Bulgarian Journal of Agricultural Science, 27 (No 5) 2021, 887–895

Effect of blue green algae extract on three different curly parsley varieties under Sinai conditions

Wafaa Hamed Abd El-Aleem, Emad Saleh Hamed* and Wael Ismail Mohamed Toaima

Desert Research Center, Medicinal and Aromatic Plants Department, 11753 Cairo, Egypt
**Corresponding author:* dr.emad128@yahoo.com

Abstract

Abd El-Aleem, W. H., Hamed, E. S. & Toaima, W. I. M. (2021). Effect of blue green algae extract on three different curly parsley varieties under Sinai conditions. *Bulg. J. Agric. Sci., 27 (5)*, 887–895

The effect of spray with blue green algae extract on the yield of some curly parsley varieties was investigated. The experiment was carried out during the 2016/2017 and 2017/2018 seasons at North Sinai Governorate, Egypt. Treatments were arranged in a split-plot design with three replicates. Foliar spray with three aqueous dilutions of *Spirulina platensis* extract (0, 5, and 10 ml/liter water) was assigned in the main plots whereas, sub-plots were devoted to the cultivation of three curly parsley varieties (Bravour, Xenon, and Moskrul 2-Petra). Results showed that foliar spray of algae extracts significantly improved herb fresh and dry weights per feddan, chlorophyll content, volatile oil percent, oil yield, and the concentration of 10 ml/liter gave maximum values in this concern. Bravour and Xenon varieties yielded the heaviest herb fresh and dry weights per feddan with non-significant differences in between, while Petra was the lowest. Xenon variety had the significantly maximum oil percent and oil yield. Data of chlorophyll contents within varieties were non-significant. Cultivation of Xenon variety combined with a spray of algae extract at 10 ml/liter was promising for cutting the highest foliage yield with intense flavor and color.

Keywords: North Sinai; curly parsley; yield; flavor; color

Introduction

Curly parsley (*Petroselinum crispum* var. *crispum*, Apiaceae Family) is a valuable culinary plant, has very decorative, curled, and crisp leaves of high ornamental value. This parsley variety is known typically for its excellent garnishing properties because of the texture and color that add to all kinds of foods. The plant is considered new in Egypt. It began to be cultivated a few years ago due to the increased demand of foreign markets over the regular flat parsley type because of its superiority in color and shape. With the efforts of researchers, and companies the plant was cultivated in the country. Technical support was provided to farmers in various production stages in cooperation with local agricultural administrations (EMAP, 2014; Ciju, 2019).

Several European cultivars were imported to meet the export qualifications. The most popular were (i) Bravour: it has curled, high-yielding, winter-resistant, strong-growing variety, upright growth, dark green, finely curled leaves, suited for fresh market and industry; (ii) Xenon: it is very uniform, very curly leaf, dark green color, compact, suited for fresh consumption, processed or industrial and (iii) Moskrul 2-Petra: it is very suitable for forest parsley, finely curled leaves with a beautiful dark green color, produces strong stems (Enza Zaden Company; Bejo Zaden Company).

Today curly parsley is grown for fresh and dry herbs production in Beni Suef and El Minya provinces. However, the government's target is to increase the cultivated areas of spices in newly reclaimed lands for rising production and quality. El-Maghara region at North Sinai Governorate is important newly reclaimed desert land as other several medicinal and aromatic plants successfully cultivated there. The area lies in the northern part of the West Sinai Peninsula between longitude 33° East and latitude 30° North (Osman, 2000; Arab Millennium Ecosystem Assessment, 2006; Osman & Abd El- Wahab, 2009; Hamed, 2011; Abd El-Wahab et al., 2015).

Organic farming is an agricultural system that emphasizes environmental protection and the use of natural farming techniques, in which the use of chemical fertilizers and pesticides is excluded. Organic farmers rely on natural farming methods and modern environmental knowledge to achieve maximum health and preserve the ecosystem to become more sustainable. The yield from organic farming is considered low compared to conventional ones. However, organic products are sold at a higher price than traditional agricultural products, which offsets the high costs of organic production (Morgera et al., 2012; Chandran et al., 2018).

El-Maghara has an arid climate, water resources are supplied from groundwater, rainfall, and flash flood-water. Thus, for successful organic production there, it is necessary to cultivate the appropriate varieties which can tolerate the existing environment. Also, using effective biostimulants is highly required. Extract of *Spirulina platensis* algae regulates and enhances the crop's physiological processes. It acts on the plant physiology through different pathways, improving crop growth, yields, quality, nutrient uptake, and tolerance to abiotic stresses (Abd El-Aleem et al., 2017; Yakhin et al., 2017; Rouphael & Colla, 2018; Ronga et al., 2019).

The current research in this area aims to select the varieties of curly parsley that perform better, foliar spray with concentrations of Spirulina extract as a natural biostimulator for plants, and their interaction to have the highest yield characters.

Materials and Methods

The present study was carried out at the Experimental Field of the Desert Research Center, El-Maghara Region, 30.71º N and 33.33º E, North Sinai Governorate. The experiment was achieved through the two consecutive seasons of 2016/2017 and 2017/2018. The soil properties, well irrigation water analysis, and meteorological data of this site were given (Tables 1, 2, 3 and 4).

The trial was adopted in a split-plot design with three repetitions. The main plots included spray with three aqueous dilutions of *Spirulina platensis* blue green algae extract (0, 5, and 10 ml/liter water), and the sub-plots included the cultivation of three curly parsley varieties (Bravour, Xenon, and Moskrul 2-Petra) (Figure 1). The blue green algae extract

Table 1. The mechanical analysis of the experimental field soil

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

Table 2. The chemical analysis of the experimental field soil

pH	E.C. (ppm)	O.M. (%)	Soluble anions (meq/l)				Soluble cations (meq/l)			
			CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.9	1792	0.5	–	1.0	20.0	7.0	6.0	8.0	12.6	1.4

Table 3. The chemical analysis of irrigation water

pH	E.C. ppm	Soluble anions, meq/l				Soluble cations, meq/l			
		CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.32	2547.15	–	4.26	23.59	11.44	11.45	9.64	17.31	0.89

Table 4. Means of the meteorological data of El-Maghara Region

Months	Average air temperature, °C		Solar, MJ/m^2	Rain fall, mm/day	Wind speed m/s
	Max	Min			
October	29.75	15.49	16.67	0.00	4.15
November	22.53	10.41	13.37	2.94	4.47
December	21.09	9.11	12.02	3.22	4.26
January	20.57	7.04	10.94	9.70	5.11
February	22.20	9.85	14.26	9.05	4.13
March	23.80	8.09	20.03	7.60	3.98
April	27.54	12.70	22.96	0.00	4.39

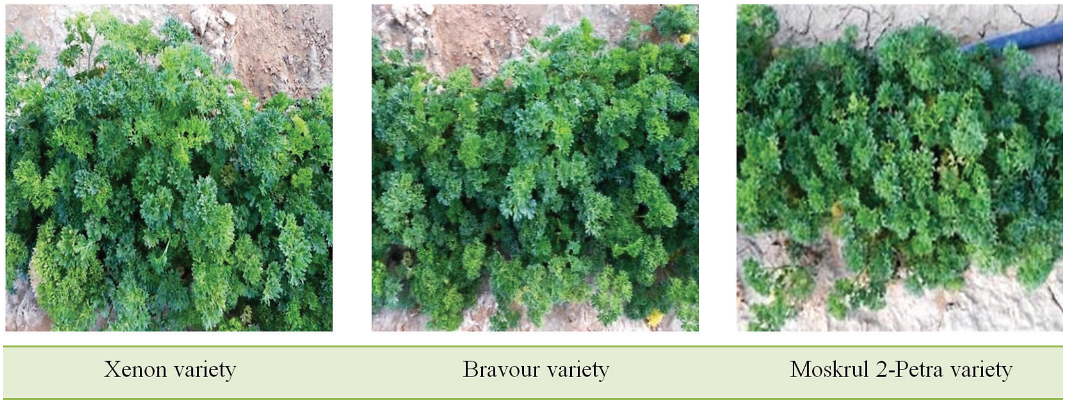

Fig. 1. Cultivated curly parsley varieties

Table 5. The chemical analysis of *Spirulina platensis* extract

N, %	P, %	K_2O, %	Fe, %	Mn, %	Zn, %	Cu, %	Cytokinin, mg/l	Gibberellic acid, mg/l	Auxin, mg/l
4.30	2.15	0.10	2.11	3.04	2.42	0.75	720.00	2729.10	531.58

of Spirulina was provided from Algae Production Unit at the National Research Center, Cairo, Egypt. The chemical analysis of the algae extract was illustrated (Table 5). The seeds of Bravour, and Xenon varieties were imported from Enza Zaden Company, Germany, while the seeds of Moskrul 2-Petra were imported from Bejo Zaden Company, Netherlands.

Compost manure was added to soil at 20 m^3 per feddan. The analysis of applied compost was shown in Table 6. Seeds of the different varieties were sown on November 15th in 2016 and 2017 years under a drip irrigation system in rows 60 cm apart and 30 cm within hills. Spraying with Spirulina extracts was done at the end of January. All organic farming recommendations were followed, according to the conclusions of the Egyptian Ministry of Agriculture and land Reclamation.

The plants were manually harvested on May 8th by cutting the aerial parts at 5 cm height above the soil surface. L.S.D. test at 0.05 was used to compare the average means of treatments (Snedecor & Cochran, 1982). The subsequent measurements were recorded:

A- Growth and yield parameters:

Herb fresh weight/m^2 (kg), herb fresh weight / feddan (ton), herb dry weight/m^2 (kg), and herb dry weight/feddan (ton).

B- Quality parameters:

Total chlorophyll content

Total chlorophyll content of the leaves was taken by using a portable chlorophyll meter of SPAD-502, Minolta, Tokyo, Japan. Total chlorophyll was estimated by this equation: $X = (Y - 8.71)/14.37$ where Y= SPAD reading and X = total chlorophyll as g/kg f.w. (Rodriguez & Miller, 2000).

Essential oil percentage

Essential oil percentage was extracted from the air dried herb by hydrodistillation using a Clevenger apparatus (British Pharmacopoeia, 1963).

Essential oil yield/m^2 (ml)

This was calculated as follows: oil percentage × herb dry weight per m^2 / 100

Essential oil yield per feddan (l):

This was calculated as follows: essential oil yield/m^2 × 4200 m^2

Essential oil composition

GC-MS analysis of essential oils was performed by Gas Chromatography-Mass Spectrometry instrument at the Lab-

Table 6. The chemical analysis of applied compost manure

pH (1:10)	EC (1:10) (ppm)	Weight of m^3, kg	Humidity, %	O.M, %	C/N ratio, %	Ash, %	N, %	P, %	K, %
6.38	4464	655.00	27.00	41.58	1:20.97	58.42	1.15	1.20	0.48

oratory of Medicinal and Aromatic Plants, National Research Center, Egypt with the following specifications. Instrument: a TRACE GC Ultra Gas Chromatographs (THERMO Scientific Corp., USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). The GC-MS system was equipped with a TR-5MS column (30 m x 0.32 mm i.d., 0.25 μm film thickness). Analyses were conducted using helium as carrier gas at a flow rate of 1.3 ml/min at a split ratio of 1:10 and the following temperature program: 80ºC for 1 min; rising at 4ºC/min to 300ºC and held for 1min. The injector and detector were held at 220 and 200ºC, respectively. Diluted samples (1:10 hexane, v/v) of 1 μL of the mixtures were always injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. Identification of the compounds depended on both comparison of the retention times with those of authentic samples, comparing their linear retention indices relative to the series of n-hydrocarbons, and on computer matching against commercial and libraries mass spectra built up from pure substances, components of known oils and MS literature data (Stenhagen et al., 1974; Massada, 1976; Jennings & Shibamoto, 1980; National Committee for Clinical Laboratory Standards, 2002; Adams, 2007; Babushok et al., 2011).

Results and Discussion

I. Effect of blue green algae extract

The influence of different aqueous dilutions of Spirulina extract on plants for both study years is shown in Tables 7, 8, 9 and 10). The results showed that all concentrations had a positive influence on the yield compared to non-sprayed plants. The highest concentration of 10 ml/liter water gave the significantly most increments in the herb fresh and dry weights per square meter and feddan. These values were 1.15, 0.28 kg/m^2 and 4.81, 1.17 ton/feddan. Using the highest concentration also led to the significantly highest increases in chlorophyll content, volatile oil percentage, and the yield of oil per square meter and feddan. These data were 2.02 g/kg f.w., 0.10 %, 0.29 ml/m^2 and 1.23 liter/feddan.

The stimulatory influence of spray with Spirulina extract on plants might be due to its high contents of macro and micro elements, as well as free amino acids. Furthermore, containing natural carotene and xanthophyll phytopigments,

Table 7. Effect of algae extracts concentrations, varieties, and their interaction on herb fresh and dry weights/m^2 (kg) (mean values of 2016/2017 and 2017/2018 seasons)

Varieties / Algae extract concentrations	Herb fresh weight/m^2				Herb dry weight/m^2			
	Bravour	Xenon	Moskrul 2-Petra	Mean	Bravour	Xenon	Moskrul 2-Petra	Mean
0 ml/liter water	0.91	0.87	0.62	0.80	0.23	0.22	0.14	0.20
5 ml/liter water	1.08	1.02	0.76	0.95	0.27	0.25	0.18	0.23
10 ml/liter water	1.26	1.22	0.96	1.15	0.32	0.30	0.22	0.28
Mean	1.08	1.04	0.78		0.27	0.26	0.18	
LSD at 0.05								
Algae extract con.	0.07				0.02			
Varieties	0.07				0.02			
Algae extract con. x Varieties	0.12				0.03			

Table 8. Effect of algae extracts concentrations, varieties, and their interaction on herb fresh and dry weights/feddan (ton) (mean values of 2016/2017 and 2017/2018 seasons)

Varieties / Algae extract concentrations	Herb fresh weight/feddan				Herb dry weight/feddan			
	Bravour	Xenon	Moskrul 2-Petra	Mean	Bravour	Xenon	Moskrul 2-Petra	Mean
0 ml/liter water	3.82	3.65	2.60	3.36	0.97	0.92	0.59	0.83
5 ml/liter water	4.54	4.28	3.19	4.00	1.13	1.05	0.76	0.98
10 ml/liter water	5.29	5.12	4.03	4.81	1.34	1.26	0.92	1.17
Mean	4.55	4.35	3.27		1.15	1.08	0.76	
LSD at 0.05								
Algae extract con.	0.29				0.07			
Varieties	0.29				0.07			
Algae extract con. x Varieties	0.51				0.12			

Table 9. Effect of algae extracts concentrations, varieties, and their interaction on total chlorophyll content (g/kg f.w.) and essential oil percentage (mean values of 2016/2017 and 2017/2018 seasons)

Varieties / Algae extract concentrations	Total chlorophyll content				Essential oil percentage			
	Bravour	Xenon	Moskrul 2-Petra	Mean	Bravour	Xenon	Moskrul 2-Petra	Mean
0 ml/liter water	1.15	1.16	1.12	1.14	0.03	0.14	0.05	0.07
5 ml/liter water	1.71	1.69	1.76	1.72	0.05	0.17	0.06	0.09
10 ml/liter water	2.01	2.02	2.02	2.02	0.05	0.19	0.07	0.10
Mean	1.62	1.62	1.63		0.04	0.17	0.06	
LSD at 0.05								
Algae extract con.	0.07				0.01			
Varieties	n.s.				0.01			
Algae extract con. x Varieties	0.13				0.02			

Table 10. Effect of algae extracts concentrations, varieties, and their interaction on essential oil yield/m^2 (ml) and essential oil yield/feddan (liter) (mean values of 2016/2017 and 2017/2018 seasons)

Varieties / Algae extract concentrations	Essential oil yield/m^2				Essential oil yield/feddan			
	Bravour	Xenon	Moskrul 2-Petra	Mean	Bravour	Xenon	Moskrul 2-Petra	Mean
0 ml/liter water	0.07	0.31	0.07	0.15	0.29	1.30	0.29	0.63
5 ml/liter water	0.14	0.43	0.11	0.23	0.59	1.81	0.46	0.95
10 ml/liter water	0.16	0.57	0.15	0.29	0.67	2.39	0.63	1.23
Mean	0.12	0.44	0.11		0.52	1.83	0.46	
LSD at 0.05								
Algae extract con.	0.05				0.20			
Varieties	0.05				0.20			
Algae extract con. x Varieties	0.08				0.34			

which are the richest natural source of vitamin B-12. In addition to the presence of high levels of various plant hormones such as auxins and cytokinins that are important for raising plant productivity and increasing plant to withstand abiotic stresses (Table 5). These results were in agreement with those reported by Anitha et al. (2016) on *Amaranthus gangeticus*; Khater (2016) on *Cyamopsis tetragonoloba*; Moghith (2016) on *Origanum vulgar*e and El-Mahrouk et al. (2018) on *Cymbopogon citratus*.

II. Effect of varieties

The effect of varieties on the yield characteristics in both seasons is presented in Tables 7, 8, 9 and 10. The results revealed that both Bravour and Xenon varieties gave the highest fresh and dry herb weights per plant and feddan without significant differences in between, whereas Moskrul 2-Petra recorded the lowest yield. These estimates were 1.08 and 0.27 kg/m^2, 4.55 and 1.15 ton/feddan for Bravour variety; 1.04 and 0.26 kg/m^2, 4.35 and 1.08 ton/feddan for Xenon variety. Regarding the aroma concentration, the Xenon variety produced the significantly highest volatile oil percentage, oil content per plant, and oil yield per feddan but both Bravour and Moskrul 2-Petra varieties recorded the lowest readings. The parameters for Xenon variety were 0.17%, 0.44 ml/m^2 and 1.83 liter/feddan while the values were 0.04 and 0.06%, 0.12 and 0.11 ml/m^2 and 0.52 and 0.46 liter/feddan for Bravour and Moskrul 2-Petra, respectively. Concerning the foliage color, there were non-significant differences between the three varieties in total chlorophyll contents.

These differences in yield quantitative and qualitative attributes could be due to the genetic diversity between varieties and environmental conditions. The results were in line with those obtained by Sabry et al. (2013); Abd El-Aleem et al. (2016); Moustafa & Abdelwahab (2016); Hamed et al. (2021) who observed variations in the crop among curly parsley genotypes farmed at numerous areas.

III. Effect of the interaction

Tables 7, 8, 9, 10 and 11 compiled data of the interaction between varieties, and the spray of Spirulina extract concentrations. Both treatments of cultivation Bravour variety combined with a spray of the highest extract concentration at 10 ml/liter and cultivation of Xenon variety combined with a spray of the same rate gave the highest fresh and dry herb weights per plant and per feddan without statistical differences between them. These characters reached 1.26 and 0.32 kg/m^2, 5.29 and 1.34 ton/feddan for Bravour variety; 1.22 and 0.30 kg/m^2, 5.12 and 1.26 ton/feddan to Xenon variety. The other treatments provided lower values. As for volatile oil aspects, the treatment of growing Xenon variety combined with a spray of algae extract at 10 ml/liter had the significantly maximum volatile oil percent, oil content per plant, and oil yield per feddan. These means were 0.19%, 0.57 ml/m^2 and 2.38 liter/feddan. Moreover, the significantly top readings of total chlorophyll contents resulted from treatments of cultivation Xenon, Moskrul 2-Petra, and Bravour varieties with the spray of extract at 10 ml/liter without significant variances among themselves. These photosynthetic pigment values were 2.02, 2.02 and 2.01 g/kg f.w., respectively.

The uneven crop of the previous treatments could be attributed to the interaction between genetically differed va-

Table 11. Chemical constituents (%) of essential oils of the different treatments

No	R.T.	Compound	Spray with spirulina extract at 10 ml/liter water + cultivation of Bravour variety	Spray with spirulina extract at 10 ml/liter water + cultivation of Xenon variety	Spray with spirulina extract at 10 ml/liter water + cultivation of Moskrul 2-Petra variety
1	16.20	Carvone	1.74	10.62	2.35
2	21.05	(-)-Isoledene	0.31	1.52	0.48
3	21.30	Calarene	0.91	2.58	–
4	21.62	Dehydroaromadendrene	0.38	–	0.61
5	21.71	Aromadendrene oxide	–	–	0.58
6	21.82	α-elemene	2.19	4.22	2.19
7	22.90	Isosativene	2.05	3.82	3.28
8	23.45	β-elemene	1.51	2.36	2.16
9	23.54	Isolongifolan-7-ol	0.30	1.01	0.55
10	24.17	α-gurjunene	0.41	0.52	2.68
11	24.50	cis-α-farnesene	0.35	–	0.54
12	24.60	Cycloisolongifolene, 8,9-dehydro	–	–	1.06
13	24.62	α-guaiene	1.09	1.00	–
14	24.66	α-vatirenene	–	–	0.29
15	24.72	β-muurolene	0.46	0.86	2.39
16	24.92	α-longipinene	0.33	0.39	–
17	25.24	Cadinene	1.49	2.05	2.19
18	25.39	α-sesquiphellandrene	3.85	3.92	2.35
19	25.49	β-curcumene	1.65	2.30	0.75
20	25.57	Germacrene-D	–	–	0.54
21	25.71	α-ionone	0.68	0.43	0.52
22	25.93	Spathulanol	3.30	0.55	0.72
23	26.21	α-selinene	2.41	3.55	–
24	26.71	α-bisabolene	0.79	0.81	0.59
25	27.09	δ-cadinene	0.72	2.14	0.95
26	27.52	Globulol	2.01	1.66	2.62
27	28.09	Myristicin	50.49	24.39	37.15
28	28.23	α-ylangene	–	–	0.27
29	28.45	Isolongifolene, 4,5,9,10-dehydro	0.22	–	–
30	28.59	α-calacorene	–	–	0.22
31	28.79	Elemicin	4.18	2.29	3.72
32	28.94	Isolongifolan-8-ol	–	–	3.11
33	28.97	Dihydro-α-agarofuran	2.29	2.45	–
34	29.15	Isoshyobunone	1.00	0.93	–

Table 11. Continued

35	29.78	β-himachalene	0.22	0.90	0.25
36	30.56	Carotol	5.39	8.08	7.83
37	30.92	β-eudesmol	0.32	1.20	0.73
38	31.00	Isolongifolene, 4,5,9,10-dehydro	–	–	0.33
39	31.10	Veridiflorol	0.20	3.47	3.33
40	31.36	Khusinol	–	–	0.91
41	31.37	Isoshyobunone	0.35	0.90	1.88
42	31.46	Cis-isomyristicin	0.29	0.82	–
43	31.62	2-tert-Butyl-4-methoxybenzaldehyde	0.28	–	–
44	32.11	Daucol	–	–	0.40
45	32.52	Cadinol	–	–	0.25
46	32.65	Juniper camphor	0.28	0.81	0.41
47	33.48	Apiole	2.28	0.42	4.80
48	34.50	Ledene alcohol	–	–	0.24
49	35.13	Longipinocarveol, trans-	0.25	–	0.40
50	36.76	Aristolenepoxide	–	–	0.39
51	36.82	Azunol	0.24	–	–
		Total oxygenated compounds	76.09	60.03	74.28
		Total hydrocarbon compounds	21.12	32.94	22.73
		Total identified compounds	97.21	92.97	97.01

* RT= Retention Time

rieties, agriculture processes, and growing conditions that all influenced yield. Cultivation of Xenon variety combined with the highest extract concentration was superior because Xenon variety might be was more adapted than others for the prevailing environmental conditions such as temperature, light, wind speed, irrigation salinity, and soil properties (Tables 1, 2, 3 and 4). Also, the enhancing influence of algae extracts on plants was discused before. Thus, plants produced more growth and secondary metabolites. These results coincided with the investigations of Ibrahem (2000); Abd El-Aleem et al. (2017) and Toaima et al. (2017) on Apiaceae Family plants (Tables 7, 8, 9, 10 and 11).

Regarding volatile oil composition, around 51 compounds were identified by GC-MS analysis in curly parsley essential oil, and its proportions varied according to the different treatments. However, myristcin was the major component and ranged from 24.39 to 50.49%.

The cheif oil constituents of the treatment spray with Spirulina extract at 10 ml/liter + cultivation of Bravour variety were myristcin (50.49%), carotol (5.39%), elemicin (4.18%), α-sesquiphellandrene (3.85%), spathulanol (3.30%), α-selinene (2.41%), apiole (2.28%), dihydro-α-agarofuran (2.29%), α-elemene (2.19%), isosativene (2.05%), globulol (2.01%), carvone (1.74%), β-curcumene (1.65%), β-elemene (1.51%), cadinene (1.49%), α-guaiene (1.09%) and isoshyobunone (1.00%). The major oil ingredients of spraying with Spirulina extract at 10 ml/liter + cultivation of Xenon variety were myristcin (24.39%), carvone (10.62%), carotol (8.08%), α-elemene (4.22%), α-sesquiphellandrene (3.92%), isosativene (3.82%), veridiflorol (3.47%), α-selinene (3.55%), calarene (2.58%), dihydro-α-agarofuran (2.45%), β-elemene (2.36%), β-curcumene (2.30%), elemicin (2.29%), δ-cadinene (2.14%), cadinene (2.05%), globulol (1.66%), (-)-isoledene (1.52%), β-eudesmol (1,20%), isolongifolan-7-ol (1.01%) and α-guaiene (1.00%). Finally oil of spraying with Spirulina extract at 10 ml / liter + cultivation of Moskrul 2-Petra variety contained myristcin (37.15%), carotol (7.83%), apiole (4.80%), elemicin (3.72%), isosativene (3.28%), veridiflorol (3.33%), isolongifolan-8-ol (3.11%), α-gurjunene (2.68%), globulol (2.62%), β-muurolene (2.39%), carvone (2.35%), α-sesquiphellandrene (2.35%), cadinene (2.19%), α-elemene (2.19%), β-elemene (2.16%), isoshyobunone (1.88%) and cycloisolongifolene, 8,9-dehydro (1.06%). The composition of analyzed oils was in harmony with the literature stated by Sabry et al. (2013); Moustafa & Abdelwahab (2016) and Craft & Setzer (2017). Moreover, these results were in the same trend as reported by AHDB (2018) that myristicin content is an essential contributor to parsley aroma, and high content is associated with high-quality fresh herbs. Conditions in the field and ideal light have a large effect on the production of terpene flavor compounds. Cultivar choice is beneficial due to the specific variation in the metabolic pathways of flavor terpenes between varieties.

Thus, the quantity and quality patterns for the previous promising treatments could be summarized as follows:

Spraying with Spirulina extract at 10 ml/liter combined with growing Bravour variety: herb fresh weight/m^2 1.26 kg, herb dry weight/m^2 0.32 kg, herb fresh weight/fed. 5.29 ton, herb dry weight/fed. 1.34 ton, total chlorophyll content 2.01 g/kg f.w., essential oil percentage 0.05%, essential oil yield/m^2 0.16 ml, essential oil yield fed. 0.67 liter, and oil myristcin content 50.49%.

Spraying with Spirulina extract at 10 ml/liter combined with growing Xenon variety: herb fresh weight/m^2 1.22 kg, herb dry weight/m^2 0.30 kg, herb fresh weight/fed. 5.12 ton, herb dry weight/fed. 1.26 ton, total chlorophyll content 2.02 g/kg f.w., essential oil percentage 0.19%, essential oil yield/m^2 0.57 ml, essential oil yield/fed. 2.39 liter, and oil myristcin content 24.39%.

Spraying with Spirulina extract at 10 ml/liter combined with cultivation of Moskrul 2-Petra variety: herb fresh weight/m^2 0.96 kg, herb dry weight/m^2 0.22 kg, herb fresh weight/fed. 4.03 ton, herb dry weight/fed. 0.92 ton, total chlorophyll content 2.02 g/kg f.w., essential oil percentage 0.07%, essential oil yield/m^2 0.15 ml, essential oil yield/fed. 0.63 liter, and oil myristcin content 37.15%.

Many spices have positive effects on human health (Zheng et al., 1992; Piagentini et al., 2002; United States Standards for Grades of parsley, 2007; Lee & Park, 2011; Badr et al., 2013; Abdelfattah et al., 2020; https://myfoodjobrocks.com/parsley/). Thus depending on these data, spraying with Spirulina extract at 10 ml/liter combined with the cultivation of Xenon variety gave the uppermost quantitative and qualitative yield in this region.

Conclusions

It could conclude by the treatment of cultivating Xenon variety and spraying with *Spirulina platensis* extract at the concentration of 10 ml/liter due to several reasons:

It recorded high profitable mass production.

Curly parsley is typically associate with garnish. There is a small debate over the flavor of curled parsley as some claim that no value is added due to insignificant flavor. In contrast, others indicate that it has a strong taste flavor. This debate is likely based on where someone obtains their parsley. The previous treatment recorded the highest volatile oil parameters.

Pigments of total chlorophylls are important in parsley and determine the appearance of both material and its health value. The standard parsley grade should have a rich green color free from yellow or discolored leaves. The former treatment had high chlorophyll content.

Myristicin of parsley oil is an antioxidant, cancer chemopreventive agent, anti-inflammatory, and antimicrobial. The preceding treatment gave the highest oil percent, oil content, and so myristicin content.

References

Abd El-Aleem, W. H., Hendawy, S. F., Hamed, E. S. & Toaima, W. I. M. (2017). Effect of planting dates, organic fertilization and foliar spray of algae extract on productivity of Dutch fennel plants under Sinai conditions. *Journal of Medicinal Plants Studies*, *5 (3),* 327-334.

Abd El-Aleem, W. H., Ramadan, M. E. & Shalaby, O. A. (2016). Effect of magnesium fertilization on growth, yield, chemical composition and essential oils of some new cultivars of parsley under Sinai conditions. *Egyptian Journal of Desert Research*, *66 (2),* 267-286.

Abdelfattah, M. S. , Badr, S. E. A. , Lotfy, S. A. , Attia, G. H., Aref, A. M., Abdel Moneim, A. E. & Kassab, R. B. (2020). Rutin and selenium co-administration reverse 3-nitropropionic acid-induced neurochemical and molecular impairments in a mouse model of Huntington's disease. *Neurotoxicity Research*, *37*, 77-92.

Abd El-Wahab, M. A., Toaima, W. I. M. & Hamed, E. S. (2015). Effect of different planting locations in Egypt on *Salvia fruticosa* Mill. plants. *Egyptian Journal of Desert Research*, *65 (2),* 291-307.

Adams, R. P. (2007). Identification of essential oil components by gas chromatography/Quadrupole mass spectroscopy, 4th ed., Allured Publishing Corporation, Illinois.

AHDB (Agriculture and Horticulture Development Board) (2018). Technical Review: Optimising Flavour in Parsley. UK.

Anitha, L., Bramari, G. S. & Kalpana, P. (2016). Effect of supplementation *of Spirulina platensis* to enhance the zinc status in plants of *Amaranthus gangeticus*, *Phaseolus aureus* and tomato. *Advances in Bioscience and Biotechnology*, *7,* 289-299.

Arab Millennium Ecosystem Assessment, Sinai Subglobal Assessment, El-Maghara, North Sinai, Egypt (2006) Progress Report, October. http://www.millenniumassessment.org/documents_sga/Egypt%20Copy%20of%20Progress%20Report%20October%2006.pdf

Babushok, V. I., Linstrom, P. J. & Zenkevich, I. G. (2011). Retention indices for frequently reported compounds of plant essential oils. *Journal of Physical and Chemical Reference Data*, *40*, 043101-47.

Badr, S. E. A., Sakr, D. M., Mahfouz, S. A. & Abdelfattah, M. S. (2013). Licorice (*Glycyrrhiza glabra* L.): Chemical composition and biological impacts. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, *4*, 606-621.

Bejo Zaden Company. https://www.bejo.com/

British Pharmacopoeia (1963). Determination of volatile oil in drugs. The Pharmaceutical Press, London.

Chandran, S., Unni, M. R. & Thomas, S. (2018). Organic farming: Global perspectives and methods. *Woodhead Publishing*, 436 pp.

Ciju, R. J. (2019). Parsley: Growing practices and nutritional information. Agrihortico, 102 pp.

Craft, J. D. & Setzer, W. N. (2017). The volatile components of parsley, *Petroselinum crispum* (Mill.) Fuss. *American Journal of Essential Oils and Natural Products*, *5(1),* 27-33.

El-Mahrouk, E. M., Abido, A. I., Radwan, F. I., Hamed, E. S. & El-Nagar, E. E. (2018). Vegetative growth and essential oil productivity of lemongrass (*Cymbopogon citratus*) as affected by NPK and some growth stimulators. *International Journal of Botany Studies*, *3 (6),* 48-55.

Enza Zaden Company. https://www.enzazaden.com/

EMAP (2014). https://kenanaonline.com/users/Emap/tags/344799/posts#https://kenanaonline.com/users/Emap/post s/673198

Hamed, A. N. E., Moustafa, Y. M. M., Tawfike, A. F., Bishr, M. M. & Abdelmohsen, U. R. (2021). GC/MS of volatile oils and horticultural characteristics of four curled and non-curled Netherlands' parsley genotypes grown under the conditions of middle Egypt in clay soil for the first time. *Journal of Advanced Biomedical and Pharmaceutical Sciences*, *4,* 7-11.

Hamed, E. S. (2011). Study of the effect of fertilization and irrigation levels on growth, production and chemical contents of *Brassica alba* L. under Sinai conditions. PhD Thesis, Fac. Agric., Kafr El-Sheikh Univ.

Ibrahem, Zahira, T. Z. (2000). Effect of some cultural practices on growth and chemical composition of some medicinal plants under conditions of northern Sinai. PhD Thesis, Fac. Agric. Kafr El-Sheikh, Tanta University., Egypt.

Jennings, W. & Shibamoto, T. (1980). Qualitative analysis of flavor and fragrance volatiles by Glass capillary gas chromatograph. 1st ed., Academic Press, New York.

Khater, R. M. R. (2016). Effect of sowing dates and foliar spray with algae extract on cluster bean (*Cyamopsis tetragonoloba* L.). *International Journal of PharmTech Research*, *9 (9),* 75-84.

Lee, J. Y. & Park, W. (2011). Anti-inflammatory effect of myristicin on RAW 264.7 macrophages stimulated with polyinosinic-polycytidylic acid. *Molecules*, *16 (8),*7132-42.

Massada, Y. (1976). Analysis of essential oils by gas chromatography and mass spectrometry. Illustrated, ed.Wiley & Sons, New York.

Moghith, W. M. A. (2016). Effect of organic and biofertilization on the growth, production and the chemical constituents of *Origanum vulgare* L. plants, MSc. Thesis, Fac. Agric., Tanta Univ., Egypt.

Morgera, E., Caro, C. B. & Durán, G. M. (2012). Organic Agriculture and the Law. FAO, Rome.

Moustafa, Y. M. M. & Abdelwahab, M. A. (2016). Evaluation of four novel imported and Egyptian curly and non-curly leafed parsley genotypes for yield and essential oil composition under the Egyptian sandy soil growing conditions. *Journal of Basic And Applied Research in Biomedicine*, *2 (3),* 345-352.

National Committee for Clinical Laboratory Standards (2002). Performance standards for antimicrobial susceptibility testing. 29th ed., Clinical and Laboratory Standards Institute, Wayne.

Osman, Y. A. H. (2000). Possibility of production of coriander (*Coriandrum sativum* L.) under Sinai conditions. PhD. Thesis, Fac. Agric. Cairo Univ., Egypt.

Osman, Y. A. H. & Abd El-Wahab, M. A. (2009). Economic evaluations for harvesting management of parsley (*Petroselinium sativum crispum* (Mill.) Nym) and dill (*Anethum graveolens* L.) plants under North Sinai conditions. *Research Journal of Agriculture and Biological Sciences*, *5(3),* 218-222.

Piagentini, A. M., Guemes, D. R. & Pirovani, M. E. (2002). Sensory characteristics of fresh cut spinach preserved by combined factors methodology. *Journal of Food Science*, *64 (4),* 1544–1549.

Rodriguez, I. R. & Miller, G. L. (2000). Using a Chlorophyll Meter to determine the chlorophyll concentration, nitrogen concentration, and visual quality of St. Augustine grass., *J. Hort. Science*, *35(4),* 751–754.

Ronga, D., Biazzi, E., Parati, K., Carminati, D., Carminati, E. & Tava, A. (2019). Microalgal biostimulants and biofertilisers in crop productions. *Agronomy*, *9 (192),* 2-22.

Rouphael, Y. & Colla, G. (2018). Synergistic biostimulatory action: Designing the next generation of plant biostimulants for sustainable agriculture. *Frontiers in Plant Science*, *9,* 1655.

Sabry, R. M., Kandil, M. A. M. & Ahmed, S. S. (2013). Comparative study of some parsley cultivars grown in Egypt for some potent compounds. *Journal of Applied Sciences Research*, *9 (10),* 6419-6424.

Snedecor, G. W. & Cochran, W. G. (1982). Statistical methods. The Iowa State Univ. Press, Ames, Iowa, 507 pp.

Stenhagen, E., Abrahamsson, S. & McLafferty, F. W. (1974). Registry of mass spectral data. 12th ed., Wiley & Sons, New York.

Toaima, W. I. M., Osman, Y. A. H. & Hamed, E. S. (2017). Comparative study for the effect of spraying with blue green algae extract on some Russian dill varieties under El-Maghara Region – North Sinai conditions. *Journal of Medicinal Plants Studies*, *5 (2),* 112-119.

United States Standards for Grades of Parsley (2007). Available from: https://www.ams.usda.gov/sites/default/files/media/Parsley_Standard%5B1%5D.pdf

Website. https://myfoodjobrocks.com/parsley/

Yakhin, O. I., Lubyanov, A. A., Yakhin, I. A. & Brown, P. H. (2017). Biostimulants in plant science: A global perspective. *Frontiers in Plant Science*, *7,* 2049.

Zheng, G. Q., Kenney, P. M. & Lam, L. K. T. (1992). Myristicin: a potential cancer chemopreventive agent from parsley leaf oil. *Journal of Agricultural and Food Chemistry*, *40 (1),* 107-110.

Received: December 1, 2020; *Accepted:* June 7, 2020; *Published:* October, 2021