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ORIGINAL ARTICLES

Influence of cobalt nutrition on coriander (*Cariandrum sativum* L.) Herbs yield quantity and quality

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ABSTRACT

Two field experiments were conducted to evaluate the effect of cobalt on coriander herb yield quantity and quality. Coriander seeds were sown in Research and Production, National Research Centre, Nubaria cite, Beheara Governorate, Delta Egypt. Cobalt was irrigated in the form of cobalt sulphate in five concentrations (0.0, 7.5, 10.0, 12.5 and 15.0 ppm cobalt) once. Coriander herb was first harvested after 2 months from sowing and reharvested again 2 additional harvests at monthly intervals. All the plants received natural agricultural practices during the two growth seasons 2010 2011. Cobalt treatments significantly increased coriander herb yield, minerals composition (except Fe), chemical constituents as well as essential oils components compared with control plants. Cobalt at 12.5 ppm resulted the maximum figures in each three harvests during two studied seasons.

Key words: Coriander- Cobalt- Essential oils- Minerals and chemical contents.

Introduction

Green coriander is one of the most important aromatic crops in the world due to its usage across the Middle East into all Southern Asia, as well as most parts of Latin America. Coriander is extensively grown in India, Farmer Soviet States, Central Euroupe, Marocco and Egypt. There are two products from coriander plants which belong to family Apiaceae that are used for human nutrition: the fresh green herb and the seeds (fruits), but fruits and herbs prossess totally different flavor and can there for not substitute each other. Coriander herb is consumed fresh in soups and salads, food dressing and as flavoring ingredient. The green herb is also employed for the preparation of either stem-distilled essential oil or the solvent extraction oleorism, both products can be used in flavoring and aroma industries like perfumes, soaps and creams.

Coriander leaves are good source of vitamin "A" and "C" as well as minerals i.e Ca, K, P, Fe and Mn. As a medical plant, herb has been used to treat stomach disorders, intestinal complaints, colic, fatigue and indigestion (Guenther, 1961 and Fenaroli, 1971).

Cobalt is beneficial element for the growth and development for higher plants in spite of the absence of evidence direct role in their metabolism (Smith, 1991). Cobalt is an essential element for the synthesis of vitamin B_{12} which is required for human and animal nutrition (Young, 1983). Unlike other heavy metals, cobalt is saver for human consumption up to 8 ppm can be consumed on a daily basis without health hazard (Young, 1983). Laila Helmy *et al.,* (2002) reported that cobalt at 25 mg per kg soil significantly increased parsley leaves and its essential oil yields. Nadia Gad *et al.,* (2006) found that cobalt at 22.5 ppm had a significant promotive effect on olive yield quantity and quality, fruits oil and minerals composition as well as endogenous hormones of both Manzanillo and Arbicon cvs growing in sandy calcareous soil at Rass Seder under drip irrigation system; especially with organic fertilization.

Aziz, Eman *et al.,* (2011) revealed that cobalt at 15 ppm gave the greatest fresh and dry herb yield, the highest essential oil yield as well as improve the nutritional status of peppermint plants grown in newly reclaimed soil (Nubaria, Delta Egypt). Aziz, Eman and Nadia Gad (2011) stated that cobalt at 22.5 ppm gave the highest values of fresh and dry herb yield and the greatest essential oil yield of lemongrass leaves. Nadia Gad and Aziz Eman (2011) added that applying cobalt at 22.5 ppm gave synergistic effect on the endogenous hormones, chemical constituents and minerals composition of lemongrass. Confirm, Nadia Gad (2005) cobalt gave apositive effect due to several induced effects in hormonal synthesis and metabolic activity and attributed to catalase and peroxidase activities which enhancement all growth parameters of tomatoes.

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Materials and Methods

Two field experiments were conducted during two successive seasons in Research and Production station, National Research Centre, Nubaria Site, Behira Governorate, West of the Nile Delta of Egypt under drip irrigation system. Experiments were carried out to study the influence of cobalt nutrition on leaves yield quantity and quality of coriander.

Soil analysis:

Physical and chemical properties of Nubaria Soil were determined and particle size distributions along with soil moisture were determined as described by Blackmore (1972). Soil pH, EC, cations and anions, organic matter, $CaCO_3$, total nitrogen and available P, K, Fe, Mn, Zn, Cu were run according to Black *et al.,* (1982). Determination of soluble, available and total cobalt was determined according to method described by Cottenie *et al.,* (1982). Some physical and chemical properties of Nubaria soil are shown in Table (1).

Table 1: Some physical and chemical properties of Nubaria soil.

Physical properties							
Particle size distribution %				Soil moisture constant %			
Sand	Silt	Clay	Soil texture	Saturation	FC	WP	AW
70.8	25.6	3.6	Sandy loam	32.0	19.2	6.1	13.1

Chemical properties											
				Soluble cations ($meq^{-1}L$)				Soluble anions ($meq^{-1}L$)			
pH 1:2.5	EC ($dS\ m^{-1}$)	CaCO3 %	OM %	Ca^{++}	Mg^{++}	K^+	Na^+	HCO_3^-	CO_3	Cl^-	$SO_4^=$
8.49	1.74	3.4	0.20	0.8	0.5	1.6	1.80	0.3	-	1.9	0.5

Cobalt			Total	Available		Available micronutrients			
ppm			mg 100 g^{-1} soil			ppm			
Soluble	Available	Total	N	P	K	Fe	Mn	Zn	Cu
0.35	4.88	9.88	15.1	13.3	4.49	4.46	2.71	4.52	5.2

FC (Field capacity), WP (Welting point), AW (Available water).

During the soil preparation for cultivation organic manure, at 40 $m^3\ ha^{-1}$, calcium super phosphate at 300 kg ha^{-1} and potassium sulfate at 150 kg ha^{-1} were added as is customary for the region.

Plant material and Experimental works:

Experiments were carried out the influence of cobalt on coriander yield leaves quantity and quality.

Coriander *(coriandrum sativum L.)* seeds were sown on 25th October in two seasons and cultivated under drip irrigation system with all agricultural management required for production of seedlings as usually recommended. A preliminary pot experiment was conduct at wire house of National Research Centre to define cobalt concentrations: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0 ppm. According to the preliminary experiment results, the concentration range of cobalt which gave the coriander growth and herbs yield production. The seedlings (at the third truly leaf) were irrigated with different cobalt levels (7.5, 10.0, 12.5 and 15 ppm) once as the cobalt sulphate form. Each treatment represented by three plots. Each plot area was 5 * 3 meters consisting of three rows. Twenty five plants in each row (20 cm apart) were planted. All the plants received natural agricultural practices whenever they needed. Two months after seed sowing coriander plants were harvested by cutting 4-5 mm above soil surface, and then plants reharvested 3 additional harvests at monthly intervals. At each harvesting time, fresh and dry weights of herb (gm $plot^{-1}$) were recorded according to Gabal *et al.,* (1984).

Chlorophyll was determined in fresh coriander herb representing third upper leaf using chlorophyll meter Spad- 502, MINOLTA according to Wood *et al.,* (1992). The essential oil percentage of fresh herb was determined by hydrodistillation in clevenger's apparatus for 3 h. according to the Egyptian Pharmacopoeia (1984). The essential oil yield (ml $plant^{-1}$ and L ha^{-1}) was calculated. The resulted oil was dehydrated over anhydrous sodium sulphate in glass vials. The GLC analysis of the oil samples was carried out using Hewlett Packard gas chromatograph according to Bunzen *et al.,* (1969).

Macronutrients (N, P and K) and micronutrients (Fe, Mn, Zn and Cu) as well as cobalt were determined according to Cottenie *et al.,* (1982). The chemical constituents of total soluble solids, total soluble sugars, total protein, oil, total phenoles, L-Ascorbic acid and tetrable acidity were determined according to A.O.A.C. (1995).

The obtained data were statistically analyzed according to Snedcor and Conchran (1982).

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Results and Discussion

Vegetative growth and herb yield:

Data presented in Table (2) show that all growth parameters such as plant hight, number of leaves per plant, leaf area per plot of coriander plants increased gradually by increasing cobalt concentration from 0.0 to 12.5 ppm. Cobalt at 12.5 ppm gave the greatest values of fresh and dry weights of both shoots and roots in each the three harvests. The third harvest gave the maximum growth and yield. Cobalt had a significantly promotive effect of coriander growth parameters. Increasing cobalt above 12.5 ppm decreased the promotive effect. These results are in harmony with those obtained by Liala Helmy and Nadia Gad (2002) who found that all growth parameters of parsley i.e. plant hight, number of leaves per plant as well as fresh and dry weights of both herbs and roots are significantly increased with low cobalt level (25 mg/kg soil). Confirm, Nadia Gad (2005), low cobalt levels had a positive effect due to several induced effects in endogenous hormonal (Auxins- Gibberllins) synthesis and metabolic activity, also decreased the activity of some enzymes such as peroxidase and catalse in tomato plants. While the higher cobalt level (15 ppm) was found increase the enzymes activity and decreased the hormonal synthesis in plants and hence increasing the catabolism rather than anabolism. Aziz *et al.,* (2011) added that cobalt at 15 ppm gave the highest fresh and dry herb yield (11.81 and 3.12 ton ha^{-1}) of peppermint.

Table 2: Effect of cobalt nutrition on coriander growth parameters in each of the three harvests (mean of two seasons).

Harvesting Frequency	Cobalt treatment (ppm)	Plant hight (cm)	Number of leaves/ plant	Leaf area (cm^2)/plot	Fresh weight (gm)/plot		Dry weight (gm)/plot	
					Shoot	Roots	Shoot	Roots
First Harvest	Control	9.31	5.2	54.6	12.5	1.39	3.15	0.46
	7.5	12.2	5.9	62.0	15.3	2.46	3.92	0.84
	10.0	13.8	7.5	78.7	16.2	2.78	4.07	0.93
	12.5	15.2	8.3	86.9	18.8	3.11	4.68	1.05
	15.0	12.7	6.6	69.3	16.9	2.67	4.22	0.89
Second Harvest	Control	10.2	5.5	58.9	12.9	1.38	3.18	0.46
	7.5	14.2	6.2	66.0	16.5	2.39	3.99	0.86
	10.0	16.5	7.5	78.2	17.8	2.98	4.36	0.94
	12.5	18.6	8.5	92.6	19.9	3.22	4.96	1.19
	15.0	17.1	7.0	74.8	18.6	2.80	4.57	1.04
Third Harvest	Control	11.3	5.8	59.4	12.6	1.35	3.15	0.46
	7.5	15.9	6.9	69.8	16.9	2.55	3.77	0.81
	10.0	18.8	7.5	88.1	18.1	2.98	4.81	0.99
	12.5	21.6	8.8	112.0	20.0	3.36	5.48	1.31
	15.0	19.4	7.3	78.5	15.2	3.07	5.19	1.12
LSD at 5%		0.09	0.02	0.08	0.03	0.02	0.03	0.01

Nutritional status:

Macronutrients (N, P, K, Ca and Mg):

Data in Table (3) indicate that all cobalt doses significantly increased the content of N, P, K, Ca and Mg in coriander herb compared with control. The highest values of macronutrients of coriander herb were obtained by cobalt rate at 12.5 ppm compared with other cobalt doses. Increasing cobalt level in plant media above 12.5 ppm were significantly reduced the promtive effect. These results are agree with those obtained by Liala Helmy and Nadia Gad (2002) who stated that cobalt gave a significantly promotive effect in the status N, P, K, Ca and Mg of parsley herb. Nadia Gad and Aziz (2011) added that cobalt significantly increase macronutrients (N, P and K) of lemongrass.

Micronutrients (Mn, Zn and Cu):

Data in Table (3) show that cobalt at 12.5 ppm had a beneficial effect on the content of Mn, Zn and Cu figures in the third harvest. Berry (1998) found that synergistic effect were obtained between cobalt and other micronutrients especially Zn in lettuce seedlings grown in water culture.

Increasing cobalt dose in plant media resulted the deprition of the beneficial effect. These results are in harmony with those obtained with Satio and Takahashi (1979) and Aziz *et al.,* (2011).

Iron content:

Presented data in Table (3) stated that, iron content in coriander herb significantly decreased with the increasing cobalt level in plant media in the three harvests without hazard chlorophyll content. Yagodin *et al.,* (1990) and Angelov *et al.,* (1993) reported that cobalt and iron are competitive elements in the nutrition of tomato plants. Bisht (1991) added certain antagonistic relationship between both Co and Fe elements. Confirm, Nadia Gad and Nagwa Hassan (2011) who indicated that increasing cobalt doses in plant media resulted in a progressive depression effect of iron content in sweet potato roots.

Cobalt content:

Data in Table (3) also reveal that cobalt content in coriander herb (in three harvests) significantly increased when cobalt addition increasing in plant media. These results are good agreement with those obtained by Aziz *et al.,* (2011) who demonstrated that, increasing cobalt doses in plant media significantly increased cobalt content in peppermint herbs as compared with control. The highest cobalt content in coriander herb which treated with 12.5 ppm is 7.85 ppm. Young (1983) reported that the daily cobalt requirement for human nutrition could reach 8 ppm depending on cobalt levels in local supply of drinking water without health hazard.

Table 3: Effect of cobalt nutrition on coriander herb minerals composition in each of the three harvests (mean of two seasons).

Harvesting Frequency	Cobalt treatment ppm	Macronutrients (%)					Macronutrients (ppm)				Co (ppm)
		N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	
First harvest	Control	3.11	0.66	2.51	1.65	76.7	154.2	64.2	41.6	39.2	0.66
	7.5	3.64	0.81	2.73	1.82	80.2	151.0	66.5	44.0	41.0	1.83
	10.0	3.98	0.89	2.94	1.96	84.6	146.9	69.0	47.5	43.5	3.89
	12.5	3.06	0.98	3.00	2.09	91.1	141.5	74.2	83.8	46.1	7.81
	15.0	4.01	0.77	2.46	2.03	88.0	138.0	76.6	81.0	44.2	8.80
Second harvest	Control	3.15	0.71	2.61	1.65	76.9	145.0	64.5	41.7	39.3	0.67
	7.5	3.77	0.83	2.95	1.80	89.0	153.2	69.0	45.6	41.9	1.85
	10.0	3.88	0.95	2.98	1.99	93.6	149.6	64.3	48.0	44.3	3.91
	12.5	4.12	1.02	3.11	2.12	79.9	150.7	66.4	41.5	39.3	7.85
	15.0	4.08	0.97	3.02	2.07	86.4	145.2	78.1	44.6	47.6	8.83
Third harvest	Control	3.10	0.68	2.59	1.65	76.3	154.3	81.6	51.2	47.6	0.68
	7.5	3.59	0.75	2.66	1.79	98.3	146.0	76.2	47.0	45.5	1.84
	10.0	4.03	0.84	2.79	1.86	95.0	140.0	70.2	47.7	43.4	3.92
	12.5	4.01	1.65	3.41	2.43	91.0	139.0	75.8	54.0	46.2	7.82
	15.0	3.99	1.21	3.21	2.12	86.2	136.6	71.5	51.4	44.7	8.81
LSD at 5%		0.02	0.01	0.03	0.02	0.13	0.24	0.11	0.07	0.08	0.04

Chemical constituents:

Data in Table (4) indicated, in response to cobalt nutrition, coriander herb contents of total protein, total soluble solid, L-Ascorbic acid (vitamin C), total phenols and oil percentages were enhancement with all cobalt concentrations as compared with control plants, in the three harvests. Cobalt at 12.5 ppm resulted the maximum figures during two studied seasons. These results are in harmony with those obtained by Nadia Gad and Hala Kandil (2008) who reported that cobalt at 10 ppm increased the contents of protein 26-27%, starch 7-8%, total soluble sugare 18-21%, Carotenoids (vitamin A) and L- Ascorbic acid (vitamin C) 19-21% respectively of sweet potato roots in two seasons.

Table (4) also revealed that increasing cobalt above 12.5 ppm decreased the promotive effect. Data in Table (4) also show that total phenols resulted increased with increasing cobalt level in plant media from 7.5 to 15.0 ppm. The percentage of total phenols content with 15 ppm (1.76%) less 2.5% safty human health. These data are in harmony with Mona Dawood (2005) and Nadia Gad (2010) who found that, increasing cobalt addition in plant media from 2.5 to 20 ppm increased in canola seeds the percentage of total phenols content (1.98%) less 2.5% safety human health. Also cobalt at 12.5 ppm gave the greatest canola seed oil 287% compared with control plants.

Chlorophyll content:

Data in Table (4) indicate that all levels not significant effect on chlorophyll content of coriander leaves. These results are good agreement with those obtained by Terry (1981) who found that, low levels of cobalt on photosynthetic electron transport capacity per leaf area. A linear relationship was reported between chlorophyll content and total leaf iron. With increasing cobalt levels in plant media decreased coriander herb Fe content (Table, 3) without chlorophyll hazard.

Table (4) also indicated that the titrable acidity gave the adverse effect with increasing cobalt addition in plant media. Decreasing total acidity in coriander herb enhance herb flavour and quality. These data are good in harmony with Nadia Gad (2005) who revealed that titrable acidity (as citric acid) on tomato fruits showed negative response to all levels of cobalt compared with control. This response enhances fruits quality.

Table 4: Effect of cobalt nutrition on chemical constituents of coriander herb in each three harvests (mean of two seasons).

Harvesting Frequency	Cobalt treatment ppm	Total Protein	Total soluble solids	Total carbohydrates	Vitamin "C"	Total phenols	Oil	Tetrable acidity	Chlorophyll (Spad)
	%								
First harvest	Control	19.4	14.6	14.36	36.8	1.11	0.093	8.91	51.6
	7.5	22.8	16.5	14.93	38.0	1.19	0.169	8.66	51.6
	10.0	24.9	17.2	15.15	42.1	1.32	0.185	8.22	51.3
	12.5	25.4	18.9	15.90	44.2	1.56	0.261	7.98	51.2
	15.0	25.0	17.6	15.53	43.0	1.76	0.228	7.54	51.0
Second harvest	Control	19.4	14.5	14.74	36.9	1.12	0.095	8.85	51.6
	7.5	22.4	16.9	15.22	38.3	1.21	0.110	8.59	51.5
	10.0	24.3	14.6	15.88	43.3	1.34	0.189	8.21	51.6
	12.5	25.1	16.7	16.02	45.4	1.53	0.266	7.87	51.3
	15.0	24.3	18.5	15.89	44.7	1.49	0.233	7.55	51.2
Third harvest	Control	19.7	18.0	15.01	36.9	1.14	0.790	8.86	51.6
	7.5	24.3	19.8	15.19	39.9	1.28	0.173	8.65	51.6
	10.0	25.2	17.0	15.89	44.5	1.39	0.227	8.19	51.5
	12.5	25.8	18.6	16.08	46.6	1.59	0.275	7.87	51.6
	15.0	25.5	17.4	15.91	44.4	1.50	0.243	7.51	51.4
LSD at 5%		-	0.05	0.03	0.07	0.02	0.003	0.03	N.S

Essential oil yield:

It is evident from the data presented in Table (5), that the essential oil of coriander herb contains 13 compounds. Thirteen compounds of coriander herb (in the third harvest) were identified 2-decenal was the first major oil constituent forming about 26% of the oil. Cobalt at 12.5 ppm improved not only coriander herb oil yield and its quality. Cobalt at 12.5 ppm enhanced coriander herb oil several fractions such as α-pinene, B-pinene and B- caryophellene which can be used as starting materials for synthetic production on other flavauring. Cobalt at 12.5 ppm increased the essential oil about 44.8% as compared with untreated plants. These results are in harmony with those obtained with Liala Helmy and Nadia Gad (2002) who stated that cobalt fertilization at 50 mg/Kg soil significantly increased essential oil yield of parsley leaves. The main aroma consistent for parsley leaves, 1,3,8-p-menthatriene which forms about 76% of leaves essential oil, showed about 10% increase over that of control.

Table 5: Effect of cobalt nutrition on coriander herb essential oil constituents (aroma compounds).

Essential oil constituents in three harvest	Third harvest				
	Cobalt treatment (ppm)				
	Control	7.5	10.0	12.5	15.0
	Oil fatty acids (ml/kg)				
α-Pinene	0.035	0.043	0.051	0.066	0.055
B-pinene	0.098	0.112	0.102	0.314	0.100
Sabinene	0.401	0.606	0.680	0.811	0.743
α-terpindene	0.212	0.316	0.347	0.386	0.341
Decanal	8.144	8.214	9.031	9.781	14.137
Linalool	5.322	6.656	7.751	8.566	5.689
B-Caryophyllene	1.119	1.399	1.512	1.840	1.619
2-decenal	23.220	23.419	23.645	24.812	26.408
α- terpineol	2.240	2.529	3.110	3.367	2.560
Heptenal	5.808	7.404	7.639	7.804	5.220
Nonenal	3.122	4.997	7.035	7.911	6.763
octadecane	2.506	3.983	4.735	6.466	3.798
Farnesol	2.619	3.983	4.522	6.714	4.882
Total	54.846	63.661	70.160	79.432	72.315
Unidentified	45.154	36.339	29.840	20.568	27.685

Conclusion:

On other results, cobalt nutrition led to in coriander growth, yield quantity and quality as well as the contents of nutritional status, chemical constituents and oil. Cobalt also, increased the essential oils in coriander herb about 44.8% as compared with untreated plants.

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