Nutri-Facts

Agronomic fact sheets on crop nutrients

Cobalt

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North American Edition

Cobalt (Co) fertilization is occasionally reported to benefit crop growth, but the need for supplemental Co is rather rare. Cobalt has only recently been recognized as a potentially essential nutrient for plants. Cobalt is necessary for nitrogen (N) fixation occurring within the nodules of legume plants.

Cobalt is a metallic element located in the same row of the chemical periodic table as many other micronutrients. This group of metals is vitally important for biochemical reactions in most organisms, especially for reactions involving enzymes. Cobalt has been long known as essential for animals. However, the understanding of the essential role of Co in plant enzyme reactions is still incomplete.

25	26	27	28	29	30
Mn	**Fe**	**Co**	**Ni**	**Cu**	**Zn**
54.93	55.84	58.93	58.69	63.54	65.40
Manganese	Iron	Cobalt	Nickel	Copper	Zinc

Cobalt in relation to other nearby transition metals that are essential micronutrients in plants.

The best-known function of Co in plants is for N-fixing microorganisms, such as *Rhizobia*, which live symbiotically with legume plants. In N-fixing bacteria, Co is a vital component needed to synthesize vitamin B_{12}, which is necessary to form hemoglobin. The hemoglobin content in legume root nodules is directly related to successful N fixation.

Cobalt in Plants

Some plants appear to benefit from trace amounts of Co, but the concentration of beneficial Co for plants is not known. Cobalt concentrations in forage dry matter typically range from 0.01 to 0.5 parts per million (ppm). Forage mixtures ideally contain at least 0.1 ppm Co to meet animal nutritional requirements. There is greater Co uptake by broadleaf plants (i.e., legumes and bush species) than in grass species. Even if a soil is comparatively low in Co, having legumes in the mix of forage species along with grasses often improves the Co supply to grazing livestock.

Recent research on Co has shown it to be an essential component of several enzymes and co-enzymes that can affect the growth and metabolism of plants. In some low-Co conditions, a small increase in Co stimulates growth for both simple algae and higher plants. However, high Co concentrations can become toxic to plants.

Cobalt is actively absorbed by roots as Co^{2+}, and it can be moderately mobile within plants by complexing with organic compounds. However, inorganic Co^{2+} movement from roots to stems and leaves is limited, and it is considered poorly mobile in plants.

There is insufficient understanding of the role of Co in plant nutrition. Some observed beneficial effects of Co include retardation of leaf senescence, increase in drought resistance in seeds, regulation of alkaloid accumulation in medicinal plants[1], and blocking ethylene formation[2], a plant stress hormone. Cobalt is not found at the active site of any respiratory chain enzymes, but is involved in mitochondrial respiration[1].

Cobalt is essential in animal nutrition for the synthesis of vitamin B_{12}. Where animal Co deficiencies occur, mineral supplements can be provided to animals, or crop fertilization with Co can be useful. Cobalt deficiencies were first identified in grazing cattle and sheep in New Zealand and Australia consuming low-Co feed. Since Co is essential for animals, low concentrations in plant forages can cause poor health of grazing animals. Most research on plant Co was conducted to define critical concentrations needed in forages to support grazing livestock.

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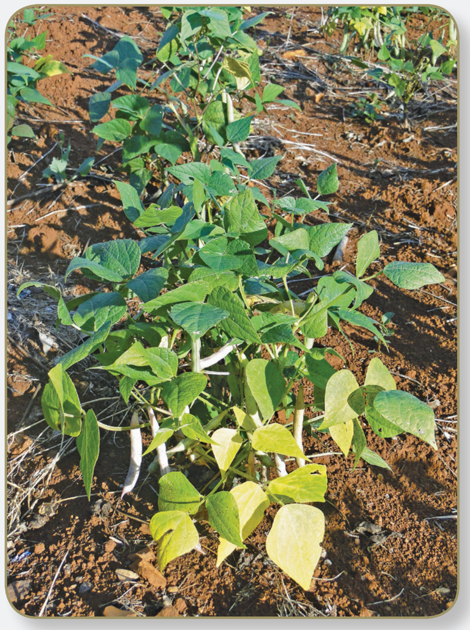
This Nutri-Fact is one of a series of fact sheets written by scientific staff of the International Plant Nutrition Institute (IPNI) that is focused on essential plant nutrients and their use. This series is available as PDF files at www.ipni.net/nutrifacts.

Cobalt in Soils

Cobalt is found in medium abundance in the earth's crust and in low concentrations in most soils, depending on the parent material. Soils developed from minerals such as olivine and pyroxene have ample Co that can be acquired by plants and grazing animals. Cobalt is largely present as Co^{2+} and participates in soil cation exchange reactions. Soils low in Co are generally weathered, coarse-textured soils, where the Co has been transported deep into the soil profile. Finer-textured soils, and soils containing higher levels of organic matter tend to have greater Co concentrations.



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Common bean showing N deficiency symptom.

Fertilizing with Cobalt

Cobalt deficiency in grazing animals (due to low Co concentrations in plants) has been corrected by mixing Co-containing salts with a fertilizer or sand carrier and spreading over grazed pastures[3]. Application rates of Co required to improve legume growth are very low, e.g., 0.04 to 0.13 lb Co/A[4]. Other methods to boost plant Co concentrations include seed treatment or foliar sprays. Providing mineral supplements directly to grazing animals can also alleviate deficiencies.

Deficiency Symptoms

Adequate Co is required for N fixation, and leguminous plants growing in Co-deficient soil will develop N deficiency symptoms due to inadequate vitamin B_{12} synthesis. Non-legume plant species (i.e., grasses) can grow on soils lower in Co availability compared to legume plant species, but animals grazing on the forage may develop Co deficiency symptoms. There are no known visual Co deficiency symptoms for non-legume plants.

Crop Response

The most obvious plant response to Co deficiency is yellowing and stunting in legume crops. Cobalt fertilization of peanuts greatly increased the concentration of N, phosphorus (P), potassium (K), manganese (Mn), and zinc (Zn), and also allowed peanuts to more effectively use supplemental N fertilizer[5]. The growth of peanuts was improved 34% when 8 ppm Co was dissolved in the irrigation water, compared with peanuts without Co fertilization. This positive growth response was attributed to improved N-fixation.

There are reports of enhanced crop growth from non-legume crop species following seed treatment with dilute Co solutions (**Table 1**). For example, summer squash responded to Co seed treatment with increased dry matter growth, female flowers, and fruit yields, while oats responded to supplemental Co with increased panicle length, seeds per panicle, and grain yield[6]. Symptoms of excessively high Co accumulation appear as interveinal chlorosis in new leaves, followed later by white leaf margins and tips.

Research into Co nutrition of plants has shown that it is not only an essential nutrient for N-fixing bacteria, but is also beneficial, and possibly essential to numerous non-legume plants. However, the critical concentration of Co needed in soils to meet the plant requirement varies between crop species. Rates of supplemental Co applied to crops, as soil-applied fertilizer, seed treatment, and or foliar applications are very low, and there needs to be additional research to improve the understanding of Co behavior.

References

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Table 1. Influence of cobalt seed treatments on crop yields in noted crops[6].

Source	Solution Concentration	Crop Species	Yield Increase, %
$Co(NO_3)_2$	1 mg Co/L	Common bean	53
$CoSO_4$	10 mg Co/L	Oat	11
$CoSO_4$	0.5 mg Co/L	Summer squash	41