Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
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Nickel: a tiny nutrient with an overlooked role in plant growth

Press Release

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Gatersleben/Shanghai, 11 November 2026. **Nickel is needed only in tiny amounts, but it plays a greater role in crop growth than previously recognised. An international team involving the IPK Leibniz Institute and led by the CAS Centre for Excellence in Molecular Plant Sciences reports this finding in the science magazine Cell. The researchers show that developing shoots require nickel to break down urea and recycle amino acids, processes important for plant growth and yield. They also identified ZmNAET1, a transporter that helps nickel reach developing organs by moving nicotianamine, a molecule that binds nickel. The findings highlight the importance of delivering nickel to where it is needed for nitrogen metabolism, growth and seed vitality.**

Nearly two centuries ago, Justus von Liebig, one of the founding figures of modern plant nutrition, formulated the Law of the Minimum. Plant growth is limited by the nutrient that is least available. Often illustrated by a barrel whose capacity is determined by its shortest stave, this principle remains fundamental in agriculture today. Due to the tiny amounts of Ni that plants require for growth, Ni has not been considered to limit agricultural crop productivity. The present study identified ZmNAET1 as a key regulator of long-distance nickel (Ni) transport in maize, underlining that not only the total amount of Ni, but also its distribution within the plant is crucial for crop productivity.
In a genome-wide association study using multi-year and multi-location field data from 1,404 maize lines, the researchers identified natural variation in the *ZmNAET1* gene that associates with Ni accumulation in maize grains. This natural variation resides in the regulatory region of the gene and controls its expression, with high-expression variants accumulating up to around 60% more Ni in maize kernels. However, the corresponding protein does not transport the micronutrient directly. Instead, it exports nicotianamine (NA), a plant-specific non-proteinogenic amino acid that can bind metal ions. In maize nodes and the ear stalk, *ZmNAET1* mediates the secretion of NA from phloem cells. Outside the cells, NA binds Ni^{2+} to form Ni(II)–NA complexes, facilitating their subsequent translocation through the phloem towards developing sink organs, including kernels, leaves and the shoot tip.

“Our results indicate that it is not simply a question of how much nickel a plant contains,” says Dr Zhenfei Chao, first author of the study. “For proper plant development, Ni has to reach the right tissues at the right time.” Actually, Ni^{2+} is an essential cofactor of the urease enzyme that breaks down urea to release ammonia for re-assimilation into amino acids. The importance of this transport pathway became apparent when the researchers examined maize plants lacking functional *ZmNAET1*. Nickel concentrations in developing sink organs were strongly reduced, accompanied by substantial effects on important agricultural traits. Ear weight, kernel size and starch content declined, while seed performance after storage was severely impaired. Foliar application of Ni to field-grown maize reversed the suppression of plant height and urease activity caused by impaired *ZmNAET1* function.
“The presence of ineffective allelic *ZmNAET1* variants in modern maize lines suggests that their nutritional requirements for Ni may not be fully met, particularly in rapidly developing and high-yielding maize cultivars,” says Prof. Dr Nicolaus von Wirén, a coauthor of the study. “Thus, our study calls for a re-evaluation of the nutritional status of Ni in modern maize that can be easily tested by field sprays with Ni. More sustainable, however, will be the genetic introduction of efficient *ZmNAET1* alleles through maize breeding.”
The researchers found a similar mechanism in rice. Two related genes, *OsNAET1* and *OsNAET2*, control how much nickel accumulates in the grains. This suggests that the findings extend beyond maize to other cereal crops. The study challenges the view that cereals need so little nickel that a shortage is unlikely to affect their growth. It also brings the story back to Liebig’s Law of the Minimum. Even a nutrient required in tiny amounts can limit plant growth if it does not reach the tissues that need it.

Original publication: Chao et al. (2026): Nicotianamine-driven nickel transport to sink organs underpins maize productivity. Cell. DOI: 10.1016/j.cell.2026.10.035

Image caption: The bronze statue of Justus von Liebig at the IPK commemorates the founder of modern mineral fertilisation and his law of the minimum. This states that plant growth is limited by the nutrient in shortest supply relative to the plant's requirements. The current study demonstrates this using nickel as an example. Plants require only minute quantities of nickel. However, it is crucial that this trace nutrient reaches the growing tissues. Photo: IPK Leibniz Institute.

