

Final Project Report to the NYS IPM Program, Agricultural IPM 2000 – 2001

Title:

Reduced Rates of Roundup Ultra and Tank-Mix Partners for Herbicide Resistance Management

Project Leader(s):

Russell R. Hahn
Department of Crop and Soil Sciences

Cooperator(s):

None

Type of grant:

Pheremonies; biorationale; microbiale; conventional pesticides

Project location(s):

Findings might be applied throughout the Northeast.

Abstract:

Since Roundup (glyphosate) herbicide was introduced in the mid-1970's, it has become the most widely used herbicide in the world. Until recently, most of this use was as a between crop applications. The introduction of Roundup Ready soybeans and corn in 1996 and 1998 respectively has drastically changed the way this herbicide is used. Prior to this new technology, Roundup was used in combination with other weed management practices, including herbicides with different modes-of-action. With Roundup Ready crops, the temptation, and in many cases, the recommendation will be to use this non-selective herbicide alone in some cropping systems. The development of glyphosate-resistant weed populations has been limited compared to resistance problems with other classes of herbicides. Only four species have developed in glyphosate-resistant populations after 26 years of glyphosate use. As glyphosate becomes more widely used than in the past, and with the possibility of multiple applications within a single growing season, selection pressure for developing glyphosate-resistant weed populations will increase. There is little evidence to date that residual herbicides are needed for Roundup Ready soybean or corn weed control programs in New York, so the temptation for growers will be to use Roundup alone. Preliminary results from 1999 showed that 1/4X and 1/2X rates of Roundup Ultra in combinations with a 1/2X rate of Scorpion III (a mixture of flumetsulam, clopyralid, and

2,4-D) provided excellent control of annual weeds, including velvetleaf which is not always well controlled with Roundup alone.

Field experiments were conducted in 2000 and 2001 at Aurora and Mt. Morris, NY to determine the efficacy of reduced (1/4X and 1/2X) rates of Roundup Ultra in combinations with 1/2X rates of tank-mix partners in Roundup Ready7 corn. Roundup Ultra at 0.5 and 1 pt/A was applied early and mid-postemergence (EPO and MPO) in combinations with 1/2X rates of AAtrex, 2,4-D, Clarity, Hornet, and Scorpion III. Each experiment also included EPO and MPO applications of 2 pt/A of Roundup Ultra alone, a preemergence (PRE) standard treatment of 1.5 qt/A of Bicep Lite II Magnum plus 3.6 pt/A of Prowl, and an untreated check.

There were no differences between the average yield of the EPO and MPO applications in any of the four experiments and the average yield of all Roundup Ultra applications was not different from those of the PRE standard. At Aurora, the average yield of all Roundup Ultra treatments was 128 and 140 bu/A in 2000 and 2001 respectively compared with 130 and 147 bu/A for the PRE standard. At Mt. Morris, the average yield of all Roundup Ultra treatments was 176 and 185 bu/A in 2000 and 2001 respectively compared with 188 and 190 bu/A for the PRE standard. Weed control and corn yields were affected by herbicide treatments in some instances. At Aurora in 2001, control of all species was good to excellent with the reduced rate combinations except for common lambsquarters control. EPO and MPO applications of 0.5 pt/A of Roundup Ultra plus 1 oz/A of Hornet controlled only 63 and 73% of the lambsquarters respectively compared with an average of 96% with the other reduced rate combinations. The average yield for this combination was 126 bu/A compared with 143 bu/A for the other reduced rate combinations. At Mt. Morris, the dominant weeds were redroot pigweed and common lambsquarters in 2000. Pigweed control was good to excellent with all treatments but lambsquarters control was reduced with application of 0.5 pt/A of Roundup Ultra plus 1 oz/A of Hornet. The EPO and MPO applications of this combination controlled 86 and 80% of the lambsquarters respectively compared with an average of 98% with the other reduced rate combinations. Reduced lambsquarters control did not result in yield reductions at this location. In 2001 the dominant weeds were velvetleaf and redroot pigweed. Velvetleaf control was 82% with the 0.5 pt/A rate of Roundup Ultra tank mixes and 93% with the 1 pt/A Roundup Ultra tank mixes. The EPO application of 0.5 pt/A of Roundup Ultra plus 1 pt/A of AAtrex only controlled 55% of the velvetleaf. Pigweed control with 0.5 pt/A rates of Roundup Ultra plus 1 oz/A of Hornet averaged 87% compared with 98% for 0.5 pt/A of Roundup Ultra with the other tank mix partners. There were no differences in yield among the herbicide treatments at Mt. Morris in 2001. These results suggest that the 0.5 pt/A rate of Roundup Ultra may not be reliable in all situations and that Hornet may not be a reliable tank mix partner for common lambsquarters control. On the other hand, the 1 pt/A (1/2X) rate of Roundup Ultra in combinations with 1/2X rate of AAtrex, 2,4-D, Clarity, and Scorpion III did provide control of a broad spectrum of annual grass and broadleaf weeds. Yields of these reduced-rate combinations did not differ from those of the PRE standard and each combination involved herbicides with two or three different modes-of-action. Such combinations would delay/prevent the development of Roundup resistant weed populations.

Background and justification:

Since Roundup (glyphosate) herbicide was introduced in the mid-1970's, it has become the most widely used herbicide in the World. Until recently, most of this use was as a between crop applications. The introduction of Roundup Ready soybeans and corn in 1996 and 1998 respectively has drastically changed the way this herbicide is used. Prior to this new technology, Roundup was used in combination with other weed control practices, including herbicides with different modes-of-action. With Roundup Ready crops, the temptation, and in many cases, the recommendation will be to use this non-selective herbicide alone in some cropping systems. The development of glyphosate-resistant weed populations has been limited compared to resistance problems with other classes of herbicides. Only four species have developed glyphosate-resistant populations after 26 years of Roundup use. Glyphosate-resistant populations of rigid ryegrass (*Lolium rigidum* Gaudin) were confirmed in Australia (1996) and in California (1998). Glyphosate-resistant goosegrass [*Eleusine indica* (L.) Gaertn.] populations have been identified in Malaysia (1997). Now, glyphosate resistance has been confirmed for horseweed [*Conyza canadensis* (L.) Crong.] in Delaware (2000) and for Italian ryegrass (*Lolium multiflorum* Lam.) in Chile (2001). As glyphosate becomes more widely used than in the past, and with the possibility of multiple applications within a single growing season, selection pressure for developing glyphosate-resistant populations will increase.

There is little evidence to date that residual herbicides are needed for Roundup Ready soybean or corn weed control programs in New York, so the temptation for growers will be to use Roundup alone. Preliminary results from 1999 showed that 1/4X and 1/2X rates of Roundup Ultra in combinations with a 1/2X rate of Scorpion III (a mixture of flumetsulam, clopyralid, and 2,4-D) provided excellent control of annual weeds, including velvetleaf (*Abutilon theophrasti* medicus) which is not always well controlled with Roundup alone. This tank-mixture included reduced rates of herbicides with three different modes-of-action. Such tank mixes could be an important tool in glyphosate resistance management and would use a minimum amount of active ingredients per acre.

Objectives:

Evaluate the efficacy of reduced rates (1/4X and 1/2X) of Roundup Ultra in combinations with reduced rates of other postemergence corn herbicides.

Procedures:

Field experiments were conducted at the Musgrave Research Farm in Cayuga County and near Mt. Morris in Livingston County in 2000 and 2001 respectively. Corn >DK520RR= was planted June 1, 2000 and May 16, 2001 in Cayuga County and on May 31, 2000 and May 24, 2001 in Livingston County. Herbicide treatments were applied to 10 by 25 foot plots in a split plot design with four replications with application timing as main plots and herbicide treatments as subplots. A preemergence (PRE) standard herbicide treatment of 1.5 qt/A of Bicep Lite II Magnum (S-metolachlor and atrazine) plus 3.6 pt/A of Prowl (pendimethalin) was applied in each experiment. Early postemergence (EPO) and mid-postemergence (MPO) applications of the 2 pt/A (X rate) of Roundup Ultra and of 0.5 and 1 pt/A rate of Roundup Ultra in combinations with 0.5 pt/A of Weedar 64 (2,4-D), 0.5 pt/A of Clarity (dicamba), 1 oz/A of Hornet WDG (flumetsulam and clopyralid) and 2 oz/A of Scorpion III in 2000. In 2001, Scorpion III was replaced with 1 pt/A of AAtrex since Scorpion III is no longer a commercial

product. In Cayuga County, the dominant weeds were common ragweed (*Ambrosia artemisiifolia* L.) and green foxtail [*Setaria viridis* (L.) Beauv.] in 2000 and wild mustard [*Brassica kaber* (D.C.) L.C. Wheeler] and common lambsquarters (*Chenopodium album* L.) in 2001. In Livingston County redroot pigweed (*Amaranthus retroflexus* L.) and velvetleaf were the dominant weeds. EPO and MPO herbicide applications were made when weeds averaged 3 to 6 inches tall and 8 to 12 inches tall respectively. Each experiment included an untreated check. Weed control ratings, as a percent of the untreated checks, were made in August in each experiment and corn grain yields harvested from the center two rows of each plot with a small-plot combine.

Results and discussion:

Cayuga County

In 2000, common ragweed control (Table 1) averaged 98% with the EPO and MPO applications of reduced rate Roundup Ultra tank mixes compared with 91 and 96% with the EPO and MPO applications of the full rate of Roundup Ultra. Ragweed control with the PRE standard of 1.5 qt/A of Bicep Lite II Magnum plus 3.6 pt/A of Prowl was 95%. Green foxtail control averaged 94% with the EPO and MPO applications of the reduced rate Roundup Ultra tank mixes. There was no difference between the 0.5 pt/A and 1 pt/A EPO Roundup Ultra combinations. When applied MPO, green foxtail control averaged 88% with the 0.5 pt/A Roundup Ultra combinations. This was significantly less than the 98% control achieved with the 1 pt/A Roundup Ultra combinations applied MPO. The full rate (2 pt/A) of Roundup Ultra provided 95 and 100% foxtail control when applied EPO and MPO respectively and the PRE standard controlled 100% of the foxtail. Although there were small differences in foxtail control at the MPO timing, the reduced rate Roundup Ultra combinations had an average yield of 127 bu/A and there were no significant differences among these treatments. The EPO and MPO applications of the full rate of Roundup Ultra alone averaged 133 bu/A and the PRE standard yielded 130 bu/A. The untreated check yielded only 56 bu/A.

In 2001 wild mustard control with the EPO and MPO applications of reduced rate Roundup Ultra tank mixes was 100 and 99% respectively (Table 2). This was similar to mustard control with the full rate of Roundup Ultra and with the PRE standard. EPO and MPO applications of 0.5 pt/A of Roundup Ultra plus 1 oz/A of Hornet controlled only 63 and 73% of the common lambsquarters respectively compared with an average of 96% with the other reduced rate combinations. The average yield for this combination was 126 bu/A compared with 143 bu/A for the other reduced rate combinations and there were no significant differences among yields from these other treatments. The EPO and MPO applications of the full rate of Roundup Ultra alone averaged 132 bu/A and the PRE standard yielded 147 bu/A. The untreated check yielded only 72 bu/A.

Livingston County

In 2000, velvetleaf control with reduced rate Roundup Ultra combinations was similar to that with the full rate of Roundup Ultra (99%) and with the PRE standard (97%) with several exceptions (Table 3). The MPO combinations of 0.5 pt/A of Roundup Ultra with 0.5 pt/A of

Clarity and with 1 oz/A of Hornet clearly provided less velvetleaf control (82%) than the standard programs. Likewise, redroot pigweed control with the reduced rate Roundup Ultra combinations compared favorably with the full rate of Roundup Ultra (100%) and with the PRE standard (100%) with the exception of the MPO application of 0.5 pt/A of Roundup Ultra with 2 oz/A Scorpion III which controlled 91% of the pigweed. Grain corn yield from the EPO and MPO full rate Roundup Ultra applications averaged 182 bu/A while the PRE standard yielded 188 bu/A. All of the reduced rate combination treatments compared favorably with these yields except the EPO applications of 0.5 pt/A of Roundup Ultra with Weedar 64 and of 1 pt/A of Roundup Ultra with Scorpion III which yielded 166 and 165 bu/A respectively. The untreated check yielded 158 bu/A.

In 2001, velvetleaf control averaged 82% with the 0.5 pt/A rate of Roundup Ultra tank mixes and 93% with the 1 pt/A Roundup Ultra tank mixes (Table 4). The EPO applications of 0.5 pt/A of Roundup Ultra plus 1 pt/A of AAtrex controlled only 55% of the velvetleaf compared with an average of 89% with the other 0.5 pt/A Roundup Ultra tank mixes. The EPO application of the 1 pt/A Roundup Ultra combination with 1 pt/A of AAtrex controlled 80% of the velvetleaf while the other 1 pt/A Roundup Ultra tank mixes provided an average velvetleaf control of 95%. Pigweed control with 0.5 pt/A rates of Roundup Ultra plus 1 oz/A of Hornet averaged 87% compared with 98% for 0.5 pt/A of Roundup Ultra with the other tank mix partners. The reduced rate of Roundup Ultra tank mixes produced an average grain corn yield of 184 bu/A and there were no differences among these treatments and they were not different from the full rate Roundup Ultra or PRE standard treatment. The EPO and MPO full rate of Roundup Ultra applications averaged 191 bu/A while the PRE standard yielded 190 bu/A and the untreated check yielded 159 bu/A.

The results from these four experiments demonstrated that all of the EPO and most of the MPO applications of the reduced rate Roundup Ultra combinations provided weed control and grain corn yields similar to the full rate of Roundup Ultra and to the PRE standard. Should these reduced rate combinations continue to perform favorably, there could be a significant reduction in the amount of herbicide active ingredient with these reduced rate combinations. The average amount of active ingredient for the 2001 treatment combination would be 0.69 and 0.94 lb ai/A for the 0.5 and 1 pt/A reduced rate Roundup Ultra combinations respectively compared with 11b ai/A for the 2 pt/A rate of Roundup Ultra alone and 3.74 lb ai/A for the PRE standard. In addition to a reduction in the active ingredient of herbicide applied per acre, each of these reduced rate combinations adds one or two different herbicide modes-of-action to the weed control programs. This should delay or prevent the development of glyphosate-resistant weed populations.

Table 1. Common ragweed (AMBEL) and green foxtail (SETVI) control and grain corn yields with reduced rates of Roundup Ultra and tank-mix partners in Cayuga County in 2000.

Herbicides	Rate Amt/A	-----EPO-----			-----MPO-----		
		<u>Control (%)</u>		Yield	<u>Control (%)</u>		Yield
		AMBE L	SETVI	(bu/A)	AMBE L	SETVI	(bu/A)
Roundup Ultra	2.0 pt	91	95	132	96	100	134
Roundup Ultra Weedar 64	0.5 pt 0.5 pt	96	93	123	96	89	126
Roundup Ultra Clarity	0.5 pt 0.5 pt	100	94	123	100	87	118
Roundup Ultra Hornet	0.5 pt 1.0 oz	100	95	129	97	87	122
Roundup Ultra Scorpion III	0.5 pt 2.0 oz	97	94	127	99	89	140
Roundup Ultra Weedar 64	1.0 pt 0.5 pt	95	97	125	100	97	139
Roundup Ultra Clarity	1.0 pt 0.5 pt	99	98	120	99	98	132
Roundup Ultra Hornet	1.0 pt 1.0 oz	99	95	126	99	100	128
Roundup Ultra Scorpion III	1.0 pt 2.0 oz	99	96	127	97	97	130
LSD (0.05)		4	6	31	4	6	31

Table 2. Common lambsquarters (CHEAL) and wild mustard (SINAR) control and grain corn yields with reduced rates of Roundup Ultra and tank-mix partners in Cayuga County in 2001.

Herbicides	Rate Amt/A	-----EPO-----			-----MPO-----		
		<u>Control (%)</u>		Yield	<u>Control (%)</u>		Yield
		CHEAL	SINAR	(bu/A)	CHEAL	SINAR	(bu/A)
Roundup Ultra	2.0 pt	96	100	133	100	99	131
Roundup Ultra Weedar 64	0.5 pt 0.5 pt	95	100	140	97	99	140
Roundup Ultra Clarity	0.5 pt 0.5 pt	100	100	144	95	99	141
Roundup Ultra Hornet	0.5 pt 1.0 oz	63	100	123	73	99	130
Roundup Ultra AAtrex	0.5 pt 1.0 pt	95	100	148	86	99	145
Roundup Ultra Weedar 64	1.0 pt 0.5 pt	99	100	149	100	99	141
Roundup Ultra Clarity	1.0 pt 0.5 pt	99	100	147	100	99	140
Roundup Ultra Hornet	1.0 pt 1.0 oz	90	100	145	91	99	137
Roundup Ultra AAtrex	1.0 pt 1.0 pt	100	100	146	100	99	145
LSD (0.05)		6	0	15	6	0	15

Table 3. Velvetleaf (ABUTH) and redroot pigweed (AMARE) control and grain corn yields with reduced rates of Roundup Ultra and tank-mix partners in Livingston County in 2000.

Herbicides	Rate Amt/A	-----EPO-----			-----MPO-----		
		Control (%)		Yield	Control (%)		Yield
		ABUTH	AMARE	(bu/A)	ABUTH	AMARE	(bu/A)
Roundup Ultra	2.0 pt	99	100	182	100	100	183
Roundup Ultra Weedar 64	0.5 pt 0.5 pt	99	100	166	96	99	178
Roundup Ultra Clarity	0.5 pt 0.5 pt	89	100	176	83	97	175
Roundup Ultra Hornet	0.5 pt 1.0 oz	97	97	176	81	96	177
Roundup Ultra Scorpion III	0.5 pt 2.0 oz	99	97	178	90	91	175
Roundup Ultra Weedar 64	1.0 pt 0.5 pt	99	100	171	94	100	183
Roundup Ultra Clarity	1.0 pt 0.5 pt	98	100	183	91	100	185
Roundup Ultra Hornet	1.0 pt 1.0 oz	94	100	178	89	100	171
Roundup Ultra Scorpion III	1.0 pt 2.0 oz	99	100	165	91	99	174
LSD (0.05)		10	4	19	10	4	19

Table 4. Velvetleaf (ABUTH) and redroot pigweed (AMARE) control and grain corn yields with reduced rates of Roundup Ultra and tank-mix partners in Livingston County in 2001.

Herbicides	Rate Amt/A	-----EPO-----			-----MPO-----		
		Control (%)		Yield	Control (%)		Yield
		ABUTH	AMARE	(bu/A)	ABUTH	AMARE	(bu/A)
Roundup Ultra	2.0 pt	96	100	194	100	100	187
Roundup Ultra Weedar 64	0.5 pt 0.5 pt	95	99	184	87	100	187
Roundup Ultra Clarity	0.5 pt 0.5 pt	83	97	178	84	100	185
Roundup Ultra Hornet	0.5 pt 1.0 oz	89	83	188	80	91	179
Roundup Ultra Aatrex	0.5 pt 1.0 pt	55	97	187	87	94	182
Roundup Ultra Weedar 64	1.0 pt 0.5 pt	97	100	183	97	100	190
Roundup Ultra Clarity	1.0 pt 0.5 pt	91	100	187	95	100	183
Roundup Ultra Hornet	1.0 pt 1.0 oz	96	100	178	99	100	179
Roundup Ultra Aatrex	1.0 pt 1.0 pt	80	100	189	89	100	185
LSD (0.05)		10	4	18	10	4	18

References: (if applicable)