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Impact of Cobalt Form and Level Addition on Wheat Plants *(Triticum aestivum L.)*: II. Yield and nutrients contents

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ABSTRACT

Two pot experiments were conducted at greenhouse of National Research Center. Experiments were carried out to studies the effect of cobalt levels (0, 5, 10, 15, 20 and 25 mg/ kg) and forms (cobalt sulphate, cobalt oxide and cobalt chloride) on growth and nutrient status of wheat.

The obtained results are summarized in the following:

1. The highest yield parameters such as plant height, no. of leave plant^{-1}, fresh and dry weight of shoot and roots, no. of spikes plan^{-1}t, no. of grain spike^{-1} were obtained at the rate of 10 mg kg^{-1} soil as cobalt sulphate. It is clear that cobalt enhance all growth parameters compared with the control.
2. Yield of grain fed^{-1} and straw yield fed^{-1} increased about 18.24%, 18.21% with cobalt sulphate at 10 mg kg^{-1}, 12.08%, 12.05% with cobalt oxide and 14.12%, 14.10% with cobalt chloride treatments. The highest significant yield parameters were obtained by using cobalt at 10.0 mg kg^{-1} with cobalt sulphate.
3. Cobalt gave the significant increase of all minerals like N, P, K, Zn, Mn and Cu with all cobalt forms. Generally, the obtained data show that the highest macronutrients and micronutrient (except Fe) were obtained by using cobalt sulphate followed by cobalt chloride and cobalt oxide in decreasing order.
4. Addition cobalt significant decreased iron content in wheat shoots and roots in the end of vegetative stage compared with untreated plants. Protein increased about 53.89% as cobalt sulphate followed 38.12% as cobalt chloride and 10.51% as cobalt oxide. The highest significant protein percentage was obtained by using cobalt at 10.0 mg kg^{-1} as cobalt sulphate compared with other treatments.

KEY WORDS: Wheat yield, Nutrient Status, Cobalt Sulphate, Cobalt chloride, Cobalt oxide.

INTRODUCTION

Wheat *(triticum aestivum L.)* is one of the most important strategy crops, which plays an especial role in people's nutrition. It is the main food crop for the population of Egypt. Increasing wheat production is an ultimate goal to reduce the wide gap between production and consumption.

Cobalt is a beneficial element for higher plants. Cobalt is an essential element for certain micro-organisms particularly those fixing atmospheric N_2; its deficiency seems to depress the efficiency of N_2 fixation **(Riely and Dilwarth, 1986).** Cobalt is essentiality for photosynthetic activities of lower plants such as *Euglena gracilis* and *rhizobium* is frequently reported. It is well known that cobalt is localized in various sub-cellular fractions as in chloroplasts **(Jolley, 2004).**

Cobalt deficiencies in ruminants are often associated with forages produced on soils containing less than 5 ppm of total cobalt **(Samuel *et al.* 1990). Sarkar *et al.* (1992)** reported that a weak correlation between cobalt content in plants and available cobalt in soil. The authors added that adsorbed cobalt was strongly bound to the soil particles and correlated with pH of soil whose high values inhibited absorption by plants and reduce cobalt availability in soil. **Shao *et al.* (1993)** reported that in cobalt deficient soils, the content of available form normally does not exceed 3 ppm, content up to 50 ppm being usual in soils of healthy plants. **Gad (2002)** found that in some soils of Egypt; total cobalt ranged between 6.11-49.2 ppm; available cobalt ranged between 1.4- 9.91 ppm while soluble cobalt ranged between 0.24- 2.49 ppm. Availability status of cobalt in soil should be a resultant of several factors such as soil pH, texture, calcium carbonate, oxides, organic matter and soil fertility.

Wen-hua *et al.* (2005) studied the effect of cobalt on yield and protein content of winter wheat and available Co content in soils. The main results were summarized as follows: cobalt application increased wheat yields compared with control, and the greatest enhances were 4 mg kg^{-1} soil. Lower (1-2mg kg^{-1}) concentration of cobalt produced higher crude protein content, whereas higher (4-8mg kg^{-1}) addition of cobalt resulted in lower grain quality

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compared with the control. Cobalt content in wheat grain and DPTA - extractable cobalt in soil showed significantly positive correlation with soil - applied cobalt. **Hala Kandil (2007)** showed that cobalt at 20 ppm significantly increased faba bean growth and yield (pods and seeds).

Nessim and Abdalla (2008) studied the effect of adding cobalt in the form of $CoSO_4$ at the rates 0, 5, 10, 20, 40, 80 and 100 mg Co kg^{-1} soil using three soils on relative cobalt availability to barley plants. The higher dry matter yields were obtained with the application of cobalt to the soils at the rate of 20 mg Co kg^{-1} soil. **Balachandar *et al.* (2003 a)** found that the foliar application of cobalt chloride (50 ppm cobalt), molybdenum at 50 ppm and boron at 0.2 % significant increase in the number and weight of nodules, biomass production, plant height and grain yield. **Jayakumar *et al.* (2009 b)** studied the effect of cobalt as finely powdered ($CoCl_2$) as (0, 50, 100, 150, 200 and 250 mg kg^{-1} soil) on pigment accumulation of soybean. Cobalt at lower concentrations has some beneficial values on soybean. **Mohandas (1985)** found that applying cobalt nitrite at 1 ppm increased nodulation, dry matter, nitrogen content and bean yield. **Raj (1987)** studied the effect of cobalt nitrate on pigeonpea and peanut seed. Cobalt nitrate (500 mg/kg seed) increased plant height numbers of branches and leaves, total dry matter and yield. Groundnut seed treatment with cobalt nitrate (500 mg kg^{-1} seed) followed by 2 foliar sprays before and after flowering (500 mg.L^{-1} water) increased plant height, leaf number and total dry matter. Pod yield, shelling percentage, test weight and harvest index increased significantly.

MATERIALS AND METHODS

Soil analysis:

Particle size distribution and soil texture along with soil moisture constants of the representative soil samples collected from Research and Production Station, National Research Centre (Nobaria) were determined by **Blackmore et al., (1972).** Contents of organic matter and $CaCO_3$ as well as EC and pH along with soluble cations and anions were evaluated according to **Black et al., (1982).** Total N and available P, K, Fe, Mn, Zn and Cu were also determined according to **Jackson (1973).** Total cobalt was determined in Aqua rejia extract, the water soluble cobalt as well as available cobalt (DTPA extractable) being assayed according to **Cottenie et al., (1982).** Physical and chemical properties of the used soil are given in Table (1).

Pot experiment was conducted in a wire house of the National Research Center, Dokki, Egypt to study the effect of cobalt source and level on growth and nutrients status of wheat plants. The sampled soils were air dried, passed through a 2 mm sieve and packed uniformly in plastic pots containing 5 kg of soil. The experiment included three cobalt source (cobalt sulfate, cobalt oxide and cobalt chloride) and each source application level at (0, 5, 10, 15, 20, 25 $mgkg^{-1}$ cobalt) and three replicates for each treatment.

Table (1): Some physical and chemical properties of El-Nobaria soil.

Particle size distribution	Value	Available Micronutrients (mg kg^{-1})	Value
Sand %	69.8	Fe	7.77
Silt %	26.7	Mn	2.12
clay %	3.5	Zn	1.78
Texture class	Sandy loam	Cu	3.01
Chemical analysis		**Soluble cations (mmol L^{-1})**	
E.C. $dS.m^{-1}$	0.43	Na^+	1.09
pH (1:2.5) soil water suspention	7.80	K^+	0.24
$CaCO_3$ $g.kg^{-1}$	32.1	Mg^{++}	1.10
O.M g kg^{-1}	0.20	Ca^{++}	2.00
Total N (mg kg^{-1})	165		
Available P (mg kg^{-1})	134	**Soluble anions (mmol L^{-1})**	
		$SO_4^{=}$	1.97
		Cl^-	0.86
		HCO_3^-	1.60
		CO_3^-	0.00
Available K (mg kg^{-1})	110	**Cobalt (mg kg^{-1})**	
		Total	7.66
		Available	1.67
		Soluble	0.34

The pots were arranged in a complete randomized design, and moisture content was maintained at field capacity using distilled water. Each pot was planted with 8 grains of wheat (*Triticum aestivum* cvs Mill Sakha- 93) on the 19th of November 2009, then after three weeks seedlings were thinned to 4 ones per pot. On the 13th

December 2009 (at third truly leaves) were irrigated once with cobalt different sources and levels both by his treatment. Super phosphate (15.5%P_2O_5) was applied during seed- bed preparation at the rate of 13.1 kg P ha^{-1}. Nitrogen was applied at a rate of 120 kg N fed-1 as urea at the beginning of growth, while potassium was added as potassium sulfate (48 % K_2O) at rate of 50 kg K_2O fed^{-1}. All required agricultural managements for plants and production were carried out as recommended. All yield parameters were determined for the tested plant at 100 days age according to **FAO (1980).**

RESULTS AND DISCUSSION

Data in Table 2 show the effects of cobalt level and form on spikes length, weight of spikes, weight of grains/plant, weight of 1000 grain, grain yield/fed and straw yield/fed. Maximum value of spikes length (8.23 cm), weight of spikes (7.15 g), weight of grains/plant (17.62 g), weight of 1000 grain (53.88 g), grain yield/fed (1409.6 kg) and straw yield/fed (1937.5 kg) were achieved due to application of cobalt in the sulphate form at a rate 10 mg kg^{-1} followed by cobalt chloride at 10 mg kg^{-1}. Untreated treatment recorded the minimum values for all the yield parameters. Cobalt increased all wheat yield parameters under the different forms and levels as compared with untreated. These results agree with those of **Yadovee *et al.* (1986).** They pointed out that cobalt gave the highest cowpea yield parameters. **Due *et al.* (1999)** found that cobalt at 8 ppm had a greatest pod and seeds yield in cowpea compared with the untreated plants. Generally, yield of grains/pot and straw yield/pot increased approximately by 18.24% and 18.21% due to cobalt sulphat, 12.08% and 12.05% due to cobalt oxide and 14.12% and 14.10% due to cobalt chloride treatments. The highest significant yield parameters were obtained by using cobalt at 10.0 mg kg^{-1} as cobalt sulphate and cobalt chloride. Increasing cobalt in plant media to more than 10.0 mg kg^{-1} decreased the promotive effect of cobalt sulphate and cobalt chloride, but at the same time, cobalt oxide recorded the minimum effect and increased all yield parameters by increasing Co rate. These results are in harmony with those obtained by **Balai *et al.* (2005), Banerjee *et al.* (2005) and Gad (2006)** who found that cobalt recorded the maximum leaf area index, dry matter accumulation in plant shoot and roots as well as pods yield in both cowpea and groundnut compared with the control.

Table 2: Effect of cobalt level and form on yield parameters of wheat plant

Treatments		Spikes length (cm)	Weight of spike (g)	Weight of grain/ plant (g)	Weight of 1000 grain (g)	Grain yield/pot (kg)	Straw yield/pot (kg)
Cobalt form	**Co rate (mg kg^{-1})**						
Cobalt sulphate	5	6.14	6.21	14.54	46.44	0.1662	0.2284
	10	8.23	7.15	17.62	53.88	0.2014	0.2768
	15	7.67	6.96	17.08	49.16	0.1952	0.2683
	20	7.19	6.74	16.71	48.93	0.1909	0.2625
	25	6.52	6.35	15.93	46.88	0.1820	0.2502
Mean		7.15	6.68	12.85	49.15	0.1871	0.2572
LSD at 5%		0.03	0.05	0.01	0.02	0.12	0.11
Cobalt oxide	5	5.92	5.95	14.15	44.35	0.1617	0.2222
	10	6.00	6.09	15.00	44.64	0.1714	0.2356
	15	6.58	6.48	15.75	46.82	0.1800	0.2474
	20	6.64	6.74	15.82	47.11	0.1808	0.2485
	25	7.72	6.98	16.90	49.75	0.1931	0.2655
Mean		6.57	6.44	15.52	46.53	0.1774	0.2438
LSD at 5%		0.02	0.03	0.02	0.03	0.14	0.13
Cobalt chloride	5	6.00	6.05	14.36	45.13	0.1641	0.2256
	10	7.91	7.00	17.20	49.81	0.1966	0.2702
	15	7.43	6.92	16.75	47.32	0.1914	0.2631
	20	6.85	6.81	15.50	45.14	0.1771	0.2334
	25	6.11	6.17	15.22	44.75	0.1739	0.2391
Mean		6.86	6.59	15.81	46.43	0.1806	0.2483
None	0	5.80	5.40	13.85	40.89	0.1583	0.2176
LSD at 5%		0.02	0.03	0.02	0.03	0.14	0.13

According to **Abdul Jaleel *et al.* (2009 a&b),** cobalt addition in soil increased all growth parameters and yield parameters such as seedling vigour, number and weight of pods and seeds yield/plant in green gram *(Vigna radiate L.)* and maize *(Zea maiz L.)* plants.

Protein percentage:

Data in Fig. 1 show the effect of cobalt form and level on protein percent in wheat grain. Data revealed that cobalt in all forms had a significant synergistic effect on protein percent. Protein increased by approximately 53.89%, as cobalt sulphate followed by 38.12% when Co was applied as cobalt chloride and 10.51% when Co was applied as cobalt oxide. The highest significant protein percentage was obtained by using cobalt at 10.0 mg kg^{-1} as Co sulphate compared with other forms. Increasing cobalt above 10.0 mg Co kg^{-1} decrease of the promotive effect of chemical constituents except in case of cobalt oxide where it slightly increased protein percent. These results are in harmony with those obtained by **Gad and Kandil (2010)** who found that cobalt enhanced the content of chemical parameters of tomato fruits such as total soluble solids, total soluble sugar, total protein and vitamin “C”. **Gad and Kandil (2011)** added that applied cobalt at 15 ppm increased all chemical contents in wheat seeds such as total carbohydrates, total sugars, protein and lipids percentages compared with control and other cobalt concentrations in salinity soil.

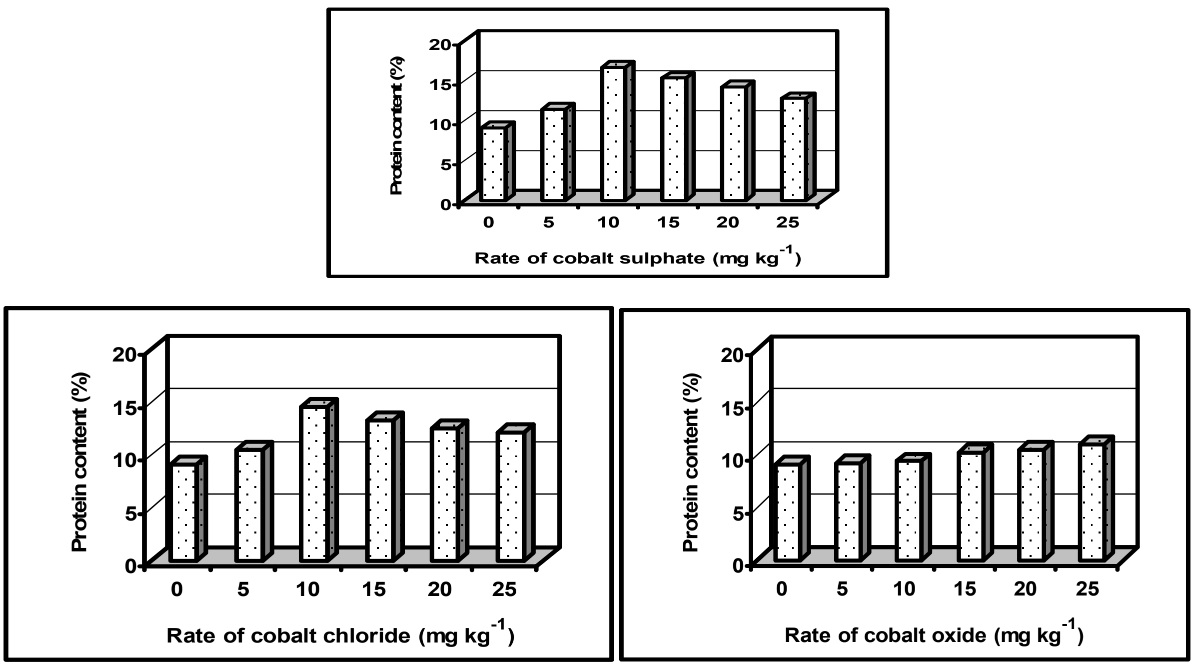

Fig. 1: Effect of cobalt level and form on protein content in grain of wheat plant.

Nutritional status in grain:

Macronutrients (N, P and K) contents:

Data in Fig. 2 show the effects of cobalt forms and rates on macronutrient contents N, P and K in wheat grain. Data reveal that using the different rates and forms of Co significantly increased the contents of N, P and K as compared with those of the untreated plants.

The maximum value of N content (2.66%), P content (0.47%), and K content (1.28%) were achieved due to cobalt sulphate at a rate of 10 mg Co kg^{-1} soil followed by cobalt chloride at a rate of 10 mg Co kg^{-1} soil (2.33%, 0.43% and 1.05% for N, P and K respectively). Untreated treatment recorded the minimum NPK values. Increasing cobalt above 10.0 mg kg^{-1} caused in decrease the promotive effect of macronutrients except upon addition cobalt in the form oxide which slightly increased N, P and K percent. These results are in good agreement with those of **Gad and Kandil (2011),** who pointed out that cobalt had a beneficial effect on status of all mineral in wheat plants. **Basu *et al.* (2003)** added that cobalt gave higher nutrients uptake by groundnut seeds compared with control. According to **Jayakumar *et al.* (2008),** all mineral contents of blackgram increased with cobalt at 50 mg kg^{-1} soil compared with the control. These results may go with the finding of **Aziz *et al.* (2011)** who found that all cobalt levels (7.5, 15, 22.5 and 30 ppm cobalt) significantly increased the contents of N, P and K compared with the control in peppermint plants. **Basu *et al.* (2006)** found that the highest values of N, P and K content were obtained by using cobalt dose at 15.0 ppm.

Micronutrient (Fe, Zn, Mn and Cu) contents:

Results presented in Table 3 indicated that, increasing cobalt concentration in the plant media resulted in a progressive depression effect on iron content in the wheat grains. The maximum Fe content was obtained to the control treatment and followed by cobalt oxide at 5 mg Co kg^{-1}soil then cobalt chloride at 5 mg Co kg^{-1}soil in a decreasing order. This agrees with the results obtained by **Blaylock *et al.* (1993)** who showed certain antagonistic relationships between the two Fe and Co.

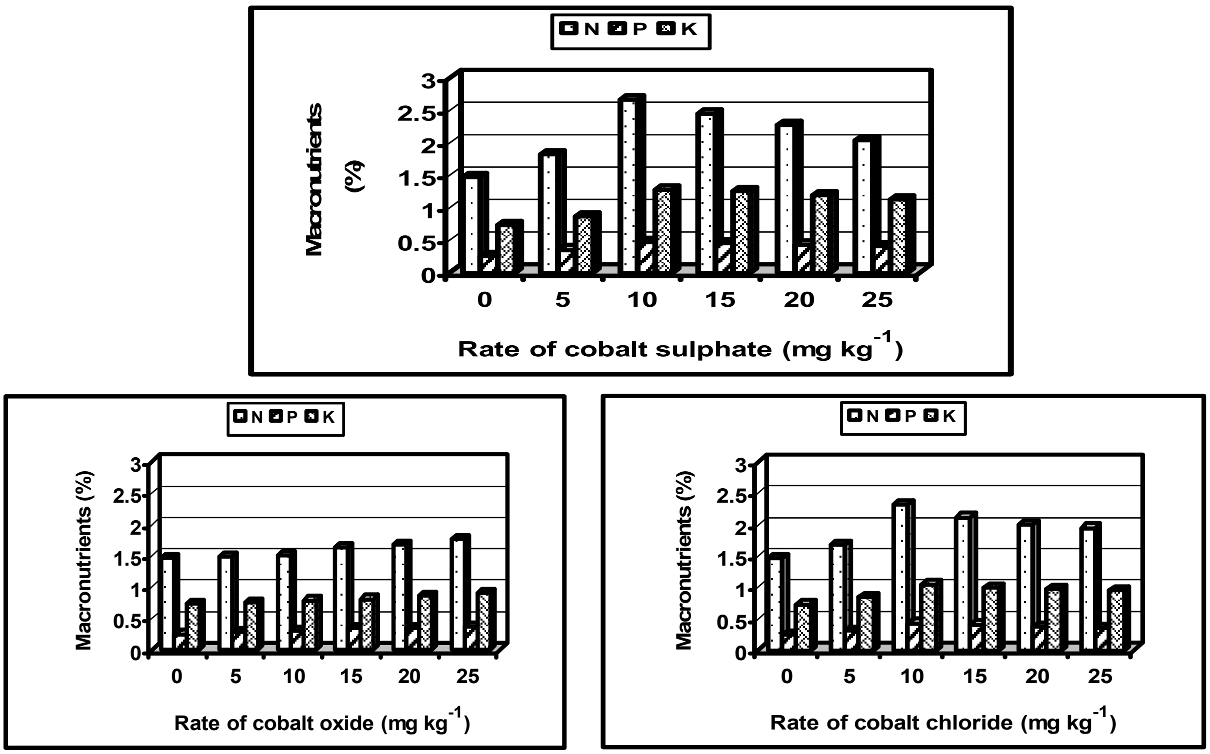

Fig. 2: Effect of cobalt level and form on contents of the macronutrients in grain of wheat plant.

The contents of micronutrients Zn, Mn and Cu of wheat grains as affected by cobalt level and form are given in Table 3. Cobalt application led to significant increases in Zn, Mn and Cu contents of wheat grain compared with untreated treatments.

The maximum value of Zn content (14.24 mg kg^{-1}), Mn content (99.45 mg kg^{-1}), and Cu content (15.22 mg kg^{-1}) were recorded due to the treatment cobalt sulphate at a rate of 10 mg Co kg^{-1} soil followed by cobalt chloride at the rate of 10 mg kg^{-1} (13.52, 96.82 and 14.97 mg kg^{-1}) for Zn, Mn and Cu respectively. Untreated control recorded the minimum NPK values. While, increasing cobalt rate to more than 10.0 mg kg^{-1} as sulphate or chloride decreased the contents of Zn, Mn and Cu in wheat grains compared with the control. These results agree with those of **Helmy and Gad (2002)** who indicated that addition of low Co level had a significant promotive effect on status of Mn, Zn and Cu in coriander herbs, **Gad and Abd El Moez (2011), Aziz *et al.* (2011) and Gad and Kandil (2011 b)** stated that cobalt had a promotive effect on Zn, Mn and Cu content of brocooli, peppermint and wheat while increasing cobalt dose gave an adverse effect.

Table 3: Effect of cobalt level and form on micronutrients and cobalt content in grain wheat.

Treatments		Micronutrient concentration (mg kg^{-1}) in grain				Co (mg kg^{-1})
Cobalt form	Co rate (mg kg^{-1})	Fe	Zn	Mn	Cu	
Cobalt sulphate	5	119.04	13.57	83.22	14.35	1.35
	10	118.32	14.24	99.45	15.22	2.58
	15	115.53	14.18	98.64	14.98	4.23
	20	112.11	13.39	97.33	14.87	5.84
	25	108.64	12.52	97.30	13.13	6.71
Mean		114.73	13.58	95.19	14.51	4.14
LSD at 5%		0.04	0.05	0.02	0.01	0.03
Cobalt oxide	5	120.57	13.18	79.25	14.15	0.88
	10	119.31	13.22	80.34	14.32	1.42
	15	118.12	13.29	81.15	14.46	2.03
	20	116.14	13.34	82.37	14.62	2.75
	25	114.45	13.45	83.52	14.75	3.11
Mean		117.72	13.30	81.33	14.46	2.04
LSD at 5%		0.03	0.02	0.01	0.03	0.05
Cobalt chloride	5	120.13	13.38	81.14	14.20	1.28
	10	119.11	13.52	96.82	14.97	2.44
	15	118.14	13.46	95.96	14.64	4.11
	20	116.43	12.68	95.10	14.11	5.75
	25	111.72	11.92	94.75	13.46	6.50
Mean		117.11	12.99	92.75	14.28	4.02
None	0	121.41	13.14	78.31	14.12	0.81
LSD at 5%		0.01	0.03	0.05	0.05	0.08

Cobalt Content

Increasing cobalt concentration in plant media increased cobalt content in wheat grains as compared with untreated plants (Table 3). These results clearly indicate that cobalt content goes along with the concentration of added cobalt in all forms. The obtained results are in harmony with those obtained by **Gad (2010)** who found that increasing cobalt in plant media increased cobalt content in canola plants.

The maximum Co content value (6.71 mg kg^{-1}) was found upon application of Co at rate of 25 mg kg^{-1} in the sulphate. **Young (1983)** found that the daily cobalt requirements for human nutrition could reach 8 ppm without health hazard.

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