• Soil nutrient deficiencies can cause decreased yield and less bioavailable nutrients in rice crops.
• Silicon and zinc supplementation through nanoparticle fertilizers increases rice crop yield and nutrient content in harvested grains.
• Increased rice grain nutrient content could help combat nutrient deficiencies in those who rely on rice as a staple in their diets.
For the more than three billion people who consume rice for more than 20% of their daily calorie intake, small increases in nutritional value could have a big impact. In the Middle East, rice consumption has nearly doubled in the past two decades, according to Ricepedia (https://bit.ly/35CRA84).

Nutrient deficiency causes long-term symptoms: individuals lacking Si in their diet experience poor bone formation and decreased bone density while those with diets low in bioavailable Zn have decreased immune responses. Zinc deficiency during pregnancy, infancy, or childhood can lead to stunted growth and development.

Researchers from the Islamic Azad University and the Gorgan University of Agricultural Sciences and Natural Resources in Iran understand that the soil micronutrient deficiencies regional farmers encounter may cause decreased yield and nutrient content in rice crops.

To combat the lack of Si and Zn common in Iranian soils, these researchers studied the effects of two different kinds of fertilization on rice plants. In a recent Agronomy Journal article (https://doi.org/10.2134/agronj2019.04.0304), this team demonstrated that the application of supplemental Si and Zn to growing rice plants increases protein and Zn content of harvested grains.

The researchers compared traditional soil application of fertilizer with foliar application of nanoparticles to study effects on nutrient uptake, plant growth, and grain formation as well as the final nutrient content of harvested grains.

Using plots at two different locations in northern Iran, Norollah Kheyri and his research team evaluated soil-Zn, soil-Si, nano-Zn, and nano-Si application on the growth of Oryza sativa L. All plots were fertilized with phosphorus and potassium and lined with plastic to prevent fertilizer exchange between treatments.

Nano-fertilizers were applied to rice leaves at four key times in the plant’s life cycle: early tillering, middle tillering, panicle initiation, and full heading stage. Soil fertilizers were applied once when rice seedlings were transplanted into paddies at the beginning of the growing season.

Multiple foliar applications of nanoparticles are thought to increase rice growth through the slow release of micronutrients over a plant’s life cycle while a single application to the soil may create unwanted waste and provides only one boost of nutrients for plant growth. Potentially, using nanoparticle fertilizer may lead to less waste, higher yields, and more bioavailable nutrients in the rice crop. Farmers need to balance this with the extra time it takes to apply foliar sprays.

Opportunity for Technological Advance

Kheyri, an agronomy professor at Islamic Azad University, sees this as an opportunity for technological advance. “These problems can be solved by the use of sprayer drones,” Kheyri says. Though his team used a backpack sprayer to fertilize their small test field, large-scale farmlands would benefit from the use of unmanned aerial vehicle (UAVs). Kheyri also pointed out that nanoparticles are a cost-effective option for farmers since a smaller amount of fertilizer is required compared with traditional soil fertilizer and rice yields are increased.

Here may be a unique opportunity for researchers to adopt a new method of fertilization along with a less personnel-intensive means of fertilizer application. That is, the combination of UAV technology with more precise, economic fertilization may mean that four applications a growing season is no problem at all.

In analyzing the harvested crop, the team found that adding Si and Zn fertilizer, regardless of treatment type, increased grain yields and protein content in rice, particularly when Si and Zn were applied together. In a few instances, the location in which rice crops were grown also affected yield and grain micronutrient content.

“There is a synergistic interaction between Si and Zn, which improves the absorption of these elements in the plant,” Kheyri says. This synergy is most visible in the increased protein content when nanoparticles of Si and Zn were applied to the leaves of rice plants at four critical periods during the growing season.

Foliar application also led to higher accumulation of Si and Zn in rice tissue—that is, a greater concentration of micronutrients, compared with traditional Si and Zn fertilizer application, though both fertilizer methods were still better than the control.

The team’s research also suggests that foliar applications of zinc may lead to more bioavailable Zn in cooked rice compared with soil applications. Further research is needed to support this finding.

For the farmers of northern Iran and other areas reliant on staple crops, the small amount of nanoparticle fertilizer needed to achieve the same, or better, yields as traditional fertilizer may lead them to adopt the practice. “If farmers have enough positive effects on increasing yields and incomes, improving human nutrition and reducing environmental pollution, they will be willing to adopt nanoparticle fertilizers,” said Kheyri.

There is plenty of room for further research: altering the amount of nitrogen and/or phosphorus fertilizer may affect silicon and zinc accumulation in rice tissue. Increasing nitrogen and potassium fertilizer application in combination with Si and Zn increases rice uptake of nanoparticles. With the right concoction of fertilizers, coupled with advances in genetic biofortification and UAV technology for precise foliar fertilizer application, nutritional deficiencies may be a thing of the past.

Dig Deeper

Read the full Agronomy Journal article, “Effects of Silicon and Zinc Nanoparticles on Growth, Yield, and Biochemical Characteristics of Rice” at https://doi.org/10.2134/agronj2019.04.0304.