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The Interaction Effect Compost and Chitosan on Growth, Yield and Volatile Oil of Fennel Plants Grown Under Sandy Soil Conditions

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Abstract: A field experiment was done under sandy soil conditions at faculty of agriculture experimental farm, Misurata University, Libya. Examining the influences of varying compost rates (0, 5, 10, and 20 tons/hectare), chitosan concentrations (0, 50, 100, and 200 ppm) beside the combination treatments between them on the growth, yield, and volatile oil production of fennel (*Foeniculum vulgare*) plants was the primary goal of this study. The results cleared that, when compared with control and the other rates under investigation, using 20 tons of compost per hectare resulted in meaningfully higher values of fennel growth, fruit yield as well volatile oil production. Higher concentrations of chitosan (100 and 200 ppm) significantly improved every attributes observed (plant highest, branches number as well herb fresh and dry weights, fruit and volatile oil yield per plant and per hectare) as compared to the control (chitosan-free spray). The better values were noticed by the combination treatment between 20-ton compost / hectare and 200 ppm chitosan. Since this combination offers the highest fruit and volatile oil yield advantages, as well as the most profitable rate and concentration, fennel growers might apply it under the same conditions.

Key words: Fennel, compost, chitosan, growth, yield, volatile oil.

1. Introduction

Foeniculum vulgare, Mill. (fennel) is sole of the most significant plants in the Apiaceae (Umbelliferae) family, which also includes many other significant aromatic and medicinal herbs. Fennel is native to southern Europe, Asia, Mediterranean Region and North Africa (**Abd El- Wahab and Mehasen, 2009**). The fennel fruits and volatile oil are utilized in the pharmaceutical, medical, nutrition, industries of agricultural as well chemical (**Basem, 2012** and **Shabbara *et al.*, 2018**). In folk medicine, ripe, dry, green-brown fennel fruits - also called seeds - are utilized either by themselves or in concoctions to treat in folk remedies (**Lucinewton *et al.*, 2005**). The dried fruits are also utilized to treat respiratory and digestive worry and have diuretic and sedative (**Ebeed *et al.*, 2010**), lactagogue and stimulant impacts (**Mohamad *et al.*, 2011** and **Figueredo *et al.*, 2016**).

Organic materials improve soil fertility due to their contents of micro- and macro nutrients, organic acids, vitamins and amino acids **(Naguib *et al.*, 2007)**. The direct and indirect advantages in the plant growth and its production that organic fertilizers offer for enhancing soil properties, plant development, and yields have sparked a lot of attention among farmers and environmentalists (**Toumpeli *et al.*, 2013; Hussein *et al.*, 2022**). Compost fertilizer increase plant growth, yield and active ingredient contents (**Mostafa, 2018; Alwoshesh *et al.*, 2023; Sarhan and Shehata, 2023)**

Chitosan is derived from chitin, which is regarded as the next most prevalent naturally occurring carbohydrate in plants after cellulose (**Rinaudo 2006**). Additionally, because of its cationic nature, chitosan exhibits a broad range of biological and physicochemical characteristics, such as antibacterial, antioxidant, and antihypertensive qualities (**Aranaz *et al.*, 2009**). In many crops, it has been shown to be effective in protecting plants against oxidative stress (**Ibrahim and Arafa, 2020**) and to enhance plant growth and productivity (**Elshetry *et al.*, 2020**; **Rani and Viji, 2023**).

In this study, the beneficial effects of foliar spraying chitosan under compost fertilization in terms of increased fennel productivity under sandy soil conditions were evaluated in order to achieve adequate growth, yield, and volatile oil production during the winter season.

2. Materials and Methods

At the experimental farm of Misurata University's Faculty of Agriculture in Libya, a field experiment was conducted over the two seasons in 2022/2023 and 2023/2024. The goal of this study was to find out how fennel growth, yield, and volatile oil production were affected by varying compost rates (0.0, 5, 10, and 20 tons/hectare), chitosan concentrations (0.0, 50, 100, and 200 ppm), and their interaction treatments. Table 1 displays the results of the physical and chemical investigations of the experimental soil at a depth of 0–30 cm in compliance with **Chapman and Pratt (1978)**.

Table (1). Some physical and chemical analysis of the experimental soil (average of both seasons)

Physical analysis				Soil texture
Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Sandy
4.22	79.12	9.79	6.87	

Chemical analysis												
pH	Organic mater (%)	E.C. m.mohs /cm	Soluble anions (meq. /L)				Soluble cations (meq./ L)			Available (ppm)		
			Cl^-	SO_4^{--}	HCO_3^-	Na^+	Mg^{++}	K^+	Ca^{++}	N	P	K
7.68	0.74	0.84	5.6	2.2	2.3	4.3	1.3	3.1	1.4	53.5	75.3	7.2

2.1. Experimental design

A split-plot design with three replicates was utilized in of the current experiment. There were four compost fertilizer rates in the main plots. Four different chitosan concentrations were allowed for the subplots. There were 16 treatments that interacted with the main and sub-factors.

2.2. Treatments and application:

Compost made entirely of plant waste was acquired from the Al-Rabi Company in Misurata City; Table 2 shows the compost's physical and chemical analysis. Before sowing, compost was applied to the soil and mixed in. This was done to get the soil preparing for farming.

Table (2). The physical and chemical characteristics of compost that were utilized in this study (average over both seasons)

pH	Organic carbon (%)	Organic matter (%)	C:N ratio	E.C. m.mohs/ cm	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	P
					(ppm)				
8.12	23.53	41.52	1:9	0.74	1243.08	22.46	628.34	432.15	5.70

At New Cairo, Cairo, Egypt from Modern Agricide Company the chitosan crystallite powder ($C_{56}H_{103}N_9O_{39}$) was obtained. The various chitosan treatments were administered topically 30, 50, and 70 days following the date of sowing. Five liters of solution were given to each experimental unit at a rate of one milliliter per liter using the spreading agent Super Film.

2.3. Cultivation

Five rows, spaced 60 cm apart, were included in each 3.0 × 3.0 m subplot. The plants were spaced 30 cm apart. Forty-three days after the original planting, the plants were thinned, leaving two plants per hill. All other agricultural procedures were implemented in accordance with the guidelines set by the Ministry of Agriculture in Egypt.

2.4. Recorded data

Plant height (cm), branches number/plant, dry and fresh weights of fennel herb (g), number of umbels per fennel plant, fruit yield per plant (g) and fruit yield per hectare (ton) were among the data collected during the first week of May. Additionally, **Guenther's (1961)** percentage of volatile oil was calculated, followed by the volatile oil yield per plant (ml) and volatile oil yield per hectare (l).

2.5. Statistical Analysis

The current study's data were statistically analyzed using the Statistix Version 9 (**Analytical Software, 2008**) computer program, and differences between the treatment means (compost rates and chitosan concentrations) were deemed significant when they exceeded the least significant differences (L.S.D.) at the 5% level.

3. Results and Discussion

3.1. Plant growth

Data illustrated in Tables 3, 4, 5 and 6 clear that the different rates of compost were found to significantly affect fennel plant height as well as branches number and herb fresh and dry weights per fennel plant compared to control (without compost application). Maximum means of fennel plant height (111.33 and 115.00 cm) and branches number /fennel plant (37.00 and 38.92 branches) as well as fresh (218.83 and 228.42 g/plant) and dry (39.46 and 42.67 g/plant) weights of herb per plant were recorded for 20 ton compost/hectare in both seasons, respectively, with significant difference compared to the lowest rates and control. Similar results were noticed with those stated by **Shahmohammadi *et al.* (2014)** on dill, **Mostafa (2018)** on dragonhead and **Sarhan and Shehata (2023)** on French basil, who stated that the utilize of compost has had a significant impact on vegetative traits.

The greatest fennel plant height values (106.50 and 110.50 cm), branches count per plant (33.00 and 34.25 branches/plant) and herb fresh (210.00 and 208.08 g/ plant) and dry weights (38.67 and 41.25 g/plant) of fennel plant were achieved from chitosan at 200 ppm compared to control and the lowest concentrations (0, 50 and 100 ppm) under study (Tables 3, 4, 5 and 6). Moreover, fennel growth traits significantly enhanced with using any chitosan concentration under study compared to control (without foliar spray with chitosan) in 1st and 2nd seasons. In general, increasing chitosan concentrations gradually increased fennel growth. Furthermore, **Kra *et al.* (2019)** shown that, in comparison to control, the use of chitosan (25, 50, 75, 100 and 125 mg L^{-1}) increased the growth of cassava (*Manihot esculenta*) as measured by stem length, leaf area and herb weights.

The obtained data in Tables 3, 4, 5 and 6 clear that, the combination between different compost rates and chitosan concentrations notably increased fennel plant height and branches count /plant and fresh and dry weight of herb per plant compared to control. Almost, the highest values in these parameters were gained with the combination treatment of 20 ton compost/hectare + 200 ppm chitosan concentration in the two tested seasons. Many research workers gained best plant growth when used compost for example **El-Sayed *et al.* (2018)** on *Cymbopogon citratus*, Stapf. In addition to improving antioxidant enzymes through hydrogen peroxide and nitric oxide signaling pathways, chitosan treatment increases ABA synthesis which leads to stomatal closure and rate ant photosynthetic. Additionally, it promotes the synthesis of sugars, organic acids, amino acids, and other metabolites that are essential for osmotic correction and manifest as greater plant growth (**Hidangmayum *et al.*, 2019**).

Table (3). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on plant height (cm) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	89.67	91.67	94.00	95.33	**92.67**
5	98.33	100.33	102.00	104.00	**101.17**
10	100.33	103.67	107.67	111.33	**105.75**
20	105.33	111.33	113.33	115.33	**111.33**
Mean (B)	**98.42**	**101.75**	**104.25**	**106.50**	
L.S.D. at 5 %	For (A)= 7.32		For (B)= 1.90	For (A×B)= 8.01	
	Second season				
Control	92.33	94.33	96.00	98.00	**95.17**
5	103.00	104.67	106.67	108.67	**105.75**
10	104.67	109.67	112.00	116.67	**110.75**
20	109.00	114.00	118.33	118.67	**115.00**
Mean (B)	**102.25**	**105.67**	**108.25**	**110.50**	
L.S.D. at 5 %	For (A)= 5.64		For (B)= 2.66	For (A×B)= 7.25	

Table (4). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on branches number per *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	23.33	24.33	25.33	27.33	**25.08**
5	26.33	28.33	30.00	31.67	**29.08**
10	28.00	30.00	32.00	33.33	**30.83**
20	33.33	37.00	38.00	39.67	**37.00**
Mean (B)	**27.75**	**29.92**	**31.33**	**33.00**	
L.S.D. at 5 %	For (A)= 0.56		For (B)= 0.25	For (A×B)= 0.71	
	Second season				
Control	24.00	25.00	26.00	27.00	**25.50**
5	28.00	29.00	31.67	33.67	**30.58**
10	30.33	31.67	33.00	34.00	**32.25**
20	35.33	37.00	41.00	42.33	**38.92**
Mean (B)	**29.42**	**30.67**	**32.92**	**34.25**	
L.S.D. at 5 %	For (A)= 2.70		For (B)= 1.26	For (A×B)= 3.46	

Table (5). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on herb fresh weight (g) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	168.00	170.00	172.00	174.33	**171.08**
5	209.67	212.00	214.33	216.67	**213.17**
10	210.67	214.67	218.33	223.00	**216.67**
20	215.33	217.67	220.33	226.00	**219.83**
Mean (B)	**200.92**	**203.58**	**206.25**	**210.00**	
L.S.D. at 5 %	**For (A)= 1.42**		**For (B)= 0.85**		**For (A×B)= 2.04**
	Second season				
Control	173.33	175.33	178.33	180.67	**176.92**
5	217.33	221.00	223.33	225.67	**221.83**
10	218.67	223.33	226.00	231.33	**224.83**
20	222.67	227.33	229.00	234.67	**228.42**
Mean (B)	**208.00**	**211.75**	**214.17**	**218.08**	
L.S.D. at 5 %	**For (A)= 0.83**		**For (B)= 0.70**		**For (A×B)= 1.46**

Table (6). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on herb dry weight (g) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	32.00	33.00	34.33	36.00	**33.83**
5	23.67	35.17	36.33	37.33	**33.13**
10	35.33	36.33	38.33	39.00	**37.25**
20	36.83	38.33	40.33	42.33	**39.46**
Mean (B)	**31.96**	**35.71**	**37.33**	**38.67**	
L.S.D. at 5 %	**For (A)= 4.45**		**For (B)= 3.65**		**For (A×B)= 7.70**
	Second season				
Control	34.00	34.67	36.67	37.33	**35.67**
5	35.50	36.67	38.00	40.00	**37.54**
10	38.33	40.00	41.00	42.33	**40.42**
20	40.67	41.67	43.00	45.33	**42.67**
Mean (B)	**37.13**	**38.25**	**39.67**	**41.25**	
L.S.D. at 5 %	**For (A)= 1.01**		**For (B)= 0.34**		**For (A×B)= 1.16**

3.2. Yield components

Using compost fertilizer at any rate seriously increased fennel umbels count per plant plant and hectare fruit yield compared to control during both seasons (Tables 7, 8 and 9). The greatest values in this regard were observed with 20 ton compost/ hectare with significant difference compared to the lowest rates (0, 5 and 10 ton/hectare). Generally, increasing compost rates gradually increased plant and hectare fruit yield (as g and ton, respectively) in both seasons. Moreover, the increases in fruit yield/hectare were about 26.96 and 25.70 % for 20 ton compost/ hectare over treatment of control (untreated plants) in the 1st and 2nd seasons, respectively. Also, according to **Rekaby *et al.* (2023)**, using compost significantly raised zucchini plant yields by 17 and 53%, respectively, when compared to chemical fertilizer treatment.

From data listed in Tables 7, 8 and 9 it is obvious that, umber number and plant as well as hectare fruit yield of fennel was enhanced by utilizing chitosan treatments compared to control (without chitosan spray) in the two seasons. In addition, the highest values in yield components of fennel were obtained by chitosan at 200 ppm compared to control and the lowest ones under study in the 2022/2023 and 2023/2024 seasons. Moreover, **Ibrahim (2019)** pointed out that treat chamomile plants with chitosan at various concentrations (2.5 and 5 ml/l) induced significant increases in yield components (expressed as flower heads dry yield/feddan) as compared with control plants.

All combination treatments between compost rates and chitosan concentrations gave an increase in fennel umbels number per plant, plant and hectare fruit yield compared to control plants as well as chitosan treatments alone (Tables 7, 8 and 9). Furthermore, the fennel yield components were enhanced as a result of the combination treatments between 200 ppm chitosan and 20 ton/hectare of compost compared to most of other combinations. Increasing chitosan concentrations under each compost rates gradually increased yield components in the two seasons. Compost and chitosan have a simulative influence on fennel fruit output, which can be explained by their roles in antioxidant defense, photosynthetic regulation, and growth (**Blokhina *et al.*, 2003 and Rekaby *et al.*, 2023**).

Table (7). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on number of umbels per plant of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	23.33	24.33	25.33	26.33	**24.83**
5	25.00	26.00	27.00	28.00	**26.50**
10	27.00	28.00	29.00	30.00	**28.50**
20	29.00	30.33	31.33	32.33	**30.75**
Mean (B)	**26.08**	**27.17**	**28.17**	**29.17**	
L.S.D. at 5 %	**For (A)= 0.78**		**For (B)= 0.12**		**For (A×B)= 0.80**
	Second season				
Control	25.67	26.67	27.67	28.67	**27.17**
5	27.00	28.00	29.33	30.33	**28.67**
10	29.67	31.00	32.00	33.00	**31.42**
20	32.00	33.67	35.00	36.67	**34.33**
Mean (B)	**28.58**	**29.83**	**31.00**	**32.17**	
L.S.D. at 5 %	**For (A)= 0.87**		**For (B)= 0.26**		**For (A×B)= 0.97**

Table (8). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on fruit yield /plant (g) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	32.00	35.67	37.00	40.00	**36.17**
5	37.67	42.00	43.33	45.67	**42.17**
10	41.00	42.67	44.33	47.33	**43.83**
20	43.00	45.33	46.33	49.00	**45.92**
Mean (B)	**38.42**	**41.42**	**42.75**	**45.50**	
L.S.D. at 5 %	For (A)= 0.38		For (B)= 0.38	For (A×B)= 0.76	
	Second season				
Control	35.00	38.00	40.00	42.67	**38.92**
5	40.67	44.67	45.67	48.33	**44.83**
10	43.67	45.67	47.00	50.00	**46.58**
20	46.00	48.00	49.67	52.00	**48.92**
Mean (B)	**41.33**	**44.08**	**45.58**	**48.25**	
L.S.D. at 5 %	For (A)= 0.58		For (B)= 0.33	For (A×B)= 0.81	

Table (9). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on fruit yield /hectare (ton) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	2.560	2.853	2.960	3.200	**2.893**
5	3.013	3.360	3.467	3.653	**3.373**
10	3.280	3.413	3.547	3.787	**3.507**
20	3.440	3.627	3.707	3.920	**3.673**
Mean (B)	**3.073**	**3.313**	**3.420**	**3.640**	
L.S.D. at 5 %	For (A)= 0.031		For (B)= 0.030	For (A×B)= 0.605	
	Second season				
Control	2.800	3.040	3.200	3.413	**3.113**
5	3.253	3.573	3.653	3.867	**3.587**
10	3.493	3.653	3.760	4.000	**3.727**
20	3.680	3.840	3.973	4.160	**3.913**
Mean (B)	**3.307**	**3.527**	**3.647**	**3.860**	
L.S.D. at 5 %	For (A)= 0.047		For (B)= 0.026	For (A×B)= 0.065	

3.3. Volatile oil production

The highest values in *Foeniculum vulgare* volatile oil percentage (2.046 and 2.193 %), yield per fennel plant (0.944 and 1.074 ml/plant) and feddan fruit yield (75.48 and 85.99 l/ hectare) were obtained from 20 ton compost/ hectare compared to the other rates under study during and control through the

both seasons (Table 10, 11 and 12). Utilizing any compost treatments notably increased volatile oil yield/plant and / hectare compared to control in the two tested seasons. Likewise, **Ali *et al.* (2017)** reported that the highest volatile oil trait values of fennel (percentage of volatile oil, its yield / plant and / feddan were noticed when compost was added at the high level (24 m^3 /feddan) compared to control.

Table (10). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on volatile oil (%) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	1.937	1.950	1.980	2.037	**1.976**
5	1.983	2.000	2.037	2.093	**2.028**
10	2.027	1.717	2.087	2.140	**1.993**
20	2.073	1.777	2.137	2.197	**2.046**
Mean (B)	**2.005**	**2.861**	**2.060**	**2.117**	
L.S.D. at 5 %	For (A)= N.S.		For (B)= 0.170	For (A×B)= 0.360	
	Second season				
Control	1.977	1.993	2.033	2.113	**2.029**
5	2.017	2.040	2.090	2.157	**2.076**
10	2.067	2.097	2.147	2.200	**2.128**
20	2.123	2.163	2.213	2.273	**2.193**
Mean (B)	**2.046**	**2.073**	**2.121**	**2.186**	
L.S.D. at 5 %	For (A)= 0.032		For (B)= 0.011	For (A×B)= 0.038	

Table (11). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on volatile oil yield per plant (ml) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	0.620	0.696	0.733	0.816	**0.716**
5	0.748	0.841	0.883	0.957	**0.857**
10	0.831	0.732	0.926	1.013	**0.876**
20	0.892	0.814	0.991	1.077	**0.944**
Mean (B)	**0.773**	**0.771**	**0.883**	**0.966**	
L.S.D. at 5 %	For (A)= 0.096		For (B)= 0.072	For (A×B)= 0.157	
	Second season				
Control	0.692	0.758	0.814	0.902	**0.791**
5	0.821	0.912	0.955	1.043	**0.933**
10	0.903	0.958	1.010	1.101	**0.993**
20	0.977	1.039	1.100	1.183	**1.075**
Mean (B)	**0.848**	**0.917**	**0.970**	**1.057**	
L.S.D. at 5 %	For (A)= 0.020		For (B)= 0.007	For (A×B)= 0.023	

Table (12). Effect of compost rate (A) and chitosan (B) concentration as well as their interactions (A×B) on volatile oil yield per hectare (l) of *Feoniculum vulgare* plant during 2022/2023 and 2023/2024 seasons

Compost rate (ton/hectare)	Chitosan concentration (ppm)				Mean (A)
	Control	50	100	200	
	First season				
Control	49.61	55.68	58.66	65.24	**57.30**
5	59.83	67.26	70.64	76.54	**68.57**
10	66.53	58.59	74.05	81.07	**70.06**
20	71.36	65.12	79.26	86.17	**75.48**
Mean (B)	**61.83**	**61.66**	**70.65**	**77.26**	
L.S.D. at 5 %	For (A)= 7.67		For (B)= 5.79		For (A×B)= 12.59
	Second season				
Control	55.36	60.63	65.11	72.17	**63.32**
5	65.65	72.94	76.40	83.43	**74.61**
10	72.25	76.66	80.79	88.04	**79.44**
20	78.18	83.13	88.02	94.63	**85.99**
Mean (B)	**67.86**	**73.34**	**77.58**	**84.57**	
L.S.D. at 5 %	For (A)= 1.61		For (B)= 0.55		For (A×B)= 1.87

As shown in Tables 10, 11 and 12 it is clear that, utilizing chitosan significantly increased percentage of volatile oil, volatile oil yield per fennel plant (ml) and per hectare (l) compared to control in both seasons. In general, sprayed fennel plants with 200 ppm chitosan recorded the highest means in this connection (2.117 and 2.186 %; 0.996 and 1.057 ml/plant and 77.26 and 84.57 l /hectare) in first and second seasons compared to the other concentrations under study, respectively. At the same time, **Dehghani *et al.* (2019)** discovered that the best production of essential oil of *Matricaria chamomilla* (German chamomile) was obtained when 125 mg/l of chitosan was sprayed on the plants 60 days after they were planted under deficiency water stress circumstances.

The data tabulated in Tables 10, 11 and 12 reveal that, rising concentrations of chitosan from 100 to 200 ppm under each compost rates gradually increased fennel percentage of volatile oil, yield per fennel plant and per hectare in the two consecutive seasons. Over and above that, the highest values in these attributes were produced by 20 ton/hectare of compost and 200 ppm chitosan plots compared to the other combinations under study in 1st and 2nd seasons. In general, as was previously noted, different chitosan concentrations and compost rates (each separately) raised the percentage of volatile oil and the amount of fruit produced per hectare of fennel plants. When combined, they may have the greatest effect, producing more volatile oil per hectare. These findings are consistent with the compost influence of fennel that was described by **Ali *et al.* (2017)** as well as **Dehghani *et al.* (2019)** on chamomile regard chitosan influence.

4. Conclusion

This study points out that fennel plants fertilized by 20 ton compost/hectare combined with 200 ppm of chitosan as foliar spray might be utilized by farmers instead of fennel as medicinal and aromatic crop. Generally, the utilize of the compost rates for this plant and chitosan resulted in increases in fennel growth and fruit yield as well as maximized volatile oil production under sandy soil conditions.

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