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Cobalt: 18th Essential Nutrient for Plant Growth?

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Summary

The functions of various nutrient elements influence biochemical processes and eventually affect the overall growth of various crops and their production. The beneficial elements (Al, Co, Na, Se and Si) are not deemed essential for all crops but may be vital for particular plant. These elements are not critical for all plants but may improve plant growth and yield. With the advancement of omics, it is predicted that co will be revealed for the first time as a constituent of enzymes and proteins and its specific role in plant metabolism. If co is confirmed as an essential micronutrient, our understanding of plant mineral nutrition will be enhanced, as well as our crop production practices.

Introduction

Plant growth is influenced by a number of factors including temperature, available water, light and available nutrients in the soil. A German scientist Justus von Liebig in the mid-19th century was one of the first scientists to show that nutrients are essential for plant growth (Tucker, 1999). (Jones and Jacobsen, 2001) In addition to the essential mineral elements are the beneficial elements, elements which promote plant growth in many plant species but are not absolutely necessary for completion of the plant life cycle, or fail to meet Arnon and Stout's criteria on other grounds. Recognized beneficial elements are: Silicon, sodium, aluminium, cobalt, and selenium. Nutrients reviewed in this article include only Cobalt (Co). The essentiality of Co to plants is proposed by Ahmad and Evans, 1957.It is a transition metal with the symbol Co and the atomic number 27. Cobalt is located in the fourth row of the periodic table, Iron (Fe) and Nickel (Ni). Rather, it has been already considered a beneficial element for plant growth along with other elements such as Vanadium (V), Silicon (Si), and Sodium (Na).

- **Uptake forms of cobalt: -** Co^{++}.
- **Mobility in Plant:-** Immobile.

- **Mobility in Plant:-** Somewhat mobile.
- **Co in the surface soils of the world** varies from **4.5 to 12** ppm with the highest level occurring in heavy loamy soils and the lowest in organic and light sandy soils (*Kabata-Pendias and Mukherjee, 2007).*

Points that favors the essentiality of Cobalt

1. Cobalt Is Essential for Lower Plants e.g. Non-vascular plants (bryophytes & algae).
2. Cobalt Is Essential for Symbiotic Bacteria in N Fixation.
3. Cobalt Is Essential for Humans & Animals.
4. Cobalt Is Essential for Lower Plants.
5. Cobalt Improves the Growth of Higher Plants.
6. Plants are afflicted with cobalt deficiency.
7. The cobalt atom is a key component of vitamin B12 (cyanocobalamin), which prevents anemia in humans.

Crop Response

The most obvious plant response to Co deficiency is yellowingand stunting in legume crops. Cobalt fertilization of peanutsgreatly increased the concentration of N, phosphorus (P),potassium (K), manganese (Mn), and zinc (Zn), and also allowedpeanuts to more effectively use supplemental N fertilizer. Thegrowth of peanuts was improved 34% when 8 ppm Co was dissolved in the irrigation water, compared with peanuts withoutCo fertilization. This positive growth response was attributed toimproved N-fixation.

Cobalt Is Essential for Symbiotic Bacteria in N Fixation

Co was identified to be essential for Rhizobium in the 1950s and 1960s *(Ahmed and Evans, 1960; Reisenauer, 1960*). Rhizobium uses nitrogenase to catalyze the conversion of N2 to NH3, which can be readily absorbed and assimilated by plants. Three enzymes, namely, methionine synthase, methyl malonyl-CoA mutase, and ribonucleotide reductase in Rhizobium and Bradyrhizobium species, are known to be cobalamin-dependent and significantly affect nodulation and N fixation. Cobalt (Co) may be an essential micronutrient for plants since it is an essential element for prokaryotes, humans, and other mammals.

A close relationship was established amongst Co supply, cobalamin content in Rhizobium, leghemoglobin formation, N fixation, and plant growth *(Kliewer and Evans, 1963a,b).* The deficiency in Co significantly affects methionine synthase by reducing methionine synthesis, which subsequently decreases protein synthesis and produces smaller-sized bacteroids (bacteria in the nodules capable of N fixation) *(Marschner, 2011).* Methyl malonyl-CoA mutase catalyzes the production of leghemoglobin. If Co becomes limited, leghemoglobin synthesis is directly affected, resulting in reduced N fixation and ultimately a shortage of N supply. This is because leghemoglobin can protect nitrogenase from oxygen by limiting its supply *(Hopkins, 1995).*

Plants are afflicted with cobalt deficiency:-

1. Symptoms of chlorosis and necrosis in leaves, growth retardation, and reduced crop yield are similar to those of N deficiency in plants (Liu, 1998).
2. Legume plants deficient in Co have smaller leaves, pale-yellow colors, and smaller pods compared to non-deficient plants.
3. There is also a reduction in root volume and root length, which inhibits root growth.
4. Compared to the plants without Co deficiency, nodules are smaller and fewer in number.
5. The deficiency of cobalt also affects non-leguminous plants, Co deficiency retards the growth of rubber trees and tomato plants.
6. Corn and wheat with Co deficiency show leaf chlorosis and reduced growth.
7. Grass with low levels of Co can lead to Co deficiency in sheep and cattle.

Toxic effects of cobalt on plants:-

1. Similar to Cu, Ni, and Zn, cobalt causes cytotoxicity and phytotoxicity in plants at high concentrations.
2. The toxicity of cobalt on morphology includes leaf fall, inhibition of greening, discolored veins, premature leaf closure, and reduced shoot weight.

Conclusion

Despite not being essential for most species, cobalt appears to be beneficial to at least some plants. However, it has been shown to be essential for nitrogen fixation by nitrogen-fixing bacteria associated with legumes and other plants. Additionally, plants must have Co enzymes or proteins that are specifically responsible for Co metabolism. Due to its similar properties to other transition elements, its biological roles in plants have been largely ignored and simply attributed to its ability to substitute for those elements.

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