Journal of Applied Sciences Research, 7(11): 1569-1574, 2011
ISSN ISSN 1819-544X
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ORIGINAL ARTICLES

Maximizing the Tolerance of Wheat Plants to Soil Salinity Using Cobalt 1- Growth and Mineral Composition

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ABSTRACT

Two field experiments were carried out, at El- Hamoul district- Kafr El-Sheikh Governorate, Delta Egypt; to study the effect of cobalt on wheat growth, grains yield quantity and quality under salinity conditions. At the third truly leaf, wheat seedlings were irrigated once with cobalt concentrations: 0.0, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0 ppm.

The obtained results showed that:-

- All cobalt levels had a significant promotive effect on wheat growth and yield parameters compared with control.
- Increasing cobalt level in the cultural media up to 15.0 ppm cobalt stimulated growth, dry matter content, yield and its quality.
- Cobalt at 15.0 ppm gave a significant of wheat growth; yield and nutritional status expected Fe.
- When cobalt concentration was increased more than 15.0 ppm, resulted a progressive depression.
- Iron content was decreased with increasing cobalt doses; there is certain antagonistic relationships between the two elements (Co and Fe).
- Cobalt treatments, in general increased. The content of N, P, K, Ca, Mg, Mn, Zn and Cu in wheat shoots while Na and Cl concentrations were decreased.

Key words: Cobalt- Salinity- Wheat- Yield quantity and quality.

Introduction

Wheat *(triticum aestivum L.)* is one of the most important strategy crops, which plays a special role in people's nutrition. It is the main food crop for the population of Egypt. The amount of wheat needed for human consumption. But unfortunately abiotic stresses, such as salinity, decreased wheat growth and productivity by reducing water uptake and cause nutrient disorder and ion toxicity in this region. Salt stress is the most limiting factor (Ezatollal Esfandiari *et al.,* 2007).

All over the world salinity became a serious problem for agriculture. Egypt still adapting furrow irrigation system and also expanding in cultivating desert. Salinity, as well as water shortage and low water quality are the main problems for agriculture production under such circumstances. The north coast of Egypt comprised marginal soils ready for agricultur. The available irrigation water there has a relatively high salt content. The ability of plants to tolerate excess in the rhizosphere is of considerable importance in the arid and semi-arid regions where salinization of soils usually prevails (Abdel Gawad *et al.,* 1987).

Saline soils have salt levels high enough that either crop yields begin to suffer or cropping is impractical. Excessive salts injure plants by disturbing the uptake of water into roots and interfering with the uptake of competitive nutrients (David Franzen, 2007).

Soil salinity is considerable problem adversely affecting physiological and metabolic processes, finally, diminishing growth and yield (Ashraf and Harris, 2004). Salinity is known to retard plant growth through, its effect on several facts of plants behavior like osmotic adjustment, ion uptake, protein and nucleic acid synthesis, photosynthesis, enzyme activities and hormonal balance (Dumbroff and Cooper, 1974). Under salinity conditions, Hussien (1984) pointed out that cobalt was used to reduce the harmful effect of salinity on tomato plants, transpiration rate being reduced.

El-Kobbia and Osman (1987) showed that there was evidence when plant roots absorb water containing cobalt more than that from the non-rhizosphere soil toward roots by mass flow. Kumari and singh (1990) reported that mobility of heavy metals (including cobalt) was higher in acid soils than in alkaline ones. When soil were treated with saline (Ca SO_4, Mg SO_4) and alkali (Na HCO_3, Na_2 CO_3) solutions, the movement of the indicated heavy metals was greatest with the saline salts but lower with the alkaline ones. Angelove *et al.,* (1993) and Stewart (2001) found that cobalt reduced the salinity and /or ethrel injury on tomato plants, a

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suggestion being introduced for possible use of cobalt to irrigated transplants with saline water to overcome the salinity hazard. Bernstein *et al.,* (1994) stated that with only a few cases did salinity induse or aggravate a nutrient deficiency. This is true in spite of adverse response of cobalt for barley subjected to saline conditions (Hassan *et al.,* 1970). Nadia Gad (2005 a) demonstrated that, cobalt help tomato plants to resist stresses caused by high salinity. She added that, cobalt content in tomato plants increased with cobalt application. Increasing cobalt level in growth media increased cobalt content in shoots and roots of both salt-tolerant (Edcawy) and salt-sensitive (Mony Maker) tomatoes. Cobalt concentrations up to 15 ppm resulted on increase in Ca^{++} and Mg^{++} content of shoots and roots while Na^{++} and Cl^{-} concentrations decreased. Bedoglio and Cole (2004) pointed that low level of applied cobalt increased the leaf area as well as the size of chloroplasts in potato plants.

The Egyptian policy aims to increase the productivity of wheat for reducing the gab between wheat production and consumption. Therefore, wheat cultivation should be extended in more areas particularly in the newly reclaimed area and delta Egypt.

Materials and Methods

Soil Analysis:

Physical and chemical properties of El-Hamoul soil, are shown in Table (1).

Soil sample (Taken from El-Hamoul location) was dried and then prepared for analysis using the conventional techniques.

Particle size distribution along with soil moisture parameters of the soil sample was determined as described by Blackmore (1972). Soil organic matter, $CaCO_3$, EC, pH, cation and anions were determined according to Black *et al.,* (1982). Soluble and available micronutrients as well as soluble, available and total cobalt were determined according to Cottenie et al., (1982).

According to the Soil Taxonomy (1996) and Soil Map of Egypt (1982) the selected El-Hamoul district - Kafr El-Sheikh Governorate as saline soil (Typic Salorthids).

Plant Material and Experimental Works:

Two field experiments were carried out, at El-Hamoul location Kafr El-Sheikh Governorate to study the effect of different cobalt levels on wheat growth; grains yield quantity and quality under salinity conditions.

Two field experiments were conducted at the agricultural experimental location at Kafr El-Sheikh in El-Hamol district to study the effect of different cobalt concentration on growth, yield attributes as well as grain quality of wheat.

- Preliminary experiment was conducted at El-Hamoul- Kafr El- Sheikh Governorate Delta Egypt to define the concentrations of cobalt, which gave promotic effect on wheat growth.
- The soil was clayey with plot area about 21 m^2 (4.2 m wide by 5.0 m long).
- Plot width allowed for six rows as (70 cm rows). Wheat grains were sown in constant spaced hills 25 cm on one side of ridge, at approximately 28000 plant fed^{-1}.
- Wheat grains *(Triticum aestivum cvs Mill Sakha- 93)* were broadcasted on the soil at the rate of 80 kg fed^{-1} on both seasons. The experimental unite (plot) area was 21 m^2.
- The grains were sown at the second week of November in both seasons. The other cultural practices were performed in May in the first and second seasons.
- The seedlings (at third truly leaves) were irrigated only once with different cobalt levels (5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0 ppm).

Measurement of Plant Growth and Yield Parameters:

- After heading stage samples of ten wheat plants were taken randomly from each plot to determine plant high, leaves No/plant flag and leaf area (cm^3) according to Gabal *et al.,* (1984).
- Samples of ten wheat tillers were taken randomly from each plot at the end of the season to measure plant height, spike length, number of spike lets/ spike, number of grains/ spike, weight of grains/ spike and weight of 1000-grains according to A.O.A.C. (1970).
- At harvest, samples from one square meter were taken.

Measurement of Nutritional Contents:

- Macronutrients (N, P, K, Ca, Mg. Na and Cl) and micronutrients (Fe, Mn, Zn and Cu) as well as cobalt were determined according to Cottenie *et al.,* (1982).
- Combine data of the two seasons was statistically analyzed according to Snedcor and Cochran (1982).

Table 1: Some physical and chemical properties of the used soil at El-Hamoul location.

Physical	Particle size distribution (%)			Soil texture class	Saturation	Field capacity	Welting point	Available water
	Sand	Silt	Clay		%			
	19.25	15.64	65.11	clayey	64.8	46.2	15.9	30.3

Chemical	pH^a	EC^b	Soluble cations (meq/l)				Soluble anions (meq/L)			
			Ca^{++}	Mg^{++}	K^+	Na^+	HCO_3^-	CO_3	Cl^-	$SO_4^=$
	8.6	26.6	47.5	23.7	0.15	167	0.80	-	178	69.5

Total Available macronutrients (mg/100g)			Available micronutrients (ppm)				CEC meq/100 g soil	ESP	Cobalt (ppm)			$CaCO_3$	$O.M^c$
N	P	K	Fe	Mn	Zn	Cu			Soluble	Available	Total	%	
3.2	3.0	8.1	7.5	2.0	1.0	5.0	58.3	14.2	0.34	4.46	16.9	2.71	1.20

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

Results and Discussion

Plant Growth:

The results presented in Table (2) showed that, increasing cobalt concentration in plant media up to 15.0 ppm, cobalt stimulated all growth parameters i.e plant highet, leaves No. per plant, leaves area and dry weight of wheat shoots and roots. Such trend appeared to be reversed as applied cobalt concentration increased, least growth being obtained at 20.0 ppm rate in spite of similarity to 17.5 ppm cobalt treatment with that control approximately. The greatest effect of cobalt on dry matter of wheat shoots and roots production was observed at 15.0 ppm cobalt. However, higher cobalt levels above 15.0 ppm had depressive effect and caused reduction in plant growth due to the effect of soil salinity. These data are in harmony with those obtained by Nadia Gad (2005 a) who found that, under salinity condition, cobalt increased the growth and dry matter of tomato *(Edcawy and Money maker)* varieties.

Table 2: Effect of cobalt treatments on wheat plants grown in salinity soil (El-Hamoul) (mean of two seasons).

Treatments Cobalt (ppm)	Plant high(cm)	Leaves No./plant	Leaves area (cm^2/plant)	Dry weight (gm)	
				Shoots	Roots
Control	61.8	6.75	20.0	4.50	1.04
5.0	67.4	7.32	22.5	5.08	1.16
7.5	74.0	7.98	24.0	5.85	1.33
10.0	79.7	8.13	25.7	6.31	1.60
12.5	85.6	8.72	27.3	7.25	1.87
15.0	91.9	8.83	28.1	8.96	2.14
17.5	88.7	8.55	27.5	8.22	1.86
20.0	82.5	8.30	26.2	7.71	1.69
LSD 5%	1.05	0.04	0.24	0.11	0.015

Yield Characteristics:

Data presented in Table (3) clearly indicated that addition of different cobalt levels (5.0, 7.5, 10.0, 12.5, 15.0, 17.5 and 20.0 ppm) to the wheat growth media significantly increased all yield parameters i.e number of spikes, spikes length, weight of grains in spike, weight of 1000 grains, yield as (ton/fed) and yield (ardab/fed) compared with control treatment. The highest recorded results of the mentioned yield parameters of wheat were obtained from plants treated with 15.0 ppm cobalt. When cobalt addition increased more than 15.0 ppm the promotive effect of yield parameters had reduced.

These observations are in consistent with previous obtained data by Nadia Gad and Abd El-Moez (2011) who stated that cobalt enhanced broccoli growth and yield up to 6 ppm, while increasing cobalt levels gave adverse effect. They reported that responses associated with low cobalt concentrations may be attributed to catalase and peroxidise activities which were found to decreased with low levels of cobalt and increased with the higher ones. Those enzymes are known to induce plant respiration and hence increasing catabolism rather than the anabolism (Atta Ali *et al.*, 1991).

Nutritional Status in Plants:

Data in Table (4) clearly indicated the following:

Table 3: Effect of cobalt treatments on wheat yield grown in salinity soil (El-Hamoul) (mean of two seasons).

Treatments Cobalt (ppm)	Spikes length (cm)	No. of /Spikes	Weight of grains in Spikes (gm)	Grain No./Spike	Weight of 1000 grains (gm)	Grain yield (Ardab/fed)	Yield (Ton/fed)
Control	7.6	13.3	1.02	35.0	37.3	7.15	1.95
5.0	8.6	15.2	1.15	42.1	42.5	8.32	2.25
7.5	9.2	17.1	1.45	46.7	45.7	8.90	2.67
10.0	10.5	17.9	2.17	50.8	50.3	9.82	3.10
12.5	10.7	18.6	2.35	54.7	53.6	10.17	3.25
15.0	11.4	19.2	2.60	58.1	55.0	10.80	3.61
17.5	11.0	18.4	2.56	57.3	54.0	9.95	2.90
20.0	10.5	18.0	2.50	55.9	53.2	8.31	2.29
LSD 5%	0.05	0.24	0.01	0.13	0.21	0.32	0.12

Nitrogen, Phosphorus and Potassium:

Results presents in Table (4) showed that the effect of soil salinity on N, P and K content of wheat plants. In general, native salts had decreased the content of N, P and K. Obtained data indicated that the addition of cobalt to plant media up to 15.0 ppm has shown a significant beneficial effect on the status of N, P and K in wheat plants compared with control. Cobalt at 15.0 ppm resulted in superior figures on N, P and K content of wheat shoots. Increasing cobalt concentration above 15.0 ppm reduced the promotive effect. These results are in harmony with those obtained by Nadia Gad (2005 a) who found that under salinity condition, cobalt has a significant status of N, P and K in tomatoes. Higher cobalt levels caused depressive reduction in N, P and K status of tomatoes grown under salinity condition.

Table 4: Effect of cobalt treatments on nutrients content of wheat shoots grown in salinity soil (El-Hamoul) (mean of two seasons).

Treatments Cobalt (ppm)	Macronutrients (%)							Micronutrients (ppm)				Co (ppm)
	N	P	K	Ca	Mg	Na	Cl	Mn	Zn	Cu	Fe	
Control	0.98	0.63	2.73	2.76	0.24	5.74	9.42	18.6	14.4	23.0	27.5	0.96
5.0	1.34	0.87	3.46	5.53	0.27	5.53	8.67	19.8	15.7	24.2	25.3	1.41
7.5	1.89	0.98	3.92	5.88	0.31	5.31	8.11	20.5	16.0	24.9	22.9	3.35
10.0	2.01	1.53	4.36	6.02	0.34	4.40	7.56	21.7	16.8	25.5	21.4	4.96
12.5	2.13	1.82	4.87	6.95	0.39	3.77	7.03	22.8	17.6	26.8	20.5	6.00
15.0	2.78	2.07	5.21	7.44	0.44	3.32	6.59	24.2	18.2	27.4	19.6	7.12
17.5	1.95	1.96	5.01	5.89	0.41	2.91	6.11	23.0	19.5	26.2	19.0	8.04
20.0	1.28	1.61	4.79	5.54	0.31	2.39	5.67	22.6	20.3	25.0	17.7	9.81
LSD 5%	0.01	0.02	0.12	0.15	0.002	0.11	0.16	0.22	0.02	0.04	0.12	0.06

Calcium, Magnesium, Sodium and Chloride:

Data tabulated in Table (4) revealed the effect of cobalt on Ca, Mg, Na and Cl content of wheat shoots grown in saline soil (El-Hamul- Kafr El-Sheikh government). Data indicated that salinity condition increased the content of Ca, Mg, Na and Cl content. All cobalt treatments significantly enhanced the status of the Ca and Mg elements compared with control. Cobalt at 15.0 ppm gave the highest figures of Ca and Mg content in wheat shoots. However, higher cobalt levels above 15.0 ppm has depressive effect where it caused reduction in both Ca and Mg status. Data in Table (4) also indicated that salinity hazard increased both Na and Cl content in the control plants. Cobalt addition in plant media significantly decreased both Na and Cl status of wheat shoots compared with the control. These results are in agreement with Dahiya and Singh (1996).

Iron Content:

Results in Table (4) indicated that increasing cobalt levels in plant media resulted in a progressive depression effect on iron status in shoots of wheat plants grown under salinity condition. This may be explained on the basis of results obtained by Bisht (1991) and Nadia Gad (2010) who indicated certain antagonistic relationships between the two elements (Co, Fe). Hazardous effects of increasing cobalt levels in the media being severely involved in wilting appearance and reductions for net photosynthesis.

Manganese, Zinc and Copper Content:

Salinity affected plants contents of Mn, Zn and Cu by: (I) Changing the available levels of these elements in plant media (II) Altering their absorption by plant roots and (III) Inhibiting cell expansion and plant growth (Suhayda *et al.*, 1994).

Data in Table (4) indicated that increasing cobalt concentration up to 15.0 ppm increased the content of both Mn, Zn and Cu in wheat shoots. Data also showed that cobalt level of 10.0 ppm gave the highest values of Mn, Zn and Cu in wheat shoots. While increasing cobalt more than 15.0 ppm has a hazardous effect. These results are in harmony with those obtained by Nadia Gad (2005 b) who showed that increasing cobalt in plant media gave a significant adverse effect on tomato plants grown under salinity conditions.

Cobalt Content:

Increasing cobalt concentration in plant media increased cobalt content in shoots of wheat plants. These results were in agreement with those obtained by Nadia Gad and Hala Kandil (2010).

References

Abd El-Gawad, A.A., K.A. El- Shouny, S.A. Saleh and M.A. Hamed, 1987. Partition and migration of dry matter in newly cultivated wheat varieties. Egypt J. Agron., 12: 1-10.

Angelov, M., T. Tsonev, K. Dobrinova, V. Velikova and T. Stoynaova, 1993. Changes in some photosynthetic parameters in pea plants after treatment with cobalt. Phytosynthetica, 28: 289-295.

A.O.A.C., 1970. Official Methods of Analysis of The Association of Official Edition, Washington, D. C.

Ashraf and Harris, 2004. Potential biochemical indicators of salinity tolerance in plants. Plant Sci., 166: 3-6.

Atta-Aly, M.A., N.G. Shehata and T.M. El-Kobbia, 1991. Effect of cobalt on tomatoplant growth and mineral content. Annals Agric. Sci., Ain Shams Univ., Cairo., 36: 617-624.

Bedoglio, N. and J.L. Cole, 2004. The role of cobalt on salanized potato plants. Commun. Soil Sci. and Plant Anal., 21: 578.

Bernstein, A.K., P.R. Anderson and T.H. Christensen, 1994. Effect of salinity on nutrients uptake by plant. J. Soil Sci., Oxford., 39: 15- 22.

Bisht, J.C., 1991. Interrelations between mineral plant tissues, iron and cobalt. Pescui, Agropecu. Bras, 16: 739-746.

Black, C.A., D.D. Evans, L.E. Ensminger, G.L. White and F.E. Clarck, 1982. Methods of soil analysis Part 2. Agron. Inc. Madison. Wisc.

Blackmore, L.C., 1972. Methods for chemical analysis of soils. Newzealand soil Durean, Rep. No. 10.

Cottenie, A., M. Verloo, L. Kiekens, G. Velgh and R. Camerlynck, 1982. Chemical Analysis of Plant and Soil. Lab. Anal. Agrochem. State Univ. Gthent, Belgium, 63.

Dahiya, S.S. and M. Singh, 1996. Effect of salinity, alkalinity and iron application on the availability of iron, manganese, phosphorous and sodium in pea *(Pisum sativum L.)* crops. Plant and Soil, 44: 697-702.

David Franzen, 2007. Salt accumulation processes. North Dakota state Univ., Fargo ND 58105.

Dumbroff, E.B. and A.W. Cooper, 1974. Effect of salt stress applied in balanced nutrient solutions a several stages during growth tomato. Bot. Gaz., 135: 219- 224.

El-Kobbia, T. and A. Osman, 1987. Salinity and cobalt interaction in wheat and barly plants. Soil Sci. and Rural Sociology, 47: 103-115.

Ezatollah Esfandiari, Fariborz Shekari, Farid Shekari and Manouchehr Esfndiari, 2007. The effect of salt stress on antioxidant enzymes activity and lipid peroxidation on the wheat seedling. Bot., Hort. Agrobot. Cluj., 35: 1848-1856.

Gabal, M.R., I.M. Abd-Allah, F.M. Hass and S. Hassannen, 1984. Evaluation of some American tomato cultivars grown for early summer production in Egypt, Annals of Agric. Sci. Moshtohor, 22: 487-500.

Hassan, N.A.K., J.V. Drew, D. Knudsen and R.A. Olson, 1970. Influence of soil salinity on production of dry matter and uptake and distribution of nutrients in barley and corn: II Corn *(Zea mays)* Agron. J., 62: 46-48.

Hussein, L.A., 1984. Plant tolerance to salt and heavy metals. Ph.D Thises, Fac. Agric. Ain Shams Univ., Egypt.

Kumari, K. and R.P. Singh, 1990. The effect of different factors on the mobility of cobalt manganese and nickel in soils. Ind. J. Planer Chromotoo Mod. TLC., 3: 349-351.

Nadia Gad, 2005 a. Interactive effect of cobalt and salinity on tomato plants I- Growth and mineral composition as affected by cobalt and salinity. Research Journal of Agriculture and Biological Sciences Pakistan, 1(3): 261-269.

Nadia Gad, 2005 b. Effect of cobalt on tomato growth, yield and fruit quality. Egypt.J. Appl. Sci., 20(4): 260-270.

Nadia Gad, 2010. Improving quantity and quality of canola oil yield through cobalt nutrition. Agriculture and Biological J. of North America, 1(5): 1090-1097.

Nadia Gad and M.R. AbdEl-Moez, 2011. Broccoli Growth, Yield Quantity and Quality as Affected by Cobalt Nutrition. Agriculture and Biological J. of North Am., 2(2): 226-231.

Nadia Gad and Hala Kandil, 2010. Influence of cobalt on phosphorus uptake, growth and yield of tomato. Agriculture and Biological J. of North Am., 1(5): 1069-1075.

Snedecor, G.W. and W.G. Cochran, 1982. Statistical methods. 7th Edition Iowa State Univ. Press. Ames. Iowa, USA.

Suhayda, C.G., R.E. Redmann and X. Wang, 1994. Salinity rates roots cell wall properties and trace metal uptake in barley. J. A. Man They, London, pp: 325-342.

Stewart, S.E., 2001. Effect of cobalt on tomato plants under saline irrigation. Hort. Sci., 6: 82-85.