An Equation for Trouble?

Glyphosate x Weeds = Resistance

"Will I get glyphosate resistant weeds?" This is a question that is becoming more common among farmers. While the question is simple, the answer is complex.

For each herbicide and weed species, there is a certain chance that a naturally occurring resistant plant may be in a field, which could lead to a resistance problem. Resistant plants initially occur naturally at very low frequencies. So it follows that the actual chance of finding one of these resistant plants increases as more weeds are sprayed. If a trillion weeds are sprayed, it is more likely that a resistant plant will be found than if a million weeds are sprayed.

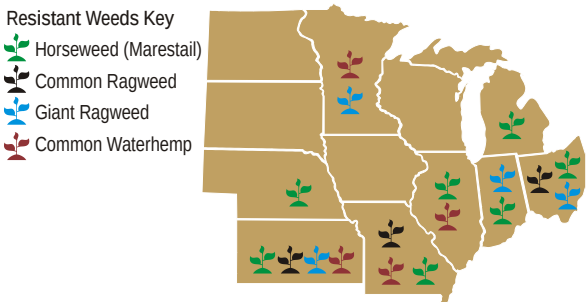
Another way of considering glyphosate resistance is the following equation:

Glyphosate use x trillions of weeds = Risk of resistance

In this equation, the risk of resistance can be reduced by either reducing glyphosate use, reducing the number of weeds sprayed with glyphosate, or both. To illustrate this point, the following scenarios are based on an 8-year field study. It demonstrates how the risk of developing glyphosate resistance can be reduced.

Consider the following three fields in a corn/soybean rotation. All fields have giant foxtail, redroot pigweed, and common lambsquarters as frequent weeds. In each of the 8 years, field 1 had a single annual postemergence application of glyphosate. Field 2 had a single postemergence application of glyphosate in each soybean year, and a non-glyphosate herbicide program in each corn year. Field 3 had Dual II Magnum applied preemergence followed by a postemergence application of glyphosate in each year. In the table below, the number of weeds sprayed with glyphosate was the total number over 8 years in a 75 acre field. Risk is relative to the number of giant foxtail plants exposed to glyphosate in Field 3.

Currently, glyphosate-resistant weeds have not been confirmed in Wisconsin. However, surrounding states have reported many species with glyphosate resistance. Does this mean that we needn't worry about glyphosate resistant weeds in Wisconsin? The simple answer is no. Just because glyphosate resistance hasn't been confirmed in Wisconsin, it doesn't mean that small infestations don't exist already or won't develop.



Confirming glyphosate resistance in weeds is more difficult than confirming resistance to triazine or ALS (Accent, Raptor, etc.) herbicides. Triazine- or ALS-resistant weeds often survive at 100 times more than a normal herbicide rate, whereas glyphosate resistant weeds may survive at 4 to 10 times a normal glyphosate rate. This makes identifying them more difficult because resistance may be confused with survivors caused by application errors, large weeds, weather conditions, etc.

	Field 1 *(Glyphosate applied each year)*		***Field 2*** *(Glyphosate in alternate years)*		***Field 3*** *(Dual II PRE plus glyphosate POST)*	
	Weeds sprayed	Resistance relative risk	Weeds sprayed	Resistance relative risk	Weeds sprayed	Resistance relative risk
Foxtail	388 million	47	83 million	10	8 million	1
Pigweed	96 million	13	22 million	3	4 million	<1
Lambsquarters	280 million	35	62 million	8	86 million	11

Based on relative risk, the chance for resistance was reduced 50 times when Dual was applied preemergence before glyphosate than compared to glyphosate applied alone.

Why were there more weeds sprayed with glyphosate in Field 1 than in Field 3?

What herbicide could be used to lower the risk similar to foxtail?

Foxtail
The single, annual application of glyphosate in field 1 had a greater risk for resistance than the herbicide programs in fields 2 and 3. Field 1 had about a 50 times greater risk of glyphosate-resistant foxtail than field 3, and about a 5 times greater risk than field 2. The risk was reduced in field 2 because non-glyphosate herbicides effectively controlled foxtail and glyphosate was used half as often. Risk was lowest in field 3 when Dual II Magnum controlled most of the foxtail and few remained to be sprayed with glyphosate. This highlights the benefits of when herbicides with different modes of action overlap to control the same weed.

Pigweed
Similar to foxtail, the greatest risk of resistance was with a single, annual application of glyphosate. However, the magnitude of resistance risk for pigweed is much lower than for foxtail. Why would this be? Think back to the equation. The greater the number of weeds sprayed with glyphosate, the greater the risk of resistance. There was about 4 times more foxtail sprayed with glyphosate than pigweed in field 1. Comparing fields 1, 2 and 3, the risk of resistance drops from 13, to 3 to less than 1, respectively, as alternate herbicides are used to control the pigweed and fewer pigweed are sprayed with glyphosate.

Lambsquarters
Similar to foxtail and pigweed, lambsquarters in field 1 has the highest relative risk of resistance due to intensive glyphosate use. The story is the same. Rotation of glyphosate with non-glyphosate alternatives or a preemergence herbicide followed by postemergence glyphosate reduces the risk of resistance compared to annual glyphosate applications. However it's important to point out that in this example, the preemergence application of Dual II Magnum was less effective on lambsquarters than foxtail or pigweed. This resulted in greater risk of resistance than rotating glyphosate with non-glyphosate herbicides. It also highlights the importance of selecting the right preemergence herbicide(s) so it has overlapping activity on the weed complex.

From these field scenarios, it's clear that reducing the number of weeds sprayed with glyphosate or managing the number of times that glyphosate is sprayed will help delay glyphosate resistance.

We recommend the following strategies to reduce the risk of glyphosate resistant weeds.

- Start with a **clean field** and control weeds early by using a burndown treatment or tillage in combination with a **preemergence residual** herbicide as appropriate.
- Apply **integrated** weed management practices.
    - Use multiple herbicide modes-of-action with **overlapping weed spectrums** in **rotation, sequences, or mixtures**.
    - Use cultural practices such as cultivation and crop rotation, where appropriate.
- Use the **full recommended herbicide rate** and **proper application timing** for the hardest to control weed species present in the field.
- **Scout fields** after herbicide application to ensure control has been achieved. Avoid allowing weeds to reproduce by seed or to proliferate vegetatively.
- Use **good agronomic principles** that enhance crop competitiveness as well as scouting, monitoring and cleaning equipment between fields.

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