Biotech In focus

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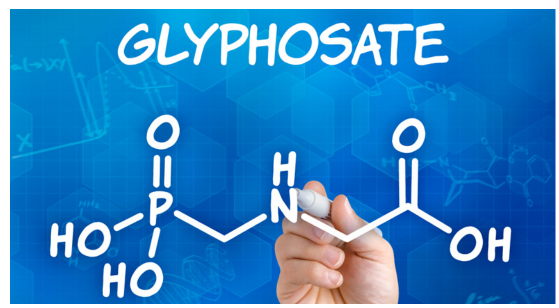
Glyphosate and Human Health I: Conflicting Assessments

In 1996, Roundup Ready (RR) soy was one of the first GM crops to enter the U.S. market. RR soy and subsequent RR varieties of canola, corn, sugar beet, and alfalfa have been popular with farmers. These RR crops are engineered to tolerate glyphosate, the active ingredient in Roundup and many other herbicide brands. With the expiration of glyphosate's last important commercial U.S. patent in 2000, generic versions are now available and manufactured across the globe. Today, glyphosate is among the world's most widely used herbicides.

Glyphosate kills by blocking a plant's ability to produce three amino acids essential for plant growth: phenylalanine, tyrosine, and tryptophan. A gene that allows glyphosate-treated RR crops to produce these three amino acids came from a common soil bacterium. At high concentrations, glyphosate has not been found to harm soil microbes. Humans and other animals obtain these amino acids from food and do not have the enzyme that is targeted by glyphosate.



Glyphosate binds to soil, tends not to leach into groundwater, and releases almost no vapor. It is broken down by soil microbes and does not accumulate in living organisms. Since its introduction as an herbicide in the early 1970s, these traits and the findings of many laboratory tests supported glyphosate's reputation for low toxicity in animals and humans.

In March 2015, the World Health Organization's International Agency for Research on Cancer (IARC) called that reputation into question by classifying glyphosate as "probably carcinogenic to humans". Later in the year, a different agency arrived at a different finding: a November 2015 report conducted by the German Federal Institute for Risk Assessment and released by the European Food Safety Authority (EFSA) concluded that glyphosate is unlikely to damage DNA or cause human cancers.

How can farmers and consumers make informed decisions when regulatory bodies present such contradictory conclusions? In our next series of bulletins we will explore how the potential health effects of glyphosate have been assessed in terms of hazard (the potential to cause harm, used by IARC in its assessment) and risk (the likelihood of causing harm, used by EFSA).

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SAFETY MEASURES

Safety testing of chemicals encompasses a range of measures, each of which can provide useful information. Some of these measures involve exposing cultured cells or living organisms under laboratory conditions. Tests can differ in the route of exposure—eating (ingestion), breathing (inhalation), or touching (direct contact)—and the duration of exposure, which can be acute (short term) or chronic (long term).

To determine how chemical agents in the environment affect people, researchers typically compare the health outcomes of populations exposed under real-world conditions to non-exposed populations. These comparisons are more informative if researchers can control for other factors that influence health, such as tobacco use.

A commonly used measure of acute toxicity is the chemical dose at which half of a group of laboratory animals die. A high value for this median lethal dose, or LD50, indicates a low measure of acute toxicity—a large amount of the chemical is required to cause mortality in the test organisms. The LD50 for oral ingestion of glyphosate by rats exceeds 4000 milligrams of glyphosate per kg of body weight. In rats, glyphosate is more toxic than grain alcohol (ethanol, LD50 = 7000 mg/kg) but less toxic than vinegar (acetic acid, less than 3500 mg/kg), table salt (sodium chloride, LD50 = 3000 mg/kg), or caffeine (about 200 mg/kg).

Averaging It Out

According to the U.S. Department of Agriculture, an average apple weighs about 180 g, so we can estimate that equivalently lethal amounts for a human weighing 150 pounds (68 kg) would be more than 1.5 medium apples of pure glyphosate (9.6 ounces, 272 gm), versus about 1 apple of table salt (7.1 ounces, 204 g). Considering that a farmer typically applies a fraction of a drop of pure glyphosate per square foot of soil, the human version of an LD50 dose of glyphosate would require eating more than four-fifths of an acre.

Determining Values

Similar to the LD50, the median lethal concentration, or LC50, is the concentration of toxin at which acute exposure results in the death of half of the animals tested. LC50 values for glyphosate are typically determined by immersing aquatic animals—fish, crustaceans, or insect larvae—in water-based solutions at a range of herbicide concentrations for a defined period of time.

Different Compounds

Published LC50 values associated with glyphosate vary widely, even for similar test animals at similar stages of maturity. Much of this variation can be traced to differences in the compounds being tested. For example, commercial formulas of glyphosate contain surfactants (detergents) that help the herbicide stick to leaves and penetrate their waxy coating. Many surfactants, including the surfactant used in Roundup, are toxic to aquatic organisms; this is why Roundup is not approved for use on surface water, on land where surface water is present, or on shorelines below the average high-water mark.

We will again encounter the question of testing individual compounds versus complex formulations in our next bulletin, which will examine how glyphosate and glyphosate-containing herbicides have been evaluated for long-term toxicity and potential to cause cancer.

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