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Effect of cobalt on growth, herb yield and essential quantity and quality in Dill (*Anethum gravealens)*

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ABSTRACT

Dill *(Anethum gravealens* L.*)* is an annual, aromatic herb plant belongs to umbelliferae Family. Two field experiments had been done in Research and Production Station, National Research Centre, El-Nubaria location, Beheara Governorate. Delta Egypt under sprinkler irrigation system during 2012 and 2013 seasons. The present investigation has been carried out to estimate the effect of different concentration of cobalt (0.0, 5.0, 7.5, 10.0, 12.5 and 15.0 ppm) on Dill herb yield, essential oil content and its composition, minerals composition as well as chemical constituents. Dill herb was first harvest two month after seed sowing and reharvested again for three harvests at monthly intervals.
The obtained results showed:-

- All cobalt concentrations significantly increased all growth and yield parameters as well as nutritional status, chemical constituents and essential oil content and its composition compared with control plants.
- Cobalt at 10 ppm resulted the superior growth, yield quantity and quality of Dill.
- An increasing cobalt level in growing media more than 10 ppm the favorable effect reduced.

Key words: Dill, cobalt, essential oils, nutritional and chemical contents.

Introduction

Dill *(Anethum gravealens* L.*)* is an annual, aromatic herb plant belongs to umbelliferae Family. It is cultivated in central and southern regions as a winter crop. Dill plant is native to India and it has spread to Mediterranean and Europe later and then to America and Japan (Bailer *et al*, 2001). The plant has a potential importance as a medicinal herb that contains volatile oils such as B-camphene, a-pinene, anethol, Ionone, unbelliferone and carvone (Dhalwall *et al,* 2008*)*. Dill leaves and seeds (small fragrant fruits) are used as seasoning. The leaves could be used in eggs, meats, salads, sea foods and soups; the seeds could be used in bread and flavouring pickles and soups. Dill essential oil, extracted from both leaves and seeds, could also be used in chewing gums, candies and pickles (Just, 2008 and Zohary and Hopf, 2000). Literature demonstrates that dill leaf consumption could lower the risk of concer (Yang *et al*, 1996) and reduce the level of cholesterolaemia (Lanky *et al*, 1993). Moreover, dill leaves, seeds and their essential oil could provide good antioxidant activities (Delaquies *et al* 2002 and Singh *et al* 2005). Many reports indicate that plant flowers have remarkable antioxidant activity (Elzaawely *et al*, 2007).

Cobalt is a beneficial element for higher plants growth, cobalt is an essential element for the synthesis of vitamin B_{12}, which is required for human and animals nutrition (Young, 1983, Smith, 1991). Cobalt does not accumulate in human body as other heavy metal up to 8 ppm can be consumed on a daily basis without health hazard. Cobalt does not accumulate in human body as the other heavy metals. Laila Helmy and Nadia Gad (2002) stated that cobalt at 25 or 50 mg per Kg soil had a significant beneficial effect on parsley leaves yield as well as the status of N, P, K, Ca, Mg, Zn, Cu and cobalt compared with control. Eman Aziz *et al* (2007) found that cobalt at 20mg per Kg soil posses a synergitic effect on the growth, flower yield, number of branches as well as minerals composition (N, P, K, Mn, Zn, Cu and Cu) of roselle leaves and calyces.

Eman Azia *et al* (2011) showed that cobalt at 15 ppm gave the greatest fresh and dry herb yield, the highest essential oil yield as well as improve the status of macronutrients (N, P and K) and micronutrients (Mn, Zn andCu) contents. The highest level of cobalt (30 ppm) increased the principal components of menthone (37.84%), and isomenthone (15.19%). This effect was complained with decreasing the relative content of L-(-)-menthol (28.54%) as compared with control and other treatments. Thus the relatively high level of menthol in the peppermint oil suggests that a marketable peppermint essential oil could be successfully in newly reclaimed land of Egypt.

Nadia Gad and Eman Aziz (2011) stated that cobalt at 22.5 ppm had a significant positive role of lemongrass endogenous hormones such as Auxins, Gibberllins and cytokinens, herbs quality such as total soluble solids, protein, total lipids, total phenols as well as the contents of N, P, K, Mn, Zn and Cu compared

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with other concentration. With increasing cobalt levels Abscise acid increased. Higher concentrations more than 22.5 ppm exerted adverse effect.

Nadia Gad and Hala Kandil (2012) showed that cobalt application significantly increased coriander herb yield, nutrients status, chemical constituents as well as essential oil components compared with control plants. Cobalt at 12.5 ppm resulted the maximum figures in each three harvests during two studied seasons. Man Aziz *et al* (2013) demonstrated that cobalt at 15 ppm gave the greatest values of sweet basil fresh and dry herb yield. Increasing cobalt level from 0.0 to 22.5 ppm significantly increased the essential oil yield from 38.39 to 181.48 L ha^{-1}. While the highest level of cobalt (30ppm) reduced the positive effect. Nadia Gad and Hala Kandil (2013) stated that cobalt at 12.5ppm significantly promotive effect of fresh and dry herb of stevia as well as oil yield and essential oil content while increasing cobalt levels in plant media reduced the promotive effect.

The aim of present experiment to study the effect of cobalt on growth, yield and essential oil quantity and quality in Dill herbs.

Materials and Methods

Tow field experiments were carried out during the growing season of 2012-2013 in the Research and production Station, National Research Centre, El-Nubaria location, Beheara Governorate, Delta Egypt to study the effect of cobalt on growth, yield and essential oil quantity and quality in Dill (*Anethum gravealens).*

Soil analysis: Physical and chemical properties of El-Nubaria soil samples were determined well as particle size distributions and 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, Cu were run according to Black *et al* (1982). Determination of soluble, available and total cobalt were determined according to method described by Cottenie *et al* (1982). Some physical and chemical properties of El-Nubaria soil sample are shown in Table (1).

Table 1: Some physical and chemical properties of the used soil at El-Nubaria, Research and Production Station, National Research Centre.

Soil property	Particle size distribution %				Soil moisture constant %			
Physical	Sand	Silt	Clay	Texture	Saturation	FC	WP	AW
	68.7	24.5	6.8	S L	32.0	19.2	6.1	13.1
Chemical	pH[a]		EC[b] dS/m		$CaCO_3$ %		OM [c] %	
	7.8		0.18		7.07		0.16	
	Soluble cations (meq/l)				Soluble anions (meq/l)			
	Ca^{++}	Mg^{++}	K^+	Na^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$
	3.00	2.00	0.32	2.09	0.00	1.41	0.70	5.30
	Total	Available			Available micronutrients			
	N	P		K	Fe	Mn	Zn	Cu
	mg/100 g soil				ppm			
					7.8	3.3	1.86	4.0
					Cobalt (ppm)			
	15.0	9.4		16.0	Soluble	Available		Total
					0.49	4.43		15.00

a: Soil pH was measured in 1:2.5 soil-water suspension, b: EC was measured as dSm^{-1} in soil paste, S L: sandy loam c: organic matter.

Experimental works: Seeds of Dill were planted at 15/10/2012 during both 2012 and 2013 successive seasons. Each experiment consisting of6 treatments. Each treatment represented by three plots. Each plot area was 5x3 meters consisting of three rows. After one month from sowing, seedlings transplanting, twenty five seedlings in each row (20 cm a part) were planted. All the plants received natural agriculture practices whenever they needed. Dill seedlings (at the true leaves) irrigated once with cobalt concentrations: 0.0, 5.0, 7.0, 10.0, 12.5 and 15.0 ppm. One month after cobalt treatments Dill plants were harvested (10 cm above soil surface), and then plants reharvested second harvest after one month from first harvest, third harvest after one month from second one.

Measurement of herb growth and yield parameters: At each harvesting time, all growth and yield parameters as well as fresh and dry weighs of dill herb were recorded according to FAO (1980) and Gabal *et al* (1984).

Measurement of herb nutritional status: Micronutrients (N, P and K) and micronutrients (Fe, Mn, Zn and Cu) along with cobalt were determined according to Cottenie *et al* (1982).

Measuring of herb chemical constituents: Total soluble solids, total soluble sugars, L-Ascorbic acid, titrable acidity were determined according to A.O.A.C (1995).

Measuring of essential oil: The essential oil percentage of fresh herb was determined according to A.O.C.S (1982). The essential oil yield (ml $plant^{-1}$and L ha^{-1}) was calculated.

Measuring of essential oil components: Percentage of fresh herb was determined by hydrodistillaqtion in clevenger's apparatus for 3 hours according to the Egyptian harvest at monthly intervals the essential oil yield (ml $plant^{-1}$andLha^{-1})was calculated. The resulted oil was dehydrated over anhydrous sodium sulfate in glass vials. The GLC analysis of the oil samples was carried out using HEWIETT PACKARD quipped with FID, Hp 6890 series system, USA according to Bunzen *et al* (1969).

Statistical analysis: The obtained data were statistically analyzed of variance procedure outlined by (SAS, 1996) computer program and means were compared by LSD method according to Snedecor and Cochran (1980).

Results and Discussion

Vegetative growth:

Data in Table (2) indicate that cobalt levels (5.0, 7.5, 10.0, 12.5 and 15.0 ppm) has a positive effect on Dill plant growth parameters compared with control. Cobalt significantly promoted all parameters of Dill plant growth including plant height, number of branches per plant, number of leaves per plant and leaf area per plant in each of the three harvests, during two growing seasons. The highest recorded results of the mentioned parameters of Dill were obtained in plants treated with 10 ppm cobalt.
When cobalt addition in plant media, increased more than 10 ppm (12.5 and 15.0 ppm) the promotive effect reduced in each of the three harvests, during two seasons. These observations are consistent with previous reports obtained by Nadia Gad and Hala Kandil (2012) how stated that cobalt significantly increased all coriander growth parameters compared with untreated plants in each three harvests during two studied seasons.

Table 2: Effect of cobalt on some growth parameters of Dill herb for third harvests (mean of two seasons).

Cobalt treatments (ppm)	Plant height (cm)			Number of branches / plant			Number of leaves / plant			Leaf area / plant $(cm)^2$		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Control	49.6	55.7	59.6	5.17	5.19	5.22	19.32	20.56	23.24	43.6	51.0	58.8
5.0	52.1	58.5	62.3	5.24	5.51	5.81	21.36	24.40	26.90	47.8	54.2	64.0
7.5	54.8	62.6	64.9	6.11	6.44	6.78	24.05	26.93	29.18	52.9	59.6	69.5
10.0	58.2	65.0	68.5	7.87	7.97	8.14	28.11	29.78	33.34	57.7	65.0	76.8
12.5	56.0	63.1	66.0	7.50	7.66	7.87	26.50	28.33	32.11	53.0	61.1	76.8
15.0	54.3	60.8	63.3	6.33	6.50	6.62	25.41	26.81	30.76	49.3	58.4	67.3
LSD at 5%	0.22	0.31	0.23	0.12	0.14	0.13	0.11	0.21	0.41	0.07	0.09	0.09

Herb yield: Data presented in Table (3) show that different cobalt levels significantly increased Dill herb fresh weight per plant, herb dry weight per plant, total fresh weight per plant, total dry weight per plant as well as fresh herb (Ton ha^{-1}) and dry herb (Ton ha^{-1}) in the harvests during two studied seasons. Cobalt at 10 ppm gave the greatest values of fresh herb and biomass (59.51% and 61.7%). Increasing cobalt in plant media more than 10 ppm, the promotive effect reduced Dill yield parameters. These results are in harmony with those obtained by Nadia Gad (2005) who indicated that the optimum cobalt level of tomato (7.5 ppm) being with positive effect due to several induced effect in hormonal synthesis and metabolic activity, while the higher cobalt doses were found to increase the activity of some enzymes such a peroxidase and catalase in plant and hence increasing the catabolism rather than the anabolism.

Table 3: Effect of cobalt on yield of Dill herb (mean of two seasons).

Cobalt treatments (ppm)	Herb fresh weight/plant (g)			Herb dry weight/plant (g)			Total fresh weight/plant (g)	Total dry weight/plant (g)	Fresh herb Ton ha^{-1}	Dry herb Ton ha^{-1}
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut				
Control	51.33	52.61	54.01	14.08	14.65	14.86	157.95	43.59	3.413	0.919
5.0	56.83	58.04	60.38	15.59	16.05	16.82	175.25	48.46	3.794	1.036
7.5	63.96	64.75	66.89	17.24	18.71	19.81	195.60	55.76	4.366	1.192
10.0	71.63	73.11	75.32	21.33	23.11	25.09	220.06	69.53	5.444	1.486
12.5	68.04	69.50	72.51	19.60	22.00	23.87	210.05	65.47	5.126	1.399
15.0	65.46	66.60	69.19	18.33	20.91	22.34	201.25	61.58	4.822	1.316
LSD at 5%	1.13	1.18	1.24	0.33	0.25	0.31	-	-	-	-

Essential oil yield: Data in Table (4) and Fig. (1) clearly indicate that all cobalt levels have significant promotive effect on Dill essential oil percent and yield (ml per plant and L ha^{-1})compared with control. Cobalt at 10 ppm resulted the greatest values in Dill essential oil percent (0.31, 0.45 and 0.58) in the first, second and third harvests respectively. Cobalt at 10 ppm significantly increased total oil yield per plant from 2.22 ml $plant^{-1}$ to 7.58 ml $plant^{-1}$. When cobalt addition in plant media above than 10 ppm the promotive effect was reduced. These results are good agreement with those obtained by Eman Aziz *et al*., (2011) how showed that cobalt at 15 ppm gave the greatest fresh and dry herb yield as well as the highest essential oil yield of peppermint. Confirm these result Nadia Gad and Hala Kandil (2012) stated that cobalt significantly increased coriander essential oil yield compared with control plants. Cobalt at 12.5 ppm resulted the maximum figures in each three harvests during two studied seasons.

Table 4: Effect of cobalt on essential oil content of Dill herb (mean of two.

Cobalt treatments (ppm)	First harvest		Second harvest		Third harvest		Total yield ml plant^{-1}
	Oil (%)	ml plant^{-1}	Oil (%)	ml plant^{-1}	Oil (%)	ml plant^{-1}	
Control	0.21	0.71	o.36	0.75	o.49	0.75	2.22
5.0	0.24	0.87	0.38	0.97	0.52	0.99	2.83
7.5	0.27	1.06	0.41	1.19	0.55	1.26	3.51
10.0	0.31	2.32	0.45	2.59	0.58	2.67	7.58
12.5	0.31	2.18	0.43	2.27	0.58	2.34	6.79
15.0	0.29	1.97	0.41	2.18	0.56	2.12	6.27
LSD at 5%	0.01	0.03	0.009	0.01	0.01	0.07	-

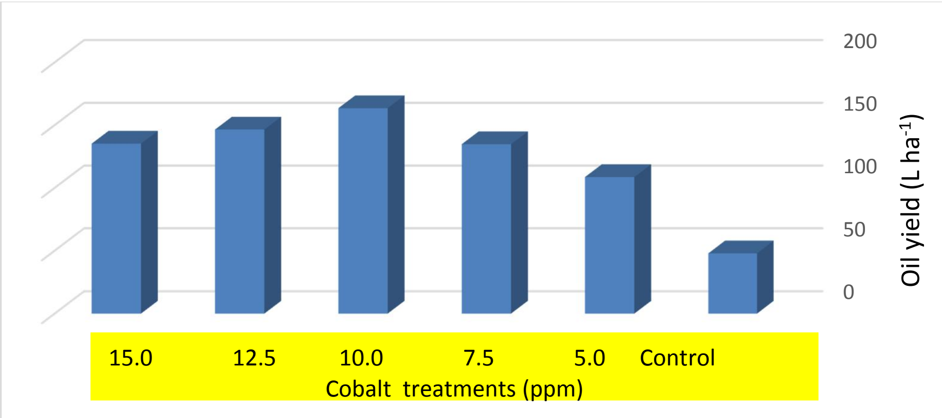

Fig 1: Effect of cobalt on oil yield (L ha^{-1}) of Dill herb (mean of two seasons).

Essential oil composition: Data presented in Table (5) obviously reveal that Dill oil composition responded greatly to cobalt supplement. The GLC analysis of essential oil extracted from Dill herbs which treated with cobalt reveal that 5 peaks. The major constituents were carvon, limonene, a-phell-andrene, Dill ether and trans-Dihydro-carvon. Cobalt significantly increases carvon, a-phell-andrene and Dill ether. Cobalt at 10 ppm resulted the greatest values in the three harvests during two studied seasons. The higher content of carvon a-phell-andrene and Dill ether oil. Increasing cobalt concentration above 10 ppm reduce the promotive effect. On the other hand, both limonene and Trans-Dihydro carvon oils were reduced with all cobalt doses.

Table 5: Effect of cobalt on essential oil composition of Dill herb (mean of two seasons).

Essential oil compound (%)	Cobalt treatments (ppm)					
	Control	5.0	7.5	10.0	12.5	15.0
First harvest						
Carvone	53.12	53.87	54.79	55.37	54.18	53.85
Limonene	26.47	26.19	25.71	25.56	25.13	24.80
a-phell-andrene	2.44	2.59	2.71	2.84	2.75	2.69
Dill ether	1.01	1.12	1.19	1.31	1.26	1.19
Trans-Dihydro carvon	4.25	4.18	4.18	4.14	4.06	3.96
Second harvest						
Carvone	51.31	55.66	55.89	56.24	56.11	55.87
Limonene	28.89	28.45	28.21	28.08	27.87	27.49
a-phell-andrene	2.94	3.05	3.34	3.56	3.49	3.42
Dill ether	1.21	1.33	1.56	1.77	1.69	1.69
Trans-Dihydro carvon	4.67	4.59	4.52	4.41	4.36	4.21
Third harvest						
Carvone	57.69	57.91	58.23	58.89	58.54	58.19
Limonene	31.88	31.36	31.12	31.01	30.85	30.67
a-phell-andrene	3.63	3.74	3.89	4.03	3.91	3.78
Dill ether	2.14	2.25	2.54	2.78	2.78	2.76
Trans-Dihydro carvon	4.84	4.86	4.89	4.78	4.66	4.57

These results are in harmony with those obtained by Eman Aziz *et al*., (2013) who indicated that cobalt significant increased the essential oil yield in sweet basil plants and it's have possible role in the essential oil compounds in both two harvests during two growing seasons.

Chemical constituents: The amounts of protein, total soluble solids, total soluble sugars and vitamin "C" as L-Ascorbic acid in Dill herb as affected by different levels of cobalt are given in Table (6). Data indicate that all the mentioned parameters were significantly increased by cobalt treatments compared with control. Cobalt at 10 ppm resulted the greatest values in the three harvests during two studied seasons. Data also show that increasing cobalt levels more than 10 ppm reduced the promotive effect. In this concern, Nadia Gad *et al*., (2013) revealed that applying cobalt at 15 ppm gave synergistic effect on total soluble solids, total soluble sugars, total protein and total phenols in sweet basil herb. Confirm these results Nadia Gad and Hala Kandil (2008) stated that cobalt at 10 ppm increased the sweet potato contents of carotenoids 27-31%, protein 26-27%, starch 7-8%, total soluble solids 58-61%, total soluble sugars 18-21% and L-Ascorbic acid 19-21% respectively. In Dill herbs cobalt at 10 ppm significantly increased vitamin "C" as L-Ascorbic acid 12.15% in the first harvest, 13.05% in the second harvest and 13.55% in the third harvest. L-Ascorbic acid is the major antioxidant in plant cells and is involved in photo protection metal and xenobiotic detoxification, the cell cycle cell wall growth and cell expansion. It acts as Co-enzyme in metabolic changes and involved in photosynthesis and respiration processes (Franceschi and Tarlyn, 2002). For human high vitamin "C" directory intake correlates with reduced gastric cancer risk (Griffiths and Lunec; 2001).

Table 6: Effect of cobalt on chemical constituents of Dill herb (mean of two seasons).

Cobalt treatments (ppm)	Protein	Total soluble solids	Total soluble sugars	L-Ascorbic acid
	(%)			(mg/100 g F.W)
First harvest				
Control	5.32	8.06	2.40	14.90
5.0	7.19	8.34	2.44	14.98
7.0	6.16	9.28	2.51	15.42
10.0	7.08	9.44	2.66	16.71
12.0	7.05	9.39	2.61	15.63
15.0	6.98	9.36	2.59	15.58
Second harvest				
Control	5.41	10.61	2.86	16.71
5.0	5.91	10.69	2.88	16.88
7.0	6.19	10.86	2.91	17.33
10.0	7.14	11.78	2.95	18.89
12.0	7.09	11.71	2.92	17.63
15.0	7.04	11.67	2.89	17.57
Third harvest				
Control	5.43	12.23	3.72	18.45
5.0	5.94	12.78	3.75	18.67
7.0	6.22	12.91	3.79	19.71
10.0	7.18	13.55	3.83	20.95
12.0	7.13	13.46	3.83	19.63
15.0	7.10	13.41	3.80	19.58

Nutritional status in herb:

Data in Table (7) clearly indicate the following:

Macronutrients (N, P and K) content: Resulted in Table (7) show that all cobalt concentration significantly increased the content of N, P and K compared with control. Cobalt at 10 ppm gave the highest figures. Increasing cobalt levels in plant media above10 ppm reduced the promotive effect in the three harvests during two studied seasons. These data are in harmony with those obtained by Laila Helmy and Nadia Gad (2002) who reported that cobalt had a beneficial effect on parsley herb content of N, P and K in four harvests compared with control.

Micronutrients (Mn, Zn, and Cu) content: Presented data in Table (7) show that all cobalt doses significantly increased the status of Mn, Zn and Cu. These observation are consistent with previous reports obtained by Eman Aziz *et al*., (2011) who pointed that cobalt improve the status of Mn, Zn and Cu in peppermint herb.

Iron status: Increasing cobalt concentration in plant media resulted in a progressive depression effect on iron content in Dill herb in the three harvests during two seasons. This may be explained on the basis of obtained by Blaylock *et al*., (1993) who showed antagonistic relationships between the two elements (cobalt and iron). Confirm these results Nadia Gad and Hala Kandil (2012).

Cobalt status: Increasing cobalt doses in plant media increased cobalt content in Dill herb. These results clearly indicate that cobalt content goes along with the concentration of added cobalt. These obtained results are in good agreement with those obtained with Atia *et al*., (2014) who found that cobalt content in onion shoots with increasing cobalt concentration in plant media.

Table 7: Effect of cobalt on nutritional status of Dill herb (mean of two seasons).

Cobalt treatments (ppm)	Macronutrients (%)			Micronutrients (ppm)				Cobalt (ppm)
	N	P	K	Mn	Zn	Cu	Fe	
First harvest								
Control	0.861	0.510	1.32	39.2	26.2	31.0	141	0.89
5.0	0.941	0.617	1.37	42.9	27.9	33.2	139	1.81
7.0	0.986	0.711	1.43	46.8	30.4	35.0	136	2.79
10.0	1.132	0.836	1.56	49.5	32.7	37.1	132	4.33
12.0	1.128	0.812	1.51	52.6	35.0	39.2	129	6.27
15.0	1.116	0.798	1.48	54.0	37.1	40.6	127	7.68
Second harvest								
Control	0.865	0.516	1.33	39.5	26.9	33.0	141	0.90
5.0	0.946	0.620	1.38	43.0	28.1	34.6	138	1.83
7.0	0.991	0.719	1.45	47.2	31.0	36.1	136	2.82
10.0	1.142	0.841	1.57	49.9	32.9	37.7	131	4.36
12.0	1.134	0.822	1.53	53.5	36.0	39.5	128	6.30
15.0	1.127	0.808	1.50	55.3	37.6	41.1	125	7.71
Third harvest								
Control	0.869	0.519	1.36	41.0	27.5	33.9	141	0.92
5.0	0.951	0.628	1.42	43.9	29.2	35.1	139	1.85
7.0	0.995	0.724	1.49	49.5	32.4	37.5	135	2.84
10.0	1.149	0.846	1.60	51.8	34.5	38.9	132	4.39
12.0	1.140	0.839	1.57	54.3	37.2	40.6	128	6.33
15.0	1.136	0.828	1.52	56.2	38.9	42.4	126	7.74

Conclusion:

Cobalt had a significant effect of Dill growth, herb yield, herb essential oil and its fatty acid composition. Cobalt resulted the greatest values of nutrient status as well as chemical constituents in Dill herb in the three harvests during two studied seasons.

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