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# NICKEL IS A PLANT NUTRIENT… REALLY?

**Nickel was formally recognized as an essential nutrient in 1987, making it the most recent addition to the list.** Compared to other plant nutrients, relatively little is know about Ni nutrition. In fact, it is sometimes referred to as "the forgotten essential trace element."

**Ni in Plants:** Nickel is taken up from soils as $Ni^{2+}$. It is readily mobile in plants, and in some species is preferentially translocated to developing seeds. The Ni concentration of most plant material normally ranges from about 0.1 to 5 ppm dry weight, but can be highly variable depending on its availability in soils, plant species, plant part, and season. Concentration greater than 10 ppm is considered toxic in sensitive species, and when greater than 50 ppm it becomes toxic in moderately tolerant species. Some plants can tolerate levels of Ni in tissue as high as 50,000 ppm dry weight. These are called "hyperaccumulators", and are defined as plants that can accumulate at least 1,000 ppm Ni without phytotoxicity.

Pecan is a species that has a relatively high Ni requirement due to its unique physiology. Deficiency in pecan occurs when tissue Ni concentrations fall below 1 ppm, with toxicity occurring when concentrations exceed 100 ppm. The adequate range is estimated to be between 2.5 and 30 ppm; however, these Ni threshold values depend on concentrations of competing cations such as zinc ($Zn^{2+}$), copper ($Cu^{2+}$), and iron ($Fe^{2+}$).

**Nickel is known to be an irreplaceable constituent of the urease enzyme.** Urease has a Ni metallo-center, making Ni essential for urease activity. The urease enzyme assists in the hydrolysis of urea to ammoniacal-N, which plants can utilize. Nickel is thus important in N nutrition of plants. Under certain conditions where Ni is insufficient and urea is the major source of N, urea can accumulate in leaves to the point of toxicity. This urea toxicity, often manifested as necrosis of leaf tips, is actually a symptom of Ni deficiency. Nickel nutrition has also been shown to play a role in protecting against plant diseases. For example, it is involved in the synthesis of chemicals (phytoalexins) that the plant produces to defend against pathogens.

**Ni in Soils:** Nickel is present in nearly all agricultural soils, which commonly have Ni concentrations of 20 to 30 ppm and seldom exceed 50 ppm. The most important single soil factor affecting Ni availability is pH—as soil pH increases Ni plant availability decreases. Therefore plants grown in high pH soils may be vulnerable to Ni deficiency. Also, high concentrations of divalent cations such as $Zn^{2+}$, $Cu^{2+}$, and $Fe^{2+}$ in soil solution can inhibit uptake of Ni. Soil testing for Ni as a plant nutrient is not an established practice since there has been little research in the area of Ni nutrition of most crops.

**Soil application of Ni is rarely needed since most plants are adequately supplied.** Also, trace amounts of Ni are contained in some commonly applied fertilizers. Where Ni fertilizer is needed to address a deficiency, it is most often applied as a foliar spray. Nickel salts (e.g., sulfates and nitrate) and organic Ni ligands (lignosulfonates, heptogluconates) are effective foliar fertilizers. The Ni-lignosulfonate form is preferred for field use due to potential safety concerns with other sources.

Although it is unlikely that Ni input will be needed in the production of major crops, it is nevertheless a recognized micronutrient, and therefore warrants a brief review. For more on Ni nutrition see IPNI's *Nutri-Facts* series (https://www.ipni.net/nutrifacts-northamerican), or a recent and comprehensive chapter by Wood (Wood, B.W. 2015. Nickel. p. 511-536. In A.V. Baker and D.J. Pilbeam (ed.) Handbook of plant nutrition. CRC Press, Boca Raton, FL).

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