates in caraway (*Carum carvi* L.) (Ezz El-Din *et al*. 2010). Hornok (1980) indicated that, NPK fertilization increased the quantity of vegetative and generation mass as well as the EO content of dill (*Anethum graveolens* L.). Hussien (1995) reported that NPK fertilization increased the main constituents of dill EO. NPK fertilization increased the vegetative growth and EO content of some medicinal *Apiaceae* plants (Khalid 1996). The effect of different amounts of NPK on the essential oil composition was very slight and was not significant but the amount of some component such as carvacrol, γ-terpinene and α-terpinene was changed (Alizadeh *et al*. 2010).

Sandy soils in Egypt are characterized by poor nutrients (including macro- and micronutrients) and unfavorable environmental conditions which negatively affect growth and productivity of medicinal and aromatic plants, including chamomile (Abd-Allah *et al*. 2001). In addition, pollution with chemical fertilizers arose as an aim of health cure, thus attempts were done for solving problems of chemical fertilization, and the organic farming technique represents a move towards an alternative system of agriculture (Abd-Allah *et al*. 2001). Organic material improve soil physical properties (structure and aggregation) and soil chemical properties (decrease soil pH, increase cation exchange capacity and enhance the most nutrient) that important for plant growth (Snyman *et al*. 1998). Barker and Bryson (2002) reported that, heavy metals pollutant are not degraded during composting but may be converted into organic combinations that have less bio-availability than mineral combinations of the metals, so the pollution can decrease with organic fertilizers. Application of organic fertilizer increased the biomass yield of the main crop and total EO yields of davana (*Artemisia pallens* Wall. ExD.C.) plant (Parakasa Rao *et al*. 1997). Marculescu *et al*. (2002) revealed that the soil with its content in macro- and micro-elements, enhanced by the use of organic fertilizers, plays an essential role in the plants growing and development, in the biosynthesis of the organic substances, also it can be noted that, the vegetative mass is rich and the amount of EO is high in chrysanthemum (*Chrysanthemum balsamita* L.) plant when using organic fertilizer. Khalid and Shafei (2005) indicated that treated plants with different combinations of organic fertilizers and their rates resulted in a significant increase in growth, yield characters, EO and main components of EO extracted from dill (*Anethum graveolens* L.). Khalid *et al*. (2006) reported that organic fertilization increase the vegetative growth and EO content of marigold (*Calendula officinalis* L.) plants. Hussein *et al*. (2006) revealed that organic fertilizers had a promoting influence on most vegetative growth parameters and accelerated EO accumulation of dragonhead (*Dracocephalum moldavica* L.). Organic fertilizer treatments *i.e.* a mixture of farmyard and chicken manure improved the volatile oil and some of the main constituents of EO in onion (*Allium cepa* L.) plants (Yassen and Khalid 2009).

Liquid manure or liquid compost is applied to establish and support biologically diverse and metabolically dynamic process during the growth of plant and EO production and extending to long- term and stewardship. The various liquid treatments are intended to serve, primarily, as a source of soluble of plant nutrients, growth stimulants, EO production and disease suppressors (Weltzien 1990). Applying compost and liquid compost improved vegetative growth characters, EO and some chemical composition of EO extracted from sweet basil (*Ocimum basilicum* L.) plants (Khalid *et al*. 2006). Said-Al Ahl and Khalid (2010) indicated that organic compost and liquid compost resulted in a significant increase EO and main components of EO extracted from coriander (*Coriandrum sativum* L.) plants.

The main objective of the present investigation was to study the effect of different levels of chemical fertilizers (NPK), organic fertilizers (compost and liquid compost) on the flower heads yield and EO characters of chamomile (*M. chamomilla* L.) plants under sandy soil conditions.

MATERIALS AND METHODS

Experimental

The experiments were carried out under sandy soil conditions at the experimental station of Sekem Company, Sharkiya region, Egypt during two successive seasons of 2008/2009 and 2009/2010. Mechanical and chemical properties of the soil [Typic Torrifluvents soil (USDA 1999)] used in this study were determined according to Jackson (1973) and Cotteni *et al*. (1982) and are presented in **Table 1**. Seeds of *M. chamomilla* were kindly produced from the Medicinal and Aromatic Plants Department, Ministry of Agriculture, Egypt. *M. chamomilla* seeds were sown in the first week of September during both seasons. The seedlings were transplanted 45 days after sowing. Transplanting was done in rows (2 per each ridge) with spacing of 25 cm in the row. The experimental design was complete randomized blocks with four replicates. The experimental area (plot) was 4 m^2 (2 m × 2 m) containing 4 rows. The experiment included 14 treatments representing the different chemical fertilizers (N: P: K, 2:1:1), compost and liquid compost i.e. control (no fertilizers); 3 levels of NPK fertilization

Table 1 Physical and chemical properties of the soil.

Texture		**Sand (%)**				**Silt (%)**			**Clay (%)**		
Sand		81.8				16.79			1.23		
Available (mg g^{-2})		**Total (mg g^{-2})**	**Soluble anions (meq l^{-1})**				**Soluble cations (meq l^{-1})**			**EC Dsm^{-1}**	**pH 3.27**
P	K	N	CO_3	HCO_3	Cl	SO4	Na	Mg	Ca	2.22	7.56
8.6	18	55	-	3.49	6.54	3.2	5.5	1.65	4.55		

Table 2 Compost analysis.

Contents	Values
Moisture (g kg $^{-1}$)	17.6
EC (dsm^{-1})	10.2
pH	7.8
O C (g kg $^{-1}$)	23.5
OM (g kg $^{-1}$)	35.9
Total N (g kg $^{-1}$)	1.1
C/N Ratio	18
NH4 –N (mg kg^{-1})	760
No3 –N (mg kg^{-1})	415.0
Total P (g kg $^{-1}$)	0.9
Available P (mg kg^{-1})	298
Total K (g kg $^{-1}$)	1.65
Available K (mg kg^{-1})	415
Fe (mg kg^{-1})	816
Zn (mg kg^{-1})	251
Mn (mg kg^{-1})	298
Cu (mg kg^{-1})	123

Table 3 Chemical analysis of liquid compost.

pH	N	P	K	Ca	Mg	Fe	Zn
	(mg kg^{-1})						
6.5	250	6 .0	184.0	87 .0	101.0	48.0	5 .0

(119, 178.6 and 238.1 kg ha^{-1}) and compost (23.8, 47.6 and 71.4 m^3 compost ha^{-1}); the same treatments (control, NPK and compost) but liquid compost was added.

Chemical fertilizers were added after 30 days from transplanting. Compost was added during preparing the soil. Liquid compost was sprayed after 60 days from transplanting. Chemical analyses of used organic fertilizers (compost and liquid compost) are presented in **Tables 2** and **3**. All agriculture practices operation other than experimental treatments were donning according to the recommendations of Ministry of Agriculture, Egypt.

Harvesting

Fresh flower heads were collected from each treatment at flowering stages in both seasons (1st season + 2nd season), all of which were air dried. Yield [fresh weigh (FW) and dry weight (DW) of flower heads (g plant^{-1})] and flower head diameters (cm) were recorded.

EO isolation

Fresh flower heads were collected from each treatment through flowering stages in both seasons (1st season + 2nd season), air dried and weighed to extract the EO. Dry flower heads (500 g) from each of these treatments was hydro-distilled for 3 h using a Clevenger-type apparatus (Clevenger 1928). The EO content was calculated as a percentage. Also EO (g plant^{-1}) was calculated according to the DW (s) of flower heads per plant.

Gas Chromatography-Mass Spectrophotometric (GC-MS)

The ADELSIGLC-MS system (Model HPSBUOA, Switzerland), equipped with a BPX5 capillary column (0.22 mm id × 25 m, film thickness 0.25 μm) was used. Analysis was carried out using helium as the carrier gas, with a flow rate of 1.0 ml/min. The column temperature was programmed from 60 to 240°C at 3°C/min. The sample size was 2 μl, the splitting ratio 1:20. The injection temperature was 250°C. The ionization voltage applied was 70 eV, mass range m/z 41-400 a.m.u. Kovat's indices (Adams 1995) were determined by co-injection of the sample with a solution containing a homologous series of *n*-hydrocarbons, in a temperature run identical to that described above.

Identification of components

The separated components of the EO were identified by matching with the National Institute of Standards and Technology (NIST) mass-spectral library data, with those of authentic components (obtained from Sigma Aldrich Co.) and with published data (Adams 1995).

Statistical analysis

In this experiment, 2 factors were considered: fertilization treatments: NPK, compost treatments and liquid compost treatments. For each treatment there were 4 replicates, each of which had 2 plots. The number of experimental units was 112 plots. The experimental design followed a complete random block design according to Snedecor and Cochran (1990). The averages of FW and DW of flower heads, flower head diameter and EO (% and g plant^{-1}) were statistically analyzed using two-way analysis of variance (ANOVA-2), while the averages values of the interaction treatments (NPK or compost × liquid compost) for EO chemical constituent data were statistically analyzed using one-way analysis of variance (ANOVA-1), significant values determined according the P values ($P \leq 0.05$ = significant, $P < 0.01$ = more significant and $P < 0.001$ = highly significant) using STAT-ITCF program (Foucart 1982).

RESULTS AND DISCUSSION

Effect of NPK (or compost), liquid compost and their interactions on the flower growth characters

Data presented in **Table 4** indicates that NPK, compost and/ or liquid compost had a positive effect on flower heads growth characters i.e. FW or dry DW of flower heads (g plant^{-1}) and flower head diameter (cm). It can be noticed that NPK (or compost) + liquid compost caused a pronounced increment in FW and DW of flower heads or flower head diameter compared with the treatments of NPK (or compost) without liquid compost. It is appeared that compost used at 71.4 m^3 ha^{-1} + liquid compost gave the maximum mean values of flower heads FW (238.9 g plant^{-1}), flower heads DW (33.2 g plant^{-1}) as well as flower head diameter (2.85 cm). ANOVA indicated that the increase in FW of flower heads was highly significant for NPK (or compost), liquid compost and NPK (or compost) + liquid compost treatments. The increase in DW of flower heads was highly significant for NPK (or compost) and liquid compost treatments while it was insignificant for NPK (or compost) + liquid compost treatments. The increase in flower head diameter was insignificant for NPK (or compost) and NPK (or compost) + liquid compost treatments but it was significant for liquid compost treatment (**Table 4**). Obtained results agreed with those of Borin *et al.* (1987) and Brwaldh (1992), they reported that, organic fertilizers is a rich and a slow release fertilizer which usage leads to a clean product of plants. They added that using organic fertilizer improves the soil texture. The structural improvement can encourage the plant to have a good root development by improving the aeration in the soil, which leads to a higher plant growth. Also the obtained results indicated the favorable effect of compost on chamomile plant productivity, this results might be due to the role of organic material for continues supply of nutrients, which improve some physical properties of soil and increase water retention than that for chemical fertilizers (Abd-Elmoez *et al.* 1995; Fliessbach *et al.* 2000). Liquid compost is applied to establish and support biologically diverse and metabolically dynamic process during the plant growth and extending to long-term and stewardship. The various liquid treatments are intended to serve, primarily, as a source of soluble of plant nutrients, growth stimulants, and disease suppressors (Weltzien 1990). The effect of liquid compost agreed with the results of Khalid *et al.* (2006) they demonstrated that applying compost and liquid compost improved vegetative growth characters of sweet basil (*Ocimum basilicum* L.) plants.

Table 4 Effect of NPK (or compost), liquid compost and their interactions on the growth and essential oil contents of chamomile flower heads.

Treatments		**Flower heads fresh weight (g plant^{-1})**	**Flower heads dry weight (g plant^{-1})**	**Flower heads diameter (cm)**	**Essential oil (%)**	**Essential oil (g plant^{-1})**
Without liquid compost	Control	93.9	16.0	2.00	0.17	0.030
	NPK (119 kg ha^{-1})	126.3	17.3	2.20	0.19	0.034
	NPK (178.6 kg ha^{-1})	139.6	19.6	2.23	0.21	0.041
	NPK (238.1 kg ha^{-1})	155.2	21.2	2.31	0.23	0.052
	23.8 m^3 compost ha^{-1}	180.5	22.7	2.35	0.26	0.061
	47.6 m^3 compost ha^{-1}	156.1	25.7	2.37	0.29	0.078
	71.4 m^3 compost ha^{-1}	205.4	27.9	2.39	0.31	0.090
Overall without liquid compost		151.0	21.5	2.30	0.24	0.056
With liquid compost	Control	117.2	17.9	2.45	0.19	0.037
	NPK (119 kg ha^{-1})	140.1	19.3	2.48	0.22	0.044
	NPK (178.6 kg ha^{-1})	173.4	22.1	2.56	0.24	0.055
	NPK (238.1 kg ha^{-1})	196.9	24.8	2.61	0.27	0.071
	23.8 m^3 compost ha^{-1}	210.7	28.0	2.66	0.30	0.087
	47.6 m^3 compost ha^{-1}	222.0	30.4	2.69	0.32	0.100
	71.4 m^3 compost ha^{-1}	238.9	33.2	2.85	0.35	0.120
Overall with liquid compost		185.6	25.1	2.60	0.27	0.073
Overall treatments	Control	105.6	17.0	2.23	0.18	0.034
	NPK (119 kg ha^{-1})	133.2	18.3	2.34	0.21	0.039
	NPK (178.6 kg ha^{-1})	156.5	20.9	2.40	0.23	0.048
	NPK (238.1 kg ha^{-1})	176.05	23.0	2.46	0.25	0.062
	23.8 m^3 compost ha^{-1}	195.6	25.4	2.51	0.28	0.074
	47.6 m^3 compost ha^{-1}	189.1	28.1	2.53	0.31	0.089
	71.4 m^3 compost ha^{-1}	222.2	30.6	2.62	0.33	0.105
F ratio						
Treatments		3925.3***	106.0***	0.7	35.1***	185.2***
Liquid compost		5283.9***	97.3***	8.8*	22.4***	111.1***
Treatments * liquid compost		163.8***	2.5	0.1	0.2	3.9*

* $P \leq 0.05$ according to *F*-values of the 2-way analysis of variance (ANOVA-2).
** $P < 0.01$ according to *F*-values of the 2-way analysis of variance (ANOVA-2).
*** $P < 0.001$ according to *F*-values of the 2-way analysis of variance (ANOVA-2).

Table 5 Effect of NPK (or compost) and liquid compost on the chemical constituents of essential oil extracted from chamomile flower heads.

Constituents	**Treatments**														***F*-ratio**
	Without liquid compost							**With liquid compost**							
		NPK (kg ha^{-1})			**Compost (m^3 ha^{-1})**				**NPK (kg ha^{-1})**			**Compost (m^3 ha^{-1})**			
	Cont.	119	178.6	238.1	23.8	47.6	71.4	Cont.	119	178.6	238.1	23.8	47.6	71.4	
p-Cymene	0.14	0.29	0.16	0.27	0.14	0.11	0.25	0.15	0.14	0.23	0.25	0.13	0.17	0.27	7.4***
β-Ocimene	1.15	0.27	1.09	0.23	0.12	0.54	0.25	0.17	0.14	0.23	0.25	0.13	0.17	0.28	3.6*
β-Farnesene	8.12	5.10	6.30	1.22	0.39	4.34	0.43	1.17	0.65	1.22	1.10	0.48	0.24	0.33	3.5*
Germacrene D	2.80	1.20	1.30	4.50	8.69	2.38	6.40	4.55	4.30	4.50	2.40	5.55	6.90	5.20	6.2***
α-Farnesene	9.70	8.50	7.80	1.70	1.12	8.32	2.50	1.20	1.50	1.70	2.40	2.80	3.30	1.58	2.3
Bisabololoxide B	11.30	12.80	14.30	12.90	8.30	14.35	8.00	12.40	5.70	12.90	6.00	7.30	9.40	8.60	2.2
α-Bisabolol	8.45	8.35	9.72	11.50	14.76	9.55	12.70	12.40	12.90	11.50	12.10	14.14	11.00	12.40	7.3***
Chamazulene	35.40	46.20	44.30	38.50	37.23	41.26	38.50	46.90	46.30	38.50	44.61	40.12	37.50	45.30	0.9
Bisabololoxide A	15.70	12.40	12.40	9.20	7.11	13.21	9.64	8.33	8.43	9.20	9.25	8.76	8.00	9.00	2.2
Total identified	92.76	95.11	97.37	80.02	77.86	94.06	78.67	87.27	80.06	79.98	78.36	79.41	76.68	82.96	
Unknown compounds	7.24	4.89	2.63	19.98	22.14	5.94	21.33	12.3	19.94	20.02	21.64	20.59	23.32	17.04	

* $P \leq 0.05$ according to F-values of the one-way analysis of variance (ANOVA-1).
** $P < 0.01$ according to F-values of the one-way analysis of variance (ANOVA-1).
*** $P < 0.001$ according to F-values of the one-way analysis of variance (ANOVA-1).

Effect of NPK (or compost), liquid compost and their interactions on the EO and its constituents

Data presented in **Table 4** revealed that NPK (or compost), liquid compost and their interaction treatments had a positive effect in EO content (% and g plant^{-1}). However, NPK (or compost) + liquid compost treatment resulted the highest increase of EO content compared with control and other treatments. Compost at 71.4 m^3 ha^{-1} + liquid compost gave the maximum mean values of EO content. ANOVA indicated that the increase in EO (%) was highly significant for NPK (or compost) and liquid compost treatments but it was insignificant for NPK (or compost) + liquid compost treatments. The increase in EO yields (g plant^{-1}) was highly significant for NPK (or compost) and liquid compost but it was significant for NPK (or compost) + liquid compost treatment (**Table 4**).

The composition of the EO with different treatments was studied (**Table 5**). A total of 9 compound representing 76.68-97.37% of total detected constituents with different treatments. The unknown compounds representing 2.63-23.32% of total detected constituents. The main constituents of *M. chamomilla* EO as detected by GC-MS were chamazulene, bisabololoxide A, bisabololoxide B, α-bisabolol, α-farnesene and β-farnesene. Within the EO, the relative level for various constituents increased, decreased, or did not change in *M. chamomilla* plants under chemical and organic fertilizers as compared with unfertilized control plants. These results show that the type fertilizes and rate in the production system, either chemical or organic fertilizers should be considered in the chemical characterization of the oil produced from EO -bearing plants when treating different kinds of fertilizers. ANOVA indicated that changes in EO constituents i.e. *p*-cymene, germacrene D and α-bisabolol were highly significant for different fertilization treatments but it were significant for β-ocimene and β-farnesene constituents. On the other hand, changes α-farnesene, bisbololoxide B, chamazulene and bisabololoxide A were insignificant for all fertilization treatments (**Table 5**). Obtained results agreed with those of Parakasa Rao *et al.* (1997) who reported that application of organic fertilizer increased total EO yields of davana (*Artemisia pallens* Wall. ExD.C.) plant and Marculescu *et al.* (2002), they revealed that the soil with its content in macro and microelements, enhanced by the use of organic fertilizers, plays an essential role in the plants development, in the biosynthesis of the organic substances at all level, also it can be noted that, when using manure, the amount of active principal (EO) is high in chrysanthemum (*Chrysanthemum balsamita* L.) plant. On the other hand the effect of liquid compost agreed with the results of Khalid *et al*. (2006) and Said-Al Ahl and Khalid (2010), they indicated that organic fertilizer and liquid compost resulted in a significant increase EO and main components of EO extracted from *Ocimum basilicum* L. (sweet basil) and coriander (*Coriandrum sativum*) plants. The effect of different treatments on EO yield and constituents may be due to their effect(s) on enzyme activity and metabolism of EO production (Burbott and Loomis 1969).

CONCLUSION

Adding compost to liquid compost had a positive effect on growth characters [FW or dry DW flower heads (g $plant^{-1}$) and flower head diameter (cm)] and EO content [% and g $plant^{-1}$] compared with chemical fertilizers or compost treatments For various volatile oil constituents increased, decreased, or did not change in *M. chamomilla* plants under chemical and organic fertilizers as compared with unfertilized control plants.

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