Cobalt: Physiological Effects and Uptake Mechanisms in Plants

by

Jukong Liu

B. and M. Agr. Sci., Northwest Agricultural University, Shaanxi, China

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SUMMARY

This thesis describes an investigation into the mechanism of uptake of cobalt (Co) into plants and the physiological consequences of Co uptake and distribution within plants. The experiments were conducted with mung beans grown in solution culture but comparison was also made with Co uptake in a giant alga, Chara corallina.

Co has no known function in plant cells yet there appeared to be 3 possible uptake systems for Co; 1) a high affinity system which saturates at approximately 1 μM with a Km of approximately 0.3 μM, 2) a system with intermediate affinity for Co with a Km of approximately 3 μM and 3) a linear phase which extends to at least 500 μM.

Co influx was sensitive to the internal Co status, plants which had been previously exposed to Co had lower ⁶⁰Co influx that plants which had not been treated with Co. Influx of Co was also sensitive to other divalent cations. The degree of inhibition of influx of ⁶⁰Co decreased in the order Cd>Cu>Hg>Ni>Zn>Mn>Fe>Pb. Ca and Mg were only inhibitory at high concentrations and this was interpreted in terms of direct effects of these metals on membrane surface charge. Influx was also inhibited by the sulphydryl reagent NEM, which suggested that the uptake mechanism might involve binding of Co to –SH groups within the membrane.

Experiments with Chara showed that Co accumulated in both vacuole and cytoplasm. The rapid appearance of Co in the vacuole suggested that there was a high affinity Co transporter on the tonoplast or alternatively that Co transfer to the vacuole was direct (e.g. by endocytosis). ⁶⁰Co influx in Chara differed from that in mung bean in terms of pH optimum (Chara: 6 – 9; mung bean: 5 – 6) and a lower sensitivity to other divalent trace metals. However, influx was sensitive to NEM and to mM concentrations of Ca and Mg, as in mung beans.

Co inhibited growth of mung bean seedlings in ½ Hoagland’s solution at 5 μM but not at 0.5 μM. Co caused alterations in the concentrations of micronutrient elements and to a lesser extent macronutrient elements. The main visual symptoms of Co toxicity were similar to
those of Fe deficiency, which was consistent with the large reduction of Fe content in plants exposed to Co, even at 0.5 μM. Toxicity of Co was ameliorated by increasing Ca concentration in the range 0.1 to 1 mM. A comparison was made between the effects of Co and of other toxic metals, Hg, Zn, Cd, Pb, Cu and Ni on growth and nutrient balance of mung beans. Metals, Zn, Cd, Ni are also essential nutrients, but there are some situations (e.g. high concentrations) when they can become toxic.