

REDUCED RATES OF ROUNDUP ULTRA AND TANK-MIX PARTNERS FOR HERBICIDE RESISTANCE MANAGEMENT

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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 "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 two grass species (rigid ryegrass and goosegrass) have developed glyphosate-resistant populations after 25 years of glyphosate use. In both cases, multiple glyphosate applications were made annually. 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 Cayuga and Livingston Counties in 2000 to determine efficacy (weed control and grain yields) of early and mid-postemergence (EPO and MPO) applications of reduced rates (1/4X and 1/2X) of Roundup Ultra in combinations with 1/2X rates of Weedar 64 (2,4-D), Clarity (dicamba), Hornet (flumetsulam and clopyralid), and Scorpion III in Roundup Ready corn. Each experiment included EPO and MPO applications of the full rate (2 pt/A) of Roundup Ultra alone, a preemergence (PRE) standard treatment of 1.5 qt/A of Bicep Lite II Magnum (*S*-metolachlor + atrazine) plus 3.6 pt/A of Prowl (pendimethalin), and an untreated check.

In Cayuga County, the dominant weeds were common ragweed and green foxtail. Common ragweed control 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 and 95% with the PRE standard. Green foxtail control averaged 94% with EPO and MPO reduced rate Roundup Ultra tank mix applications. There was no difference in foxtail control between the 1/4X and 1/2X EPO Roundup Ultra combinations. When applied MPO, foxtail control averaged 88 and 98% with the 1/4X and 1/2X rates. The full rate of Roundup Ultra provided 95 and 100% foxtail control when applied EPO and MPO respectively and the PRE standard controlled 100% of the foxtail. There were no significant differences in grain corn yields among any of these herbicide treatments. Their average yield was 128 bu/A compared with 56 bu/A from the untreated check. In Livingston County the dominant weeds were velvetleaf and redroot pigweed. 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 the exception of two of the MPO 1/4X rate Roundup Ultra combinations. 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 one MPO 1/4X rate combination. The average grain corn yield from the reduced rate combinations was 176 bu/A. This was not significantly less than from the full rate of Roundup Ultra (182 bu/A) or from the PRE standard (188 bu/A).

These results demonstrate that 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, the active ingredient would be 0.4 and 0.66 lb ai/A for the 0.5 and 1.0 pt/A Roundup Ultra combinations respectively compared with 1 lb ai/A for the 2 pt/A rate of Roundup Ultra alone and 3.74 lb ai/A for the PRE standard. In addition, the reduced rate combinations would add one or two different modes-of-action which would delay or prevent the development of glyphosate-resistant weed populations.

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INTRODUCTION

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 "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 two species have developed glyphosate-resistant populations after 25 years of Roundup use. Glyphosate-resistant populations of rigid ryegrass (*Lolium rigidum* Gaudin) were confirmed in Australia (1995) and in California (1998). Now glyphosate-resistant goosegrass [*Eleusine indica* (L.) Gaertn.] populations have been identified in Malaysia. In both cases, multiple glyphosate applications were made annually. 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 populations of 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.

MATERIALS AND METHODS

Field experiments were conducted at the Musgrave Research Farm in Cayuga County and near Mt. Morris in Livingston County. Corn 'DK520RR' was planted June 1 and May 31, 2000 in Cayuga and Livingston Counties respectively. 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 at each location. Early postemergence (EPO) and mid-postemergence (MPO) applications of the X rate of Roundup Ultra alone and of reduced rates (1/4X and 1/2X) of Roundup Ultra in combinations with 1/2X rates (shown in Tables 1 and 2) of Weedar 64 (2,4-D), Clarity (dicamba), Hornet (flumetsulam and clopyralid), and Scorpion III. In Cayuga County the dominant weed species were common ragweed (*Ambrosia artemisiifolia* L.)

and green foxtail [*Setaria viridis* (L.) Beauv.]. EPO and MPO applications were made when ragweed was 2.5 and 5 inches tall respectively and foxtail was 5 and 12 inches tall respectively. In Livingston County redroot pigweed (*Amaranthus retroflexus* L.) was the dominant weed and velvetleaf was of secondary importance. Pigweed was 5 and 18 inches tall respectively and velvetleaf was 6 and 16 inches tall respectively when EPO and MPO herbicide applications were made. Each experiment included an untreated check. Weed control ratings, as a percent of the untreated checks, were made in August at each location and grain corn yields harvested from the center two rows of each plot with a small-plot combine in November.

RESULTS AND DISCUSSION

Cayuga County

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 1.0 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 1.0 pt/A Roundup Ultra combinations applied MPO. The standard, 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.

Livingston County

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 2). 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.

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|---|---------------|
| 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. | |
| -----EPO----- | -----MPO----- |
| ----- | ----- |

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

The results from these two 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 those obtained with the PRE standard. Although the soil moisture conditions were very favorable during the 2000 growing season, it is unlikely that the small differences in weed control among the EPO reduced rate combinations would result in significant yield differences with less than normal rainfall. Clearly, the potential for yield losses increase with the delayed MPO applications. 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 would be 0.4 and 0.66 lb ai/A for the 0.5 and 1.0 pt/A reduced rate Roundup Ultra combinations respectively compared with 1.0 lb 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

| Herbicides | Rate Amt/A | -----EPO----- | | | -----MPO----- | | |
|---------------|---------------|---------------|-------|---------------|---------------|-------|---------------|
| | | Control (%) | | Yield bu/A | Control (%) | | Yield bu/A |
| | | ABUTH | AMARE | | | ABUTH | |
| Roundup Ultra | 2.0 pt | 99 | 100 | 182 | 100 | 100 | 183 |
| Roundup Ultra | 0.5 pt | 99 | 100 | 166 | 96 | 99 | 178 |
| Weedar 64 | 0.5 pt | | | | | | |

| | | | | | | | |
|-------------------------------|------------------|----|-----|-----|----|-----|-----|
| 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 |

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.