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(Original Article)

Evaluating the Efficiency of Organic Manures and Seaweed Extract on the Improvement of Growth and Productivity of *Foeniculum Vulgare* Mill. Plants

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Abstract

A field experiment was conducted during the two consecutive seasons of 2020/2021 and 2021/2022 to evaluate the influence of organic manures (cattle and chicken manure) at rates of 2, 4 kg/plot (2 m^2) and seaweed extract (SWE) concentrations (0, 2, 3 and 4 ml/l) on vegetative growth, fruit yield and volatile oil components of *Foeniculum vulgare* plants. The chicken manure treatment at 4 kg/plot achieved the best results in terms of all vegetative growth (except plant height), fruit yield productivity and volatile oil components. Foliar sprays of SWE with a high concentration (4 ml/l) had a significant influence on plant height, stem diameter, branch number/plant, umbel number/plant, fruit yield/plant, total fruit yield/fed., percentage of volatile oil, and volatile oil yield per plant and per fed. during both seasons. Volatile oil samples of *F. vulgare* fruits grown in soil amended with chicken manure at 4 kg/plot gave the highest rate of anethole compound (39.13 %) and the lowest rate of estragole compound (14.08%) in comparison with the other organic manure treatments. SWE at the high concentration increased the percentage of anethole compared to the other concentrations. Foliar application of seaweed extract at high concentration to plants fertilized with chicken manure at the highest level appears to be the most distinguished interaction for obtaining higher yield and volatile oil of *F. vulgare* plants.

***Keywords**: Chicken manure, Cattle manure, Seaweed extract, Volatile oil, Fennel*

Introduction

Fennel (*F. vulgare* Mill.) in Apiaceae family, depending on the cultivar, is considered an annual, biennial or perennial medicinal plant (Farrell, 1988; Wichtl and Bisset, 1994). It includes phytochemical hormones, fats, saponins, proteins, flavonoids and essential oils. *F. vulgare* is used in traditional medicine as a carminative, diuretic, sedative and stimulant (Charles *et al*., 1993) and emmenagogic, galactagogic, antispasmodic and expectorant (Chiej, 1984). It is known as a spice due to terpenoids separated from the fruit's essential oil (Masada, 1976). Also, *F. vulgare* fruits are greatly used in the preparing of different dishes such as sauces, soups, confectioneries, pastries, pickles and meat dishes (Bhati *et*

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al., 1988). The volatile oil of *F. vulgare* is used to flavor various foods and in the perfume industry. Anethole is the main component in the sweet fennel that plays a major role in the quality of its essence (Gross *et al*., 2002). Other ingredients in the essence are, Limonene, Estragole and Fenchone (Abdul-Hafeez *et al*., 2020). The oil includes fenchone component which plays a great role in the pharmaceutical industry (Abdallah *et al*., 1978) .

To increase the medicinal and aromatic plants quality, organic fertilization is considered safer than chemical fertilizers, and organic farming is a quality standard that must be used by small farmers (Abou El-Fadl *et al*., 1990). It is recommended to completely or partially replace mineral nutrients (NPK) with organic and biological nutrients that are safe and economical for farms. Organic farming is more reliable than others because chemicals are not used in this type of industry (Rigby and Caceres, 2001). Hence, the organic cultivation of medicinal plants can reduce the negative influences on the quality of its medicinal purpose. Many researchers have indicated the effectiveness of organic fertilizer in increasing the growth, productivity of yield and volatile oil of fennel (Badran and Safwat, 2004), roselle (Ezz-Eldin and Abd-Elmoaz, 1998) and cumin (Safwat and Badran, 2002).

Cattle manure increases the amount of volatile oil and seed yield of *Carum copticum* L. So that 30 t/ha of cattle manure increased the volatile oil by 4% compared to controls (Akbarinia *et al*., 2003). Focusing on the cattle manure for medicinal plants, it has been reported that the materials increase the yield of the treated plants by influencing their physical, chemical and biological properties of soil (Sharma, 2002; Chatterjee, 2002). Many advantages of cattle manure such as retaining water in the soil and having nutritious elements can increase the amount of plant essence by raising the vegetative growth which has an important role in essence .

Chicken manure is one of the great organic fertilizer sources than other manures. Jasmine and Andriyani (2005) cleared that 10 t/ha of chicken manure can enhance growth and production of organic soybean. Research Widowati *et al*. (2005) also reported that treatment of chicken manure on crops gave the great response. This happens because chicken manure decomposes relatively quickly and has an adequate nutrient level when compared to an equivalent manures.

Seaweed extracts (SWE) considered as commercial formulations to using as plant growth regulator to improve the tolerance of drought, heat and salinity. It targets a several pathways to improve tolerance under stress and is account for 10% of marine productivity (Battacharyya *et al*., 2015). SWE considered as a great source of bioactive components such as protein, carotenoids, essential fatty acids, amino acids, vitamins, growth regulators and minerals (Bhaskar and Miyashita, 2005). SWE have been shown to enhance plant growth and health. It provides N, P and K, as well as micro nutrients like Zn, Mn, Mg, Fe (Crouch *et al*., 1990). SWE includes natural plant growth regulators such as gibberellins, cytokinins and auxins (Crouch and Van Staden, 1994). These trace elements found in SWE are naturally present in chelated form and are readily available to plants. It improves photosynthesis and produces healthy foliage (Kavitha *et al*., 2008). It is necessary to explore the possibility of applying SWE in organic farming techniques.

The current research aimed to evaluate the production of *F. vulgare*, as one of the great important medicinal plants, by organic farming system through supporting the soil with organic manures and stimulating the growth and productivity of plants with the foliar application of SWE as a bio-stimulant .

Materials and Methods

An experiment was conducted at the Medicinal Plants Farm, Fac. Agric., Assiut University in two continual seasons (2020/2021 and 2021/2022) to investigate the influence of two organic fertilizers (cattle manure and chicken manure) and seaweed extract on morphological parameters, fruit yield, volatile oil content and its chemical constituents of *F. vulgare* plant as an attempt to improve the yield productivity and quality.

Fennel fruits were obtained from Hort. Res. Ins., Agric. Research Center, Giza, Egypt. Before sowing, the fruits were treated with fungicide (Micronized Soreil-KZ 70% w.p.) at 10 g/kg. This treatment is used to combat any fungal infection during cultivation.

On November 5th 2020 and 2021, fruits of fennel were sown in plots (experimental units) of 2 square meters (2 x 1 m), each one included 2 rows with 50 cm distance and each row included nine hills spaced 25 cm interval, the thinning was done after six weeks and leaved one seedling/hill (18 plant/plot). Fennel plants as a total were approximately 36000/fed. Some physicochemical characters of experimental field soil are presented in Table (1). Ambient temperatures averages ranging between 20 and 35°C, and the relative humidity was between 70 and 75% in the study area during the period of experimentation. Irrigation and weeding practices were similarly done whenever needed. No herbicides and fertilizers were applied to the experimental soil.

Table 1. Physicochemical characteristics of the experimental soil.

Soil type	Soluble ions meq/100 g soil (Extract 1:5)							Soluble K mg/100g soil	pH (1:2.5)	EC dS m^{-1}	Organic matter %
	Cations				Anions						
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO_4^=$				
Clay	3.2	2.50	3.81	0.007	3.26	3.62	2.63	0.23	8.14	0.97	1.72

The cattle and chicken manures used in this study were obtained from Animal Production and Poultry Farms, Fac. Agric., Assiut University, Egypt. Physicochemical characteristics for cattle and chicken manure are shown in Table 2 and 3, respectively.

Seaweed extract produced by CHEMA Company, used as liquid extract contains Zn, Fe, Cu, Mo and Mn minerals, enzymes, vitamins, amino acids, plant hormones and sugars. The doses used were at rate of 0, 2, 3 and 4 ml L^{-1}.

Table 2. Physicochemical characteristics of the cattle and chicken manures.

Organic manure	Humidity %	Organic matter %	Carbon %	Nitrogen %	C/N ratio	pH
Cattle manure	32.47	45.11	26.16	1.80	14.53	7.86
Chicken manure	28.63	26.21	28.63	3.20	8.95	7.61

The rates of 2 and 4 kg/plot, in addition to control treatment (without amendment). Seaweed extract at concentrations of 0 (water only), 2, 3 and 4 ml/l were sprayed in aqueous solutions after 60, 75, 90 and 105 days, during 2021 and 2022 seasons. Plants were sprayed to run off using a hand-pressurized air sprayer pump in the early morning, triton B was used as a surfactant at 1 ml/l .

The experiment consisted of 20 treatments (5 organic fertilizer x 4 seaweed extract) distributed randomly in a split-plot design, the five organic fertilizer treatments as main-plots and the four seaweed extract applications as sub-plots. Each treatment (experimental unit) replicated four times. At full maturity in May of both seasons, fennel fruits were harvested. At the end of the experiment on May 1st, 2021 and 2022, data were recorded.

To measure plant growth and fruit parameters, samples of twelve plants were randomly chosen from each experimental unit in both seasons. Data were recorded on plant height (cm), stem diameter (cm), branch number per plant, umbel number per plant, fruit yield per plant (g) and per fed. (Kg) .

Volatile oil characteristics

Extraction of volatile oil

The volatile oil components of *F. vulgare* plants were extracted by hydro-distillation using Clevenger's apparatus, using 50 g of crushed fruits from each treatment and adding 500 ml of water placed in one-liter round flask. The distillation time was three hours. Thereafter, the oil was left to stand undisturbed to assure complete separation in accordance with the U.S.P. (1995) .

Analysis of volatile oil composition

Completely Random samples analyzed by gas chromatography–mass spectrometry. The chemical components of each one were detected with the Trace GC-ISQ mass spectrometer apparatus. The active components were identified by comparison of their retention times and mass spectra with mass spectral database of NIST version 11 and WILEY version 09.

Determination of total phenolic content

Dried samples (0.1 g) were extracted twice at room temperature with stirring for 60 min, first used 20 ml of a mixture of methanol/water (50:50 vol/v) and followed with 20 ml of acetone/water (70:30 vol/v) and centrifuged at 4000 rpm for 15 min. Soluble phenol contents were determined using Folin-Ciocalteu reagent assay in accordance to Strail *et al*. (2006). The total phenolic was determined calorimetrically at 750 nm and expressed as gallic acid equivalents (mg GAE/g DW).

Determination of total soluble carbohydrates

Total soluble carbohydrates were estimated according to Hansen and Moller (1975) by hydrolyzing 0.1 g of the fine powdered leaves and seeds with 0.1 N HCl overnight, then in water bath at 100°C for 20 minutes. After cooling the solution, it filtered into 25 ml measuring flask, and completed to mark with distilled water. Total carbohydrates were measured colorimetrically in this solution by the anthrone sulphuric acid method at 630 nm wavelength .

Determination of photosynthetic pigments

Samples of mature leaves were randomly collected from the middle parts of the plants to evaluate chlorophyll a, chlorophyll b and carotenoids, the pigments fractions were calculated as µg/g leaf FW. The spectrophotometric determination was done according to Lichtenthaler and Wellburn (1983).

Statistical analysis

Data were statistically analyzed by Statistix 8.1 analytical software (Analytical Software, 2008) and means were compared using a significant difference test (L.S.D.) according to Gomez and Gomez (2010).

Results and Discussions

The data in Tables (3, 4 and 5) show that the organic manure treatments had a significant influence on plant height, branch number/plant, stem diameter, umbel number/plant, fruit yield/plant, fruit yield/fed., volatile oil %, volatile oil yield/plant and /fed. in both continuous seasons. Also, foliar application of seaweed extract showed a significant influence on plant height, branch number/plant, stem diameter, umbel number/plant, fruit yield/plant, total fruit yield/fed., volatile oil %, volatile oil yield/plant and /fed. in the 1st and 2nd seasons .

Data presented in Table (3) refer to that among the tested organic manures, chicken manure at 4 kg/plot recorded the best results with regard to the growth of fennel except for plant height which recorded the best results with cattle manure at 4 kg/plot. Plants grown on soil amended with cattle manure at 4 kg/plot reached 127.2 and 122.1 cm height, in both seasons respectively. Meanwhile, plants fertilized with chicken manure at rate of 4 kg/plot were stated by more branches (6.17 and 5.24). Differences in plant stem diameter were striking (1.55 and 1,52 cm in both seasons, respectively) when soil fertilized with chicken manure at 4 kg/plot as compared to other organic manure treatments during both seasons. These results are in accordance with the findings of EL-Sayed *et al*. (2009), Mohamed and Abdu (2004) and Mohamed and Ahmed (2002) on fennel, El-Banna and Fouda (2018) and Awad (2016) on caraway, Yaldiz *et al*., (2019) and Massoud (2007) on sweet basil and Betül (2017) on origanum .

Seaweed extract at 4 ml/l produced highest plants (129.18 and 122.65 cm, thickest stems (1.48 and 1.47 cm) and more branch number per plant (6.16 and 5.26) for both seasons, respectively when compared with other seaweed concentrations. Similar results were reported by El–Shoura *et al*. (2019), Zulfiqar *et al*. (2019) and Mostafa (2015) on fennel, El-Naggar *et al*. (2015) and Elansary *et al*. (2016) on sweet basil, Waly *et al*. (2020) on thyme, Ghatas *et al*. (2021) on artemisia and Khater *et al*. (2022) on *Ruta graveolens*.

Table 3. Impact of different organic manures and seaweed extract applications on plant height, branch number/plant and stem diameter of fennel during 2020/2021 and 2021/2022 seasons

Organic manure	Seaweed extract ml/l	Plant height (cm)		Branch number/plant		Stem diameter (cm)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control unfertilized	Control	120.00	116.63	4.98	4.44	1.21	1.14
	2	122.67	117.84	5.06	4.62	1.25	1.18
	3	123.76	119.19	5.41	4.82	1.33	1.26
	4	125.38	120.81	6.03	5.01	1.51	1.32
Mean		122.95	118.62	5.37	4.72	1.33	1.22
Cattle manure 2 kg/plot	Control	120.86	118.53	4.89	4.59	1.33	1.20
	2	123.25	119.71	5.65	4.90	1.42	1.28
	3	127.45	121.26	5.80	5.08	1.43	1.34
	4	131.51	123.23	5.93	5.21	1.34	1.42
Mean		125.77	120.68	5.57	4.94	1.38	1.31
Cattle manure 4 kg/plot	Control	123.03	119.64	5.40	4.94	1.47	1.21
	2	126.79	121.52	5.74	5.10	1.26	1.32
	3	128.25	122.99	5.78	5.18	1.34	1.40
	4	130.73	124.07	6.00	5.48	1.50	1.46
Mean		127.20	122.05	5.73	5.18	1.39	1.34
Chicken manure 2 kg/plot	Control	122.60	118.69	5.16	4.76	1.42	1.26
	2	125.67	119.66	5.49	4.89	1.43	1.38
	3	126.85	120.88	5.78	5.08	1.31	1.47
	4	127.64	122.03	6.47	5.19	1.53	1.53
Mean		125.69	120.32	5.73	4.98	1.42	1.41
Chicken manure 4 kg/plot	Control	121.72	119.72	5.48	5.07	1.37	1.38
	2	122.94	120.87	6.51	5.20	1.68	1.47
	3	129.14	121.97	6.33	5.28	1.65	1.58
	4	130.65	123.13	6.35	5.41	1.51	1.65
		126.11	121.42	6.17	5.24	1.55	1.52
Mean of Seaweed extract treatments	Control	121.64	118.64	5.18	4.76	1.36	5.24
	2	124.26	119.92	5.69	4.94	1.41	1.33
	3	127.09	121.26	5.82	5.09	1.41	1.41
	4	129.18	122.65	6.16	5.26	1.48	1.47
LSD 0.05	Organic manures	3.25	1.07	0.70	0.04	0.26	0.30
	Seaweed extract	2.91	0.23	0.59	0.03	0.15	0.14
	Interaction	N.S.	N.S.	1.33	0.07	0.39	0.40

Data tabulated in Table (4) showed that chicken manure at 4 kg/plot significantly increased umbel number (25.40 and 26.06) and fruit yield per plant (30.59 and 35.53 g) and per fed. (1101 and 1279 kg) for both seasons, respectively. These findings were supported by EL-Sayed *et al*. (2009), Mohamed and Abdu (2004) on fennel, El-Banna and Fouda (2018) and Awad (2016) on caraway. Using the higher concentrations of seaweed extract resulted in a significant increase over other treatments in terms of fruit yield/plant (30.45 and 32.50 g) during the two seasons, respectively and total fruit yield/fed. (1096 and 1170 kg) in the two seasons, respectively, as shown in Table (4). These results are in agreement with those reported by El–Shoura *et al*. (2019), Zulfiqar *et al*. (2019), Mostafa (2015) on fennel, Tursun (2022) on coriander, Hassan (2015) on dill, Aly *et al*. (2021) on parsley and Al Mohammedi *et al*. (2014) on black cumin.

Table 4. Impact of different organic manures and seaweed extract applications on umbel No./plant, fruit yield/plant and fruit yield/fed. of fennel during 2020/2021 and 2021/2022 seasons.

Organic manure	Seaweed extract ml/l	Umbel No./plant		Fruit yield (g/plant)		Fruit yield (kg/fed.)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control unfertilized	Control	18.47	16.25	20.16	19.50	726	702
	2	20.67	17.25	23.70	20.50	853	738
	3	21.65	18.25	24.24	21.50	873	774
	4	22.92	19.50	25.51	22.50	918	810
Mean		20.93	17.81	23.40	21.00	842	756
Cattle manure 2 kg/plot	Control	19.34	17.91	21.57	20.50	776	738
	2	21.07	20.16	23.17	22.50	834	810
	3	22.28	21.00	25.50	24.50	918	882
	4	25.13	21.85	26.09	29.50	939	1062
Mean		21.96	20.23	24.08	24.25	867	873
Cattle manure 4 kg/plot	Control	23.60	18.50	22.53	22.50	811	810
	2	23.84	20.50	24.42	27.50	879	990
	3	24.69	22.50	25.48	30.50	917	1098
	4	26.39	23.45	33.63	33.50	1211	1206
Mean		24.63	21.24	26.52	28.50	954	1026
Chicken manure 2 kg/plot	Control	19.00	22.65	23.98	23.50	863	846
	2	20.05	23.70	25.88	26.50	932	954
	3	24.92	24.80	26.62	33.52	958	1207
	4	25.53	25.70	30.28	37.50	1090	1350
Mean		22.38	24.21	26.69	30.26	961	1089
Chicken manure 4 kg/plot	Control	21.83	23.50	24.21	31.63	871	1139
	2	25.29	25.25	29.52	33.50	1063	1206
	3	26.18	27.25	31.88	37.50	1148	1350
	4	28.28	28.25	36.76	39.50	1323	1422
		25.40	26.06	30.59	35.53	1101	1279
Mean of Seaweed extract treatments	Control	20.45	19.76	22.49	23.53	809	847
	2	22.19	21.37	25.34	26.10	912	940
	3	23.95	22.76	26.74	29.50	963	1062
	4	25.65	23.75	30.45	32.50	1096	1170
LSD 0.05	Organic manures	3.76	6.67	6.03	7.18	151	209
	Seaweed extract	2.32	3.00	4.16	5.88	104	156
	Interaction	4.62	8.34	10.06	12.38	251	296

According to the showed results in Table (5), fruit content of volatile oil yield per plant reached 0.44 and 0.69 ml in conducting with chicken manure treatment at 4 kg/plot comparing with 0.37 and 0.52 ml in chicken manure treatment at 2 kg/plot and 0.30 and 0.29 ml in unfertilized plants during both seasons, respectively. The soil supported with chicken manure at rate of 4 kg/plot showed superiority in the volatile oil % followed by chicken manure at rate of 2 kg/plot. Similar results were obtained by EL-Sayed *et al*. (2009) and Mohamed and Abdu (2004) on fennel, Awad (2016) on caraway, Khalid and Shafei (2005) on dill and Yousef *et al*. (2008) on sweet marjoram.

Table 5. Impact of different organic manures and seaweed extract applications on volatile oil percentage, volatile oil yield/plant and volatile oil yield/fed. of fennel during 2020/2021 and 2021/2022 seasons.

Organic manure	Seaweed extract ml/l	Volatile oil (%)		Volatile oil yield (ml/plant)		Volatile oil yield (l/fed.)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Control unfertilized	Control	1.04	1.05	0.21	0.21	7.53	7.38
	2	1.25	1.35	0.30	0.28	10.67	9.97
	3	1.32	1.45	0.32	0.31	11.52	11.23
	4	1.42	1.70	0.36	0.38	13.04	13.79
Mean		1.26	1.39	0.30	0.29	10.69	10.59
Cattle manure 2 kg/plot	Control	1.12	1.20	0.24	0.25	8.70	8.87
	2	1.28	1.45	0.30	0.33	10.68	11.75
	3	1.33	1.60	0.34	0.39	12.21	14.11
	4	1.46	1.85	0.38	0.55	13.67	19.66
Mean		1.30	1.53	0.32	0.38	11.32	13.60
Cattle manure 4 kg/plot	Control	1.16	1.30	0.26	0.29	9.39	10.55
	2	1.32	1.55	0.32	0.43	11.57	15.35
	3	1.37	1.75	0.35	0.53	12.54	19.22
	4	1.48	2.00	0.50	0.67	17.92	24.12
Mean		1.33	1.65	0.36	0.48	12.86	17.31
Chicken manure 2 kg/plot	Control	1.20	1.35	0.29	0.32	10.38	11.45
	2	1.35	1.60	0.35	0.42	12.57	15.28
	3	1.43	1.75	0.38	0.59	13.68	21.13
	4	1.52	2.05	0.46	0.77	16.60	27.70
Mean		1.38	1.69	0.37	0.52	13.31	18.89
Chicken manure 4 kg/plot	Control	1.22	1.50	0.29	0.47	10.61	17.09
	2	1.36	1.70	0.40	0.57	14.43	20.50
	3	1.44	2.05	0.46	0.77	16.50	27.70
	4	1.60	2.40	0.59	0.95	21.12	34.15
		1.41	1.91	0.44	0.69	15.67	24.86
Mean of Seaweed extract treatments	Control	1.15	1.28	0.26	0.31	9.32	11.07
	2	1.31	1.53	0.33	0.40	11.98	14.57
	3	1.38	1.72	0.37	0.52	13.29	18.68
	4	1.50	2.00	0.46	0.66	16.47	23.88
LSD 0.05	Organic manures	0.11	0.32	0.02	0.04	3.18	3.45
	Seaweed extract	0.09	0.29	0.01	0.03	2.77	2.96
	Interaction	0.18	0.59	0.03	0.05	4.12	4.56

The high level of seaweed extract (4 ml/l) showed the highest volatile oil content per plant and per fed. in both seasons, in addition to the increase in the volatile oil percentage with the highest concentration of seaweed extract compared to the other treatments and control plants (1.50 and 2.00 %) during the 1st and 2nd seasons, respectively. These results are in agreement with those reported by Mohamed (2020), El–Shoura *et al*. (2019), Zulfiqar *et al*. (2019), Mostafa (2015) on fennel, Tursun (2022) on coriander, Hassan (2015) on Anethum graveolens, Aly *et al*. (2021) on parsley and El-Naggar *et al*. (2015), Omer *et al*. (2016) on basil.

Twenty four components were identified from volatile oil samples and presented in Table (6). The main components of the fennel volatile oil were anethole (27.50 – 40.52 %), estragole (13.44 – 21.65%), fenchone (14.32 – 22.11%) and limonene (17.88 – 23.56%). Fruit volatile oil was collected from plants grown in soil fertilized with chicken manure at 4 kg/plot induced a high percentage of anethole compared to the plants fertilized with other organic manure treatments. Seaweed extract at 4 ml/l increased the anethole % compared to the other levels. An increase in the anethole % was accompanied by a decrease in estragole .

Table 6. Impact of different organic manures and seaweed extract treatments on the volatile oil content of Anethole, Estragole, Fenchone and Limonene (Area %) of fennel plants as average of both seasons.

Seaweed extract (ml/l)	Anethole						Estragole					
	Organic manure (Kg/Plot)						Organic manure (Kg/Plot)					
	Cont.	Cattle manure		Chicken manure		Mean	Cont.	Cattle manure		Chicken manure		Mean
		2	4	2	4			2	4	2	4	
0	27.93	28.92	30.62	33.17	40.55	32.24	22.94	21.56	20.56	17.59	14.78	19.49
2	28.01	30.76	31.81	34.68	36.96	32.44	21.52	21.27	20.33	16.59	14.55	18.85
3	27.50	29.52	34.46	35.02	38.49	33.00	20.81	18.89	17.49	15.32	13.55	17.21
4	30.75	31.22	32.05	34.21	40.52	33.75	22.65	17.56	16.44	14.68	13.44	16.95
Mean	28.55	30.11	32.24	34.27	39.13		21.98	19.82	18.71	16.05	14.08	

Seaweed extract (ml/l)	Fenchone						Limonene					
	Organic manure (Kg/Plot)						Organic manure (Kg/Plot)					
	Cont.	Cattle manure		Chicken manure		Mean	Cont.	Cattle manure		Chicken manure		Mean
		2	4	2	4			2	4	2	4	
0	18.53	18.19	15.18	13.92	18.06	16.78	21.33	20.88	20.61	17.88	21.46	20.43
2	14.50	20.46	15.99	14.32	17.88	16.63	21.40	22.04	19.50	20.24	21.26	20.89
3	18.86	22.11	15.75	17.50	14.66	17.78	20.69	19.45	21.65	22.01	18.17	20.39
4	16.21	17.75	14.46	14.65	17.18	16.05	21.40	22.24	18.50	23.52	21.74	21.48
Mean	17.03	19.63	15.35	15.10	16.95		21.21	21.15	20.07	20.91	20.66	

Both applications of organic manure and seaweed extract treatments significantly interacted with the most parameters of *F. vulgare* plants in both seasons. The best results were noticed on plants fertilized with chicken manure at 4 kg/plot and treated with the higher level of seaweed extract at the rate of 4 ml/l. Fennel fruit content of volatile oil recorded its highest values when plants were applicated with 4 ml/l SWE and grown in soil amended with chicken manure at 4 kg/plot comparing with other combinations.

Chicken industries are growing rapidly and supplied job opportunities to the people. But problems also come with poultry industry and its waste management that comes from chicken production, if this waste is not released well, it causes environmental pollutions that led to problems to environment and humans. Chicken waste can spread diseases and contaminate soil and groundwater resources if not handled properly. Therefore, the inflated demand of chicken meat has led to an increase in the production of organic waste. Organic wastes consist of varying amounts of water, mineral nutrients and organic matter (Edwards and Daniel, 1992; Brady and Weil, 1996). The use of organic wastes as manure has also been in traditions for centuries all over the world (Straub, 1977). Chicken manure is the most basic fertilizer among any other manures depending on its high concentration of macro-elements (Duncan, 2005; Warman, 1986). Polutry manure provides a great percentage of nitrogen and phosphate. Currently, waste and manure from the chicken industry are used in agricultural soil. However, contamination and blockage problems could be recorded when fertilizers are applied under environmental conditions which do not favor agricultural use of the nutrients (Kaiser *et al*., 2009; Casey *et al*., 2006; Sharpley *et al*., 1998). Poultry manure has great potential for recycling the agricultural land. A profitable assay from applying land is depends on its ability to favorably change soil properties, such as soil pH, nutrient availability to the plant, organic matter content by cation exchange capacity, water holding capacity and soil tiltability.

With respect of seaweed extract treatments, the tabulated data of all studied characters of fennel plants showed responded significance to the foliar spray with examined concentrations of seaweed extract during the two experimental seasons. In this connection, using seaweed extract at the high concentration (4 ml/l) proved to be more effective than other treatments and untreated plants, in both seasons. This positive effect of SWE can be attributed to its composition such as natural growth regulators (cytokinins and auxins) that support plant growth by increasing the number of metabolic events; cell division and enlargement which in turn increases plant height (Prasad *et al*., 2010). Also, the extract contains a large amount of macro- and microelements that play a great role in activating many enzymes and coenzymes which are involved in several biological processes leading to cell division and enlargement (Sivasankari *et al*., 2006). It was also observed from the previous results that the use of SWE led to an increase in the number of branches in treated plants. This caused depending on the role of cytokinins in improving overall growth and promoting the development of lateral buds and vascular tissues (Wu and Lin, 2000). This can also be explained on the basis of the presence of carbohydrates in the extract that are closely related to the stimulation of lateral buds for growth and differentiation (Hartmann *et al*., 2002). In addition to the increasing the dry weight of shoot and roots, it may be associated with an increase in vegetative growth, which may be reflected in the increase in photosynthesis and the availability of organic nutrients which led to an increase in the plant dry weight (Spinelli *et al*., 2010 and Attememe, 2009).

The present study indicates that the application of seaweed extract leading to increase essential oil, total photosynthetic activity and chlorophyll accumulation, carbohydrates and total phenolic, compared to respective control during both seasons. The increase of these traits could be attributed to the effect of these bio-stimulant to promote plant growth when applied. These bio-stimulant function known as metabolic enhancers because they contained constituents such as macro- and microelement nutrients, amino acids, vitamins, cytokinins and auxins which affect cellular increase of crop yield metabolism in explicated plants leading to improve growth and to chlorophyll a, b and carotenoids contents in the fresh leaves (Mohamed *et al*., 2016).

As evident from the results presented in this study, the combination of chicken manure as organic fertilizer at rate 4 kg/plot and foliar application of seaweed extract at highly concentration (4 ml/l) proved to be the superior treatment which has high efficiency to produce fennel yield and quality. This combined treatment was correlated with enhancement in vegetative and root characteristics which reflected on producing the maximum fruit yield (1323 and 1422 kg/fed.) during both seasons, respectively compared to control (726 and 702 kg/fed.), as well as increased essential oil yield (21.12 and 34.15 l/fed.) and produced the optimum percentages of main components.

References

Abdallah, N.; El-Gengaihi S. and Sedrak E. (1978). The effect of fertilizer treatments on yield of seed and volatile oil of fennel (*Foeniculum vulgare* Mill.). Pharmazie, 33 (9): 607-608.

Abdul-Hafeez, E.Y.; Soliman Y.M. and Elsayed A.M.A. (2020). Influence of Sowing Date and Foliar Application of Humic Acid on Yield and Volatile Oil of Sweet Fennel (*Foeniculum vulgare*) Plants, Egyptian Journal of Horticulture, The Egyptian Horticulture Society, 47 (1): 81-92.

Abou El-Fadl, I.A.; Abou-Baker M. and El-Gamal A.M. (1990). Effect of different organic manure composts on roselle (*Hibiscus sabdariffa* L.) plants and soil characteristics. Agic. Res. Review, 68 (5): 1077- 1087.

Akabarinia, A.; Ghalavand A.; Sefidkan F.; Rezaee M. and Sharifiashurabadi A. (2003). Evaluation of quality and quantity on essential oil content of *Carum copticum*. Journal of Research and Development. 61: 32-41. [In Persian].

Almohammedi, A.N.; Almehemdi A.F. and Al Ajeelee R.K. (2014). Impact of bat guano *Otonycteris hemprichii* Camd and seaweed extract on some growth and yield traits of Barakaseed *Nigella sativa* L. Journal of Biology, Agriculture and Healthcare, 4 (1): 57-65.

Aly, M.K.A.; Ahmed E.T.; Mohamed M.A.H. and Youssef E.Z.N. (2021). Effect of nitrogen and biofertilization, seaweed extract and thiamine on growth, yield and essential oil of parsley plant. Scientific journal of flowers and ornamental plants, 8 (2): 235-249.

Analytical Software (2008). Statistix version 8.1., Analytical software, Tallahassee, Florida, USA.

Attememe, J.Y. (2009). The effect of humic acid and seaweed extracts on growth, chemical characteristics of *Rosmarinus officinalis* L. The 6th Scientific Conference, Biology Dept., College of Education, Tikrit Univ., pp. 1-17.

Awad, M. (2016). poultry manure and humic acid foliar applications impact on caraway plants grown on a clay loam. Journal of Soil Sciences and Agricultural Engineering, 7 (1): 1-10.

Badran, F.S. and Safwat M.S. (2004). Response of fennel plants to organic manure and bio-fertilizers in replacement of chemical fertilization. Egypt. J. Agric. Res., 82 (2): 247- 256.

Battacharyya, D.; Babgohari M.Z.; Rathor P. and Prithiviraj B. (2015). Seaweed extracts as biostimulants in horticulture. Sci. Hortic., 30 (196): 39-48.

Betül, A. (2017). Influence of chicken manure applications on the yield and the essential oil content of *Origanum onites* L. Indian Journal of Pharmaceutical Education and Research, 51 (3): 290-294.

Bhaskar, N. and Miyashita K. (2005). Lipid composition of *Padina tetratomatica* (Dictyotales, Pheophyta), abrown seaweed of the west coast of India. Ind. J. Fisheries., 52 (3):263–268.

Bhati, D.S.; Shaktawat M.S.; Somani L.L. and Agarwal H.R. (1988). Response of fennel (*Foeniculum vulgare* Mill.) to nitrogen and phosphorus. Transactions of Indian Society of Desert Technology, 2: 79-83.

Brady, N.C. and Weil R.R. (1996). The nature and properties of soils. 11th Edition. Prentice Hall International, Inc.

Buntain, M. and Chung B. (1994). Effects of irrigation and nitrogen on the yield components of fennel (*Foeniculum vulgare* Mill.). Australian J. of Experimental Agriculture, 34 (6): 845-849.

Casey, K.D.; Bicudo J.R.; Schmidt D.R.; Singh A.; Gay S.W.; Gates R.S.; Jacobsen L.D. and Hoff S.J. (2006). Air quality and emissions from livestock and poultry production/waste management systems, in: RICE, J.M., CALDWELL, D.F. & HUMENIK, F.J. (Eds.) Animal Agriculture and the Environment: National Center for Manure and Animal Waste Management White Papers, Publication No 913C0306, pp. 1-40.

Charles, D.J.; Morales M.R. and Simon J.E. (1993). Essential oil content and chemical composition of finocchio fennel. In: Janick, J. and J. E. Simon (eds.), New crops. Wiley New York, pp: 570-573.

Chatterjee, S.K. (2002). Cultivation of medicinal and aromatic plants in India, A Commercial Approach Proceeding of an International Conference on Map. Acta Horticulture (ISHS), 576: 191–202.

Chiej, R. (1984). The Macdonald Encyclopedia of Medicinal Plants. Macdonald & Co., London.

Crouch, I.J. and Van Staden J. (1994). Commercial seaweed products as biostimulants in horticulture. J. Home Consumer Hortic., 1: 19-76.

Crouch, I.J.; Beckett R.P. and Van Staden J. (1990). Effect of seaweed concentrates on the growth and mineral nutrition of nutrient-stressed lettuce. J. of Applied Phycology., 2 (3): 269–272.

Dowdy, S. and Wearden S. (1983). Statistics for Research. John Wiley and Sons, New York, USA, p. 640.

Duncan, J. (2005). Composting chicken manure. WSU Cooperative Extension, King County Master Gardener and Cooperative Extension Livestock Advisor.

Edwards, D.R. and Daniel T.C. (1992). Environmental impacts of on-farm poultry waste disposal: A review. Bioresource Technology 41: 9-33.

Elansary, H.O.; Yessoufou K. and Shokralla S. (2016). Enhancing mint and basil oil composition and antibacterial activity using seaweed extracts. Industrial Crops and Products, 92: 50-56.

El-Banna, H. and Fouda K. (2018). Effect of mineral, organic, biofertilizers and humic acid on vegetative growth and fruit yield quality of caraway plants (*Carum carvi* L.). Journal of Soil Sciences and Agricultural Engineering, 9 (5): 237-241.

El-Naggar, A.H.M.; Hassan M.R.A.; Shaban E.H. and Mohamed M.E.A. (2015). Effect of organic and biofertilizers on growth, oil yield and chemical composition of the essential oil of *Ocimum basilicum* L. plants. Alex. J. Agric. Res. 60 (1): 1-16.

El-Sayed, A.; Sidky M.; Mansour H. and Mohsen M. (2009). Effect of organic fertilizer and Egyptian rock phosphate on the growth, chemical composition and oil production of tarragon (*Artemisia dracunculus,* L.). Journal of Productivity and Development, 14 (1): 87-110.

El-Shoura, A.M.; Dapor A.S. and Masoud G.F. (2019). Effect of sowing dates and foliar spraying with moringa leaf extract, seaweed extract and potassium sulphate fertilizer on growth, yield and chemical composition of sweet fennel (*Foeniculum vulgare* Mill) plant. The Future Journal of Biology, 4: 11-25.

Ezz-Eldin, A. and Abd-Elmoaz M.R. (1998). Productivity of roselle (*Hibiscus sabdariffa* L.) plants under organic fertilization treatments. Sec. Conf. Ornam. Hort. Ismailia, Egypt.

Farrell, K.T. (1988). Spices, Condiments and Seasonings. AVI Publ. Westport, CT., pp: 106-109.

Ghatas, Y.; Ali M.; Elsadek M. and Mohamed Y. (2021). Enhancing growth, productivity and artemisinin content of *Artemisia annua* L. Plant using seaweed extract and micronutrients. Industrial Crops and Products, 161 (164):1-10.

Gross, M.; Friedman J.; Dudai N.; Larkov O.; Cohen Y. and Bar E. (2002). Biosynthesis of Estragole and t- in bitter fennel (*Foeniculum vulgare* Mill. var. vulgare) chemotypes. Changes in SAM: phenylpropene o-methyltranferase activities during development. Plant Science, 163: 1047-1053.

Hansen, J. and Moller I. (1975). Percolation of starch and soluble carbohydrates from plant tissue for quantitative determination with anthrone. Analytical Biochemistry, 68 (1): 87-94.

Hartmann, H.T.; Kester D.E.; Davis F.T. and Genev J.R. (2002). Plant propagation: Principle and practices, 7th edition. Prentice Hall, Upper Saddle River, New Jersey pp. 880.

Hassan, E.A. (2015). Influence of mixed minerals ores and seaweed liquid extract on growth, yield and chemical constituents of dill (*Anethum graveolens,* L.) plants. Middle East Journal of Applied Sciences, 5 (3): 751-758.

Jasmine, M. and Andriyani W. (2005). The effect of chicken manure and green manure *Calopogonium mucunoides* on the growth and production of vegetative soybean under organic farming system crops organically grown young. Bul. Agron., 33 (2): 8-15.

Kaiser, D.E.; Mallarino A.P. and Haq M.U. (2009). Runoff phosphorus loss immediately after poultry manure application as influenced by the application rate and tillage. Journal of Environmental Quality 38: 299-308.

Kavitha, M.P.; Ganesaraja V. and Paulpandi V.K. (2008). Effect of foliar spraying of seaweed extract on growth and yield of rice (*Oryza sativa* L.). Agric. Sci. Digest, 28 (2): 127–129.

Khalid, K.A. and Shafei A.M. (2005). Productivity of dill (*Anethum graveolens* L.) as influenced by different organic manure rates and sources. Arab Universities Journal of Agricultural Sciences, 13 (3): 901-913.

Khater, R.M.; Wafaa H. Abd-Allah; Hanan A.E. Hashem and Abd El-Gawad A.M. (2022). Effect of humic acid and algae extract on productivity of *Ruta graveolens* L. Plant under Sinai conditions. Egyptian Journal of Desert Research, 72 (1): 139-155.

Masada, Y. (1976). Analysis of essential oils by gas chromatography and mass spectrometry. Copyright by the Hirokawa Publishing company, INC printed in Japan.

Massoud, H.Y.A. (2007). Evaluation of some varieties of *Ocimum basilicum* L. and their response to some organic manures. Journal of Plant Production, 32 (4): 2863-2880.

Mohamed, A.A. and Ahmed M.E. (2002). A comparative study on the effect of sugarcane filter mud, sheep and chicken manures used for fertilization of sweet fennel (*Foeniculum vulgare,* L.). Minia J. Agric. Res. Dev. 22 (3): 221-234.

Mohamed, M.A. and Abdu M. (2004). Growth and oil production of fennel (*Foeniculum vulgare* Mill): effect of irrigation and organic fertilization. Biological agriculture & horticulture, 22 (1): 31-39.

Mohamed, Y. (2020). Impact of some growth stimulants in cooperation with arbuscular mycorrhizal fungi on growth, productivity and chemical constituents of Dutch fennel plant. Scientific Journal of Flowers and Ornamental Plants, 7 (3): 303-319.

Mohamed, Y.F.Y.; Zewail R.M.Y. and Ghatas Y.A.A. (2016). The role of boron and some growth substances on growth, oil productivity and chemical characterization of volatile oils in basil (*Ocimum basilicum* L.) cv. Genovese. Journal of Horticultural Science & Ornamental Plants, 8 (2):108-118.

Mostafa, G.G. (2015). Improving the growth of fennel plant grown under salinity stress using some bio stimulants. American Journal of Plant Physiology, 10 (2): 77-83.

Omer, E.A.; Hussein M.S.; Osman A.R.; Sewedan E.; Elgohary A.I. and Salman A.M. (2016). Response of basil essential oil to cultivation date and organic fertilization. International Journal of PharmTech. Research, 9 (5): 86-98.

Prasad, K.; Das A.K.; Oza M.D.; Brahmbhatt H.; K. Siddhanta A.; Meena R.; Eswaran K.; Rajyagur M.R. and Ghosh P.K. (2010). Detection and Quantification of Some Plant Growth Regulators in a Seaweed-Based Foliar Spray Employing a Mass Spectrometric Technique Sans Chromatographic Separation. Journal of Agricultural and Food Chemistry, 58 (8): 4594-4601.

Rigby, D. and Caceres D. (2001). Organic farming and the sustainability of agricultural systems. Agricultural Systems, 68: 21-40.

Safwat, M.S. and Badran F.S. (2002). Efficiency of organic and bio-fertilizers, in comparison with chemical fertilization, on growth yield and essential oil of cumin plants. The 9th Conf. of Medicinal and Aromatic Plants, Cairo, Egypt.

Sharma, A.K. (2002). A Handbook of organic farming. Publication Agrobios. India.

Sharpley, A.; Meisinger J.J.; Breeuwsma A.; Sims J.T.; Daniel T.C. and Schepers J.S. (1998). Impact of animal manure management on ground and surface water quality, in: HATFIELD, J.L. & STEWART, B.A. (Eds) Animal Waste Utilisation. Effective Use of Manure as Soil Resource. pp. 173-242 (Chelsea, MI, Ann Arbor Press).

Sivasankari, S.; Venkatesalu V.; Anantharaj M. and Chandrasekaran M. (2006). Effect of seaweed extracts on the growth and biochemical constituents of *Vigna sinensis*. Bioresource Technology, 97: 1745–1751.

Spinelli, F.S.; Fiori G.K.; Noferini M.L.; Sprocatti M.D. and Costa G.R. (2010). Anovel type of seaweed extract as a natural alternative to the use of iron chelates in strawberry production. J. Sci. Hort., 125 (6): 263-269.

Strail, P.; Klejdus B. and Kuban V. (2006). Determination of total content of phenolic compounds and their antioxidant activity in vegetables-evaluation of spectrophotometric methods. J. Agric. Food Chem., 54: 607-617.

Straub, D. (1977). A hot issue-chicken manure. Tilth producers quarterly. A Journal of Organic and Sustainable Agriculture. United States Department of Agriculture (USDA) .1995. Laboratory methods for soil and foliar analyses in long-term environment monitory programs. EPA/600/R-95/077.

Tursun, A.O. (2022). Effect of foliar application of seaweed (organic fertilizer) on yield, essential oil and chemical composition of coriander. PLoS One, 17 (6): 1-14.

U.S.P. (1995). United States Pharmacopeia. Convention, INC.

Vernon, L. P. (1960). Spectrophotometric determination of chlorophylls and pheophytins in plant extracts. Anal Chem., 32: 1144-1150.

Waly, A.A.; El-Fattah A.; Hassan M.A.E.; EL-Ghadban E.A. and Abd Alla A.S. (2020). Enhancing growth, productivity and essential oil percentage of *Thymus vulgaris* L. plant using seaweeds extract, chitosan and potassium silicate in sandy soil. Scientific Journal of Flowers and Ornamental Plants, 7 (4): 549-562.

Warman, P. R. (1986). The effect of fertilizer, chicken manure and dairy manure on Timothy yield. Tissue composition and soil fertility. Agric. Wastes. 18: 289-298.

Wichtl, M. and Bisset N.G. (1994). Herbal drugs and phytopharmaceuticals (ed), Med. Pharm scientific Publ Stuttgart, pp: 107-108.

Widowati, L.R.; Widati S.; Jaenudin U. and Hartatik W. (2005). Effect of Organic Fertilizer Compost Enriched with Mineral Materials and Biological Fertilizer on the properties of soil, Nutrient Uptake and Organic Vegetable Production. Research Project Report Agribusiness Development Program, Soil Research Institute.

Wu, Y.T. and Lin C.H. (2000). Analysis of cytokinin activity in commercial aqueous seaweed extract. Gartenbauwissenschaft, 65 (4): 170–173.

Yaldız, G.; Çamlıca M.; Özen F. and Eratalar S.A. (2019). Effect of poultry manure on yield and nutrient composition of sweet basil (*Ocimum basilicum* L.). Communications in soil science and plant analysis, 50 (7): 838-852.

Yousef, R.M.M. ; Hamouda A.M.A. and Ghaly N.G. (2008). Effect of irrigation and organic fertilization on growth and productivity of *Majorana hortensis*, L. in sandy soils. Journal of Plant Production, 33 (11): 8039-8056.

Zulfiqar, I.; Zahid N.Y.; Qureshi A.A. and Hafiz I.A. (2019). Impact of biostimulants to improve the growth of local fennel (*Foeniculum vulgare*) under salinity stress. Journal of Pure and Applied Agriculture, 4 (1): 38-50.

تقييم كفاءة الأســمدة العضــوية ومســتخلص الطحالب البحرية في تحســين نمو وإنتاجية نباتات الشمر

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الملخص

أجريت تجربة حقلية بهدف تقييم تأثير الســماد العضــوي (روث الأبقار وروث الدجاج) بمعدلات 2 و4 كجم/ وحدة تجريبية (2 متر مربع) ومستخلص الطحالب البحرية بتركيزات (0، 2، 3 و4 مل/لتر) على النمو، المحصول ومحتوى الزيت الطيار لنباتات الشمر خلال موسمي الزراعة 2021/2020 و2022/2021. وكانت أهم النتائج:

ســجلت معاملة روث الدجاج بمعدل 4 كجم/ وحدة تجريبية أفضــل نتائج لصــفات النمو، المحصــول ومحتوى الثمار من الزيت الطيار، بينما ســجلت المعاملة روث الأبقار بمعدل 4 كجم/ وحدة تجريبية أطول النباتات.

أظهرت معاملات الرش بمســتخلص الطحالب البحرية بالتركيز الأعلى (4 مل/لتر) تأثيرا معنويا في ارتفاع النبات، عدد الفروع لكل نبات، قطر الســاق، عدد النورات لكل نبات، محصــول الثمار لكل نبات، المحصول الكلى للثمار لكل فدان، النسبة المئوية للزيت الطيار، محصول الزيت الطيار للنبات وللفدان مقارنة بالمعاملات الاخرى في معظم الحالات.

أعطى الزيت الطيار المستخلص من النباتات المنزرعة في تربة مضــاف إليها روث الدجاج بمعدل 4 كجم/ وحدة تجريبية أعلى نســبة من الأنيثول (39.13 %) وأقل نســبة من الاســتراجول (14.08 %) مقارنة مع معاملات السماد العضوي الأخرى .

التركيز الأعلى من مســتخلص الطحالب البحرية زاد من نســبة الأنيثول مقارنة بالتركيزات الأخرى.

أظهر التأثير المتبادل بين المعاملات أن زراعة نباتات الشمر في تربه مسمدة بروث الدجاج بمعدل 4 كجم/ وحدة تجريبية والرش بمستخلص الطحالب البحرية بتركيز (4 مل/لتر) تعتبر أفضل توليفة لإنتاج أعلى محصول ثمار وجودة مرتفعة للزيت الطيار وينصح باستخدامها.