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Glyphosate's Impact on Field Crop Production and Disease Development

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The U.S. Department of Agriculture's recent decision to approve Roundup Ready alfalfa renewed a debate about the safety of genetically modified crops and the use of glyphosate in the environment.

This is not a new controversy, but many statements released in recent weeks by groups opposed to the use of genetically modified (GM) crops have claimed that glyphosate use and Roundup Ready® technology will be disastrous and that glyphosate has damaged crop production by decreasing nutrient availability to plants, reducing nutrient content of food and livestock feed, and increasing plant susceptibility to disease (Zerbe, 2011). There also are claims that glyphosate is contributing to an increase in more than 40 plant diseases that may also affect human and animal health (Smith, 2011; Zerbe, 2011). However, evidence to support these claims has neither been presented to nor evaluated by the scientific community.

As scientists, we are equally concerned about the health of the environment and the sustainability of agricultural production. We have previously addressed questions on the impact of glyphosate and manganese (Mn) interactions on soybean (see http://www.btny.purdue.edu/weedscience/2010/GlyphosateMn.pdf). In this article, we discussed the limited research available on the impact of glyphosate and glyphosate-resistant crops on Mn nutrition of soybeans, and encouraged producers to avoid "insurance" applications of Mn for the sole purpose of counteracting perceived plant health damage due to glyphosate use. However, the most recent press releases around this issue are focused on the impact of glyphosate on plant and human disease development. This article is intended to clarify the relationship between glyphosate and plant disease development.

The claim that herbicides, such as glyphosate, can make plants more susceptible to disease is not entirely without merit. Research has indicated that plants sprayed with glyphosate or other herbicides are more susceptible to many biological and physiological disorders (Babiker et al., 2011; Descalzo et al., 1996; Johal and Rahe, 1984; Larson et al., 2006; Means and Kremer, 2007; Sanogo et al., 2000; Smiley et al., 1992). Our research with glyphosate-susceptible weeds has shown that some weeds die more rapidly after they have been sprayed with glyphosate when grown in soil that contains certain soil-borne fungi. This suggests that some soil fungi are more effective in infecting a weed after it has been weakened by glyphosate. Herbicides with other modes of action, such as ALS inhibitors and dinitroanilines, can influence fungal growth and disease severity of some soybean pathogens (Bradley et al., 2002;

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Harikrishnan and Yang, 2001; Sanogo et al., 2000). Based on observations from our research, we speculate that this happens when weeds are exposed to ACCase inhibitors as well.

Despite the potential for herbicides to increase disease levels in certain plants, plant pathologists have NOT observed a widespread increase in susceptibility to plant diseases in glyphosate-resistant corn and soybean. There is limited research data available to suggest that disease is of greater concern in GM or Roundup Ready® soybean and corn, compared with non-GM soybean and corn. In fact, research indicates that glyphosate-tolerant soybean and wheat are no more susceptible to soil-borne fungal diseases than conventional glyphosate-sensitive varieties, regardless of whether or not glyphosate is applied (Baley et al., 2009; Njiti et al., 2003). The target of glyphosate is an enzyme (5-enol-pyruvul shikimate 3-phosphate synthase or EPSPS) that aids in the synthesis of aromatic amino acids. This enzyme is present in plants, fungi, and bacteria, but not in humans or animals (Kishore, 1998). Therefore, glyphosate may inhibit fungal development as well as the growth of weeds. Research on glyphosate-resistant wheat and soybean indicates that applications of glyphosate have the potential to control or suppress stripe and leaf rust of wheat, and soybean rust (Anderson and Kolmer, 2005; Feng et al., 2005). This research is limited, and therefore we do not advocate applications of glyphosate for disease control. The research simply demonstrates that glyphosate may also have the ability to inhibit growth of certain fungi, and indicates that additional research is necessary to fully understand the interactions between glyphosate, fungal diseases and plants.

Although some research indicates there is an increase in disease severity on plants in the presence of glyphosate, it does NOT necessarily mean that there is an impact on yield. The most important point to make about the majority of research available on glyphosate-disease interactions is that the research does not always quantify the effect of glyphosate-influenced disease development on yield. Despite claims linking glyphosate use to increases in yield-limiting diseases such as Goss's wilt of corn, or sudden death syndrome (SDS) of soybean, we are not aware of published research that fully examines the impact of glyphosate on disease development and yield under disease pressure. Previous research examining the effect of herbicides, including glyphosate, on disease development in soybean has been conducted in greenhouse or limited field trials, and has not examined the effect of these interactions on yield (Bradley et al., 2002; Sanogo et al., 2000). All plant diseases do not have an equal impact on yield. Plants have natural defense systems that are able to limit infection and prevent yield loss in some cases. Disease-causing organisms exist naturally in the environment, but only cause infection when a susceptible host and a favorable environment are present. Even when infection occurs, the disease must reach a level in the host where the plant is weakened enough to cause yield loss.

The claim that plant disease has "skyrocketed" due to glyphosate usage is also unfounded. **Many factors influence the level and type of disease present in any given year.** For instance, reduced tillage or no-till operations have become more common across the Midwest. Many fungi and bacteria that cause plant disease survive from year to year on crop residue or in the soil. An increase in residue and a reduction in soil disturbance can

Information listed here is based on research and outreach extension programming at Purdue University and elsewhere.

The use of trade names is for clarity to readers of this site, does not imply endorsement of a particular brand nor does exclusion imply non-approval. Always consult the herbicide label for the most current and update precautions and restrictions.

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favor disease development in certain diseases (Cotton and Munkvold, 1998; Flett et al., 1998; Workneh et al., 1998). In the past, disease management recommendations focused on using hybrids and varieties with strong disease resistance packages. The current push for high-yielding varieties and quick variety turnover in the market means that some varieties may not have resistance to all major diseases, and disease resistance is not always a high priority when producers are selecting hybrids or varieties. These practices increase the likelihood that disease could develop in a given year.

It is also important to note that crop yields have been protected from yield-robbing weeds by many different herbicides for more than 50 years. Use of herbicides has not been linked to yield-limiting disease outbreaks during that time. In fact, glyphosate has been used extensively for more than 30 years and no yield-limiting disease outbreaks have been attributed to glyphosate use prior to these recent reports.

The articles and websites state that fungi in the genus Fusarium cause not only plant diseases but also disease outbreaks in humans and animals. **In fact, very few pathogens infect both plants and animals.** Some fungi can produce toxic compounds called mycotoxins that can be harmful to animals and humans (Desjardins and Proctor, 2007). However, only certain species within the genus Fusarium have been shown to produce mycotoxins. The majority of Fusarium fungi that produce mycotoxins are pathogens of corn and wheat. Wheat and certain types of food-grade corn are non-GMO crops, meaning that mycotoxin development in these crops would not be directly linked to glyphosate usage or interactions. Plants and grain affected by the fungus that causes SDS, Fusarium virguliforme, have not been shown to be toxic to humans or livestock. Additionally, the United States Food and Drug Administration has set levels for the amount of mycotoxins that can be in animal feed, and in food for human consumption, and these markets are closely regulated to prevent introduction of mycotoxin-contaminated grain into the market.

Overall, the claims that glyphosate is having a widespread effect on plant health are largely unsubstantiated. To date, there is limited scientific research data that suggest that plant diseases have increased in GM crops due to the use of glyphosate. Most importantly, the impact of these interactions on yield has not been demonstrated. Therefore, we maintain our recommendations of judicious glyphosate use for weed control. We encourage crop producers, agribusiness personnel, and the general public to speak with University Extension personnel before making changes in crop production practices that are based on sensationalist claims instead of facts.

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