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Response of Dutch Fennel to Algae Extract Partial Replacement of Mineral NPK under Sinai Conditions

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ABSTRACT

Two field trials were carried out during 2014/2015 and 2015/2016 seasons at the El-Maghara Research Station-Desert Research Center., to study the effect of algae extract foliar application as partial replacement for chemical fertilization on vegetative growth, fruits yield, essential oil and its main components as well as chemical constituents of Dutch fennel under Sinai conditions. Treatments were the combination of five fertilization levels (full recommended dose of NPK only, 75, 50, 25% of the recommended NPK plus spraying with algae extract and spraying algae extract only), as treatments were arranged in a randomized complete blocks design with three replications for each treatment. The results showed that, application of T2 (75% of the recommended NPK plus algae extract) increased plant height, number of umbels, fresh and dry weights / plant and maximized the essential oil yield compared to other treatments. However, the least amount of essential oil yield was obtained in plants treated with spraying algae extract only. Application of T2 also increased the concentration of N, P and K in plant tissues, Meanwhile, T5(spraying with only algae extract) led to the lowest values compared other treatments in both seasons. As general the main chemical constituents of Dutch fennel essential oil were trans-anethole, estragole, fenchone, limonene, alpha-pinene.
Keywords: *Foeniculum vulgare*, algae extract, volatile oil, trans-anethole, estragole.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill), Family Apiaceae, is considered an important economic crop, used in the domestic market as important spice, in pharmaceutical industries, and is ranked the first in the list of Egyptian exports of herbs and spices (EMAP, 2011-2012). Moreover, fennel fruits possess anticancer activity (Anand *et al.*, 2008) and also has an antimicrobial, anti-inflammatory effect (Ali, 2002). Thus, it can be utilized as carminative, diuretic, expectorant and stimulant, antispasmodic, stomachic and sedative (Mahfouz and Sharaf-Eldin, 2007). It is also used in gastroenteritis, hernia, indigestion and abdominal pain according to (Boulos,1983 and Lawless, 1997). The flavor of fennel oil depends upon its main constitutes: fenchone, estragole which is a bitter tasting element and anethole with a sweet anise-like flavor (Braun and Franz, 1999). Proportions of these ingredients vary according to strains and region as mentioned by (Osman and Abd El-Wahab, 2003). The local variety of Egyptian fennel contain higher percentage of estragole (20–60%) as recorded by (Shahat *et al*., 2011); accordingly, exports of organic fennel from Egypt have been panned in some products in the EU markets (Yousef and Omneya, 2014). Several attempts have been made since octets of the last century to introduce new strains of sweet fennel, which featuring with proportion height of anethole to more than 50%, and less estragole proportion less than 10% (Shalaby *et al*., 2011 and Abd-Allah, 2012). Dutch fennel (*Foeniculum vulgare* sp. Vulgare) is a new strain of fennel imported from Holland by Sekem Co. and has been tested in different regions of Egypt and was marked for superiority in the oil yield and chemical components compared to other cultivated strains with an average ratio of anethole up to 75%.

Many factors influence oil content in umbelliferous crops i.e. salinity, fertilization and irrigation (Olle and Bender., 2010), fertilization with N affected not only the quantity, but also the composition of the essential oils (Schaller *et al*., 1998). balanced mineral fertilization of aromatic plants is an important cultivation factor determining essential oil quantity and quality (Renata, 2013). It is recommended for the organic production that completely or partially substitute of mineral fertilization (NPK) by using of organic and bio-fertilizers. Many researchers have pointed out efficacy of using blue-green algae as bio fertilization as it increases production as well as the plant's ability to withstand various stress conditions. Spirulina alga extract contains up to 62% amino acids and vitamin B-12 combination as well as higher levels of the major and micro minerals important for growth. Also, it was found that Spirulina extract contains high proportions of different plant hormones such as auxin and cytokinin (kemka *et al*., 2007; Aly and Esawy, 2008).

For many reasons, the government encourages the expand in agriculture activity with the emphasis of medicinal and aromatic plants in the region of Sinai. Thus, the present research aimed to investigate the production of Dutch fennel using Spirulina algae extract foliar application as partial replacement for chemical fertilization under Sinai sandy soil conditions.

MATERIALS AND METHODS

1. Location and plant material

The present study was carried out during the two successive seasons of 2014/2015 and 2015/2016 at the El-Maghara Research Station- Desert Research Center (latitude 30.35^{o} N, longitude 33.20^{o} E and 200 meters above sea level 90 km South El-Arish City) in the middle of Sinai (North Sinai Governorate). The physical and chemical properties of the experimental soil are presented in Tables (A and B). Underground water was used as irrigation source; chemical analysis of the underground water is presented in Table (C).

Soil and water analysis:

Table A. The mechanical analysis of the experimental soil area.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture
0-30	95.00	4.00	1.00	Sandy

Table B. The chemical analysis of the experimental soil area.

pH	E.C.	O.M.	Soluble anions (meq/l)				Soluble cations (meq/l)			
	(ds/m)	(%)	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.9	2.8	0.5	-	1.0	20.0	7.0	6.0	8.0	12.6	1.4

Table C. The chemical analysis of irrigation water.

pH	E.C.	Soluble anions (meq/l)				Soluble cations (meq/l)			
	(ds/cm)	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.32	4.11	8.50	9.29	23.50	0.18	1.00	3.00	9.97	27.5

2. Soil preparation and seed sowing:

During soil preparation, a sandy soil was amended with botanical compost from local source at 10 m^3/fed with adding calcium superphosphate immediately before planting in each season in only one dose during the preparation of the soil. The distances were 50 cm between hill and 75 cm between rows, under drip irrigation system within 50 cm between drippers with a rate of 4 liter/hour/hill every two days in the whole period of both seasons. Three to five seeds were sown into hills at 18th October in the first season and 21th October in the second season within the drippers of irrigation lines and irrigation was done immediately after sowing. After germination, seedlings were thinned to two plants/hill.

Chemical fertilizer sources

Ammonium sulphate 20.5% N was used as a source of nitrogen, calcium superphosphate 15% P_2O_5 was used as P source and potassium sulphate 48% K_2O was used as K source.

3. Fertilization treatments

T1. The recommended dose (85 kg N, 32 kg P and 48 kg K/feddan) after (Ali, 2002) was used as a control treatment.
T2. 75% of recommended dose plus alga extract.
T3. 50% of recommended dose plus alga extract.
T4. 25% of recommended dose plus alga extract.
T5. Alga extract without chemical fertilizer.

Application time:

Fertilization with calcium superphosphate was conducted immediately before planting in each season in only one dose during the preparation of the land for agriculture. Nitrogen and potassium fertilizers were applied in three equal doses at 30, 60 and 90 days after seed sowing in both seasons. Application of algae extract was done twice at two stages; the first stage was 60 days after full germination and the second stage was at 90 days after germination just at the beginning of flowering stage.

Algae extract:

Algae extract was obtained from Algae Production Unit at the National Research Center as an extract of the algae Spirulina platensis. Analysis of the used algae extract is represented in Table (A). The algae extract was applied as foliar application in the early morning before sunrise at concentration 1 l/200 l water/fed.

Table D. Chemical analysis of algae extract.

Macro elements (%)						Micro elements (ppm)				
N	P_2O_5	K_2O	Ca	S	Mg	Fe	Zn	Mn	Cu	B
4	8.5	3.5	0.8	1.7	0.6	1100	1300	400	100	400

Growth evaluation:

Harvesting was carried out in the second week of May 2015 and 2016. Harvest was done early as possible and plant height (cm) was recorded before harvest using measuring tape. After harvest, yield characteristics recorded were fresh and dry weighs/plant (g), number of umbels/plant, fruit yield/plant (g) and/feddan (ton), weight of 1000 fruits(g).

Essential oil productivity: Essential oil percentage of fennel fruits was determined by hydro distillation for 3 h using the method of Guenther, (1961), the oil percentage was used to calculate essential oil yield/plant (ml), and feddan (l). The extracted volatile oil was dehydrated over anhydrous sodium sulphate and stored in a refrigerator until GC/MS analysis.

Chemical analysis

Chlorophyll a, b, total chlorophyll and Carotenoids (mg/g f.w.) were determined in leaf fresh samples at 90 days after seed sowing in both seasons as described by as described by (Saric *et al.,* 1967). N, P and K percentages as well as total carbohydrates in the dry herb were estimated at flowering time. Nitrogen was determined by modified micro Kjeldahle method as described by (A.O.A.C. 1970). Phosphorus was colorimetrically determind using the method described by (Murphy and Riley, 1962) using spectrophotometer at 882 µv. Potassium percentage was estimated using flame photometry according to (Cottenie *et al.,* 1982). Total carbohydrates in the dry leaves was determined by using a colorimetric method of (Herbert *et al*., 1971).

Essential oil GC/MS analysis:

The GC-MS analysis for oil samples from the second season was carried out at the Central Laboratory of National Research Center, Giza. Essential oil GC/ Mass analysis was performed using a Hewlett-Packard 5890 A series 11 instrument equipped with flame ionization detector (FID) and a carbon wax fused silica column (50 m x 0.25 mm. i. d., film thickness 0.32 µm). Initial column temperature was 50 Cº and held for 3 minutes, then raised to 60 Cº by rate 3.0 Cº / minute and raised to 260 Cº by rate 3.0 Cº /minute and hold at 260 Cº for 5 minutes. The volatile oil components were identified by comparing their retention times and mass spectrum with those of standards, NIST library of the GC-MS system and literature data.

Experiment layout and statistical analysis

Treatment of this experiment were arranged in a randomized complete block design. Each treatment contained three replicates of 10 plants. Collected data were analyzed using MSTAT C Program, (Bricker, 1991) Means were compared using LSD test at 0.05 level according to (Snedecor and Cochran, 1980).

RESULTS

Vegetative growth characters:

Plant height: The presented results in table (1) showed that, plants treated with 75% NPK plus algae extract T2 had the highest growth parameters compared to other

treatments. Meanwhile, plants treated with full NPK dose only T1 came in the second place. Treatment T5 of spraying algae extract only recorded the shortest plants compared to other treatments in both seasons.

Table 1. Plant height and fresh and dry weights of Dutch fennel under partial replacement of NPK using Spirulina algae extract foliar application during the two seasons of 2014/2015 and 2015/2016.

Treatment	Plant height (cm)	Fresh weight /plant(g)	Dry weight /plant(g)
	First season		
T1	94.33	520.40	237.20
T2	101.40	602.20	287.90
T3	85.33	537.90	238.70
T4	81.63	413.8 0	225.20
T5	68.78	292.10	137.00
LSD at p<0.05	2.66	83.54	27.45
	Second season		
T1	94.56	520.60	240.80
T2	102.3	677.80	288.30
T3	85.22	540.00	241.70
T4	82.34	414.20	227.50
T5	69.33	293.30	138.30
LSD at p<0.05	2.98	125.0	29.85

Means within the same column for each trait significantly differ from each other according to the LSD test at p<0.05. T1 (full recommended dose of NPK), T2 (75% NPK recommended dose plus algae extract), T3 (50% NPK recommended dose plus algae extract), T4 (25% NPK recommended dose plus algae extract), T5 (algae extract only).

Plant fresh weight (g): It is evident from data presented in Table (1) that, plant fresh weight was positively increased due T2 treatment in both seasons (602.20 and 677.80 g/plant), respectively without any significant differences neither with T1 nor with T3 treatments in the first season. Individual treatment of T5 resulted in the least plant fresh weight in both seasons.

Plant dry weight (g): The largest amount of plant dry weight occurred with the application of T2 treatment as shown in Table (1) compared to other treatments. Following the same pattern, application of individual alga extract resulted in the lowest values for plant dry weight in both seasons in comparison with all other treatments.

Number of umbels: Data presented in Table (2) show that, number of umbels took the same direction of plant height, T2 treatment gave the highest number of umbels compared to other treatments, while treatment of T5 recorded the lowest number of umbels compared to other treatments in both seasons.

Fruit yield/plant (g) and/feddan (ton): The highest fruit yield 81.11 g/plant and 1.82 ton/feddan in the first season and 81.67 g/plant and 1.83 ton/feddan in the second one was obtained by T2. However, the lowest fruit yield 45.00 g / plant or 1.01 ton / feddan in the first season and 46.11 g / plant or 1.03 ton / feddan in the second season were obtained with T5 in both season as shown in Table (2).

Table 2. yield characteristics of Dutch fennel under partial replacement of NPK using Spirulina algae extract foliar application during the two seasons of 2014/2015 and 2015/2016.

Treatment	Number of umbels	Weight of 1000 fruits(g)	Fruit yield/ Plant (g)	Fruit yield/ feddan (ton)
		First season		
T1	99.56	13.67	75.00	1.68
T2	116.70	12.90	81.11	1.82
T3	96.67	15.10	71.11	1.59
T4	76.44	14.13	57.78	1.29
T5	74.11	12.33	45.00	1.01
LSD at p<0.05	5.40	0.23	2.03	0.05
		Second season		
T1	103.00	13.60	75.56	1.69
T2	118.20	13.10	81.67	1.83
T3	98.84	15.17	72.22	1.62
T4	76.00	14.33	58.89	1.32
T5	75.08	13.77	46.11	1.03
LSD at p<0.05	6.78	0.11	3.39	0.08

Means within the same column for each trait significantly differ from each other according to the LSD test at p<0.05. T1 (full recommended dose of NPK), T2 (75% NPK recommended dose plus algae extract), T3 (50% NPK recommended dose plus algae extract), T4 (25% NPK recommended dose plus algae extract), T5 (algae extract only).

Weight of 1000 fruits: Concerning weight of 1000 fruits, data presented in Table (2) represent that, it was significantly increased by using T3 treatment followed by T4 compared to other treatments, while, the least weight of 1000 fruits resulted from T5 treatment in both seasons.

Essential oil percentage: Data presented in Table (3) show that fertilizing Dutch fennel plants using T2 treatment significantly increased essential oil percentage and T4 and T3 treatments came in the second place, respectively compared to other treatments, the lowest essential oil percentage was obtained by T5 and T1 treatments (1.54and 1.55 %, respectively in both seasons).

Table 3. Essential oil productivity of Dutch fennel under partial replacement of NPK using Spirulina algae extract foliar application during the two seasons of 2014/2015 and 2015/2016.

Treatment	Essential oil Percentage	Oil yield/ plant(ml)	Oil yield/ feddan(liter)
	First season		
T1	1.56	1.17	26.17
T2	2.03	1.64	36.80
T3	1.75	1.24	27.83
T4	1.78	1.02	22.97
T5	1.54	0.70	15.50
LSD at p<0.05	0.12	0.07	1.42
	Second season		
T1	1.58	1.19	26.70
T2	2.04	1.67	37.37
T3	1.78	1.28	28.73
T4	1.81	1.06	23.83
T5	1.55	0.71	16.00
LSD at p<0.05	0.17	0.059	1.37

Means within the same column for each trait significantly differ from each other according to the LSD test at p<0.05. T1 (full recommended dose of NPK), T2 (75% NPK recommended dose plus algae extract), T3 (50% NPK recommended dose plus algae extract), T4 (25% NPK recommended dose plus algae extract), T5 (algae extract only).

Oil yield/plant (ml) and/feddan (l): It is evident from data presented in Table (3) that, the highest oil yield of 1.64 ml/plant and 36.80 l/feddan in the first season and 1.67 ml/plant and 37.37 l/feddan in the second one was obtained by T2 treatment. The lowest oil yield of 0.70 ml/plant and 15.50 l/feddan in the first season and 0.71 ml/plant and 16.00 l/feddan in the second one resulted with the T5 treatment compared to other treatments in both seasons.

Pigments content: Data presented in Table (5) indicate that, the pigments content (chlorophyll a, b, total chlorophyll, and carotenoids) recorded their lowest values when plants were treated by T5 treatment. However, treatments didn't record any significant effect and the highest values in this concern was recorded for plants treated with T2 treatment which showed a significant increase in both chlorophyll and carotenoids contents in the both seasons.

Nutrient elements (%): Table (4) also showed that the highest N, P and K percentages were obtained by fertilizing the plants with T2 treatment, while the lowest percentages resulted from T5 treatment compared to other treatments in both seasons.

Total carbohydrates (%): The results presented in table (4) showed that there was significant increase in total carbohydrates percentage due to T2 treatment (26.36% and 26.37% in both seasons, respectively). T5 treatment recorded that the lowest carbohydrates percentage (19.93% and 20.02% in doth seasons, respectively) compared to other combinations treatments in both seasons.

Volatile oil GC/ Mass analysis: The analysis of the essential oils in Dutch fennel (Table 5) showed the presence of 14 compounds with the presence of trans-anethole as the main component followed by estragole. The highest percentage of trans-anethole (72.16%) was obtained by T2 treatment followed by T1 and T5 respectively. However, the lowest percentage of trans-anethole (38.06%) resulted from T3 compared to other treatments. The lowest percentage of estragole (8.30%) resulted with T2 and in the second place came T5 and T1 respectively. However, the highest percentage of estragole (32.46%) was obtained by T3 followed byT1 and T4 respectively, compared to other treatments.

Table 4. Chemical constituents of Dutch fennel under partial replacement of NPK using Spirulina algae extract foliar application during the two seasons of 2014/2015 and 2015/2016.

Treatment	Chl. a	Chl. b	Total chl.	Carotenoids	N %	P %	K %	Total Carbohydrates
First season								
T1	0.870	0.273	1.143	0.147	1.05	0.27	3.34	25.92
T2	0.900	0.297	1.197	0.163	1.25	0.36	3.97	26.36
T3	0.677	0.227	0.904	0.133	1.14	0.30	3.22	23.84
T4	0.603	0.197	0.800	0.117	1.23	0.33	2.84	21.08
T5	0.597	0.183	0.780	0.107	1.01	0.22	2.66	19.93
LSD at p<0.05	0.001	0.001	0.001	0.001	0.05	0.06	0.08	0.038
Second season								
T1	0.847	0.277	1.124	0.183	1.06	0.26	3.34	25.98
T2	0.887	0.307	1.194	0.220	1.26	0.34	3.97	26.37
T3	0.783	0.267	1.050	0.163	1.13	0.30	3.21	23.44
T4	0.717	0.247	0.964	0.147	1.24	0.33	2.85	21.11
T5	0.617	0.210	0.827	0.127	1.03	0.23	2.67	20.02
LSD at p<0.05	0.001	0.001	0.001	0.001	0.08	0.04	0.18	0.08

Means within the same column for each trait significantly differ from each other according to the LSD test at p<0.05. T1 (full recommended dose of NPK), T2 (75% NPK recommended dose plus algae extract), T3 (50% NPK recommended dose plus algae extract), T4 (25% NPK recommended dose plus algae extract), T5 (algae extract only).

Table 5. Volatile oil GC/ Mass analysis of Dutch fennel plants treated by chemical fertilization and spraying with algae extract treatments in second season.

Compounds	R. T	Concentration of compounds (%)				
		T1	T2	T3	T4	T5
a-Pinene	9.75	0.78	1.20	2.02	1.55	1.19
Camphene	10.31	0.03	0.07	0.06	0.07	0.08
Sabinene	11.14	0.59	0.64	0.63	0.8	0.59
ß-Pinene	11.26	0.05	0.03	0.08	0.06	0.04
Myrcene	11.64	0.18	0.32	0.42	0.26	0.33
□-Phellandrene	12.26	0.08	0.09	0.10	0.09	0.10
Limonene	13.13	4.93	11.24	17.96	10.77	6.64
□-Terpinene	13.16	0.15	0.34	0.24	0.15	0.32
1,8-cineole	14.44	0.03	0.14	0.14	0.14	0.29
Fenchone	15.19	2.60	5.18	7.50	4.95	5.66
Camphor	16.90	0.05	0.25	0.28	0.1	0.22
Estragole	18.76	20.72	8.30	32.46	20.24	15.89
Fenchyl acetate	19.24	0.09	0.04	0.05	0.06	0.07
Trans-anethole	21.84	69.72	72.16	38.06	60.76	68.58

T1(full recommended dose of NPK), T2(75% NPK recommended dose plus algae extract), T3(50% NPK recommended dose plus algae extract), T4(25% NPK recommended dose plus algae extract), T5(algae extract only).

DISCUSSION

Blue-green algae plays a key role in improving growth of many plants when applied as a bio fertilizer. This evidence was clearly appeared in growth criteria of Dutch fennel presented in Table (1). The performance of Dutch fennel plants, in terms of plant height, fresh and dry weights/plant, were enhanced by algae extract application in both seasons. The use of blue-green algae is known to cause many beneficial effects on plants as they contain growth promoting hormones (IAA and cytokinins) trace elements (Fe, Cu, Zn, Co, Mo, Mn, and Ni), vitamins and 62% of the amino acids (Challen and Hemingway, 1965).

The stimulatory effect of blue-green alga extract could be due to its high content of macro and micro elements. However, micronutrients fertilizer has only the effect of encouraging roots to absorb more nutrients from the soil medium as mentioned by (Shaaban and Mubarak, 2000), as well as its contains the whole spectrum of natural mixed carotene and xanthophyll phyto pigments which are considered as the richest

natural source of vitamin B-12. Also, it contains high content of free amino acids. In addition to the presence of high levels of various plant hormones such as auxins and cytokinins, which are considered important and vital for raising the plants production and increasing the ability of plants to withstand various stress conditions as reported by (Aly and Esawy, 2008 and Kemka *et al*., 2007).

These results were in agreement with those obtained by (Abd El-Wahab *et al*., 2016) on *Origanum vulgare* L. who found that, the significantly highest increase for growth characters resulted when plants were treated by algae extract plus biofertilizer plus 15m^3 compost and (Sahu *et al*., 2013) on coriander (*Coriandrum sativum*) who showed that, the highest plant height and dry weight plant was obtained by using the treatment 100% K and 75% NP along with *Azotobacter, Azospirillum* and PSB.

Further studies claimed that algae extract stimulate growth as it contains a series of plant growth promoters. Of these, (Rama Rao, 1991) reported that, aqueous extract of *Sargassum wightii* when applied as a foliar spray on *Zizyphus mauritiana* showed an increase in yield and quality of fruits. This may the attributed to the high protein content of the algal extract which split into natural plant amino acids involved directly in the metabolism (Shaaban, 2001). Two nutrient sources might be considered in the case of algal extract treatments. One source is the algal extract itself and the second is its positive effect on the nutrients uptake by the plant roots (Shaaban, 2001).

These results were in harmony with those reported by (Sahu *et al*., 2013) who indicated that, the highest number of umbels / plant, weight of 1000 seed and seed yield were obtained by using the treatment (100% K and 75% NP along with *Azotobacter, Azospirillum* and PSB) on coriander (*Coriandrum sativum*) and in the same the regard (Abd El-Wahab *et al*., 2016) recorded that, the use of algae, with biofertilizer plus 15m^3 compost on *Origanum vulgare* L. recorded that, the highest treatment of yield characters, also the highest oil yield resulted with the treatment of algae, with biofertilizer and compost at 15m^3. The same effect of algae extract was retired on some Russian dill varieties (Toaima *et al*., 2017). The interaction results indicated that cultivation of Aurora variety combined with foliar spray of 1.5 liter of blue-green algae extract of *Spirulina platensis* produced significantly maximum seed yield / plant and / feddan, volatile oil yield / plant and / feddan (cultivation of local type without foliar spray of algae extract) which recorded the lowest parameters.

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إستجابة الشمر الهولندى للاستبدال الجزئى للتسميد المعدنى باستخدام الرش بمستخلص الطحالب

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تم اجراء تجرتين حقليتين خلال عامى 2015/2014و2016/2015 بمحطة بحوث المغارة – مركز بحوث الصحراء. لدراسة تأثير مستخلص الطحالب الورقية كبديل جزئي للتسميد المعدنى على النمو الخضري، والزيوت العطرية ومكوناتها الرئيسية وكذلك المكونات الكيميائية للشمر الهولندي تحت ظروف سيناء . واجريت التجربة فى خمس معاملات (اضافة الدفعة الكاملة من التسميد المعدنى الموصى بها واضافة 75و50و25 % من التسميد المعدنى + الرش بمستخلص الطحالب بمعدل لتر/200 لتر ماء للفدان واخر المعاملات كانت الرش بمستخلص الطحالب فقط). وتم وضع المعاملات فى تجربة قطاعات كاملة العشوائية فى ثلاث مكررات لكل معاملة. أظهرت النتائج ان استخدام معاملة T2 (75 % من التسميد المعدنى + الرش بمستخلص الطحالب) ادى الى زيادة فى كافة صفات النمو الخضرى ومحصول الثمار وأعلى متوسط قيمة لمحصول الزيت لنبات والفدان. فى حين ان أقل محصول زيت للفدان تحقق مع النباتات التى تمت معاملتها بالرش بمستخلص الطحالب فقط T5 . وايضا استخدام المعاملة T2 ادى الى زيادة المحتوى من نسب عناصر النيتروجين والفوسفور والبوتاسيوم فى انسجة النبات. فى حين ان المعاملة T5 اعطت اقل قيم مقارنة بباقى المعاملات فى الموسمين. وبصفة عامة كانت المكونات الكيميائية الرئيسية للزيت الطيار للشمر الهولندى هى Trans- Anethole, Estragole, Fenchone, Limonene, a-Pinene.