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Comparative Efficiency of Organic and Chemical Fertilizers on Herb Production and Essential Oil of Lovage Plants Grown in Egypt

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Abstract: Application of organic (compost and compost tea) and chemical (NPK) fertilization treatments and their interaction effect on herb production, oil percentage and content of lovage plants was studied in two field experiments during 2008 and 2009 seasons. The obtained results indicated that the highest herb production (fresh leaves) recorded from plants fertilized by compost ($20m^3$) and compost tea ($20m^3$ fed^{-1}) in the first harvest of the first season and $10m^3$ of compost + 20 m^3 fed^{-1} from compost tea for the 2nd and 3rd harvest, also for the 3 harvests of the second season compared with control. NPK at 75 kg fed^{-1} gave the maximum fresh leaves in both seasons. The superior interaction doses were NPK at the rate of 50kg fed^{-1} and $20m^3$ of compost tea for fresh and dry weight of lovage plants. Essential oil maximum percentage in leaves 0.34% was achieved from NPK 100 kg in the second season. The roots oil% reached (0.75%) with 75 kg NPK + compost tea $20m^3$ fed^{-1}. α-terpinyl acetate was the major compound in leaves, while Z-lingustilide was the major one in the roots.

Key words: Lovage *(Levisticum officinale)* NPK · Organic fertilization · Essential oil · Medicinal and aromatic plants

INTRODUCTION

Lovage (*Levisticum officinale*) is a hardy perennial aromatic plant with ribbed stalks similar to celery belonging to Apiaceae family. It is a traditional spice in Southern Europe whose usage dates back to antiquity. The leaves are used in salads, flavoring soup, leafstalks can be eaten fresh and whole seeds or ground is manufactured in candy, cakes and cheese [1]. Lovage tea can be applied to wounds as an antiseptic or drunk to stimulate digestion. Dried leaves were used in an infusion for sore throats, fevers and mouth wash. Chemical analysis of lovage has shown that this aromatic plant encloses a volatile oil, coumarins, plant acids gums and resins [2, 3]. Ibrahim [4] stated that under Egyptian cultivation condition, the yield of fresh herbage and oil of lovage plants reached their peaks during the early growth (May). The essential oil in the leaves was made up to 3 major components, β-phellandrene, α-terpinyl acetate and myrcene which accounted for approx. 73.92% of the total oil. Najda and Wolski, [5] the essential oil contents of the fruits and roots of lovage (*Levisticum officinale*) using distillation followed by GC-MS. They found that phtalides and mono-cyclic terpenes comprised the major compounds of the essential oil from fruits and the roots of the crop, respectively. Generally, NPK fertilizers are applied to promote growth in different ways. Nitrogen is responsible for vegetative growth of plants above ground and rapid maturity, while, phosphorus is essential for strong roots and greater resistance to diseases. Potassium protects plants from cold conditions and preventing excessive water loss. Galambosi and Szebeni-Glambosi [6] reported that the optimum nitrogen level was between 45 to 75 kg N ha^{-1} due to the increase of nitrate content in the dry root of lovage plants. Root yield and aroma content in plants which vegetative parts had been harvested were lower quality. Vulsteke [7] studied the influence of different nitrogen forms on blanched celery. The highest yield has been obtained with 225 kg N ha^{-1} of sodium nitrate and after early potatoes with 150 kg Na^{-1}. The researcher also concluded that fractionation on nitrogen fertilization was better than a broadcast of N in one time of planting date. David Ojo [8] identified the optimal fertilizer rate for production of *Celosia argentea* plants. It was clear that 90 kg ha^{-1} of NPK (15-15-15) gave the highest values of fresh shoot weight, plant height;

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branches number and stem girth, which corresponded to 10.8 ton ha^{-1}, 37.3 cm plant^{-1}, 1.8 per plant, 0.68 cm plant^{-1}, respectively. NPK fertilizers at four levels were applied to two species of *Colchicum* (*hierosolymitanum* and *tunicatum*). Both species are source of colchicines, a drug used as an anti-inflammatory to treat gout condition. Fertilizers rates significantly modified corm yield production and morphological characteristics such as leaf number, corm weight and leaf area. Flowering period of the two species is also reported by Al-Fayyad *et al.* [9]. Nowadays medicinal aromatic plants occupy a priming economic position because of the continuous and increase demand for their products from the local and foreign markets. The compost tea is a highly concentrated microbial solution produced by extracting beneficial microbes from vermicompost and/or compost. It is a source of foliar and soil organic nutrients, contains chelated micronutrients for easy plant absorption and the nutrients are in biologically available forms for both plant and microbial uptake. Application of organic fertilizer increased the biomass yield of the main crop and total essential oil yields of davana plant as reported by Parakasa *et al.* [10]. Marculescu *et al.* [11] revealed that the soil with its content in macro and microelements, enhanced by the use of organic fertilizers, plays a promoting role in *Chrysanthemum balsmita* plants growing, development and essential oil amount. Khalid and Shafei, [12] found that treated dill plants with different combinations of organic fertilizers and its rates resulted in a significant increase in growth, yield characters, essential oil percentage and its main components.

Since the research studies under Egyptian conditions are limited regarding to this plant, the present work aims to find out the NPK and organic fertilization requirements of Lovage.

MATERIALS AND METHODS

Two field experiments were conducted in HELIOPOLIS ACADEMY experimental farm (50 km North Cairo) during the successive seasons of 2007/2008 and 2008/2009 to investigate the effect of mineral and organic fertilization on herb production and essential oil of loavge plants. The seeds were sown in the nursery in 23rd of August for both seasons. Healthy seedlings were transplanted two months from sowing to the permanent soil. Individual and combined treatments of chemical (NPK) and organic fertilization were arranged in a complete randomized block design with four replicates. The experimental plot area was 16m^2 and the applied treatments were as follows:

- Compost at the rate of 10m^3 feddan^{-1} (one feddan =4200 m^2).
- Compost at the rate of 10m^3 + compost tea (20m^3 fed^{-1}).
- Compost at the rate of 20m^3 fed^{-1}.
- Compost at the rate of 20m^3 + compost tea (20m^3 fed^{-1}).
- Compost at the rate of 30m^3 fed^{-1}.
- Compost at the rate of 30m^3 + compost tea (20m^3 fed^{-1}).
- NPK (30, 20, 10) at the rate of 50 kg fed^{-1}.
- NPK (30, 20, 10) at the rate of 50 kg + compost tea (20m^3 fed^{-1}).
- NPK (30, 20, 10) at the rate of 75 kg fed^{-1}.
- NPK (30, 20, 10) at the rate of 75 kg + compost tea (20m^3 fed^{-1})
- NPK (30, 20, 10) at the rate of 100 kg fed^{-1}.
- NPK (30, 20, 10) at the rate of 100 kg + compost tea at 20m^3 fed^{-1}.
- Control (no added chemical or organic fertilizers).
- Compost tea (20 m^3 fed^{-1}).

The chemical analysis of used compost is shown in Table 1 and macro and micro- nutrients of compost tea in Table 2.

Compost was applied before sowing in field experimental farm. Chemical fertilizers were added into three portions. The first one was at 105 days after transplanting. The second portion was a month from the first one. The third and last addition of fertilizers was 45 days from the second one. Three cuts were collected from lovage plants during the life cycle. A regular time (45 days) was left between a cut and another. The following vegetative parameters were recorded to evaluate each cut: (average of 3 plants).

- Fresh and dry weight of leaves g. plant^{-1}.
- Number of leaves plant^{-1}.
- Fresh and dry weight of roots (g).
- Essential oil percentage.
- Essential oil yield.

Quantitative determination of lovage (leaves) essential oil of different treatments was achieved by hydro-distillation according to Guenther [13] based on dry weight in the three harvests. Root essential oil% was determined in the third harvest only.

Table 1: Chemical analysis of compost

Constituents	Value
Bulk density kg/m^3	510
Moisture content%	18.2
Electrical conductivity dS/m	9.65
pH	7.6
Total organic carbon %	24.6
Total organic matter %	42.41
Total nitrogen %	1.35
C/N ratio	18.22
NH4-N (mg/kg)	880
NH3-N (mg/kg)	450
Total phosphorus%	1.6
Available phosphorus (mg/kg)	410
Total potassium %	2.3
Available potassium (mg/kg)	620
Fe (ppm)	960
Zn (ppm)	280
Mn (ppm)	320
Cu (ppm)	140

Nematodes (nil), Weeds germination (nil), Parasites (nil), Radish germination test (98%), Pathogenic (nil)

Table 2: Soluble macro and micro-nutrients of used compost tea

		Turned Compost Tea						
		Macro and micro-nutrients (ppm)						
E.C dS/m	pH	N	P	K	Ca	Mg	Fe	Zn
0.89	6.5	250	8	206	87	116	66	7

GLC analysis of the volatile oil of each treatment was performed separately with a Hewlett-Packard model 5890; a fused silica capillary column (Carbowax 20M measuring 20 m x 0.32 mm internal diameter, thickness of 0.17 μm) was used. The temperature program adopted was maintained at 75°C for 5 min. with an increase of 4°C min^{-1} until 220°C (10min). The carrier gas was Helium and the working flow rate was 1.0ml/min, with a detector of 9144 HP. The identification of the compounds of the essential oil was achieved by matching their retention times with those of authentic samples injected under the same conditions. The statistical analysis of results was carried out according to Sendecor and Cochran [14].

RESULTS AND DISCUSSION

Data in Tables 3 and 4 showed the response of growth and yield of lovage plants to various organic and NPK fertilization. Three harvests (represented number of leaves and fresh and dry weight of leaves) were responding to both kinds of fertilizers.

Effect of Compost: Increasing organic fertilization (compost and/or compost tea) significantly increased growth parameters except for the middle dose in both seasons. The superior treatment among combined rates of compost and compost tea was at 30 m^3 fed^{-1} and 20 m^3 fed^{-1}, respectively. The maximum mean values of fresh and dry weight of leaves g^{-1} during the first harvest in the 1st season were 143.76 and 41.94. The minimum value of fresh (94.19 g^{-1}) and dry weight (28.04 g^{-1}) of lovage leaves were obtained from compost at the rate of 20m^3 + compost tea at 20 m^3 fed^{-1}. The highest numbers of leaves were recorded from plants which received compost at the level of 10m^3 and compost tea (20 m^3 fed^{-1}). Concerning the second and third harvests, applying treatment comprised compost at the rate of 10m^3 and 20m^3 of compost tea resulted in the best fresh and dry weight of leaves, while, the minimum fresh and dry weight of leaves in the 2nd and 3rd harvests were accompanied with application of 20m^3 fed^{-1} of compost and compost tea at the dose of 20m^3.

Table 3: Effect of organic and mineral fertilization on growth of lovage plants (3 harvests) during season 2008

	First harvest			Second harvest			Third harvest				
	Leaves			Leaves			Leaves			Roots weight gm^{-1}	
Treatment (fed^{-1})*	Fresh	No.	Dry	Fresh	No.	Dry	Fresh	No.	Dry	Fresh	Dry
Compost $10m^3$	136.00	31.33	41.05	132.20	15.00	26.83	102.17	14.33	32.50	334.00	49.10
Compost $10m^3$ + compost tea $20m^3$	138.12	38.00	38.14	155.88	34.67	33.17	120.59	19.67	43.09	284.67	43.81
Compost $20m^3$	96.63	28.00	28.54	119.20	24.00	48.17	93.75	19.67	30.58	377.67	41.81
Compost $20m^3$ + compost tea $20m^3$	94.19	34.67	28.04	102.35	31.67	28.33	88.00	24.67	25.35	234.00	35.62
Compost $30m^3$	134.52	30.00	40.86	132.60	28.33	32.00	115.59	21.00	34.54	284.33	42.76
Compost $30m^3$ + compost tea $20m^3$	143.76	26.00	41.94	117.38	22.00	23.17	92.12	24.33	28.54	205.67	34.81
NPK 50 kg	114.58	34.00	35.93	114.07	30.00	22.06	97.24	22.47	29.75	274.00	41.29
NPK 50 kg + compost tea $20m^3$	132.53	31.33	36.86	145.52	24.00	38.56	108.65	24.00	38.72	278.33	41.90
NPK 75 kg	137.86	38.00	39.63	118.30	31.00	31.16	96.83	19.33	31.61	265.00	40.14
NPK 75 kg + compost tea $20m^3$	100.40	27.67	29.64	71.86	25.33	19.21	56.06	21.00	18.02	244.00	37.57
NPK 100kg	113.09	41.33	32.31	71.47	37.33	20.60	55.64	27.33	19.46	230.00	35.00
NPK 100 kg+ compost tea $20m^3$	94.98	30.67	28.06	103.40	30.00	26.92	87.49	23.00	25.27	255.33	38.62
Control	102.57	38.00	30.26	89.53	34.00	27.51	74.92	28.00	22.68	274.67	41.38
Compost $20m^3$	95.79	35.67	28.30	118.12	37.33	32.62	100.51	27.00	30.52	284.33	42.29
L.S.D. at 5%	6.51	2.44	2.56	5.70	3.11	2.65	8.93	2.35	3.52	11.04	2.35

*One feddan= 4200 m^2

Table 4: Effect of organic and mineral fertilization on growth of lovage plants (3harvests) during season 2009

	First harvest			Second harvest Leaves			Third harvest Leaves				
	Leaves			Leaves			Leaves			Roots weight gm^{-1}	
Treatment (ed^{-1})	Fresh	No.	Dry	Fresh	No.	Dry	Fresh	No.	Dry	Fresh	Dry
Compost $10m^3$	111.21	27.00	35.98	134.07	15.00	28.09	99.30	12.33	33.10	307.33	43.90
Compost $10m^3$ + compost tea $20m^3$	127.07	38.33	32.25	142.47	28.33	54.00	115.59	19.67	38.53	264.00	37.71
Compost $20m^3$	84.63	25.00	24.54	122.20	25.00	45.67	97.75	20.67	32.58	264.67	37.81
Compost $20m^3$ + compost tea $20m^3$	82.90	33.00	24.04	103.50	33.00	19.67	82.04	25.33	27.35	214.33	30.62
Compost $30m^3$	115.63	27.00	33.53	135.60	27.00	34.67	109.62	22.00	36.54	271.33	38.76
Compost $30m^3$ + compost tea $20m^3$	119.85	23.00	34.76	113.75	23.00	25.67	92.93	24.33	30.98	192.67	27.52
NPK 50 kg	99.33	27.67	28.81	106. 77	27.67	21.73	85.93	23.67	28.64	261.00	37.29
NPK 50 kg + compost tea $20m^3$	113.29	25.00	32.86	141.59	25.00	41.06	112.65	22.67	37.55	265.33	37.90
NPK 75 kg	112.08	31.33	32.50	116.08	30.33	33.66	93.54	20.33	31.18	252.00	36.00
NPK 75 kg + compost tea $20m^3$	88.40	23.00	25.64	74.86	23.00	21.71	60.06	22.00	20.02	224.00	32.00
NPK 100kg	97.63	25.00	28.31	74.47	35.00	21.60	59.64	26.67	19.88	217.00	31.00
NPK 100 kg+ compost tea $20m^3$	82.98	24.33	24.06	89.99	24.33	26.10	71.82	24.00	23.94	242.33	34.62
Control	90.57	35.00	26.26	92.53	35.00	26.83	74.03	29.00	24.68	261.67	37.38
Compost $20m^3$	83.79	30.33	24.30	121.12	31.33	35.12	97.56	28.00	32.52	253.67	36.24
L.S.D. at 5%	5.74	2.22	2.43	5.56	2.01	1.82	5.41	2.6	1.95	14.62	3.95

Data in Table 4 showed that lovage plants fertilized by $10m^3$ of compost + compost tea at the rate of $20m^3$ fed^{-1} gave the highest fresh and dry weight in each harvest compared with control. Adding compost and compost tea at $20m^3$ fed^{-1} for each statistically increased number of leaves in the 1st and 2nd harvests but failed to reach the significantly level at 5% in the 3rd harvest. The promoting effect of compost tea on herb yield may be due to the microbial function and chelated micronutrients content that provide biological and mineral nutrition. These findings were in agreement with those obtained by Hendawy [15] on *Plantago arenaria*, Hussein *et al.* [16] on *Dracocehalum moldovica* and Mishra and Negi [17] on *Salvia sclarea*.

Effect of NPK: It was clear that applying NPK treatments increased number of leaves and fresh and dry weight of leaves of lovage plants. This increment was significant with 50, 75 and 100kg fed^{-1} NPK (30, 20, 10) compared with control. The maximum fresh and dry weight of leaves in each harvest were obtained from lovage plants which have taken NPK (30, 20, 10) at the rate of 75 kg fed^{-1} in both seasons. While, number of leaves recorded minimum values when adding 75 kg fed^{-1} NPK in each harvest in the 1st. season and the 1 stharvest in the second one. NPK fertilizers provide plants with macro-elements necessary for growth and yield. Nitrogen promotes vegetative growth, phosphorus is a main constituent of energy compounds, nucleic acids, phospholipids and co-enzymes and potassium increases plant resistance to

Table 5: Essential oil percentage of lovage plants under different organic and chemical fertilization 2008& 2009 seasons

Treatments Oil%	10 m^3 Compost	10 m^3 compost + tea compost	20m^3 Compost	20m^3 compost + tea compost	30m^3 compost	30m^3 compost + tea compost	50kg NPK (30,2 0,10)	50kg NPK (30,20,10) + tea compost	75kg NPK (30,20,10)	75kg NPK (30,20,10) + tea compost	100kg NPK (30,20,10)	100kg NPK (30,20,10) + tea compost	Control	Tea compost	LSD 5%
Season 2008 1st cut herb	0.14	0.19	0.17	0.25	0.18	0.20	0.16	0.22	0.18	0.24	0.22	0.26	0.11	0.21	0.017
2nd cut herb	0.22	0.19	0.24	0.25	0.24	0.23	0.21	0.20	0.24	0.27	0.26	0.25	0.15	0.23	0.020
3rd cut herb	0.31	0.24	0.25	0.32	0.26	0.29	0.24	0.27	0.24	0.29	0.31	0.29	0.18	0.27	0.026
3rd cut root	0.66	0.64	0.63	0.72	0.65	0.68	0.65	0.64	0.71	0.75	0.62	0.69	0.45	0.48	0.031
Season 2009 1st cut herb	0.15	0.17	0.18	0.27	0.21	0.24	0.17	0.23	0.22	0.21	0.26	0.24	0.13	0.18	0.022
2nd cut herb	0.24	0.21	0.26	0.28	0.26	0.27	0.24	0.25	0.25	0.28	0.27	0.29	0.19	0.26	0.028
3rd cut herb	0.28	0.25	0.28	0.30	0.28	0.30	0.26	0.30	0.31	0.32	0.34	0.29	0.22	0.22	0.025
3rd cut root	0.63	0.60	0.61	0.69	0.66	0.65	0.64	0.70	0.74	0.75	0.72	0.65	0.50	0.59	0,043

Table 6: Essential oil content of lovage plants (ml plants-1) under different organic and chemical fertilization 2008& 2009 seasons

Treatments Oil%	10 m^3 Compost	10 m^3 compost + tea compost	20m^3 Compost	20m^3 compost + tea compost	30m^3 compost	30m^3 compost + tea compost	50kg NPK (30,2 0,10)	50kg NPK (30,20,10) + tea compost	75kg NPK (30,20,10)	75kg NPK (30,20,10) + tea compost	100kg NPK (30,20,10)	100kg NPK (30,20,10) + tea compost	Control	Tea compost
Season 2008 1st cut herb	0.057	0.072	0.048	0.070	0.073	0.083	0.057	0.081	0.071	0.071	0.071	0.072	0.033	0.059
2nd cut herb	0.059	0.063	0.115	0.070	0.076	0.053	0.046	0.077	0.074	0.052	0.060	0.067	0.041	0.075
3rd cut herb	0.100	0.103	0.076	0.081	0.081	0.082	0.071	0.104	0.075	0.052	0.060	0.073	0.040	0.082
3rd cut root	0.324	0.280	0.263	0.256	0.256	0.236	0.268	0.264	0.285	0.081	0.217	0.266	0.186	0.203
Season 2009 1st cut herb	0.053	0.054	0.044	0.065	0.070	0.083	0.048	0.075	0.071	0.054	0.073	0.057	0.034	0.043
2nd cut herb	0.067	0.113	0.119	0.055	0.090	0.069	0.052	0.103	0.076	0.061	0.058	0.075	0.051	0.091
3rd cut herb	0.92	0.096	0.091	0.082	0.102	0.093	0.074	0.113	0.097	0.064	0.076	0.069	0.054	0.071
3rd cut root	0.276	0.226	0.231	0.211	0.256	0.179	0.242	0.265	0.266	0.240	0.223	0.225	0.187	0.214

diseases and prevents excessive water loss. The obtained out-puts were similar to those investigated by Al-Fayyad *et al.* [9] on *Colchicum tunicatum*, Ashok and Manjunath [18] on pumpkin and Jeliazkova *et al.* [19] on peppermint.

Effect of Interaction: The combined treatment (organic and chemical fertilization) of NPK at the rate of 50 kg fed^{-1} and 20m^3 of compost tea performed the best significant values with respect to fresh and dry weight of lovage plants in both seasons compared with control. These results were in accordance to those found by Anwar *et al.* [20] on Frensh basil, they indicated that basil plants grown under integrated nutrient management of both organic (5 ton ha^{-1} of vermicompost) and inorganic fertilizer (NPK 50:25:25 kg ha^{-1}) gave the highest growth, herb dry matter, oil content and oil yield of *Ocimum basilicum* plants. Means of fresh and dry weight of roots in the third harvest recorded their highest values with compost at the rate of 10m^3 fed^{-1} in both seasons. Highly significant differences were observed in fresh and dry weight of roots compared with control treatment.

Table 5 showed the essential oil percentage of lovage plants fertilized with different organic and chemical fertilization treatments (2008 and 2009). The essential oil percentage of leaves reached its maximum values at the third harvest in both seasons. The highest oil percentage (0.32%) was obtained from *Levisticum officinale* plants received compost at the rate of 20m^3 + compost tea 20m^3 fed^{-1} in the first season and (0.34%) from plants fertilized by 100kg NPK (30, 20, 10) in the second one. Roots essential oil percentage was higher than that in the leaves. The combined treatment of 75 kg NPK + compost tea 20m^3 fed^{-1} recorded the highest percentage (0.75%) of root oil in both seasons. Data in Table 6 indicated that oil content (ml $plant^{-1}$) of leaves recorded the highest mean (0.115) with application of 20 m^3 fed^{-1} of compost for the first and second season, respectively. Adding compost at the rate 10m^3 fed^{-1} resulted in the maximum oil content ml $plant^{-1}$ (0.324 and 0.276) in the 1st and 2nd season, respectively. Oil composition of lovage leaves using GLC were shown in Table 7.

The Analyzed Treatments Were as Follows:

- Combined between 20m^3 fed^{-1} of compost + 20m^3 fed^{-1} of compost tea.
- Compost only at the rate of 30m^3 fed^{-1}.
- NPK at 75 kg fed^{-1}+ compost tea (20m^3 fed^{-1}).
- NPK only at the level of 100 kg fed^{-1}.
- Control (no added chemical or organic fertilization).
- Compost tea only (20m^3 fed^{-1}).

A total of eleven compounds were identified. α-terpinyl acetate was the major compound. It ranged from 59.8% to 66.5% and the maximum percentage came

Table 7: Oil composition of lovage leaves as affected by compost, NPK and their interaction

Treatments Components	$20m^3$ compost + tea compost	$30m^3$ compost	75kg NPK(30, 20, 10)+ tea compost	100kg NPK(30, 20, 10)	Control	Tea compost
α-pinene	0.8	1.0	1.10	0.8	1.2	0.8
Camphene	0.0	0.0	0.60	0.5	0.0	0.0
β-pinene	1.5	1.8	1.60	1.6	1.3	1.1
α-phellandrene	2.4	2.8	5.10	3.5	4.2	2.2
Myrcene	3.6	3.6	5.02	2.8	2.3	3.7
β-phellandrene	12.8	11.3	15.40	9.6	14.3	18.3
Limonene	1.2	0.0	1.60	1.8	0.0	0.0
γ-terpinene	1.2	0.9	1.10	1.0	1.8	1.6
Linalool	0.0	0.4	0.40	0.0	0.0	0.2
α-terpinyl acetate	66.4	64.2	61.20	66.5	60.6	59.8
Gernaly acetate	1.8	1.7	1.70	1.6	1.5	1.1
Total	91.7	87.7	94.82	89.7	87.2	88.8

Table 8: Oil composition of lovage roots as affected by compost, NPK and their interaction

Treatments Components	$20m^3$ compost + tea compost	$30m^3$ compost	75kg NPK(10, 20, 30)+ tea compost	100kg NPK(10, 20, 30)	Control	Tea compost
α-pinene	0.3	0.9	1.4	0.9	1.7	1.1
Camphene	2.4	2.4	1.6	1.8	2.5	2.0
Sabinene	1.3	1.1	1.1	0.9	1.7	1.3
β-pinene	4.3	4.2	0.5	0.8	1.3	2.7
β-myrcene	0.4	0.4	0.9	1.3	0.8	1.1
β-Phellandrene	9.3	8.6	11.4	16.5	7.3	6.4
Limonene	1.4	1.4	2.3	1.6	1.5	1.4
Terpinolene	3.5	3.8	3.0	2.6	4.1	3.9
Carvacrol	1.6	1.7	1.7	1.9	1.1	1.1
β-Elemene	4.5	2.6	4.8	4.6	2.1	2.4
β-Farnesene	10.6	11.7	8.5	5.3	12.3	14.6
Germacrene-D	0.3	0.4	0.1	0.6	0.5	0.1
Bornyl 2-Methylbutyrate	0.1	0	0.1	0.3	0	0
(Z)-Ligustilide	24.1	22.8	30.5	33.6	23.4	24.6
(E)-Ligustilide	0.6	0.8	0.2	0	0.3	0.4
Falcarinol	25.8	32.6	22.6	24.5	26.1	27.3
Total	90.5	95.4	90.7	97.2	86.7	90.4

from $20m^3$ fed^{-1} from NPK (30, 20, 10) at the rate of 100kg fed. The second component was β-phellandrene with the highest percentage of 18.3% and minimum of 9.6%. Individual application of compost tea recorded the highest percentage while, NPK at 100 kg fed^{-1} led to the minimum percentage. The third compound is myrcene with a maximum percentage of 5.02% accompanied with fertilization of 75 kg NPK (30, 20, 10) + $20m^3$ of compost tea. In this connection, hydrodistillation extractions of the aerial parts of Levisticum officinale were analyzed by GC and GC/MS. In the oil, α-terpinyl acetate (40.5%) and β-phellandrene (16.7%) were the main constituents as confirmed by Keivandokht *et al.* [21].On the other side, variation in principal components of essential oil from different European countries were determined by Ain *et al.* [22]. They mentioned that dominance of oil constituents was affected by different geographical locations. Estonian oil of high amounts of α-terpinyl acetate (55.8%) followed by β-phellandrene (11.3%) which was similar to our results.

Data in Table 8 illustrated that lovage root oil was characterized by high content of Z-lingustilide followed by Falcarinol. The maximum of Z-lingustilide was obtained (33.6%) when *Levisticum officinale* plants received 100kg NPK (30, 20, 10). The highest percentage of Falcarinol (32.6%) resulted from plants fertilized with $30m^3$ of compost. These findings were in a harmony with Ibrahim [4]. On the contrary, Najda and Wolski [5] found that phtalides and monocyclic terpenes comprised the major components of the essential oil from the roots of lovage plants.

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