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Vegetative growth characters, yield and chemical composition of *Anthriscus cerefolium* plants grown under Egyptian conditions on different sowing dates

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Two field experiments were conducted during two successive seasons of 2016/2017 and 2017/2018 at a private farm in Abo El matamer, El-Beheira governorate, Egypt. The objective of this study was to determine the appropriate planting date for chervil plant under the Egyptian environmental conditions as a new imported plant. The impact of four different dates (15th Sept., 1st Oct., 15th Oct., and 1st Nov.) were studied on vegetative growth, yield and chemical composition of *Anthriscus cerefolium* plants. The results of the two studied seasons revealed that the effect of sowing dates was significant on plant height, herb fresh weight per plant and per feddan, herb dry weight per plant and per feddan, root length, root fresh weight per plant and per feddan, root dry weight per plant and per feddan, total chlorophyll, nitrogen, phosphorus and potassium percentage, essential oil percentage, essential oil content per plant and yield per feddan for aerial parts of chervil plants in the first and second seasons, respectively. The greatest vegetative growth, yield and chemical composition of *Anthriscus cerefolium* plant were obtained when plants were sown on 1st Oct. The main component of *Anthriscus cerefolium* essential oil was Methyl eugenol and the sowing date of 1st Oct recorded the maximum percent of it compared with sowing date of 1st Nov. Therefore, after this study, it appears that the best date to cultivate *Anthriscus cerefolium* plant as a new imported plant under mentioned location under Egyptian environmental condition is 1st Oct then followed by 15th Oct., 15th Sept and 1st Nov, respectively.

Keywords: Sowing date, *Anthriscus cerefolium*, vegetative growth characters, essential oil yield, and essential oil constituents.

INTRODUCTION

The family of Apiaceae is fine known as a source of essential oils and many of its species are especially cultivated for it, like *Pimpinella anisum, Coriandrum sativum, Petroselinum crispum, Levisticum officinale* and *Anthriscus cerifolium.* The *Anthriscus cerifolium* (chervil) is native to the Caucasus and was spread by the Romans through most of Europe, where it is now naturalized (Vaughan et al., 1997). The chervil plants generally grow to be about 50 cm in height and have an erect, branched, and hollow stem. The leaves are first light green in color and then as they become mature, they turn reddish-brown (Allakhverdiev et al., 2000). Leaves of the *Anthriscus cerifolium* are nearly always used fresh but can bepreserved by deep freezing or by making a pesto-like preparation. The plant contains essential oil with methyl chavicol (estragol) as the main constituent and is popular

in Central and Western Europe. Because of its resemblance to the myrrh given to Jesus and as well as the way it symbolized new life, it became traditional to servechervil soup on Holy Thursday. Its herb is an interesting and generally characterized by strong and unique flavor compounds and in some cases providing important nutrients which can enrich the consumer's diet. Moreover, it is commonly used to season mild-flavoured dishes and is a constituent of the French herb mixture fines herbs. It is a good source of antioxidants that stabilize cell membranes and reduce inflammation associated with headache, sinusitis, peptic ulcer, and infections. The essential oil contains estragole (as does tarragon and basil) plus anethole. The leaves contain a fixed oil, high concentrations of potassium and calcium and apiin-a glycoside. The characteristic constituents of *Anthriscus cerefolium* were investigated for free radical scavenging effects (Feijes et al., 2003). Flavonoids from the herb and lignans from the root showed strong free radical quenching activity. The identification of the constituents of the extracts indicated that apiin is the main flavonoid, deoxypodophyllo toxin the major lignan, and methyl chavicol the predominant constituent of the essential oil (Feijes et al., 2003) A comparative study of the essential oil from the different plant parts of the plant collected in the urban area of Vienna showed that the essential oils of were dominated by estragole (methyl chavicol) and 1-allyl-2,4dimethoxybenzene, their content varying in the different samples. Thus, while the oils from young flowering plants contained more estragole than 1allyl-2,4-dimethoxybenzene, the fruits from one of the studied locations reached 95% estragole in the essential oil (Chizzola 2011). Another study has shown that the four main components of the wild growing plant in Turkey are methyl chavicol (83.10%), 1-allyl-2,4-dimethoxybenzene (15.15%), undecane (1.75%) and β-pinene (<0.01%) (Baser, *et al*., 1998). El Gendy *et al* (2015) found that the major components of chervil plant essential oil were methyleugenol (37.3–62.03%), estragole (14.74–26.43%) and 2-allyl-1,4-dimethoxybenzene(4.94–9.48%). It seemed that, the content and composition of the essential oil in chervil plant is determined by many factors such as stage of growth, location and date of sowing…etc. Sowing date is very vital and this is one of the important factors for obtaining maximum yield in plants and affecting oil compositions. Effect of environmental factors on plant physiological steps causes the sowing date to vary significantly from one area to another or even in an area depending on genetic differences (Hadley and Summer, 1983 and Sandhu, 1984). Therefore, in this study the variation in essential oil composition as well as vegetative growth and yield prameters of *Anthriscus cerifolium* plant grown in different sowing dates were studied to reach the best sowing date under the Egyptian environmental conditions for this new import plant.

MATERIALS AND METHODS

Two field experiments were carried out at a private farm in Abo El matamer, Beheira governorate, Egypt. chervil seeds were planted in four different dates (15th Sept., 1st Oct., 15th Oct., and 1st Nov.) in two seasons of 2016/2017 and 2017/2018 to determain the best sowing date under the Egyptian environmental conditions for chervil plant as a new import plant. The experimental layout was randomized complete block design (RCBD) with three replications. Distances between rows and within plants in row were 30 and 15 cm, respectively. Drip irrigation system was applied. Fertilization and other agricultural practices were applied as commonly recommended in commercial chervil production. Prior to planting, soil samples from the experimental field location were selected, randomly and analyzed according to Jackson (2005) during both seasons to determine both chemical and physical properties (Table 1).

Table 1: Physical and chemical analyses of the experimental site during 2016/2017 and 2017/2018 seasons.

		2016/2017	2017/2018
	Physical analysis		
	Clay (%)	30	38
	Silt (%)	52	45
`	Sand (%)	18	17
	Texture class	**Loomy clay sandy**	**Loomy clay sandy**
	Chemical analysis		
	EC (dSm^{-1}) *	1.27	1.35
	pH **	8	8.2
	$CaCO_3$ (%)	3.42	3.47
	HCO_3($meql^{-1}$)	2.8	3.1
	N (ppm)	60	73
	p (ppm)	64	66
	K (ppm)	410	400
	Ca (meql-1)	6	6.2
	Na ($meql^{-1}$)	1.83	1.92
	Cl ($meql^{-1}$)	0.92	0.87
	Mg ($meql^{-1}$)	3.45	3.69
	SO_3 ($meql^{-1}$)	0.28	0.30

*measured in the saturated soil paste extract, **measured in 1:2.5 Soil: water suspension, O.M: Organic Matter.

Table 2: The maximum, minimum air temperatures (C°) , relative humidity (%) , rain (mm / day) and day Length (hour) in Behiera location during two growing seasons of 2016/2017 and 2017/2018.

Date	2016-2017					2017-2018				
	Temperature (°C)		Relative humidity %	Rain /(mm day)	Day Length (hour)	Temperature(°C)		Relative humidity	Rain /(m day)	Day Length (hour)
	Max	Min				Max	Min			
01/09 : 15/09	31.6	24.1	49.8	0.0	12:28	31.5	23.3	48.1	0.0	12:26
16/09 : 30/09	30.3	23.2	49.2	0.0	12:06	29.8	22.7	52.5	0.0	12:07
01/10 : 15/10	29.7	21.9	52.7	0.1	11:42	27.3	20.9	57.3	0.0	11:45
16/10 : 31/10	26.6	23.7	62.3	1.0	11:24	26.7	19.6	57.1	0.0	11:25
01/11 : 15/11	25.0	18.8	59.0	0.3	11:03	24.0	17.6	59.1	0.2	11:03
16/11 : 30/11	23.3	17.3	58.4	2.5	10:48	21.9	16.3	65.5	1.7	10:48
01/12 : 15/12	19.7	14.8	68.8	1.3	10:38	21.1	15.4	69.4	0.2	10:36
16/12 : 31/12	17.0	12.4	66.3	0.1	10:33	20.0	14.8	67.2	0.2	10:35
1/01 : 15/01	16.4	10.4	64.1	0.2	10:40	19.2	13.0	68.9	1.6	10:40
16/01 : 30/01	17.6	11.7	68.4	0.1	10:56	17.4	12.4	66.0	1.0	10:52
01/02 : 15/02	17.7	10.8	65.9	0.2	11:11	20.2	13.3	65.6	0.5	11:11
16/02 : 28/02	17.3	11.1	62.6	0.1	11:30	19.3	12.4	58.7	0.2	11:27
01/03 : 15/03	20.6	12.8	58.2	0.0	11:46	23.5	14.0	49.2	0.0	11:49

The maximum, minimum air temperatures (°C) , relative humidity (%) , rain amount (mm / day) and day length (hour) in Behiera location during two growing seasons of 2016/2017 and 2017/2018 acording to Meteorological data from Central Lab. for Agricultural Climate, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt. (Table 2).

Plant material

Seeds of *Anthriscus cerefolium*. (chervil) were imported from Enza Zaden company in North Holland. Seeds were cultivated in different four dates (15th Sept., 1st Oct., 15th Oct., and 1st Nov.) of 2016 and 2017 and the grown plants were harvested on 15th Mar. of 2017 and 2018 for the first and second seasons, respectively.

Plant measurements

After the chervil plants harvest, some parameters were recorded to achieve the objectives of this experiment for measuring characters of plant growth, yield and chemical composition of chervil plants. These parameters were measured as follows : For each treatment, fifteen plants for every sowing date were randomly chosen (five plants per block).

1: Plant height (cm).

2: Herb fresh weight per plant (g/plant) and per feddan (ton/fed)

3: Herb dry weight per plant (g/plant) and per feddan (kg/fed)

4: Root length (cm).

5: Root fresh weight per plant (g/plant) and per feddan (ton/fed)

6: Root dry weight per plant (g/plant) and per feddan (kg/fed)

7: Total chlorophyll content (SPAD unit) was quantified using a SPAD-502 Chlorophyll Meter (Minolta Camera Co., Ramsey, NJ).

8: Nitrogen percentage (N) in leaves were determined by micro kjeldahl method according to Page *et al*. (1982).

9: Phosphorus percentage (P_2O_5) in leaves was determined colorimetrically as reported by Jackson (1973).

10: Potassium percentage (K_2O) in leaves was determined by atomic absorption spectrophotometry following the method was described by Ghosh *et al*. (1983).

11: Essential oil extraction:

Essential oils were extracted from herb of each sowing date by water distillation using Clevenger apparatus for 2 h according to Guenther 1961 expressed as ml/100g, while essential oil yield was expressed as ml/plant and l/fed.The extracted essential oil was dehydrated over anhydrous sodium sulphate and stored at freezer till used for gas chromatography-mass spectrometry (GC-MS) analysis.

12: Gas chromatography–mass spectrometry analysis (GC-MS)

The GC-MS system (Agilent Technologies) was equipped with gas chromatograph (7890B) and mass spectrometer detector (5977A) at Central Laboratories Network, National Research Centre, Cairo, Egypt. Samples were diluted with hexane (1:19, v/v). The GC was equipped with HP-5MS column (30 m x 0.25 mm internal diameter and 0.25 µm film thickness). Analyses were carried out using helium as the carrier gas at a flow rate of 1.0 ml / min at a split ratio of 10 : 1, injection volume of 1 µl and the following temperature program: 40 °C for 1 min; rising at 4 °C /min to 150 °C and held for 6 min; rising at 4 °C/min to 210 °C and held for 1 min. The injector and detector were held at 280 °C and 220 °C, respectively. Mass spectra were obtained by electron ionization (EI) at 70 eV; using a spectral range of m/z 40-550 and solvent delay 3.7 min. Identification of different constituents was determined by comparing the spectrum fragmentation pattern with those stored in Wiley and NIST Mass Spectral Library data.

13: Simple correlation coefficients among each of herb fresh weight (ton/fed), fresh weight (ton/fed) and essential oil yield per feddan (l/fed) and each of various studied characters.

14: Simple Regression analysis among each of herb fresh weight (ton/fed), fresh weight (ton/fed) and essential oil yield per feddan (l/fed) and each of various studied characters.

Statistical analysis:

Analysis of variance with SAS software (SAS Institute, 1988) was carried out on the test treatments data. Treatments' means were compared using the LSD test at 5% level of probability. The experiment was repeated in the second year at the same site using the same steps and techniques of the first year to compare the results of the two successive seasons.

RESULTS AND DISCUSSION

Effect of sowing date on plant height of chervil:-

The culture of chervil seeds in different sowing dates was able to influnce on plant height

in both seasons, respectively (Table 3). The maximum plant height (21.60 and 24.00 cm) was found with the second sowing date of 1st Oct for the first and second seasons, respectively with insignificant differences between the first, second and third sowing date in both seasons, respectively. From the other hand the significant shortest chervil plants (13.60 and 15.50 cm) were found with the fourth sowing date in the first and second seasons, respectively.

Effect of sowing date on herb fresh weight of chervil plants:-

Based on the analysis of variance for herb fresh weight per plant and per fed, the results revealed the absence of significant differences among the first, second and the third sowing dates regarding herb fresh weight per plant and also between second and third sowing dates with the herb fresh weight per feddan in the first seasons, respectively. Moreover, the maximum herb fresh weight per plant (312.00 and 290.01 g/plant) and per fed (29.12 and 27.06 ton/fed) were found with chervil plants cultured in the second sowing date. From the other hand, the minimum values of herb fresh weight per plant (63.33 and 68.83 g/plant) and per fed (5.91 and 6.42 ton/fed) in the first and second season, respectively were recorded with the fourth sowing date (Table 3).

Effect of sowing date on herb dry weigh of chervil plants:-

The highest herb dry weight per plant (30.33 and 29.17 g/plant) and per fed (2830.8 and 2722.2 kg/fed) in the first and second season, respectively were recorded with the second sowing date. Insignificant differences were recorded in herb dry weight per plant between second and third sowing dates in the first season. In addition, there were not significant differences found between the first and third sowing dates concerning herb dry weight per plant and per feddan feddan in the second season. The minimum herb dry weight per plant (12.07 and 13.50 g/plant) and per fed (1126.5 and 1259.9 kg/fed) in the first and second season, respectively were recorded with the fourth sowing date (Table 3).

Effect of sowing date on root length of chervil plants:-

The results in the table (3) showed that, first, second and third sowing date outperformed the fourth sowing date Moreover, the longest roots (12.97and 10.53cm) were observed with the chervil plants cultured in the second sowing date, while, the shortes chervil roots (5.27and 5.17 cm) were found with those cultured in the fourth sowing date in both seasons, respectively.

Table 3: effect of planting date on plant height, plant fresh weight , plant dry weight, root length, root fresh weight, root dry weight of chervil plant during two seasons.

Treatments	Plant height (cm)		Herb fresh weight (g/plant)		Herb dry weight (g/plant)	
	First season	Second season	First season	Second season	First season	Second season
First date	20.20	21. 53	240.00	226.67	22.83	21.30
Second date	21.60	24.00	312.00	290.01	30.33	29.17
Third date	21.43	24.00	280.00	213.31	29.83	21.50
Fourth date	13.60	15.50	63.33	68.83	12.07	13.50
L.S.D.	3.71	2.55	99.08	20.42	3.2925	1.9652
Treatments	**Herb fresh weight (ton/fed)**		**Herb dry weight (kg/fed)**		**Root length (cm)**	
	First season	Second season	First season	Second season	First season	Second season
First date	22.4	21.15	2130.8	1987.9	10.83	9.08
Second date	29.12	27.06	2830.8	2722.2	12.97	10.53
Third date	26.13	19.91	2784.1	2006.6	12.50	8.07
Fourth date	5.91	6.42	1126.5	1259.9	5.27	5.17
L.S.D.	9.24	1.93	307.29	183.41	1.89	1.12

Effect of sowing date on root fresh weigh of chervil plants:-

It was found from table (4) that the differences between some sowing dates were significant. In addition, the greatest root fresh weight per plant (40.67 and 56.17 g/plant) and per fed (3.80 and 5.24 ton /fed) in the first and second seasons, respectively were found in the second sowing date. On the contrary, the significant minimum root fresh weight per plant (30. 41 and 21. 60 g/plant) and per fed (2.84 and 2.02 ton/fed) were noticed with the fourth sowing date in the first and second season, respectively. Insignificant differences were found with the first, second and third sowing date in the first season.

Effect of sowing date on root dry weigh of chervil plants:-

Regarding both studied seasons, respectively the maximum values of root dry weight per plant (5.45 and 6.07 g/plant) and per fed (508.67 and 566.53 kg/fed), respectively were found with the second sowing date both. Conversely, the minimum value of root dry weight per plant (2.65 and 2.28 g/plant) and per fed (247.33 and 212.80 kg/fed), respectively were observed with the fourth sowing date (Table 4).

Effect of sowing date on total chlorophyll content in chervil leaves:-

The results of total chlorophyll content in the first season showed insignificant differences between the second and third studied sowing dates. The maximum total chlorophyll content (31.50 and 32.11spad unit) were observed with the plants that were sown in the second sowing dates in the first and second seasons, respectively. Furthermore, the lowest significant chlorophyll content (14.30 and 12.73 SPAD unit) were measured with the chervil plants cultured in the fourth sowing date in the first and second seasons, respectively (Table 4).

Table 4: effect of planting date on root fresh weight, root dry weight, total chlorophyll (spad unit) of chervil plant during two seasons.

Treatments	Root fresh weight (g/plant)		Root dry weight (g/plant)		Root fresh weight (ton/fed)	
	First season	Second season	First season	Second season	First season	Second season
First date	38.17	33.01	2.78	3.18	3.56	3.08
Second date	40.67	56.17	5.45	6.07	3.80	5.24
Third date	38.67	40.01	3.60	4.83	3.61	3.73
Fourth date	30. 41 B	21. 60	2.65	2.28	2.84	2.02
L.S.D.	5.04	3.93	0.48	1.15	0.47	0.36

Treatments	Root dry weight (kg/fed)		Total chlorophyll (spad unit)	
	First season	Second season	First season	Second season
First date	259.47	296.80	24.67	25.67
Second date	508.67	566.53	31.50	32.11
Third date	336.00	450.80	31.17	29.01
Fourth date	247.33	212.80	14.30	12.73
L.S.D.	45.2	107.6	2.11	1.71

Effect of sowing date on NPK percent in chervil leaves:-

The plants sown in the second sowing date had the highest level of nitrogen (2.31 and 2.39 %), phosphorus (0.50 and 0.52%) and potassium percentage (2.49 and 2.64%). Moreover, the differences between the all sowing date were insignificant in both seasons, respectively regarding potassium percentage and the same situation was observed in nitrogen, phosphoure percentage in the first season only. From the other hand, the lowest percentage of nitrogen (1.97 and 1.95%), phosphoure (0.41 and 0.46 %) and potassium percentage (2.36 and 2.30 %) were recorded with the fourth sowing date compared with all other studied sowing dates in the first and second seasons, respectively (Table 5).

Effect of sowing date on oil content in chervil herb:-

The essential oil percentage, content per plant and yield per feddan for aerial parts of chervil plants were affected with the application of different sowing dates treatments. Moreover, the maximum values of essential oil percentage (0.20 - 0.21%), content per plant (0.063 and 0.062 ml/plant) and yield per feddan (5.83 and 5.81 l/fed) were found with the application of the second sowing date. Contrariwise, the minimum values of essential oil percentage (0.14 - 0.13 %), content per plant (0.017 and 0.018 ml/plant) and yield per feddan (1.58 and 1.67 l/fed) were found with the application of the fourth sowing date. values of essential oil percentage (0.20 - 0.21%), content per plant (0.063 and 0.062 ml/plant) and yield per feddan (5.83 and 5.81 l/fed) were found with the application of the second sowing date. (Table 5).

Table 5: **Effect of planting date on nitrogen, phosphoure and potassium percentage of leaves, essential oil percentage, essential oil content (ml/plant) and essential oil yield (l/fed) of chervil herb during both seasons.**

Treatments	**Nitrogen** (N) **%**		**Phosphoure** (P_2O_5)**%**		**Potassium** (K_2O)**%**	
	First season	Second season	First Season	Second season	First season	Second season
First date	2.21	2.19	0.47	0.46	2.33	2.27
Second date	2.31	2.39	0.50	0.52	2.49	2.64
Third date	2.17	2.18	0.49	0.49	2.45	2.47
Fourth date	1.97	1.95	0.41	0.46	2.36	2.30
L.S.D.	0.603	0.369	0.11	0.06	0.27	0.44
Treatments	**Essential oil %**		**Essential oil content (ml/plant)**		**Essential oil yield (l/fed)**	
	First season	Second season	First season	Second season	First season	Second season
First date	0.19	0.18	0.043	0.038	3.97	3.58
Second date	0.20	0.21	0.063	0.062	5.83	5.81
Third date	0.18	0.19	0.054	0.040	5.01	3.74
Fourth date	0.14	0.13	0.017	0.018	1.58	1.67
L.S.D.	0.02	0.02	0.003	0.00475	0.28	0.44

Effect of sowing date on essential oil composition of chervil herb:-

Data presented in table (6) pointed out variable changes in the relative percentages of different ingredients which constituted the main constituents of essential oil distilled from chervil herb under different treatments. Data presented in table (6) pointed out variable changes in the relative. It can be remarked that about 4 main compounds were identified from essential oil of herb underwent at two different sowing dates treatments that represented 98.05 – 100% of the oil. It can be noticed that total identified hydrocarbon compounds ranged from 0.79 to 1.17 % against total identified oxygenated compounds which ranged from 96.88 to 99.21 %. The total oxygenated compounds were superior comparing with hydrocarbon compounds under all treatments. The first major compound is Methyl eugenol (66.5- 67.41%) followed by Estragole (24.94- 29.84%). The maximum relative pronounce of methyl eugenol was obtained under the second sowing date while the maximum relative pronounce of estragole was obtained under the fourth sowing date.

Effect of sowing date on simple correlation coefficients of various characters among herb fresh weight (ton/fed), root fresh weight (ton/fed) and oil yield per feddan :-

The data regarding the simple correlation coefficient over two seasons are given in table 6. It is evident the associations between characters could of a benefit in understanding the influence of different sowing dates in chervil fresh herb, fresh root and essential oil yield per feddan.

The simple correlation coefficient of each of chervil fresh herb, fresh root and essential oil yield per feddan was positive and high significant correlated with all studied prameters except some of them as sown.

The correlation coefficient between herb fresh weight yield per feddan and each of phosphorus percentage in the first season and essential oil percentage in the second season was positive and significant. While it was positive and insignificant between herb fresh weight yield per feddan and each of nitrogen percentage and essential oil percentage in the first season, phosphorus percentage in the second season and potassium percentage in both seasons, respectively.

The relationship between root fresh weight per feddan and all of root dry weight per plant and per feddan in the first season and phosphorus percentage in the second season was positive and significant. From the other hand the relationship was positive and insignificant between root fresh weight per feddan and all each of nitrogen percentage and phosphorus percentage in the first season as well as potassium percentage and essential oil percentage in both seasons, respectively.

Regarding the simple correlation coefficient between essential oil yield per feddan and each of essential oil percentage in the first season and nitrogen percentage in the second season was positive and significant. From the other hand, it was positive and insignificant between essential oil yield per feddan and each of root dry weight per plant and per feddan and nitrogen percentage in the first season, phosphorus percentage in the second season and potassium percentage in both seasons, respectively.

Table (6) : The relative percentage of main components of chervil essential oil under the 2nd and 4th sowing dates.

RT		Components	Formula	The relative percentage of main components	
				2nd sowing date	4th sowing date
1	17.251	Estragole	$C_{10}H_{12}O$	24.94	29.84
2	17.945	cis-2-Nonene	C_9H_{18}	1.17	0.79
3	23.802	2-Allyl-1,4-dimethoxybenzene	$C_{11}H_{14}O_2$	4.53	2.87
4	24.269	Methyl eugenol	$C_{11}H_{14}O_2$	67.41	66.5
Total identified compounds				98.05	100
Total hydrocarbon compounds				1.17	0.79
Total Oxygenated compounds				96.88	99.21

Table 7: Simple correlation coefficients among each of herb fresh weight (ton/fed), root fresh weight (ton/fed) and oil yield per feddan (l/fed) and various studied characters as affected with planting date in the first and second seasons.

Parameters	Herb fresh weight (ton/fed)		Root fresh weight (ton/fed)		Essential oil yield (l/fed)	
	First season	Second season	First season	Second season	First season	Second season
Plant height (cm)	0.857**	0.868**	0.749**	0.807*	0.921**	0.824**
Herb fresh weight (g/plant)	1.000**	1.000**	0.715**	0.902**	0.938**	0.971**
Herb dry weight (g/plant)	0.945**	0.956**	0.792**	0.962**	0.937**	0.936**
Herb fresh weight (ton/fed)	1.000**	1.000**	0.715**	0.902**	0.938**	0.971**
Herb dry weight (ton /fed)	0.945**	0.956**	0.792**	0.962**	0.937**	0.936**
Root length (cm)	0.870**	0.959**	0.901**	0.860**	0.932**	0.977**
Root fresh weight (g/plant)	0.715**	0.902**	1.000**	1.000**	0.799**	0.841**
Root dry weight (g/plant)	0.638*	0.817**	0.629*	0.950**	0.494	0.762**
Root fresh weight (ton/fed)	0.715**	0.902**	1.000**	1.000**	0.799**	0.841**
Root dry weight (ton /fed)	0.638*	0.817**	0.629*	0.950**	0.494	0.762**
Total chlorophyll	0.909**	0.946**	0.835**	0.881**	0.928**	0.939**
Nitrogen % (N)	0.449	0.726**	0.450	0.749**	0.390	0.625*
Phosphorus % (P_2O_5)	0.582*	0.429	0.553	0.629*	0.606*	0.377
Potassium % (K_2O)	0.297	0.468	0.088	0.666*	0.200	0.417
Essential oil %	0.533	0.667*	0.519	0.324	0.706*	0.750**
Essential oil content (ml/plant)	0.938**	0.971**	0.799*	0.841**	1.000**	1.000**
Essential oil yield (l/fed)	0.938**	0.971**	0.799**	0.841**	1.000**	1.000**

Effect of sowing date on simple regression analysis among each of herb fresh weight (ton/fed), root fresh weight (ton/fed) and essential oil yield per feddan and various studied characters:-

Simple regression models of relationships between various studied characters and each of herb fresh weight (ton/fed), root fresh weight (ton/fed) and oil yield per feddan (l/fed) of chervil plants, respectively as affected with planting date in the both seasons are shown in table (8). The results of regression analysis models between the studied characters as independent variables and each of herb fresh weight (ton/fed), root fresh weight (ton/fed) and oil yield per feddan (l/fed) as dependent variable had positive trend. The intercept of all studied characters and each of herb fresh weight (ton/fed), root fresh weight (ton/fed) and essential oil yield per feddan (l/fed) ranged between (- 175.5 and + 13.284), (-699.69 and +12.481) and (-59.364 and + 26.251), respectively for the first and second seasons together. Moreover, the regression coefficient of all studied characters and each of herb fresh weight (ton/fed), root fresh weight (ton/fed) and essential oil yield per feddan (l/fed) ranged between (0.0082 and 665.78), (0.0078 and 271.6) and (0.009 and 74.445), respectively for the first and second seasons together.

The relationship between herb fresh weight (ton/fed) and each of plant height (cm), root fresh weight (g/plant), root fresh weight (ton/fed) ans phosphorus percentage in the first season as well as herb fresh weight (g/plant), root length (cm) in both studied seasons, respectively was positive and high significant. Moreover, it was positive and

significant between herb fresh weight (ton/fed) and each of herb dry weight (g/plant), herb dry weight (ton /fed) and total chlorophyll in both studied seasons, respectively, essential oil content (ml/plant) and essential oil yield (l/fed) in the first season and also nitrogen percentage in the second season.

As shown in table (8) the simple regression relationship among root fresh weight (ton/fed) and each of plant height (cm), herb fresh weight (g/plant), herb fresh weight (ton/fed), root length (cm), root dry weight (g/plant) and phosphorus percentage in the first season and root fresh weight (g/plant) in the second season was positive and high significant. In addition it was positive and significant between root fresh weight (ton/fed) and each of herb dry weight (g/plant) and herb dry weight (ton /fed) in both seasons, total chlorophyll, essential oil content (ml/plant) and essential oil yield (l/fed) in the first season in addition to root dry weight (g/plant), root dry weight (ton /fed) and phosphorus percentage in the second season.

Regarding the simple regression relationship between essential oil yield (l/fed) and each of plant height (cm) in the first season, herb fresh weight (g/plant), herb fresh weight (ton/fed) and root length (cm) in the second season as well as essential oil content (ml/plant) in both seasons, respectively was positive and high significant. It was positive and significant between essential oil yield (l/fed) and each of herb fresh weight (g/plant), herb fresh weight (ton/fed), root length (cm), root fresh weight (g/plant), root dry weight (g/plant), phosphorus percentage in the first season, total chlorophyll and nitrogen percentage in the second season and essential oil percentage in both seasons, respectively.

From the abovementioned results it appears that the difference in the date of sowing chervil seeds was able to induce clear differences in the studied parameters of chervil plants in the first and second seasons, respectively. Such results were supported by Booij and Meurs (1995) on *Apium graveolens* L. var rapaceum (Mill.) and Data *et al*. (2008) on black cumin and Kanase (2017) on *Brassica oleracea* L. var. italica) cv who showed that plant growth parameters were significantly affected by the sowing date.

Moreover, the results showed also, the superiority of the second sowing date in reaching the best results for chervil plants at the level of vegetative, rooting and chemical constituent, mean while having the best yield of fresh and dry weight of herb and root and maximum essential oil yield per fed as well as the maximum percent of Methyleugenol as the major component of chervil essential oil. Despite the superiority of the second sowing date on all studied parameters of chervil plant, both of first and third sowing date had close results to the second sowing date compared with the fourth sowing date which recorded the lowest values of all studied parameters in the first and second seasons, respectively. It may be due to the small differences in environmental conditions under Egyptian condition as appears from table (2) compared with the fourth sowing date. These effects might be due to the higher temperature and longer photoperiod during early sowing date that can give the plants a chance to build up more stored foods than the later sowing dates and this may be reflected on faster growing of plants and consequently a higher yield per plant than under the colder conditions (Yadav et al., 2000; Abou El-Magd and El-Abagy, 2003; Tunio et al., 2005; Sudeep et al., 2006; Abd El-Wahab and Mehasen 2009; Abou El-Ghait *et al*., 2012). Tiwari *et al*. (2002) recorded that, by comparing the effect of sowing dates of October 15 and 30 on Coriander. The results indicated that fruit yield, number of initial and secondary branches and number of umbels per plant were higher in sowing date of October 15 compared to October 30. Meena *et al*. (2006) found that, *Coriandrum sativum* L. had more growth and yield in sowing date of October 15 compared to sowing date of November 15. Soleimani et al., (2010) reported decrease in fennel yield due to the delay in sowing date. Moosavi (2014) reported that the highest fruit and biological yield of fennel single plant was observed at the first sowing date. Wafaa et al., (2017) found that the different sowing dates affected significantly plant height, fresh weight per plant, umbel number per plant, fruit yield per plant as well as per feddan. The results showed significant variations among the different sowing dates in both seasons. The maximum values were detected in the early sowing date of 15th of October whereas the lowest parameters were detected in the late sowing date of 15th of November. Also these results are in agreement with findings of Zahtab Salmasi et al., (2003) and Rasam et al., (2007) on *Pimpinella anisum*, Gujar et al., (2005), Zheljazkov et al., (2008) on *Coriandrum sativum* L., Malhotra and Vashishtha (2007) on *Anethum graveolens* and Ghorbani et al., (2009) on *Cuminum cyminum*.

Table 8. Simple regression models of relationship between various studied characters and each of herb fresh weight (ton/fed), root fresh weight (ton/fed) and essential oil yield per feddan (l/fed), respectively as affected with planting date in both studied seasons.

Parameters	Seasons	Herb fresh weight (ton/fed)	Root fresh weight (ton/fed)	Oil yield per feddan (l/fed)
Plant height (cm)	First season	Y= 2.7108X - 31.179**	Y = 9.2532X - 12.253**	Y = 2.2971X+ 9.9738**
	Second season	Y = 0.4279X + 13.284	Y = 2.5259X + 12.481	Y = 2.939X + 11.031
Herb fresh weight (g/plant)	First season	Y= 0.0932X + 0.0369**	Y= 271.6X - 699.69**	Y = 65.877X - 41.076*
	Second season	Y = 10.716X + 0.0207**	Y = 62.473X- 17.387	Y = 74.445X - 59.364**
Herb dry weight (g/plant)	First season	Y= 1.1933X- 7.4699*	Y = 20.212X - 44.956*	Y = 4.876X + 4.1634
	Second season	Y = 0.7094X + 8.1482*	Y = 4.6293X + 5.2805*	Y = 4.8525X+ 4.4808
Herb fresh weight (ton/fed)	First season	--	Y= 25.312X - 65.171**	Y = 6.139X- 3.7887*
	Second season	--	Y= 5.83X - 1.6244	Y = 6.9473X - 5.5417**
Herb dry weight (ton /fed)	First season	Y= 0.0755X+ 0.6381*	Y = 1.892X - 4.2178*	Y = 0.4564X+ 0.3802
	Second season	Y = 0.0665X+ 0.7478*	Y = 0.4344X+ 0.4779*	Y = 0.455X + 0.404
Root length (cm)	First season	Y = 2.9228X - 9.4848**	Y = 8.624X- 18.929**	Y = 2.1081X + 1.918*
	Second season	Y = 0.2573X+ 3.4186**	Y = 0.8144X+ 5.9963	Y = 1.7965X + 1.9607**
Root fresh weight (g/plant)	First season	Y = 2.2839X - 63.569**	Y = 11.012X - 0.4608	Y= 2.669X + 26.251*
	Second season	Y = 1.5053X + 9.6458	Y= 10.752X+ 0.3348**	Y = 10.109X + 2.5168
Root dry weight (g/plant)	First season	Y = 5.6484X+ 0.4428	Y = 2.086X - 3.4724**	Y = 0.4053X + 1.9905*
	Second season	Y = 0.1641X + 1.0313	Y = 1.2315X- 0.1895*	Y = 1.0857X+ 0.3118
Root fresh weight (ton/fed)	First season	Y = 0.0393X+ 2.5786**	--	Y = 0.245X + 2.4152
	Second season	Y = 0.1387X + 0.8903	--	Y = 1.7005X - 2.9544
Root dry weight (ton /fed)	First season	Y= 0.0082X + 0.1667	Y = 0.1942X- 0.323	Y = 0.0377X + 0.1857
	Second season	Y = 0.0153X + 0.0968	Y = 0.1147X- 0.0169*	Y= 0.1012X + 0.0297
Total chlorophyll	First season	Y = 1.2644X- 11.24*	Y = 19.142X- 39.673*	Y = 4.6295X+ 6.7994

	Second season	Y = 0.9493X + 7.1893*	Y = 5.7019X + 5.0659	Y = 6.5284X+ 2.1611*
Nitrogen % (N)	First season	Y = 68.881X - 128.24	Y= 0.332X + 1.0362	Y = 0.078X + 1.8515
	Second season	Y = 0.0202X+ 1.8014*	Y= 0.1284X + 1.7314*	Y = 0.1386X + 1.6951*
Phosphorus % (P_2O_5)	First season	Y = 256.51X - 99.03**	Y= 0.098X + 0.1343**	Y = 0.0237X + 0.3723*
	Second season	Y = 0.0024X+ 0.4381	Y= 0.0203X + 0.4119*	Y= 0.0154X+ 0.429
Potassium % (K_2O)	First season	Y = 81.576X - 175.5	Y = 0.1X + 2.0675	Y = 0.0224X + 2.3173
	Second season	Y = 0.0132X + 2.1745	Y= 0.1177X + 2.0109	Y= 0.084X+ 2.1277
Essential oil %	First season	Y = 217.4X- 16.612	Y= 0.06X - 0.0315	Y= 0.0167X + 0.1055*
	Second season	Y = 0.0026X+ 0.1233	Y = 0.0078X+ 0.1454	Y= 0.0196X+ 0.1043*
Essential oil content (ml/plant)	First season	Y = 665.78X - 7.4056*	Y = 0.036X - 0.0799*	Y = 0.0091X + 0.0058**
	Second season	Y = 0.0014X+ 0.0107**	Y = 0.0086X+ 0.0076	Y = 0.01X + 0.0028**
Essential oil yield (l/fed)	First season	Y = 6.139X - 3.7887*	Y = 3.948X - 9.4032*	--
	Second season	Y = 0.1431X + 0.8132**	Y = 0.805X+ 0.6827	--

There are positive and significant correlation between all of herb fresh weight per feddan, root fresh weight per feddan and oil yield per feddan as affected with sowing date in the first and second seasons and some of studied traits. These results are in harmony with Hendawy et al., (2017) on *Rosmarinus officinalis*. The major component of chervil plant essential oil in this study were methyleugenol and estragole is in harmony with El Gendy et al., (2015) and Hendawy et al., (2019).

CONCLUSION

It could be concluded that sowing date is one of the most environmental factors affecting on the quantity and quality of aromatic plants that have to be studied on every climatic condition. According to the results of this study more suitable date for sowing of chervil seeds with the maximum yield of herb, root and essential oil yield per feddan and as a potential source of methyl eugenol in location under study was the second sowing date then the third and first sowing dates and at last the fourth one, respectively,

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

All authors equally contributed in all aspects of this paper.

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