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Response of Canola *(Brassica napas L.)* Production to Cobalt and Ammonium Sulphate as a Source of Sulphur

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ABSTRACT

Field experiment has conducted in Research and Production Station, National Research Centre, El-Nobaria Location, Beheara Governorate, Delta Egypt. Experiment was carried out to study the effect of different ammonium sulphate rates (0, 50, 100, 200 and 300 kg fed^{-1}) as a source of sulphur and cobalt levels (0, 4, 8, 12 and 16 ppm) on canola growth, seeds yield, oil percentage, nutritional status and chemical contents under drip irrigation system.

The obtained results indicate that:-

- Ammonium sulphate addition in plant media enhanced all parameters of canola growth, seeds and oil yield as well as chemical and minerals content of canola seeds especially with 300 Kg fed^{-1} rate.
- All cobalt concentrations significantly increased all canola growth, seed yield oil percentage, nutritional status and chemical contents. Cobalt at 12 ppm gave the maximum values of seeds yield, oil and its composition.
- The highest yield of canola was recorded by 300 kg fed^{-1} ammonium sulphate fertilizer with 12 ppm cobalt.
- The increased percent of oil, protein, total carbohydrate and total phenol of canola seed was recorded by 300 kg fed^{-1} ammonium sulphate with 12 ppm cobalt 9.61, 64.42, 16.75 and 59.8% respectively.
- Increasing cobalt levels above 12 ppm in plant growing media cobalt promotive effect reduced.

KEYWORDS: Canola, Cobalt, Sulphur, Seed and oil yield.

INTRODUCTION

Canola is a member of the Brassicaceae family and has become one of the most important sources of vegetable oil in the world. Canola oil is generally regarded as one healthiest edible oil available to consumers, used for cooking and other uses of edible oils in many parts of the world. The composition of canola oil is similar to that of peanut and olive oil, with large amounts of oleic acid, which is desirable in frying oils. Another distinct advantage of canola oil is low saturated fatty acid content (6%), and it is low also in cholesterol. Canola oil contains about half the level of saturated fatty acids in corn oil and soybean oil and about one quarter the level percent in cotton seed oil **(Gillis, 1988). Abdle-Salam (2002)** pointed that vegetable oils remain one of the most difficult problems of agriculture of Egypt with regard to the possibility of achieving a reasonable degree of self-sufficiency.

Canola *(Brassica napus L.)* is a specific type of rape seed associated with high quality oil and meal. It has less than 2% erucic acid and its meal has less than 30 µg of glucosinolates. It contains 40-45% oil and 36-40% protein. Oil and meal are now very acceptable as alternatives to soyabean oil and meal **(Amin and Khalil, 2005 and Muhammad, *et al.,* 2007).** Canola grows well in dry environments and can tolerate moderately saline soil conditions **(Ban˜uelos, *et al.,* 1997 and Stricker, *et al.,* 1997).** Canola has been introduced to Egypt more recently as a promising new vegetable oil crop especially in the new reclaimed lands.

Sulphur (S) is an essential plant nutrient for all crop production. This situation is especially true for canola, which has a higher requirement for S than other annual crops such as wheat. Sulphur is essential for protein synthesis and the formation of chlorophyll. Sulphur is required in the development of fertile canola flowers **(Hall, 1999).** Ammonium sulphate form gave the superior results of canola growth, seed quantity and quality and oil production **(Hala Kandil and Nadia Gad 2012).**

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 sever for human consumption and up to 8 ppm can be consumed on a daily basis without health hazard **(Young, 1983). Nadia Gad *et al* (2006)** pointed that, cobalt is a promising element in the newly reclaimed soils such as Rass Seder, Egypt. Cobalt had a significant promotive effect on olive trees (Manzanello and Arbicon) growth yield, fruit quality, minerals content, endogenous hormones and oil percentage especially with organic fertilization

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under drip irrigation system. Organic matter decreased soil pH and increases the availability of cobalt and cobalt increases the efficiency trees to tolerate drought and salinity. **Bibak (1995)** found that, while treatment of the winter wheat plants grown on a sandy loam soils supplied with N increased, cobalt uptake by crops. **Laila Helmy and Nadia Gad (2002)** showed that cobalt at 25 mg/kg soil had a positive effect of parsley plant growth, yield as well as chlorophyll content, TSS, L-Ascorbic acid. Cobalt significantly increased essential oil yield of parsley leaves. The main aroma constituent of parsley leaves, is 1, 3, 8-p-menthatriene which forms about (67%) of leaves essential oil compared with control. Cobalt is required in low levels for maintaining high yields of tomato **(Runner *et al*, 2003)** squash **(Att Aly, 1998)** groundnut **(Basu *et al*, 2006)** sweet potato **(Nadia Gad and Hala Kandil, 2008)** and potato **(El- Bordiny and Nadia Gad, 2008).** Egypt being a developing country, suffer from a gap between production and consumption. The gap in wheat was about 5.9; in corn by 4.5; in barley by 0.017 and in sugar by 0.306 million ton while in oil reached 1.251 million tons **(FAO report, June, 2008).**

The aim of the present work to study the role of cobalt with Ammonium sulphate as a source of sulphur on canola growth, seed yield and oil yield (kg fed^{-1}) and quality. Cobalt with Ammonium sulphate may be help canola plants in maximizing the oil yield production and enhance quality of oil.

MATERIALS AND METHODS

Soil analysis:-

Particle size distribution and soil texture along with soil moisture content of the representative soil samples collected from Research and Production Station, National Research Centre (El-Nobaria) were determined according to **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 determined according to **Jackson (1973).**

Total cobalt was determined in Aqua regain extract, the water soluble cobalt as well as available cobalt (DTPA extractable) being assayed according to **Cottanei *et al.,* (1982).** Data of soil analysis were recorded in Table (1).

Table (1): Some physical and chemical properties of the used soil at El-Nobaria, 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			
	15.0		9.4	16.0	7.8	3.3	1.86	4.0
					Cobalt (ppm)			
					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.

Plant material and experimental analysis design:

Field experiment has been conducted at Research and Production Station, National Research Centre, El-Nobaria district, Behera Governorate, Egypt, under drip irrigation system to evaluate the effect of different concentrations of cobalt on canola productivity, % oil and fatty acids content. The experiment contains plots and the area was 15 m2 (5 X 3 m) containing 3 rows each planted with 10 plants. Farmyard manures at a rate of 20 m^3 fed^{-1} and super phosphate (15.5 % P_2O_5) at 200 kg /fed were added during soil preparation. Treatment source of sulphur (Ammonium sulphate) five levels (0, 50, 100, 200, 300 kg fed^{-1}) according to **Hala Kandil and Nadia Gad (2012)**. Seeds of canola *(Brassica napus L.)* var. pactol were sown at 29 September, 2012. Ammonium nitrate (150 kg fed^{-1}, 33.3 % N) and potassium sulphate (50 kg fed^{-1}, 50 % K_2O) after plants were thinned. Fertilizing and other agriculture practices were followed as recommended practice, whenever they need. According to **Hala Kandil and Nadia Gad (2012)**, seedlings were irrigated with cobalt sulphate once at concentrations: 0, 4, 8, 12 and 16 ppm cobalt. After 120 days, end of the vegetative stage, growth parameters as plant height, number of branches and leaves, leaves area; root length as well fresh and dry weights were recorded according to **Gabal *et al.,* (1984).** Plants were harvested and the parameters of seeds and oil yield, pods no per plant, seeds no. per pod, weight of seed yield, seeds yield oil per fadden, oil yield (kg fed^{-1}) were recorded according to **A.O.A.C. (1995).** Seeds chemical content such as crud protein, oil % and total carbohydrates were determined according to **A.O.A.C. (1995)** also total phenols aqueous acetone (70%) was determined by **Kaluza *et al.*, (1980).** Finally the seed nutritional content (N, P, K, S, Mn, Fe, Cu and Zn) were determined according to **Cottanei *et al.*, (1982).**

All data were subjected to statistical analysis according to procedure outlined by **(Snedecor and Cochran, 1982)**.

RESULTS AND DISCUSSIONS

Vegetative growth:

Mean values of plant height, number of branch per plant, number of leaves per plant, root length, fresh and dry weight are presented in Table (2). The results in Table (2) show that all growth parameters significant increased with increasing cobalt levels. The highest values of plant growth parameters were obtained with 12 ppm cobalt following by 16 ppm cobalt. The results in Table (2) showed also the relative calculated values as percentage from control it is evident that cobalt at 12 ppm increased means of fresh weight for both shoots and roots 73.96 and 14.63%, respectively. While increased means of dry weight for both shoots and roots 74.71 and 17.53%, respectively. The results add more support to those reported by **Nadia Gad (2010)** who found that cobalt addition of 12.5 ppm gave a synergistic effect on canola growth parameters.

Result in Table (2) clearly indicate that parameters of plant growth of canola were significant increased by (300 kg fed^{-1}) ammonium sulphate level applied. The highest values of plant height (151, 161, 169, 175 and 164 cm), number of branch per plant (13, 13, 16, 19 and 16), number of leaves per plant (59, 59, 65, 69 and 64), root length (17.6, 19.1, 28.4, 33.8 and 30.1), fresh weight (238, 256, 307, 353 and 336 g) and dry weight (71.1, 74.4, 90.7, 102.1 and 96.6 g) respectively under different cobalt levels. These results are in harmony with those obtained by **Hala Kandil and Nadia Gad (2012).** They showed that increasing ammonium sulphate rates in plant media from 50 up to 300 kg fed^{-1} increased canola growth and oil seed yield as well as seed quality.

The results presented in Table (2) also indicated that all growth parameters were significantly affected by the interaction between the cobalt levels and rate of sulphur source. The highest values of plant growth parameters were obtained by applied of 300 kg fed^{-1} ammonium sulphate with 12 ppm cobalt.

Table (2): Effect of ammonium sulphate and cobalt on the growth of canola plants.

Sulphur treatments (kg fed^{-1})		Plant height (cm)	Number plant^{-1}		Root length (cm)	Fresh weight g plant^{-1}		Dry weight g plant^{-1}	
			Branches	Leaves		Shoot	Root	Shoot	Root
Without cobalt									
Ammonium sulphate	0	104	9	40	11.5	119	58.3	34.5	16.9
	50	124	10	45	12.4	171	65.2	49.6	20.3
	100	137	11	52	13.3	215	67.7	58.1	21.8
	200	148	12	56	16.2	221	70.1	64.3	22.6
	300	151	13	59	17.6	238	73.5	71.1	23.7
Mean		132.8	11.0	50.4	14.2	192.8	67.0	55.52	21.1
With 4 ppm cobalt									
Ammonium sulphate	0	105	10	41	12.6	225	58.9	65.4	22.8
	50	126	11	46	16.7	238	67.3	69.2	26.1
	100	141	12	54	17.9	241	69.8	70.0	27.0
	200	154	13	58	18.3	253	71.9	73.5	28.1
	300	161	13	59	19.1	256	75.6	74.4	29.0
Mean		137.4	11.8	51.6	16.9	242.6	68.7	70.5	26.6
With 8 ppm cobalt									
Ammonium sulphate	0	109	11	42	15.5	261	59.4	77.1	24.5
	50	132	12	48	17.8	267	68.7	78.9	28.3
	100	147	13	59	19.5	279	70.4	82.4	29.0
	200	158	14	63	24.8	288	73.2	85.1	30.2
	300	169	16	65	28.4	307	77.1	90.7	31.8
Mean		143.0	13.2	55.0	21.2	280.4	69.8	82.8	28.8
With 12 ppm cobalt									
Ammonium sulphate	0	150	17	58	26.5	314	71.2	90.8	22.9
	50	159	17	60	27.5	323	73.5	93.4	23.7
	100	168	18	64	28.7	335	76.3	96.9	24.5
	200	174	19	69	33.6	352	81.5	101.8	26.2
	300	175	19	69	33.8	353	81.7	102.1	26.5
Mean		165.2	18.0	64.0	30.0	335.4	76.8	97.0	24.8
With 16 ppm cobalt									
Ammonium sulphate	0	138	14	49	24.6	296	60.8	85.1	21.2
	50	146	15	52	26.2	318	69.8	91.4	24.3
	100	158	15	57	26.9	329	74.6	94.6	26.0
	200	163	16	63	29.2	332	78.5	95.5	27.4
	300	164	16	64	30.1	336	79.7	96.6	27.8
Mean		153.8	15.2	57.0	27.4	322.2	72.7	92.6	25.3
LSD at 5%		2.84	0.11	1.04	0.67	3.89	1.17	1.03	0.46

Yield and yield components:

Present data in Table (3) clearly indicate the effect of ammonium sulphate and cobalt on canola yield.

Data in Table (3) outline the response of canola yield parameters to different cobalt level (from 4 to 16 ppm) under different ammonium sulphate levels (from 50 to 300 kg fed^{-1}). It is clear that cobalt promote all yield parameters of canola. The highest yield parameters were recorded by 12 ppm cobalt, the yield parameters were recorded by control. These results are harmony with those obtained by **Nadia Gad (2010)**. She found that applying cobalt at 12.5 ppm gave a synergistic effect on canola yield compared with control.

Also, the results in the Table (3) clearly revealed that, using ammonium sulphate fertilizers significantly increased total yield of canola. The highest yield of canola was recorded by 300 kg fed^{-1} ammonium sulphate fertilizer. While, the lowest total yield was recorded by control treatment. The results add more support to those reported by **Hala Kandil and Nadia Gad (2012)** who found that the addition of ammonium sulphate in plant media enhanced all parameters of canola growth, seeds and oil yield as well as chemical and minerals content of canola seeds especially with 300 kg fed^{-1} rate.

The interaction between ammonium sulphate fertilizer and cobalt had a significant effect on the total yield of canola. The highest total yield of canola was recorded (133, 111, 4.58, 186.9, 1495.2 and 547.4 for number of pod per plant, number of seeds per pod, weight of 100 seeds, seeds yield per plant, seeds yield per fadden and oil yield respectively) by 300 kg fed^{-1} ammonium sulphate fertilizer as a source of sulphur with 12 ppm cobalt treatment. Meanwhile, the lowest total yield was recorded by control treatment.

Data proved that canola need source of sulpher to produce maximum pod and seeds yield per plant. These data are in harmony with those obtained by **Ahmed *et al.*, (1998)** who found that sulphur fertilization increased seed yield of canola plants *(B. juncea cv. Pusa jai Kisan)* by 30% and *(B. rapa cv. Pus Gold)* by 46% compared with zero sulphur (control). And **Malhi and Gill, (2002)** who found that the addition of sulphur in plant media increased oil percentage in canola seeds.

Also, Cobalt gave the beneficial effect on canola yield parameters. These data are agreement with those obtained by **Nadia Gad (2010)** who found that the applied cobalt in suitable concentration gave a significant increase in canola yield compared with control. The balanced application between cobalt and ammonium sulphate played a positive role in production of canola.

Table (3): Effect of ammonium sulphate and cobalt on canola yield.

Sulphur treatments (kg fed^{-1})		Number		Weight of 100 seeds (g)	Seeds yield plant^{-1} (g)	Seed yield (kg fed^{-1})	Oil yield (kg fed^{-1})
		Pods plant^{-1} (g)	seeds pod^{-1} (g)				
Without cobalt							
Ammonium sulphate	0	73	63	2.06	95.1	761.8	254.2
	50	90	74	2.68	128.5	897.5	313.9
	100	98	78	2.97	137.9	996.4	353.8
	200	106	86	3.54	158.8	1095.5	391.0
	300	118	98	4.09	175.8	1143.2	409.7
Mean		97.0	79.8	3.07	139.2	978.9	344.5
With 4 ppm cobalt							
Ammonium sulphate	0	80	67	2.11	96.3	770.4	262.8
	50	95	78	2.75	133.2	1065.6	374.6
	100	101	83	3.21	142.7	1141.6	408.5
	200	115	93	3.78	163.5	1308.0	470.2
	300	121	100	4.26	180.9	1447.2	525.6
Mean		102.4	84.2	3.22	143.3	1146.6	408.5
With 8 ppm cobalt							
Ammonium sulphate	0	83	76	2.34	98.7	789.6	274.3
	50	99	81	3.18	136.8	1094.4	386.9
	100	110	95	3.56	144.5	1156.0	415.4
	200	119	101	4.05	165.8	1326.4	480.9
	300	124	105	4.46	183.6	1468.8	534.9
Mean		107.0	91.6	3.52	145.9	1167.0	418.5
With 12 ppm cobalt							
Ammonium sulphate	0	98	89	3.21	113.0	904.0	324.1
	50	115	97	3.68	141.2	1129.6	406.4
	100	126	106	3.89	162.7	1301.6	471.8
	200	132	110	4.56	186.5	1492.0	545.7
	300	133	111	4.58	186.9	1495.2	547.4
Mean		120.8	102.6	3.98	158.1	1264.5	459.1
With 16 ppm cobalt							
Ammonium sulphate	0	87	81	2.85	111.4	891.2	317.4
	50	101	94	3.38	137.2	1097.6	393.2
	100	122	100	3.75	151.9	1215.2	437.1
	200	128	104	4.32	172.1	1376.8	498.5
	300	129	105	4.34	172.6	1380.8	500.3
Mean		113.4	96.8	3.73	149.0	1192.3	429.3
LSD at 5%		2.69	1.13	0.21	12.14	12.9	5.87

Data presented in Tables (4) reveal that effected of all the ammonium sulphate rate and cobalt levels on chemical contents of oil, protein, total carbohydrates and total phenol in canola seeds. Data clearly indicated that the highest values of all chemical parameters were obtained by using 12 ppm cobalt. Results also showed that the relative calculate values as percentage from control. It is evident that cobalt at 12 ppm increased the contents of: oil 7.34%, protein 53.89% and total carbohydrates 15.21%. While total phenols were increased as cobalt levels in plant media increased. Data also revealed that increasing cobalt above 12 ppm decreased all the mentioned parameters as compared with their corresponding values by using cobalt level at 12 ppm exception total phynoles which increased as cobalt level increased. Increasing cobalt addition in plant media from 4 to 16 ppm increased the percentage of mean total phynoles content (1.02 to 1.63%) less 2.5 % safety human health. **Shahidi and Naczk (1989)** showed that, extraction of phynolic compounds from canola seeds and their possible use natural antioxidants would present new opportunities for canola industry. **Pratt and Hudson (1990)** found that sources of natural antioxidants are primarily plant phenolics that may occur in all parts of the plant.

These results are in harmony with those obtained by **Nadia Gad (2010).** She showed that cobalt at 12.5 ppm increased the contents of: oil 37.4%, protein 22.4%, total carbohydrates 37.4% in canola seeds. Increasing cobalt in plant media above 12.5 ppm resulted in proportion significantly reduction in canola seeds yield.

Data presented in Table (4) also show that the highest values of chemical contents are noticed with ammonium sulphate at 300 kg fed^{-1}. Mean oil percentage in seed increased with different ammonium sulphate rate (from 50 to 300 kg fed^{-1}) resulting oil 4.76, 6.35, 6.92 and 7.31%, total protein 27.57, 32.84, 43.37 and 46.11%, total carbohydrate 10.79, 11.92, 13.25 and 14.69% and total phenol 17.65, 26.47, 28.43 and 38.24% respectively in canola seeds compared with control. These results are agrees with those obtained by **Hala Kandil and Nadia Gad (2012)** who found that the highest values of chemical contents are noticed by ammonium sulphate at 300 kg fed^{-1}.

The interaction between ammonium sulphate fertilizer and cobalt addition had effect on the chemical content of canola seeds. The highest oil, protein, total carbohydrate and total phenol of canola seed was recorded by 300 kg fed^{-1} ammonium sulphate with 12 ppm cobalt. The calculated as a percentage oil, protein, total carbohydrate and total phenol from control increased the percentage in canola seeds 9.61, 64.42, 16.75 and 59.8% respectively.

Table (4): Chemical contents of canola seeds as affected by ammonium sulphate and cobalt.

Sulphur treatments (kg fed^{-1})		Oil	Protein	Total carbohydrate	Total phenol
		(%)			
Without cobalt					
Ammonium sulphate	0	33.40	4.75	9.73	1.02
	50	34.99	6.06	10.78	1.20
	100	35.52	6.31	10.89	1.29
	200	35.71	6.81	11.02	1.31
	300	35.84	6.94	11.16	1.41
Mean		35.09	6.17	10.72	1.25
With 4 ppm cobalt					
Ammonium sulphate	0	34.11	6.81	10.91	1.30
	50	35.15	6.94	10.98	1.32
	100	35.78	7.05	11.04	1.36
	200	35.95	7.25	11.08	1.48
	300	36.32	7.44	11.24	1.51
Mean		35.46	7.09	11.05	1.39
With 8 ppm cobalt					
Ammonium sulphate	0	34.74	7.00	11.06	1.36
	50	35.36	7.06	11.14	1.39
	100	35.93	7.19	11.18	1.42
	200	36.26	7.31	11.26	1.50
	300	36.42	7.50	11.31	1.53
Mean		35.74	7.21	11.19	1.44
With 12 ppm cobalt					
Ammonium sulphate	0	35.85	7.31	11.21	1.44
	50	35.98	7.43	11.24	1.48
	100	36.25	7.56	11.28	1.51
	200	36.58	7.81	11.35	1.62
	300	36.61	7.81	11.36	1.63
Mean		36.25	7.58	11.29	1.54
With 16 ppm cobalt					
Ammonium sulphate	0	35.61	7.25	10.98	1.46
	50	35.82	7.31	11.12	1.50
	100	35.97	7.44	11.19	1.53
	200	36.21	7.63	11.27	1.63
	300	36.23	7.63	11.29	1.62
Mean		35.97	7.45	11.19	1.55
LSD at 5%		0.22	0.09	0.05	0.02

Data present in Table (5) show that, all cobalt levels significantly increased the content of macronutrients (N, P, K and S) and micronutrients (Mn, Zn and Cu) as compared with control plants. The highest values of N, P and K were obtained by using 12 ppm cobalt, as compared with the other levels. This means that increasing cobalt levels more than 12 ppm in plant media the promotive cobalt effect reduced. These results agrees with those obtained by **Nadia Gad (2010)** who showed that, cobalt level of 12.5 ppm gave a significantly promotive effect on macronutrients and micronutrients except of Fe in canola seeds. Increasing cobalt concentrations in canola plants media increased cobalt content in canola seeds since cobalt concentrations in the safety limits for human.

Table (5): Effect of ammonium sulphate and cobalt on mineral composition of canola seeds.

Sulphur treatments (kg fed^{-1})		Macronutrients (%)				Micronutrients (mg kg^{-1})				Cobalt (ppm)
		N	P	K	S	Fe	Mn	Zn	Cu	
Without cobalt										
Ammonium sulphate	0	0.76	0.23	1.16	0.16	233	24.1	26.0	13.4	0.097
	50	0.97	0.40	1.26	0.65	240	27.1	30.3	14.5	0.098
	100	1.01	0.49	1.34	0.89	248	29.8	33.0	16.3	0.098
	200	1.09	0.53	1.39	1.16	254	33.2	36.2	18.1	0.098
	300	1.11	0.56	1.43	1.38	259	36.1	39.1	19.6	0.099
Mean		0.99	0.44	1.32	0.85	246.8	30.6	32.9	16.4	0.098
With 4 ppm cobalt										
Ammonium sulphate	0	1.09	0.39	1.25	0.16	231	29.9	34.1	17.4	1.15
	50	1.11	0.43	1.31	0.65	233	34.2	35.2	17.9	1.23
	100	1.13	0.51	1.37	0.89	236	36.8	35.7	18.3	1.28
	200	1.16	0.55	1.48	1.17	239	39.5	36.8	18.7	1.31
	300	1.19	0.59	1.54	1.38	242	42.7	38.2	19.1	1.37
Mean		1.14	0.49	1.39	0.85	236.2	36.6	36.0	18.3	1.27
With 8 ppm cobalt										
Ammonium sulphate	0	1.12	0.41	1.29	0.16	229	31.9	37.7	18.5	2.73
	50	1.13	0.44	1.39	0.64	230	35.8	39.2	19.2	2.75
	100	1.15	0.56	1.43	0.90	234	38.7	41.5	20.3	2.78
	200	1.17	0.59	1.50	1.18	236	41.8	43.8	21.1	2.81
	300	1.20	0.62	1.59	1.38	239	44.3	45.6	21.8	2.84
Mean		1.15	0.52	1.44	0.85	233.6	38.5	41.6	20.2	2.78
With 12 ppm cobalt										
Ammonium sulphate	0	1.17	0.46	1.34	0.16	221	35.7	39.2	19.9	2.98
	50	1.19	0.50	1.41	0.68	224	36.9	42.5	20.8	3.04
	100	1.21	0.58	1.52	0.96	228	40.2	45.1	21.5	3.11
	200	1.25	0.66	1.65	1.38	233	44.7	48.3	23.7	3.32
	300	1.25	0.66	1.66	1.42	235	44.9	48.4	23.8	3.39
Mean		1.21	0.57	1.52	0.92	228.2	40.5	44.7	21.9	3.17
With 16 ppm cobalt										
Ammonium sulphate	0	1.16	0.44	1.31	0.16	218	33.8	38.5	18.8	4.88
	50	1.17	0.48	1.40	0.64	220	35.2	41.3	19.7	4.92
	100	1.19	0.56	1.48	0.90	223	38.1	43.4	20.9	5.08
	200	1.22	0.62	1.54	1.16	225	39.8	46.7	21.6	5.21
	300	1.22	0.63	1.55	1.38	227	40.0	46.9	21.7	5.32
Mean		1.19	0.55	1.46	0.85	221.0	37.4	43.4	20.5	5.08
LSD at 5%		0.014	0.011	0.03	0.09	1.25	0.57	0.46	0.39	0.11

Results in Table (5) also clearly indicated that, increasing cobalt levels (from 4 to 16 ppm) in plant media resulted in a progressive depression effect on iron content in canola seeds. This may be explained on the basis of the obtained by **Blaylock (1995) and Nadia Gad (2010)** who showed certain antagonistic relationships between the two elements (Co and Fe), and revealed that the relative response of iron to the control indicated continuous decrease of this element.

Data in Table (5) also, showed that ammonium sulphat alone at 300 kg fed^{-1} gave the highest figures of macronutrients (N, P, K and S) and micronutrients (Fe, Mn, Zn and Cu) as compared with control plants in canola seeds. All ammonium sulphat rate significantly increased the content of macronutrients (N, P, K and S) and micronutrients (Fe, Mn, Zn and Cu). These data are in harmony with those obtained by (**Jackson, 2000, Malhi *et al.*, 2007 and Hala Kandil and Nadia Gad, 2012)** who stated that sulphur sources increased nutrients in canola seeds especially ammonium sulphate..

Data in Table (5) reveal that macronutrient and micronutrient contents responded significantly to the effect of the interaction between ammonium sulphate rate and cobalt level. The highest values of all nutrients content (1.25, 0.66, 1.66, 1.42, 235, 44.9, 48.4 and 23.8) for N, P, K, S, Mn, Zn and Cu respectively by adding 300 kg fed^{-1} with 12 ppm cobalt. While the lowest value were obtained by control plants.

Conclusion:

Cobalt at 12 ppm with ammonium sulphate at 300 kg fed^{-1} enhances canola growth, seeds yield, oil percentage, nutritional status and chemical contents. Cobalt content in canola seeds 3.39 ppm with the applied cobalt rate 12 ppm. Daily cobalt requirement for human nutrition could reach 8 ppm depending on cobalt levels in local supply of drinking water without health hazard.

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