GLYPHOSATE RESISTANCE STRATEGIES AND MANAGEMENT RECOMMENDATIONS FOR PROBLEM WEEDS

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Introduction

Several common weeds within Wisconsin have the potential to develop glyphosate-resistance based on their evolution of glyphosate-resistance or reduced sensitivity in other Midwestern states. These weeds include horseweed, common lambsquarters, waterhemp, common ragweed, and giant ragweed, but other weeds also have the potential for developing resistance. Some of these weeds also pose problems in obtaining consistent control even without any type of herbicide resistance and are considered "problem weeds".

Problem Weed Management vs. Herbicide Resistance Management

In discussing management options, a clear distinction should be made between recommendations that are intended to prevent or delay herbicide resistance and recommendations that will improve the control of problem weeds. These two sets of recommendations may share some of the same tactics, but the goals are different. Management tactics to control problem weeds may use multiple application timings to reduce the risk of poorly timed herbicides or to control late emerging weeds. The result is to reduce risks and increase yield protection. For instance, a preemergence herbicide might be used and followed with a postemergence herbicide application to improve giant ragweed control. Or, an early postemergence application might be followed with a later postemergence application. However, depending on the herbicides used in the system, there may still be moderate or high selection intensity for herbicide resistance.

The selection intensity for glyphosate resistance depends on the frequency of use and the number of acres or number of weeds treated. Applying glyphosate as the sole herbicide each year creates a high selection intensity and is certainly a poor management plan. A better alternative is to rotate herbicide modes of action between years. Adding a preemergence residual herbicide may reduce the total number of weeds treated postemergence with glyphosate, but many plants may still be treated postemergence with glyphosate. Using this approach on an annual basis reduces the selection intensity, but does not provide the best management option to delay resistance. The best resistance management scenario might be to use alternate herbicide modes on action in one year and rotate with a program where a preemergence herbicide is followed with glyphosate in the second year. A range of glyphosate resistance management strategies certainly exist. I will continue to argue that Wisconsin should use the best alternatives to reduce the selection intensity for glyphosate and a key tactic is rotating among herbicide modes of actions.

Proactive vs. Reactive Herbicide Resistance Management

Despite the clear evidence that glyphosate-resistance can develop in key Midwestern weeds, Wisconsin growers still need to decide if they should use tactics to delay or prevent resistance. Two general management strategies can be considered – reactive management or proactive management.

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Reactive management is the strategy of using the herbicide until resistance develops. Only after resistance occurs will the grower react to manage the herbicide resistant weed. It is reasonable to assume that the cost of weed control will increase after resistance develops because an additional herbicide will be needed or weed control may not be as good. In the context of glyphosate, a scenario could be relying on single or multiple glyphosate applications every year until glyphosate-resistant develops. The additional future cost with this strategy is that weed control costs will be higher in future years when an herbicide tank mixture is required. In addition, yield losses may occur during the year or two when glyphosate fails to control the weed and other herbicide options are applied too late to achieve adequate control.

The proactive management strategy employs resistance delaying tactics prior to the development of resistance. This strategy will likely increase the current cost of management if the tactics used to delay resistance include herbicide tank mixtures or preemergence herbicides. Even herbicide rotations may increase these short-term costs depending on the herbicide programs used. The economic choice between these two strategies depends on the number of years that it takes for resistance to develop, the cost of the delaying tactics, the cost of controlling the resistant weed after it develops, and the interest rate. Reactive management is economically wise if resistance is not likely to occur for a long time into the future. However, investing in proactive management makes more sense if resistance is likely to occur in a shorter time frame or if the cost of controlling the herbicide resistant weed is high.

Waterhemp management in soybean was recently used as a case study for this economic decision (Mueller et al. 2005). In the case of proactive management, the authors proposed switching from two in-season glyphosate applications to a preemergence residual herbicide program followed by one in-season glyphosate application. Thus, proactive management increased total cost by $3.66/a in the soybean year or $1.83/a when averaged across a corn-soybean rotation. If glyphosate-resistant waterhemp developed, the authors estimated it would cost an additional $35.83/a to control waterhemp in soybean. Thus, the cost of resistant waterhemp would be $17.91/a when averaged across a corn-soybean rotation. Based on these costs and assuming an 8% interest rate, the benefit of proactive vs. reactive management can be calculated in relation to the number of years for resistance to develop. With the low cost of proactive management and high cost of controlling glyphosate-resistant waterhemp, proactive management is a better economic choice if resistance happens in less than 28.5 years. Even if the cost of controlling glyphosate-resistant waterhemp was only an additional $10/a in soybean (or $5/a averaged over 2 years), proactive management is still a better choice if resistance develops in 12 years or less.

A simple matrix to compare proactive management costs against the cost of controlling a glyphosate-resistant weed is shown in Figure 1, which is based on the equation used by Mueller et al. (2005). It is logical to just wait until resistance occurs if the cost to control a resistant weed is very low. In contrast, the benefit of investing to prevent resistance is great if the cost of controlling a resistant weed is high, even if the resistance does not occur for many years into the future. This suggests that weeds that are currently difficult or expensive to control without glyphosate may be the best targets for proactive management.

Figure 1. Matrix of proactive management costs vs. the costs of controlling glyphosate-resistant weeds.

		Additional annual cost for proactive management				
		$2/a	$4/a	$6/a	$8/a	$10/a
Additional annual cost to control the glyphosate-resistant weed	$2.50/a	3	-	-	-	-
	$5/a	11	3	-	-	-
	$10/a	20	11	6	3	-
	$20/a	29	20	15	11	9

Proactive management pays if resistance occurs before the number of years listed in the table

This example assumes a discount rate of 8%.

The increasing frequency of glyphosate-resistant weeds over the past few years should provide additional justification for proactive management strategies. Proactive management strategies can incorporate several approaches such as herbicide mode of action rotation, crop rotation, and tillage or cultivation. However, for any individual tactic to be successful, it must reduce the selection intensity for glyphosate.

Management of Specific Problem Weeds

Common lambsquarters: The consistency of common lambsquarters control in soybean seems to be more variable in recent years. The simplest and most economic tactic to include another herbicide with glyphosate would be to tank mix Harmony GT with glyphosate. However, some people are concerned with the risk of injury from Harmony GT and the application should be made to smaller lambsquarters to obtain the most activity from the Harmony GT. Alternatively, it may by more logical to use a soil-applied herbicide like Sencor, Valor, Intrro, Prowl, or Turbo to reduce early season common lambsquarters control prior to applying glyphosate postemergence. The use of soil-applied herbicides will probably have a greater benefit in row soybean as compared to drilled soybean. Several good non-glyphosate herbicides are available to control common lambsquarters in corn. Shifting to a non-glyphosate program in corn would be a good approach to reducing the selection intensity for glyphosate resistance in common lambsquarters.

Waterhemp

Waterhemp has a high probability of being ALS resistant in Wisconsin. As a consequence, few postemergence options for non-glyphosate herbicides are available in soybean. Sencor, Valor, Intrro, Prowl, and Turbo are some of the more economical soil-applied herbicides that should improve the postemergence timing of glyphosate applications in soybean. Because waterhemp emerges later than several other common weeds, an early season residual herbicide will allow glyphosate to be delayed slightly. Postemergence options other than glyphosate are limited to Cobra, Flexstar, and Ultra Blazer. Several good non-glyphosate herbicides are available to control waterhemp in corn. Alternating to a non-glyphosate program in corn would be a good approach to reducing the selection intensity for resistance in waterhemp.

Horseweed

As a winter annual, horseweed is a primary threat in no-till production. Tank mixing 2,4-D with glyphosate and making applications before horseweed exceeds 4 to 6 inches in height are standard recommendations. This is a low cost, proactive tactic.

Giant Ragweed

Giant ragweed is a challenge in both corn and soybean because preemergence herbicides do no give adequate or consistent control, the rapid growth rate of seedlings makes the timing of postemergence herbicides challenging, and ALS-resistant populations limit herbicide options in soybean (e.g., resistance to FirstRate). In corn, a two pass program is necessary for adequate control of moderate infestations of giant ragweed. Preemergence herbicide options include atrazine, Hornet, Camix, Lumax, or acetanilide plus atrazine premixes. These herbicides could be followed by several effective postemergence herbicides. To reduce glyphosate selection intensity, a non-glyphosate herbicide could be used in corn because glyphosate may have greater value if used in soybean. FirstRate is the most effective preemergence herbicide in soybean if the giant ragweed is not ALS resistant. Most other soil-applied soybean herbicides will only suppress giant ragweed. However, they may still have value in stunting the ragweed so that postemergence applications are more effective. FirstRate, Cobra, and Flexstar are the most effect-tive postemergence options in soybean other than glyphosate.

Common Ragweed

Common ragweed has not been a major problem in Wisconsin with the exception of ALS-resistant populations. However, common ragweed warrants our attention because of the potential for glyphosate resistance. Many of the soil-applied herbicides used to control common lambsquarters will be effective with common ragweed with the exception of Prowl, which does not control ragweed. Valor will also be less effective on ragweed than lambsquarters. Several good non-glyphosate herbicides are available to control common lambsquarters in corn. Alternating to a non-glyphosate program in corn would be a good approach to reducing the selection intensity for resistance in common ragweed.

Reference

Mueller, T.C., P.D. Mitchell, B.G. Young, and A.S. Culpepper. 2005. Proactive versus reactive management of glyphosate resistant or –tolerant weeds. Weed Technol. 19:924-933.