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The influence of adding organic fertilizer and some stimulant substances on the growth, yield and chemical components of fennel (*Foeniculum vulgare*) plants

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Abstract

A field trial was carried out during the two experimental seasons of 2021 /2022 and 2022 /2023 to determine the effects of filter mud as organic manure, some stimulant substances and their interaction on growth traits (plant height, branch number /plant and herb dry weight /plant), fruit yield /plant and per feddan (feddan = 4200 m^2), essential oil %, essential oil yield /plant and per feddan, as well as, the elements of N, P and K% of fennel (*Foeniculum vulgare*) plants. Filter mud was applied at 0, 6, 12 and 18 m^3 /feddan and the treatments of stimulant substances as follows: control (no sprayed plants), yeast extract (YE) at 5 and 10 g /liter, seaweeds extract (SE) 2 and 3 ml /liter, YE at 5 g / liter + SE at 2 ml /liter and YE at 10 g /liter + SE at 3 ml /liter. The obtained results indicated that the addition of filter mud at all levels resulted a significant increase in all studied characteristics, except for the low one (6 m^3 /feddan) of such manure, mostly. Clearly, applying the high level (18 m^3 /feddan) of filter mud was the most effective treatment in augmenting all examined traits. In regard to stimulant substances, all measurements significantly elevated due to foliar spray with these substances, either single or together at all concentrations, except for the low concentration (5 g /liter) of yeast extract, mostly. Foliar spray with the combined treatment (10 g /liter yeast extract + 3 ml /liter seaweeds extract) proved to be more effective in increasing all tested parameters. In general, plants grown in organic conditions (filter mud) at the high level (18 m^3 /feddan) plus foliar spray with the combined treatment (yeast extract at 10 g /liter + seaweeds extract at 3 ml /liter) gave the most effective treatment in elevating the growth, fruit yield, essential oil % and yield, as well as the elements of N, P and K %.

Keywords: fennel, *Foeniculum vulgare*, filter mud, yeast extract, seaweeds extract.

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1. Introduction

Fennel (*Foeniculum vulgare*) is an annual plant belonging to Apiaceae Family, Mediterranean region was original native to fennel, now days, it has naturalized and cultivated worldwide (Lim, 2013). Fennel is member of the most important medicinal and aromatic plants. In Egypt, particularly in middle Egypt, Minia and Assiut are the most Governorates which growing fennel. Fruits of fennel can be used in medicinal folklore, food industries bakery and condiments. It is utilized as tincture and infusion (Lawless, 1995). The fruits contain essential oil which is applied as laxative, carminative and flavoring agents (Lawless, 1995) and, also as antimicrobial, hepatoprotective activities and antioxidant (Lucinewton *et al.*, 2005). The essential oil is a vital role in anti-inflammatory action, analgesic and antispasmodic effect on smooth muscle (Stary and Jirasck, 1975). Also, the oil can be applied to treat flatulence or in toothpaste, soaps and air fresheners. Besides, it could be utilized externally whereas can be eases muscular and rheumatic pain (Lim, 2013). In recent years, organic farming is expanded rapidly and is seen as a sustainable alternative to chemical-based cultivation system (Panda, 2006). Organic agriculture is considered as the best agricultural practices for crop production that have been supported for the environment (Narkhede *et al.,* 2011). Organic manures could be served as an alternative to chemical fertilizers for improving soil structure (Dauda *et al.*, 2008). Also, organic manures are beneficial role in enhance microbial biomass (Dhull *et al.*, 2004). So, compost canable enhances physiological status of plant and exert protective influence against diseases (Liguori *et al.*, 2015). Filter mud is local fertilizer, it is one of organic manures which can improves the growth, yield and chemical components of different species of plants due to it contains high concentrations of macronutrients and essential micronutrients, as well as organics matter. The capability of organic manures on improving the growth, yield and chemical constituents was studied by Azzaz *et al.* (2009), Abdou *et al.* (2012), Ali *et al.* (2016), Abo- Kutta (2016), Ayyat (2017) and Youssef *et al.* (2020) on fennel, Ali *et al*. (2017) and Hamed (2017) on anise, Helmy (2016) on cumin, Rekaby (2013) on coriander and Hassan *et al.* (2010) on dill. Yeast (*Saccharomyces cerevisiae*) is stimulant substance and is one of biofertilizer applied, either drench or foliar spray (El-Motty *et al.*, 2010), because it contains elements nutritional and high concentration of phytohormones namely, auxins, gibberellins and cytokinins (Jaiboon *et al.*, 2016; Tawfiq *et al.*, 2018). Yeast extract has to be significant impact on making available nutrient elements for plants (Khalil and Ismael, 2010). The primitive impact of yeast extract on growth, yield and chemical components was described by Ali *et al.* (2006) on anise, Abd-El Satar (2020) on dill and Helmy (2016) on cumin. Seaweeds extract has to be

stimulant substance, it is applied as natural fertilizer and as a good source of organic matter (Fornes *et al.*, 1993; Ho *et al.*, 2003). Several numerous disclosed that seaweeds extract contains plant growth substances like, auxins, gibberellins and cytokinins, vitamins, amino acids and many nutritional elements (N, P, K, Ca, Zn, Mn, Fe, B, Cu, Mo, and Co such as Stirk *et al*. (2004), Zamani *et al.* (2013) and Begum *et al.* (2018). In addition, seaweeds extract can enhance nutrients uptake from the soil (Turan and kose, 2004). The efficiency of seaweeds extracts on augmenting the growth attributes, yield and chemical components was explored by Ali *et al.* (2017) and Hamed (2017) on anise, Hassan (2015) on dill, Shehata *et al.* (2011) on celeriac, Atteya and Amer (2018) and Mahmoud (2021) on roselle and Mohammad (2020) on *Nigella sativa*. Therefore, this experiment was conducted aiming to study the impacts of filter mud as organic manure and some stimulant substances (yeast and seaweed extracts, as well as their interactions on growth traits, yield and chemical components of fennel (*Foeniculum vulgare*) plants to figure out the most suitable treatment for improving these aspects.

2. Materials and methods

2.1 Experimental site and treatments description

The present research was carried out during the two consecutive seasons of 2021/2022 and 2022/2023 at the private farm in Abo-Kurkas, Minia, Egypt to elucidate the impact of filter mud as organic manure and some stimulant substances, as well as their interactions on growth attributes, yield and chemical constituents of fennel (*Foeniculum vulgare*) plants. A split plot design was conducted in this work with3 replicates, 4 filter mud levels (A) at 0, 6, 12 and 18 m^3 /feddan) occupied the main plots (A), while 7 stimulant substance treatments (0, yeast extract (YE) at 5, 10 g /liter, seaweeds extract (SE) at 2, 3 ml /liter, 5 g /liter YE + 2 ml /liter SE and 10 g /liter + 3 ml /liter SE) were arranged in sub-plots (B). Therefore, the interaction treatments (A × B) were 28 treatments. Fennel seeds were obtained from Department of Medicinal and Aromatic plants, Horticulture Research Institute, Agricultural Research Centre, Giza, Egypt. These seeds were sown on Oct. 15^{th} in both seasons in 2.8 × 1.8 m plot with 60 cm apart between the rows (row contained 7 hills) and each plot included 3 rows. The plants were thinned to one plant /hill 42 days later from sowing date, in the two seasons, thus, the experimental plot contained 21 plants Physical and chemical characteristics of the experimental soil were analyzed according to Jackson (1973) and are shown in Table (1).

Table (1): Physical and chemical properties of the used soil (average for the two seasons).

Soil texture	Organic matter (%)	$CaCO_3$ (%)	EC (m.mohs/ cm)	pH (1:2.5)	Available			Water Soluble Ions (meq/ l) in the soil paste				
					N %	P ppm	K mg/100g soil	Ca^{++}	Mg^{++}	HCO_{3^-}	Cl^-	SO_4
Loamy	0.53	2.47	1.37	7.54	0.14	0.23	3.0	2.9	2.3	2.8	2.1	5.5

The used filter mud was obtained from sugar factory company, Abo-Kurkas, Minia, Egypt. The chemical analysis of applied filter mud was estimated according to Black (1965) and is listed in Table (2).

Table (2): The chemical analysis of the applied filter mud (average for both seasons).

Characteristics	Value	Characteristics	Value
Organic matter (%)	27.5	K (ppm)	73.1
Organic carbon (%)	25.9	Zn (ppm)	167
E.C. (ds/m)	3.0	Mn (ppm)	225
pH	7.2	Fe (ppm)	3100
C/N ratio	15.2	Cu (ppm)	139
Total N (%)	1.7		
Available P (ppm)	39.5		

All levels of such manure were added during preparing the soil to cultivation, in both seasons. The plants were foliar sprayed with the two studied stimulant substances namely, yeast extract (YE) and seaweeds extract (SE) at all concentrations, three times at 2 weeks interval starting Dec. 12th during the two experimental seasons. The plants were sprayed till run off. All other agricultural practices were performed as usual. Table (3) showed the chemical analysis of yeast (*Saccharomyces cervisiae*) extract authorized by Khedr and Farid (2000).

Table (3): Chemical analysis of yeast (*Saccharomyces cervisiae*) extract (weight /100 g D.W.).

Minerals		Amino acid mg/100g DW		Vitamins mg/100g DW		Carbohydrates mg/100g DW	
N	33.24 g	Arginine	1.99	Vitamin B1	2.23	Carbohydrates	23.2
P_2O_3	7.22 g	Histidine	2.63	Vitamin B2	1.33	Glucose	13.33
K_2O	49.66 g	Isoleucine	2.31	Vitamin B6	1.25		
Mg	5.75 mg	Leucine	3.09	Vitamin B12	0.15		
CaO	3.02 mg	Methionine	0.72	Riboflavin	4.96		
Nacl	0.28 mg	Phenylalanine	2.01	Insitrol	0.26		
Zn	335.9 mg	Threonine	2.09	Biotin	0.09		
Mn	82.3 mg	Tryptophan	0.45	Nicotinic acid	39.88		
B	177.3 mg	Valine	2.19	Panthothenic acid	19.56		
FeO	0.93 mg	Glutamic acid	2.00	Paminobenzoic acid	9.23		
Al	650.2 mg	Serine	1.59	Folic acid	4.36		
Co	67.8 mg	Aspartic acid	1.33	Pyridoxine	2.90		
Sn	223.9 mg	Cystine	0.23				
SiO_2	1.55 mg	Proline	1.53				
SO_2	0.49 mg	Tyrosine	1.49				
Cl	0.06 mg						

Oligo X product contains seaweeds extract and was obtained from United Agricultural Development, Egypt. The chemical properties of applied seaweeds

extract are emphasized in Table (4). At the end of the experiment (the last week of April), in both seasons, the data were recorded as follows: Plant height (cm), branch number /plant, herb dry weight (g) /plant, fruit yield (g) /plant and fruit (kg) /feddan was calculated. Also, essential oil% in the fruit was extracted and determined according to the method described by Guenther (1961), essential oil yield (ml) /plant was measured by multiplying essential oil % in fruit yield (g) /plant then essential oil yield (liter) /feddan was calculated. Additionally, the elements of N, P and K % in dried herb were estimated as follows: N % was measured according to the modified micro-Kjeldahl method as described by Wilde *et al.* (1985), P % was determined colorimetrically according to Chapman and Pratt (1975) and K % was measured by Flame photometer according to Cottenine *et al.* (1982). All obtained data were tabulated and statistically analyzed according to MSTAT-C (1986) using L.S.D. test at 5 % to know the differences among all treatments according to Mead *et al.* (1993).

Table (4): Chemical properties of the applied seaweeds extract.

Macro and micro elements	Value	Organic components	Value	Growth regulators	Value
Organic (N)	3.12%	Carbohydrates	35%	IAA	0.03%
P_2O_5	2.61%	Total amino acids	6%	Cytokynins	0.02%
K_2O	4.71%	Manitol	4%	Adenine	0.01%
CaO	0.25%	Alginic acid	10%		
S	3.56%	Betaines	0.04%		
Mg	0.58%				
Fe	150 ppm				
Zn	70 ppm				
Mn	13 ppm				
B	60 ppm				
Organic (N)	3.12%				
I	30ppm				

3. Results and Discussion

3.1 Vegetative growth traits

The presented data in Tables (5, 6 and 7) revealed that vegetative growth traits of fennel (plant height, branch number /plant and herb dry weight /plant) were positively affected by the addition of filter mud as organic manure, during the two experimental seasons. Obviously, the use of filter mud at all levels, in both seasons, led to a significant increase in all growth attributes, except for the low level (6 m^3 /feddan) of filter mud regarding plant height in the two seasons and both branch number /plant and herb dry weight /plant in the first one, in relative to the check treatment. Apparently, by augmenting the levels of such manure, the three studied characteristics were gradually significantly increased, during both seasons, mostly. Therefore, supplying the plants with filter mud at the high level (18 m^3 /feddan) proved to be more effective in elevating plant height, branch number /plant and

herb dry weight /plant. Numerically, this previous superior treatment increased plant height by 7.7 and by 7.8 %, augmented branch number /plant by 16.3 and by 12.5 % and, also elevated herb dry weight /plant by 12.4 and by 9.4 % over unfertilized ones, during the two growing seasons, respectively. The beneficial role of organic manures in augmenting vegetative growth aspects detected in this work was, also described by Azzaz *et al*. (2009), Abdou *et al.* (2012), Ali *et al.* (2016), Abo-Kutta (2016), Ayyat (2017) and Youssef *et al.* (2020) on fennel plants and Abdel Rahman *et al.* (2023) and Abdel Rahman (2023) on borage. As for stimulant substance treatments, the listed data in Tables (5, 6 and 7) exhibited that vegetative growth parameters of fennel in terms of plant height, branch number and herb dry weight /plant were positively responded to foliar spray with the examined stimulant substances, during the two successive seasons. Clearly, these tested parameters were significantly increased due to foliar spray with the two stimulant substances, either single or in mixture at all concentrations, in the two seasons, except for yeast extract at the low concentration (5 g /liter), concerning number of branches /plant in the second season and herb dry weight /plant in the first season, as compared to untreated ones. In this connection, higher values of these aspects were obtained when applying the combined treatments than those given by individual ones, during the two experimental seasons, mostly. Generally, the most effective treatment in increasing the three growth attributes was observed by foliar spray with the combined treatment (10 g /liter yeast extract + 3 ml /liter seaweeds extract) which augmented plant height by 13.2 and by 11.7%, increased branch number /plant by 33.3 and by 31.6 % and, also augmented herb dry weight /plant by 23.0 and 14.4% over no sprayed plants, during the two consecutive seasons, respectively. The enhancement in growth aspects (plant height, branch number /plant and herb dry weight /plant) revealed in the present study due to spraying yeast extract was, also explored on anise (Ali *et al.*, 2006), on coriander (Rekaby, 2013), on cumin (Helmy, 2016) and on dill (Abd-El Satar, 2020) and, also on anise (Ali *et al.*, 2017 and Hamed, 2017), on dill (Hassan, 2015) and on black cumin (Mohammad, 2020), regarding seaweeds extract application. With respect to the interaction, it was statistically significant effect on plant height in both seasons and on herb dry weight /plant, in the second season only, while it was no significant influence on branch number /plant in the two seasons. In general, it could be noticed that the use of filter mud at the high level (18 m^3 /feddan) plus foliar spray with the combined treatment (10 g /liter yeast extract + 3 ml /liter seaweeds extract) proved to be more effective in elevating growth traits than those detected by other combination treatments, during the two experimental seasons, as clearly shown in Tables (5, 6 and 7).

Table (5): The impact of filter mud levels and some stimulant substances, as well as, their interactions on plant height (cm) of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	136.6	142.5	147.1	150.4	144.2	142.4	152.7	154.6	162.2	153.0
Yeast extract (YE) at 5 g/L	141.9	147.6	150.2	152.7	148.1	154.9	153.9	155.7	162.9	156.9
Yeast extract (YE) at 10 g/L	146.2	150.3	152.6	156.3	151.4	153.8	158.6	160.6	168.1	160.3
Seaweed extract (SE) at 2 m/L	148.7	151.9	153.8	157.8	153.1	156.2	159.9	164.2	167.5	162.0
Seaweed extract (SE) at 3 m/L	151.3	154.2	158.8	161.7	156.5	161.9	164.3	166.9	168.2	165.3
YE at 5 g/L + SE at 2 m/L	153.7	155.8	162.8	163.8	159.0	159.6	164.7	165.2	169.4	164.7
YE at 10 g/L + SE at 3 m/L	155.4	159.6	167.9	170.2	163.3	164.1	167.9	172.8	178.9	170.9
Mean (A)	147.7	151.7	156.2	159.0		156.1	160.3	162.9	168.2	
L.S.D. at 5%	For (A): 4.4 (B): 1.5 (A×B): 3.0					For (A): 6.5 (B): 2.3 (A×B): 4.5				

Table (6): The impact of filter mud levels and some stimulant substances, as well as, their interactions on branch number /plant of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	8.1	8.6	9.2	10.0	9.0	8.6	9.2	9.6	10.4	9.5
Yeast extract (YE) at 5 g/L	8.7	9.4	9.8	10.6	9.6	9.1	9.4	10.0	10.5	9.8
Yeast extract (YE) at 10 g/L	9.0	9.1	10.4	11.0	9.9	9.7	10.4	10.7	11.2	10.5
Seaweed extract (SE) at 2 m/L	9.7	10.2	10.7	11.4	10.5	10.7	11.1	11.5	11.7	11.3
Seaweed extract (SE) at 3 m/L	10.6	11.0	11.3	11.7	11.2	11.3	11.6	12.0	12.2	11.8
YE at 5 g/L + SE at 2 m/L	10.9	11.2	11.7	12.1	11.5	11.1	11.9	12.4	12.8	12.1
YE at 10 g/L + SE at 3 m/L	11.3	11.7	12.0	12.9	12.0	12.0	12.3	12.7	13.0	12.5
Mean (A)	9.8	10.2	10.7	11.4		10.4	10.8	11.3	11.7	
L.S.D. at 5%	For (A): 0.5 (B): 0.4 (A×B): N.S					For (A): 0.3 (B): 0.4 (A×B): N.S				

Table (7): The impact of filter mud levels and some stimulant substances, as well as, their interactions on herb dry weight (g) /plant of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	90.4	94.5	100.9	104.2	97.5	106.7	119.3	119.8	124.6	117.6
Yeast extract (YE) at 5 g/L	92.6	97.0	103.0	107.9	100.1	119.4	119.5	122.2	124.3	121.4
Yeast extract (YE) at 10 g/L	105.1	108.3	113.4	116.6	110.9	124.6	129.4	130.9	131.9	129.2
Seaweed extract (SE) at 2 m/L	101.5	105.0	109.7	115.5	107.9	121.1	123.0	129.6	134.0	126.9
Seaweed extract (SE) at 3 m/L	107.8	109.3	114.6	118.9	112.7	123.0	128.2	133.6	136.3	130.3
YE at 5 g/L + SE at 2 m/L	109.7	112.0	116.6	120.9	114.8	125.9	131.4	134.9	137.0	132.3
YE at 10 g/L + SE at 3 m/L	115.4	116.5	119.8	127.8	119.9	128.6	132.8	135.6	140.8	134.5
Mean (A)	103.2	106.1	111.1	116.0		121.3	126.2	129.5	132.7	
L.S.D. at 5%	For (A): 3.2 (B): 3.3 (A×B): N.S					For (A): 2.0 (B): 1.7 (A×B): 3.5				

3.2 Fruit yield /plant and per feddan

The obtained results in Tables (8 and 9) proved that the application of filter mud positively affected fruit yield /plant and per feddan of fennel, during the two growing seasons. Apparently, fruit yield / plant and per feddan were significantly elevated, in both seasons, due to the presence of filter mud as organic manure at all levels, except for the low one (6 m^3 /feddan) of such manure, in the second

season, as compared to control plants. It seems that these traits were gradually significantly increased with augmenting filter mud levels in the two seasons. Thus, plant grown in high level of organic manure (18 m^3 /feddan) produced the heaviest fruit yield as ranged 22.5 and 16.4 % over the check treatment, during the two successive seasons, respectively. Such above mentioned superior treatment yielded 1170.8 and 1267.9 kg /feddan fruit, while control recorded 955.4 and 1090 kg / feddan in the first and second seasons, respectively.

Table (8): The impact of filter mud levels and some stimulant substances, as well as, their interactions on fruit yield (g) /plant of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	50.9	56.3	59.5	60.0	56.7	56.8	57.4	62.9	64.8	60.5
Yeast extract (YE) at 5 g/L	54.2	57.6	61.9	65.2	59.7	57.5	58.8	64.9	66.2	61.9
Yeast extract (YE) at 10 g/L	58.8	60.7	64.8	66.5	62.7	59.8	64.5	69.8	73.8	67.0
Seaweed extract (SE) at 2 m/L	55.9	59.9	65.3	70.8	63.0	65.7	67.9	71.0	77.6	70.6
Seaweed extract (SE) at 3 m/L	58.6	62.4	68.0	74.0	65.8	67.8	72.8	74.9	79.4	73.7
YE at 5 g/L + SE at 2 m/L	60.0	64.8	70.9	75.4	67.8	74.6	75.0	77.4	81.9	77.2
YE at 10 g/L + SE at 3 m/L	62.8	65.9	72.6	79.8	70.3	75.8	76.3	80.0	88.8	80.2
Mean (A)	57.3	61.1	66.1	70.2		65.4	67.5	71.6	76.1	
L.S.D. at 5%	For (A): 2.4 (B): 1.7 (A×B): 3.3					For (A): 2.5 (B): 1.6 (A×B): 3.2				

The unique role of organic manures in raising fruit yield obtained in this experiment was, also reported by Azzaz *et al.* (2009), Abdou *et al.* (2012), Abo-Kutta (2016), Ayyat (2017) and Youssef *et al.* (2020) on fennel and Abdel Rahman *et al.* (2023) and Abdel Rahman (2023) on borage. In regard to stimulant substance treatments, fruit yield /plant and per feddan of fennel were significantly influenced by utilizing these materials, during the two consecutive seasons. It is obvious that foliar spray with the two examined stimulants, either separately or in combination at all concentrations led to a significant augment in fruit yield /plant and per feddan, during both seasons, except for the low concentration (5 g /liter) of yeast extract, in the second season, as compared to no sprayed ones. Clearly, the use of combined treatments resulted higher values of fruit yield /plant and per feddan than those noticed by single treatments, during the two growing seasons. In general, foliar spray with the combined treatment (yeast extract at 10 g /liter + seaweeds extract at 3 ml /liter) proved to be more effective in elevating fruit yield reached 24.0 and 32.6% over untreated plants in both seasons, respectively. In connection, such aforementioned superior treatment amounted 1171.2 and 1337.1 kg /feddan fruit in contrast to the check treatment produced 944.8 and 1007.7 kg /feddan fruit, during the two consecutive seasons, respectively, as clearly declared in Tables (8 and 9).

Table (9): The impact of filter mud levels and some stimulant substances, as well as, their interactions on fruit yield (kg) /feddan of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	849.0	938.4	991.2	1000.6	944.8	946.2	956.7	1047.9	1080.1	1007.7
Yeast extract (YE) at 5 g/L	903.4	959.5	1032.3	1086.2	995.4	959.0	980.1	1082.3	1102.9	1031.1
Yeast extract (YE) at 10 g/L	979.5	1012.3	1080.1	1107.9	1045.0	997.3	1075.1	1164.0	1230.7	1116.8
Seaweed extract (SE) at 2 m/L	931.7	998.4	1088.4	1180.1	1049.7	1094.5	1131.2	1184.0	1293.4	1175.8
Seaweed extract (SE) at 3 m/L	976.7	1040.1	1132.9	1234.0	1096.0	1130.7	1213.4	1248.5	1323.5	1229.0
YE at 5 g/L + SE at 2 m/L	1000.1	1080.1	1181.7	1257.3	1129.8	1242.9	1249.5	1290.7	1365.1	1287.1
YE at 10 g/L + SE at 3 m/L	1047.3	1097.9	1210.1	1329.5	1171.2	1263.4	1271.8	1333.4	1479.6	1337.1
Mean (A)	955.4	1018.1	1102.4	1170.8		1090.6	1125.4	1193.0	1267.9	
L.S.D. at 5%	For (A): 39.9 (B): 27.5 (A×B): 55.1					For (A): 41.8 (B):27.0 (A×B): 54.0				

The favourable action of yeast extract on enhancing fruit yield given in this research have been studied by Ali *et al.* (2006) on anise, Rekaby (2013) on coriander, Helmy (2016) on cumin and Abd El-Satar (2020) on dill plants and also by Ali *et al.* (2017) and Hamed (2017) on anise, Hassan (2015) on dill and Mohammad (2020) on *Nigella sativa* plants, for seaweeds extract. Considering the impact of the interaction, the given data pointed out that fruit yield /plant and per feddan of fennel were significantly influenced by the two experimental seasons (Tables 8 and 9). Apparently, the most effective treatment in increasing fruit yield / plant and per feddan was detected when adding the high level of filter mud (18 m^3 /feddan) with the combined treatment (yeast extract at 10 g /liter + seaweeds extract at 3 ml /liter) in comparison with those observed by other combination treatments, in both seasons. Such previous superior treatment produced 1329.5 and 1479.6 kg /feddan fruit, while control gave 849.0 and 946.2 kg /feddan fruit, during the two consecutive seasons.

3.3 Essential oil (%)

Shown data in Table (10) postulated that receiving fennel plants filter mud positively affected essential oil % in the fruits, during the two consecutive seasons. It appears that such aspect was significantly increased, in both seasons, due to adding all levels of filter mud, except for the low one (6 m^3 /feddan), in the first season as compared to unfertilized ones by augmenting the levels of filter mud, essential oil % was gradually significantly elevated, in the two seasons. Thus, the highest values of such parameter were detected when using the high level (18 m^3 /feddan) of filter mud as ranged 8.7 and 15.7 % over control, during the two growing seasons, respectively. With respect to stimulant substance treatments, data in Table (10) exhibited that essential oil % in fennel fruits were positively responded to the use of the tested stimulant substances, in both seasons. Clearly, such trait was significantly augmented resulting from spraying the two stimulants either single or in combination at all

concentrations, during the two experimental seasons, except for yeast extract at 5 g /liter in the first season. It is obvious that the supplying mixture treatments gave higher values of these traits than those revealed by individual ones, during the two experimental seasons, mostly.

Table (10): The impact of filter mud levels and some stimulant substances, as well as, their interactions on essential oil (%) of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	2.05	2.07	2.14	2.27	2.13	2.17	2.28	2.33	2.57	2.34
Yeast extract (YE) at 5 g/L	2.06	2.08	2.16	2.31	2.15	2.22	2.26	2.40	2.60	2.37
Yeast extract (YE) at 10 g/L	2.15	2.13	2.17	2.29	2.19	2.25	2.27	2.38	2.62	2.38
Seaweed extract (SE) at 2 m/L	2.21	2.23	2.28	2.36	2.27	2.22	2.29	2.39	2.67	2.39
Seaweed extract (SE) at 3 m/L	2.26	2.27	2.30	2.40	2.31	2.32	2.32	2.44	2.65	2.43
YE at 5 g/L + SE at 2 m/L	2.30	2.33	2.39	2.46	2.37	2.39	2.40	2.55	2.68	2.51
YE at 10 g/L + SE at 3 m/L	2.34	2.35	2.44	2.58	2.43	2.51	2.54	2.61	2.84	2.63
Mean (A)	2.20	2.21	2.27	2.38		2.30	2.34	2.44	2.66	
L.S.D. at 5%	For (A): 0.02 (B): 0.03 (A×B): 0.05					For (A): 0.03 (B): 0.03 (A×B): 0.06				

Foliar spray with the combined treatment (10 g /liter yeast extract + 3 ml /liter seaweeds extract) proved to be more effective in increasing essential oil reached 14.1 and 12.4 % over no sprayed plants, during the two successive seasons, respectively. It worthy mentioned that the interaction effect on essential oil % in fennel fruits had significant, for both seasons. Apparently, plants grown in organic conditions at the high level (18 m^3 /feddan) with spraying the combined treatment (10 g /liter yeast extract + 3 ml /liter seaweeds extract) was the most effective treatment in augmenting such aspect, in comparison with those obtained by other combination treatments, as clearly proved in Table (10).

3.4 Essential oil yield (ml) /plant and (l) / feddan

The presented data in Tables (11 and 12) indicated that the application of filter mud significantly influenced essential oil yield /plant and per feddan of fennel, during the two growing seasons. Obviously, the presence of organic manure at all levels led to a significant increase in these aspects, in both seasons. In connection, by increasing the levels of such manure, essential oil yields were gradually significantly elevated, in the two seasons. Therefore, the addition of filter mud at the high level (18 m^3 /feddan) produced the heaviest essential oil yield as ranged 33.3 and 34.4 % over the check treatment, in the first and second seasons, respectively. This abovementioned superior treatment yielded 27.98 and 33.84 liter /feddan essential oil while control gave 21.02 and 25.15 liter /feddan essential oil, during the two experimental seasons, respectively. The importance of organic manures in elevating essential oil detected in this investigation was, also studied by Azzaz *et al.* (2009), Abdou *et al.* (2012), Ali *et*

al. (2016), Abo-Kutta (2016), Ayyat (2017) and Yousseif *et al.* (2020) on fennel. In relation to the examined stimulant substances application, the given data in Tables (11 and 12) pointed out that essential oil yield /plant and per feddan of fennel were positively affected by utilizing these materials, in both seasons. Apparently, these characteristics were significantly raised by foliar spray with the two substances either alone or together at all concentrations, during the two consecutive seasons. In most cases, higher values of these parameters were detected when using the combined treatments than those revealed by single ones. In this regard, foliar spray with the combined treatment namely, yeast extract at 10 g /liter + seaweeds extract at 3 ml /liter proved to be more effective in augmenting essential oil yield which increased it by 41.3 and 48.6 % over no sprayed ones, during the two successive seasons, respectively. This previous superior treatment amounted 28.50 and 35.23 liter /feddan essential oil in contrast to no sprayed plants recorded 20.18 and 23.63 liter /feddan essential oil, in both seasons, respectively. The capability of yeast extract on augmenting essential oil observed in the present work was, also reported by Ali *et al.* (2006) on anise, Abd-El Satar (2020) on dill, Rekaby (2013) on coriander and Helmy (2016) on cumin plants and by Ali *et al.* (2017) and Hamed (2017) on anise and Hassan (2015) on dill, concerning seaweeds extract treatments. Accordingly, the interaction between the two studied factors on essential oil yield /plant and per feddan of fennel was significant effect, during both seasons (Table, 11 and 12). However, the most effective treatment in increasing these traits was detected when applying filter mud at the high level (18 m^3 /feddan) plus spraying the combined treatment (yeast extract at 10 g /litre + seaweeds extract at 3 ml / litre), in comparison with those noticed by other combination treatments, during the two experimental seasons. In this concern, this aforementioned superior treatment produced 34.23 and 42.06 liter /feddan essential oil in relative to untreated ones (17.39 and 20.50) liter /feddan essential oil, in the first and second seasons, respectively.

Table (11): The impact of filter mud levels and some stimulant substances, as well as, their interactions on essential oil yield (ml) /plant of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	1.04	1.16	1.27	1.36	1.21	1.23	1.31	1.47	1.67	1.42
Yeast extract (YE) at 5 g/L	1.12	1.20	1.34	1.50	1.29	1.28	1.33	1.56	1.72	1.47
Yeast extract (YE) at 10 g/L	1.26	1.29	1.41	1.52	1.37	1.34	1.46	1.66	1.93	1.60
Seaweed extract (SE) at 2 m/L	1.23	1.34	1.49	1.67	1.43	1.46	1.55	1.70	2.07	1.70
Seaweed extract (SE) at 3 m/L	1.33	1.41	1.56	1.78	1.52	1.57	1.69	1.83	2.10	1.80
YE at 5 g/L + SE at 2 m/L	1.38	1.51	1.69	1.86	1.61	1.78	1.80	1.97	2.20	1.94
YE at 10 g/L + SE at 3 m/L	1.47	1.55	1.77	2.05	1.71	1.90	1.94	2.09	2.52	2.11
Mean (A)	1.26	1.35	1.50	1.68		1.51	1.58	1.75	2.03	
L.S.D. at 5%	For (A): 0.06 (B): 0.04 (A×B): 0.08					For (A): 0.06 (B): 0.05 (A×B): 0.09				

Table (12): The impact of filter mud levels and some stimulant substances, as well as, their interactions on essential oil yield (liter) /feddan of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	17.39	19.39	21.22	22.73	20.18	20.50	21.78	24.45	27.78	23.63
Yeast extract (YE) at 5 g/L	18.61	19.94	22.33	25.06	21.49	21.28	22.17	25.95	28.67	24.52
Yeast extract (YE) at 10 g/L	21.00	21.50	23.45	25.34	22.82	22.39	24.39	27.73	32.22	26.68
Seaweed extract (SE) at 2 m/L	20.56	22.28	24.78	27.89	23.88	24.28	25.84	28.28	34.45	28.21
Seaweed extract (SE) at 3 m/L	22.06	23.56	26.06	29.61	25.32	26.22	28.17	30.50	35.06	29.99
YE at 5 g/L + SE at 2 m/L	23.00	25.17	28.23	31.00	26.85	29.72	30.00	32.89	36.61	32.31
YE at 10 g/L + SE at 3 m/L	24.50	25.78	29.50	34.23	28.50	31.67	32.34	34.84	42.06	35.23
Mean (A)	21.02	22.52	25.08	27.98		25.15	26.38	29.23	33.84	
L.S.D. at 5%	For (A): 1.00 (B): 0.64 (A×B): 1.27					For (A): 1.05 (B): 0.76 (A×B): 1.53				

3.5 Nitrogen, phosphorus and potassium %

The obtained data in Tables (13, 14 and 15) emphasized that the tested elements (N, P and K %) in fennel herb were positively affected by utilizing filter mud, during the two successive seasons. Clearly, the presence of such manure at all levels resulted a significant augment in N, P and K %, in both seasons, except for the low one (6 m^3 /feddan) of filter regarding K % for the second season, as compared to unfertilized plants. However, these aspects were gradually significantly elevated with increasing the levels of filter mud, during the two growing seasons. Therefore, the highest values of N, P and K% were given by applying the high level (18 m^3 /feddan) of such manure as ranged 9.1 and 8.4 for N %, 14.2 and 12.8 % for P % and 18.2 and 9.7 % for K % over the check treatment, during the two experimental seasons, respectively. The efficiency of organic manures on increasing N, P and K % detected in this research was, also insured by Abo-Kutta (2016) on fennel, Hamed (2017) on anise, Helmy (2016) on cumin, Rekaby (2013) on coriander and Abdel Rahman (2023) on borage.

Table (13): The impact of filter mud levels and some stimulant substances, as well as, their interactions on N % of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	2.14	2.20	2.23	2.34	2.23	2.28	2.26	2.32	2.40	2.32
Yeast extract (YE) at 5 g/L	2.16	2.22	2.31	2.30	2.25	2.29	2.30	2.34	2.39	2.33
Yeast extract (YE) at 10 g/L	2.29	2.28	2.33	2.42	2.33	2.39	2.41	2.40	2.43	2.41
Seaweed extract (SE) at 2 m/L	2.32	2.35	2.39	2.57	2.41	2.44	2.51	2.54	2.66	2.54
Seaweed extract (SE) at 3 m/L	2.37	2.41	2.50	2.55	2.46	2.47	2.49	2.53	2.63	2.53
YE at 5 g/L + SE at 2 m/L	2.40	2.40	2.48	2.68	2.49	2.38	2.52	2.61	2.74	2.56
YE at 10 g/L + SE at 3 m/L	2.45	2.46	2.60	2.73	2.56	2.50	2.55	2.65	2.90	2.65
Mean (A)	2.30	2.33	2.41	2.51		2.39	2.43	2.48	2.59	
L.S.D. at 5%	For (A): 0.02 (B): 0.03 (A×B): 0.06					For (A): 0.02 (B): 0.03 (A×B):0.05				

Table (14): The impact of filter mud levels and some stimulant substances, as well as, their interactions on P % of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	0.189	0.219	0.227	0.235	0.218	0.218	0.240	0.251	0.261	0.243
Yeast extract (YE) at 5 g/L	0.196	0.224	0.225	0.236	0.220	0.235	0.238	0.248	0.265	0.247
Yeast extract (YE) at 10 g/L	0.215	0.237	0.240	0.246	0.235	0.245	0.247	0.263	0.270	0.256
Seaweed extract (SE) at 2 m/L	0.230	0.229	0.242	0.244	0.236	0.239	0.250	0.260	0.272	0.255
Seaweed extract (SE) at 3 m/L	0.228	0.239	0.247	0.250	0.241	0.254	0.256	0.268	0.275	0.263
YE at 5 g/L + SE at 2 m/L	0.237	0.242	0.245	0.265	0.247	0.249	0.258	0.271	0.278	0.264
YE at 10 g/L + SE at 3 m/L	0.239	0.241	0.260	0.273	0.253	0.257	0.261	0.276	0.292	0.272
Mean (A)	0.219	0.233	0.241	0.250		0.242	0.250	0.262	0.273	
L.S.D. at 5%	For (A): 0.003 (B): 0.004 (A×B):0.008					For (A):0.003 (B): 0.003 (A×B): 0.005				

Table (15): The impact of filter mud levels and some stimulant substances, as well as, their interactions on K % of fennel plants, during the two growing seasons of 2021/2022 and 2022/2023.

Stimulant substance treatments (B)	Filter mud levels (A)									
	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)	Control	6 m^3/feddan	12 m^3/feddan	18 m^3/feddan	Mean (B)
	First season					Second season				
Control	1.44	1.72	1.77	1.80	1.68	1.70	1.76	1.82	1.89	1.79
Yeast extract (YE) at 5 g/L	1.50	1.68	1.79	1.77	1.69	1.75	1.78	1.80	1.92	1.81
Yeast extract (YE) at 10 g/L	1.55	1.71	1.76	1.85	1.72	1.79	1.81	1.90	1.88	1.85
Seaweed extract (SE) at 2 m/L	1.64	1.73	1.81	1.83	1.75	1.86	1.83	1.93	2.04	1.92
Seaweed extract (SE) at 3 m/L	1.60	1.75	1.82	1.90	1.77	1.91	1.94	2.06	2.10	2.00
YE at 5 g/L + SE at 2 m/L	1.67	1.69	1.86	1.94	1.79	1.97	2.03	2.11	2.17	2.07
YE at 10 g/L + SE at 3 m/L	1.70	1.74	1.93	2.05	1.86	2.02	2.00	2.08	2.25	2.09
Mean (A)	1.59	1.72	1.82	1.88		1.86	1.88	1.96	2.04	
L.S.D. at 5%	For (A): 0.02 (B): 0.03 (A×B): 0.05					For (A): 0.03 (B): 0.04 (A×B): 0.08				

It is evident from the revealed data that N, P and K % in fennel herb were positively responded to spraying yeast extract, seaweeds extract, and their combinations, in both seasons. Obviously, foliar spray with these substances, either separately or mixture at all concentrations led to a significant increase in N, P and K %, except for the low concentration (5 g /liter) of yeast extract, for the two seasons, mostly, in relative to no sprayed plants. In this regard plants supplemented with the combined treatment (10 g /liter yeast extract + 3 ml /liter seaweeds extract) proved to be more effective in augmenting the three examined elements than those obtained by other treatments and control, in the two consecutive seasons. Numerically, this previous superior treatment increased N % by 14.8 and by14.2 %, by 16.1 and by 11.9 % for P % and by 10.7 and by 16.8 % for K % over no sprayed ones, in the first and second seasons, respectively, as clearly declared in Tables (13,14 and 15). These results detected in the present investigation due to the use of yeast extract are accordance with those findings of Rekaby (2013) on coriander and Helmy (2016) on cumin and, also Hamed (2017) on anise, Hassan (2015) on dill, Atteya and Amer (2018) and Mahmoud (2021) on roselle and Mohammad (2020) on black cumin, concerning seaweeds extract

application. As for the interaction, it was statistically significant influence on N, P and K % in fennel herb, during the two consecutive seasons (Tables, 13, 14 and 15). It could be noticed that the addition of filter mud at the high level (18 m^3 / feddan) in combination with spraying the combined treatment (yeast extract at 10 g /plant + seaweeds extract at 3ml /plant) achieved the most effective treatment in elevating the three elements (N, P and K %), mostly than those revealed by other combination treatments, during the two experimental seasons. From the obtained results, it could be discussed as follows: The increments in growth aspects, yield and chemical constituents of fennel in this investigation as a result of adding filter mud as organic manures which were described as follows: Organic manure considered the main source of the elements (N, P and S) and it contains high amounts of B and Mo. Besides, organic matter has a source of energy for Azotobacter growth (Bohn *et al.*, 1985). Organic manure is a vital role in promotes microbial biomass (Dhull *et al.*, 2004). Organic manures micronutrients, necessary micronutrients and beneficial microorganisms (Natarajan, 2007 and Sreenivasa *et al.*, 2010). Compost can be enhancing physical and biological characteristics of soil namely, soil reaction, water retention capacity and microorganisms' activity (Zhelijazkov and Warman, 2004). The enhancement of the tested parameters in this work due to applying yeast extract reflects the important roles of yeast extract which were examined as follows: Yeast extract is a good source of plant growth regulators such as, cytokinins, nutritional elements like, P, K, S, Ca, Mg and Na, as well as high concentrations of vit. B and bioactive compounds namely, proteins, lipids, nucleic acids and carbohydrates (Nagodo, 1991). Yeast plays an important role in raise cell division and enlargement, synthesis of nucleic acid and chlorophyll formation, besides carbohydrates accumulation (Marzouk *et al.*, 2014; Medani, 2006). The unique role of seaweeds extracts on augmenting the studied traits in this research could be explained in the light of the beneficial roles of seaweeds extract which were proved by several numerous such as, seaweeds extract contains phytohormones namely, IAA, GA and Cytokinins (Adam, 1999). Seaweeds extract has been natural fertilizer, it is as an excellent source of organic matter. It contains a lot of nutritional elements (N, P, K, S, Ca, Mg, Zn, Mn, Fe and C (Fornes *et al.*, 1993; Ho *et al.*, 2003). So, it has a good source of bioactive compounds like, vitamins, proteins, minerals, necessity fatty acids, carotenoids and dietary fiber (Osman and Salem, 2011). However, seaweeds extract is rich in many primary nutrients such as, Zn, Mn, Fe and Cu, as well as beneficial elements like, N and Na. Furthermore, it acts enhances growth attributes and development might be due to a good health around the plants (Pramanick *et al.*, 2013). From the obtained results, it could be recommended to supply the soil of fennel (*Foeniculum vulgare*) plants with

filter mud at 18 m^3 /feddan and foliar spray with yeast extract at 10 g /liter + seaweeds extract at 3 ml /liter to improve the growth, fruit yield, essential oil % and yield, as well as the elements of N, P and K% under the present study conditions.

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