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Influence of cobalt on cabbage (*Brassica rapa L.*) yield characteristics.

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Abstract : Two field experiments were conducted in El-Nubaria farm of the National Research Centre during 2013, 2014 seasons under drip irrigation system, to study the effect of cobalt on cabbage production.
Cobalt was added in the form of cobalt sulphate in four concentration namely, 3, 6, 9 and 12 ppm cobalt beside the control.
The obtained results indicate that:
*All study cobalt concentration significantly increase cabbage growth yield parameters, nutritional status and chemical constituents compared with control.
*Cobalt at 6 ppm gave the greatest figures.
*Increasing cobalt rate in plant growth media above 6 ppm, cobalt promotive effect reduced.
Key word: Cabbage- cobalt- yield quantity and quality.

Introduction:

Cabbage *(Brassica aleracea Var. capitate)* is the most important leafy vegetable crop. Cabbage, as other cruciferous vegetables, has high nutritional value and contains specific Sulphur compounds glucosinolates that increase its antioxidant activity. Cabbage has high requirements for all nutrients.

Cobalt is considered to be beneficial element for higher plants in spite of the absence of evidence for direct role in their metabolism. Cobalt is an essential element for the synthesis of vitamin B_{12} which is required for human and animal nutrition [1]. Cobalt does not accumulate in human body, as other heavy metals with the increase in age [2]. Boureto and Kagawa [3] mentioned that application of cobalt at rate of 2.3 kg per ha increased sugar beet growth, roots and sugar yield. Lisnik and Toma [4] found that cobalt have a favorable effect in both tomato and cucumber plants dry weight, leaf number, leaf area as well as fruits yield. Nadia Gad and Abd El Moez [5] showed that the cobalt addition significantly increased the broccoli growth, head yield and its quality compared with control. Cobalt at 6 ppm had a greatest value of broccoli growth, head yield, mineral composition as well as heads chemical contents such as total soluble solids, total soluble sugars, total phenols, vitamins "A" and " C". On the other hand, titrable acidity as citric acid showed negative response to all levels of cobalt which mean increasing the heads quality of broccoli. Nadia Gad and Hala Kandil [6] stated that cobalt doses significantly increased coriander *(Cariandrum sativum L.)* herb yield, nutitional status, chemical constituents as well as essential oils and its components compared with control plants. Cobalt at 12.5 ppm resulted the maximum figures in each three harvests during two studied seasons. Nadia Gad *et al* [7] found that applying cobalt suitable concentration gave a significant promotive effect on okra growth, yield quantity and quality compared to untreated plants. Cobalt at 7.5 ppm resulted the highest values with all studied levels of humic acid especially with 10% level. The aim of the present experiments to investigate the effect of cobalt on cabbage growth and productivity.

Materials and Methods:-

Tow field experiments were carried out during the growing season of 2013 and2014 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 quantity and quality of cabbage leaves.

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 [8]. 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* [9]. Determination of soluble, available and total cobalt were determined according to method described by Cottenie *et al* [10]. 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.

<table>
<tr><td>Soil property</td><td colspan="4">Particle size distribution %</td><td colspan="4">Soil moisture constant %</td></tr>
<tr><td rowspan="2">Physical</td><td>Sand</td><td>Silt</td><td>Clay</td><td>Texture</td><td>Saturation</td><td>FC</td><td>WP</td><td>AW</td></tr>
<tr><td>68.7</td><td>24.5</td><td>6.8</td><td>S L</td><td>32.0</td><td>19.2</td><td>6.1</td><td>13.1</td></tr>
<tr><td rowspan="10">Chemical</td><td colspan="2">pH[a]</td><td colspan="2">EC[b] dS/m</td><td colspan="3">$CaCO_3$ %</td><td>OM [c] %</td></tr>
<tr><td colspan="2">7.8</td><td colspan="2">0.18</td><td colspan="3">7.07</td><td>0.16</td></tr>
<tr><td colspan="4">Soluble cations (meq/l)</td><td colspan="4">Soluble anions (meq/l)</td></tr>
<tr><td>Ca^{++}</td><td>Mg^{++}</td><td>K^{+}</td><td>Na^{+}</td><td>$CO_3^{=}$</td><td>HCO_3^{-}</td><td>Cl^{-}</td><td>$SO_4^{=}$</td></tr>
<tr><td>3.00</td><td>2.00</td><td>0.32</td><td>2.09</td><td>0.00</td><td>1.41</td><td>0.70</td><td>5.30</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">Available</td><td colspan="4">Available micronutrients</td></tr>
<tr><td colspan="2">N</td><td colspan="2">P</td><td>K</td><td>Fe</td><td>Mn</td><td>Zn</td><td>Cu</td></tr>
<tr><td colspan="3" rowspan="2">mg/100 g soil</td><td colspan="4">ppm</td></tr>
<tr><td>7.8</td><td>3.3</td><td>1.86</td><td>4.0</td></tr>
<tr><td rowspan="2">15.0</td><td rowspan="2">9.4</td><td rowspan="2">16.0</td><td colspan="4">Cobalt (ppm)</td></tr>
<tr><td>Soluble</td><td colspan="2">Available</td><td>Total</td></tr>
<tr><td colspan="4"></td><td>0.49</td><td colspan="2">4.43</td><td>15.00</td></tr>
</table>

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:-

Two field experiments were conducted at the Research and Production Station, National Research Centre, El-Nubaria location, Beheara Governorate, Delta Egypt, during two successive seasons of 2013 and 2014, to evaluate the effect of different rates of cobalt on cabbage growth and production.

On mid July, 2013 and 2014 seeds of cabbage *(Brassica oleracea L.)* were sown in trays filled with a mixture of sand and peat moss (1:1 volume). Trays being kept under greenhouse condition with practicing all agricultural management required for production of cabbage seedlings.

Superphosphate at 100 kg per Fadden; farmyard manure at 15 m^3 and ammonium sulphate at 100 kg per Fadden were added during soil preparation before sowing.

The sandy loam soil with plot area consists of sex plots. Each plot area was 5 * 3 meter, consisting of the three rows. On mid of September, seedlings were transplanting in plots (50 cm drip irrigation system. The seedlings (at the third truly leaves) were irrigated with cobalt concentration: 0, 3, 6, 9 and 12 ppm during 2.5 and 3 month heads were growth and formation. At 15 and 17 December 2013, 2014, the heads of cabbage were harvesting.

Measurement of vegetative growth:-

After harvest, at 2, 5 November, 2013 and 2014 respectively all growth parameters of cabbage plants such as plant hight, Rosett diameter, stem diameter, number of extra leaves per plant as well as fresh weight per plant were recorded according to FAO [11].

Measurement of yield:-

At 15 and 17 December 2013 and 2014 respectively, cabbage yield parameters such as head hight, head diameter, head length, head width, head weight and marketable yield were recorded according to Gabal *et al*[12].

Measurement of Nutritional status:-

In cabbage leaves, macronutrients (N, P, K and S), micronutrient (Mn, Zn, Cu and Fe) as well as cobalt were determined according to Cottenie *et al* [10].

Measurement of chemical constituents:-

Total proteins, total carbohydrates, total soluble sugars as well as vitamin "C" as L-ascorbic acid of cabbage leaves were determined according to A.O.A.C [13].

Statistical analysis:-

All data were subject to statistical analysis according to procedure outlined by SAS [14] computer program and means were Compared by LSD method according to Snedecor and Cochran[15].

Results and Discussion:-

Vegetative growth:

Data presented in Table (2) outline the response of cabbage growth parameters to different cobalt levels. Cobalt at 6 ppm was shown to promote all growth parameters of cabbage plants such as plant height, Rosette diameter, stem diameter, number of extra leaves per plant and plant fresh weight significantly in vegetative stage. Increasing cobalt concentration in plant growth media decrease cobalt promotive effect. These data are in harmony with those obtained by Nadia Gad *et al* [16]. Confirm these results Nadia Gad *et al* [5] who stated that all studied cobalt rates had a promotive effect on broccoli growth parameters compared with control. Cobalt at 6 ppm gave the greatest figures.

Table (2): Influence of cobalt on growth of cabbage plant (means of two seasons).

Cobalt treatments (ppm)	Plant hight (cm)	Rosett diameter (cm)	Stem diameter (cm)	No. of Extra leaves per plant	Fresh weight per plant (kg)
Control	18.5	43.8	1.70	4	1.96
3.0	19.7	45.4	2.58	5	2.40
6.0	22.7	51.8	3.60	6	2.97
9.0	20.9	49.5	2.80	5	2.65
12.0	20.0	48.2	2.52	5	2.00
LSD at 5%	0.26	0.43	0.03	0.01	0.18

Yield characteristics:-

Data in Table (3) show that all cobalt rates has improve cabbage yield parameters such as head height, head diameter, head length, head width, head weight and marketable yield (Ton per Fadden).

Table (3): Influence of cobalt on cabbage yield (means of two seasons).

Cobalt treatments (ppm)	Head hight (cm)	Head Diameter (cm)	Head length (cm)	Head width (cm)	Head weight (kg)	Marketable yield (Ton fed^{-1})
Control	12.9	12.0	10.2	11.8	1.62	12.96
3.0	14.5	14.3	11.9	13.6	1.94	15.52
6.0	16.3	16.0	15.6	16.0	2.90	23.20
9.0	15.2	14.9	14.2	14.4	2.25	18.00
12.0	14.6	13.5	12.8	12.7	1.96	15.68
LSD at 5%	0.3	0.11	0.5	0.4	0.2	-

Cobalt at 6 ppm gave the highest values of yield. As cobalt concentrations in plant media increased, the promotive effect of cobalt reduced. These results are good agreement with those obtained by Liu *et al* [17] who stated that the growth of onion roots significantly increased with cobalt addition at 3 kg per ha. Nadia Gad *et al* [18] who found that cobalt had a significant promotive effect on all lettuce yield parameters compared with control.

Nutritional status:-

Data presented in Table (4) clearly indicate that cobalt has a favorable effect on both macronutrients (N, P, K and S) and micronutrients (Mn, Zn and Cu) compared with control. Cobalt at 6 ppm gave the highest values. Increasing cobalt level in plant growth media above 6 ppm, cobalt promotive effect reduced. The results reveal as expected and as mentioned by Nadia Gad *et al* [7] who show that cobalt had a significant promotive effect on okra pod macronutrients (N, P and K) and micronutrients (Mn, Zn and Cu) compared with untreated plants especially with humic acid.

Table (4): Influence of cobalt on nutritional status of cabbage leaves (means of two seasons).

Cobalt treatments (ppm)	Macronutrients (%)				Micronutrients (ppm)				Cobalt (ppm)
	N	P	K	S	Mn	Zn	Cu	Fe	
Control	0.78	0.36	0.49	22.81	36.3	23.5	40.5	198	0.86
3.0	0.86	0.39	0.53	23.40	38.7	26.0	42.3	195	1.00
6.0	1.06	0.45	0.62	24.32	47.0	29.6	45.9	191	2.13
9.0	1.02	0.45	0.59	24.19	44.5	28.2	44.0	186	4.86
12.0	0.94	0.41	0.55	23.83	42.6	26.7	42.6	182	7.11
LSD at 5%	0.01	0.002	0.001	0.31	0.16	0.24	0.35	1.26	0.22

Data in Table (4) also indicate that iron content in cabbage leaves to be decrease with cobalt addition in plant media increase. These results are agree with those obtained by Blaylock *et al* [19]. Data also indicate certain antagonistic relationships between cobalt and iron[20]. Cobalt content in cabbage leaves which treated with cobalt higher than untreated plants. These results are in harmony with those obtained by Nadia Gad *et al* [7].

Chemical constituents:-

Data presented in Table (5) show that all cobalt rates significantly increase the studied chemical constituents in cabbage leaves such as total proteins, total carbohydrates, total soluble sugars as well as vitamins "A" and "C" compared with control.

Cobalt at 6 ppm gave the superior figures. Increasing cobalt concentration in plant growth media, the promotive effect of cobalt was decreased. These results are good agreement with those obtained by Nadia Gad and Abd El-Moez [5]. Vitamins "C" is antioxidant and is necessary to several metabolic processes. Vitamins "C" dietary intake correlated with reduced gastric cancer risk[22].

Table (5): Influence of cobalt on chemical constituents of cabbage leaves (means of two seasons).

Cobalt treatments (ppm)	Total protein	Total carbohydrate	Total soluble sugars	Vitamin 'C'	Vitamin 'A'
	(%)			(mg/100 g F.w.)	
Control	4.88	13.33	7.69	35.6	11.6
3.0	5.38	14.58	8.47	36.8	12.0
6.0	6.93	16.95	9.75	38.2	14.7
9.0	6.38	16.14	9.25	38.2	14.5
12.0	5.88	15.08	8.66	37.5	14.5
LSD at 5%	-	0.23	0.07	0.23	0.09

Conclusion:-

Cobalt has a significant effect of cabbage growth and yield. From this study it could be suggest that cobalt is consider a beneficial element for higher plants. All cobalt rates significantly increased cabbage growth and yield compared with control. Cobalt at 6 ppm gave the highest figures of leaves yield, minerals composition and chemical constituents.

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