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Effects of Seaweed Extract and Phosphorus Fertilization on the Chemical Composition of Fennel (*Foeniculum vulgare* Mill.) Leaves and Fruit

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Abstract. The experiment was conducted in one of the fields of the College of Agriculture, University of Basrah, Iraq. The experiment aimed to study the effect of foliar application seaweed extract (algazon) at concentrations of (0, 3, 6) $ml.L^{-1}$ and high phosphorus fertilizer (prosol) 10-52-10 at the concentrations of (0, 0.3, 0.6) $g.L^{-1}$ on the chemical components of fennel leaves and fruits. A randomized complete block design was used in the factorial experiment with three replicates. The results were statistically analyzed using analysis of variance and the mean values were compared using the least significant difference test (LSD) at a probability level of 5%. The most important results obtained showed that plants sprayed with seaweed extract at concentrations of 3 and 6 $ml.L^{-1}$ significantly outperformed the leaf content of total chlorophylls, carotene, protein, nitrogen and phosphorus, the refractive index of volatile oil, the density and specific weight of volatile oil, while the concentration of 3 $ml.L^{-1}$ significantly increased the leaf content of potassium and the percentage of volatile oil in the fruits. Plants sprayed with high-phosphorus fertilizer at concentrations of 0.3 and 0.6 $g.L^{-1}$ significantly outperformed the leaf content of carotene, protein, nitrogen, phosphorus, the percentage of volatile oil, density and specific weight of volatile oil in the fruits. The interaction between seaweed extract and high-phosphorus fertilizer had a significant effect on most of the studied characteristics. GC-MS chromatographic analysis showed the most important chemical components of the oil, as 49 compounds were identified; and the dominant compound were 6-Octadecenoic acid, (Z)-cis-vaccenic, at a rate of 30.32%. Foliar application of 3 $ml{\bullet}L^{-1}$ seaweed extract combined with 0.3 $g{\bullet}L^{-1}$ phosphorus fertilizer improved fennel quality and oil yield.

Keywords. *Foeniculum vulgare*, Seaweed extract, High phosphorus fertilizer, Chemical composition.

1. Introduction

Fennel (*Foeniculum vulgare* Mill) is a biennial or perennial herb of the Apiaceae family, commonly cultivated as a winter crop in temperate and subtropical regions. It is one of the four important spice plants grown in temperate and subtropical regions of the world for the use of aromatic fruits as flavorings and in the pharmaceutical industry [1] because of its high content of nutrients, vitamins and essential oils which are rich in active compounds such as Anethol, Limonene, Camphene, Estrogole, and Fenchone [2]. Therefore, it is used for several medical purposes, including an appetite stimulant, diuretic, carminative, antioxidant, antimicrobial, lactation stimulant, treatment of nervous disorders and diarrhea as an anti-inflammatory agent for urinary tract infections, intestinal and renal spasms, and as a stimulant for anti-cancer diseases [3-5].

There are several applications of medicinal plants in stimulating the production of more bioactive compounds [6, 7]. The bioactive ingredients in fennel plants can be increased by using seaweed extracts in foliar application to increase and strengthen vegetative and root growth and increase the efficiency of the photosynthesis process because they contain many major and minor nutrients in addition to plant hormones [8].

Mostafa [9] sprayed the fennel plant grown under salt stress with seaweed extract at concentrations of (0, 1.5, 3, 4.5) ml.L^{-1}, and obtained that the concentrations of 3 and 4.5 ml.L^{-1} caused a significant increase in the percentage of volatile oil and potassium. Eisa [10] noted that when fennel plants were sprayed with seaweed extract at a concentration of 2 g.L^{-1}, there was a significant increase in the leaf content of total chlorophyll, nitrogen, phosphorus, potassium, and the percentage of volatile oil in the fruits compared to untreated plants.

The use of phosphate fertilizers is important for increasing the active substances in plants because of their role in increasing the construction and accumulation of carbohydrates [11] as a result of their participation in energy transfer reactions and the formation of ATP, which is used in fixing CO_2 gas in the photosynthesis process and then building oils and essential organic compounds [12].

Khalid [13] observed a significant increase in the percentage of essential oil, crude protein, nitrogen, and phosphorus when fennel plants were sprayed with NP fertilizer at a concentration of 1 g.L^{-1}.

Due to the lack of previous studies on the use of seaweed extract and high phosphorus fertilizer to improve the growth and chemical components of fennel leaves and fruits in the southern regions of Iraq, the present study was conducted.

2. **Materials and Methods**

The experiment was carried out in one of the fields of the College of Agriculture, University of Basrah, Iraq, with the aim of studying the effect of foliar application with seaweed extract "algazon" and high phosphorus fertilizer "prosol" on the chemical components of fennel plants. The experiment included 9 factorial treatments consisting of the interaction between three concentrations of seaweed extract (0, 3, 6) ml.L^{-1} and three concentrations of high phosphorus fertilizer "10-52-10" (0, 0.3, 0.6) g.L^{-1} with three replicates, so that the number of experimental units became 27 units implemented as a factorial experiment according to randomized complete block design. The data obtained were statistically analyzed using analysis of variance, and the mean values were compared using the least significant difference test (LSD) at a probability level of 5% [14].

Table 1. Physical and chemical properties of field soil.

Parameters	Value
pH	7.3
E.C	7.1
O.M(gm.kg)	1.84
CEC(centimole.kg^{-1})	331.2
Calcium (mmol.l^{-1})	14.20
Magnesium (mmol. l^{-1})	11.60
Total nitrogen (g.kg-1)	0.25
Ready phosphorus (mmol. l^{-1})	0.38
Ready potassium (mmol. l^{-1})	1.57
Soil separators	gm. kg^{-1}
sand	68.3
silt	396.3
clay	535.4
soil texture	Silty clay

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The seeds were planted at a distance of 25 cm between each hole, and all agricultural service operations to produce the crop were carried out. Table 2 lists the chemical components of the seaweed extract.

Table 2. Some chemical components of the seaweed extract "algazon".

Parameters	Value
N	7.8
P	3.9%
K	13.0%
Mo	0.4%
Zn	0.5 %
Fe	0.1 %
Mg	32.0 ppm
Mn	31.0 ppm
Cu	12.6 ppm
Organic matter	6.0%
Carbohydrate and Vitamins	12-16%
Auxins, Cytokinins and Gibberins	28-32%

The percentage of volatile oil was extracted from the dry-ground material using the volatile organic solvent extraction method described by Guenther [15]**.** The specific weights, densities, and refractive indices of the essential oil were estimated. Total chlorophyll and carotene content in the leaves was determined according to the Zaehringer method described by Goodwin [16]. Nitrogen content was estimated according to the method described by Page *et al*. [17]. The percentage of phosphorus was estimated after adjusting the acidity of the mixture according to the method described by Murphy and Riley [18]. The percentage of potassium was estimated using a flame photometer (JEN WAY PEP 73) and the results were expressed according to a standard curve in which potassium chloride was used. The percentage of protein in the leaves was estimated by the Microkieldhal method according to A.O.A.C. [19], and the total nitrogen was calculated by multiplying the percentage of nitrogen by 6.25.

The quantitative and qualitative components of the oil were analyzed by gas chromatography using a Shimadzu GC–MS–QP2010 Ultra mass spectrometer. Dilute with 1 ml of Hexane, after preparing the methyl ester of the sample fats, 0.1 µl of the resulting solution was injected into the GC-MS [20].

Oven

Injection temperature 250.0 °C
Detector interface temperature 250.0 °C
Initial temperature 50.0 °C
Final temperature 250.0 °C

Column

Column length 30 m
Column diameter 0.25 mm
Carrier gas Helium
Carrier gas pressure 90.0 kPa
Column flow 1.53 ml/min.
Linear velocity 44.8 cm / sec.
Spilt ratio 46.9
Total flow 79.2 ml/min.
GC Program Mass Spectrometer
M/Z range 0.50 to600.0 amu
Scan interval 0.50 sec
Threshold 0
Scan speed 2000 amu/sec
Solvent cut time 4.0 min
Detector gain 0.84 kv + 0.40 kv

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3. **Results and Discussion**

Table 3 shows that foliar application with seaweed extract at concentrations of 3 and 6 ml.L⁻¹ caused a significant increase in the leaf content of total chlorophyll by 37.8 rate of 25.22% compared to the control treatment. Both concentrations differed significantly in the leaf content of carotene (Table 4) and protein (Table 5), with an increase rate of (23.90, 50.14) % (5.36, and 11.21) %, respectively, compared to the control treatment. The effect increased significantly with increasing the concentration of the seaweed extract It also appeared from the Table 3 that foliar application with high phosphorus fertilizer had a significant effect on the leaf content of total chlorophyll, as both concentrations of 0.3 and 0.6 g. L^{-1} caused a significant decrease compared to the control treatment by a decrease rate of (5.73, 6.36) %, respectively, while both concentrations caused a significant increase in the content of carotene (Table 4) and protein (Table 5) in the leaves with an increase rate of (30.44, 52.53) % and (9.52, 8.54) %, respectively, compared to the control treatment. The interaction between the two factors showed a significant effect on all the traits under study, as the plants sprayed with the seaweed extract at a concentration of 3 ml.l^{-1} and with high phosphorus fertilizer at a concentration of 0.6 g.L^{-1} gave the highest leaf content of total chlorophyll, reaching 21.683 mg.100 g^{-1} fresh weight and carotene, reaching 0.0781 mg.100 g^{-1} fresh weight, while the plants sprayed with the extract at a concentration of 6 ml.L^{-1} and high phosphorus 0.6 g.L^{-1} gave the highest protein percentage, reaching 28.43%. The lowest values appeared in the treatment of high phosphorus at a concentration of 0.6 g.L^{-1} and 0 ml.L^{-1} seaweed extract, reaching 12.873 mg.100 g^{-1} fresh weight for total chlorophyll concentration. Plants sprayed with high phosphorus fertilizer gave the lowest value of carotene concentration, reaching 0.0228 mg.100 g^{-1} fresh weight. The lowest percentage of protein (21.33%) was observed in the control plants.

The significant superiority of foliar application with seaweed extract for the studied characteristics may be due to the extract content of many nutrients (Table 2), including nitrogen, which is important in building chlorophyll pigments because of its participation in the composition of porphyrin structure, in which four pyrrole rings are united by their nitrogen atoms to magnesium (Singh, 2003). In addition to the role of Nitrogen is also involved in the composition of amino acids and proteins. The iron content of seaweed extract (Table 2) has an essential effect on activating oxidation and reduction enzymes in the electron transfer chain in the respiration process, in the addition to its role in chlorophyll synthesis [21]. These results are consistent with those obtained in previous studies [9-10, 22].

The significant increase in the content of carotene and protein in the leaves when sprayed with high-phosphorus fertilizer may be due to the increased effectiveness of phosphorus in the vital processes that occur inside the plant, which is positively reflected in the quantity of manufactured nutrients needed to build plant tissues [23]. This result was consistent with that reported by El-Labane *et al.* [24].

Table 3. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of total chlorophyll mg.100 g^{-1}.

Seaweed extract (ml.L⁻¹)	**Phosphorus (ml.L⁻¹)**			**Means of seaweed extract**
	0	**0.3**	**0.6**	
0	18.49	13.83	12.87	15.06
3	19.82	20.78	21.68	20.76
6	18.68	19.11	18.81	18.87
Means of phosphorus	19.00	17.91	17.78	
RLSD 0.05 seaweed extract 0.16	Phosphorus 0.16	Interaction 0.29		

Table 4. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of carotene mg.100 g^{-1}.

Seaweed extract (ml.L^{-1})	**Phosphorus (ml.L^{-1})**			**Means of seaweed extract**
	0	**0.3**	**0.6**	
0	0.024	0.051	0.027	0.034
3	0.022	0.026	0.078	0.042
6	0.052	0.053	0.048	0.051
Means of phosphorus	0.033	0.043	0.051	
RLSD 0.05				
seaweed extract	Phosphorus	Interaction		
0.006	0.006	0.010		

Table 5. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of protein %.

Seaweed extract (ml.L^{-1})	**Phosphorus (ml.L^{-1})**			**Means of seaweed extract**
	0	**0.3**	**0.6**	
0	21.33	26.95	26.08	24.79
3	26.08	26.44	25.85	26.12
6	26.62	27.71	28.83	27.57
Means of phosphorus	24.68	27.03	2.79	
RLSD 0.05				
seaweed extract	Phosphorus	Interaction		
1.20	1.20	2.08		

Tables (6,7,8) showed that foliar application with seaweed extract caused a significant increase in the content of leaves of nitrogen, phosphorus and potassium elements, as the concentrations of 3 and 6 ml.L^{-1} gave a significant increase compared to the control treatment by a percentage of (5.55, 11.36) % and (27.72, 40.47) % for nitrogen and phosphorus, respectively. The effect increased significantly with increasing spray concentration, while the concentration of 6 ml.L^{-1} caused a significant increase in the concentration of potassium compared to the control treatment by a percentage of 13.86%, and the concentration of 3 ml.L^{-1} did not differ significantly from them. Both concentrations of high phosphorus fertilizer caused a significant increase in the concentrations of nitrogen and phosphorus by an increase in percentage of (9.64% and 8.62%), and (7.90% and 13.17%), respectively, while the high phosphorus fertilizer did not affect the percentage of potassium in the leaves. The interaction between the two factors had a significant effect on the concentrations of nitrogen and phosphorus only, as the plants sprayed with the extract at a concentration of 6 ml.L^{-1} and high phosphorus at a concentration of 0.6 g.L^{-1} gave the highest percentage of both elements, reaching (4.55, 1.081) %, respectively, while the untreated plants with both fertilizers gave the lowest percentage of both elements, reaching (3.41, 0.708) %, respectively. The superiority of the plants sprayed with the seaweed extract in nitrogen, phosphorus and potassium may be attributed to the extract containing these elements (Table 2), which led to an increase in their concentration in the leaves, as well as to their role in increasing the strength of root system growth, which increased the absorption of nutrients and their accumulation in the leaves [10, 24]. The superior effect in plants sprayed with high phosphorus fertilizer in the concentrations of nitrogen and phosphorus may be due to the fertilizer containing both elements and then absorbing them efficiently by the leaves, as well as its role in increasing the plant's efficiency in absorbing water and nutrients and transporting them to all parts of the plant. These results are consistent with those obtained by Khalid [13].

Table 6. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of nitrogen %.

Seaweed extract (ml.L⁻¹)	**Phosphorus (ml.L⁻¹)**			**Means of seaweed extract**
	0	**0.3**	**0.6**	
0	3.41	4.13	4.17	3.96
3	4.17	4.23	4.13	4.18
6	4.26	4.43	4.55	4.41
Means of phosphorus	3.94	4.32	4.28	
RLSD 0.05 seaweed extract 0.19	Phosphorus 0.19	Interaction 0.33		

Table 7. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of phosphorus %.

Seaweed extract (ml.L⁻¹)	**Phosphorus (ml.L⁻¹)**			**Means of seaweed extract**
	0	**0.3**	**0.6**	
0	0.708	0.753	0.823	0.761
3	0.850	1.000	1.059	0.972
6	1.060	1.067	1.081	1.069
Means of phosphorus	0.873	0.942	0.988	
RLSD 0.05 seaweed extract 0.034	Phosphorus 0.034	Interaction 0.059		

Table 8. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of potassium %.

Seaweed extract (ml.L⁻¹)	**Phosphorus (ml.L⁻¹)**			**Means of seaweed extract**
	0	**0.3**	**0.6**	
0	1.23	1.38	1.50	1.37
3	1.44	1.35	1.53	1.44
6	1.65	1.43	1.62	1.56
Means of phosphorus	1.44	1.39	1.55	
RLSD 0.05 seaweed extract 0.15	Phosphorus NS	Interaction NS		

Table 9 showed that the concentration of foliar application with 6 ml.L⁻¹ seaweed extract caused a significant increase in the percentage of volatile oil in the fruits compared to the control treatment and the concentration 3 ml.L⁻¹, by a percentage of (17.82, 13.79) %, respectively, while foliar application with both concentrations 6 and 3 ml.l⁻¹ led to a significant increase in the physical properties of the oil represented by the refractive index, specific gravity and oil density by a percentage of (0.08, 0.11) %, (23.48, 26.04) % and (19.80, 28.96) %, respectively, compared to the control treatment (Tables 10,11, and 12). Foliar application with high phosphorus fertilizer also led to a significant increase in all properties under study except for the refractive index, as both concentrations 0.3 and 0.6 g.L⁻¹ caused a significant increase in the percentage of volatile oil by a percentage of (17.03, 19.70)% and specific gravity by (11.32% and 7.63%), respectively. The oil density was (9.56% and 14.45%), respectively, compared to the control treatment.

It appears from the same tables that the interaction between the two studied factors had a significant effect on the refractive index and oil density only, as the plants sprayed with the extract at a concentration of 6 ml.L⁻¹ and high phosphorus at a concentration of 0.6 g.L⁻¹ gave the highest refractive index of 1.3629, while the plants sprayed with the extract at a concentration of 6 ml.L⁻¹ and high phosphorus at a concentration of 0.3 g.L⁻¹ gave the highest oil density of 0.8317 mg.µl⁻¹, while the control plants gave the lowest values of refractive index and oil density (1.3593, 0.5453 mg.µl⁻¹) respectively.

The significant increase in foliar application seaweed extract may be due to the role of the extract in increasing the efficiency of the photosynthesis process, which is positively reflected in increasing the yield and active components, including volatile oil and its physical properties, owing to the seaweed extract content of major and minor nutrients and plant hormones [25, 26]. These results are consistent with those obtained by Mostafa et al. [9], Eisa et al. [10], and El-Labane et al. [24]. The significant increase when foliar application high-phosphorus fertilizer may be due to the role of the phosphorus in entering the composition of lipid compounds directly or as cofactors in their manufacture, as well as by increasing the construction and accumulation of carbohydrates and then increasing the production of secondary compounds, including volatile oils [11], which is consistent with the results obtained by Khalid [13] and Abdelkader *et al*. [27].

Table 9. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the fruit volatile oil content %.

Seaweed extract (ml.L⁻¹)	Phosphorus (ml.L⁻¹)			Means of seaweed extract
	0	0.3	0.6	
0	0.616	0.630	0.778	0.707
3	0.751	0.763	0.856	0.732
6	0.755	0.804	0.865	0.833
Means of phosphorus	0.675	0.790	0.808	
RLSD 0.05 seaweed extract	Phosphorus	Interaction		
0.063	0.063	NS		

Table 10. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of refractive index.

Seaweed extract (ml.L⁻¹)	Phosphorus (ml.L⁻¹)			Means of seaweed extract
	0	0.3	0.6	
0	1.3593	1.3613	1.3620	1.3609
3	1.3623	1.3620	1.3615	1.3620
6	1.3623	1.3622	1.3629	1.3624
Means of phosphorus	1.3614	1.3618	1.3621	
RLSD 0.05 seaweed extract 0.0008	Phosphorus NS	Interaction 0.0014		

Table 11. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of specific gravity.

Seaweed extract (ml.L⁻¹)	Phosphorus (ml.L⁻¹)			Means of seaweed extract
	0	0.3	0.6	
0	0.6860	0.5860	0.6482	0.6384
3	0.8337	0.8337	0.7747	0.7877
6	0.8160	0.8160	0.8350	0.8047
Means of phosphorus	0.6994	0.7786	0.7528	
RLSD 0.05 seaweed extract 0.034	Phosphorus 0.034	Interaction NS		

Table 12. The effect of foliar application with seaweed extract and high phosphorus fertilizer and the interaction between them on the leaf content of oil density mg.µl⁻¹.

Seaweed extract (ml.L⁻¹)	Phosphorus (ml.L⁻¹)			Means of seaweed extract
	0	0.3	0.6	
0	0.5453	0.6350	0.7053	0.6286
3	0.6887	0.7573	0.8133	0.7531
6	0.7957	0.8317	0.8047	0.8107
	0.6766	0.7413		

Seaweed extract (ml.L⁻¹)	**Phosphorus (ml.L⁻¹)**			**Means of seaweed extract**
	0	**0.3**	**0.6**	
Means of phosphorus			0.7744	
	Phosphorus	Interaction		
RLSD 0.05	0.0277	0.0481		
seaweed extract 0.0277				

Table 13 shows the quantitative and qualitative components of the volatile oil obtained through gas chromatography. Forty-nine compounds were identified in the fennel seed oil. The predominant compound were 6-Octadecenoic acid, (Z)-(cis-vaccenic acid) (30.32%), hexadecanoic acid (palmitic acid) (22.81%), estragole (14.78%), linoleic acid (7.53%), beta- camphor (5.35%), arachidic acid (1.76%), geranylgeraniol (1.42%), 6-Aminocaproic acid (1.35%), D-limonene (1.13%), alpha –pinene (0.36%), and the rest of the other compounds constituted less than 1%.

Table 13. Components identified in fennel seed oil.

No.	**RT**	**MW**	**Name of the compound**	**Peak Area %**
1	4.102	407	4-Fluoro-1-ribofuranosylimidazole-5-carboxamide	0.68
2	4.159	418	alpha -Pinene	0.36
3	4.459	397	Estradiol 17-benzoate-3-p-phenylazobenzoate	0.52
4	6.087	397	D-Limonene	1.13
5	6.258	387	1,3,6-Octatriene, 3,7-dimethyl	0.14
6	7.188	412	beta.- Camphor	1.76
7	9.124	441	5-Methoxyindane	0.56
8	10.522	423	Estragole	14.78
9	13.960	363	Phthalic acid, cyclobutyl ethyl ester	0.77
10	14.033	424	Diethyl Phthalate	0.29
11	14.847	379	l-Alanine, n-pentafluoropropionyl-, octadecyl ester	0.32
12	14.906	369	2H-3,9a-Methano-1-benzoxepin-4,5,6,7,9,10-hexol, 5a-[(acetyloxy)methyl]octahydro-2,2,9-trimethyl-, 4,6,7,10-tetraacetate-5-benzoate, [3R	0.29
13	14.976	360	4-Hydroxy-3-valeramido-2(1H)-quinolinone	0.42
14	15.000	349	1,3,5-Triazine, 2,4-bis(2,2,2-trifluoro-1-trifluoromethylethoxy)-6-(2-methylphenylamino)-	0.56
15	15.065	437	Phthalic acid, ethyl isoporpyl ester	0.68
16	28.134	489	Hexadecanoic acid (Palmitic acid)	22.81
17	30.590	368	n-Nonadecanol	0.69
18	30.667	447	Z,Z-3,13-Octadecedien-1-ol	0.26
19	30.817	430	8-Octadecenoic acid, methyl ester	0.29
20	31.497	443	Linoleic acid	7.53
21	31.615	524	6-Octadecenoic acid, (Z)-(cis-Vaccenic acid)	30.32
22	32.041	480	Arachidic acid	5.35
23	32.041	376	Methacrylic acid, heptadecyl ester	0.31
24	33.326	434	beta.-Phenylpropionic acid,	0.41
25	35.467	382	l-Alanine, N-(heptafluorobutyryl)-, octadecyl ester	0.22
26	38.655	361	Morphinan-6-one, 4,5-epoxy-N-methyl-2-[4-trifluoromethylphenoxy	0.17
27	38.713	384	Lanostane-7,11-dione, 3,18-bis(acetyloxy)-, cyclic 7-(1,2-ethanediyl mercaptole), (3.beta.,20.xi.)-	0.28
28	38.761	402	Cholesteryl 3-cyclohexylbutyrate	0.27
29	38.793	384	1H-Pyrazole-1-acetamide, 4-iodo-N-(phenylmethyl)-	0.37
30	38.873	369	Silane, [[(3.alpha.,5.beta.,17.beta.)-androstane-3,17-diyl]bis(	0.51
31	38.980	360	6-Aminocaproic acid, N-allyloxycarbonyl-, heptadecyl ester	1.35
32	39.152	380	Chloromethyl 5-chloroundecanoate	0.26
33	39. 273	414	1-Naphthalenepentanol, decahydro-5-(hydroxymethyl)-5,8a-dimethyl-.gamma.,2-bis(methylene	0.52
34	39.300	382	9-Octadecenoic acid (Z)-,	0.15
35	39.353	371	l-Leucine, n-heptafluorobutyryl-, octadecyl ester	0.28

No.	RT	MW	Name of the compound	Peak Area %
36	39.407	387	8,14-Seco-3,19-epoxyandrostane-8,14-dione, 17-acetoxy-3.beta.-methoxy-4,4-dimethyl	0.27
37	39.441	383	Glycine, N-[(3.alpha.,5.beta.,7.alpha.,12.alpha.)-24-oxo-3,7,12-tris[(trimethylsilyl)oxy]cholan-24-yl]-, methyl ester	0.16
38	39.485	379	Tungsten, tris[(O,1,2,3-.eta.)-1-phenyl-2-propen-1-one]-	0.32
39	39.496	392	Fumaric acid, 2-methylpentyl tetradecyl ester	0.22
40	39.527	381	Glycine, N-(2-fluorobenzoyl)-, hexadecyl ester	0.11
41	39.553	396	erythro-9,10-Dibromopentacosane	0.30
42	39.596	396	19-Octacosenoic acid, pyrrolidide	0.11
43	39.653	448	(4E,8E,12E)-4,9,13,17-Tetramethyl-4,8,12,16-octadecatetraenal(Geranylgeraniol)	1.42
44	40.382	370	Furane-2-carboxamide, N-(3-nitrodibenzo[b,f]oxepin-1yl)-	0.34
45	40.800	375	Cholesteryl 3-cyclohexylbutyrate	0.16
46	40.920	366	Silane, dimethyl(pentafluorobenzyloxy)docosyloxy-	0.37
47	41.013	366	Silane, dimethyl(pentafluorobenzyloxy)docosyloxy-	0.12
48	41.112	396	2-Methoxy-4-[2,2,3,3,3-pentafluoro-1,1-bis(trifluoromethyl)propyl]-6-[2,2, -2-trifluoro-1,1-bis(trifluoromethyl)ethyl]-1,3,5-triazine	0.39
49	41.147	402	2-Phenanthrenol, 1,2,3,4,4a,4b,5,6,8a,9,10,10a-dodecahydro-4a,7-dimethyl-8-[3-cyano-3-(trimethylsilyloxy)propyl]-, acetate	0.11

Conclusion

Studied factors represented by the foliar application with seaweed extract and high phosphorus fertilizer had a significant impact on studied properties of fennel plants, so that to improve the growth, the chemical components and the active ingredients of leaves and fruits of fennel grown under the conditions of the southern regions of Iraq, it is useful to be sprayed with seaweed extract at a concentration of 6 ml.L^{-1}, and with high phosphorus fertilizer at a concentration of 0.6 g.L^{-1}.

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