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The impact of sowing date and liquid fertilizer on growth, yield, and bioactive components of parsley plant

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Abstract: The research was conducted in the private farms of Abi Al-Khasib district (Latitude and longitude 30°26'46.9"N (30.4463600°), 47°58'41.3"E (47.9781300°)), Basrah governorate, during the winter growth season of 2023-2024. The experiment aimed to know the effect of sowing dates (1 September, 15 September, and 1 October) on the local parsley cultivar growth, yield, and bioactive products. The parsley plants were then applied with three different concentrations of organic liquid fertilizer (0, 1, and 2 ml L^{-1}). The results showed that the late sowing date had a significant effect on plant height, branch count, leaf content of total carbohydrates and vitamin C, and the percentage of volatile and constant oil. In comparison to the initial sowing date of 1/9, both sowing dates (15/9) and 1/10 demonstrated a substantial increase in the number of leaves, oil density, specific weight, seed yield per plant, and total seed yield. The plants that were treated with 2 ml L^{-1} of liquid fertilizer recorded the highest values more shoots, leaves, total soluble carbohydrates, vitamin C, volatile oil, and a higher specific weight than the plants sprayed with 1 ml L^{-1} of liquid fertilizer. The control and 1 ml L^{-1} treatments were considerably superior in plant height. However, the leaf number, carotene concentration in leaves, seed yield per plant, and total seed yield were in stark contrast. The highest values in the yield of seeds and the total yield of the crop were achieved with a late sowing date of 1/10 and a 2 ml L^{-1} liquid fertilizer application, respectively, at 3.910 g and 0.573 tons ha. The GC-MS analysis revealed the identification of 40 bioactive compounds and the most significant chemical components of the oil. The predominant bioactive compound was 7-octadecanoic acid, methyl ester, with a concentration of 47.21%. D-limonene was the second most important compound, with a concentration of 19.89%.

Keywords: Parsley plant, foliar nutrition, GC-MS device, volatile oil.

Introduction

The parsley (*Petroselinum crispum* Mill.) plant is a biennial winter herbaceous of the Apiaceae family. This plant is considered a salad vegetable and gives food a desirable flavor. It has a good nutritional value. The dry matter percentage in its leaves ranges from 12-20%. The proportion of carbohydrates is 5-7%, proteins 2-4.5%, and fibers 1.5-2% (Bouras *et* *al.,* 2011). This plant is rich in vitamins, especially vitamin C, A, B1, B2, B5, B6, B9, mineral elements K and Ca, and essential oils that cause its distinctive smell because it contains bioactive substances, the most important of which are apiol and myristicin. The parsley is used in alternative medicine, as it helps to facilitate digestion and adjust the acidity of the stomach, which benefits the boiling of its leaves in the treatment of colic, expelling gases and increasing urine output. The volatile oil of this plant also activates sexual ability in men as a diuretic and stimulates blood circulation in women (Bouras *et al*., 2011).

Vokk *et al*., (2011) indicated the essential chemical components of oil in the parsley plant growing in winter and summer in Estonia. The researchers were able to identify 24 bioactive compounds, and myristicin was the dominant compound that ranked first with a percentage of 30.7-42.7%, followed by B-phellandrene with 21.8-35.9%, then P-1,3.8-menthatriene with 5.4-10.0% and B-myrene with a percentage of 5.4-10.0% 4.5-8.7%, respectively. The highest percentage of these compounds was in plants grown in summer. Figueredo *et al*., (2017) noted the chemical components in parsley seed were essential oils consisting of α-pinene at 39.27%, B-pinene at 29.61%, Limonene at 9.73%, myrtenal at 1.82% and sabinene at1.59%.

According to Saqqa *et al*., (2018) the chemical components of the essential oil of the parsley seeds consist of 29 bioactive compounds. The bioactive compound myristicine ranked first with 34.18%, followed by α-pincen with 16.14%, apiol with 15.69% and allyl-2,3,4,5-tetra methoxy, benzene with 9%. Farouk *et al*., (2017) found that the chemical components of the essential oil differed between two varieties of Egyptian and Saudi parsley plants, in which myristicin occupied the highest percentage of 26 and 20%, then B-phellandrene 11 and 17%, respectively.

One of the basic things to increase the growth and yield of parsley plants is choosing the appropriate planting date and considering the agricultural service process, including foliar fertilization. Petropoulos *et al*. (2004) showed that planting date and climatic conditions such as temperature, light and humidity which have a significant effect on the main components of plant oil (Ibrahim *et al*., 2012; Al-Drisi *et al*., 2022). Gruzecki & Salata (2013) when they planted parsley cv. Hamburg on six sowing dates 5/7, 25/8, 5/9, 15/9 and 17/11 for the 2004 growing season and 12/4 in the 2005 growing season, they noticed that plants grown on the mentioned sowing dates differed significantly in the number of leaves. The growing plants on sowing dates 5/7 and 17/11 were significantly superior compared to dates 5/9 and 12/4. While the parsley plants grown on sowing dates 15/9 and 17/11 were significantly superior in leaf weight compared to date 5/7.

Fertilization is also related to an increase in growth indicators, yield and bioactive components of oils, including foliar fertilization with nutritional solutions. Pokhrel (2017) indicated that irrigating parsley plants with a nutritional solution consisting of major and minor elements caused a significant increase in the leaf number and the fresh and dry weight of plants compared to plants irrigated with water only. Massoud *et al*., (2019) noted when spraying parsley plants with a nutrient solution Super Mix that contains minerals and amino acids at a 7 ml L^{-1} for two seasons, it caused a significant increase in plant height in the first cutting of the first season and in the second cutting of the second season. It also showed a significant increase in the total soluble carbohydrates, vitamin C and total chlorophyll in both seasons. The sowing date did not significantly affect the percentage of essential oils for both seasons. Shehata (2019) confirmed that treatment of parsley plants growing in sandy soil with humic acid at a 100 mgL^{-1} with 50% of NPK and seed inoculation before planting with microbial biofertilizers and phosphorine showed a significant increase in plant height, chlorophyll a and b in leaves and their vitamin C content in both seasons. The humic acid treatment at a 200 mgL^{-1}, 75% of the NPK and inoculating the seeds before planting with phosphorine led to a significant increase in the components of the essential oils apiol, myristicin, B-pinene and B-phellandrene. This study was conducted in the absence of previous studies on the effect of sowing date and foliar nutrition on growth, yield and bioactive components of the essential oil of the parsley plant grown in the Basrah governorate in southern Iraq.

Materials & Methods

The experiment was carried out through the winter season of 2023-2024 in Abi Al-Khasib district, Basrah governorate, Iraq. Temperature and air humidity were obtained from the Meteorological Center, Basrah Governorate, Abu Al-Khasib Station, Ministry of Agriculture, Iraq (Table1). The physicochemical properties of the field soil samples were analyzed before starting the experiment (Table 2). The soil of the field was plowed with a tilt plow in an orthogonal manner, with a depth of 30 cm. Then the soil was smoothed and leveled, and decomposed animal manure (cow manure) was added to it at a rate of 24 tons $hectare^{-1}$, after which it was divided into plots length of 3.6 m. Each plot contains ten lines and one line contains 15 plants in one experimental unit. The space between one plant and the other was 16 cm. That is, one hectare contains 146667 plants.

Number of plants per hectare = 8800 x 60÷ 3.6 = 146667 plants

Parsley, a “Local cultivar”, was planted directly on three sowing dates, 1/9, 15/9 and 1/10. Three seeds were placed in one hole and the seeds were covered with a light layer of peat moss. After germination, the plants were thinned to one plant per hole, so the plant density was 146667 plants ha^{-1}. The plants were sprayed with organic liquid university fertilizer at 0, 1, and 2 ml L^{-1} concentrations (Table 3) during the vegetative growth phase one month after sowing the seeds. All agricultural service operations used to produce the crop were carried out, including hoeing, weeding, irrigation and fertilization. Harvesting of the seed crop has been started on the first sowing date from 1-10 March, the second sowing date from 11-20 March, and the third sowing date from 21-31 March.

The studied characteristics:

Plant height (cm); Leaf and branch number per plant; Total soluble carbohydrates (DuBois et al., 1956); Total chlorophyll and carotene, mg $100g^{-1}$ (Goodwin, 1965); Vitamin C, mg $100g^{-1}$ (Kapur *et al*., 2012); Volatile oil (%); Specific weight; Specific density (mg μL^{-1}); Refractive index; Constant oil (%); Seed yield per plant (g); Total productivity of seeds (Ton ha^{-1}).

Table (1): Decimal averages of temperature and relative humidity during the growing season of parsley in the field, Abi Al-Khasib District, Basrah, Iraq

Date	Maximum Temperature (ºC)	Minimum Temperature (ºC)	Maximum Relative humidity (%)	Minimum Relative humidity (%)
1-10/9/ 2023	46.16	24.24	57.35	26.86
11-20/9/ 2023	45.76	23.16	57.86	27.16
21-30/9/ 2023	44.13	22.29	59.57	32.13
1-10/10 2023	41.12	19.95	68.28	35.65
11-20/10/ 2023	40.23	18.34	70.12	38.19
21-31/10/ 2023	39.65	17.46	71.97	37.25
1-10/11/ 2023	39.66	10.67	74.55	42.38
11-20/11/ 2023	31.56	7.26	73.29	45.17
21-30/11/ 2023	27.25	6.72	78.79	49.26
1-10/12/ 2023	23.17	5.89	83.28	54.85
11-20/12/ 2023	20.79	5.21	87.81	57.01
21-31/12/ 2023	19.24	4.43	89.98	59.87
1-10/1/ 2024	18.72	5.47	82.45	43.98
11-20/1/ 2024	17.25	4.15	85.62	41.81
21-31/1/ 2024	20.32	7.26	86.27	48.94
1-10/2/ 2024	21.37	8.32	88.34	43.17
11-20/2/ 2024	20.65	9.08	84.20	36.98
21-29/2/ 2024	23.68	12.87	79.98	32.63
1-10/3/ 2024	21.89	11.65	70.78	31.86
11-20/3/ 2024	23.18	14.76	67.54	27.75

Table (2): Physical and chemical properties of field soil in Abu Al-Khasib.

Property	Value
pH	7.34
E.C.	12.7
O.M (g kg^{-1})	1.92
Calcium (mmol L^{-1})	12.58
Magnesium (mmol L^{-1})	11.65
Total Nitrogen (g kg^{-1})	0.68
Uptake phosphorous (mmol L^{-1})	0.72
Uptake potassium (mmol L^{-1})	1.87
Soil texture	g. kg^{-1}
Sand	27.0
Silt	463.8
Clay	520.2
Texture	Silty clay

GC-MS analysis

Bioactive components analysis was performed using GC device that contacted a Mass Spectrometer (GC-MS) Model: Shimadzu, APAN, GC-MS QP210 Ultra supplied with capillary column DB-MS5 (5%phenyl, 95%methyl polysiloxane) as stationary phase, and using helium gas (99.9%) as the employing phase. The next conditions: Column Oven Temperature: 50°C, Injection Temperature: 280°C, Column flow: 1.00 ml min^{-1}, Split ratio: 30.0, Injection Mode: Direct, Purge flow: 10.0 ml min^{-1}, Pressure: 53.5 kPa, Total flow: 41.0 ml min^{-1}, Linear velocity: 36.3 $cm.sec^{-1}$. The MS: Interface Temp.: 280°C, Ion Source Temp.: 200°C, Detector Gain Mode: Relative, Detector Gain: 0.70 kV +0.00 kV, Start Time: 3.00 min, Solvent Cut Time: 1.00 min, ACQ Mode: Scan, End Time: 50.00 min, Event Time: 0.50 sec, Start m/z: 50.00, End m/z: 800, Scan Speed: 625.

Experimental design and statistical analysis

The experiment was planned with a randomized complete block design. The experiment was factorial with two factors (Al-Mohammadi & Mohammadi, 2012). The first factor included three sowing dates (1/9, 15/9, and 1/10), and the second factor included foliar spraying of parsley plants at 0, 1, and 2 ml L-

[1]concentrations of Universal Liquid Fertilizer (Table 3). Each experimental treatment was repeated three times.

Table (3): The components of the liquid university fertilizer used in the experiment

Metal composition	Value (%)
Nitrogen	5
Phosphorous	5
Potassium	7
Magnesium	0.5
Potassium humate	0.5

Results & Discussion

It is evident from Table 4 that sowing dates had a significant impact on all studied vegetative growth indicators. The plants grown on the sowing date of 1/10 were significantly superior in plant height, with an increase of 20.65 - 25.61%, and in the number of branches, with an increase of 18.47 - 35.10% compared to the dates 1/9 and 15/9, respectively. Whereas, the dates 9/15 and 1/10 were significantly outperformed in the total leaf number compared to the date 1/9, with an increase of 39.3% and 39.88%, respectively. This increase could be attributed to the availability of the appropriate climatic conditions that accompanied the growth of the plant, represented by temperature, light and humidity (Table 1), which directed to an increase in the photosynthesis efficiency process and the collection of metabolic products, which stimulated the increase in cell division and the emergence of new vegetative buds that developed into lateral branches, so the number of leaves increased. The study results are in agreement with those found by Gruszecki & Salata (2013) and El-Zaeddi *et al.,* 2020).

Table (4): Effect of sowing dates and foliar spraying with liquid fertilizer and the interaction between them on some indicators of vegetative growth of parsley plants

Treatments			Plant height (cm)	Leaf number (Leaves plant^{-1})	Branch number (Branches plant^{-1})
Sowing dates		1/9	21.67	17.00	6.33
		15/9	22.56	23.00	7.22
		1/10	27.22	23.78	8.55
L.S.D p≥0.05			1.58	1.74	0.50
Liquid fertilizer concentrations (ml L^{-1})		0	17.67	17.44	6.11
		1	26.11	22.67	7.66
		2	27.67	23.67	8.33
L.S.D p≥0.05			1.58	1.74	0.50
Sowing date × Liquid fertilizer concentration	1/9	0	14.67	16.00	5.66
		1	24.67	16.00	6.33
		2	25.67	19.00	7.00
	15/9	0	16.67	18.33	6.00
		1	25.33	24.67	7.33
		2	25.67	26.00	8.33
	1/10	0	21.67	18.00	6.66
		1	28.33	24.67	9.33
		2	31.67	26.00	9.66
L.S.D p≥0.05			N.S	3.02	0.87

The data from the same table showed that the foliar spraying with liquid fertilizer caused an increase in the examined vegetative growth indicators. Spraying with both concentrations of 1 and 2 ml L^{-1} directed to a significant increase in plant height by 47.77% and 56.59% and in the total leaf number by 29.98% and 35.72%, respectively, compared to the treatment of control. Whereas, spraying with the 2 ml L^{-1} liquid fertilizer directed to a significant increase in the shoot number compared to the control treatment and 1 ml L^{-1} concentration with an increase of 36.33% and 8.75%, respectively. The significant increase may be attributed to the nutrients that the liquid fertilizer contains (Table 3) necessary for plant growth and added by spraying on the leaves, which are the center of many bioactivities (Al-Shater & Al-Balkhi, 2010). These results agree with what was obtained (Pokhrel *et al*., 2017; Massoud *et al*., 2019).

Statistical analysis showed a significant effect on the total number of leaves, as the plants grown on sowing dates 9/15 and 1/10, which were sprayed with liquid fertilizer at a concentration of 2 ml L^{-1}, gave the most number of leaves, amounting to 26.0 leaves. Whereas, the plants grown in 1/10 that were sprayed with liquid fertilizer at 2 ml L^{-1} gave the highest shoot number which reached 9.66 shoots. The plants grown in 1/9 that were not sprayed with liquid fertilizer had the lowest number of leaves and branches, which was 16.0 leaves and 5.66 branches, respectively.

Results of Table 5 revealed that the planting dates had a significant effect on the total carbohydrates and vitamin C of the leaves. The plants grown in 1/10 significantly outperformed the total soluble carbohydrates and vitamin C concentration compared to the sowing dates 1/9 and 15/9 with an increase of (21.35% and 10.44%) and (124.96 and 27.60%), respectively.

The significant increase is attributed to the fact that the plants planted on the sowing date 1/10 were grown under suitable temperatures and air humidity (Table 1), which helped to increase the speed of bioactivities, including the process of photosynthesis (Zehtab *et al*., 2001; Sany *et al*., 2022). While planting dates did not significantly affect the concentration of total chlorophyll and carotene in the leaves.

It also appears from the same table that foliar application with liquid fertilizer significantly affected the chemical components in leaves except for the total chlorophyll concentration. The concentration of 2 ml L^{-1} caused a significant increase in the concentration of total soluble carbohydrates and vitamin C, with an increased rate of (42.52% and 11.61%) and (36.12% and 17.76%) compared to the control and the 1 ml L^{-1} treatments, respectively. While both 1 and 2 ml L^{-1} caused a significant increase in carotene concentration compared to the control treatment with an increase of 9.87% for each. The reason for the significant increase may be attributed to the liquid fertilizer including the major nutrients necessary for plant growth (N, P, K and Mg) as well as humic acid (Table 3), which in turn caused permeability of the cell membranes to facilitate the movement and transfer of nutrients directly to the leaves, which led to Increasing the efficiency of the photosynthesis process and increasing the metabolic products (Halvin *et al*., 2005; Al-Sereh *et al*.; 2020). The findings of this study are in a good agreement with those found by Messoud *et al*., (2019) and Shehata (2019).

The interaction of the two factors also showed a significant effect in all the traits under study with an exception for the total chlorophyll concentration. As the plants grown in 1/10 that were sprayed with liquid fertilizer at a 1 ml L^{-1} had the highest concentration of total soluble carbohydrates that reached 111.05 mg 100 g^{-1}. While the plants grown on 15/9 that were sprayed with liquid fertilizer at a 2 ml L^{-1} recorded the highest concentration of carotene that was 0.094 mg 100 g^{-1}. But the plants grown in 1/10 and sprayed with liquid fertilizer at a 2 ml L^{-1} achieved the highest vitamin C concentration was 35.24 mg 100 g^{-1}. The plants on the date 1/9 that were sprinkled with liquid fertilizer gave the lowest values for total soluble carbohydrates amounted to 72.01 mg 100 g^{-1} and carotene concentration was 0.074 mg 100 g^{-1} the plants on the date 15/9 that were sprayed with liquid fertilizer at a 2 ml L^{-1} gave the lowest concentration of vitamin C which was 13.30 mg 100 g^{-1}.

Table (5): Effect of sowing dates and foliar spraying with liquid fertilizer and the interaction between them on some chemical components of parsley leaves

Treatments			Total carbohydrate (mg $100g^{-1}$)	Total chlorophyll (mg $100g^{-1}$)	Carotene (mg $100g^{-1}$)	Vitamin C (mg $100g^{-1}$)
Sowing dates	1/9		80.16	21.88	0.084	14.18
	15/9		88.08	21.93	0.088	25.00
	1/10		97.28	22.64	0.087	31.90
L.S.D p≥0.05			4.92	N.S	N.S	2.55
Liquid fertilizer concentrations (ml L^{-1})	0		71.72	20.44	0.081	20.21
	1		91.58	22.16	0.089	23.36
	2		102.22	22.85	0.089	27.51
L.S.D p≥0.05			4.92	N.S	0.005	2.55
Sowing date × Liquid fertilizer concentration	1/9	0	72.01	20.79	0.074	14.18
		1	81.59	23.74	0.093	14.35
		2	86.89	21.11	0.083	14.00
	15/9	0	73.25	20.74	0.089	20.88
		1	82.10	20.11	0.081	20.33
		2	108.91	24.92	0.094	13.30
	1/10	0	69.91	19.79	0.079	25.56
		1	111.05	22.63	0.092	34.89
		2	110.87	22.51	0.090	35.24
L.S.D p≥0.05			8.53	N.S	0.007	4.42

Table 6 shows that sowing dates had a significant effect on the oil characteristics of parsley seeds, except for the refractive index. The plants on the date 1/10 was significantly superior in the percentage of volatile oil, with an increase of 18.83% and 8.67% and in the percentage of constant oil with an increase of 12.47% and 7.87% compared to the two sowing dates 1/ 9 and 15/9 respectively. The sowing dates 15/9 and 1/10 was significantly superior to the 1/9 date in the specific weight of the oil with an increase of 0.87% and 1.06%, and in the specific gravity of the oil with an increase of 0.68%, respectively.

The significant increase in the plants of the sowing dates 9/15 and 1/10 may be because these two dates were characterized by a high photosynthesis process efficiency as a result of the availability of all the requirements of this process, which led to the production of high quantities of secondary metabolites, of which oils are one of its types (Mohamed & Al-Younis, 1991; Ibrahim *et al.*, 2012; Al-Drisi *et al.*, 2022).

It appears from the same table that spraying with liquid fertilizer had a significant effect only on the characteristics of the volatile oil and the specific weight of the oil. The spraying with liquid fertilizer at a 2 ml L^{-1} led to significant increase in the volatile oil and the specific weight of the oil with an increase rate of (13.18% and 9.05%) and (0.77% and 0.48%, respectively compared to the control and the 1 ml L^{-1} treatments.

Table (6): Effect of sowing dates and foliar spraying with liquid fertilizer and the interaction between them on some chemical components of parsley seed oil

Treatments			Volatile oil (%)	Specific weight	Specific density (mg µL^{-1})	Refractive index	Constant oil (%)
Sowing dates	1/9		7.91	1.035	1.019	1.518	8.74
	15/9		8.65	1.044	1.026	1.523	9.12
	1/10		9.40	1.046	1.026	1.522	9.83
L.S.D p≥0.05			0.40	0.005	0.003	NS	0.51
Liquid fertilizer concentrations (ml L^{-1})	0		8.19	1.038	1.023	1.521	9.04
	1		8.50	1.041	1.024	1.521	9.40
	2		9.27	1.046	1.023	1.520	9.24
L.S.D p≥0.05			0.40	0.003	NS	NS	NS
Sowing date × Liquid fertilizer concentration	1/9	0	7.61	1.035	1.023	1.523	8.99
		1	7.91	1.036	1.020	1.516	8.87
		2	8.22	1.036	1.015	1.514	8.36
	15/9	0	8.63	1.043	1.024	1.522	9.16
		1	7.89	1.037	1.027	1.523	9.08
		2	9.42	1.057	1.027	1.524	9.11
	1/10	0	8.33	1.037	1.024	1.519	8.98
		1	9.71	1.051	1.026	1.525	10.25
		2	10.17	1.049	1.028	1.522	10.26
L.S.D p≥0.05			0.70	0.005	0.005	NS	0.88

The significant increase may be due to the role of liquid fertilizer in increasing the vegetative growth indicators (Table 4), which positively reflected the increase in the photosynthesis process efficiency and the increase in the formed metabolites, including oils (Al-Jabir *et al*., 2021; Taiz *et al*., 2022). These results are consistent with the results mentioned by Shehata (2019). The interaction of the two factors demonstrated a significant effect on the traits under study except for the refractive index, as the plants grown at the time 1/10 that was sprayed with liquid fertilizer at 2 ml L^{-1} recorded the highest values in the percentage of volatile oil 10.17%, constant oil 10.26% and specific density 1.028 mg µL^{-1}. The plants on date 15/9 that were sprayed with liquid fertilizer at 2ml L^{-1} recorded the highest specific weight of the oil, which was 1.057. As for the lowest values, they appeared in the plants on date 1/9 that were not sprayed with liquid fertilizer, in which the percentage of volatile oil was 7.61% and the specific weight was 1.035. The lowest specific oil density and constant oil (%) in plants on date 1/9 that were sprayed with liquid fertilizer at 2 ml L^{-1} were 1.015 mg µL^{-1} and 8.36%, respectively.

The results from Table 7 show that sowing dates, liquid fertilizer concentrations, and the interaction between them had a significant effect on the plant yield of seeds and total seed productivity. The plants of these two sowing dates 15/9 and 1/10 did not differ significantly in these traits. The reason for this superior increase may be due to the role of both dates in increasing the vegetative growth indicators (Table 4), led to the accumulation of carbohydrates in those plants (Table 5) and their transfer to seeds, which reflected positively on the increase in yield.

It is noted from the same previous table that the concentrations of spraying with liquid fertilizer 1 and 2 ml L^{-1} caused a significant increase in plant yield and total productivity of seeds contrasted to plants that were not sprayed with liquid fertilizer with an increase of 21.14% and 17.49% for each of them, respectively. These two concentrations did not differ significantly. This significant increase may be due to the role of liquid fertilizer in increasing the vegetative growth indicators (Table 4) and the process of carbohydrate accumulation (Table 5), which was positively reflected in the increase in the seed yield of the parsley plant. The data of GC-MS analysis that was conducted on the oil extracted from the seeds of the parsley plant that was planted on the sowing date on September 15 and sprayed with a 1 ml L^{-1} of liquid fertilizer, showed the containing of 40 different bioactive compounds (Fig. 1). Among these bioactive compounds, which were at high levels in parsley seed oil, were 7-Octadecanoic acid, methyl ester and D-Limonene, and the area percentage in these two compounds was about 47.21% and 19.89%, respectively (Table 8).

Table (7): Effect of sowing dates and foliar spraying with liquid fertilizer and the interaction between them on seed yield of parsley plants

Treatments			Seed yield per plant (g)	Total productivity of seeds (Ton ha^{-1})
Sowing dates	1/9		3.101	0.454
	15/9		3.411	0.500
	1/10		3.581	0.524
L.S.D p≥0.05			0.231	0.034
Liquid fertilizer concentrations (ml L^{-1})	0		2.978	0.436
	1		3.617	0.530
	2		3.499	0.512
L.S.D p≥0.05			0.231	0.034
Sowing date × Liquid fertilizer concentration	1/9	0	2.843	0.416
		1	3.173	0.465
		2	3.287	0.481
	15/9	0	3.160	0.463
		1	3.773	0.553
		2	3.300	0.483
	1/10	0	2.930	0.428
		1	3.903	0.572
		2	3.910	0.573
L.S.D p≥0.05			0.401	0.059

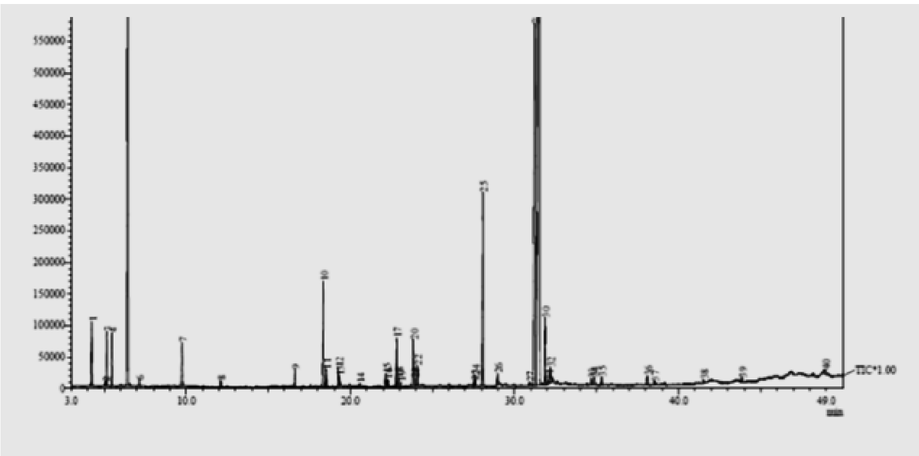

Fig. (1): A bioactive components in oil seeds that identified by GC-Mass device in samples of Abu Al Khasib district, Basrah governorate, southern of Iraq.

Table (8): Diagnosis of bioactive components in the of parsley seed oil

Peak	R Time	Mw	Peak area (%)	Bioactive component
1	4.257	136	0.89	1S-.alpha.-Pinene
2	5.075	136	0.06	beta.-Phellandrene
3	5.173	136	0.83	Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-, (1S)-
4	5.479	136	0.85	Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-, (1S)-
5	6.461	136	19.89	D-Limonene
6	7.146	136	0.10	1,4-Cyclohexadiene, 1-methyl-4-(1-methylethyl)-
7	9.753	150	1.00	6-Butyl-1,4-cycloheptadiene
8	12.104	148	0.17	Propanal, 2-methyl-3-phenyl-
9	16.626	204	0.36	Bicyclo[7.2.0]undec-4-ene
10	18.362	204	2.26	Bicyclo[5.3.0]decane
11	18.541	204	0.35	Naphthalene
12	19.278	192	0.44	1,3-Benzodioxole
13	19.343	214	0.22	Dodecanoic acid, methyl ester
14	20.582	220	0.06	Caryophyllene oxide
15	22.166	150	0.30	6-Butyl-1,4-cycloheptadiene
16	22.280	164	0.17	3-Benzofuranmethanol, 2,3-dihydro-3-methyl-
17	22.832	222	1.10	Apiol
18	22.924	223	0.21	Valeric acid, 4-nitrophenyl ester
19	23.074	222	0.11	.alpha.-Bisabolol
20	23.841	108	1.10	Pyrazine, 2,5-dimethyl-
21	23.913	242	0.14	Methyl tetradecanoate
22	24.076	194	0.45	Cyclododecanone, 2-methylene-
23	27.541	268	0.13	Methyl hexadec-9-enoate
24	27.607	268	0.28	7-Hexadecenoic acid, methyl ester, (Z)-
25	28.080	270	4.53	Hexadecanoic acid, methyl ester
26	28.975	242	0.33	Pentadecanoic acid
27	30.915	350	0.08	Methyl 5,13-docosadienoate
28	31.249	294	12.95	9,12-Octadecadienoic acid, methyl ester
29	31.506	296	47.21	7-Octadecenoic acid, methyl ester
30	31.864	298	1.50	Octadecanoic acid, methyl ester
31	32.063	280	0.10	9,12-Octadecadienoic acid (Z,Z)-
32	32.189	282	0.51	cis-Vaccenic acid
33	34.686	312	0.15	Oxiraneundecanoic acid, 3-pentyl-, methyl ester, cis-
34	34.846	324	0.29	cis-11-Eicosenoic acid, methyl ester
35	35.320	326	0.19	Methyl 18-methylnonadecanoate
36	38.106	352	0.20	Methyl 11-docosenoate
37	38.532	354	0.10	Docosanoic acid, methyl ester
38	41.516	410	0.06	Hexacosanoic acid, methyl ester
39	43.854	618	0.10	Tetratetracontane
40	48.927	296	0.26	E,E,Z-1,3,12-Nonadecatriene-5,14-diol

The detection of bioactive components differed from one medicinal plant to another, as well as the difference in their levels in a single plant, and this is due to the genetic variations among them which makes each plant have its important health and medical side that distinguishes it from the rest of the other plants according to the bioactive compounds that it produces (Al-Jabir *et al.,* 2020; 2021; Ibrahim, 2022).

Conclusion

It is concluded from this study that the cultivation of parsley plants under the conditions of the city of Basrah in southern Iraq on the sowing dates of 15th September and 1st November and spraying them with liquid fertilizer 1 ml L^{-1} improved the vegetative growth of the plant, increased the yield of seeds and improved the bioactive components in the plants.

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Contributions of Authors

H.S.S.A: Collection of samples, Laboratory techniques, wrote and revised the manuscript.

M.A.I: Suggestion the proposal of the article wrote and revised the manuscript.

A.A.A: Suggestion the proposal of the article, wrote the manuscript.

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Conflicts of interest

The authors declare that they have no conflict of interests.

Ethical approval

All ethical guidelines related to Medicinal plants issued by national and international organizations were implemented in this report.

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تأثير موعد الزراعة والسماد السائل على النمو والإنتاجية والمكونات الفعالة حيويا لنبات المعدنوس

حيدر صبيح شنو الجابر[1] و ماجد عبد الحميد ابراهيم[2] وعبد الله عبد العزيز عبد الله[3]

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المستخلص: أُجري البحث في المزارع الخاصة في قضاء أبي الخصيب على خط عرض وطول 30°26'46.9" شمالاً (30.4463600°)، 47°58'41.3" شرقاً (47.9781300°) في محافظة البصرة، خلال موسم النمو الشتوي 2023–2024. وهدفت التجربة إلى معرفة تأثير مواعيد الزراعة (1 أيلول، 15 أيلول، 1 تشرين الأول) على نمو صنف المعدنوس المحلي والغلة والمكونات الفعالة حيوياً. ثم رشت نباتات المعدنوس بثلاثة تراكيز مختلفة من السماد السائل العضوي (0، 1، 2 مل لتر$^{-1}$). أظهرت النتائج أن موعد الزراعة المتأخر أثر معنوياً على ارتفاع النبات وعدد الأفرع ومحتوى الأوراق من الكربوهيدرات الكلية وفيتامين ج ونسبة الزيت الطيار والثابت بالمقارنة مع موعد الزراعة الأول في (1 أيلول). أظهر كل من موعدي الزراعة 15 أيلول و1 تشرين الأول هناك زيادة كبيرة في عدد الأوراق وكثافة الزيت والوزن النوعي وإنتاجية البذور لكل نبات وإنتاجية البذور الكلية. وسجلت النباتات المعاملة بـ 2 مل لتر$^{-1}$ من السماد السائل أعلى القيم من حيث عدد الافرع والأوراق والكربوهيدرات الكلية الذائبة وفيتامين ج والزيت الطيار ووزن نوعي أعلى في النباتات التي تم رشها بـ 1 مل لتر$^{-1}$ من السماد السائل. كانت معاملة السيطرة ومعاملة 1 مل لتر$^{-1}$ متفوقة بشكل كبير في ارتفاع النبات. ومع ذلك، كان عدد الأوراق وتركيز الكاروتين في الأوراق وإنتاجية البذور لكل نبات وإنتاجية البذور الكلية متناقضين تمامًا. تم تسجيل أعلى القيم في إنتاج البذور لكل نبات والإنتاجية الكلية للمحصول عند موعد الزراعة المتأخر 10/1 ومعاملة السماد السائل بتركيز 2 مل لتر$^{-1}$ التي بلغت 3.910 غم و0.573 طن هكتار$^{-1}$ على التوالي. وقد كشف تحليل GC–MS عن وجود 40 مركباً فعالاً حيوياً وأهم المكونات الكيميائية للزيت. وكان المركب الحيوي النشط السائد هو حامض 7–أوكتاديكانويك، ميثيل إستر، بتركيز 47.21%. وكان د–ليمونين ثاني أهم مركب بتركيز 19.89%.

الكلمات المفتاحية: نبات المعدنوس، التغذية الورقية، جهاز GC–MS، الزيوت الطيارة.