Herbicide How-To: Maximizing Glyphosate Activity

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Glyphosate is an extremely important tool for weed control in many production systems because it is highly effective on many weed species over a range of sizes and is very cost-effective. In fact, the Oklahoma Department of Agriculture pesticide database shows more than 75 glyphosate and glyphosate-containing herbicides of various formulations and concentrations registered for use in Oklahoma crop production. As a result, there are often questions about proper use rates and adjuvants for these products. This fact sheet will help explain some of the subtle differences between glyphosate products that can impact use and important considerations when using glyphosate.

Glyphosate Use Rates

Active ingredient (also referred to as "ai") and acid equivalent ("ae") may sound alike, but they have different purposes for calculating the appropriate rate of glyphosate to apply.

On the herbicide label, glyphosate is listed as the active ingredient in the form of a salt. The amount of active ingredient, usually 4 pounds to 6 pounds per gallon, refers to the total amount of glyphosate salt in the product. Depending on the product, the salt is a combination of glyphosate acid combined with ammonium, diammonium, dimethylammonium, isopropylamine, and/or potassium. Despite the different salt formulations available, it is important to know that the type of salt formulation does not affect weed control, but rather it is simply the way glyphosate is formulated as a concentration.

In the case of glyphosate, it is the acid portion that provides the herbicide activity. To determine the appropriate use rate, you must consider the amount of glyphosate acid per gallon of product. This information is often found below the active ingredient portion on the product label. Glyphosate products are available as formulations of 3; 3.7; 4; 4.17; 4.5; or 5 pounds of acid equivalent per gallon. Therefore, depending on the amount of acid equivalent per gallon of product, the use rate must be adjusted accordingly to apply an equal amount of glyphosate acid if using different products. Table 1 summarizes use rates for the various glyphosate formulations.

For most postemergence applications in glyphosate-resistant crops, the recommended glyphosate rate is 0.75 pounds of acid equivalent per acre. Depending on the glyphosate product, this means that use rates could range from 20 fluid ounces to 32 fluid ounces per acre. Most Roundup™ brand products are used at 22 fluid ounces per acre, while most generic glyphosate products are used at 32 fluid ounces per acre. The difference in use rates is especially important to consider when comparing prices of glyphosate products with varying amounts of acid equivalent per gallon. Be sure to check the label to determine the amount of acid equivalent, appropriate rate to apply, and necessary adjuvants to improve weed control. Additionally, be sure to check the label for the

Table 1. Use rates for glyphosate products with various active ingredient (ai) and acid equivalent (ae) concentrations. Information regarding the amount of active ingredient and acid equivalent can be found on the product label. 0.75 pounds of acid equivalent per acre is considered to be the standard rate of glyphosate.

Glyphosate formulation		*Glyphosate application rate*		
		0.75 lbs ae/acre	*1.13 lbs ae/acre*	*1.5 lbs ae/acre*
		Standard 1x dose	*1.5x dose*	*2x dose*
lbs ai/gal	lbs ae/gal	fl oz/acre		
4	3	32	48	64
5	3.7	26	39	52
5.4	4	24	36	48
5	4.17	24	34	48
5.5	4.5	22	32	44
6	5	20	30	40

maximum amount of glyphosate that may be applied in a single application and for the entire growing season. Always use full rates of glyphosate—"cut rates" may save some money in the short run, but will quickly lead to the selection of glyphosate-resistant weeds.

Glyphosate Additives and Adjuvants

In addition to the amount of glyphosate acid, be sure to read the product label to determine if the addition of a surfactant is necessary. Many glyphosate products come "fully loaded," meaning they are formulated to include a surfactant. Some glyphosate products contain no surfactant or may require additional surfactant to increase activity. A non-ionic surfactant (NIS), at a rate of 0.25 percent to 1.0 percent (1 quart to 1 gallon per 100 gallons of spray solution), should be used for glyphosate products which require the addition of a surfactant. Crop oil concentrates (COC) or methylated seed oils (MSO) are not recommended for use with glyphosate. Previous research has indicated a reduction in weed control with glyphosate when using COC or MSO instead of NIS. When tank-mixing glyphosate with other herbicides or crop protection products, always check the labels to determine if additional adjuvants are required.

Adding ammonium sulfate (AMS) to the water in the spray tank before adding glyphosate will act as a water conditioner and improve weed control, regardless of whether or not a surfactant is needed. The sulfate component of AMS (SO_4^-) is negatively charged and will bind to positively charged hard water ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), and iron (Fe^{2+}), preventing the hard water ions from binding to the glyphosate molecule and decreasing its activity in the plant. Therefore, adding AMS to the spray solution after adding the glyphosate will do little to improve the herbicide's activity. Dry, spray-grade AMS should be added at a rate of 8.5 pounds to 17 pounds of AMS per 100 gallons of spray solution. Dry and liquid AMS replacement products are available, but when using them be sure to add them at a rate equal to 8.5 pounds to 17 pounds of AMS per 100 gallons of spray solution. Other nitrogen fertilizers, such as 28 percent urea ammonium nitrate (UAN), do not have the same water conditioning effects as AMS.

Glyphosate Application Timing

Like most herbicides, glyphosate will provide maximum activity on weeds when applied to small weeds. Generally, weeds should be 4 inches or less in height at the time of application. If the weeds are taller than 4 inches, do not expect to achieve satisfactory weed control with glyphosate alone.

Glyphosate-resistant Weeds in Oklahoma

Unfortunately, glyphosate-resistant weeds are becoming more and more common throughout the United States. In Oklahoma, populations of glyphosate-resistant marestail have been confirmed in several counties. Glyphosate-resistant pigweed species, particularly Palmer amaranth and waterhemp, are also becoming more common in soybean and cotton production fields. To prevent or delay the development of glyphosate-resistant weeds, it is necessary to rotate crops and use multiple herbicides and weed control methods. The easiest and most effective way to improve weed control and include additional herbicides is to use preemergence herbicides prior to or at planting. Over-reliance on glyphosate for weed control prior to planting, during the growing season, and after harvest greatly increases the chances for populations of glyphosate-resistant weeds to develop.

Additional resources

Oklahoma Department of Agriculture, Food, and Forestry Pesticide Registry Database. Available at http://www.kellysolutions.com/OK/pesticideindex.htm

"Herbicide How-To: Understanding herbicide mode of action. Oklahoma Cooperative Extension Service Fact Sheet PSS-2778. Available at http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-6656/PSS2778web.pdf

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