MANAGEMENT OF GIANT RAGWEED, LAMBSQUARTERS, AND OTHER TOUGH TO CONTROL WEEDS IN ROUNDUP READY SOYBEANS

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One of the characteristics of Roundup Ready soybeans in the first few years following their introduction was the notable absence of weeds following postemergence glyphosate applications. This applied to relatively easy-to-control weeds, as well as those that are not well controlled by other herbicides. Some growers continue to have excellent success at weed control in Roundup Ready soybeans. However, 10 years later, several weeds have become problematic in soybeans again, and we no longer assume that all Roundup Ready soybean fields will be free of weeds at the end of the season. Weeds that currently seem to be most problematic in Roundup Ready soybeans in the eastern Corn Belt are giant ragweed, lambsquarters, horseweed (marestail), and pokeweed.

There can be any number of reasons why these weeds have become more prevalent, and more difficult to control. Within the United States, populations of horseweed, common ragweed, and Palmer amaranth have developed resistance to glyphosate over the past five years, and we believe the same is happening with giant ragweed. Some problems are certainly due to the assumption by many growers that, even when grossly mismanaged, glyphosate will eventually control any population of weeds if applied often enough. This may have been true for several years after the adoption of Roundup Ready soybeans, but no longer seems to be the case in many fields. We suspect that problems with these weeds will continue to get worse unless they are subject to better management soon.

Glyphosate Management — Separating the "Good" from the "Bad"

It is possible to observe within short distances individual Roundup Ready soybean fields that vary greatly in the effectiveness of the weed control, and this can be attributed to differences in the level of management between fields. Some of the problems with ineffective control of lambsquarters and giant ragweed are due to glyphosate mismanagement, especially rate, timing, and number of applications. Growers mismanaging glyphosate also usually fail to account for the biology of the weed with regard to emergence patterns and its ability to reduce soybean yield if not controlled when small. A common scenario in fields where these weeds are not well controlled might be something like the following:

- The grower has grown no-till Roundup Ready soybeans in the field for a number of years, and used only glyphosate. Control has been getting incrementally worse in the field from year to year (patches first, then larger areas of weed escapes), and the grower fails to recognize that his management of glyphosate is at fault. Weed escapes are contributing an increasing amount of weed seed to the soil seedbank every year, which results in generally higher weed populations. Reliance on glyphosate may be causing weed populations to evolve resistance to glyphosate.
- The grower has decides that, having had to pay for the Roundup Ready soybean seed, he is going to put as little additional money into weed control as possible. This approach to weed control usually takes the form of a single application of glyphosate applied sometime after the no-till soybeans have emerged. Application might be delayed until weeds are fairly large, in order to minimize the need for a second application of glyphosate. Early-emerging plants can be old and large by this point, and infested with stalk borers, and generally less sensitive to herbicide. Even on large weeds, the grower may use the lowest labeled rate of glyphosate, 0.75 lb ae/A, which is too low for the weed size in the field. Unknown to him, the grower loses yield in at least some areas of the field, because weeds are allowed to compete with soybeans for too long into the season.

- The grower may make a second application of glyphosate if it becomes apparent that the first application did not provide acceptable weed control. Weed escapes may not be noticed until July or August when survivors of the first application or late emergers become large enough to be evident from a distance. The grower makes a second glyphosate application at this time, possibly grudgingly increasing glyphosate rate to 1.1 or 1.5s lb ae/A. Some of the weed escapes are controlled, but others are too large/old/resistant to be controlled. The grower may apply glyphosate a third time to attempt additional control. Soybeans may lose pods on upper part of the plant due the late timing of the glyphosate application, well past R2.

In contrast, growers who have maintained effective control of weeds until now in Roundup Ready soybeans practice more effective management of glyphosate, and opt to include other herbicides besides glyphosate in weed management programs. These growers may use several of the following practices, which help ensure more consistent control, reduce selection for glyphosate resistance, and preserve soybean yield:

- Soybeans are rotated with corn, and possibly also wheat, and herbicides other than glyphosate are used for weed control in corn and wheat.
- Application of herbicides the previous fall and/or shortly before planting in the spring to ensure that soybeans are planted into a relatively weed free seedbed.
- Use of 2,4-D ester in fall or spring preplant treatments, along with glyphosate or other herbicides that are used.
- Use of residual herbicides in fall or spring, which reduces early-season weed populations, reduces weed competition with the crop, and reduces reliance on glyphosate for control of summer annual weeds.
- Application of the first postemergence glyphosate treatment when weeds are relatively small, less than 6 to 8 inches tall for most summer annuals, and when giant ragweed is not more than 6 to 12 inches tall. A glyphosate rate of at least 0.75 lb ae/A is used, and rate is increased to 1.1 to 1.5 lbs ae/A in fields where: populations of tough weeds such as giant ragweed are present; a later than desirable application results in large weeds; and/or there is a history of less than adequate weed control.
- Fields are scouted within 3 weeks or so after the initial postemergence glyphosate application, and retreated with glyphosate where late-emerging weeds are observed, or where weeds are not completely controlled with the first application.

The ability of glyphosate to control a broad spectrum of weeds, even large weeds when necessary, does not change the need for the following components in weed management programs:

1. Either a fall or spring treatment to control winter weeds, and early-emerging summer annuals.
2. An early postemergence glyphosate application when weeds are 4 to 8 inches tall
3. A second postemergence application as necessary to control late-emerging weeds or those not completely controlled with the first application.

Producers who integrate glyphosate with other herbicides (such as including 2,4-D ester and residual herbicides in fall or preplant treatments) may improve control of certain weeds, reduce the need for a second postemergence application, and reduce selection for glyphosate resistance. Deviation from this two to three application program can result in less effective weed control in general, and problems may be most acute with weeds such as giant ragweed, lambsquarters, and marestail.

Glyphosate Resistance Issues

Glyphosate-resistant marestail is widespread throughout Ohio and Indiana, especially in the southern areas. This problem has developed in continuous Roundup Ready soybean fields as well as fields where Roundup Ready soybeans have been rotated with non-Roundup Ready corn. A key cause of the problem appears to be the exclusive use of glyphosate in the soybeans. Marestail seed is dispersed by wind, so glyphosate-resistant marestail can be expected to spread and become a problem even in fields where herbicides other than glyphosate have been included in Roundup Ready programs. The guidelines for management of glyphosate-resistant marestail also provide the most effective control of marestail that is not resistant, and should be followed in any fields where this weed has been a problem.

The more frequent mid- to late-season infestations of lambsquarters and giant ragweed in the last several years could be an indication of the adaptation of weed populations to intensive use of glyphosate. The number of Roundup Ready soybean fields with giant ragweed control problems increased from 2005 to 2006, and we expect this to increase again into 2007. The most severe control problems appear to be occurring in continuous Roundup Ready soybean fields, with a history of relying exclusively on glyphosate for weed control. Some of these fields were treated three to four times with glyphosate in 2006, and giant ragweed was still not well controlled. In contrast, lambsquarters has been difficult to control in some fields over the past several years, but the number of fields does not appear to be increasing to the same extent that has been observed for giant ragweed.

Greenhouse research conducted over the past several years by Ohio State University and Purdue University has resulted in the identification of a number of populations of lambsquarters and giant ragweed that are less sensitive to glyphosate. A number of these are from fields where control of these weeds with glyphosate has been inadequate. We have the greatest concern about giant ragweed, which is generally more difficult to control in soybeans compared to lambsquarters, and glyphosate has been one of our most effective tools. In greenhouse and field dose response studies with these populations, we have observed giant ragweed surviving 3 lbs ae/A of glyphosate, and also multiple applications of lower rates.

We conducted field studies at four sites in Ohio and Indiana in 2006 with giant ragweed populations that exhibited this type of response, with the goals of validating our greenhouse research findings and determining whether these populations could be controlled with glyphosate-based programs (see table that follows this section). Plants survived multiple applications of glyphosate at all of these sites. We were not able to adequately control the giant ragweed where we used glyphosate exclusively, except at one site. We were able to obtain effective control at all sites where the weed management program consisted of all of the following:

1. A preplant burndown treatment that included glyphosate and 2,4-D ester.
2. An initial postemergence application of either glyphosate (1.5 lbs ae/A) or Flexstar (1.3 pts/A) when plants were not more than about 6 to 12 inches tall.
3. A second postemergence glyphosate application of 0.75 lb ae/A three weeks later.

Where we included a residual herbicide in the preplant treatment (Gangster, in this case), we obtained adequate control using the same sequence of treatments, but we were able to use 0.75 lb ae/A of glyphosate in the first postemergence application. We were not able to adequately control giant ragweed with a single postemergence glyphosate application, even where we used a preplant burndown and residual herbicide. In addition, although we observed adequate control with these programs, we almost always had a few small plants surviving and producing seed. This was our second year of research at one of these sites, and we made similar observations on control the previous year. Based on the results of these studies, we have concluded that giant ragweed populations with a low level of resistance to glyphosate have developed. These populations are not consistently controlled where glyphosate is the

only herbicide used, which may explain some of the giant ragweed control failures evident in Ohio and Indiana in 2006.

Table 1. Control of giant ragweed in fields with a history of glyphosate performance problems. Results shown are the average of four field studies conducted by The Ohio State University and Purdue University in 2006. Glyphosate rates in parentheses are lbs acid equivalent per acre.

	Percent Control (at harvest)
No preplant herbicide	
POST glyphosate (1.5)	39
POST glyphosate (1.5) + Late POST glyphosate (0.75)	78
Preplant herbicides = glyphosate + 2,4-D ester	
POST glyphosate (0.75)	55
POST glyphosate (0.75) + Late POST glyphosate (0.75)	88
POST glyphosate (1.5)	61
POST glyphosate (1.5) + Late POST glyphosate (0.75)	96
POST Flexstar (1.3 pts/A) + Late POST glyphosate (0.75)	99
Preplant herbicides = glyphosate + 2,4-D ester + Gangster	
POST glyphosate (0.75)	70
POST glyphosate (0.75) + Late POST glyphosate (0.75)	97
POST glyphosate (1.5)	71
POST glyphosate (1.5) + Late POST glyphosate (0.75)	97

What's the Weed Doing?

Weed management programs are too often planned without consideration of the biology of the weed, and how it is most easily controlled by herbicides. One example of this is the increase in populations of winter annual weeds and dandelion, which has been due, in part, to the omission of preplant herbicide treatments (burndown) in Roundup Ready soybeans. Growers may fail to realize that these weeds finish their life cycle and produce seed in late spring, and that application of herbicide too late in the spring allows abundant seed production by these weeds. The characteristic lack of seed dormancy in winter annual weeds and dandelion results in further increases in population later the same year. In addition, once dandelion produces seed and starts to senesce in the spring, herbicides have less activity on the root, which is an important component of this weed's ability to be a continuous problem. For each of the weeds discussed in this article, the following is a brief synopsis of the important characteristics of their biology and response to herbicides, followed by specific guidelines for control in Roundup Ready soybeans.

Lambsquarters

Lambsquarters can emerge fairly early in spring, and is usually not considered a late-season emerger. However, plants emerging after early postemergence treatments can be a problem where populations are high, which is often typical of fields with triazine-resistant populations. Lambsquarters plants may be evident in the field at the time of soybean planting, and they should be controlled at that time with a burndown treatment. Lambsquarters is far more easily controlled in soybeans with preemergence herbicides than with postemergence herbicides, and preemergence herbicides often provide seasonlong control. Even when applied in the fall, several preemergence herbicides provide control into early summer, so that any plants present at the time of postemergence application are small. The sensitivity of lambsquarters to glyphosate appears to be decreasing across the Corn Belt, so use of preemergence

herbicides should be emphasized. Postemergence application should be made to small plants, and control of some populations will be improved by using higher glyphosate rates. Specific guidelines for lambsquarters control are as follows:

1. Start weed free at planting using tillage or a preplant herbicide treatment consisting of 2,4-D ester plus either glyphosate or Gramoxone.
2. In no-till, include an herbicide that provides residual control of lambsquarters in preplant burndown treatments. Where the field is tilled prior to planting, apply residual herbicide before soybeans emerge. The following herbicides provide residual control of lambsquarters: Canopy, Synchrony, FirstRate, Python, Spartan, Scepter, Pursuit, Valor, Gangster, pendimethalin, and metribuzin (except triazine-resistant).
3. Where a preemergence herbicide has been applied, a POST application of glyphosate at 0.75 lb ae/A should be adequate to control small, late-emerging plants.
4. In fields not treated with preemergence herbicide, apply glyphosate POST at 1.5 lbs ae/A when plants are less than 6 inches tall. In fields with a history of lambsquarters control problems, or where scouting indicates that some plants are still alive, make a second POST glyphosate application at 0.75 lb ae/A approximately three weeks later.

Marestail (Horseweed)

Marestail emerges almost all year, and is considered to be both a winter and summer annual. Two broad periods of emergence result in plant populations that become problematic in soybeans. Plants that emerge in late summer and fall will overwinter as rosettes (plants with elongated stems in fall do not survive winter), and these will be present at the time of crop planting. Considerable emergence can also occur from early spring through early summer, although most of the emergence occurs by mid-May. Spring emergence can result in new populations before and after planting, which will compete with the crop. Control programs must take this emergence pattern into account, and also that postemergence herbicide treatments may be ineffective due to herbicide resistance.

We expect the marestail observed in almost any Roundup Ready soybean field to be glyphosate-resistant, and some populations may also be resistant to ALS inhibitors. A primary goal of management for this weed should be to avoid having to control it postemergence in soybeans, which can be extremely difficult. Obtaining consistently effective control of marestail depends on effectively controlling emerged plants prior to planting and using residual herbicides to control plants that germinate after planting and into early summer. Fall herbicide treatments effectively control plants that have emerged by the time of application, but do not adequately address spring emergence, even where the fall treatment includes residual herbicide. Residual herbicides should be saved for spring application where this weed is a problem. Specific guidelines are as follows:

1. Start weed free at planting using tillage or a preplant herbicide treatment consisting of 2,4-D ester plus glyphosate, or Gramoxone plus 2,4-D ester plus metribuzin or Canopy DF. When applying glyphosate plus 2,4-D, the addition of a product containing chlorimuron (Canopy, Synchrony) or cloransulam (FirstRate, Gangster) can improve control of large plants as long as they are not ALS-resistant. Note on fall treatments: application of herbicide the previous fall will control plants that emerge in late summer or fall, but still may not result in a field free of marestail at planting. Apply preplant herbicides as necessary to start weed free even where herbicides were applied the previous fall.
2. In no-till fields where the preplant herbicide treatment is applied before mid-May, include herbicides that can provide residual control of marestail into early summer. Where the population is not ALS-resistant, the following herbicides can be used for residual control: Canopy,

Synchrony, FirstRate, Python, Spartan, Valor, Gangster, or metribuzin. Where ALS resistance is suspected or has been confirmed, one of the following should be used: Spartan, Valor, Gangster, or metribuzin (can also use Canopy DF, but need to add more metribuzin). Note on fall treatments: residual herbicides applied in the fall are less likely to provide residual marestail control through early summer, compared to a spring application of a residual herbicide.

3. It is possible to have marestail emerging in early summer, even where an effective residual herbicide has been used. Should this occur, apply the following when plants are less than 6 inches tall: glyphosate (1.5 lbs ae/A) plus either FirstRate (0.3 oz/A) or Classic (2/3 oz/A).

Giant Ragweed

Giant ragweed has a number of characteristics that make it a "great" weed, and inherently difficult to control. Giant ragweed emerges from late March through early July, and management programs need to address this long period of emergence. It is usually present at the time of planting, and should be controlled with an effective preplant burndown treatment. A combination of preemergence and postemergence herbicides should be used to control this weed from planting through late June. Several preemergence herbicides have activity on giant ragweed, and these should be used to reduce the populations that emerge after planting and slow the growth of surviving plants. It is possible to obtain adequate control with a single postemergence glyphosate application in fields without a history of control problems, but only where an effective preplant burndown and residual herbicides have been used. The populations and emergence patterns in many fields justify two postemergence applications.

Giant ragweed grows rapidly and is extremely competitive with soybeans, and should be controlled when relatively small, which usually results in the need for a second postemergence application to control later-emerging plants. Except where giant ragweed populations are extremely low, this is another weed where the residual herbicide should be applied in the spring, not in the fall.

While many growers rely on multiple applications of glyphosate to control giant ragweed, this has led to control failures in some fields, and the development of populations with a low level of glyphosate resistance. Based on recent research from Purdue University and The Ohio State University, it is still possible to control giant ragweed with glyphosate-based herbicide programs in fields where previous reliance on glyphosate alone has resulted in resistance and poor control. Growers experiencing problems with control should follow the guidelines shown below as closely as possible. Where control of giant ragweed has not been a problem, and the soybeans have been rotated with non-Roundup Ready corn, growers may choose not to use residual herbicides. We strongly suggest that no-till soybeans be treated with a preplant application of 2,4-D ester even where problems with control have not been experienced. Specific guidelines are as follows:

1. Start weed free at planting using tillage or a preplant herbicide treatment consisting of 2,4-D ester plus either glyphosate or Gramoxone.
2. In no-till, include an herbicide that provides residual control of giant ragweed in preplant burndown treatments. Where the field is tilled prior to planting, apply residual herbicide before soybeans emerge. The following preemergence herbicides provide some control of giant ragweed, so they can reduce the population and slow the growth of remaining plants: Canopy, Synchrony, FirstRate, Scepter, and Gangster. Note: these herbicides will not control ALS-resistant giant ragweed.
3. Growers with a history of giant ragweed control problems should apply one of the following POST treatments when giant ragweed plants are no more than 6 to 10 inches tall: glyphosate (1.5 lbs ae/A); Flexstar (1.3 pts/A), Cobra/Phoenix (12.5 oz/A), or FirstRate (0.3 oz/A — only where population is not ALS resistant). Where Flexstar, Cobra, Phoenix, or FirstRate are applied, include

a POST grass herbicide such as clethodim or Fusion. In fields where control has not been a problem, use a glyphosate rate of 0.75 lbs ae/A on plants up to 6 inches tall, and 1.5 lbs ae/A on larger plants.

4. In fields with a history of control problems, make a second POST application of glyphosate (0.75 lbs ae/A) approximately three weeks after the first POST treatment. Proper timing of this application is essential to obtain control. Do not delay application until giant ragweed plants are evident above the soybean canopy, or control will be reduced. Where control has not been a problem in the past, scout fields three weeks after the first POST treatment. Make a second POST glyphosate application (0.75 lb ae/A) as necessary to control late-emerging plants or to complete control of plants that survive the first application.

Pokeweed

Pokeweed is a warm-season perennial, which grows from a deep (and often large) taproot in late spring after soybeans have been planted. Options for control, aside from tillage, are few. Early-season burndown and preemergence herbicides have no activity on pokeweed, so use of postemergence herbicides must be emphasized. While glyphosate is more effective than any other postemergence herbicide in soybeans, multiple applications are required for most effective control. Pokeweed spreads by seed, and it is possible to observe a patch of new seedlings under a crop canopy in July, which is the result of the seed produced by an established plant the previous year. Preventing seed production is therefore an important component of management programs, in addition to control of established plants.

Pokeweed has become more prevalent in Roundup Ready soybeans, but multiple postmergence applications of glyphosate still provide the most effective control. Problems with pokeweed control in some fields may be due to inappropriate timing of postemergence applications. Control could be reduced where the first postemergence glyphosate treatment is applied too early (as can occur in fields where the preplant burndown is omitted), or too late, when plants are very large. For most effective control, apply glyphosate postemergence at 1.1 lbs ae/A when the pokeweed plants are 12 to 24 inches tall and make a second application at the same rate when plants have approximately 12 inches of regrowth. A single postemergence application will result in less effective control, and the likelihood of significant regrowth later in the season. For a single postemergence application, use a glyphosate rate of 1.5 lbs ae/A.

We suspect that there may be spray coverage issues on larger pokeweed plants. If so, it is possible that control may be improved by taking steps to ensure spray coverage on the entire plant. These include making sure the spray boom is high enough, increasing spray volume, and/or slowing sprayer speed.

Resources for More Information

The recommendations presented here can also be found in the *Weed Control Guide for Ohio and Indiana*, available at county extension offices in Ohio and Indiana, or from the OSU publications office, (614) 292-1607). Weed scientists at OSU and Purdue have also collaborated on several fact sheets on the value of preemergence herbicides in Roundup Ready soybeans and control of lambsquarters and giant ragweed. Weed scientists across the Midwest have collaborated on a series of bulletins on glyphosate stewardship and resistance, and control of specific weeds that can be problematic in Roundup Ready systems. Free copies of these fact sheets and bulletins should be available in county extension offices, and directly from extension weed scientists at OSU (Mark Loux, (614) 292-9081, loux.1@osu.edu) and Purdue (Bill Johnson, (765) 494-4656, wgj@purdue.edu). They can also be downloaded from:

OSU Weed Science– http://agcrops.osu.edu/weeds
Purdue Weed Science – http://www.btny.purdue.edu/weedscience/
Glyphosate, Weeds and Crops Group – http://www.glyphosateweedscrops.org