

Evaluation of weed control strategies for Roundup Ready soybean in a hypothetical glyphosate resistant weed situation in soybean at Rochester, MN, in 2007 and 2008.

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INTRODUCTION AND BACKGROUND

According to the 2008 Minnesota Integrated Pest Management Assessment, 31% of the Minnesota farmers surveyed believe they have glyphosate resistant weeds on their farm. In addition, 63% choose to manage weed resistance by tank mixing additional herbicides with glyphosate. In 2009 preliminary survey results (SE data only), 35% believe they have glyphosate resistant weeds on their farm and 54% of growers choose to manage by tank mixing additional herbicides with glyphosate while only 26% choose a sequential (pre followed by postemergence) program.

Glyphosate is a valuable tool. It provides broad-spectrum weed control, is low in cost and has excellent crop safety. Glyphosate also controls larger weeds, has no soil residual and low environmental and human health risks. Diversification of weed management systems has been in decline in Midwestern corn and soybean production since the adoption of glyphosate-resistant crops over ten years ago. A high percentage of Minnesota acres are planted to glyphosate tolerant crops. For soybeans, approximately 98% of acres are treated with glyphosate with minimal use of preemergence herbicides. For corn, approximately 85% of acres are treated with glyphosate, and less than 50% of acres use a preemergence grass herbicide at the "glyphosate rate" (~1/2 of label rate). For sugar beet, the first year of introduction (2008) approximately 15% of acres in southern MN and approximately 50% of acres in northwestern MN were treated with glyphosate. This is expected to increase to 80% of MN sugar beet acres in 2009, with minimal use of preemergence herbicides.

In 2008, we experienced an increase in the number of fields with poor glyphosate performance, especially in soybean. The following weeds were most frequently reported: giant ragweed, common ragweed, tall waterhemp, common lambsquarters, barnyardgrass, and wild buckwheat. The most likely cause for the increase in glyphosate's lack of performance is an area of uncertainty. It may be due to poor application technique; poor timing; environment; weed spectrum with extended or delayed emergence patterns, and/or inherent tolerance to glyphosate; or repeated use of the same herbicide resulting in selection for resistance.

The following species have demonstrated resistance to glyphosate at 4 to 8 X rates: giant ragweed (south central and west central MN), common ragweed (central and northwest MN), tall waterhemp (south central, southwest, and west central MN). Note there are indicators that some of these biotypes could also be resistant to ALS herbicides. Fields with the highest frequency to glyphosate resistant giant and common ragweed are associated with lack of crop rotation, no-till, total postemergence weed control practices, one or two applications per year, lack of chemical rotation, continuous glyphosate applications in corn and soybean rotation.

Tank mixing a second herbicide with glyphosate can reduce convenience, increase costs and the risk of crop injury, as well as limit the window of application for other herbicide (s) in the tank mix. Management of glyphosate resistant weeds in glyphosate tolerant crops will be a major problem facing the farmers in Minnesota.

The good news, there is still time to adopt good management practices, limit the selection of additional glyphosate resistant weeds, and extend the benefit of glyphosate and Roundup-Ready crop technology. Strategies to adopt include:

1. Increase chemical diversity in corn and soybean acres to help delay herbicide resistance development. Consider alternating Roundup Ready crops with Liberty Link technology or a conventional herbicide program. Consider in which crop you could most easily substitute other herbicides for glyphosate or consider in which crop you are most dependent upon the effectiveness of glyphosate. Also, don't forget to consider the influence of herbicide selection on crop rotation interval.

2. Utilize other modes of action by using a preemergence herbicide or tank-mix partners.
3. Increase the use of residual herbicides
4. Scout fields soon after herbicide applications to detect escapes and take timely action.
5. Avoid multiple glyphosate applications

OBJECTIVE

The objective of this trial was to evaluate weed control strategies for glyphosate tolerant soybean in a hypothetical glyphosate resistant weed situation in soybean in southeastern Minnesota. The intent of this study was to determine how we could improve weed control above and beyond glyphosate by itself. The glyphosate rate used in this study would be considered ½ X (half rate) of the suggested labeled use rate. Comparisons were made to the one-pass glyphosate treatment

METHOD

In 2007, the research site was a Lawler loam series with a pH of 6.8 and soil test P and K levels of 12 ppm and 171 ppm, respectively. The field was spring disked and field cultivated prior to planting. The soybean variety, Dairyland DSR 199, was planted on May 17, 2007, at a depth of 1.5 inches in 30-inch rows at 150,000 seeds per acre. A randomized complete block design was used with four replications. preemergence (PRE) and postemergence (POST I, POST II, and POST III) treatments were applied with a tractor-mounted sprayer delivering 20 gpa at 32 psi using Turbo Tee 11002 nozzles. Evaluations of the plots were taken on June 6, 14, 20, 28, July 6, 18, and September 14. The center two rows of each plot were machine harvested on October 4, 2007.

In 2008, the research site was a Lawler loam series with a pH of 6.9 and soil test P and K levels of 19 ppm and 112 ppm, respectively. The field was spring disked and field cultivated prior to planting. The soybean variety, Dairyland DSR 1302, was planted on May 23, 2008, at a depth of 1.5 inches in 30-inch rows at 150,000 seeds per acre. A randomized complete block design was used with four replications. Preplant incorporated (PPI), preemergence (PRE) and postemergence (POST) treatments were applied with a tractor-mounted sprayer delivering 20 gpa at 32 psi using Turbo Tee 11002 nozzles. Evaluations of the plots were taken on June 23 and 30, July 7, 16, 28, and September 19, 2008. Application dates, environmental conditions, crop and weed stages are listed in Tables 1 and 2. The center two rows of each plot were machine harvested on October 10, 2008.

CONCLUSIONS

Tables 3 - 7 provide the herbicide results by weed species for 2008. Tables 8 – 11, provide performance details of herbicide tank mix partners and preemergence sequential programs in 2007 and 2008 for the control of giant ragweed, common lambsquarters common waterhemp and velvetleaf (2008 only).

Tank-Mix Partners: No one tank-mix partner provided 90% or better control of all four weed species evaluated. The addition of FirstRate as a tank mix partner, gave 90% control of giant ragweed in 2007 but only 80% control in 2008. Harmony GT and Pursuit as tank mix partners gave 94% and 96% , respectively, control of common lambsquarters in 2007, but only Harmony GT resulted in 90% control in 2008. For common waterhemp, Flexstar was the only tank mix partner that resulted in 90% control and this only occurred in 2008. For velvetleaf, the addition of Cadet resulted in 95% control in 2008.

Sequential, Preemergence Systems: The sequential programs provided many more options that resulted in 90% or more control of all four weed species. In addition, Gangster provided over 90% control of all four species in 2007 and 2008. Preemergence programs with Prefix resulted in over 90% control of giant ragweed, common lambsquarters, and common waterhemp in 2007 and 2008, but only 74% control of velvetleaf. Enlite, Valor, Sonic, Authority MTZ and Authority Assist provided over 90% control of common lambsquarters, common waterhemp and velvetleaf. The only sequential program that resulted in poor control of all weed species was Prowl, applied PPI. (University of Minnesota Extension Regional Office – Rochester)

Table 1. 2007 Application dates, environmental conditions, crop, and weed stages.

Date	5/18	6/15	6/20	7/6
Treatment	PRE	POST I	POST II	POST III
Temperature (F)				
Air	69	82	86	79
soil	--	79	81.7	79
Relative Humidity (%)	48	50	30	50
Wind (mph)	12	8	15	3
Soil moisture	Inadequate	Adequate	Adequate	Inadequate
Bean				
stage	--	V2	V3	R1
height (inch)	--	5.0	8.5	13.0
Giant Ragweed				
weed density (ft ²)	--	11.4	11.4	11.4
height (inch)	--	6.8	9.7	5.3
Common Lambsquarters				
weed density (ft ²)	--	5.4	5.4	5.4
height (inch)	--	1.6	4.2	4.1
Common Waterhemp				
weed density (ft ²)	--	13.8	13.8	13.8
height (inch)	--	2.4	2.9	4.0
Giant Foxtail				
weed density (ft ²)	--	20.3	20.3	20.3
height (inch)	--	2.4	6.6	2.9
Rainfall after each application (inch)				
week 1	2.41	2.97	2.09	0.66
week 2	1.25	0.52	0.21	0.50
week 3	0.44	0.21	0.66	

Table 2. 2008 Application dates, environmental conditions, crop, and weed stages.

Date	5/23	5/23	6/30	7/8
Treatment	PPI	PRE	POST I	POST II
Temperature (F)				
Air	67	67	77	80
soil	68	68	76	84
Relative Humidity (%)	45	45	32	46
Wind (mph)	14	14	7	15
Soil moisture	Inadequate	Inadequate	Adequate	Adequate
Soybean				
stage			V2	R1
height (inch)			8.0	12.0
Giant Ragweed				
weed density (ft ²)			4.0	4.0
height (inch)			8.0	13.5
Common Lambsquarters				
weed density (ft ²)			3.7	3.7
height (inch)			2.1	3.3
Common Waterhemp				
weed density (ft ²)			77.1	77.1
height (inch)			1.9	7.5
Giant Foxtail				
weed density (ft ²)			7.7	7.7
height (inch)			5.9	3.3
Velvetleaf				
weed density (ft ²)			1.6	1.6
height (inch)			2.0	3.0
Rainfall after each application (inch)				
week 1	2.15	2.15	0.87	0.92
week 2	2.61	2.61	0.92	0.60
week 3	5.86	5.86	0.59	0.03

Table 3. Performance of herbicide systems for giant ragweed control in soybean on June 23, July 7, 16, 28 and September 19 at Rochester, MN in 2008.

Treatment	Rate	Giant Ragweed Control					Yield
		6/23	7/7	7/16	7/28	9/19	
	(rate/A)	(%)					(bu/A)
Untreated		0	0	0	0	0	3
PPI/POST I							
Prowl H2O/ Roundup Original + NIS + AMS	3 pt/ 16 fl oz + 0.25% v/v + 2 lb	0	75	70	75	65	15
PRE/POST I							
Gangster V + Gangster FR/ Roundup Original + NIS + AMS	2.5 oz wt + 0.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	94	91	97	97	96	20
Enlite/ Roundup Original + NIS + AMS	2.8 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	80	86	89	92	87	20
Valor/ Roundup Original + NIS + AMS	2.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	24	85	82	89	79	21
Valor/ Cobra + Roundup Original + COC + AMS	2.5 oz wt/ 6 fl oz + 16 fl oz + 1.25% v/v + 2 lb	19	89	83	92	89	21
Sonic/ Roundup Original + NIS + AMS	3 oz wt/ 16 fl oz + 0.25% v/v + 2 lbs	86	88	83	89	83	18
Prefix/ Roundup Original + NIS + AMS	1.75 pt/ 16 fl oz + 0.25% v/v + 2 lbs	80	92	92	97	95	16
Authority MTZ/ Roundup Original + NIS + AMS	10 oz wt / 16 fl oz + 0.25% v/v + 2 lbs	13	61	70	79	72	14
Authority Assist/ Roundup Original + NIS + AMS	12 fl oz/ 16 fl oz + 0.25% v/v + 2 lbs	72	81	80	88	79	21
POST I							
Roundup Original + NIS + AMS	16 fl oz + 0.25% v/ + 2 lbs	0	76	71	81	71	12
FlexStar + Roundup Original + NIS + AMS	12 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	85	82	83	80	16
Cobra + Roundup Original + NIS + AMS	6 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	85	79	84	77	12
Resource + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	81	68	71	55	14
Cadet + Roundup Original + NIS + AMS	0.4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	76	66	76	56	11
FirstRate + Roundup Original + NIS + AMS	0.3 oz wt +16 fl oz + 0.25% v/ + 2 lbs	0	73	78	84	80	12
Synchrony XP + Roundup Original + NIS + AMS	0.375 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	77	74	78	64	16
Classic + Roundup Original + NIS + AMS	0.5 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	76	74	79	69	15
Harmony GT + Roundup Original + NIS + AMS	0.33 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	74	71	74	64	12
Pursuit + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	76	74	73	68	10
LSD (P=0.10)		3	5	3	5	4	4.6

Table 4. Performance of herbicide systems for common lambsquarters control in soybean on June 23, July 7, 16, 28 and September 19 at Rochester, MN in 2008.

Treatment	Rate	Common Lambsquarters Control					Yield
		6/23	7/7	7/16	7/28	9/19	
	(rate/A)	(%)					(bu/A)
Untreated		0	0	0	0	0	3
PPI/POST I							
Prowl H2O/ Roundup Original + NIS + AMS	3 pt/ 16 fl oz + 0.25% v/v + 2 lb	65	53	91	93	66	15
PRE/POST I							
Gangster V + Gangster FR/ Roundup Original + NIS + AMS	2.5 oz wt + 0.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	99	99	99	99	20
Enlite/ Roundup Original + NIS + AMS	2.8 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	99	99	99	99	20
Valor/ Roundup Original + NIS + AMS	2.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	99	96	98	92	21
Valor/ Cobra + Roundup Original + COC + AMS	2.5 oz wt/ 6 fl oz + 16 fl oz + 1.25% v/v + 2 lb	99	99	98	95	93	21
Sonic/ Roundup Original + NIS + AMS	3 oz wt/ 16 fl oz + 0.25% v/v + 2 lbs	99	98	99	97	99	18
Prefix/ Roundup Original + NIS + AMS	1.75 pt/ 16 fl oz + 0.25% v/v + 2 lbs	88	98	94	96	93	16
Authority MTZ/ Roundup Original + NIS + AMS	10 oz wt / 16 fl oz + 0.25% v/v + 2 lbs	99	99	99	97	99	14
Authority Assist/ Roundup Original + NIS + AMS	12 fl oz/ 16 fl oz + 0.25% v/v + 2 lbs	99	99	99	98	99	21
POST I							
Roundup Original + NIS + AMS	16 fl oz + 0.25% v/ + 2 lbs	0	43	64	87	76	12
FlexStar + Roundup Original + NIS + AMS	12 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	90	84	89	80	16
Cobra + Roundup Original + NIS + AMS	6 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	46	79	82	73	12
Resource + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	30	85	86	63	14
Cadet + Roundup Original + NIS + AMS	0.4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	39	81	88	79	11
FirstRate + Roundup Original + NIS + AMS	0.3 oz wt +16 fl oz + 0.25% v/ + 2 lbs	0	51	75	85	73	12
Synchrony XP + Roundup Original + NIS + AMS	0.375 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	51	77	88	75	16
Classic + Roundup Original + NIS + AMS	0.5 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	56	82	87	86	15
Harmony GT + Roundup Original + NIS + AMS	0.33 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	70	90	81	90	12
Pursuit + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	50	83	86	84	10
LSD (P=0.10)		2	6	4	4	4	4.3

Table 5. Performance of herbicide systems for common waterhemp control in soybean on June 23, July 7, 16, 28 and September 19 at Rochester, MN in 2008.

Treatment	Rate	Common Waterhemp Control					Yield
		6/23	7/7	7/16	7/28	9/19	
	(rate/A)	(%)					(bu/A)
Untreated		0	0	0	0	0	3
PPI/POST I							
Prowl H2O/ Roundup Original + NIS + AMS	3 pt/ 16 fl oz + 0.25% v/v + 2 lb	71	85	86	87	65	15
PRE/POST I							
Gangster V + Gangster FR/ Roundup Original + NIS + AMS	2.5 oz wt + 0.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	86	96	99	99	20
Enlite/ Roundup Original + NIS + AMS	2.8 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	96	99	99	99	20
Valor/ Roundup Original + NIS + AMS	2.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	98	94	96	91	21
Valor/ Cobra + Roundup Original + COC + AMS	2.5 oz wt/ 6 fl oz + 16 fl oz + 1.25% v/v + 2 lb	93	99	99	97	99	21
Sonic/ Roundup Original + NIS + AMS	3 oz wt/ 16 fl oz + 0.25% v/v + 2 lbs	99	99	98	93	97	18
Prefix/ Roundup Original + NIS + AMS	1.75 pt/ 16 fl oz + 0.25% v/v + 2 lbs	99	98	95	97	95	16
Authority MTZ/ Roundup Original + NIS + AMS	10 oz wt / 16 fl oz + 0.25% v/v + 2 lbs	99	99	96	94	99	14
Authority Assist/ Roundup Original + NIS + AMS	12 fl oz/ 16 fl oz + 0.25% v/v + 2 lbs	99	99	99	97	99	21
POST I							
Roundup Original + NIS + AMS	16 fl oz + 0.25% v/ + 2 lbs	0	40	55	77	65	12
FlexStar + Roundup Original + NIS + AMS	12 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	95	92	90	90	16
Cobra + Roundup Original + NIS + AMS	6 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	95	88	87	85	12
Resource + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	53	70	70	63	14
Cadet + Roundup Original + NIS + AMS	0.4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	51	59	76	56	11
FirstRate + Roundup Original + NIS + AMS	0.3 oz wt +16 fl oz + 0.25% v/ + 2 lbs	0	41	59	77	56	12
Synchrony XP + Roundup Original + NIS + AMS	0.375 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	48	69	81	65	16
Classic + Roundup Original + NIS + AMS	0.5 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	50	75	80	63	15
Harmony GT + Roundup Original + NIS + AMS	0.33 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	50	75	86	64	12
Pursuit + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	43	67	81	58	10
	LSD (P=0.10)	2	4	5	6	5	4.3

Table 6. Performance of herbicide systems for velvetleaf control in soybean on June 23, July 7, 16, 28 and September 19 at Rochester, MN in 2008.

Treatment	Rate	Velvetleaf Control					Yield
		6/23	7/7	7/16	7/28	9/19	
	(rate/A)	(%)					(bu/A)
Untreated		0	0	0	0	0	3
PPI/POST I							
Prowl H2O/ Roundup Original + NIS + AMS	3 pt/ 16 fl oz + 0.25% v/v + 2 lb	50	41	74	90	54	15
PRE/POST I							
Gangster V + Gangster FR/ Roundup Original + NIS + AMS	2.5 oz wt + 0.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	99	99	99	99	20
Enlite/ Roundup Original + NIS + AMS	2.8 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	98	98	99	97	20
Valor/ Roundup Original + NIS + AMS	2.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	99	96	99	99	98	21
Valor/ Cobra + Roundup Original + COC + AMS	2.5 oz wt/ 6 fl oz + 16 fl oz + 1.25% v/v + 2 lb	99	99	97	98	95	21
Sonic/ Roundup Original + NIS + AMS	3 oz wt/ 16 fl oz + 0.25% v/v + 2 lbs	99	97	96	98	93	18
Prefix/ Roundup Original + NIS + AMS	1.75 pt/ 16 fl oz + 0.25% v/v + 2 lbs	55	56	86	98	74	16
Authority MTZ/ Roundup Original + NIS + AMS	10 oz wt / 16 fl oz + 0.25% v/v + 2 lbs	98	99	98	99	99	14
Authority Assist/ Roundup Original + NIS + AMS	12 fl oz/ 16 fl oz + 0.25% v/v + 2 lbs	99	99	99	99	99	21
POST I							
Roundup Original + NIS + AMS	16 fl oz + 0.25% v/ + 2 lbs	0	67	64	90	61	12
FlexStar + Roundup Original + NIS + AMS	12 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	93	87	92	69	16
Cobra + Roundup Original + NIS + AMS	6 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	87	81	92	64	12
Resource + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	98	94	97	83	14
Cadet + Roundup Original + NIS + AMS	0.4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	97	96	98	95	11
FirstRate + Roundup Original + NIS + AMS	0.3 oz wt +16 fl oz + 0.25% v/ + 2 lbs	0	83	80	92	61	12
Synchrony XP + Roundup Original + NIS + AMS	0.375 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	81	78	92	64	16
Classic + Roundup Original + NIS + AMS	0.5 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	73	73	88	60	15
Harmony GT + Roundup Original + NIS + AMS	0.33 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	79	80	95	65	12
Pursuit + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	66	78	93	66	10
LSD (P=0.10)		2	10	3	3	4	4.3

Table 7. Performance of herbicide systems for giant foxtail control in soybean on June 23, July 7, 16, 28 and September 19 and soybean injury on July 16 at Rochester, MN in 2008.

Treatment	Rate (rate/A)	Giant Foxtail Control				Injury	Yield
		6/23	7/7	7/16	7/28	7/16	(bu/A)
Untreated		0	0	0	0	0	3
PPI/POST I							
Prowl H2O/ Roundup Original + NIS + AMS	3 pt/ 16 fl oz + 0.25% v/v + 2 lb	81	94	98	99	0	15
PRE/POST I							
Gangster V + Gangster FR/ Roundup Original + NIS + AMS	2.5 oz wt + 0.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	92	86	99	99	0	20
Enlite/ Roundup Original + NIS + AMS	2.8 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	85	91	99	99	0	20
Valor/ Roundup Original + NIS + AMS	2.5 oz wt/ 16 fl oz + 0.25% v/v + 2 lb	78	97	92	99	0	21
Valor/ Cobra + Roundup Original + COC + AMS	2.5 oz wt/ 6 fl oz + 16 fl oz + 1.25% v/v + 2 lb	76	93	93	97	21	21
Sonic/ Roundup Original + NIS + AMS	3 oz wt/ 16 fl oz + 0.25% v/v + 2 lbs	66	94	88	98	0	18
Prefix/ Roundup Original + NIS + AMS	1.75 pt/ 16 fl oz + 0.25% v/v + 2 lbs	98	99	98	99	0	16
Authority MTZ/ Roundup Original + NIS + AMS	10 oz wt / 16 fl oz + 0.25% v/v + 2 lbs	76	95	98	99	0	14
Authority Assist/ Roundup Original + NIS + AMS	12 fl oz/ 16 fl oz + 0.25% v/v + 2 lbs	94	99	99	99	0	21
POST I							
Roundup Original + NIS + AMS	16 fl oz + 0.25% v/ + 2 lbs	0	90	97	98	0	12
FlexStar + Roundup Original + NIS + AMS	12 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	92	94	99	16	16
Cobra + Roundup Original + NIS + AMS	6 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	90	96	99	25	12
Resource + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	88	97	99	11	14
Cadet + Roundup Original + NIS + AMS	0.4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	89	96	99	14	11
FirstRate + Roundup Original + NIS + AMS	0.3 oz wt +16 fl oz + 0.25% v/ + 2 lbs	0	88	97	99	0	12
Synchrony XP + Roundup Original + NIS + AMS	0.375 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	90	97	99	0	16
Classic + Roundup Original + NIS + AMS	0.5 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	89	96	99	0	15
Harmony GT + Roundup Original + NIS + AMS	0.33 oz wt + 16 fl oz + 0.25% v/ + 2 lbs	0	89	97	98	0	12
Pursuit + Roundup Original + NIS + AMS	4 fl oz + 16 fl oz + 0.25% v/ + 2 lbs	0	89	98	99	11	10
LSD (P=0.10)		5	4	3	1	3	4.3

Table 8. Performance comparison of glyphosate tank mix partners to one-pass glyphosate in 2007 and 2008.

Postemergence Tank Mix partners	Giant Ragweed		Common Lambsquarters		Common Waterhemp		Velvetleaf	
	2007	2008	2007	2008	2007	2008	2007	2008
Flexstar	84	80	63	80	88	90	NR	69
Cobra	82	77	56	73	86	85	NR	64
Resource	66	55	75	63	73	63	NR	83
Cadet	NR	56	NR	79	NR	56	NR	95
FirstRate	90	80	70	73	78	56	NR	61
Classic (0.25 oz)	73	NR	63	NR	64	NR	NR	NR
Classic (0.5 oz)	80	69	68	86	69	63	NR	60
Synchrony XP	78	64	71	75	71	65	NR	64
Harmony GT	75	64	94	90	65	64	NR	65
Pursuit	86	68	96	84	60	58	NR	66
One Pass Glyphosate	78%	71%	60%	76%	73%	65%	NR	61%

Table 9. Performance comparison of sequential soil applied herbicides to one-pass glyphosate in 2007 and 2008.

SEQUENTIALS Preemergence / Postemergence	Giant Ragweed		Common Lambsquarters		Common Waterhemp		Velvetleaf	
	2007	2008	2007	2008	2007	2008	2007	2008
Prowl	NR	65	NR	66	NR	65	NR	54
Gangster	93	96	99	99	99	99	NR	99
Gangster / Glyphosate + Cobra	96	NR	96	NR	99	NR	NR	NR
Enlite	NR	87	NR	99	NR	99	NR	97
Valor	84	79	96	92	99	91	NR	98
Valor / Glyphosate + Cobra	88	89	97	93	98	99	NR	95
Sonic	88	83	99	99	94	97	NR	93
Prefix	97	95	92	93	99	95	NR	74
Authority MTZ	77	72	99	99	97	99	NR	99
Authority Assist	NR	79	NR	99	NR	99	NR	99
One Pass Glyphosate	78%	71%	60%	76%	73%	65%	NR	61%

Table 10. Performance comparison of glyphosate tank mix partners to one-pass glyphosate in 2007 and 2008.

Postemergence Tank Mix partners	Giant Ragweed		Common Lambsquarters		Common Waterhemp		Velvetleaf	
	2007	2008	2007	2008	2007	2008	2007	2008
Flexstar	+	+	=	=	+	++	NR	+
Cobra	=	+	=	=	+	+	NR	=
Resource	-	-	+	-	=	=	NR	+
Cadet	NR	-	NR	=	NR	-	NR	++
FirstRate	++	+	+	=	=	-	NR	=
Classic (0.25 oz)	=	NR	=	NR	-	NR	NR	NR
Classic (0.5 oz)	=	=	+	+	=	=	NR	=
Synchrony XP	=	-	+	=	=	=	NR	=
Harmony GT	=	-	++	++	-	=	NR	=
Pursuit	+	=	++	+	-	-	NR	+
One Pass Glyphosate	78%	71%	60%	76%	73%	65%		61%

Table 11. Performance comparison of sequential soil applied herbicides to one-pass glyphosate in 2007 and 2008.

SEQUENTIALS Preemergence / Postemergence	Giant Ragweed		Common Lambsquarters		Common Waterhemp		Velvetleaf	
	2007	2008	2007	2008	2007	2008	2007	2008
Prowl	NR	-	NR	-	NR	=	NR	-
Gangster	++	++	++	++	++	++	NR	++
Gangster / Glyphosate + Cobra	++	NR	++	NR	++	NR	NR	NR
Enlite	NR	+	NR	++	NR	++	NR	++
Valor	+	+	++	++	++	++	NR	++
Valor / Glyphosate + Cobra	+	+	++	++	++	++	NR	++
Sonic	+	+	++	++	++	++	NR	++
Prefix	++	++	++	++	++	++	NR	+
Authority MTZ	=	=	++	++	++	++	NR	++
Authority Assist	NR	+	NR	++	NR	++	NR	++
One Pass Glyphosate	78%	71%	60%	76%	73%	65%	NR	61%

(++) is 90% or better control

(+) is significantly higher control than one-pass glyphosate, but less than 90%

(=) is the same control as one-pass glyphosate

(-) is significantly lower control than one-pass glyphosate

NR = Not rated or treatment not included