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Effect of Three Different Compost Levels on Fennel and Salvia Growth Character and Their Essential Oils

[1]Mona, Y. Khalil, M.A.M. Kandil and [2]M.F. Swaefy Hend

[1]Cultivation and Production of Medicinal and Aromatic Plants,
Department National Research Centre, Giza, Egypt.
[2]Ornamental Horticulture Department, Fac. of Agric. Cairo Univ., Egypt.

Abstract: A study was conducted to compare the impact of organic compost at 3 levels (6, 12 and 18 m^3/fed.) and mineral fertilization (150 kg ammonium sulphate, 150 kg ammonium sulphate, 150 kg calcium monophosphate and 50 kg potassium sulphate/fed), on growth and productivity of bitter fennel (*Foeniculum vulgare* var. vulgare Mill.) and Egyptian sage (*Salvia officinalis*), in 2003/2004 and 2004/2005 seasons, in the Experimental Farm Station of National Research Centre, at Shalakan Kalubia Governorate. The results retrieved that all levels of compost significantly increased plant height, number of branches, fresh and dry weights of herb, oil (%) in fennel seeds and sage herb, as well as seed, herb and oil yield ml/plant and L/fed in fennel and sage, respectively, as compared to mineral fertilization. Raising compost levels increased the studied parameters; however, the high level was significantly superior to the lowest one, in most cases. 15 compounds were identified in fennel seed oil, some of them were oxygenated compounds but consisted more than double the percent of hydrocarbons ones. The major components of fennel seed oil were anethole (more than 45%) and limonene (more than 12%). In sage herb oil 22 constituents were identified, 15 of them were oxygenated compounds, amounting to 7-10 times the percentage of hydrocarbons components. The main constituents of sage herb oil were α and ß-thujone (36.5-40.5%), 1,8-cineole (10.1-12.7 %) and camphor (9.9-11.3%). No clear differences were found between organic compost and inorganic fertilizer on the percentage of oil components.

Key words: Compost, Fennel,Salvia, Growth Character and Essential Oils.

INTRODUCTION

Numbers of herbs have been traditionally regarded as natural remedies for common ailments of human population. Motivation of people towards herbs are increasing due to their concern about the side effects of drugs, those are prepared from synthetic materials.

Fennel (*Foeniculum vulgare* Mill.), a number of familly Apiaceae, is a short- lived herb, indigenouns to Europe and cultivated in India, China and Egypt[1].It is an aromatic herb whose fruits contain essential oil which is used for many purposes by human population[2,3]. The oil of fennel regulates the peristaltic functions of the gastrointestinal tract, releives the spasms of intestines[4,5]. Externally, the oil relieves muscular and rhematic pains. The seeds have a traditional reputation as an aid to weight loss and longivity. The major constituent of fennel oil is anethole[6,7].

Sage, *Salvia officinalis* L., from the Latin 'Salvere", meaning heal or save indicating the medical value of the plant, belongs to familly Laminaceae. It is perennial herb native to Southern Europe and Asia Minor[8]. The major components of sage oil are thujone, camphor, and 1,8 cineole[9,10,11]. Organic farming was recommended by EU regulations[12] and FAO and WHO (Codex Alimentarius, 2001) as it ensures saftey products for human health as well as environment[13]. Organic manures have benificial impacts on soil physical and chemical properties and provide plants with a good, neat source of better availability of nutrients[14,15] Many research workers gained best growth, yield, oil percantage and yield and chemical constituents when used organic compost manures for several medicinal and aromatic plants, as Ibrahim[16] on *Ocimum sanctum;* Khalil[17] on rosmary (*Rosemarinus officinalis)*; Khalil *et al.,*[18] on *Tagetes erecta;* Khalil and El-Sherbeny[19] on three *Menth* species*;* Naguib and Aziz[20] on *Hyosyamus muticus* and El-Sherbeny *et al.,*[21] on *Sidritis montana.*

Corresponding Author: M.Y. Khalil, Cultivation and Production of Medicinal and Aromatic Plants, Department National Research Centre, Giza, Egypt
E-mail: Khalilmona2003@yahoo.com

MATERIALS AND METHODS

This investigation was consummated at the two successive seasons of 2003/2004 and 2004/2005, in the Experimental Farm Station of National Research Centre, at Shalakan Kalubia Governorate Giza, Egypt, aiming to study the effect of organic compost as a manure on growth and oil yield of bitter fennel (*Foeniculum vulgare* var. vulgare Mill.) and sage (*Salvia officinalis* L., Egyptian cultivar) compared to mineral fertilization.

Seeds of bitter fennel and Egyptian sage, obtained from Medicinal and Aromatic Plants Department, Agricultural Researches Centre, Egypt, were sown in hills at 35cm distances on rows 60cm in between in plots 5.25 m^2 (3.0 X 1.75 m) containing 25 plants the experimental soil was clay loamy with the following properties: 5.3% coarse sand, 30.6% fine sand, 38.7% silt and 25.4% clay, 0.56 dsm^{-1}, E.C., 7.25 pH, 3.2% Ca CO_3, 512ppm total soluble salts, 0.11% total nitrogen, 41.1, 17.0 and 401ppm N, P(P_2O_5) and K(K_2O) respectively, and 22.2, 3.9, 2.1 and 2.6 mg^{-1} DTPA extractable Fe, Mn, Zn and Cu consecutively.

Organic compost a product of Green Valley for Organic Products Co, Egypt, having the following properties: 35.4% moisture content, 7.0 pH, 12.0 mmhos/cm^2 EC, 263.0 mg/kg ammonium nitrate, 45.6% organic matter, 18.89% organic carbon, 39.56% ash, 16:1 C/N ratio and 1.4, 0.466 and 1.21% total N, P and K, respectively, was used at three rates of 6, 12 and 18 m^3/feddan (the feddan is an Egyptian measure for area, equal 4200 m^2).

Mineral fertilization at the rate of 150 kg ammonium sulphate (15.5% N), 150 kg calcium monophosphate (15.5 P_2O_5) and 50 kg potassium sulphate (48% K_2O) per feddan. The organic compost was added at two portions, the first one during preparation of the soil, the other was added three months later during the two seasons, but chemical fertilization was added after 45 and 90 days from sowing. The study began on 21st, October in the two seasons. Germination was completed after 12 days. The layout of the experiment was a complete randomized blocks, with four treatments repeated three times in each season.

Fennel was harvested at fruit maturity stage, while sage herb was harvested twice in first April and in first of June in both seasons. At harvest time, plant height (cm),herb fresh and dry weights (g/plant) for both plants, number of branches/plant for fennel and number of leaves for sage were recorded.The yield (g/plant) were recorded for both plants. Essential oil in fennel fruits and fresh herb of sage were isolated using a Clevenger-type apparatus according to British Pharmacopoeia[22], Essential oil yield/feddan was calculated by multiplying oil (%) by fennel fruit yield or sage herb yield.

The means of the two seasons were calculated and subjected to the standard analysis of variance and L.S.D. values at 5% level were obtained when calculated F values were significant at 5% level[23].

The essential oil constituents were determined in fennel seeds and mixture of oil of the two cuts of sage herb in the first season. The samples were dehydrated over anhydrous sodium sulphate then subjected to GC/MS. Separation of the resulting crude, fractions and volatile oil was accomplished on a Varian Gas Chromatograph (Walnut Creek, California, USA) equipped with Finnigan mat SSQ 700 (Thermo Inst., USA) mass spectrometer and a 30cm x 0.25mm. DB-5 capillary column film thickness (J & W Scientific, USA). The column temperature was programmed from 50 ^{0}C (constant for 3 min.), at a rat of 7 ^{0}C/min to 250 ^{0}C with 10 min isothermal hold. The injector temperature was 220^{0}C and the transition time temperature was 250 ^{0}C. The carrier gas was helium and the column head pressure was 10-15 psi. The identification of the constituents was determined by comparing the spectrum with the other stored in Wiley Mass Spectral Library containing over 147000 volatile compounds.

RESULTS AND DISCUSSIONS

Vegetative Growth: (Table 1 and 2): Organic compost manure significantly increased fennel and sage growth parameter than the mineral fertilization. Increasing compost level progressively and significantly increased the values of such parameters: plant height, number of branches/plant, herb fresh and dry weights of both plants, in most cases. For fennel, the percentage of increments over the mineral fertilization ranged between 8.5 and 11.3% for plant height; 7.1 and 14.3% for number of branches; 23.9 and 32.7% for herb fresh weight and 6.8 and 11.2% for herb dry weight. The lower percentage of increase resulted by the lower level of compost (6 m^2/fed.).

Table 1: Effect of mineral fertilization and different compost levels on growth of fennel, *Foeniculum vulgare* var. vulgare and sage, *Salvia officinalis*. (Mean of two seasons)

Treatments	Fennel			
	Plant height (cm)	Branches No.	Herb (g/plant)	
			F.W.	D.W.
Compost 6 m3	141.6	9	404.8	189.6
Compost 12 m3	143.2	9.5	425.3	194.2
Compost 18 m3	145.2	9.6	433.5	197.4
Mineral fertilization	130.5	8.4	326.7	177.5
L.S.D. at 5%	1.12	0.2	5.55	1.16

Table 2: Effect of mineral fertilization and different compost levels on growth of sage, *Salvia officinalis.* (Mean of two seasons)

	Sage							
	First cut				Second cut			
	Plant height (cm)	No.Leaves	Herb (g)		Plant height (cm)	No.Leaves	Herb (g)	
			F.W.	D.W.			F.W.	D.W.
Compost 6 m^3	52.7	255.2	475.5	137.8	40.7	182.9	170.1	47.9
Compost 12 m^3	52.6	258.9	477.2	139.2	40.8	186.5	175.3	48.6
Compost 18 m^3	52.8	260.1	479.8	140.1	41.2	188.8	180.0	50.2
Mineral fertilization	0.41	3.84	4.53	1.61	0.82	2.33	3.38	1.21
L.C.D. at 5%	0.41	3.84	4.53	1.61	0.82	2.33	3.38	1.21

Table 3: Effect of mineral fertilization and different compost levels on fennel seed production and oil % and oil yield per plant (ml.) and /feddan (L) of fennel, *Foeniculum vulgare* var. vulgare and sage, *Salvia officinalis.* (Mean of two seasons)

	Fennel				Sage					
			Oil yield		First cut		Second cut		Total yield	
Treatments	Seed g/plant	Oil (%)	(ml.) /plant	(L.) /fed.	Oil (%)	Oil yield /plant(ml)	Oil (%)	Oilyield/ plant(ml)	(ml.) / plant	(L.) / fed.
Compost 6 m3	17.95	1.64	0.294	5.88	1.6	7.608	1	1.701	9.309	186.18
Compost 12 m3	18.03	1.68	0.303	6.06	1.62	7.731	1.02	1.788	9.519	190.38
Compost 18 m3	18.11	1.68	0.304	6.08	1.65	7.917	1.08	1.944	9.861	197.22
Mineral fertilization	16.66	1.6	0.266	5.32	1.52	6.047	0.94	1.569	7.616	152.32
L.S.D. at 5%	0.44	0.03	0.08	0.12	0.03	0.16	0.04	0.175	1.114	2.515

As for sage plant, the differences between the various levels of compost were insignificant in most cases. The highest level of compost (18 m^3) increased plant height, number of leaves, fresh and dry weights of herb over the mineral fertilization by 5.0, 7.3, 19.6 and 3.9%, respectively in the first cut and 4.6, 3.5, 7.8 and 12.3%, successively in the second one, where as the percentages of increase due to the lower level of compost (6 m^3/fed.) were 4.8, 5.2, 18.5 and 2.2, 3.3, 0.2, 1.9 and 7.2% for the same parameter in the two cuts, consecutively.

Such results on fennel and sage are in the same line with many researchers on different plants.Kandil[24] on fennel (*Foeniculum vulgare* Mill.); Khalil *et al.,*[18] on *Tagetes erecta;* Khalil and El-Sherbeny[19] on three *Mentha* species Naguib and Aziz[20] on *Hyosyamus muticus;* Fouad[25] on Iris and El-Sherbeny *et al*[21] on *Sidritis montana* L., who reported that compost at different levels significantly increased the vegetative growth characters including plant height, number of branches, fresh and dry weight of herb during vegetative growth and flowering stage.

Seed, Herb and Oil Yield: (Table 3): It is clear that organic compost manuring at any level increased significantly the yield of fennel seed and sage herb (g/plant), as compared to the mineral fertilization, however insignificant differences were found among compost levels.

Essential oil (%) in fennel seeds as well as in both cuts of sage herb were significantly increased by all compost levels when compared to the mineral fertilization. The highest compost level (18 m^3/fed.) resulted significant increment in oil (%) over the lowest level (6 m^3/fed.) only.

It is clear that oil yield per plant (ml) and per feddan (L.) attained a parallel trend to oil (%) and seed or herb yield, i.e. the three compost levels significantly raised oil yield over the mineral fertilization. Raising compost levels progressively increased fennel or sage oil yield; however the significant differences occurred between the highest and lowest compost levels only. These results agree with those obtained by Ibrahim[16] on *Ocimum sanctum;* Ibrahim and Ezz El-Din[26] on catnip (*Nepta cataria* L.); Khalil[17] on *Rosemarinus officinalis;* Khalil *et al.,*[18] on *Tagetes erecta;* Khalil and El-Sherbeny[19] on three *Mentha* species and El-Sherbeny *et al.,*[21] on *Sidritis montana* L., who mentioned that compost addition markedly improved oil %, productivity and herb and oil yield as compared to the control.

Table 4: Essential oil constituents in oil of fennel (*Foeniculum vulgare* var. vulgare) and sage (*Salvia officinalis)* herb as affected by organic compost levels and mineral fertilization, in the first season (2003/2004).

	Fennel seed oil				Sage herb oil			
Oil constituents	Mineral fertilizer	Compost 6 m3 /fed	Compost 12 m3 /fed	Compost 18 m3 /fed	Mineral fertilizer	Compost 6 m3 /fed	Compost 12 m3 /fed	Compost 18 m3 /fed
Monoterpenic hydrocarbons								
α-pinene	1.98	3.04	2.69	3.12	3.41	2.18	3.14	3.33
Comphene	0.44	0.33	0.37	0.42	2.88	1.95	2.13	2.64
β-pinene	1.58	1.15	2.14	1.14	0.93	1.21	1.13	1.45
Myrcene	1.9	1.15	2.06	1.6	1.68	1.55	2.38	1.98
Limonene	15.22	17.95	12.65	14.75	0.88	0.94	1.05	1
P-Cymene	1.19	0.88	1.11	1.13	--	--	--	--
Y-Terpinene	0.95	0.78	0.92	0.82	--	--	--	--
Total	23.26	25.28	21.94	22.98	9.78	7.93	9.83	10.4
Oxygenated compouds								
1,8-Cineole	0.77	0.53	0.65	0.81	10.15	11.28	12.04	12.68
Fenchone	3.13	2.3	2.98	3.22	--	--	--	--
Linalool	0.26	0.11	0.35	0.24	3.45	3.17	2.91	3.6
α-Thujone	--	--	--	--	24.3	26	27.31	26.5
β-Thujone	--	--	--	--	12.24	12.41	13.22	10.33
menthone	--	--	--	--	1.31	0.95	1.11	1.02
Camphor	--	--	--	--	10.62	10.84	9.87	11.31
Terpinene-4-ol	--	--	--	--	0.12	0.25	0.35	0.17
menthol	--	--	--	--	2.03	1.92	2.64	1.63
Borneol	--	--	--	--	2.72	3.44	3.41	2.22
Methylchavicol (estragole)	2.08	1.81	2.32	2.1	--	--	--	--
Carvone	3	3.56	2.91	3.18	0.85	0.86	0.95	0.74
Nerol	--	--	--	--	0.6	0.91	0.72	0.81
Fenchyl acetate	5.21	4.33	4.69	3.62	--	--	--	--
Linalyl acetate	--	--	--	--	0.03	0.04	0.1	0.08
Geraniol	--	--	--	--	0.45	0.72	0.63	0.55
Anis aldehyde	0.16	0.15	0.22	0.72	--	--	--	--
Anethole	46.5	45.66	46.25	45.92	--	--	--	--
Thymol	--	--	--	--	0.21	0.23	0.18	0.22
Carvacrol	--	--	--	--	1.91	1.66	2.06	2.25
Geranyl acetate	--	--	--	--	3.32	4.55	4.14	3.71
Caryophyllene	--	--	--		0.07	0.12	0.11	0.05
Total	61.11	58.45	60.37	59.36	74.38	79.35	81.79	77.87
Total identified	84.37	83.73	82.31	82.34	84.16	87.28	91.62	88.27

Table 5: Physiochemical properties of essential oil of fennel, *Foeniculum vulgare* var. vulgare seed and sage, *Salvia officinalis,* herb, as affected by mineral fertilization and different compost levels, in the first season (2003/2004).

	Fennel				Sage			
Specific characters	Control	1	2	3	Control	1	2	3
Specific gravity at 20 °C	0.9711	0.9845	0.9884	0.9772	0.9263	0.9222	0.9255	0.9324
Refractive index at 20 °C	1.5512	1.5454	1.5489	1.5227	1.4692	1.4731	1.5101	1.5124
Optical rotation at 20 °C	30° 30`	35°20`	35°30`	35°30`	24° 4`	26° 2`	28° 3`	26° 3`
Acid value	0.768	0.754	0.761	0.761	1	1.02	1	1
Saponification number	12.4	12.5	12	12	10.55	10.24	10.62	10.32
Saponification number after acetylation	24.6	25.2	23.1	23.1	21.6	22.1	20.9	21.7
Ester number	16.5	15.3	15.5	15.5	25.2	25.6	24.4	24.6
Ester number after acetylation	29.2	27.6	27.5	27.5	25.8	26.6	26.7	27.8
Solubility in 80% alcohol	3.3	3.5	3.5	3.5	5.2	5.5	5.5	5.2

Control: mineral fertilization, 1: Compost atm^3/fed;
2: Compost at 12m^3/fed; 3: Compost at 18m^3/fed

Properties and Composition of the Essential Oil: (Table 4, 5): It appears that fifteen compounds were identified in bitter fennel oil, seven are monoterpenic hydrocarbons comprising between 21.9 and 25.3% of the oil for 12 m^3 and 18 m^3 compost, respectively, and eight oxygenated compounds compromising between 58.4 and 61.1% of the oil occurred due to the 6 m^3 compost and control (chemical fertilization), successively. It is evident that total identified compounds were not markedly affected by organic or mineral fertilization.

The major components in fennel seed oil are anethole, more than 45% and limonene, more than 12%. This result agrees with that Katsiotis[27], Denys *et al.,*[28] and Braun and franz[6]. The percentage of anethole was slightly affected by different treatments; whereas the lowest limonene percentage (12.65%) resulted by the 12 m^{3}compost, but the highest percentage (17.9%) occurred due to the lowest level of compost, 6 m^3. The high compost level resulted a percentage between the other level, which might mean limonene % showed inconsistent trend.

In the oil of sage herb, twenty two compounds were identified representing between 84.4% (from the control) and 91.62% (for the 12 m^3 compost). Five components were monoterpenic hydrocarbons, while the oxygenated compounds were seventeen, which amounted about seven to ten times the percentage of monoterpenic hydrocarbons.

The main constituents of sage oil were α and ß-thujone, which represented more than one third of oil components, 1,8-cineole (10.1-12.7 %) and camphor (9.9-11.3%). Such finding coincides with that of Salameh and Dordvic[29] and Badr and Naguib[11]. Compost treatments increased the total percentage of these four compounds as compared to the control.

Data in Table (5) indicated that neither mineral fertilization nor organic compost manuring had an evident impact on physiochemical properties of fennel or sage oil. Similar findings were reported by Omidbaigi and Horok[30] and Kandil[24], that the components of fennel oil were not affected by organic or inorganic fertilization.

Conclusion: From the foregoing results it would be recommended to use 18 m^3 organic compost/feddan, added at two parts, the first parts throughout soil preparation for cultivation of bitter fennel and sage, the other portion after 90 days from sowing, that is to obtain the best growth and seed or herb and oil yield.

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