Science Societies

Silicon mitigates ammonium toxicity in plants

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Symptons of ammonia toxicity in old leaves of broccoli (first two panels starting on the left) and cabbage (last two panels).

When it comes to nitrogen in the soil, it is possible to have too much of a good thing. And in the specific case of ammonium, it can be extremely toxic to plants. Some research has pointed to the potential for the element silicon to help plants deal with the stress of ammonia toxicity, but the studies have been few and far between.

In a review article in *Agronomy Journal*, Brazilian researchers led by Cid Naudi Silva Campos of the Universidade Federal de Mato Grosso do Sul, amassed the available studies to try to identify the effects of ammonia toxicity on plants important for agriculture and to determine the effect of silicon application on plant physiology and morphology to mitigate the stress of the toxicity. By summarizing the promise of its potential benefits, they hope to turn others onto the possibility of using silicon to help solve this common problem.

Under ideal conditions, ammonia is transformed by microbes through nitrification into nitrate, which can be safely stored by plants. However, in soils with excess moisture or acid, specifically pH lower than 5.0, nitrification is inhibited and ammonia can build up and damage plant cells. Additionally, some fertilizers, in particular those with high ammonia concentrations like poultry manure, can increase soil concentrations.

“Ammonia toxicity is a problem that can be found in arable soils around the world, leading to decreased crop development and yield,” Campos says. “Recent studies have shown that the application of beneficial elements, such as silicon, has resulted in the reduction of the deleterious effects caused by ammonia toxicity in several crops, but this fact still needs to be better clarified. This review aimed to help.”

Ammonia damages plants on a biochemical and physiological level. It can cause changes in intracellular pH, osmotic balance, and increased oxidative stress. It can also result in nutrient deficiencies such as calcium, magnesium, and potassium. All of this stress means a decrease in the plants’ ability to make pigments and chloroplastids that help it photosynthesize. Without them, it can't grow as well.

Silicon Benefits, Field Application

Campos explains that silicon in this context can help increase the antioxidant activity in plants and protect them from some of the oxidative damage. Additionally, he adds that the element is involved in plant structure by improving leaf architecture, which that helps keep plants more erect, thus increasing their capacity to absorb light and carry out photosynthesis.

Effect of silicon on the mitigation of ammonium toxicity in the shoot, leaf, and root of passion fruit seedlings.

Plants vary in their sensitivity to ammonia toxicity, and sensitivity has been linked mainly to the activity of two enzymes—glutamate dehydrogenase and glutamate synthase—being higher in the leaves but lower in the roots while the opposite trend has been demonstrated to confer resistance.

Their review of the literature pointed to the feasibility of silicon application being used to mitigate the effects of ammonium toxicity on several crops, such as maize, sugar cane, cucumber, broccoli, and cabbage, helping to increase their yield even under this stress.

Silicon can be applied to a field in numerous ways. Calcium silicate is a byproduct of the steel industry and often applied to soil to correct pH. It usually must be applied in large amounts because of its low solubility. Some sources with higher solubility have recently been developed and showed promising results in several crops, Campos says. Additionally, another source called nanosilica has been tested by applying it directly to foliage, but it has some limitations, one being that it forms silicon polymers in the application syrup that decrease absorption by plants.

“The application of silicon, especially via the leaves, arouses interest because it helps the development of plants that are constantly subjected to various stresses from biotic and/or abiotic origin,” Campos says. “As we already know, during field development, plants are subject to several stresses and having the opportunity to ‘protect or help them’ by applying a beneficial element is a factor that must be considered and studied.”

Campos hopes this review inspires more studies on numerous areas of this research, such as determining the best way to apply silicon to crops and confirming that there isn't a high risk of silicon loss to the environment.

“Several studies are being developed and have shown the beneficial results of applying silicon in mitigating ammonia toxicity,” he says. “This review brings the latest major studies focusing on how silicon can minimize the damage caused by ammonium toxicity. Therefore, it was important for us to bring together in one paper the latest major scientific findings on this subject.”

Dig deeper

Read the full review article, “Silicon Mitigates Ammonium Toxicity in Plants,” in *Agronomy Journal* at **https://doi.org/10.1002/agj2.20069**.

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