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Influence of chemical and organic fertilizer on growth, yield and essential oil of dragonhead (*Dracocephalum moldavica* L.) plant

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ABSTRACT

Two field experiments were carried out to study the response of *Dracocephalum moldavica* L. to NPK fertilizer and different application techniques of MOG organic fertilizer in two regions of Iran (Piranshahr with cold Mediterranean climate and clay loam soil, Maragheh with cool sub-humid temperate climate and sandy loam soil). MOG is bio-organic fertilizer with plant origin and contains different natural enzymes and amino acids. In current study following treatments have been applied: NPK (a complete NPK 20-20-20, 90 kg fertilizer ha^{-1}); MOG_1 (soil application of MOG organic fertilizer at sowing stage); MOG_2 (foliar application of MOG organic fertilizer at early stage of flowering); MOG_3 (soil application of MOG organic fertilizer at sowing and at 5 to 6 leaf stage); MOG_4 (soil application of MOG organic fertilizer at sowing and at 5 to 6 leaf stage with foliar application at early stage of flowering). Results indicated that all MOG treatments overcome the chemical fertilizers in both locations. However, plants grown in Piranshahr were more responsive to MOG fertilizer treatments than those grown in Mragheh. Overall, it could be concluded that utilization of MOG fertilizer as both soil and foliar application (MOG_4) may increase content and yield of essential oil, which could be suggested as a suitable alternative for chemical fertilizers.

Key words: dry herbage, essential oil yield, flower, Moldavian balm, vegetative growth

IZVLEČEK

VPLIV MINERALNIH IN ORGANSKIH GNOJIL NA RAST, PRIDELEK IN VSEBNOST ETERIČNIH OLJ KAČJEGLAVKE (*Dracocephalum moldavica* L.)

V dveh poljskih poskusih je bil preučevan odziv kačjeglavke (*Dracocephalum moldavica* L.) na gnojenje z NPK in različne tehnike uporabe MOG organskih gnojil na dveh območjih Irana (Piranshahr, s hladnim mediteranskim podnebjem in glineno-ilovnatimi tlemi, Maragheh s hladnim, semi humidnim zmernim podnebjem in peščeno-ilovnatimi tlemi). MOG je biološko gnojilo rastlinskega izvora, ki vsebuje številne naravne encime in amino kisline. V tej raziskavi so bili uporabljeni naslednji tretmani: NPK (NPK 20-20-20, 90 kg gnojila ha^{-1}); MOG_1 (talna aplikacija MOG organskega gnojila ob setvi); MOG_2 (foliarna aplikacija MOG organskega gnojilav zgodnji fazi cvetenja); MOG_3 (talna aplikacija MOG organskega gnojila ob setvi in v fazi 5 do 6 lista); MOG_4 (talna aplikacija MOG organskega gnojila ob setvi in v fazi 5 do 6 lista s foliarno aplikacijo ob začetku cvetenja). Rezultati so pokazali,da so dala vsa obravnavanja z MOG boljše rezultate kot mineralna gnojila na obeh lokacijah. Rastline z območja Piranshahr so bile bolj odzivne na MOG gnojenje kot tiste z območja Maragheh. Zaključimo lahko, da uporaba MOG gnojil, tako talna kot foliarna lahko poveča vsebnost in pridelek eteričnih olj in bi se lahko priporočila kot primerna alternativa gnojenju z mineralnimi gnojili.

Ključne besede: suha zel, pridelek eteričnih olj, cvet, kačjeglavka, vegetativna rast

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1 INTRODUCTION

Dragonhead or Moldavian balm (*Dracocephalum moldavica*) is an annual herbaceous aromatic plant belonging to family of Lamiaceae (El-Baky and El-Baroty, 2007). It is native to central Asia and to eastern and central Europe (Griffiths, 1994). Dragonhead is commonly consumed as a food-related product and as a herbal preparation because of its reputed medicinal properties. In some parts of Iran, distilled aqueous extracts from *D. moldavica* is used as a beverage (Dmitruk & Weryszko-Chmielewska, 2010; Rechinger, 1986). The oil content and its composition showed high variation due to the plant origin (Hussein *et. al*, 2006). In Iran, it distributed in the north and northwestern parts of the country, especially in the western parts of Azerbaijan province, and in the Albourz Mountains (Dastmalchi et al., 2007; Dmitruk & Weryszko-Chmielewska, 2010). The seeds of Moldavian Balm have astringent, carminative and tonic properties. They are used as a demulcent in the treatment of fevers (Dastmalchi et al., 2007). Furthermore, the plant is astringent, tonic and vulnerary (Rechinger, 1986) and has antitumor properties (Chachoyan & Oganesyan, 1996).

Plant nutrition is one of the most important factors affecting quantity and quality of secondary metabolites in plants. In order to meet the ever-increasing demand of medicinal plants need to be identified the best fertilizer application strategies. It is apparent that essential oil content enhance with increasing plant age to reach the maximum values at post flowering stage. The yield of plant fresh herb, the essential oil content and its composition can be influenced by growth stages, ecological and climatic conditions. Several attempts have been made to increase yield potential of medicinal plants (Das et al., 2007; Sharma and Kumar 2011), but they are concerned with use of inorganic fertilizers which may affect biological aspect of soil. Therefore, the use of organics and biofertilizers is gaining more importance for getting higher yield and quality.

Bio-fertilizer as an organic agro-input can promotes plant growth by increasing the supply or availability of macro and micro nutrients through the natural processes (Vessey 2003). Furthermore, bio-fertilizers can be expected to reduce the use of chemical fertilizers. One of the recently introduced organic fertilizer is MOG manufactured by using of some fruits juice and crop residues and contains 18 types enzymes (like as Alkaline Protease, Glucamylase, Lipase, Lipoxigenas, Nitrogenase…), natural form of micro and macro nutrients and vegetable based vitamins. However, the information on the role of MOG organic fertilizer on morphophysiological traits and chemical contents in Dragonhead is little. Hence, there is an urgent need to study the influence of biofertilizer on biochemical, quality and yield components in Dragonhead to boost the productivity potential. The present investigation was performed to study the effect of MOG organic fertilizer and chemical fertilizers on growth and productivity in *Dracocephalum moldavica* in two regions in northwest Iran.

2 MATERIALS AND METHODS

The experiments were conducted at two different locations. The first was agricultural research stations of Piranshahr, West Azarbayejan in the north-west of Iran (36° 40' N, 45° 08' E; 1840 m) with cold Mediterranean climate and a long-term mean air temperature of 17.8°C for the April until August period. In Piranshahr summers are almost dry but rest of year could be considered as wet seasons and soil texture of field was clay loam. Second location was Research farm of University of Maragheh, East Azarbayejan in the north-west of Iran (37° 24' N, 46° 16' E; 1477 m). Maragheh has cool sub-humid temperate climate with relative warm summers and the length of dry season is about 75 days. The soil texture of the field was sandy loam. Meteorological data during the crop growth period at both sites are presented in Table 1.

Table 1. Monthly temperature and precipitation during the growing season in 2012.

Month	Average temperature (°C)						Total precipitation (mm)	
	Minimum		Maximum		Mean			
	Piranshahr	Maragheh	Piranshahr	Maragheh	Piranshahr	Maragheh	Piranshahr	Maragheh
April	10.5	5.6	19.1	21.6	14.8	13.6	95.5	40.5
May	14.7	10.9	23.7	25.3	19.2	18.1	34.1	16.4
Jun	16.7	13.9	29.5	32.7	23.1	23.3	7.2	5.0
July	18.7	3.20	32.7	33.6	26.7	26.5	1.3	0.0
Augest	22.9	2.21	33.3	34.1	28.1	27.2	0.0	1.4

For both locations, composite soil samples were collected two weeks before planting, at a depth of 0–30 cm. The soil was air-dried and crushed before its pH, electrical conductivity (EC), and saturation percentage were evaluated. Then total organic carbon (using the Walkley and Black method, which involves sulphuric acid), total nitrogen (using the Kjeldahl method), available phosphorus (using the Olsen procedure), available potassium after extraction with ammonium acetate and Total Neutralizing Value were determined following the method as described by Jackson (1973) and Tandon (1995) were measured. Details of the soil properties of the both two locations are shown in Table 2.

Table 2: Soil physical and chemical properties in two locations.

Soil properties	Values	
	Piranshahr	Maragheh
Soil texture	clay loam	Sandy loam
Total N (%)	0.103	0.058
Available K (mg kg^{-1})	462	342
Available P (mg kg^{-1})	38.6	5.67
Organic carbon	2.08	0.41
pH	6.85	7.54
EC (ds m^{-1})	0.93	1.96
Total Neutralizing Value (*TNV*)%	49.6	34

The soil characteristics were determined according to Tandon (1995).

The experiment was performed in a randomized block design layout with three replications. Six fertilizer treatments were applied, consist on; Control= no application of fertilizers; NPK= a complete NPK 20-20-20, 90 kg fertilizer ha^{-1}; MOG_1= soil application at sowing stage; MOG_2= foliar application when first flowers was observable; MOG_3= soil application at sowing and at 5 to 6 leaf stage; MOG_4= soil application at sowing and at 5 to 6 leaf stage with foliar application when first flowers was observable. MOG organic fertilizer was provided from Azarabadegan Company, (West Azarbaijan, Iran). In all MOG treatments, organic fertilizer were utilized after dilution to 5% (v/v). The physicochemical properties of MOG organic fertilizer are shown in Table 3. *D. moldavica* seeds were obtained from local market of Bonab, Iran.

Table 3: Chemical characteristics of MOG organic fertilizer.

pH	Total organic carbon (%)	Total N (%)	K_2O (%)	P (%)	Fe (%)	Cu (%)	Enzymes (%)
6.1	25	4	4	1.06	0.42	0.16	13

Each experimental plot was 3 m long and 2 m wide with the spacing of 10 cm between the plants and 40 cm between the rows. There was a space of one meter between the plots and 2 meters between replications. Dragonhead seeds were directly sown by hand on 17 April 2012 in both locations. There was no incidence of pest or disease on dragonhead during the experiment. Weeding was done manually and the plots were irrigated weekly to 70% of field capacity. All necessary cultural practices and plant protection measures were followed uniformly for all the plots during the entire period of experimentation. Harvest time for all investigated traits except 1000-grain weight and harvest index was at 50% flowering. Fresh and dry weight plants were determined with digital weighing scales.

The plants were cut at ground level and samples of plants were dried in the shade and for extracting essential oils were used distillation with water practice and Clevenger device (Yousefzadeh et al., 2013). About 100 g of each dried sample (aerial parts) was separated, triturated and steam-hydro distilled for 2.5 hours. The extraction of oils was carried out according to method of European Pharmacopoeia (1983). The oils were dried over anhydrous sodium sulphate and stored in sealed vials at 2 °C before analysis.

Gas chromatography (GC) analysis was performed using a Thermo-UFM Ultra Fast gas chromatograph equipped with a DB-5 fused silica column (10 m × 0.1 mm i.d., film thickness 0.40 µm). The oven temperature was held at 60 °C for 3 min, and then programmed to increase to 280 °C at a rate of 80 °C min^{-1}. The temperatures of the injector and flame-ionisation detector were held at 285 °C. Helium was used as carrier gas with a linear velocity of 32 cm s^{-1}. The oils were injected manually into the GC instrument without dilution. The percentages of compounds were calculated by using the area normalisation method, without consideration of response factors (Davazdahemami et al., 2008).

Gas chromatography–mass spectroscopy (GC–MS) were carried out using a Varian 3400 GC–MS system equipped with a DB-5 fused silica column (30 m × 0.25 mm i.d., film thickness 0.25 µm). Following injection, the oven temperature was increased from 50 to 240 °C at a rate of 4 °C min^{-1}, the temperature of the transfer line was maintained at 260 °C, and the linear velocity of the helium carrier gas was maintained at 31.5 cm s^{-1}, with a split ratio of 1:60, an ionisation energy of 70 eV, a scan time of 1 s, and a mass range of 40–300 amu. The components of the oils were identified by comparing their mass spectra with those held in a computer library or obtained using authentic compounds. The identities of the components were confirmed by comparing their retention indices, either with those of authentic compounds or with data published in the literature (Adams, 1995).

The statistical analysis including analysis of variance and the Least Significant Differences (LSD) among the means (at the 5% probability levels) were performed Snedecor and Cochran (1990).

3 RESULT AND DISCUSSION

Morphological traits

Plant height significantly influenced by fertilizer treatments and location (Table 4). Plant height comparison between the fertilizer treatments showed that the maximum value is related to plants received organic MOG_4 (90.92 cm), it was followed by organic MOG_2 (82.43 cm) and minimum of that was recorded for control plants (75.71cm). Moreover, the comparison of plant height between two locations revealed that *D. moldavica* plants cultivated in Piranshahr were 25% taller than those grown in Maragheh. The findings of the current study are consistent with those of Mafakheri et al. (2012) who found that concurrent application of organic fertilizer (vermicompost) could significantly improve the height of dragonhead. Numbers of the secondary branches were not affected by fertilizer treatments or by locations. Fertilizer application significantly affected the number of flower per plant, so that the highest number of flower was recorded in plants which experienced the MOG_2 and MOG_4. Furthermore, the number of flowers produced per plant significantly was different between locations, since the number of flowers in plants grown in

Piranshahr was 89% higher than those which grown in Maragheh.

The effects of fertilizer treatments on the chlorophyll content are shown in Table 4. The study showed that, regardless of location and type of fertilizer, the chlorophyll content for the control plants was about 28% lower than plants that received fertilizer. Also results revealed that nutrient source could considerably affect chlorophyll content, since the highest amount observed for MOG_4. These findings confirmed the earlier suggestion that N and Mg can be released by organic fertilizer and then incorporated to porphyrin rings of chlorophyll molecules (Amujoyegbe et al., 2007). Thus, it seems that the higher level of N and Mg could result in developed site of photosynthesis and enhanced plant growth.

Fertilizer treatments had significant effects on the 1000-grain weight and harvest index at 5% probability level. In both locations, the lowest harvest index was recorded in control plants and those grown with chemical fertilizers. The highest 1000-grain weight was observed in plants that received organic MOG fertilizer as both soil and foliar application (Table 4). Obtained results agreed with those of Rahimzadeh et al. (2011) and Mafakheri et al. (2012), they reported that, organic and bio fertilizers are rich and slow release fertilizers which usage leads to stimulate and increase of both vegetative and reproductive growth. Khalid et al. (2006) reported that applying liquid compost improved vegetative growth and reproductive characters of sweet basil (*Ocimum basilicum* L.) plants.

Dry herbage yield

Result revealed that dry herbage yield of dragonhead plants grown in Piranshahr was significantly higher (41%) than Maragheh. In addition, significant differences observed in dry herbage yield among fertilizer treatments (Table 4). In both locations, the MOG_4 treatment gave the highest dry herbage yield (7947 and 6127 kg ha^{-1} in Piranshahr and Maragheh, respectively). In addition, control plants produced the lowest dry herbage yields, with 3942 kg ha^{-1} in Piranshahr and 3206 kg ha^{-1} in Maragheh. Differences between locations can be attributed to soil and climatic conditions. It seems that environmental circumstances in Piranshahr were quite suitable for dragonhead plants. These results are in agreement with those obtained by Abdelaziz et al. (2007) on *Rosmarinus officinalis* and Rahimzadeh et al. (2011) on *Dracocephalum moldavica*. In this respect, it is possible that the favourable effect of organic fertilizer on dry herbage yield will be due to their ability to enhance the physiological, biochemical, and biological properties of the soil.

Essential oil content

The results showed that essential oil content affected by the location and fertilization treatments, and the interaction between both factors (Table 4). Mean comparison between fertilization treatments revealed that the highest essential oil content (0.77%) there is in plants grown in Piranshahr and received MOG organic fertilizer through both soil and leaves (MOG_4). This trend was also observed in Maragheh with a slower rate (0.49%). Essential oil content of the plant grown in Piranshahr averagely was 36% higher than those grown in Maragheh. Increases in the percentage oil content following the application of bio and organic fertilizer were observed in medicinal pumpkin (Habibi et al., 2011), *Rosmarinus officinalis* L. (Abdelaziz et al., 2007), dragonhead (Mafakheri et al., 2012; Yousefzadeh et al., 2013). For optimal plant growth, nutrients must be available in adequate and reasonable quantities (Chen, 2006). Intensive agriculture that emphasize heavy chemical application is led to adverse environmental, ecological; and health consequences (Habibi et al., 2011). One of the promising options to reduce the use of chemical fertilizers could be utilization of bio and organic fertilizers. Soils of arid and semi-arid regions often have low organic matter and need organic amendments to recover their characteristics and consequently their productivity and natural fertility. Addition of organic matter, from different resources may through improving physical and chemical properties of soil can affects the growth and development of plant roots and shoots and accumulation of essential oils (Elashry et al., 2008). Our results showed that the main effects of fertilizer treatments and location on yields of essential oils were significant. For plants grown in both locations, the maximum yields of essential oil were recorded in MOG_4 and MOG_2 treatments. The evaluation of the yields of essential oils between locations showed that yields of plants grown in Piranshahr (19.62 kg ha^{-1}) were 21%

higher than those grown in Maragheh (16.27 kg ha^{-1}). In general, provide the required elements for growth increases the yield of essential oil in medicinal and aromatic plants by increasing photosynthesis, chlorophyll content, and Rubisco activity, biomass yield, plant growth, and leaf surface area (Ram et al., 2003; Sekeroglu and Ozguven, 2006; Sifola and Barbieri, 2006).

Table 4: Effects of Fertilizer treatments on some traits of dragonhead plants in two locations.

Location	Fertilizer Treatments (FT)	Plant height	Number of secondary branches	number of flower	chlorophyll content	RWC	Dry herbage yield	Essential oil content	Essential oil yield	1000-grain weight	Harvest index
Piranshahr	Control	80.67^{c}	12.83^{a}	69.40^{fg}	38.49^{f}	74.60^{abc}	3942^{ef}	0.464^{cde}	11.02^{fg}	1.830^{c}	19.02^{c}
	N.P.K	88.54^{bc}	16.33^{a}	124.67^{cde}	43.42^{cde}	68.74^{bc}	5998^{bcd}	0.436^{def}	14.63^{ef}	1.862^{bc}	19.78^{c}
	MOG_1	93.07^{ab}	14.29^{a}	175.92^{bc}	46.66^{bc}	71.26^{bc}	6679^{abc}	0.409^{ef}	13.36^{efg}	1.820^{c}	21.30^{abc}
	MOG_2	96.53^{ab}	15.26^{a}	200.39^{ab}	46.61^{bc}	73.83^{abc}	7312^{ab}	0.664^{b}	24.76^{bc}	1.873^{c}	20.71^{abc}
	MOG_3	91.53^{b}	13.14^{a}	156.5^{bcd}	48.53^{b}	81.55^{a}	5946^{bcd}	0.645^{b}	20.64^{cd}	1.867^{c}	20.30^{bc}
	MOG_4	101.62^{a}	17.07^{a}	260.73^{a}	53.77^{a}	75.06^{abc}	7947^{a}	0.771^{a}	33.46^{a}	1.983^{a}	22.89^{ab}
Maragheh	Control	66.50^{d}	13.33^{a}	37.26^{g}	39.04^{ef}	71.02^{bc}	3206^{ef}	0.422^{d}	9.79^{g}	1.787^{d}	19.25^{c}
	N.P.K	70.83^{d}	14.40^{a}	62.0^{fg}	40.59^{cd}	67.21^{c}	3757^{e}	0.401^{fg}	11.74^{fg}	1.853^{bc}	19.46^{c}
	MOG_1	69.00^{d}	16.30^{a}	91.64^{efg}	43.70^{def}	69.06^{bc}	4087^{e}	0.445^{def}	12.04^{fg}	1.830^{c}	20.93^{abc}
	MOG_2	67.17^{d}	14.67	108.43^{def}	42.01^{b}	70.02^{bc}	4932^{cde}	0.366^{gh}	20.13^{d}	1.820^{bc}	20.70^{abc}
	MOG_3	69.16^{d}	13.33^{a}	86.27^{efg}	48.73^{b}	76.44^{ab}	4602^{de}	0.357^{h}	17.48^{de}	1.824^{bc}	20.86^{abc}
	MOG_4	80.33^{c}	15.07^{a}	138.56^{bcd}	54.62^{a}	75.42^{abc}	6127^{bc}	0.494^{c}	26.48^{b}	1.907^{ab}	23.12^{abc}
LSD		9.42	4.48	63.86	4.43	8.62	1776	0.041	4.33	0.093	2.78
L		**	ns	*	ns	ns	*	**	*	ns	ns
FT		**	ns	**	**	*	**	**	**	*	*
L× FT		ns	ns	ns	ns	ns	ns	**	ns	ns	ns

Values are given as means of three replicates. Means within each column followed by the same letter are not statistically different at $\alpha = 0.05$ by LSD test.
Fertilizer treatments: MOG_1: soil application at sowing stage, MOG_2: foliar application when first flowers were observable, MOG_3: soil application at sowing and at 5 to 6 leaf stage, MOG_4: soil application at sowing and at 5 to 6 leaf stage with foliar application when first flowers were observable.
*Indicate significance at P level of 0.05.
**Indicate significance at P level of 0.01.

Composition of essential oils

The composition of the essential oil with different treatments in both locations was studied (Table 5). Both GC and GC–MS analyses revealed that the major constituents of the oil that was extracted from all six fertilizer treatments in both locations were geraniol, geranial, and geranyl acetate (Tables 5). 3 mentioned compound represented 73.82-91.25% of total detected constituents with different treatments. The unknown compounds representing 0.82-19.53% of total detected constituents. Other reserchers have also reported that the major constituents of essential oils extracted from dragonhead plants are geraniol, geranial, and geranyl acetate (Davazdahemami et al., 2008; Yousefzadeh et al., 2013). However, some investigators have reported inconsistent results, which show that either citral (Nikitina et al., 2008) or linalool (Hussein et al., 2006) are the major constituents in oil from dragonhead plants. It appears that a range of contemplations, including climatic condition, geographic origin, ecological factors, genetic differences, and agricultural practices, could affect the composition of essential oil extracts from medicinal and aromatic plants (Argyropoulou et al., 2007).

Geraniol ($C_{10}H_{18}O$) is a monoterpenoid and an alcohol. The functional group based on geraniol (in essence, geraniol lacking the terminal -OH) is called geranyl. It is important in biosynthesis of other terpenes. It is a by-product of the metabolism of sorbate. The content of this component was reduced in plants that received MOG organic fertilizer as both soil and foliar applications (MOG_4) in comparison with control. Although MOG_4 may be able to increase growth and result in high dry matter production, it contains modest essential oils, which express as dilution effect hypothesis. In plant treated with MOG_3 a significant difference was observed between two locations, since geraniol content in plant grown in Piranshah was two-times more than Maragheh. This is in line with the assertion of Yousefzadeh et al. (2013) that plants differ in their response to changing soil fertility and environmental conditions.

Geranial (3,7-dimethyl-2,6-octadienal) is a pair of terpenoids with the molecular formula $C_{10}H_{16}O$. The two compounds are double bond isomers. The *E*-isomer is known as geranial or citral. It also has strong antimicrobial qualities and pheromonal effects in insects (Onawunmi, 1989). The application of chemical fertilizer (N.P.K) induced a slight increase in geranial content. Mean comparison of the locations revealed that plants grown in Piranshahr had a higher content of this compound. Although, the application of MOG organic fertilizer in some case reduced the percentage of essential oils, but it increased in growth and yields of essential oils can compensate the previous loss. Geranyl acetate (3,7-Dimethyl-2,6-octadiene acetate; $C_{12}H_{20}O_2$) is a natural organic compound that is classified as a monoterpene. Geranyl acetate is a natural constituent of more than 60 essential oils, including in different vegetables. Geranyl acetate and p-cymene also presented some antioxidant effects. Comparison of this organic compound between the locations showed that plants grown in Maragheh had a higher content of Geranyl acetate. The highest percentage of this compound was recorded in plant grown in Maragheh and treated with MOG_3.

Table 5: Essential oil composition of *Dracocephalum moldavica* L. influenced by different fertilizer regimes in two locations.

Fertilizer Treatments		**Control**[a]		**N.P.K**		**MOG$_1$**		**MOG$_2$**		**MOG$_3$**		**MOG$_4$**	
compound	RI[b]	*Pira*[c].	*Mara.*[d]	*Pira.*	*Mara.*	*Pira.*	*Mara.*	*Pira.*	*Mara.*	*Pira.*	*Mara.*	*Pira.*	*Mara.*
Sabinene	977	0.17	0.30	0.23	0.35	0.26	0.18	0.22	0.24	0.24	0.20	0.12	0.29
β-Pinene	989	1.77	1.30	1.93	1.82	1.29	0.89	2.24	1.62	2.13	0.87	2.03	1.26
(E)-β-ocimene	1041	0.24	0.13	0.21	0.22	0.22	0.20	0.26	0.17	0.24	0.14	0.29	0.16
γ-terpinene	1056	0.89	0.51	0.85	0.819	0.18	0.74	0.98	0.65	0.92	0.45	1.11	0.31
Linalool	1109	0.60	0.98	0.76	0.98	0.78	1.12	0.85	0.89	0.82	1.00	0.65	0.85
cis Limonene oxide	1167	1.10	0.87	0.99	0.92	0.62	0.64	1.05	0.92	1.11	0.53	1.05	0.53
Citronellal	1171	0.33	0.27	0.39	0.26	0.19	0.20	0.31	0.28	0.38	0.15	0.37	0.21
Trancelimonene oxide	1180	1.73	1.38	1.73	1.50	0.93	1.00	1.67	1.43	1.69	0.83	3.03	0.75
Neral	1245	0.25	0.38	0.32	0.32	0.37	0.37	0.33	0.38	0.36	0.38	0.22	0.36
Geraniol	1267	34.18	36.03	35.14	34.06	37.93	33.23	35.71	34.37	36.28	16.81	30.84	32.11
geraNial	1289	30.91	27.77	33.92	28.01	30.05	26.78	27.84	27.32	29.34	24.60	29.32	25.82
Neryl acetate	1361	1.52	1.78	1.43	2.02	1.61	2.35	1.46	2.06	1.36	2.14	1.50	3.66
Geranyl acetate	1376	25.43	27.45	21.04	27.88	23.16	30.17	26.19	28.80	24.21	32.43	28.43	29.03
E-Caryophyllene	1482	0.23	0.20	0.24	0.21	0.14	0.10	0.24	0.25	0.26	0.14	0.24	1.45
Total		99.35	99.35	99.18	99.369	97.73	97.97	99.35	99.38	99.34	80.67	99.2	96.79

[a] Fertilizer treatments: MOG_1: soil application at sowing stage, MOG_2: foliar application when first flowers were observable, MOG_3: soil application at sowing and at 5 to 6 leaf stage, MOG_4: soil application at sowing and at 5 to 6 leaf stage with foliar application when first.

[b]RI, retention indices in elution order from DB-5 column.

[c]The fist location: Piranshahr.

[d] The second location Maragheh.

4 CONCLUSION

Our results suggested that using liquid MOG organic fertilizer as both soil and foliar applications could result in better vegetative and reproductive growth, dry herbage yield, and essential oil yield. The results confirm that application of MOG_4 fertilizer treatment provides an appropriate substitute to the use of chemical N.P.K fertilizers and can lead at the end to improving the productivity of this plant. Because organic fertilizer may improve the use efficiency of essential mineral elements and reduced the amount of chemical fertilizers application, also prevented the environment contamination from widespread application of chemical fertilizers. Results revealed that in region with cold Mediterranean climate the production of dragonhead plants will be more successful than cool sub-humid temperate climate.

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