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ORIGINAL ARTICLES

Influence of Cobalt and Phosphorus on Growth, Yield Quantity and Quality of Sweet Potato (*Ipomoea batatas* L)

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Abstract: Two field experiments were carried out in the Research and production Station, National Research Centre, El-Nobaria during 2009 and 2010 seasons to evaluate the effect of cobalt and different sources of phosphate fertilizer on the growth, yield quantity and quality of sweet potato.
The obtained results showed that:

- Treatments can be arranged in descending as follows: Mono super phosphate> Triple super phosphate> Rock phosphate
- Mono super phosphate had superior effect on all growth parameters of sweet potato shoots and roots yield quantity and quality compared with other phosphorus sources.
- Rock phosphate gave the lowest values of the growth, yield, mineral composition and chemical constituents of sweet potato.
- Cobalt addition in plant media enhanced all parameters of sweet potato growth and yield quantity and quality specially with Mono super phosphate.

Key words: Sweet potato, Cobalt, Super phosphate, Rock phosphate.

Introduction

Cobalt is a beneficial element for plant growth. In higher plants, cobalt also promoted many developmental processes including stem and coleoptil elongation opening of hypocotyl, leaf expension and bud development (Howell and Skoog, 1975). Cobalt is an essential element for the synthese of viyamin B12, which is required for human and animal nutrition (Young, 1983). It is also required for maintaining cucumber (Nadia Gad et al 2008) squash (Atta-Aly, 1998), Broccoli (Nadia Gad and Abd El-Moez, 2011) plant growth with low levels of its supply. Excess cobalt induces yield reduction, Walser et al (1996) added however, that cobalt application (2.7 Kg Co/ha soil) increased tomato leaf number as well as surface of chloroplasts per unit leaf area, leaf chlorophyll content, leaf area and the rate of photosynthesis.

Phosphorus availability is considered one of the major growth – limiting factors for plants in many natural ecosystems. plants have developed several adaptive mechanisms to overcome phosphorus stress (Marschner, 1995).

There is evidence of heavy metals build – up in some agricultural soils due to long tern application of inorganic phosphate fertilizers (Ewa et al 1999). Trace elements are normally found in phosphate fertilizers (Mahammad and Athamneh, 2004).

Even through types of phosphorus fertilizers are used in crop production, the influence of phosphorus on produce quality is not well understood. Several quality attributes of tomato juice were analyzed in relation to phosphorus supplementation during a three years field study (Papadopoulos and Leena Ristimake, 2008).

Phosphorus is an essential element in the energy transfer processes, it is needed in the formation of fat, in transformation of starch to sugar, in flowering and fruitting stage. Mono super phosphate has been most widely used a P fertilizer for agricultural purposes in Egypt. Triple super phosphate with 48 % P_2O_5 and Rock phosphate with 38 % P_2O_5 (Gouda et al, 1990). Supplying vegetable crops with organic and inorganic fertilizers was proved to be very essential for production of higher yield and for improving its quality (Mengal and Kerkby, 1987).

Sweet potato (Ipomoea batatas Mill crs Apis) can be grown with high yield, in artificial conditions using hydroponics. This is important, as the sweet potato is more nutritious and flaverful than white one and therefore can be grown in greater quantities. Sweet potato is an excellent source of complex carbohydrates, high Antioxidants, vitamins (A and C), minerals (phosphorus, potassium, magnesium, calcium, sulfur, iron, manganese, copper, boron, zinc), Iodine, Folic acid, Cystine fiber, Starch, protein, Niacin, Tryptophan and Tyrosine. The starch in sweet potato converts to sugar easily and provides quick energy. It is actually super food (Griffiths and Lunec, 2001); Panda et al. (2006) added that sweet potato is an important root crop grown all over

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the world and consumed either as vegetable, boiled, backed or often fermented into food and beverages. It is generally the staple food and an important subsistances crop for human.

The aim of the present experiments is to investigate the effect of cobalt and different phosphorus sources on sweet potato growth, yield quantity and quality.

Materials and Methods

Soil Analysis:

Some physical and chemical soil properties of Research and Production Station, National Research Centre, El – Nobaria site were determined.

Partical size distribution along with soil moisture of the soil samples were determined as described by Blackmore (1972). Soil pH, EC. Cations and anions, organic matter, $CaCO_3$ as well as total nitrogen and available P, K, Fe, Mn, Zn and Cu were determined according to Black et al (1982). Total cobalt was determented in Aqua regia extract, the water soluble cobalt as well as available cobalt (DTPA extractable) being assayed according to Cottenie et al (1982).

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

Soil properties	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
	pH^a		EC^b dS/m		$CaCO_3$%		OM ^{c}%	
	7.8		0.18		7.07		0.16	
Chemical	Soluble cations (meq/l)				Soluble anions (meq/l)			
	Ca^{++}	Mg^{++}	K^+	Na^+	$CO_3^=$	HCO_3^-	Cl^-	SO4
	3.00	2.00	0.32	2.09	0.00	1.41	0.70	5.30
	Total (mg/100 g soil)		Available (mg/100 g soil)		Available micronutrients (ppm)			
	N		P	K	Fe	Mn	Zn	Cu
	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.
FC, WP; AW= Field capacity, Wilting point and Available water.

Plant Material nd Experimental Works:

Two field experiments were conducted during two successive seasons 2009 and 2010 at El – Nobaria , National Research Centre to evaluate the effect of cobalt and different sources of phosphorus fertilizer on growth as well as yield quantity and quality of sweet potato roots. Sweet potato roots (*Ipomoea batatas Mill cvs Apis*) were sown on 5th April, 2009 and 2010 seasons under drip irrigation system. All agricultural managements required for production of seedling as usually recommended. The previous experiments were carried out in randomized complete block design with three replicates. Each treatment was represented by three plots. Each plot area was 5X3 meter, consisting of three rows. Ten roots in each row (50 cm apart) were planted. All the plants received natural agricultural practices whenever they needed. At the third truly leaf, some seedlings were irrigated once with cobalt at 10 ppm. The experim contained 6 treatments as follows:

Received only the recommended doses by Ministry of agricultural of mineral fertilizers i.e 150 Kg/fed ammonium sulphate and 100 Kg/fed potassium sulphate along with three different sources of phosphorus fertilizer:

1- Mono super phosphate at the rate of 100 Kg/fed
2- Triple super phosphate at the rate of 100 Kg/fed
3- Rock phosphate at the rate of 100 Kg/fed
4- Mono super phosphate 100 Kg/fed + cobalt (10 ppm)
5- Triple super phosphate 100 Kg/fed + cobalt (10 ppm)
6- Rock phosphate 100 Kg/fed + cobalt (10 ppm)

According to Nadia Gad and Hala Kandil (2008).

Measurement of Plant Growth and Yield Parameters:

After the growth period (155 days from planting), some growth and yield parameters i.e. plant hight, number. of branches per plant, shoot fresh and dry weights, roots number per plant, root length, root diamerer and roots yield per feddan were recorded according to Gabal et al (1984).

Measurement Roots Quality:

Percentage of starch, mono sugar, total soluble sugars, total soluble solids, protein, vitamin "A" as carotenoids and vitamin "C" as L – Ascorbic acid (mg/100g fresh tissue) were determined according to standard methods described by A.O.A.C. (1980) as well as nutrients status according by Cottenie et al (1982).

Statistical analysis of the obtained data for the two growing seasons were subjected to standard analysis of variance procedure. The values of LSD were calculated at 5 % level according to the method of Snendcore and Cochran (1982).

Results and Discussion

Plant Growth:

Data presented in Table (2) outline the response of sweet potato growth parameters to different sources of phosphorus fertilizer with or without cobalt rate of 10 ppm. Results showed that the superior growth parameters i.e. plant hight, number of branches per plant, fresh and dry weight of shoots were recorded by plants supplied with mono super phosphate. All treatments can be arranged in decreasing order as follows:

Table 2: Effect of cobalt and different sources of phosphorus on sweet potato growth parameters (mean of tow seasons).

Type of phosphorus fertilizer	Plant high (Cm)	Branches no./plant	Shoots weight (gm)	
			Fresh	Dry
Without cobalt				
Mono super phosphate	234	11	440	139
Triple super phosphate	226	11	428	116
Rock phosphate	219	9	417	105
LSD 5%	3.46	1.97	2.82	1.99
With cobalt (10 ppm)				
Mono super phosphate	242	13	465	158
Triple super phosphate	235	12	444	141
Rock phosphate	225	11	429	129
LSD 5%	3.41	1.11	2.73	1.97
LSD of interaction at 5%	3.08	1.78	2.52	3.01

Mono super phosphate > Triple super phosphate > Rock phosphate. The lowest values of sweet potato growth parameters were obtained by Rock phosphate. These data are harmony with those obtained by Abdel – Hamid et al, (2003) they showed that Mono super phosphate form is more readily in the soil solution and hence to plant than Triple super phosphate. Triple super phosphate form increases the action of acid generated through nitrification of the ammonium ions. In this concern the Rock phosphate may be to slowly release and residual values accumulated in the soil.

It is obvious that cobalt addition caused an enhancement in plant growth parameters with all type of phosphorus fertilizer especially with Mono super phosphate form. These data are agreement with Nadia Gad (2002) who found that cobalt uptake from soil by corn and soybean plant increases will the increased phosphorus. Data in Table (2) also indicated that the highest recorded results of the growth parameters of sweet potato were obtained in plants treated with mono super phosphate with cobalt. These observations are consistent with previous reported by Nadia Gad (1989), who stated that cobalt resulted in maximum growth of tomato plants compared the control, cobalt attributed to catalase and peroxidase activities. These enzymes are known to induce plant respiration, so superior resulting in successive consumption for products of photosynthesis and consequently in plant growth. Moreover cobalt gave a positive effect due to several induced effects in hormonal synthesis (Auxins and Giberellins) metabolic activity-cobalt hence increasing the catabolism rather than anabolism.

Yield Quantity:

Data in Table (3) represented the effect of cobalt and different sources of phosphorus fertilizers on sweet potato yield. Results illustrate the synergistic effect of Mono super phosphate on sweet potato yield parameters i.e. roots number per plant, root length, root diameter and roots yield (ton/fed). Both Triple super phosphate and Rock phosphate fertilizes gave roots yield lower than Mono super phosphate. Mono super phosphate gave the superior yield quantity. It increased the yield by 23.7 and 38.7 % respectively compared with Triple super phosphate and Rock phosphate.

Table 3: Effect of cobalt and different source of phosphorus on sweet potato yield parameters(mean of tow seasons).

Type of phosphorus fertilizer	Roots no./plant	Roots length (Cm)	Root diameter (Cm)	Roots yield (Ton/fed)
		Without cobalt		
Mono super phosphate	10	21.5	16.4	13.88
Triple super phosphate	8	18.4	15.2	11.22
Rock phosphate	6	16.0	13.6	10.01
LSD 5%	1.95	0.77	0.59	0.37
		With cobalt (10 ppm)		
Mono super phosphate	12	24.8	19.8	16.98
Triple super phosphate	10	22.6	18.0	14.94
Rock phosphate	7	19.2	15.2	12.63
LSD 5%	1.76	0.54	0.41	0.35
LSD of interaction at 5%	1.79	0.59	0.46	0.44

These results reveal, as expected as mentioned by Nadia Gad and Hala Kandil (2010) who showed that, available phosphorus supplementation significantly increased tomoto yield compared with both Triple super phosphate and Rock phosphate. Data in Table (3) also indicated that cobalt enhancement the yield quantity with all phosphorus fertilizer sources specially Mono super phosphate. Cobalt increased the yield of sweet potato by 22.3 % with Mono super phosphate form. Cobalt increased the root yield of sweet potato by 33.2 % and 26.2 % respectively compared with Triple super phosphate and Rock phosphate. These results are in harmony with those obtained with Viny et al (1996) ; Nadia Gad and Abd El-Moez (2011) who found that, cobalt had a significant favorable effect on the yield quantity of both tomato and Broccoli.

Chemical Constituents of Roots:

Data presented in Table (4) indicated the promotive effect of Mono super phosphate on sweet potato yield i.e. starch, mono sugars, total soluble sugars, total soluble solids, protein, vitamin "A" and vitamin "C' while Rock phosphate gave the lowest figures.

These data are agreement with those obtained by Mostafa et al (2005) who found that, available phosphorus supplementation significantly improved the processing quality characteristics in tomato fruits i.e. total soluble solids, vitamin "C", color, titrable acidity.

Data in Table (4) also indicated that cobalt had a significantly increased the mentioned chemical parameters with all sources of Phosphorus fertilizer. The highest figures of all studies parameters are obtained by cobalt with Mono super phosphate followed by Triple super phosphate followed by Rock phosphate. These results are in harmony with those obtained by Nadia Gad and Hala Kandil (2008) who stated that cobalt at 10 ppm increased the percentage of carotenoids (27 – 31 %), protein (26 -27 %), starch (7 – 8 %), mono sugars (58 – 61 %), total soluble sugars (18 – 21 %), vitamin C (19 – 21 %) and total soluble solids (60 – 66 %) of sweet potato roots relative calculated values from control. Vitamin "A" as caroteniods are known recognized as an antioxidant and its essential to human growth, normal physiological functions, health of the skin as well as mucous membranes, vitamin C is an antioxidant and is necessary to several metabolic processes (Grifiths and Lunec, 2001).

Table 4: Effect of cobalt and different source of phosphorus on sweet potato chemical cons(mean of tow seasons).

Type of phosphorus fertilizer	Starch	Mono Sugars	Total Soluble sugars	Total soluble solids	Protein	Vitamin (A)	Vitamin (C)
	(%)						
	Without cobalt						
Mono super phosphate	70.6	3.83	3.87	6.45	8.24	1.65	15.6
Triple super phosphate	67.1	3.11	3.01	5.89	7.86	1.41	14.2
Rock phosphate	63.2	2.20	2.54	5.20	7.49	1.22	13.0
LSD 5%	1.27	0.17	0.12	0.35	-	0.05	0.43
	With cobalt (10 ppm)						
Mono super phosphate	73.5	4.12	4.68	7.18	8.49	1.98	16.3
Triple super phosphate	70.3	3.76	3.78	6.44	8.17	1.72	15.0
Rock phosphate	66.9	2.66	2.91	5.95	7.92	1.39	13.9
LSD 5%	0.74	0.24	0.28	0.33	-	0.21	0.42
LSD of interaction at 5%	1.10	0.36	0.31	0.48	-	0.27	0.51

Nutritional Status in Roots:

Data in Table (5) showed that Rock phosphate fertilizer gave the lowest values of both macro and micro – nutrients but Mono super phosphate gave the highest ones.

Table 5: Effect of cobalt and different source of phosphorus on sweet potato nutritional status (mean of tow seasons).

Type of phosphorus fertilizer	Macronutrients %			Micronutrients (ppm)				Cobalt (ppm)	
	N	P	K	Mn	Zn	Cu	Fe	Shoots	Roots
	Without cobalt								
Mono super phosphate	1.32	2.27	1.34	66.5	36.1	25.2	139	2.8	1.72
Triple super phosphate	1.26	2.21	1.27	62.0	32.0	21.8	136	2.5	1.51
Rock phosphate	1.20	2.01	1.14	57.2	28.6	18.4	131	2.3	1.39
LSD 5%	0.03	0.04	0.03	0.51	0.35	0.15	1.99	0.19	0.26
	With cobalt (10 ppm)								
Mono super phosphate	1.36	2.34	1.46	69.1	37.3	28.4	135	7.2	3.02
Triple super phosphate	1.31	2.28	1.41	65.5	34.5	25.9	130	6.8	2.87
Rock phosphate	1.27	2.20	1.25	61.8	31.0	20.7	126	6.2	2.48
LSD 5%	0.02	0.05	0.02	0.57	0.34	0.22	1.97	0.21	0.29
LSD of interaction at 5%	0.05	0.07	0.04	0.65	0.44	0.37	2.45	0.28	0.34

Data reflected that the superiority of Mono super phosphate may be attributed to its rapid solubility of which were more than both Triple super phosphate and Rock phosphate fertilizers. The favourable effect of Mono super phosphate on minerals content of sweet potato roots may be due to the direct effect of this phosphorus form in increasing photosynthesis rate an sutsequently N, P and K contents. These results coincided with those of Arich (1993). Data also indicated a similar trend to the micronutrients i.e. Mn, Zn, Cu and Fe. These data are agreement with Nadia Gad and Hala Kandil (2010) who stated that mono super phosphate gave the highest N, P, K, Fe, Mn, Zn and Cu content in tomato fruits followed by Tripe super phosphate while Rock phosphate gave the lowest ones.

Data in Table (5) also revealed that the addition of cobalt in plant media significantly increased elemental nutrition with all studied sources of phosphorus fertilizer specially Mono super phosphate. Cobalt enhanced the content of macronutrients (N, P and K) and micronutrients (Mn, Zn and Cu) except Fe.

The reduction rate of Fe resulted the certain antagonistic relationships between two elements (Co and Fe). This may be explained on the basis of the obtained results by Blaylock et al, (1993) and Nadia Gad (2005).

Cobalt Content:

Table (5) also indicate that the highest level of cobalt in sweet potato roots 6.20 ppm. These results confirm results Young (1983) who reported that unlike other heavy metals cobalt is sever for human consumption on a daily basis whitout health hazard.

References

Abdel Hamid, M.A., S.I. Abdel – Aal, A. Abdel – Fattah, S.A. Ismaiel and A.S. Taalab, 2003. The relative residual effectiveness of superphosphate fertilizers and rock phosphate in Torripsamments. Egypt J. Soil Sci., 43(1): 35-46.

A.O.A.C., 1980. Official Methods of Analysis of the Association of Official Agricultural Chemist 20th Ed. Washigton DC.

Arich, H.M.E., 1993. Nitrogen efficiency by natural inhibitor addition in rice ecosystems. J. Agric. Sci., Mansoura Univ., 22(5): 1787-1800.

Atta-Ali, M.A., 1998. Soaking summer squash seeds in low concentrations of cobalt solution before sowing increased plant growth, femaleness and fruit yield via increasing plant ethylene level. J. Plant Growth regu., 17: 25-32.

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 of chemical analysis of soils" New Zealand. Soil Dureanu, P.A.2.1.0, Rep. No. 10.

Blaylock, A.D., T.D. Davis, V.D. Jolly and R.H. Walser, 1993. Influence of cobalt and iron on photosynthesis chlorophyll and nutrient in regreening chlorotic tomatoes and soybeans. J. Plant Nutr., 8: 823-838.

Cottenei, A.M. Verloo, L. Kiekens, G. Velgh and R. Camerlynk, 1982. Chemical Analysis of Plants and Soils. PP 44-45. State Univ. Ghent, Belgium.

Ewa, I.O.M., M.O.A. Oladipo and L.A. Dim, 1999. Horizontal and vertical distribution of selected metals in the Kubani river. Nigeria as determined by neutron activation analysis. Comm. Soil Sci. Plant Anal., 30 : 1081–1090.

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. Annuals of Agric. Sci. Mostohor, 22: 487-500.

Gouda, M., E.E. Kaoud, K. Matter and M.A. Khamis, 1990. Effect of some soil and water management practices on groundnut in sandy soils. Egypt J. Soil Sci., 30: 331.

Griffiths, H.R. and J. Lunec, 2001. "Ascorbic acid in the 21st Century-more than a simple antioxidant" Enivron. Toxicol, and Pharmacol., 10: 173-182.

Howell, H.R. and F. Skoog, 1975. Effect of adenine and other subsurfaces on growth of excised pisum epicotyls cultured in vitro. Amircan. J. Bot., 49: 645-649.

Marschner, H., 1995. "Mineral Nutrition of Higher Plants" Academic Press, London.

Mengel, K. and E.A. Kirkby, 1987. Principles of plant nutrition 4th Ed. International Potash Institute, Basel, Switzerland.

Mohammad, M.J. and B.M. Athamneh, 2004. Changes of soil fertility and plant uptake of nutrients and heavy metals in response to sewage sludge application to calkareous soil. J. of Agron., 3(3): 229-236.

Moustafa Cke, A.H.N., Taehyun, Schofield and Gopinadhan Pailyzin, 2005. Effect of phosphorus fertilizer supplementation on processing quality and functional food ingredients in tomato. Agricultural and Food Chemistry, 519: 742-751.

Nadia Gad, 1989. Effect of cobalt on the growth and mineral composition of plant. MSc. Thesis. Faculty of Agricu., Ain Shams Univ., Cairo, Egypt.

Nadia Gad, 2002. Uptake of Cobalt and some other trace elements as affected by phosphorus levels and Mycorrhizae inoculation. Egypt J. Soil Sci., 42(3): 609-623.

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

Nadia Gad and Hala Kandil, 2008. Response of sweet potato (*ipomoea batatas L*). plants to different levels of cobalt. Australian Journal of Basic and Applied Sciences, 2(4): 449-455.

Nadia Gad, A.M. Shafie and M.S. Abdel Fatah, 2008. Effect of cobalt on cucumber growth, fruits yield and mineral composition. J. Agric. Sci. Mansoura Univ., 33(1): 909-915.

Nadia Gad and Hala Kandil, 2010. Influence of cobalt on phosphorus uptake, growth and yield of tomato. Agriculture and Biology Journal of North America ISSN, 1(5): 1069-1075.

Nadia Gad and AbdEl-Moez, 2011. Broccoli growth, yield quantity and quality as affected by cobalt nutrition Agriculture and Biology Journal of North America, 2(2): 226-231.

Panda, S.H., S.K. Naskar and R.C. Ray, 2006. Production proximate and nutritional evaluation of sweet potato crud. J. Food, Agric & Environ. World Food Ltd Helsinki, Finland, 4(1): 124-127.

Papadopoulos and Leena M. Ristimaki, 2008. Sources of phosphorous fertigation of tomato and Eggplant. Horticulture Society for Horticulture Science, Login status.

Rauser, W.E. and A.B. Samarakoon, 1980. Vein Loading of *phaseolus vulgaris* exposed to excess cobalt, Nickel and Zinc. Plant Physio., 65: 578-583.

Snedecor, G.W. and W.G. Cochran, 1982. Statistical Methods. 7th ed. The Iowa state Univ. press. Ames, Iowa, USA., pp: 365-372.

Viny, S., H.B. Singh and V. Singh, 1996. Influence of cobalt and phosphorus on their uptake and growth of clusterbean (Cyamopsis tetrogonolaba L.). Indian J. Plant Physiol., 39: 219-221.

Walser, R.H., V.D. Jolley and T.D. Davis, 1996. Effect of cobalt application on structural organization of photosynthetic apparatus of tomato leaves. J. Plant Nut., 19: 358-363.

Young, S.R., 1983. Recent adances on cobalt human nutrition. Victoria Pochvovedeniye, 3: 59-62.