IPNI
Plant Nutrition TODAY
Better Crops, Better Environment...through Science

From Scientific Staff of the
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EFFICIENCY AS A METRIC OF SUSTAINABLE CROP NUTRITION

Nutrient use efficiency attracts increasing attention in today's sustainability dialogue. Serving as one of the key metrics of crop nutrition, it reflects responsible management and relates to risks of nutrient loss. However, it hardly connects to the productivity of cropping systems or the fertility of soils, nor does it tell us where the losses are going. It is as complex as the cropping systems to which it applies, and yet it reflects only partially the outcomes we expect from applying nutrients.

It would seem to be so simple. An efficiency in most uses is the ratio of output to input. Divide nutrients out by nutrients in, and you have your answer. But, there are three complications.

First, approaches differ in defining the system out of which and into which the nutrients are flowing. Is it a field, a farm, a country, or the world? Soil surface, or farm gate? A single cropping season, a whole year, or a whole crop rotation?

Second, which of the following do you consider as outputs: the harvested crop, the whole crop, the nutrients in either, the nutrients over and above the uptake that would have occurred without the input in question, the nutrients retained in the soil, those returned to the air, and those leaving the field with the drainage water?

Third, which of the following inputs do you include or ignore: fertilizer, manure, deposition from the air, biological nitrogen fixation, and mineralization from the soil? Putting all these options together, hundreds of possible combinations could provide a ratio of outputs to inputs. Not only that, many of the outputs and inputs aren't measured and reported and can only be estimated.

So let's look at some of the simplest estimates of nutrient use efficiency. Partial nutrient balance is defined as the nutrient in the harvested crop divided by the nutrient in the fertilizer applied. For nitrogen in cereal crops in Canada, the United States, and the world, we've estimated it at 71, 74 and 67 percent, respectively, for the years 2006 to 2010. Extended to a wider range of crops, including fruits, vegetables, pulses and oilseeds, but not forages, the estimate for the world declines to just over 50 percent.

What happens to the rest of the nutrient applied, if less is harvested than applied? "Lost to the environment" is one answer commonly given. But, it doesn't tell you where in the environment. Some nutrient fates can cause harm: nitrate loss to groundwater, nitrous oxide and ammonia loss to the air, and nitrogen and phosphorus in drainage water. Some are benign, such as dinitrogen going back to the air. Some can even be beneficial. Surplus nitrogen, when combined with high inputs of crop residues, can help increase soil organic matter. Surplus phosphorus can move soil test levels from low to optimum.

And what if more is harvested than applied? In most cases, mining from soil reserves is indicated, meaning depletion of soil fertility. What this means is that nutrient use efficiency doesn't always need to increase. It has an optimum level, and that level depends on the current level of the soil's fertility.

Does higher nutrient use efficiency mean higher yield? Not always. Recent yield increases have raised nutrient use efficiencies. A singular focus on nutrient use efficiency, however, can lead to yield-reducing rate reductions. That's why the right source, rate, time and place of nutrient application optimizes nutrient use efficiency, yield, and soil fertility. Sound nutrient stewardship tracks all three.

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