



International Journal of PharmTech Research

CODEN (USA): IJPRIF, ISSN: 0974-4304
Vol.8, No.10, pp 32-39, 2015

Effect of potassium silicate as anti-transpiration on growth, essential oil of chervil plant under Egyptian conditions

Tamer M. Abd El-Razik , Mona H. Hegazy, Heba M. Amer., Hend E. Wahba, Saber F. Hendawy, Mohamed S. Hussein

Department of Medicinal and Aromatic Plants Research, National Research Centre, Dokki, Giza, Egypt, P.O. Box 12622

Abstract: A pot experiment was carried out on chervil (*Anthriscus cerefolium*) at National Research Centre Farm, Giza Governorate, in two successive seasons 2014 and 2015 to evaluate the effect of soluble potassium silicate applied to chervil plant to reduce amount of irrigation water. Potassium silicate was sprayed on vegetative growth twice before every harvest. Foliar spray was 1000 ppm level, and the irrigation intervals were (3,4 and 5 days). Untreated plants sprayed with distilled water were used as control. The results showed that potassium silicate was anti-transpiration material and reduced the effect of water stress on plant growth and yield of chervil plant.

Keywords: chervil, Water stress, essential oil, potassium silicate, anti-transpiration.

Introduction

Chervil (*Anthriscus cerefolium* L. Hoffm.) is a fragrant delicate annual herb which belongs to the Apiaceae family. Its principal use is as a flavoring agent for culinary purposes but it has been used for medicinal purposes as well. Chervil is native to Europe and has finely divided pinnate leaves. It was being cultivated in England in 1597 and in America by 1806. The origin of salad chervil lies in the southeastern Europe and western Asia. The chemical composition of chervil includes flavonoids such as luteolin^{1,2}. Chervil herb is an interesting plant generally characterized by strong and unique flavor compounds, and in some cases providing important nutrients which can enrich the consumers' diet. Water deficit (commonly known as drought) can be defined as the absence of adequate moisture necessary for a plant to grow normally and complete its life cycle. Water stress causes different morphological, physiological and biochemical changes including: leaf area reduction, leaf senescence and reduction in cell development, stomatal closure and photosynthetic limitation. Water scarcity and drought are the main features of the dry areas. Water is the single most limiting resource for world agriculture and food production, highly exceeding other key limitations. Large amount of water is used in field production of food crops, leading to a deficit of fresh water resources in many arid or semi-arid areas in the world. In regions where water scarcity is the principal limiting factor for cultivation, farmers are interested in growing crops that are able to adapt to drought conditions. Drought stress can damage plant cell membranes, and cell wall architecture, as well as inhibit photosynthesis and cell division^{3,4}. Hsiao³. Stated that "many of the changes observed under nutrient or water deficiencies seem to represent general patterns of modulation in plants under adversity." The transpiration through the cuticle may decrease by Silicon deposition⁵. Silicon deposits have also been found in guard cells around stomata in blueberry⁶. Gong H et al⁷ Found that the addition of 2.11 mM Na₂SiO₃ increased leaf water potential by ~0.2 MPa under drought conditions in potted wheat. They also observed that silicon did not decrease stomatal conductance under drought conditions.

Materials and Methods

This experiment was carried out on chervil (*Anthriscus cerefolium*) at National Research Centre Farm, Giza Governorate, in two successive seasons 2014 and 2015. A split plot design was used, the main plot was irrigation intervals and the sub-plot was potassium silicate level. The experiment contained 6 treatments with three replicates, every replicate include 10 pots and every pot contain 3 plants. Plant heights (cm), number of branches, herb fresh and dry weight (g/plant) were measured.

Spraying of potassium silicate was carried out twice before every harvest the first one was in 30th November and the second one was in 30th December respectively, the 1st harvest was in January, the second harvest was in March, respectively.

Treatments:

- 1- 3 days
- 2- 4 days
- 3- 5 days
- 4- 3 days + potassium silicate(100ppm)
- 5- 4 days + potassium silicate (100 ppm)
- 6- 5 days + potassium silicate (100 ppm)

Table (1): Physical and chemical analysis of used soil.

1-Mechanical Analysis		Value	
Sand %		80.7	
Silt %		6.8	
Clay %		12.5	
2-Chemical Analysis			
PH 1:2.5ext.	7.48	Total Nitrogen %	0.121
Electrical Conductivity 1:2.5ext	0.61	Total Phosphorus %	0.0072
Organic Carbon %	0.89	Total Potassium %	0.012
Organic Matter %	1.55	CaCO ₃ %	2.23
Soluble Cationsmeq/L		Soluble Anions meq/ L	
Na ⁺	4.25	CO ₃	0.00
K ⁺	0.10	HCO ₃ ⁻	2.68
Ca ⁺⁺	1.21	Cl ⁻	1.64
Mg ⁺⁺	0.49	SO ₄	2.55
CEC meq/100g	13.26		

The following data were recorded:

- 1- Plant height (cm).
- 2- Fresh and dry weights of herb (g/plant).
- 3- Essential oil percentage of the fresh herb.

Plant height (cm), fresh and dry weight of herb g/plant, number of branches ,essential oil %,Chlorophyll a, Chlorophyll b, total Chlorophyll and total carotenoids were recorded for all replicates in every cut. Chlorophyll and carotenoid contents were determined by the method of ⁸.

The experiment was designed in complete randomized block design and all obtained data were subjected to statistical analysis according to ⁹.

Determination of essential oil percentage :

Essential oil was extracted and determined according to ¹⁰ where a weight of 100 g of the fresh aerial parts was subjected to hydro distillation for 3h.The obtained essential oil was dried over anhydrous sodium sulphate and kept in deep freezer till used for GC-Mass analyses, the essential oil of each sample was performed separately. The GC–MS analysis of the essential oil samples of the second season was carried using gas chromatography mass spectrometry instrument with the following specifications: 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 TG-WAX MS column (30 m × 0.25 mm i.d., 0.25_μm film thickness). Analyzes were carried out using helium as carrier gas at a flow rate of

1.0 ml min⁻¹ and a split ratio of 1:10 using the following temperature program: 40°C for 1 min; rising with 4.0°C min⁻¹–160°C and held for 6 min; rising with 6°C min⁻¹–210°C and held for 1 min. The injector and detector were held at 210°C. Diluted samples (1:10 hexane, v/v) of 0, 2 -l of the mixtures were always injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z40–450. Most of the compounds were identified using two different analytical methods: (a) KI, Kovats indices in reference to nalkanes (C9–C22) (National Institute of Standards and Technology, 2009); and (b) mass spectra (authentic chemicals, Wiley spectral library collection and NSIT library).

Results

1-Vegetative Characters:

Data tabulated in Tables (2 and 3) show that, decrement was detected in some the above ground vegetative growth including plant height, fresh and dry weight of herb as a result of increasing intervals between irrigation during cuts except herb dry weight for the third cut. The highest mean values of these parameters were obtained due to the use of irrigation every 3 days. So, the maximum mean values of these parameters were obtained as a result of irrigation at 3 days intervals.

Table (2) Effect of irrigation intervals and/ or potassium silicate on growth characters of *Anthriscus cerefolium* (1st season).

Irrigation intervals	Potassium Silicate ppm	Plant height		Fresh weight		Dry weight	
		1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
3 days	0	20.84	19.86	29.63	24.01	11.85	9.60
	100	28.33	25.40	35.29	27.30	14.12	10.92
Mean value		24.59	22.63	32.46	25.66	12.985	10.26
4 days	0	17.51	17.35	27.02	21.85	10.81	8.74
	100	23.34	22.56	31.00	24.79	12.40	9.92
Mean value		20.43	19.96	29.01	23.32	11.61	9.33
5 days	0	14.94	13.98	23.48	19.90	9.39	7.96
	100	18.24	16.37	27.39	20.07	8.39	8.03
Mean value		16.59	15.18	25.44	19.99	8.89	8.00
Mean values of	0	17.76	17.06	26.71	21.92	10.68	8.77
	100	23.30	21.44	31.23	24.05	11.64	9.62
LSD at 5%	Irrig	1.95	1.03	1.45	NS	NS	NS
	Si	2.83	1.95	1.04	NS	NS	NS
	Irrig x Si	3.01	2.92	2.09	1.03	NS	NS

Table (3) Effect of irrigation intervals and / or potassium silicate on growth characters of *Anthriscus cerefolium* (2nd season).

Irrigation intervals	Potassium Silicate ppm	Plant height		Fresh weight		Dry weight	
		1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
3 days	0	19.46	18.71	28.84	23.53	11.54	9.41
	100	26.69	23.38	32.98	27.03	13.19	10.81
Mean value		23.08	21.05	30.91	25.28	12.37	10.11
4 days	0	16.99	16.49	26.12	21.02	10.45	8.41
	100	21.69	20.67	29.33	24.37	23.42	9.75
Mean value		19.34	18.58	27.73	22.70	16.94	9.08
5 days	0	14.59	13.21	22.45	20.00	8.98	8.00
	100	17.36	16.85	26.04	20.11	26.04	8.04
Mean value		15.98	15.03	24.25	20.06	17.51	8.02
Mean values of	0	17.01	16.14	25.80	21.52	10.32	8.61
	100	21.91	20.30	29.45	23.84	20.88	9.53
LSD at 5%	Irrig	2.01	1.83	1.99	1.04	NS	NS
	Si	1.09	0.95	1.05	NS	1.97	NS
	Irrig x Si	2.03	2.11	3.21	1.32	2.98	NS

The same Tables indicated that, potassium silicate treatment increased the vegetative parameters for two cuts during both seasons. Generally, the maximum mean values of vegetative parameters were obtained as a result of

potassium silicate at 100 ppm. Concerning the combination between irrigation intervals and potassium silicate, it can be noticed that these treatments had a pronounced effect on plant height and herb fresh or dry weight for both cuts during the two seasons. These parameters reached to their maximum mean values as a result of the combination treatment between irrigation intervals at 3 days with potassium silicate at 100 ppm.

2- Essential oil content (%):

From the given data in Tables (4 and 5) it can be noticed that irrigation intervals treatments had a pronounced effect on essential oil content (%). Accordingly, it can be stated that irrigation every 3 days was the most effective irrigation treatment for promoting the synthesis and accumulation of essential oil content (%) during 1st and 2nd cuts during both seasons.

Table (4) Effect of irrigation intervals and / or potassium silicate on essential oil and photosynthetic contents of *Anthriscus cerefolium* (1st season).

Irrigation intervals	Potassium Silicate ppm	Essential oil %		Chlorophyll A		Chlorophyll B		Total Chlorophyll		Total Carotenoids	
		1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
3 days	0	0.04	0.06	1.56	1.52	1.29	1.29	2.85	2.81	1.16	1.15
	100	0.09	0.09	1.60	1.59	1.53	1.52	3.13	3.11	1.18	1.16
Mean value		0.07	0.08	1.58	1.56	1.41	1.41	2.99	2.96	1.17	1.16
4 days	0	0.03	0.04	1.39	1.36	1.18	1.14	2.57	2.50	1.14	1.13
	100	0.05	0.05	1.49	1.42	1.28	1.27	2.77	2.69	1.16	1.14
Mean value		0.04	0.05	1.44	1.39	1.23	1.21	2.67	2.60	1.15	1.14
5 days	0	0.02	0.03	1.21	1.12	0.97	0.93	2.17	2.06	1.09	1.07
	100	0.03	0.04	1.25	1.20	1.04	1.04	2.29	2.24	1.03	1.03
Mean value		0.03	0.04	1.23	1.16	1.01	0.99	2.23	2.15	1.06	1.05
Mean values of Si	0	0.03	0.04	1.39	1.33	1.15	1.12	2.53	2.46	1.13	1.12
	100	0.06	0.06	1.45	1.40	1.28	1.28	2.73	2.68	1.12	1.11

The response to potassium silicate on essential oil content (%) *Chervil* is presented in Tables (4 and 5). It showed that a significant increment in mean values of essential content (%) occurred when plants treated with Si at 100 ppm during 1st and 2nd cuts in both seasons.

With respect to the combination between irrigation intervals and potassium silicate application, it was apparent that, treatments had a pronounced effect on essential oil content (%) during all cuts in both seasons. The combination treatment between irrigation intervals every 3 days with potassium silicate at 100 ppm.

Table (5) Effect of irrigation intervals and / or potassium silicate on essential oil and photosynthetic contents of *Anthriscus cerefolium* (2nd season).

Irrigation intervals	Potassium Silicate ppm	Essential oil %		Chlorophyll A		Chlorophyll B		Total Chlorophyll		Total Carotenoids	
		1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
3 days	0	0.04	0.06	1.55	1.52	1.32	1.30	2.87	2.83	1.17	1.15
	100	0.08	0.10	1.60	1.56	1.55	1.51	3.14	3.08	1.19	1.17
Mean value		0.06	0.08	1.58	1.54	1.44	1.41	3.01	2.96	1.18	1.16
4 days	0	0.03	0.05	1.37	1.34	1.20	1.15	2.57	2.49	1.15	1.13
	100	0.06	0.07	1.46	1.42	1.31	1.28	2.77	2.70	1.17	1.15
Mean value		0.05	0.06	1.42	1.38	1.26	1.22	2.67	2.60	1.16	1.14
5 days	0	0.02	0.03	1.18	1.12	0.99	0.95	2.16	2.06	1.10	1.08
	100	0.04	0.04	1.23	1.17	1.07	1.04	2.30	2.21	1.04	1.03
Mean value		0.03	0.04	1.21	1.15	1.03	1.00	2.23	2.14	1.07	1.06
Mean values of Si	0	0.03	0.05	1.37	1.33	1.17	1.13	2.53	2.46	1.14	1.12
	100	0.06	0.07	1.43	1.38	1.31	1.28	2.74	2.66	1.13	1.12

3- Essential oil constituents:

Data in Table (6) indicate the effect of irrigation intervals and / or potassium silicate on the constituents of the essential oil of *A. cerefolium L* plant. Thirty components were identified as a result of treatments.

The relative percentage of total identified compounds was ranged from 91.35 - 99.91%. On the other hand the relative percentage of total hydrocarbon component ranged from 11.96 – 18.19% while total oxygenated compounds ranged from 77.92-87.95%.

Table (6): Effect of irrigation intervals and/ or potassium silicate on the relative percentage of the main constituents of the essential oil of chervil plants (2nd cut of 2nd season).

	RT		KI*	1	2	3	4	5	6	
1	5.28	(-)- β -Pinene	1190	1.40	1.29	1.21	1.90	1.36	2.09	Monoterpenes C ₁₀ H ₁₆
2	7.38	D-Limonene	1278	1.37	1.15	1.17	1.28	1.92	1.43	a cyclic <u>terpene</u> . C ₁₀ H ₁₆
3	7.71	Eucalyptol	1291	0.36	0.77	1.70	1.26	0.88	0.95	a cyclic <u>ether</u> and a <u>monoterpenoid</u> . C ₁₀ H ₁₈ O
4	8.64	γ -Terpinene	1324	0.91	1.11	1.17	1.21	1.2	1.33	Hydrocarbons monoterpenes C ₁₀ H ₁₆
5	9.43	o-Cymene	1351	0.30	0.43	0.63	0.40	0.32	0.21	an <u>alkylbenzene</u> related to a <u>monoterpene</u> C ₁₀ H ₁₄
11	12.26	3-Nonanone	1444	0.28	0.25	0.26	0.37	0.51	0.48	Ethyl hexyl ketone C ₉ H ₁₈ O
13	14.74	1-Nonene	1524	2.91	2.81	2.81	1.71	1.19	2.36	an <u>alkene</u> with unsaturated hydrocarbon C ₉ H ₁₈ .
14	15.39	Isomenthone	1544	1.33	0.97	1.51	1.5	1.60	1.48	http://www.thegoodscentscompany.com/data/rw1003111.html - <u>inchi l</u> a <u>monoterpene</u> and a <u>ketone</u> . C ₁₀ H ₁₈ O
17	16.34	p-Menthan-3-one cis	1575	0.12	0.19	2.05	0.25	0.15	0.67	C ₁₀ H ₁₈ O
18	16.58	3-Nonanol	1582	0.30	0.12	0.27	0.37	0.15	0.37	a straight chain <u>fatty alcohol</u> C ₉ H ₂₀ O
19	17.03	Pentadecane	1597	0.59	0.56	2.12	0.90	0.86	0.86	is an <u>alkane hydrocarbon</u> C ₁₅ H ₃₂ .
21	17.90	1-Hexadecanol	1625	0.28	0.52	0.31	0.44	0.35	0.46	C ₁₆ H ₃₄ O, is a <u>fatty alcohol</u>
22	18.32	1-Nonen-3-ol	1639	0.69	0.65	0.71	1.31	1.05	0.97	C ₉ H ₁₈ O
23	19.03	Caryophyllene	1663	0.29	0.41	0.36	0.27	0.20	0.05	C ₁₅ H ₂₄ is bicyclic sesquiterpene
24	20.64	3-Octen-2-ol, (Z)-	1716	0.54	0.76	0.77	1.30	0.91	0.72	C ₈ H ₁₆ O
25	21.05	Pulegone	1731	3.13	2.80	7.04	1.94	2.45	1.57	C ₁₀ H ₁₆ O a <u>monoterpene</u>
26	21.82	Estragole	1757	20.91	16.34	15.05	23.23	20.16	24.29	C ₁₀ H ₁₂ O is a <u>phenylpropene</u>
27	22.39	Germacrene D	1777	1.15	1.32	1.52	1.55	1.80	0.43	C ₁₅ H ₂₄ Sesquiterpene
28	22.86	(-)-Zingiberene	1793	3.04	2.47	4.98	3.55	4.67	1.81	C ₁₅ H ₂₄ a <u>monocyclic sesquiterpene</u>
29	23.00	β -Bisabolene	1798	0.41	0.92	0.67	0.45	0.61	0.39	C ₁₅ H ₂₄ sesquiterpene
30	23.83	α -Farnesene	1827	0.57	0.47	0.75	0.53	0.63	0.41	C ₁₅ H ₂₄ sesquiterpene
31	24.21	β -Sesquiphellandrene	1840	0.33	0.21	0.29	0.43	0.34	0.23	C ₁₅ H ₂₄ sesquiterpene
32	24.39	Curcumene	1847	0.28	0.28	0.45	0.33	0.47	0.36	C ₁₅ H ₂₂ sesquiterpene
33	28.14	Geranyl propionate	1983	0.44	0.38	0.66	0.80	0.62	0.54	C ₁₃ H ₂₂ O ₂ ester
34	28.75	Geranyl isovalerate	2006	0.49	0.30	0.63	1.07	0.69	0.54	C ₁₅ H ₂₆ O ₂
35	30.33	2-Allyl-1,4-dimethoxybenzene	2068	6.54	5.76	5.88	7.81	8.01	7.99	C ₁₁ H ₁₄ O ₂
36	30.87	Methyleugenol	2090	46.32	47.03	39.56	46.00	40.11	47.01	C ₁₁ H ₁₄ O ₂
37	31.57	Trans-Methyl Iso-Eugenol	2115	0.41	0.42	0.99	1.06	1.03	0.99	C ₁₁ H ₁₄ O ₂
40	41.96	α -Santonin	2426	0.25	0.15	0.27	0.19	0.27	0.33	C ₁₅ H ₁₈ O ₃
41	43.74	Hexadecen-1-ol, trans-9-	2483	0.78	0.51	0.41	0.30	1.05	0.89	C ₁₆ H ₃₂ O
		Oxygenated compound		83.17	77.92	78.07	86.49	79.99	87.95	
		Hydrocarbon		13.5	13.4	18.1	13.4	15.5	11.9	
		Total		96.72	91.35	96.20	99.90	95.56	99.91	

*KI= Confirmed by comparison with Kovats indices on TG-WAX MS column 3 days 2-4 days 3-5 days 4-3 days + potassium silicate(100ppm) 5-4 days + potassium silicate (100 ppm) 6- 5 days + potassium silicate (100 ppm)

The first major component was Methyl eugenol which ranged from 39.56 – 47.03 where the lowest relative percentage was resulted from irrigated every 5 days and the highest one was obtained as a result of irrigation intervals every 4 days. The second major component was estragole (Methyl chavicol) which ranged from 15.05-24.29% where plants irrigated every 5 days combined with potassium silicate gave the maximum relative percentage. 2-allyl-1,4-dimethoxybenzene was found to be the third one (5.76 – 8.01%) followed by pulegone (1.57- 7.04%) and zingiberene (1.81 – 4.98%). In this respect, ¹¹ found that, The main constituents of essential oil for chervil were methyleugenol, estragole, 2-allyl-1,4-dimethoxybenzene. Moreover, In Turkey, ¹² the essential oil of chervil, grown wild four constituents comprising the *A. cerefolium* total oil were methyl chavicol (83.10%), 1-allyl-2,4-dimethoxybenzene (15.15%), undecane(1.75%) and pinene (0.01%). Generally, all treatments gave the same components with different relative percentage.

4- Photosynthetic pigments:

Data recorded in Tables (4 and 5) clear that photosynthetic pigments (Chlorophyll a, b, a+b and total carotenoids) decreased as irrigation intervals increased. So, irrigation interval every 3 days gave the highest values of photosynthetic pigments. Concerning the effect of potassium silicate on photosynthetic pigments, data tabulated in Tables (4 and 5) show that this treatment increased these pigments compared with untreated plants. The combination treatment between irrigation intervals every 3 days + potassium silicate at 100 ppm resulted in the maximum mean values of photosynthetic pigments.

Discussion

According to the previous results, ¹³ reported that, this may be due to the vital roles of water supply at adequate amount for different physiological processes such as photosynthesis, respiration, transpiration, translocation, enzyme reaction and cell turgidity occurs simultaneously. Such reduction could be attributed to a decrease in the activity of meristemic tissues responsible for elongation. Moreover, increasing levels of water stress reduce growth and yield due to reduction in photosynthesis and plant biomass. Under increasing water-stress levels photosynthesis was limited by low CO₂ availability due to reduced stomata and mesophyll conductance. Drought stress is associated with stomatal closure and thereby with decreased CO₂ fixation.

Similar results were observed for *Cymbopogon flexuosus* under drought¹⁴. The reduction in essential oil content may be due to disturbance in photosynthesis and carbohydrate production under stress condition and suppression of the plant growth ¹⁵. Reduction in oil content and compositional alterations in the essential oils as a consequence of drought has also been described in mints¹⁶, sweet basil¹⁷, dragon head¹⁸, oregano¹⁹ and lemon balm²⁰.

In *Artemisia annua*, ²¹ observed that water stress strongly depressed oil yield and plentiful irrigation raised it. ²² also reported that water stress had a negative impact on green yield and essential oil yield of geranium. ²³ reported that when moisture deficiency does not limit plant growth and survival, the production of secondary metabolites such as essential oil is even stimulated by limited stressful environments. In this experiment, one accession was used but based on growth retardation under drought stress conditions it seems that irrigation at optimum condition may promote greater essential oil biosynthesis in mint.

Si is generally considered a beneficial element for the growth of higher plants and most of the Si taken up by plants is deposited on cell walls ²⁴ and ²⁵. Si accumulates in the leaf, forming a doubled layer ²⁶. This accumulation promotes a reduction in transpiration and decrease water loss by the maize plant²⁷.

For overcoming the negative effects of salinity on the plant growth and yield can be to attempt to new strategies. Beneficial effects of Si on yield and quality of maize as well as other crops observed in this study. Positive effect of Si on physiological properties was in conditions that plant grew under salt stress was more remarkable in comparison with conditions that plant grown under normal conditions.

The results of this study showed that Si can be involved in the metabolic or physiological activity in higher plants exposed to a biotic stresses. Proper Si nutrition can increase salt resistance by plants. Therefore, it is necessary to investigate Si action, and optimal concentration to be used in this culture. Using of chemical materials such as sodium silicate or potassium silicate as source of Si for combating of salinity are not economical, while crop residues such as stalks of rice, sugarcane and bagasse (sugarcane pulp) can be used as source of Si.

Acknowledgement

This research was supported by National Research Centre. We are thankful to NRC who financed this research

References

1. Fejes S, Blázovics A, Lugasi A, Lemberkovics E, Petri G, Kéry A (2000) In vitro antioxidant activity of *Anthriscus cerefolium* L. (Hoffm.) extracts. *J Ethnoph* 69(3):259–265.
2. Milovanovic M, Banjac N, and Vucelic-Radovic B (2009) Functional Food: Rare herbs, seeds and vegetable oils as sources of flavors and phytosterols. *J Agr Sci* 54(1):80–93.
3. Hsiao, T.C. (1973). Plant responses to water stress. *Ann. Rev. Plant Physiol.* 24:519–570.
4. Taiz, L., and E. Zeiger. (2006). *Plant Physiology*. 4th ed. Sinauer Associates, Sunderland, MA.
5. Ma JF (2004) Role of silicon in enhancing the resistance of plants to biotic and abiotic stresses. *Soil Sci Plant Nutr* 50: 11–18.
6. Morikawa, C. K.; Saigusa, M.,(2004). Mineral composite on and accumulation of silicon in tissues of blueberry (*Vaccinium corymbosus* cv. Bluecrop) cuttings. *Plant and Soil.* 58, (1-2), 1-8.
7. Gong H, Chen K, Zhao Z, Chen G, Zhou W. (2008). Effects of silicon on defense of wheat against oxidative stress under drought at different developmental stages. *Biologia Plantarum.* 52(3): 592-596.
8. Snedecor, G.W. and W.G. Cochran,(1990). *Statistical Methods*. pp: 369 – 375, 11th Ed. Iowa State College Press. Ames, Iowa, U.S.A.
9. Lichtenthaler, H.K., 1987. Chlorophylls and carotenoids: pigments of photosynthetic biomembranes. In: Colowick, S.P., Caplan, N.O. (Eds.), *Methods in Enzymology*, vol. 148. Academic Press Inc., pp. 350–382.
10. Guenther, E., (1961). *The Essential Oils*, vol. IV. D. Van Nostrand, New York.
11. El Gendy, A.G., Taghred, A., Hegazy El-Sayed, S.M., (2013). Effect of biofertilizers and/or urea on growth, yield, essential oil and chemical compositions of *Cymbopogon citratus* plants. *J. Appl. Sci. Res.* 9, 309–320.
12. Baser, K.H.S., Ermin, N., Demirc, akmak, B., (1998). The essential oil of *Anthriscus cerefolium* (L.) Hoffm. (chervil) growing wild in Turkey. *J. Essent. Oil Res.* 10,463–464.
13. El Tahir Bastawi, Ali El- Hawary and Samia Osman Yagoub, (2011). *J. Sci. Techn.* 12, (3) 75.
14. Sangwan R.S., A.H.A. Farooqi R.P. Bansal and S.S. Neelam, (2002). Interspecific variation in physiological and metabolic responses of five species of *Cymbopogon* to water stress. *Jour Plant Physiol.* 142 , 618–22.
15. Flexas, J. and H. Medrano,(2002). Drought-inhibition of photosynthesis in C3 plants: stomatal and non-stomatal limitations revisited .*Ann. Bot.* 89, 183–9.
16. Charles D.J., R.J. Joly and J.E. Simon.(1990). Effect of osmotic stress on the essential oil content and composition of peppermint. *Phytochem.* 29, 2837–40.
17. Simon, J.E., D. Reiss-Buhenheinra, R.J. Joly and D.J. Charles, (1992). Water stress induced alterations in essential oil content and composition of sweet basil. *J. Essen. Oil Res.*, 4, 71–5.
18. Said-Al Ahl1, H.A.H. and Abdou, M.A.A. ,(2009). Impact of water stress and phosphorus fertilizer on fresh herb and essential oil content of dragonhead Int. *Agrophysics*, 23, 403-407.
19. Said-Al Ahl H.A.H., Omer, E.A. and Naguib, N.Y.,(2009). Effect of water stress and nitrogen fertilizer on herb and essential oil of oregano. *International Agrophysics Journal*, 2 (3) 269- 275
20. Said-Al Ahl, H.A.H. Abdou, M.A.A. and Omer, E.A.,(2009). Effect of potassium fertilizer on lemon balm (*Melissa officinalis* L.) grown under water stress conditions. *Journal of Medicinal Food Plants*,1 (2)16- 29.
21. Chalchat J.C., R.P. Garry and J. Lamy,(1994). Influence of harvest time on yield and composition of *Artemisia annua* oil produced in France *J. Essen. Oil Res.* 6 (1994) 261–8.
22. Putievsky, E., U. Ravid and N. Dudai ,(1990). Effect of water stress on yield components and essential oil of *Pelargonium graveolens* . *J. Ess. Oil Res.* 2: 111-114.
23. Shabih F., A.H.A. Farooqi, S.R. Ansari and S.Sharma, (1999). Effect of water stress on growth and essential oil metabolism in *Cymbopogon martinii* cultivars. *J. Essen. Oil Res.*, 11(1999) 491–6.
24. Epstein E (1999) Silicon. *Annual Review of Plant Physiology and Plant Molecular Biology* 50: 641–664.

25. Liang Y, Zhang W, Chenc Q, and Ding R (2005). Effects of silicon on H⁺-ATPase and H⁺ -PPase activity, fatty acid composition and fluidity of tonoplast vesicles from roots of salt-stressed barley (*Hordeum vulgare* L.). *Environmental and Experimental Botany* 53: 29–37.
26. Pereira TS, Da Silva Lobato AK, Tan DKY, Da Costa DV, Uchôa Perti, G., Lemberkovics, E. , Lelik, L., Vitanyi, G.,(1993).Essential oil composition of chervil growing wild in Hungary. *Acta Horticulturae*, 344; 52-62.
27. Freitas LB, Coelho EM, Maia SCM, and Silva TRB (2011). Foliar fertilization with silicon in maize. *Revista Ceres* 58: 262-267.
