Backgrounder
Glyphosate and Microorganisms in the Roundup Ready® Soybean System
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Background:

The available scientific evidence indicates that at recommended use rates, Roundup® agricultural herbicides[1] will have no unreasonable adverse effects on beneficial bacteria and fungi in the soil or those associated with plants. However, results from recent scientific investigations suggest that glyphosate, the active ingredient in Roundup agricultural herbicides, may have activity against some fungal pathogens of agricultural crops. Preliminary research conducted by Washington State University suggests that glyphosate may have activity in suppressing Asian soybean rust in Roundup Ready soybeans (Feng et al.). Independent research has also shown that glyphosate is active against leaf and stripe rust diseases in Roundup Ready wheat; results from work conducted at Washington State University suggest that glyphosate may be active against some soil-borne plant pathogens (Baley *et al.*, 2005). Hansen *et al*. (2004) observed a reduction in the severity of *Fusarium* head blight in spring wheat and durum after the application of a Roundup agricultural herbicide to Roundup Ready soybeans and subsequent spray drift to the cereal crops. However, application of a glyphosate herbicide had no significant effect on the level of *Fusarium* infection in harvested grain of oat (Henriksen and Elen 2005).

Details:

Glyphosate exhibits herbicidal activity by inhibiting a single enzyme, EPSPS (5-enol-pyruvylshikimate-3-phosphate synthase) (Franz *et al*., 1977). The EPSPS protein is a key enzyme in the shikimic acid pathway for the biosynthesis of aromatic amino acids and is ubiquitous in plants and microorganisms, including bacteria and fungi. EPSPS proteins have been isolated and characterized from microorganisms, with some exhibiting tolerance to glyphosate and others sensitive to inhibition by glyphosate (CaJacob *et al*., 2004). It is therefore likely that inhibition of the EPSPS protein in the obligate plant pathogen Asian soybean rust may contribute to the observed suppression of the disease in Roundup Ready soybeans when treated with Roundup agricultural herbicides. Further, results from research conducted by Monsanto scientists indicate that systemic glyphosate controls leaf rust in Roundup Ready wheat. The level of control is proportional to the concentration of glyphosate inside the leaf tissue and glyphosate on the leaf surface does not contribute to rust control. Thus, it is likely that glyphosate would have no adverse effect on any beneficial airborne fungi contacting the leaves of Roundup Ready crops.

The effects of glyphosate on soil microorganisms have been extensively investigated (Sullivan and Sullivan 2000). Results of standardized tests with glyphosate formulations for submission to regulatory agencies indicate no long-term effects on microorganisms in soil even at rates that exceed maximum use rates. In addition, independent researchers have reviewed numerous laboratory and field studies investigating the effects of glyphosate on soil bacteria and fungi (Felsot 2001; Giesy *et al*., 2000). Although some laboratory tests have shown effects on nitrogen-fixing bacteria (Moorman *et al*. 1992, Santos and Flores 1995) and soil fungi (Estok *et al*., 1989; Busse *et al*., 2001), effects are typically observed only under artificial laboratory conditions and at glyphosate concentrations well above normal field application rates. Several researchers have concluded that it is difficult to extrapolate results from the laboratory to the natural soil environment

[1] "Roundup agricultural herbicides" refers to Monsanto's Roundup-branded agricultural herbicides with glyphosate as the sole active ingredient.

(Estok *et al*., 1989; Wan *et al*., 1998; Busse *et al*., 2001). In studying microorganisms from soil in pine plantations, Busse *et al*. (2001) state: "Our findings suggest that artificial media assays are of limited relevance in predicting glyphosate toxicity to soil organisms and that field rate applications of glyphosate should have little or no affect on soil microbial communities in ponderosa pine plantations."

Long-term studies following repeated applications of Roundup agricultural herbicides in the field for 6 (Olson and Lindwall 1991) or over 10 years (Hart and Brookes 1996; Biederbeck *et al.,* 1997) have shown no detectable adverse effects on soil microbes. Investigations by Haney *et al.* (2000, 2002) related to the increased use of glyphosate-tolerant crops indicate that glyphosate was degraded overtime by soil microbes, even at high application rates, without adversely impacting the soil microbial community. In addition, results from field studies that have evaluated the fungal component of the soil microbial community indicate that glyphosate treatment had no deleterious effects on beneficial soil fungi (Araujo *et al*., 2003; Bierderbeck *et al*. 1997; Busse *et al*., 2001; Wardle and Parkinson 1990a, 1990b). Moreover, the history of safe use and yield data obtained for nearly 10 years of Roundup Ready crop production combined with in-crop applications of Roundup agricultural herbicides reinforce that soil microbes and microbially-mediated processes are not adversely impacted by field-rate applications of glyphosate.

Conclusions:

The weight of evidence on effects of glyphosate on free-living microorganisms in the soil or those associated with plants supports the conclusion that adverse effects to these organisms are unlikely as a result of application at normal field rates. More recently, results from independent scientific investigations suggest that glyphosate may have activity in suppressing the obligate fungal pathogen Asian soybean rust in Roundup Ready soybeans. At recommended use rates, the available scientific evidence indicates that Roundup agricultural herbicides will have no adverse effect on beneficial bacteria and fungi in the soil or those associated with plants, and further, preliminary data suggest that glyphosate applications may have the potential to suppress some important fungal diseases in some Roundup Ready systems.

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