# Nutri-Facts

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Agronomic fact sheets on crop nutrients

# Nickel

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Nickel (Ni) is the most recent element to be added to the list of essential plant nutrients. While it was identified as a component of the urease enzyme as early as 1975, it was not formally recognized as an essential nutrient until 1987[1]. Prior to this, chloride ($Cl^-$) was the most recently discovered plant nutrient (1954). Relatively little is known about Ni nutrition in plants compared with other plant nutrients. More detailed information about the role of Ni in plant nutrition can be found in the comprehensive chapter by Wood, 2015[2].

Nickel makes up only about 0.009% of the earth's crust, with most Ni concentrated in the planet's core. Nickel is widely used in the production of stainless steel and metal alloys. It is used to produce items such as rechargeable batteries, coinage, plating, and catalysts.

## Nickel in Plants

Plants take up Ni in the form of soluble $Ni^{2+}$. It is readily mobile within plants and is preferentially translocated to developing seeds in some species. The Ni concentration in most plant leaf material normally ranges from about 0.1 to 5 ppm (in dry weight), but can be highly variable depending on its availability in soils, plant species, plant part, and the season. Tissue Ni concentrations greater than 10 ppm are considered toxic in sensitive crop species. Nickel becomes toxic in moderately tolerant species at concentrations greater than 50 ppm. Some species can tolerate Ni concentrations in plant tissue as high as 50,000 ppm. There are some 350 species of these "hyperaccumulators", which 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. For pecan, deficiency symptoms occur when Ni concentrations in the tissue fall below 1 ppm. Toxicity occurs when concentrations exceed 100 ppm. The adequate range of tissue Ni in pecan is between 2.5 to 30 ppm, however, these Ni threshold values depend on concentrations of competing cations such as zinc ($Zn^{2+}$), copper ($Cu^{2+}$), and iron ($Fe^{2+}$).

Although there are still many unknowns regarding the functions of Ni in plants, it is known to be an irreplaceable constituent of the urease enzyme. Urease—whether produced by plants, microbes, or animals—contains Ni at the core. The urease enzyme is essential in converting urea to ammonium ($NH_4^+$). Thus Ni is required in the nitrogen (N) nutrition of plants[3]. Under certain conditions where Ni is insufficient and urea is the major source of N, urea can accumulate in leaves to the point of plant toxicity. This urea toxicity manifested as necrosis of leaf tips, is actually a symptom of Ni deficiency.

Nickel has been shown to play a role in protecting against some plant diseases. It is involved in the synthesis of chemicals (phytoalexins) that the plant produces to defend against pathogens. Nickel deficiency has been associated with diminished lignin production, which is a component of cell walls that strengthen plants and contribute to disease resistance.

## Nickel 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. Nickel in soils comes from geologic parent material and by human activity. Soil Ni concentration can exceed 10,000 ppm where soils are formed from parent material high in Ni. Nickel concentrations can also be elevated as a result of atmospheric deposition near metal refineries and from application of biosolids and sewage sludge.

The most important soil factor affecting Ni availability and solubility is pH. The plant availability of Ni decreases as soil pH increases. Thus, plants grown in high pH soils may be more vulnerable to Ni deficiency. Other factors reducing Ni uptake by plants include cool and/or dry soil conditions in the early spring, and nematode damage to feeder roots. Also, high soil concentrations of other metal cations such as $Zn^{2+}$, $Cu^{2+}$, $Fe^{2+}$ and cobalt ($Co^{2+}$) can inhibit uptake of Ni in soils.

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 and fertilization of most crops. However, established soil testing

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**Examples of Ni deficiency** in pecan showing (Clockwise starting top left) blunt and disorted leaf tip; cupping and leaf tip necrosis; rosetting at growing points; normal (left side) versus Ni deficient leaves (right side). **Courtesy B.W. Wood, USDA-ARS.**

methodology exists to identify "environmentally available" Ni. This procedure involves a very strong acid digestion, and is not suitable for making fertilizer recommendations.

## Fertilizing with Nickel

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 crop deficiency, it is most often applied as a foliar spray. Nickel salts (e.g., sulfates and nitrate) and organic Ni ligands (e.g., lignosulfonates, heptogluconates) are effective foliar fertilizers. The Ni-lignosulfonate form is preferred for field use due to potential safety concerns for field workers with other foliar applied sources.

## Nickel Deficiency Symptoms

The occurrence of distinct visual Ni deficiency symptoms is not nearly as common as it is with micronutrients such as Zn and Fe. But Ni deficiency may be more common than is recognized, with the impact being at the metabolic and physiological levels rather than at the morphological and visual level. Nevertheless, there are conditions where visual Ni deficiency symptoms are observed. As more is learned about the role of Ni in plants, it is likely that a better understanding of symptomology and diagnosis will also develop. Discernible Ni deficiency, while rare, is most likely to occur in high organic matter soil-less potting mixes, in solution culture, in high pH soils, where roots have been damaged by nematodes, or where excessive amounts of Fe, Zn or Cu have been applied.

One common Ni deficiency symptom across plant species is the necrosis of leaf tips due to the accumulation of urea to toxic concentrations. For non-woody plants, deficiency symptoms can also include chlorosis of young leaves, reduced leaf size, and less upright leaf growth.

For woody perennials, chlorosis similar to that of Fe or sulfur (S) deficiency has been noted as an early indicator of Ni deficiency. Other more severe symptoms that have been observed in pecan trees include a rounding or blunting of the leaflet tips, and dwarfing of foliage to produce what has been termed "mouse ear" or "little leaf". This rounding of leaf tips is associated with buildup of urea to toxic levels[4]. With severe Ni deficiency, leaf deformation is often most prominent at the top of the tree canopy. Affected foliage is thicker, less pliable, and tends to be brittle, and may exhibit cupping or wrinkling. Severe Ni deficiency results in plant stunting and abnormal growth patterns.

Nickel toxicity most commonly occurs with non-hyperaccumulating species near mining or industrial sites, where waste materials have been applied, or on serpentine soils. Toxicity symptoms vary, but in most cases they have the appearance of Fe deficiency, since Ni competes with Fe within plants.

## References


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