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Influence of $Ca(NO_3)_2$ and KNO_3 Application on Biomass, Yield, Oil and Mineral Contents of Tarragon in "Ray" Region

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Abstract

Artemisia dracunculus L. (tarragon), known as "tarkhun" in Iran, is a perennial herb in the Asteraceae family, which has a long history of use in culinary traditions. A factorial experiment based on the Randomized Completely Block Design with three replications was used. The treatments were performed at four level of foliar applications of $Ca(NO_3)_2$ and KNO_3 fertilizers (including control (sprayed with water), 1.5, 3 and 6 gl^{-1}). This experiment was conducted at field conditions in a farm in "Ray" in 2010. The results showed that $Ca(NO_3)_2$ application significantly increased plant height, fresh and dry matter yield by an average of 10.1, 35.8 and 33.5%, respectively. Essential oil content was not significantly affected with $Ca(NO_3)_2$ fertilization. Nevertheless, $Ca(NO_3)_2$ application increased essential oil content by an average of 64.4% compared with the control. Ca $(NO_3)_2$ foliar application increased N and Ca content of leaf tissues. The concentrations of P, K, Mg, Fe, Mn, Zn and Cu significantly affected by $Ca(NO_3)_2$ levels. Plant height, fresh and dry matter yield, essential oil content and yield significantly increased with KNO_3 foliar application by an average of 4.4, 60.5, 50.4, 42.5 and 119.6%, respectively compared with the control. The KNO_3 application significantly increased N, K, Fe, Mn and Zn concentrations compared with the control. Also, leaf P, Ca, Mg and Cu contents were influenced by KNO_3 fertilization. The interaction between $Ca(NO_3)_2$ and KNO_3 treatments was significant in leaf N, K, Mg, Fe, Mn, Zn and Cu contents.

Keywords: *Artemisia dracunculus*, essential oil, fertilizer, mineral

1. Introduction

In the third millennium, the promotion of human health is a priority of crop producers. With the world population increasing rapidly, and projected to do so for some time, and with improved plant nutrition remaining as one of the major factors increasing crop yields, use of our knowledge of plant nutrition to maximize agricultural yields grows in importance (Grusak, 2002). Humans and other animals are dependent on plant species to provide them with dietary minerals. Plants can contain a broad range of mineral elements, but concentrations in each plant will vary depending on species, genotype and environmental constraints (Dwyer, 1991; American Dietetic Association, 2002).The potential role of these plants as sources of minerals is now being realized, especially in situations where most of the commonly consumed foods are low in human-essential minerals (Taylor et al., 1982).

Artemisia dracunculus L. (tarragon), known as "tarkhun" in Iran, is a perennial herb in the Astraceae family, which has a long history of use in culinary traditions. It also possesses a wide range of health benefits and has therefore been widely used as a herbal medicine (Obolskiy et al., 2011). Two varieties can be distinguished (Yaichibe et al., 1997) namely, French tarragon of south European origin and Russian tarragon of Siberian origin (Greger, 1979). This research deals with French tarragon. This plant can be consumed as fresh, dried, and frozen product. The dried aerial parts of *A. dracunculus* were used orally to treat epilepsy in Iranian traditional medicine (Aqili Khorasani, 1992). Also, the amount of mineral elements on the aerial parts of tarragon is high and it has the potential to serve as a dietary source of human-essential minerals.

Plant uptake and tissue concentration of elements are mainly dictated by the combined influences of both genetic and environmental factors such as soil composition, the use of fertilizers, plant's maturity state at harvest and the storage conditions (Sanchez-Castillo et al., 1998). The absorption rate of mineral nutrients by above ground plant parts considerably differs not only among plant species but also among varieties within the same species (Wojcik, 2004).

The interest in foliar fertilizers arose due to the multiple advantages of foliar application methods such as rapid and efficient response to the plant needs, less product needed, and independence of soil conditions. It is also recognized that supplementary foliar fertilization during crop growth can improve the mineral status of plants and increase the crop yield (Kolota & Osinska, 2001).

Calcium (Ca), one of the essential nutrients for plants, plays a major role in the initiation of many signal transduction processes in higher plant cells, including bud formation, polar growth, gas-exchange, regulation, secretion, movements and light and hormone regulated growth and development (Hepler & Wayne, 1985). There are some supporting studies that calcium fertilization affects growth and essential oil yield in treated plants (Dordas, 2009; Mumivand et al., 2011; Suh & Park, 2000; Lee & Yang, 2007; and Supanjani et al., 2005). Also, several studies have been carried out on the influences of calcium on the uptake of major and minor elements by plants (Mumivand et al., 2010; Al-Hamzavi, 2010; Karaivazoglou et al., 2007; Dabuxilatu & Ikeda, 2005; Tyler & Olsson, 2001).

Potassium (K) is the essential macronutrient for all living organisms required in large amounts for normal plant growth and development (Marschner, 1986). In several studies, the beneficial effects of K fertilization on herb yield and essential oil yield and composition were investigated (Ezz El-Din et al., 2010; Davies et al., 2009; Said-Al Ahl et al., 2009; Singh & Ganesha Rao, 2005, 2009; Singh, 2008; Singh et al., 2005, 2007; Jeliazkova et al., 1999). In addition, the effects of potassium fertilizer on contents of different mineral have been shown in many studies (Hoda et al., 2011; Davies et al., 2009; Singh & Ganesha Rao, 2009; Yildirimet al., 2009; Singh et al., 2007; and Nadia, 2006).

The main objective of this work was to study the effect of foliar fertilization by $Ca(NO_3)_2$ and KNO_3 at different doses on the concentration of macro and micro elements of French tarragon leaves that cultivated for many years in Iran.

2. Materials and Methods

1.2 Field Experiment

The field experiment was conducted in 2010 at field conditions in a farm "Ray", Iran (35º33´N, 51º26´E and 1034 m mean sea level). The meteorological data recorded during the trial period of year are given in Table 1. At the beginning of research, the physicochemical properties of soil (depth of 30-45 cm) and the water sample were analyzed (Table 2).

Table 1. Monthly temperature, precipitation and Minimum average humidity during the growing season

Month	Average temperature (°C)			Total precipitation (mm)	Minimum average humidity (%)
	Minimum	Mean	Maximum		
August	24.03	29.48	34.93	0.0003	11.73
September	21.39	26.74	32.10	0.0013	13.40
October	18.70	24.00	29.30	0.0533	14.83
November	10.50	15.13	19.77	0.9314	26.56

Table 2. Physico-chemical properties of the soil and characteristics of water used for irrigation and foliar spraying

Soil properties	Values	Water characteristics	Values
EC (dS m^{-1})	3.26	EC (dS m^{-1})	2.59
pH	8.5	pH	7.5
Organic carbon (%)	1.51	K^+	0.08
Total N (%)	0.167	Na^+	12.6
Available P (meq l^{-1})	110	Ca^{2+}	8.1
Available K (meq l^{-1})	195	Mg^{2+}	9.2
Ca (meq l^{-1})	10.2	Cl^-	11
Mg (meq l^{-1})	9.2	CO_3^{2-}	0
Available Fe (meq l^{-1})	29	H CO_3^{2-}	8.3
Available Zn (meq l^{-1})	24.1	SO_4^{2-}	10.3
Available Mn (meq l^{-1})	23.1	SAR†	4.28
Available Cu (meq l^{-1})	10.6	TDS (ppm)	1600
Soil texture	Clay loam		

† Sodium Adsorption Ratio

Total Dissolved Solids

The plots were 150 × 150 cm with 3 rows, 50 cm row distance and 50 cm plant distance. Tarragon plantlets were cultivated at the farm in July. Before foliar application in August, plants were cut to 5 cm above ground.

A factorial experiment based on the Randomized Complete Block Design with three replications was used. The treatments were performed at four level of foliar applications of $Ca(NO_3)_2$ and KNO_3 fertilizers (including control (sprayed with water), 1.5, 3 and 6 gl^{-1}). Plants were sprayed three times every 20 days intervals and spraying was done when they had 10 cm height. During the growing period, the plants were irrigated and kept based on standard methods. Plants were harvested at the end of November and some production biological traits such as plant height, Fresh matter yield and Dry matter yield were measured.

2.2 Essential Oil Isolation

The plants were cut at ground surface and aerial parts were air dried for 2 weeks inside laboratory. Chopped air dried plant material was used for determination of essential oil content by hydro-distillation method using Clevenger type glass apparatus at 60 °C for 2.5 h (European Pharmacopoeia,1996). Essential oil samples were dried over anhydrous sodium sulphate and stored in sealed glass vials in refrigerator. Essential oil concentration (%) was estimated {(essential oil obtained in mg/weight of leaf dry matter in g)×100}. Essential oil yield per unit area was calculated by multiplying the biomass yield with essential oil concentration and weight of the essential oil.

2.3 Determination of Mineral Contents

Leaf samples were rinsed three times in distilled water then dried in a forced-air oven at 70 °C for 72 h. Dried leaves were ground and digested in H_2SO_4 for total N or in a ternary solution (HNO_3: H_2SO_4: $HCLO_4$ = 10:1:4 with volume) for the determination of P, K, Ca, Mg, Fe, Mn, Zn and Cu. Total nitrogen was determined using the Kjeldahl method (Helrich, 1990b). Potassium was assayed using Flame photometric method (Helrich, 1990d). Phosphorous content was measured spectrophotometrically with molybdovanadate according to Helrich (1990c). The Ca, Mg, Fe, Mn, Zn and Cu were determined according to an atomic absorption spectrophotometric method (Helrich, 1990a).

2.4 Statistical Analysis

Data analysis was carried out by using SAS 9.1 software and Duncan's multiple range tests were used to detect differences between means at probability level of 0.05.

3. Results and Discussion

3.1 Effect of $Ca(NO_3)_2$ on Growth Parameters, Essential Oil Content and Yield

There was an increase in plant height with $Ca(NO_3)_2$ fertilizationby an average of 10.1% compared with the control treatment. However, there was no significant difference between second and three levels (Table 3).A similar effect of Ca supply on plant height was also reported by Dordas (2009) in oregano (*Origanum vulgare* ssp. hirtum,), Karaivazoglou et al. (2007) in tobacco (*Nicotiana tabacum* L.) and Supanjani et al. (2005) in *Chrysanthemum coronarium* L. On the other hand, Mumivand et al. (2011) and Lee and Yang (2007) reported that $CaCO_3$ application did not significant effect on plant height in summer savory (*Satureja hortensis* L.) and *Chrysanthemum boreale* M., respectively.

Table 3. Effects of $Ca(NO_3)_2$ and KNO_3 foliar application on growth parameters, essential oil content and yield of *A. dracunculus* L.

Ca ($g\ l^{-1}$)	K ($g\ l^{-1}$)	Plant height (cm)	Fresh matter yield ($t\ ha^{-1}$)	Dry matter yield ($t\ ha^{-1}$)	Essential oil content (w/w)	Essential oil yield ($kg\ ha^{-1}$)
0		30.06 c[†]	7.12 c	2.45 c	0.44	6.54 b
1.5		31.79 b	7.93 bc	2.77 b	0.53	9.08 a
3		32.31 b	8.75 ab	3.12 a	0.55	10.45 a
6		33.11 a	9.67 a	3.27 a	0.54	10.75 a
					n.s.	
	0	31.33 b	6.46 b	2.34 d	0.40 b	5.57 c
	1.5	31.41 b	7.28 b	2.73 c	0.53 a	8.79 b
	3	31.80 b	9.36 a	3.02 b	0.56 a	10.24 ab
	6	32.71 a	10.37 a	3.52 a	0.57 a	12.23 a
0	0	29.62	5.51	1.80	0.36	3.88
	1.5	30.35	6.10	2.44	0.42	5.87
	3	29.70	8.28	2.51	0.53	8.01
	6	30.56	8.60	3.06	0.46	8.42
1.5	0	31.06	6.08	1.99	0.44	5.29
	1.5	31.11	7.05	2.64	0.50	7.97
	3	32.37	8.58	2.80	0.54	9.29
	6	32.61	10.02	3.64	0.63	13.80
3	0	31.65	6.25	2.74	0.44	7.17
	1.5	31.41	7.19	2.80	0.59	9.84
	3	32.46	10.53	3.36	0.64	12.79
	6	33.70	11.02	3.57	0.55	11.99
6	0	33.01	7.99	2.84	0.35	5.94
	1.5	32.78	8.78	3.03	0.62	11.49
	3	32.67	10.06	3.42	0.55	10.88
	6	33.97	11.84	3.78	0.65	14.70
		n.s.	n.s.	n.s.	n.s.	n.s.

† Means in the same column and year followed by the same letter do not differ significantly according to the LSD test (P = 0.05).

no significant effect.

With increasing of $Ca(NO_3)_2$ concentration from 0 to 6 g l^{-1} yield significantly increased by an average of 35.8%. However, there were no difference between control with 1.5, 1.5 with 3 and 3 with 6 g l^{-1} treatments (Table 3).This result is agreement with those of Karaivazoglou et al. (2007) who found that lime application in highest level increased total gross yield of Virginia tobacco. On the other hand, Mumivand et al. (2011) found that the fresh weight was greater in the plants fertilized by 5 t ha^{-1} $CaCO_3$ than the control plants, but no further increase was observed in the plants fertilized by10 t ha^{-1}.

Dry matter yield was significantly increased with $Ca(NO_3)_2$ foliar spraying by an average of 33.5% compared with the control, whereas there was not difference between 3 and 6 g l^{-1} treatments (Table 3). This result is in agreement with those reported by Al-Hamzawi (2010) in cucumber (*Cucumis sativus* L.) that state the highest shoot dry weight was observed due to the spray with $Ca(NO_3)_2$ at 15 mM, whereas Yildirim et al. (2009) in strawberry (*Fragaria ananassa* Duch.) reported that the highest shoot dry weight obtained from 10 mM $Ca(NO_3)_2$ spray treatment.In other study, $CaCo_3$ treatment up to 5 t ha^{-1} increased plant dry weight in Summer savory, but the higher rates (10 t ha^{-1}) decreased plant dry weight (Mumivand et al., 2011).

The increase in plant growth parameters might be attributed to increased cell division and cell elongation induced by the interaction between $Ca(NO_3)_2$ and auxin (Al-Hamzawi, 2010). Also, these positive effects may be due to the calcium actively influence one of the processes most vital to plant growth, nitrogen metabolism (Ruiz et al., 1999, 2003; Lopez-Lefebre et al., 2000). In addition, the increase in the yield might be due to greater availability of nutrients, increased uptake of nutrients and water, resulting in more photosynthesis and enhanced food accumulation in edible part of the plants (Chaurasia et al., 2005).

Table 3 demonstrates that no marked change was obtained in the essential oil percentage due to foliar spray with $Ca(NO_3)_2$ while the essential oil yield was significantly increased by an average of 64.4% compared with the control. The maximum essential oil yield (10.75 kg ha^{-1}) was recorded in plants treated with 6 g/l $Ca(NO_3)_2$ however had no significant difference with 1.5 and 3 g/l treatments. According to the results of Dordas (2009) Ca foliar spraying did not significantly influence on the essential oil content of oregano, which is in agreement with our results. However, essential oil yield and constituents were affected by foliar application of $Ca(NO_3)_2$. Similar effects of Ca supply on essential oil yield was also reported on summer savory (Mumivand et al., 2011), *Ch. boreale*. (Lee & Yang, 2007) and *Ch. coronarium* (Supanjani et al., 2005).

3.2 Effect of KNO_3 on Growth Parameters, Essential Oil Content and Yield

Plant height was increased with KNO_3application by an average of 4.4% compared with the control. However, there was no difference between control, 1.5 and 3 g l^{-1} treatments (Table 3). Similar findings were also reported by Ezz El-Din et al. (2010) in caraway (*Carum carvi* L.), Al-Hamzawi (2010) in cucumber, Singh and Ganesha Rao (2009) in patchouli (*Pogostemon cablin* [Blanco] Benth.), Singh (2008) in palmarosa (*Cymbopogon martinii* [roxb.] wats. var. motia burk) and Jeliazkova et al. (1999) in peppermint (*Mentha x piperita*).

In agreement with other reports (Hoda et al., 2011; Singh & Ganesha Rao, 2009; Singh, 2008; Jeliazkova et al., 1999), in our experiment KNO_3 fertilizer increased fresh matter yield by an average of 60.5% compared with the control. However, there were no significant difference between control with 1.5 and 3 with 6 g l^{-1} (Table 3).

With increasing KNO_3 foliar application rates from 0 to 6 g l^{-1} there was an increase in dry matter yield by an average of 50.4% (Table 3).Similar response of K application on dry matter yield reported by Hoda et al. (2011) and Yildirim et al. (2009).

The improving effect of potassium on plant growth may be due to that efficiency of the plant for the utilization of nitrogen (Adam et al., 1996; Fawzy et al., 2007). On the other hand, the role of K in an increasing the yield would can be attributed to its function in plants which include cation transport across membranes water economy, energy metabolism and enzyme activation on exchange rate and nitrogen activity as well as enhanced carbohydrate movement from the shoot to storage organs (Mengel & Kirkby, 1980). In addition, such promoting effect proved the role of potassium as an important nutrient in plant metabolism, enhancing carbohydrates synthesis, positively affecting water transport in the xylem and cell elongation (Ezz El-Din et al., 2010).

The results indicated that applying KNO_3 fertilization significantly increased essential oil content and yield by an average of 42.5% and 119.6%, respectively. The maximum essential oil content and yield (0.57% w/w and 12.23 kg ha^{-1}, respectively) were recorded in plants applied 6 g l^{-1} KNO_3, while the minimum values (0.40% and 5.57 kg ha^{-1}, respectively) were determined in control plants (Table 4). These results are in good accordance with the findings of Singh et al. (2007) on rosemary (*Rosmarinus officinalis* L.) and in contrast with the results of Ezz El-Din et al. (2010) in caraway. On the other hand, findings of some researchers showed that applying of K fertilization were not influenced the essential oil contents of patchouli (Singh & Ganesha Rao, 2009), palmarosa

(Singh, 2008), rosemary (Singh et al., 2007) and lemongrass (*Cymbopogon flexuosus* [Steud.] Wats.) (Singh et al., 2005). Besides, plant ecotype differences in regional environmental, soil, and climatic conditions, growing techniques, irrigation, as well as fertilization affect the content and composition of secondary metabolites in medicinal and aromatic plants (Ozguven et al., 2008).

Table 4. Effects of $Ca(NO_3)_2$ and KNO_3 foliar application on minerals content of leaf tissues of *A dracunculus* L.

Ca ($g\ l^{-1}$)	K ($g\ l^{-1}$)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe ($mg\ kg^{-1}$)	Mn ($mg\ kg^{-1}$)	Zn ($mg\ kg^{-1}$)	Cu ($mg\ kg^{-1}$)
0		3.51 c[†]	0.37 c	1.49 c	1.58 c	0.61 b	87.98 c	101.83 d	45.53 d	38.95 c
1.5		3.53 c	0.41 a	1.89 a	1.65 bc	0.64 a	95.93 b	106.66 c	56.63 b	48.80 b
3		3.74 b	0.40 b	1.79 b	1.68 b	0.55 c	127.65 a	123.31 a	65.18 a	50.80 a
6		3.79 a	0.36 d	1.78 b	1.83 a	0.52 d	83.18 d	116.60 b	50.13 c	48.78 b
	0	3.39 d	0.35 d	1.66 c	1.68 b	0.46 c	84.78 d	100.45 d	46.40 d	32.58 d
	1.5	3.57 c	0.37 c	1.73 b	1.90 a	0.58 b	95.43 c	107.66 c	56.55 c	41.33 c
	3	3.68 b	0.43 a	1.73 b	1.59 b	0.69 a	100.78 b	113.15 b	57.13 b	61.95 a
	6	3.94 a	0.40 b	1.83 a	1.58 b	0.60 b	113.75 a	127.13 a	57.38 a	51.48 b
0	0	3.23 i	0.34	1.37 j	1.50	0.49 ef	72.30 l	94.30 l	41.20 n	22.00 k
	1.5	3.33 h	0.36	1.53 g	1.80	0.61 cd	88.70 hi	97.00 jk	45.50 l	31.10 j
	3	3.51 f	0.41	1.41 i	1.50	0.67 bc	90.40 gh	98.90 j	38.50 o	36.90 h
	6	3.98 b	0.38	1.64 f	1.50	0.67 bc	100.50 f	117.10 e	56.90 f	65.80 b
1.5	0	3.24 i	0.36	1.26 k	1.60	0.55 de	87.20 i	96.80 k	42.60 m	34.60 i
	1.5	3.51 f	0.38	1.70 e	2.00	0.61 cd	91.10 g	103.23 h	51.40 i	56.20 d
	3	3.66 e	0.44	2.02 c	1.50	0.79 a	100.40 f	105.10 h	73.60 b	53.60 e
	6	3.71 de	0.44	2.57 a	1.50	0.61 cd	105.00 e	121.50 d	58.90 e	50.80 f
3	0	3.40 g	0.35	2.10 b	1.70	0.43 f	114.50 d	109.70 g	53.90 g	36.10 hi
	1.5	3.69 e	0.38	1.98 c	1.80	0.43 f	119.10 c	116.30 e	78.90 a	36.60 h
	3	3.78 c	0.45	1.47 h	1.63	0.73 b	127.60 b	130.70 c	66.40 c	63.70 c
	6	4.10 a	0.41	1.60 f	1.60	0.61 cd	149.40 a	136.53 a	61.50 d	66.80 b
6	0	3.68 e	0.33	1.92 d	1.90	0.36 g	65.10 m	101.00 i	47.90 k	37.60 h
	1.5	3.75 cd	0.34	1.70 e	2.00	0.67 bc	82.80 k	114.10 f	50.40 j	41.40 g
	3	3.76 cd	0.40	2.02 c	1.73	0.55 de	84.70 j	117.90 e	50.00 j	93.60 a
	6	3.98 b	0.38	1.49 h	1.70	0.49 ef	100.10 f	133.40 b	52.20 h	22.50 k
			n.s. □		n.s.					

† Means in the same column and year followed by the same letter do not differ significantly according to the LSD test (P = 0.05).

□ no significant effect.

3.3. Interaction Effectof $Ca(NO_3)_2$ and KNO_3 on Growth Parameters, Essential Oil Content and Yield

Plant height, fresh and dry matter yield, essential oil content and yield were not significantly affected by interaction effects of $Ca(NO_3)_2$ and KNO_3treatments (Table 3).

3.4 Effect of $Ca(NO_3)_2$ on Mineral Contents of Tarragon Leaves

The results obtained in this study showed that $Ca(NO_3)_2$ foliar application had a significant positive effect on Ca content of tarragon leaves. The maximum concentration of Ca (1.83%) was obtained at 6 g l^{-1} (Table 4). similar positive effects of Ca treatment on Ca content of oregano reported by Dordas (2009).

P concentration was significantly affected by $Ca(NO_3)_2$ fertilization. The highest value for P (0.41%) contents was obtained at 1.5 g l^{-1} treatment (Table 4). In cucumber, it was reported that foliar $Ca(NO_3)_2$ application up to 10 mM increased P content, but the higher concentration (15 mM) decreased (Al-Hamzavi, 2010). In addition, Yildirim et al. (2009) reported that the higher P content obtained from 10 mM foliar $Ca(NO_3)_2$ application. On the other hand, Mumivand et al. (2010) reported that $CaCO_3$ levels decreased P content of summer savory plant, while Lee and Yang (2007) and Supanjani et al. (2005) reported that higher $CaCO_3$ levels decreased P content of plant.

Regarding to obtained results, since calcium is involved in protein synthesis in mitochondria and mitochondria also involved in aerobic respiration and active transport of a large number of elements, can be concluded that there are a direct link between calcium intake and absorption of nutrients by plant. Also, calcium through inhibition of chlorophyll and protein degradation cause to increase permeability of the plasma membrane, which finally can lead to increase absorption of nutrients (Malakouti et al., 2006).

3.5 Effect of KNO_3 on Mineral Contents of Tarragon Leaves

Foliar application of KNO_3 at the rate of 3 g l^{-1} recorded high P content by average of 0.43% compared with the control at 5% level of significancy. Davies et al. (2009) reported that K application rates decreased P content of wormwood. Contrary to the results of this study, Hoda et al. (2011), Al-Hamzavi (2010), Singh and Ganesha Rao (2009) Yildirim et al. (2009) and Nadia (2006) found that increasing levels of K compounds increased accumulation of P in treated plants.

In term of Mg, Yildirim et al. (2009) and Nadia (2006) reported that Mg uptake in strawberry and barley plants appears to increase with increasing fertilizer K application. Whereas, K treatment decreased Mg content of wormwood plant (Davies et al., 2009).

The highest value for Ca content (1.90%) was obtained at 1.5 g l^{-1} KNO_3 treatment. These results are in good accordance with those obtained by Davies et al. (2009) that stated leaf Ca content decreased by increasing K treatment. Hoda et al. (2011), Al-Hamzavi (2010), Yildirim et al. (2009) and Nadia (2006) said that increasing supply of K compounds increased K content of leaves which were in contrast with the results of this study.

Potassium is a highly mobile element within the plant tissue and plays an important role in plant metabolism and enzyme seasonal activity particularly in the metabolism of carbohydrates. Also, this element plays an important role in transporting water and minerals throughout the plant's xylem (Wade Berry, 2006). Thus, our results can be attributed to the properties of potassium. In addition, Hoda et al. (2011) Believed that positive influence of K on mineral accumulation may be explained the increase of enzymatic activities which effect on absorption of mineral nutrients by plant and in turn increase its concentration in plant parts.

3.6 Interaction Effect of $Ca(NO_3)_2$ and KNO_3 on Mineral Contents of Tarragon Leaves

The results of the present study showed that the interaction effect were significant in Leaf N, K, Mg, Fe, Mn, Zn and Cu contents of tarragon (Table 4).

Integrated treatment which included 3 g l^{-1} $Ca(NO_3)_2$ with 3 g l^{-1} KNO_3 led to the highest value for N (4.10%), Fe (149.40 mg kg^{-1}) and Mn(136.53 mg kg^{-1}). Also, the maximum K percent of leaf (2.57%) was recorded in plants treated 3 g l^{-1} $Ca(NO_3)_2$ with 3 g l^{-1} KNO_3. On the other hand, $Ca(NO_3)_2$ and KNO_3 combined treatment at the rate of 1.5 g l^{-1} and 3 g l^{-1}, cause to the greatest percentage of Mg (0.79%) in tarragon leaves. In addition, the application of 3 g l^{-1} $Ca(NO_3)_2$ and 1.5 g l^{-1} KNO_3 together led to the highest content of Zn (78.90 mg kg^{-1}) in the leaf tissues. Moreover, the highest leaf Cu (93.60 $mgkg^{-1}$) content was obtained from 3 g l^{-1} $Ca(NO_3)_2$ with 3 g l^{-1} KNO_3 foliar application (Table 4).

In general, the applications of $Ca(NO_3)_2$ and KNO_3 had a significant effect on plant height, fresh matter yield, dry matter yield, essential oil yield and content. Improvement in yield attributes of tarragon due to foliar spray of Ca $(NO_3)_2$ and KNO3 might be attributed to hastened availability of N in the plant system, more chlorophyll synthesis, greater accumulation of protein in plants and efficient translocation of assimilates to reproductive parts.

Foliar application of $Ca(NO_3)_2$ and KNO_3 improved mineral elements content of tarragon leaves. This increase was expected since both nutrients were given in the form of foliar applications. These applications have a direct effect on the mineral concentration of the elements used and have a more direct effect on growth parameters and in the response of the crop to fertilizer application compared with the soil application (Dordas et al., 2007). In the soil application, the nutrients can be bound and therefore cannot be available for the plants. Also, since most nutrients are taken up with water, their uptake is restricted during water stress (Dordas, 2009). In fact, it was determined that foliar fertilization does not replace soil-applied fertilizer completely but it does increase the uptake and hence the efficiency of the nutrients applied to the soil (Tejada & Gonzalez, 2004). One of the benefits of foliar fertilization is the increased uptake of nutrients from the soil. This notion is based on the belief that the foliar fertilization causes the plant to release more sugars and other exudates from its roots into the rhizosphere. Beneficial microbial populations in the root zone are stimulated by the increased availability of these exudates. In turn, this enhanced biological activity increases the availability of nutrients, disease suppressive bio chemicals, vitamins, and other factors beneficial to the plant (Yildirim et al., 2007). In addition, a repeated application of small units of foliar fertilizers stimulates plant metabolism and an increased nutrient uptake via the roots can be observed (Fritz, 1978).

This study provides some useful information about the effect of application of Ca $(NO_3)_2$ and KNO_3 on tarragon production and in that way increases our knowledge about the effect of Ca $(NO_3)_2$ and KNO_3 on crop production. This information can be used for better Ca and K management, which in turn can be used for cost-effective applications of fertilizers there by leading to higher yield. In addition, this work attempts to contribute to knowledge of the nutritional properties of these plants. In addition, knowledge of the mineral contents, as condiments is of great interest.

4. Conclusion

In general, it can be concluded that the highest vegetative growth, essential oil content and yield of tarragon plant were obtained by 6 g $l^{-1}$$Ca(NO_3)_2$ and KNO_3foliar application. In conclusion, it is evident from the results that $Ca(NO_3)_2$ andKNO_3 foliar application improved most mineral contents of tarragon leaves, socan use this plant as a good source of mineral nutrition.

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