CONFUSING ISSUES ABOUT GLYPHOSATE

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The expiration of Monsanto's U.S. patent on glyphosate in September, 2000, provided marketing opportunities for several glyphosate products in agriculture. While the increase in the number of products has created competition and price benefits, it has also caused some confusion over a number of issues.

CONCENTRATION

The fact that many glyphosate products differ in their concentration makes it difficult to make a fair comparison of glyphosate rates. Comparing rates based on acid equivalents is usually the most logical way to evaluate products on equal terms. The acid equivalent deals with the parent molecule in the acid form. This is the part of the herbicide that does the killing.

Concentration can also be based on the active ingredient, which accounts for the parent acid plus a salt that is weakly bound to the acid. Glyphosate is formulated with a salt in order to help improve mixing with other chemicals and overall herbicide performance. The types of salts formulated in some glyphosate herbicides are indicated below:

PRODUCT	SALT
Roundup UltraMAX	isopropylamine
Touchdown IQ	diammonium
Credit Duo	monoammonium [1]
Roundup WeatherMAX	potassium
Touchdown 5	trimethylsulfonium [2]

[1] Diammonium also included in Credit Duo.
[2] No longer available.

Although many glyphosate labels list both acid equivalent and active ingredient, there are exceptions. The fact that the Roundup UltraMax label lists the amount of active ingredient, but not the amount of acid equivalent, makes it difficult to make a fair comparison of its rates to those of other products. It is interesting to note that the Touchdown IQ label lists the acid equivalent but does not list the amount of active ingredient.

SURFACTANT

The recommendations on use of surfactants can vary depending on the specific glyphosate product. While many glyphosate products already have some surfactant loaded in the formulation, their labels indicate that additional surfactant MAY BE used as an adjuvant. Additional surfactant might be a consideration in cases where there are large weeds, extremely dry conditions, high spray volumes, or extremely low rates.

In contrast, some glyphosate products do not have surfactant in the formulation; consequently, their labels REQUIRE that a nonionic surfactant be added to the spray tank mixture. These products are usually marketed in bulk quantities and used by commercial applicators, particularly those who want the flexibility in using their preferred brand of surfactant.

A third scenario deals with products which have a unique surfactant system in their formulations. For example, Roundup Ultra contains a cationic surfactant (polyoxyethylene tallow amine), compared with commonly used nonionic surfactants. The labels of these glyphosate formulations indicate to NOT add additional surfactant to the spray tank when they are applied alone.

AMMONIUM SULFATE

The labels of most, if not all, glyphosate products imply that weed control may be enhanced by including ammonium sulfate (AMS) as an adjuvant in the tank mixture. Achieving a consistent benefit from ammonium sulfate has been a matter of debate; however, there are circumstances where ammonium "may" help glyphosate performance. Examples where there can be a benefit from AMS are when glyphosate is tank mixed with certain soil-residual

herbicides; where weeds are not actively growing; where water hardness exceeds 500 ppm calcium or magnesium; or where certain weed species, such as velvetleaf are present.

One theory on how AMS is beneficial is believed to be associated with the binding of the sulfate portion of AMS with certain salts in water (example calcium and magnesium) that are considered to be antagonistic to glyphosate. Studies have shown that minute crystals form on leaf surfaces when AMS is applied to plants with glyphosate; yet these crystals are not present when AMS is not included in the spray mixture. Researchers speculate that the sulfate (negatively charged ion) combines with calcium (positively charged ion) to form a calcium sulfate complex which is not readily absorbed by plants.

Also, the ammonium ion, which is the positively charged portion of AMS, may compete with the calcium or magnesium ions to limit the amount of glyphosate being bound to the antagonistic ions.

Regardless of the water hardness, there are weed species, particularly velvetleaf, where AMS can improve control with glyphosate. This benefit is thought to be associated with high concentrations of calcium on leaf surfaces of velvetleaf plants. As in the case with hard water, the calcium on the leaf surface may bind the glyphosate to form a complex that is not easily absorbed.

Ammonium sulfate is commonly available as a dry crystalline product and retails for about $ 0.18/lb. Although there are exceptions, most glyphosate labels recommend dry AMS at a rate of 8.5 to 17 lbs/100 gallons of spray mixture. The 8.5 lb/100 gal rate is probably sufficient for most water source, yet there may be instances where the high rate of 17 lbs/100 gal is needed.

Glyphosate labels do not provide guidelines for determining the specific rate to use in the mixture. In the case of hard water, scientists at North Dakota State University have developed an equation for determining the rate needed to neutralize the negative affects of hard water. Their equation is as follows:

AMS (lb/100 gal) = 0.009 (ppm calcium) + 0.014 (ppm magnesium) + 0.002 (ppm potassium) + 0.005 (ppm sodium)

Obviously the water needs to be tested for such salts as calcium, magnesium, potassium, and sodium in order to utilize this equation.

AMS is also available as a liquid formulation. Some applicators prefer liquid over the dry form because of its convenience of measuring.

Some dry and liquid AMS products contain a blend of other adjuvants including surfactants, buffering agents, drift control additives, or defoamers. The fact that some glyphosate labels caution against using surfactants, buffering agents, or pH adjusting agents, makes it important to consult the glyphosate label as well as the AMS label to avoid any potential tank mix antagonism problems.

It is helpful to note that AMS is corrosive, therefore rinsing the spray equipment with water after use is important to the long-term maintenance of the sprayer.

RAINFASTNESS

The required rain-free periods for many postemergence herbicides are listed in specific minutes or hours on product labels. However, rainfast information on glyphosate labels is vague and varies with product. Approximately 60% of the labels we checked indicated the following statements: “Rainfall or irrigation occurring within 6 hours after application may reduce effectiveness. Heavy rainfall or irrigation within 2 hours after application may wash chemical off the foliage and a repeat treatment may be required.” The remaining product labels indicated the following: “Heavy rainfall or irrigation occurring soon after application may wash chemical off the foliage and a repeat treatment may be required for adequate control.”

Monsanto’s marketing literature indicate a rainfastness of 60 minutes for such products

as Roundup Ultra and Roundup UltraMAX. While the "Rainfast Warranty" has been used as a marketing strategy for positioning certain products, it is important to note that such information is not indicated on the product labels.

Scientists at University of Nebraska compared rainfastness of two products having different salts and inert ingredients. In their first experiment, Roundup UltraMAX (isopropylamine salt with "Transorb" surfactant system) was slightly more effective across washoff times than Touchdown (diammonium salt with unknown surfactant). However, the products did not differ in rainfastness when the experiment was repeated at a later date. Complete kill was achieved in 180 minutes in the first experiment and 120 minutes in the second experiment. Both formulations appeared to have substantial sorption at 15 and 30 minute washoff times.

While there may be differences in rainfastness among formulations, it is not clear if the difference will remain consistent across all environments or weed species.

DAY VS NIGHT APPLICATIONS

Although it has not been reported in Kentucky, there have been observations in other states of a decrease in glyphosate performance with evening applications.

One theory used to explain this response for some weeds, is associated with diurnal-leaf movement affecting herbicide interception. The leaves of velvetleaf, sickelpod, and hemp sesbania tend to hang vertically at night, while they move to horizontal position during the day. It is logical that these weeds will intercept more spray during the day than at night.

Research at University of Arkansas has shown that the diurnal response may be correlated with reduced control of hemp sesbania, but was less evident with sicklepod control.

Other researchers indicated that differences in physiological processes may explain the unique nighttime response. For example, the ESP enzyme (the target enzyme for glyphosate) requires substantially more glyphosate to reduce its activity in the dark than in the light.

It remains unclear whether the problems with night applications of glyphosate occur in Kentucky. In most cases, the advantage of making applications in the night, when wind speeds are usually minimal, probably outweigh the chance of reduced weed control, particularly where spray drift problems are a significant risk.

EFFICACY COMPARISON

Several universities have compared different glyphosate products for weed control. Most of the research indicates that all glyphosate products should provide effective control when they are applied at the recommended RATE to weeds that are ACTIVELY GROWING and at the PROPER SIZE at the time of application. Although some differences in products have been reported, these are usually small and variable across different environments and weed species.

The increasing interest in Roundup Ready® crops has lead to the development of several glyphosate products. Tables 1 and 2 lists some of the critical information on several products that contain glyphosate. These are intended to be used only as a guide for making comparisons across products. It is important to note that the label is the legal source of information.

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TABLE 1. IMPORTANT CHARACTERISTICS OF VARIOUS GLYPHOSATE PRODUCTS.

PRODUCT	COMPANY	FORM. (Lbs/gal)	SALT	ADJUVANT		RAIN-FREE PERIOD	ROUNDUP READY [4]		RATE COMPARISONS [5]	
				Surfactant	AMS [1]		CORN	SOYBEAN	EQUIVALENT TO: Roundup Original 1.5 pt/A	2 pt/A
									Acid Equivalent 0.56 ae/A	0.75 lb ae/A
Acquire	BASF	4lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	NL	NL	1.5 pt	2 pt
Buccaneer	TENKOZ	4 lb ai 3 lb ae	isoproplyamine	May be used 2-4 qt/100 gal	Optional	6 HR & 2 Hr [2]	NL	NL	1.5 pt	2 pt
Buccaneer Plus	TENKOZ	4 lb ai 3 lb ae	isopropylamine	Do Not Add when applied alone	Optional	No specific hrs [3]	L	L	1.5 pt	2 pt
ClearOut 41	Chemical Products Techn.	4lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100 gal	Optional	6 HR & 2 Hr [2]	NL	NL	1.5 pt	2 pt
ClearOut 41 Plus	Chemical Products Techn.	4 lb ai 3 lb ae	isopropylamine	Do Not Add when applied alone	Optional	No specific hrs [3]	NL	L	1.5 pt	2 pt
Cornerstone	Agriliance	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Credit Duo	Nufarm	3.97lb ai 3 lb ae	isopropylamine+ monoammonium (2.64+0.33)	May be used 1.5 qt/100gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Credit Systemic Extra	Nufarm	4 lb ai 3 lb ae	isopropylamine		Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Gly-Flo	Micro Flo	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Glyfos	Cheminova	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt

PRODUCT	COMPANY	FORM. (Lbs/gal)	SALT	ADJUVANT		RAIN-FREE PERIOD	ROUNDUP READY [4]		RATE COMPARISONS [5]	
				Surfactant	AMS [1]		CORN	SOYBEAN	EQUIVALENT TO Roundup Original 1.5 pt/A	2 pt/A
									Acid Equivalent 0.56 ae/A	0.75 lb ae/A
Glyfos X-TRA	Cheminova	4 lb ai 3 lb ae	isopropylamine	Do Not Add when applied alone	Optional	No specific hrs [3]	L	L	1.5 pt	2 pt
Glyphomax	Dow AgroSciences	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Glyphomax Plus	Dow AgroSciences	4 lb ai 3 lb ae	isopropylamine	Do Not Add when applied alone.	Optional	No specific hrs [3]	L	L	1.5 pt	2 pt
Glyphosate	DuPont	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	NL	NL	1.5 pt	2 pt
Glyphosate Original	Griffin	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	NL	L	1.5 pt	2 pt
Gly Star Original	Albaugh	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Gly Star Plus	Albaugh	4 lb ai 3 lb ae	isopropylamine	Do Not Add	Optional	No specific hrs [3]	L	L	1.5 pt	2 pt
Gly Star 5	Albaugh	5.4 lb ai 4 lb ae	isopropylamine	Required 2-4qt/100 gal	Optional	No specific hrs [3]	NL	NL	1.12 pt	1.5 pt
Honcho	Monsanto	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100 gal	Optional	6 HR & 2 Hr [2]	NL	NL	1.5 pt	2 pt
Mirage	Platte / Monsanto	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100 gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Rattler	Helena/ Monsanto	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	NL	NL	1.5 pt	2 pt

PRODUCT	COMPANY	FORM. (Lbs/gal)	SALT	ADJUVANT		RAIN-FREE PERIOD	ROUNDUP READY [4]		RATE COMPARISONS [5]	
				Surfactant	AMS [1]		CORN	SOYBEAN	EQUIVALENT TO Roundup Original 1.5 pt/A	2 pt/A
									Acid Equivalent 0.56 ae/A	0.75 lb ae/A
Roundup Original	Monsanto	4 lb ai 3 lb ae	isopropylamine	May be used 2 -4 qt/100gal	Optional	6 HR & 2 Hr [2]	L	L	1.5 pt	2 pt
Roundup Custom	Monsanto	5.4 lb ai 4 lb ae	isopropylamine	Required ≥2 qt/100 gal	Optional	No specific hrs [3]	NL	L	1.12 pt	1.5 pt
Roundup Ultra	Monsanto	4 lb/gal 3 lb ae	isopropylamine	Do Not Add when applied alone.	Optional	No specific hrs [3]	NL	L	1.5 pt	2 pt
Roundup Ultra Dry	Monsanto	71.4% ai 64.9% ae	ammonium	Do Not Add when applied alone.	Optional	No specific hrs [3]	L	L	0.86 lb	1.16 lb
Roundup UltraMAX	Monsanto	5 lb ai 3.73 lb ae	isopropylamine	Do Not Add when applied alone.	Optional	No specific hrs [3]	L	L	1.2 pt (20 oz)	1.6 pt (26 oz)
Roundup Weather MAX	Monsanto	5.5 lb ai 4.5 lb ae	potassium	Do Not Add when applied alone.	Optional	No specific hrs [2]	L	L	1 pt (16 oz)	1.33 pt (22 oz)
Silhouette	Agriliance	4 lb ai 3 lb ae	isopropylamine	May be used 2-4 qt/100gal	Optional	6 HR & 2 Hr [2]	NL	NL	1.5 pt	2 pt
Touchdown IQ	Syngenta	3.75 lb ai 3 lb ae	diammonium	May be used 1 qt/100gal	Optional	No specific hrs [3]	L	L	1.5 pt	2 pt

[1] AMS = Ammonium Sulfate. Most labels recommend dry AMS at 8.5 to 17 lb / 100 gal. Note that Touchdown IQ label recommends 4.25 to 17 lb /100gal.

[2] Rainfall or irrigation occurring within 6 hours after application may reduce effectiveness. Heavy rainfall or irrigation within 2 hours after application may wash chemical off the foliage and a repeat treatment may be required.

[3] Heavy rainfall or irrigation occurring soon after application may wash chemical off the foliage and a repeat treatment may be required for adequate control.

[4] Label directions for Roundup Ready® crops may be indicated on the main product label or on a separate supplemental label. **L= Labeled, NL = Not Labeled.**

[5] Herbicide rates used to compared with Roundup Original are approximate and have been rounded to the nearest whole number .

TABLE 2. IMPORTANT CHARACTERISTICS OF PREMIX FORMULATIONS CONTAINING GLYPHOSATE.

PRODUCT	COMPANY	INGREDIENTS (lbs/gal)	ADJUVANT		RAIN-FREE PERIOD	ROUNDUP READY [4]		RATE COMPARISONS [5]
			Surfactant	AMS [1]		CORN	SOYBEAN	EQUIVALENT TO
Backdraft SL	BASF	imazaquin (0.15 lb ai/gal) + glyphosate - IPA (1.2 5lb ai/gal)	Required 2 pt/100gal	Required 8.5-17 lb/100 gal	No specific hrs [3]	NL	L	BACKDRAFT 2.5 pt/A Scepter 2.1 oz/A RoundupUltra 1.5 pt/A
Extreme	BASF	imazethapyr (0.17 lb ai/gal) + glyphosate IPA (2 lb ai/gal)	Required 1 pt/100gal	Required 8.5-17 lb/100 gal	1 hr	NL	L	EXTREME 3pt/A Pursuit 1.45 oz/A Roundup Ultra 1.5 pt/A
FieldMaster	Monsanto	acetochlor (2 lb ai/gal) + atrazine (1.5 lb ai/gal) + glyphosate IPA (0.75 lb ai/gal) (0.56 lb ae/gal) Mon13900 safener	Additional NIS is not required	Optional	2 hrs	NL	NL	FIELD MASTER 4-5 qt/A Harness 2.3-2.85 pt/A Atrazine 3 - 3.75 pt/A Roundup Ultra 1.5-1.88 pt/A
Ready Master ATZ	Monsanto	atrazine (2 lbai /gal) + glyphosate IPA (2 lb ai/gal ipa) (1.5 lb ae/gal)	Additional NIS is not required	Optional	No specific hrs [3]	L	NL	READY MASTER ATZ 1.5 to 2 qt/A Atrazine 0.75 - 1 qt/A Roundup Ultra 1.5- 2 pt/A

[1] AMS = Ammonium Sulfate. Most labels recommend a rate of 8.5 to 17 lb / 100 gal. Note that Touchdown IQ label indicates 4.25 to 17 lb /100gal.

[2] Rainfall or irrigation occurring within 6 hours after application may reduce effectiveness. Heavy rainfall or irrigation within 2 hours after application may wash chemical off the foliage and a repeat treatment may be required.

[3] Heavy rainfall or irrigation occurring soon after application may wash chemical off the foliage and a repeat treatment may be required for adequate control.

[4] Label directions for Roundup Ready crops may be indicated on the main product label or on a separate supplemental label. **L= Labeled, NL = Not Labeled.**