- Phosphate and glyphosate interact "competitively" when both are present in the soil.
- The application of inorganic P fertilizers after glyphosate has been applied was shown to mobilize glyphosate.
- Management strategies should consider the potential for glyphosate mobilization to reduce impacts on crops and glyphosate runoff to nearby water sources.

Glyphosate & Phosphate interactions in soils

by Tracy Hmielowski

Chemical combinations have a wide range of outcomes. The wrong combination could result in toxic fumes or an explosion; the right combination can make useful products or have health benefits. Whether occurring in nature, in your home, or in the laboratory—being aware of the outcome when mixing chemicals is important for our health and safety. In agriculture, where chemicals are applied to benefit crops and reduce pests, a great deal of research goes into how products may interact if they come into contact in equipment, on crops, and in the soil.

Phosphorus and glyphosate are widely used in agricultural systems and have the potential to interact in the soil. The element phosphorus was first identified in 1669,[1] and phosphate fertilizers have increased in use since the 1960s due to changes in modern agriculture. Phosphorus is a critical nutrient for the growth of cells, and the addition of P fertilizers has helped to increase crop yields. Glyphosate [*N*-(phosphonomethyl glycine)] is a more recent discovery (1970). It is a product of the reaction between a glycine and a phosphonate. First released for use as an herbicide under the brand name Roundup in 1974, it has become the most widely used herbicide across the globe.

With both phosphorus and glyphosate being applied to agricultural fields across the globe, the chemicals

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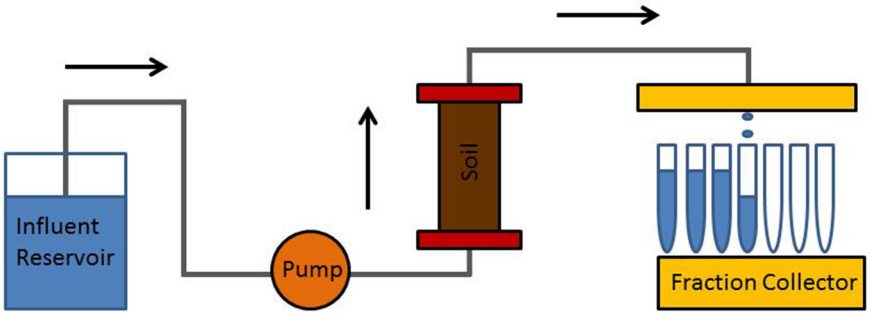
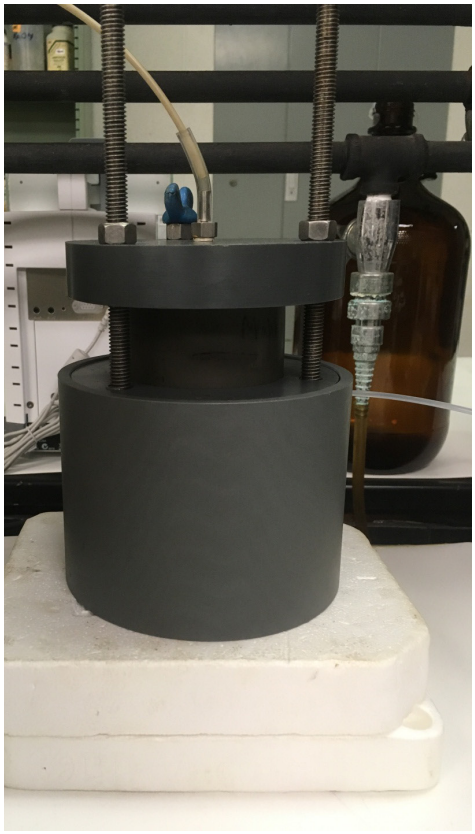
[1] This year marks the 350th anniversary of the discovery of phosphorus. The *Journal of Environmental Quality* will be publishing a special section later in the year to mark this occasion, and the Societies will be celebrating "Phosphorus Week" in September. Stay tuned for more details.

NRCS/SWCS photo by Lynn Betts





Above: Schematic representation of laboratory transport studies. **Right:** Soil column used for laboratory transport studies.

are commonly present together. Phosphorus is applied as inorganic forms of P (PO_4^{3-}) and taken up through the plant roots. Glyphosate is absorbed through foliage, and while it readily adsorbs to soil, it has been found to degrade rapidly. The two chemicals have a competitive interaction, given the similarity between the PO_4^{3-} and the phosphonomethyl function group of glyphosate. This means that inorganic P fertilizers can potentially displace glyphosate, and vice versa, on the surface of soil particles.

While this competitive interaction has been documented in earlier research, there are still questions as to how inorganic P fertilizers and glyphosate are likely to interact in the environment. Joshua Padilla, a doctoral student in the School of Plant, Environmental and Soil Science at Louisiana State University, is the lead author on a recent study published in the *Journal of Environmental Quality* (https://doi.org/10.2134/jeq2018.06.0252) that set out to determine the effect of PO_4 on sorption, desorption, and mobilization of glyphosate in soils.

For this laboratory experiment, the researchers used agricultural soils from Louisiana that had no prior use of glyphosate. They performed both batch studies and transport studies using soil columns. Something they were very interested in was how the order of application could influence the way phosphorus and glyphosate interact in the soil. Therefore, as part of this study, Padilla also investigated the timing of applications, comparing the application of phosphate before glyphosate, phosphate after glyphosate, and both applied at the same time. The thought was that any of these combinations may be occurring, depending upon the cropping system and management practices of individual farms.

As it turns out, timing does matter. Padilla points out that one of the most important results of this experiment was documentation that when phosphate was applied after glyphosate, the glyphosate was mobilized. However, when phosphate was applied before glyphosate, or both were applied at the same time, there was less mobilization of glyphosate. This could be an important consideration for farmers using cover crops, who may plan to kill the cover in the spring with glyphosate before planting a cash crop. If the field also requires the application of a phosphate fertilizer, glyphosate could be mobilized and do damage to the crop or run off into nearby waterways.

While this transport study provided new information about the interaction between glyphosate and inorganic P fertilizers, the ultimate goal is to develop a model of this system. "This study provides a useful data set and confirms the idea that competitive and non-competitive sites should be included in such models," Padilla says. Models could help with planning applications, dealing with legacy P, and adjusting management depending upon soil types. For example, soils with more Fe/Al oxides have greater potential for sorption (and maybe desorption) of the functional group on inorganic P fertilizers and glyphosate that drive this competitive interaction.

Dig Deeper

View the full article, "Interactions among Glyphosate and Phosphate in Soils: Laboratory Retention and Transport Studies," in the *Journal of Environmental Quality*: https://doi.org/10.2134/jeq2018.06.0252.