Evaluation of Weed Control Strategies for Roundup Ready Soybean in a Hypothetical Glyphosate Resistant Weed Situation in Soybean at Rochester, MN, in 2007, 2008, and 2009

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INTRODUCTION AND BACKGROUND

According to the 2008 and 2009 Minnesota Integrated Pest Management Assessment, approximately one-third of Southern MN farmers believe they have glyphosate resistant weeds on their farm. Approximately 60% of those farmers indicated they would manage glyphosate resistant weeds by tank mixing additional herbicides with glyphosate, while 40% would use a preemergence product. In 2008 and 2009, 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 resistance (giant and common ragweed) are associated with lack of crop rotation, no-till, total postemergence weed control practices, one or two applications of glyphosate per year, lack of chemical rotation, and continuous glyphosate applications in corn and soybean rotation. It is difficult to verify the percent of farms with glyphosate resistant weeds, but glyphosate resistant populations of common waterhemp and giant ragweed have been identified in Minnesota (Heap, 2008).

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). 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 to improve weed control above and beyond glyphosate by itself.

Field research was conducted at Rochester, MN in 2007, 2008 and 2009 to determine which tank mix components and sequential herbicide applications improved glyphosate efficacy. 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. 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. In 2009, the research site was a Lawler loam series with a pH 6.6 and soil test P and K levels of 62 ppm and 188 ppm, respectively. The fields were spring disked and field cultivated once prior to planting. A randomized complete block design with four replications was used. Soybean varieties 'Dairyland DSR 199', 'Dairyland DSR 1302' and 'Asgrow AG2108', were planted on May 17, 2007, May 23, 2008, and May 19, 2009, respectively. Seeds were planted 1.0 inch deep in 30 inch rows at a rate of 150,000 seeds/acre. All herbicide applications were made with a tractor-mounted sprayer delivering 20 gallons/acre at 32 psi using 11002 Turbo-Tee nozzles.

A reduced rate of glyphosate at 16 fl oz/acre was evaluated and compared to a series of glyphosate tank mixtures and sequential herbicide applications. The reduced glyphosate rate was used to better determine the effect of the tank mix and sequential herbicide treatments on weed control. Visual weed control ratings were conducted for giant ragweed, common lambsquarters, common waterhemp, velvetleaf and giant foxtail. Ratings were conducted multiple times each season, (June 6, 14, 20, 28, July 6, 18, and September 14, 2007), (June 23 and 30, July 7, 16, 28, and September 19, 2008), and (June 15, 30, July 7, 13, 20, and 29, 2009). Table 1 lists application dates, environmental conditions, crop and weed stages. Tables 2 through 7 provide the herbicide results by weed species, crop injury and grain yield for 2009. Tables 8, 9, and 10, provide performance details of herbicide tank mix partners and preemergence sequential programs in 2007, 2008, and 2009. The center two rows of each plot were machine harvested on October 4, 2007, October 10, 2008 and October 20, 2009.

CONCLUSIONS

- Over 90% control of giant ragweed was achieved with two sequential programs in 2007 and 2008 and four in 2009. Prefix provided over 90% control in all years. Only one tank mix program in 2007, FirstRate, achieved 90% control of giant ragweed. Across years, four tank mixes and one sequential program resulted in significantly reduced control of giant ragweed compared to glyphosate alone.
- All sequential programs obtained 90% or greater control of common lambsquarters, except for Prowl H_2O in 2008 and Prefix in 2009. Only two tank mix programs provided over 90% control in 2007 and 2009 and none gave over 90% control in 2008.
- All sequential programs provided over 90% control of common waterhemp, except Prowl H_2O. Only one tank mix, Prowl H_2O / Flexstar gave over 90% control. However, four tank mix programs resulted in significantly reduced common waterhemp control compared to glyphosate alone.
- All tank mix programs caused significant crop injury in 2009 because STS soybean varieties were unavailable.
- In 2009, soybean yield for tank mix programs were either no different or significantly lower than glyphosate alone, except for FirstRate which gave significantly greater weed control with the least crop injury at 13%. The majority of the sequential programs had significantly higher yields compared to glyphosate alone or the tank mix programs, and achieved significantly greater overall weed control.
- Sequential herbicide programs provide the best choice for improved weed control and soybean yield. Although some sequential treatments had weaknesses with certain weed species, weaknesses were more evident with the tank mix treatments to the point that some tank mix treatments were antagonistic. For appropriate product selection it is important to know what weeds are the major problem in a field. Weed populations with cross resistance to multiple modes of action will further complicate product selection. (University of Minnesota Extension Regional Office, Rochester)

Table 1. Application dates, environmental conditions, crop, and weed stages for 2007, 2008, and 2009.

	2007				2008				2009				
Date	**5/18**	**6/15**	**6/20**	**7/6**	**5/23**	**5/23**	**6/30**	**7/8**	**5/19**	**5/19**	**6/19**	**6/22**	**6/26**
Treatment	**PRE**	**POST I**	**POST II**	**POST III**	**PPI**	**PRE**	**POST I**	**POST II**	**PPI**	**PRE**	**POST I**	**POST II**	**POST III**
Temperature (F)													
Air	69	82	86	79	67	67	77	80	83	93	78	89	86
soil	--	79	81.7	79	68	68	76	84	69.8	72.3	75	81	84.2
Relative Humidity (%)	48	50	30	50	45	45	32	46	38	23	68	51	37
Wind (mph)	12	8	15	3	14	14	7	15	16	23	14	8	0
Soil moisture	Inadequate	Adequate	Adequate	Inadequate	Inadequate	Inadequate	Adequate	Adequate	Inadequate	Inadequate	Excessive	Excessive	Inadequate
Soybean													
stage		V2	V3	R1			V2	R1			V1	V2	V3
height (inch)		5.0	8.5	13.0			8.0	12.0			3.0	7.0	7.6
Giant Ragweed													
weed density (ft^2)		11.4	11.4	11.4			4.0	4.0			7.5	7.5	7.5
height (inch)		6.8	9.7	5.3			8.0	13.5			8.9	9.6	9.8
Common Lambsquarters													
weed density (ft^2)		5.4	5.4	5.4			3.7	3.7			2.6	2.6	2.6
height (inch)		1.6	4.2	4.1			2.1	3.3			1.8	1.5	2.3
Common Waterhemp													
weed density (ft^2)		13.8	13.8	13.8			77.1	77.1			8.4	8.4	8.4
height (inch)		2.4	2.9	4.0			1.9	7.5			1.4	1.5	3.3
Giant Foxtail													
weed density (ft^2)		20.3	20.3	20.3			7.7	7.7					
height (inch)		2.4	6.6	2.9			5.9	3.3			2.5	4.4	4.7
Velvetleaf													
weed density (ft^2)							1.6	1.6				1.5	2.0
height (inch)							2.0	3.0					
Rainfall after each application (inch)													
week 1	2.41	2.97	2.09	0.66	2.15	2.15	0.87	0.92	1.13	1.13	0.21	0.18	0.18
week 2	1.25	0.52	0.21	0.50	2.61	2.61	0.92	0.60	0.82	0.82	0.17	0.27	0.99
week 3	0.44	0.21	0.66		5.86	5.86	0.59	0.03	1.75	1.75	0.15	0.79	0.06

Table 2. Performance of herbicide systems for giant ragweed control in soybeans and grain yield at 13% at Rochester, MN, in 2009.

Treatment	Rate	Giant Ragweed Control						Yield
		6/15	6/30	7/6	7/13	7/20	7/29	
	(rate/A)	(%)						(bu/A)
PPI/POST I								
Prowl H_2O / Flexstar + Glyphosate + NIS + AMS	3 pt/a / 12 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	94	93	90	88	85	25.8 ghi
Prowl H_2O / Glyphosate + NIS + AMS	3 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	82	90	86	87	82	30.4 def
PRE/POST I								
Gangster V + Gangster FR / Glyphosate + NIS + AMS	2.5 oz wt/a + 0.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	85	74	88	84	86	85	35.4 ab
Enlite / Glyphosate + NIS + AMS	2.8 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	65	85	96	93	93	91	34.6 abc
Valor / Glyphosate + NIS + AMS	2.5 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	26	84	95	91	96	89	31.1 c-f
OpTill / Glyphosate + NIS + AMS	2 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	70	89	96	95	95	93	35.7 a
Sonic / Glyphosate + NIS + AMS	4.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	89	80	95	93	94	92	36.8 a
Prefix / Glyphosate + NIS + AMS	2 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	77	71	97	97	97	96	34.8 abc
Boundary / Glyphosate + NIS + AMS	1.8 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	24	83	94	94	92	89	33.9 a-d
Authority Assist / Glyphosate + NIS + AMS	12 fl oz/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	80	77	92	87	90	87	33.6 a-d
POST I								
Glyphosate + NIS + AMS	16 fl oz/a + 0.25% v/v + 2 lb/a	0	83	86	82	78	74	28.3 e-h
Flexstar + Glyphosate + NIS + AMS	12 fl oz/a +16 fl oz/a + 0.25% v/v + 2 lb/a	0	95	94	91	87	81	27.9 fgh
Cobra + Glyphosate + NIS + AMS	6 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	91	93	89	84	79	23.0 ij
Flexstar + Harmony SG + Glyphosate + NIS + AMS	12 fl oz/a + 0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	94	96	89	87	76	23.3 ij
Cadet + Glyphosate + NIS + AMS	0.4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	74	85	78	73	69	24.8 hi
FirstRate + Glyphosate + NIS + AMS	0.3 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	85	94	91	91	86	31.8 b-e
Synchrony XP + Glyphosate + NIS + AMS	0.375 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	77	89	85	83	76	20.2 j
Classic + Glyphosate + NIS + AMS	0.33 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	80	88	85	78	75	26.0 ghi
Harmony SG + Glyphosate + NIS + AMS	0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a		79	88	85	80	70	21.1 j
Pursuit + Glyphosate + NIS + AMS	4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	83	92	91	91	87	28.7 efg
	LSD (P=0.10)	**4**	**5**	**3**	**4**	**6**	**5**	**3.7**

Table 3. Performance of herbicide systems for common lambsquarters control in soybeans and grain yield at 13% at Rochester, MN, in 2009.

Treatment	Rate	Common Lambsquarters Control						Yield
		6/15	6/30	7/6	7/13	7/20	7/29	
	(rate/A)	(%)						(bu/A)
PPI/POST I								
Prowl H_2O / Flexstar + Glyphosate + NIS + AMS	3 pt/a / 12 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	86	94	95	94	90	89	25.8 ghi
Prowl H_2O / Glyphosate + NIS + AMS	3 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	88	95	95	91	93	90	30.4 def
PRE/POST I								
Gangster V + Gangster FR / Glyphosate + NIS + AMS	2.5 oz wt/a + 0.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	90	93	77	85	84	35.4 ab
Enlite / Glyphosate + NIS + AMS	2.8 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	95	96	94	34.6 abc
Valor / Glyphosate + NIS + AMS	2.5 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	53	92	97	93	92	93	31.1 c-f
OpTill / Glyphosate + NIS + AMS	2 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	97	97	96	35.7 a
Sonic / Glyphosate + NIS + AMS	4.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	98	98	96	98	95	36.8 a
Prefix / Glyphosate + NIS + AMS	2 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	75	77	86	81	79	75	34.8 abc
Boundary / Glyphosate + NIS + AMS	1.8 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	98	99	99	97	97	94	33.9 a-d
Authority Assist / Glyphosate + NIS + AMS	12 fl oz/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	97	99	99	98	99	94	33.6 a-d
POST I								
Glyphosate + NIS + AMS	16 fl oz/a + 0.25% v/v + 2 lb/a	0	90	92	87	86	71	28.3 e-h
Flexstar + Glyphosate + NIS + AMS	12 fl oz/a +16 fl oz/a + 0.25% v/v + 2 lb/a	0	86	82	78	76	74	27.9 fgh
Cobra + Glyphosate + NIS + AMS	6 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	91	92	85	86	82	23.0 ij
Flexstar + Harmony SG + Glyphosate + NIS + AMS	12 fl oz/a + 0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	93	94	90	89	86	23.3 ij
Cadet + Glyphosate + NIS + AMS	0.4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	93	93	78	85	80	24.8 hi
FirstRate + Glyphosate + NIS + AMS	0.3 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	92	95	94	90	91	31.8 b-e
Synchrony XP + Glyphosate + NIS + AMS	0.375 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	94	95	92	91	88	20.2 j
Classic + Glyphosate + NIS + AMS	0.33 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	94	95	87	87	86	26.0 ghi
Harmony SG + Glyphosate + NIS + AMS	0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a		91	92	83	85	85	21.1 j
Pursuit + Glyphosate + NIS + AMS	4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	97	97	93	93	93	28.7 efg
	LSD (P=0.10)	**4**	**6**	**4**	**8**	**7**	**7**	**3.7**

Table 4. Performance of herbicide systems for common waterhemp control in soybeans and grain yield at 13% at Rochester, MN, in 2009.

Treatment	Rate	Common Waterhemp Control						Yield
		6/15	6/30	7/6	7/13	7/20	7/29	
	(rate/A)	(%)						(bu/A)
PPI/POST I								
Prowl H_2O / Flexstar + Glyphosate + NIS + AMS	3 pt/a / 12 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	89	97	97	97	96	94	25.8 ghi
Prowl H_2O / Glyphosate + NIS + AMS	3 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	92	97	94	92	92	86	30.4 def
PRE/POST I								
Gangster V + Gangster FR / Glyphosate + NIS + AMS	2.5 oz wt/a + 0.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	93	97	98	96	97	92	35.4 ab
Enlite / Glyphosate + NIS + AMS	2.8 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	96	99	98	97	98	94	34.6 abc
Valor / Glyphosate + NIS + AMS	2.5 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	80	99	99	97	97	95	31.1 c-f
OpTill / Glyphosate + NIS + AMS	2 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	70	97	97	94	91	91	35.7 a
Sonic / Glyphosate + NIS + AMS	4.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	96	99	98	97	98	95	36.8 a
Prefix / Glyphosate + NIS + AMS	2 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	96	98	99	95	98	95	34.8 abc
Boundary / Glyphosate + NIS + AMS	1.8 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	96	99	98	99	97	93	33.9 a-d
Authority Assist / Glyphosate + NIS + AMS	12 fl oz/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	96	99	99	98	99	95	33.6 a-d
POST I								
Glyphosate + NIS + AMS	16 fl oz/a + 0.25% v/v + 2 lb/a	0	85	87	74	73	68	28.3 e-h
Flexstar + Glyphosate + NIS + AMS	12 fl oz/a +16 fl oz/a + 0.25% v/v + 2 lb/a	0	95	96	91	88	86	27.9 fgh
Cobra + Glyphosate + NIS + AMS	6 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	95	96	89	89	82	23.0 ij
Flexstar + Harmony SG + Glyphosate + NIS + AMS	12 fl oz/a + 0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	93	93	90	91	89	23.3 ij
Cadet + Glyphosate + NIS + AMS	0.4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	89	86	78	74	71	24.8 hi
FirstRate + Glyphosate + NIS + AMS	0.3 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	92	90	87	87	76	31.8 b-e
Synchrony XP + Glyphosate + NIS + AMS	0.375 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	90	92	87	83	73	20.2 j
Classic + Glyphosate + NIS + AMS	0.33 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	88	92	85	81	75	26.0 ghi
Harmony SG + Glyphosate + NIS + AMS	0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	91	91	84	79	74	21.1 j
Pursuit + Glyphosate + NIS + AMS	4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	86	90	83	80	70	28.7 efg
	LSD (P=0.10)	**5**	**5**	**3**	**4**	**4**	**5**	**3.7**

Table 5. Performance of herbicide systems for giant foxtail control in soybeans and grain yield at 13% at Rochester, MN, in 2009.

Treatment	Rate	Giant Foxtail Control					Yield
		6/15	6/30	7/6	7/13	7/20	
	(rate/A)	(%)					(bu/A)
PPI/POST I							
Prowl H_2O / Flexstar + Glyphosate + NIS + AMS	3 pt/a / 12 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	83	98	98	98	98	25.8 ghi
Prowl H_2O / Glyphosate + NIS + AMS	3 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	86	99	98	98	98	30.4 def
PRE/POST I							
Gangster V + Gangster FR / Glyphosate + NIS + AMS	2.5 oz wt/a + 0.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	83	78	98	98	97	35.4 ab
Enlite / Glyphosate + NIS + AMS	2.8 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	73	99	98	97	97	34.6 abc
Valor / Glyphosate + NIS + AMS	2.5 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	65	99	99	99	97	31.1 c-f
OpTill / Glyphosate + NIS + AMS	2 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	63	97	99	98	96	35.7 a
Sonic / Glyphosate + NIS + AMS	4.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	78	79	98	99	98	36.8 a
Prefix / Glyphosate + NIS + AMS	2 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	93	86	99	99	99	34.8 abc
Boundary / Glyphosate + NIS + AMS	1.8 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	91	99	99	98	98	33.9 a-d
Authority Assist / Glyphosate + NIS + AMS	12 fl oz/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	81	83	99	99	99	33.6 a-d
POST I							
Glyphosate + NIS + AMS	16 fl oz/a + 0.25% v/v + 2 lb/a	0	99	98	96	92	28.3 e-h
Flexstar + Glyphosate + NIS + AMS	12 fl oz/a +16 fl oz/a + 0.25% v/v + 2 lb/a	0	99	96	94	93	27.9 fgh
Cobra + Glyphosate + NIS + AMS	6 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	97	97	95	94	23.0 ij
Flexstar + Harmony SG + Glyphosate + NIS + AMS	12 fl oz/a + 0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	97	98	97	96	23.3 ij
Cadet + Glyphosate + NIS + AMS	0.4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	98	97	91	91	24.8 hi
FirstRate + Glyphosate + NIS + AMS	0.3 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	98	97	93	91	31.8 b-e
Synchrony XP + Glyphosate + NIS + AMS	0.375 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	97	93	93	92	20.2 j
Classic + Glyphosate + NIS + AMS	0.33 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	99	98	96	93	26.0 ghi
Harmony SG + Glyphosate + NIS + AMS	0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	97	97	94	93	21.1 j
Pursuit + Glyphosate + NIS + AMS	4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	99	98	93	89	28.7 efg
	LSD (P=0.10)	**5**	**3**	**2**	**3**	**4**	**3.7**

Table 6. Performance of herbicide systems for velvetleaf control in soybeans and grain yield at 13% at Rochester, MN, in 2009.

Treatment	Rate	Velvetleaf Control				Yield
		6/30	7/6	7/13	7/20	
	(rate/A)	(%)				(bu/A)
PPI/POST I						
Prowl H_2O / Flexstar + Glyphosate + NIS + AMS	3 pt/a / 12 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	99	25.8 ghi
Prowl H_2O / Glyphosate + NIS + AMS	3 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	98	99	99	97	30.4 def
PRE/POST I						
Gangster V + Gangster FR / Glyphosate + NIS + AMS	2.5 oz wt/a + 0.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	99	35.4 ab
Enlite / Glyphosate + NIS + AMS	2.8 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	98	99	99	99	34.6 abc
Valor / Glyphosate + NIS + AMS	2.5 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	94	98	97	98	31.1 c-f
OpTill / Glyphosate + NIS + AMS	2 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	99	35.7 a
Sonic / Glyphosate + NIS + AMS	4.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	98	99	99	36.8 a
Prefix / Glyphosate + NIS + AMS	2 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	84	94	95	93	34.8 abc
Boundary / Glyphosate + NIS + AMS	1.8 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	99	33.9 a-d
Authority Assist / Glyphosate + NIS + AMS	12 fl oz/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	99	33.6 a-d
POST I						
Glyphosate + NIS + AMS	16 fl oz/a + 0.25% v/v + 2 lb/a	96	98	99	98	28.3 e-h
Flexstar + Glyphosate + NIS + AMS	12 fl oz/a +16 fl oz/a + 0.25% v/v + 2 lb/a	98	98	99	99	27.9 fgh
Cobra + Glyphosate + NIS + AMS	6 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	96	97	98	98	23.0 ij
Flexstar + Harmony SG + Glyphosate + NIS + AMS	12 fl oz/a + 0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	98	99	99	99	23.3 ij
Cadet + Glyphosate + NIS + AMS	0.4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	99	99	99	99	24.8 hi
FirstRate + Glyphosate + NIS + AMS	0.3 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	97	98	98	97	31.8 b-e
Synchrony XP + Glyphosate + NIS + AMS	0.375 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	98	99	99	99	20.2 j
Classic + Glyphosate + NIS + AMS	0.33 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	97	96	98	97	26.0 ghi
Harmony SG + Glyphosate + NIS + AMS	0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	95	97	96	96	21.1 j
Pursuit + Glyphosate + NIS + AMS	4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	97	98	99	99	28.7 efg
	LSD (P=0.10)	**5**	**2**	**2**	**3**	**3.7**

Table 7. Soybean injury resulting from herbicide systems and grain yield at 13% at Rochester, MN, in 2009.

Treatment	Rate	Injury 6/29	Injury 7/6	Yield
	(rate/A)	(%)		(bu/A)
PPI/POST I				
Prowl H_2O / Flexstar + Glyphosate + NIS + AMS	3 pt/a / 12 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	29	15	25.8 ghi
Prowl H_2O / Glyphosate + NIS + AMS	3 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	0	30.4 def
PRE/POST I				
Gangster V + Gangster FR / Glyphosate + NIS + AMS	2.5 oz wt/a + 0.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	5	35.4 ab
Enlite / Glyphosate + NIS + AMS	2.8 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	0	34.6 abc
Valor / Glyphosate + NIS + AMS	2.5 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	0	3	31.1 c-f
OpTill / Glyphosate + NIS + AMS	2 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	0	35.7 a
Sonic / Glyphosate + NIS + AMS	4.5 oz wt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	0	36.8 a
Prefix / Glyphosate + NIS + AMS	2 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	16	34.8 abc
Boundary / Glyphosate + NIS + AMS	1.8 pt/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	0	33.9 a-d
Authority Assist / Glyphosate + NIS + AMS	12 fl oz/a / 16 fl oz/a + 0.25% v/v + 2 lb/a	0	4	33.6 a-d
POST I				
Glyphosate + NIS + AMS	16 fl oz/a + 0.25% v/v + 2 lb/a	0	0	28.3 e-h
Flexstar + Glyphosate + NIS + AMS	12 fl oz/a +16 fl oz/a + 0.25% v/v + 2 lb/a	32	15	27.9 fgh
Cobra + Glyphosate + NIS + AMS	6 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	36	18	23.0 ij
Flexstar + Harmony SG + Glyphosate + NIS + AMS	12 fl oz/a + 0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	54	21	23.3 ij
Cadet + Glyphosate + NIS + AMS	0.4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	25	15	24.8 hi
FirstRate + Glyphosate + NIS + AMS	0.3 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	13	4	31.8 b-e
Synchrony XP + Glyphosate + NIS + AMS	0.375 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	46	21	20.2 j
Classic + Glyphosate + NIS + AMS	0.33 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	24	15	26.0 ghi
Harmony SG + Glyphosate + NIS + AMS	0.125 oz wt/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	40	20	21.1 j
Pursuit + Glyphosate + NIS + AMS	4 fl oz/a + 16 fl oz/a + 0.25% v/v + 2 lb/a	24	10	28.7 efg
	LSD (P=0.10)	**3**	**4**	**3.7**

1. Means followed by the same letter do not significantly differ (P=.10, LSD)

Table 8. Control of giant ragweed, common lambsquarters, and common waterhemp (07-09) and soybean injury and yield for 2009 sequential and tank mix programs at Rochester, MN											
	Giant Ragweed			Common Lambsquarters			Common Waterhemp			INJURY	YIELD
	2007	2008	2009	2007	2008	2009	2007	2008	2009	6/26/09	2009
PRE/POST[1]	% control									%	Bu/A
Enlite / glyphosate	NR[2]	87	91	NR[2]	99	94	NR[2]	99	94	0	35
Gangster V + Gangster FR / glyphosate	93	96	85	99	99	84	99	99	92	0	35
OpTill / glyphosate	NR[2]	NR[2]	93	NR[2]	NR[2]	96	NR[2]	NR[2]	91	0	36
Sonic / glyphosate	88	83	92	99	99	95	94	97	95	0	37
Authority Assist / glyphosate	NR[2]	79	87	NR[2]	99	94	NR[2]	99	95	0	34
Authority MTZ / glyphosate	77	72	NR[2]	99	99	NR[2]	97	99	NR[2]	0	NR[2]
Valor / glyphosate	84	79	89	96	92	93	99	91	95	0	31
Prefix / glyphosate	97	95	96	92	93	75	99	95	95	0	35
Boundary / glyphosate	NR[2]	NR[2]	89	NR[2]	NR[2]	94	NR[2]	NR[2]	93	0	34
Prowl H_2O / glyphosate	NR[2]	65	82	NR[2]	66	90	NR[2]	65	86	0	30
POST[3]											
glyphosate[3] alone	78	71	74	60	76	71	73	65	67.5	0	28
Classic + glyphosate	80	69	75	68	86	86	69	63	75	24	26
FirstRate + glyphosate	90	80	86	70	73	91	78	56	76	13	32
Pursuit + glyphosate	86	68	87	96	84	93	60	58	70	24	29
Synchrony XP + glyphosate	78	64	76	71	75	88	71	65	73	46	20
Harmony GT + glyphosate	75	64	70	94	90	85	65	64	74	40	21
Flexstar + Harmony GT + glyphosate	NR[2]	NR[2]	76	NR[2]	NR	86	NR[2]	NR[2]	89	54	23
Flexstar + glyphosate	84	80	81	63	80	74	88	90	86	32	28
Cadet + glyphosate	NR[2]	56	68.8	NR[2]	79	80	NR[2]	56	71	25	25
Cobra + glyphosate	82	77	79	56	73	82	86	84	82	36	23
Resource + glyphosate	66	55	NR[2]	75	63	NR[2]	73	63	NR[2]	NR[2]	NR[2]
Prowl H_2O fb glyphosate + Flexstar	NR[2]	NR[2]	85	NR[2]	NR[2]	89	NR[2]	NR[2]	94	29	26
LSD α = 0.10	5	4	5	6	4	7	6	5	5	3	4

Table 9.

Rochester, MN Credit: F. Breitenbach, L. Behnken, R. Miller	Giant Ragweed			Common Lambsquarters			Common Waterhemp		
Sequential PRE/POST programs	2007	2008	2009	2007	2008	2009	2007	2008	2009
Glyphosate alone	78	71	74	60	76	71	73	65	68
Valor	+	+	+	++	++	++	++	++	++
Gangster V & FR	++	++	+	++	++	+	++	++	++
Prefix	++	++	++	++	++	=	++	++	++
Sonic	+	+	++	++	++	++	++	++	++
Enlite		+	++		++	++		++	++
Authority MTZ	=	=		++	++		++	++	
Authority Assist		+	+		++	++		++	++
Prowl H_2O		-	+		-	+		-	+
OpTill			++			++			++
Boundary			+			++			++

(++) 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

Table 10.

Rochester, MN Credit: F. Breitenbach, L. Behnken, R. Miller	Giant Ragweed			Common Lambsquarters			Common Waterhemp		
Postemergence Tank mix program	2007	2008	2009	2007	2008	2009	2007	2008	2009
Glyphosate alone	78	71	74	60	76	71	73	65	68
FirstRate	++	+	+	+	=	++	=	-	+
Classic	=	=	=	+	+	+	=	=	+
Synchrony XP	=	-	=	+	=	+	=	=	+
Flexstar	+	+	+	=	+	=	+	++	+
Pursuit	+	=	+	++	+	++	-	-	=
Cobra	=	+	=	=	=	+	+	+	+
Harmony GT	=	-	=	++	++	+	-	=	=
Resource	-	-		+	-		=	=	
Cadet		-	-		=	+		-	=

(++) 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