Phosphorus and Photosynthesis

CERTIFIED CROP ADVISER

by Tom Bruulsema, *CCA-ON*

Photosynthesis uses light to produce carbohydrates. Agricultural crops capture photons from the sun for energy to convert carbon dioxide in the air to food, fuel and fiber. What you might not know is that phosphorus is right up front in that photosynthetic capture of energy.

Electrons in the chlorophyll molecule get excited by photons of red or blue light.

The energy from those excited electrons transfers directly to two phosphorus-containing molecules, ADP and NADP, transforming them into ATP and NADPH. Using the energy from those two molecules, the Calvin-Benson cycle makes three-carbon sugar phosphates from atmospheric carbon dioxide.

Phosphate, when bonded to sugars, provides part of the energy to make different kinds of sugars, carbohydrates and starches, which are then ultimately transformed into all of the organic compounds of the plant. Most of the conversions of carbohydrates within plant cells involve phosphorylated forms.

Even though this energy role seems so absolutely vital, only a tiny fraction of plant phosphorus is found in these energy compounds.

ATP is incredibly efficient. At any one moment, there are many times fewer phosphate molecules in ATP than in the plant cell membranes, or its genetic material, DNA and RNA. All those fractions combined usually amount to less than what a well-nourished plant stores as inorganic phosphate in vacuoles within its cells. Where P is limiting, plants cut into the storage phosphate to keep the concentrations steady for the essential forms of P involved in energy reactions. In grains and seeds, the main storage form is phytate, an organic form of phosphate that also complexes calcium, magnesium, potassium and many micronutrients like iron and zinc. Phytate is also found in pollen grains, and in roots and tubers, and is the major form of organic phosphate added to soils.

So when it comes to photosynthesis, the phosphorus that participates represents just the tip of the iceberg in terms of the total amount in the plant. Nevertheless, it is crucial to photosynthesis, and to high yields. Phosphorus deficient crops first show a reduction in leaf area expansion, but their chlorophyll also becomes less efficient. The chlorophyll may continue to be active, but the electrons it excites may damage the rest of the photosynthetic apparatus. Light energy, interacting with chlorophyll and other light-harvesting molecules, can produce oxygen free radicals and other damaging oxidative chemicals. When plants respond by producing anthocyanins for protection, these non-green pigments curb maximum photosynthetic capacity by blocking absorption of light.

Phosphorus is involved in the photosynthetic core of any high-yield crop production system, the crucial point at which energy is transformed from light into sugar and then into the myriad unique compounds which plants provide for us. So as we develop plant production systems for ever higher levels of productivity and sustainability, we need to continue refining assessment methods for assuring the right phosphorus nutrition for all crops in the system for every day of their growth cycle. Most crop plants continue taking up phosphorus right up to maturity. Keeping roots active and healthy helps them do so. Recent research in Illinois documented that one particular benefit of the Bt rootworm protection trait was enhanced uptake and concentration of P in corn grain.

None of this means that soil test phosphorus needs to be moved higher than currently defined optimum levels. But the importance of maintaining optimum levels is likely to increase, and so will the importance of maintaining soil health to allow roots the opportunity for efficient phosphorus uptake.

The efficiency of our biggest solar collector—our crops—depends on it.

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