High nitrogen rates increase micronutrient uptake, storage in corn

October 30 2013

(Phys.org) —A Purdue University study shows that high-yielding, modern corn hybrids take up not only more nitrogen from soil but more micronutrients such as zinc, iron, manganese and copper. Nitrogen fertilizer rates also influence how much of these nutrients are stored in the grain at harvest.

Growers may need to use fertilizers to meet the increased micronutrient requirements of hybrid corn in high-yield systems, especially if soil nutrient levels are too low.

"This study raises the question of whether we need to pay more attention to micronutrients in fertilizer management," said Tony Vyn, Purdue professor of agronomy and co-author of the study. "In high-yield systems, it's not just that corn requires more macronutrients like nitrogen and phosphorus - which is what farmers normally think about - more micronutrients are needed as well. If you have soil that is deficient in micronutrients, you could be limiting your yields."

Though micronutrients are essential for optimum plant growth and reproductive development, current management practices rarely take them into account, as growers often assume that soil nutrient concentrations for these nutrients are adequate. But in modern crop production systems, deficiencies could occur, Vyn said.

"For many years, we didn't have to worry about micronutrients," he said. "But if you're in a cash crop situation where you're producing bigger

plants and more grain, you are exporting more micronutrients away from the field at harvest. If you're not replacing them, the soil is going to be depleted over time."

Soil factors such as pH and moisture can also influence micronutrient availability, said Ignacio Ciampitti, co-author of the study and assistant professor at Kansas State University.

"Nutrient availability is more complex than soil nutrient concentrations," Ciampitti said. "Nutrient availability is also related to the plant's ability to take up each nutrient at the soil-root interface."

In the second part of a study on how modern corn hybrids (post-1990) absorb and allocate nutrients under contemporary management practices, Vyn and Ciampitti measured how simultaneous increases in the number of plants per acre and nitrogen rates affected the concentration of zinc, copper, iron and manganese in two hybrids of corn.

Vyn said the influence of plant density on the uptake of micronutrients was relatively minor, even at high crowding levels, in that higher plant density resulted in similar yields as medium and low densities. But as nitrogen rates increased, yields rose and corn plants took up a substantially greater amount of micronutrients and allocated more micronutrients to the ears.

"From a human nutrition viewpoint, there's always a concern that increasing yields will dilute the nutritional quality of corn," Vyn said. "But as long as soil concentrations of nutrients are sufficient, higher yields tend to mean more micronutrients are concentrated in the grain, not less."

But higher corn yields mean more micronutrients leave the field at harvest.

"Growers are not used to thinking about how much zinc leaves the field when they harvest grain corn," Vyn said. "But that's part of the management equation that has to be considered."

At high plant density (42,000 plants per acre) and high nitrogen rates (200 pounds per acre), 58 percent of zinc taken up by corn hybrids was removed in the grain, compared with 31 percent of copper, 18 percent of iron and 15 percent of manganese.

Vyn and Ciampitti also observed differences in when micronutrients are absorbed and where they are stored in the corn plant. Zinc is taken up throughout the season and is primarily stored in the stems during the vegetative stage, while iron is allocated to the leaves. Copper and manganese are distributed to both leaves and stems and are taken up mostly before the flowering period.

To prevent deficiencies, Vyn suggests growers add zinc to bulk fertilizer with phosphorus - which has a similar uptake pattern - or put it in a starter, while manganese can be supplied in a foliar application where necessary. Growers usually can rely on soil for sufficient levels of iron and copper, he said.

Further research will concentrate on developing estimates for micronutrient requirements to help inform growers which kinds of fertilizers to apply and when.

"There's no question that when you have more biomass and higher grain yields, you require more of certain micronutrients," Vyn said. "It's something to be aware of."

Funding for the study was provided by Dow AgroSciences, the U.S. Department of Agriculture, the Purdue Bilsland Dissertation Fellowship, Potash Corp. and The Mosaic Co.

The study was published in *Agronomy Journal*.

More information: Maize Nutrient Accumulation and Partitioning in Response to Plant Density and Nitrogen Rate: II. Calcium, Magnesium, and Micronutrients, dl.sciencesocieties.org/publications/aj/tocs/105/6

Abstract

Maize (Zea mays L.) yields have advanced through breeding complemented with evolving management technologies including plant density (PD) and macronutrient fertilizer inputs. Little is known about management-induced changes in plant uptake or allocation of nutrients other than macronutrients. Therefore, impacts of both PD and N rate at three levels (low, medium, and high) on Ca, Mg, and micronutrient partitioning (for pertinent plant organs at six growth stages) were investigated at four environments in Indiana. Grain Ca, Mg, Fe, and Zn contents at maturity were primarily influenced by N rate, while the PD × N rate interaction influenced those of Mn and Cu. At the whole-plant scale, PD and N rate significantly influenced all nutrient contents, and vegetative-stage nutrient accumulation averaged 91% (Ca), 51% (Fe), 47% (Zn), and 73% (Mn, Mg, and Cu) of corresponding nutrient contents at maturity. During the vegetative phase, three modes of leaf vs. stem nutrient partitioning were: (i) preferential allocation of Mg and Zn to stems; (ii) preferential allocation of Fe and Ca to leaves; and (iii) isometric partitioning of Cu and Mn. Isometric nutrient concentration patterns between Mg and Zn were documented in leaf, stem (vegetative phase), and ear (reproductive phase). Early-reproductive-stage nutrient partitioning from plant to ear was greatest for Zn and Mg and mirrored their respective harvest indices (HI) at maturity. Nutrient HIs, concentrations (grain + stover), and internal efficiencies at maturity were positively impacted by N rate but negatively by PD. Reliable micronutrient requirement estimations for maize under diverse management and yield levels help inform future balanced-nutrient input decisions.

Provided by Purdue University