CHLOROACETAMIDE TANK MIXES WITH PYRITHIOBAC IN GLYPHOSATE- AND GLUFOSINATE-BASED HERBICIDE SYSTEMS

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Abstract

Cotton development is slow and even more sluggish under cooler temperatures early in the growing season. Although delaying herbicide applications for 4 to 6 weeks after emergence of cotton had no effect on yield in early competition studies, glyphosate-resistant (GR) Palmer amaranth left uncontrolled for that period of time would be too large for adequate kill by available herbicides. Therefore, residual herbicides in combination with postemergence (POST) herbicides are critical to achieving season-long control of Palmer amaranth. However, few residual herbicides can be applied over-the-top of cotton without the potential for significant injury. For example, topical applications of fluometuron and pyrithiobac have all been reported to cause injury, and in some cases, reduction in yield. Recently, topical applications of *s*-metolachlor and encapsulated acetochlor (acetochlor) have increased in popularity. These herbicides have demonstrated the ability to provide adequate preemergence control of GR Palmer amaranth with little to some injury noted. Typical injury by these herbicides is described as necrotic speckling on exposed leaves and a leathery appearance of developing leaves. Furthermore, the addition of a tank mix partner, especially pyrithiobac, was originally thought to increase necrosis caused by *s*-metolachlor and acetochlor on cotton. However, previous research on this topic is limited.

The objective of this study was to determine if pyrithiobac enhances necrosis caused by *s*-metolachlor and acetochlor on cotton. Furthermore, researchers also wanted to compare Palmer amaranth control by acetochlor/ *s*-metolachlor plus pyrithiobac tank mixes in both glyphosate- and glufosinate-based systems.

Glyphosate-based System

The experiment was conducted in 2011 at two separate fields on the Central Crops Research Station near Clayton, NC (North CCRS and South CCRS) and on a private farm near Mount Olive (MO), NC. In 2012, research was repeated at North CCRS and MO. Palmer amaranth was present at all locations.

In 2011, Phytogen (PHY) 375WRF, PHY 499WRF, and Delta Pine (DP) 0924 B2RF cotton varieties were planted at South-CCRS, MO, and North-CCRS on May 5th, 11th, and 12th, respectively. The following year PHY 499WRF and FiberMax (FM) 1944 GLB2 were planted on May 2nd and May 7th at North-CCRS and MO, respectively. Design of the experiment was a randomized complete block replicated four times. Dimensions of plots were four rows by 9 m long, with a row spacing of 97 cm.

Postemergence (POST) residual herbicide treatments included pyrithiobac sodium applied at 0, 48, and 85 g ai ha^{-1} alone or in combination with encapsulated acetochlor at 1260 g ai ha^{-1} or *s*-metolachlor at 1067 g ai ha^{-1}. In addition, a non-treated control was included in the experiment. All residual herbicide were applied 16 to 25 days after planting (DAP) or POST 1. The potassium salt of glyphosate was applied at 866 g ae ha^{-1} alone or in combination with residual herbicides at POST 1. Additionally, glyphosate was applied 29 to 56 DAP (POST 2) and 39 to 65 DAP (POST 3) at 866 g ae ha^{-1}. Cotton was at the 1- to 2-leaf, 6- to 9-leaf, and 9- to 12-leaf at POST 1, POST 2, and POST 3, respectively. In 2011, at MO, all plots except the non-treated control received diuron applied preemergence (PRE) at 561 g ai ha^{-1}. When cotton was planted no-till at MO in 2012, excluding the non-treated control, all plots received glyphosate plus the dimethlyamine salt of 2,4-Dichlorophenoxyacetic acid (2,4-D) at 866 g ae ha^{-1} plus 216 g ai ha^{-1} 20 days prior to planting and paraquat plus crop oil concentrate at 841 g ai ha^{-1} plus 1% v/v PRE. Furthermore, at MO in both years and at North-CCRS in 2012, diuron plus MSMA plus non-ionic surfactant at 841 g ai ha^{-1} plus 2240 g ai ha^{-1} plus 0.25% v/v were applied postemergence-directed (POST-Dir) when cotton was approximately 46 to 61 cm tall. POST 1, POST 2, and POST 3 herbicides were applied using CO2-pressurized backpack sprayers equipped with flat-fan nozzles delivering 140 L ha^{-1} at 165 kPa. POST-Dir herbicides were applied using a single flood nozzle per row middle delivering 140 L ha^{-1} at 210 kPa.

Glufosinate-based System

In 2011, the experiment was conducted at two separate fields on the Central Crops Research Station near Clayton, NC (North CCRS and South CCRS) and on a private farm near Mount Olive (MO), NC. In 2012, research was repeated at North CCRS, MO, and on a private farm near Micro, NC. Palmer amaranth was present at all locations. Cotton varieties PHY 375WRF, PHY 499 WRF, and Stoneville (ST) 4145 LLB2 were planted on May 12th, 11th, and 12th at South-CCRS, MO, and North CCRS, respectively. In 2012, PHY 499WRF was planted on May 2nd, 7th, and 22nd at North-CCRS, MO, and Micro, respectively. The experimental design and plot size was identical to those used in the glyphosate-based system.

Using a treatment structure identical to the glyphosate-based system, residual herbicides were applied 16 to 22 DAP (POST 1) in the glufosinate-based system. Applied in combination with residual herbicides POST 1, all plots except the non-treated control received glufosinate-ammonium at 543 g ae ha^{-1}. In addition, 543 g ae $^{ha-1}$ of glufosinate was applied 29 to 56 DAP (POST 2) and 43 to 65 DAP (POST 3). At POST 1, POST 2, and POST 3, cotton was approximately at the 1- to 2-leaf, 5- to 10-leaf, and 8- to 12-leaf stage, respectively. Diuron at 561 g ai ha^{-1} was applied PRE at MO in 2011 whereas in 2012, paraquat at 841 g ai ha^{-1} plus crop oil concentrate at 1% v/v were applied PRE at MO and Micro. Furthermore, at MO in 2012, glyphosate plus 2,4-D was applied at 866 g ae ha^{-1} plus 241 g ai ha^{-1} 20 days prior to planting. A POST-Dir application of diuron (841 g ai ha^{-1}) plus MSMA (2240 g ai ha^{-1}) plus non-ionic surfactant (0.25% v/v) was made at MO in 2011 and North-CCRS, MO, and Micro in 2012 when cotton was approximately 46 to 81 cm tall. Postemergence (POST) and POST-Dir herbicides were applied using flat-fan nozzles calibrated to deliver 140 L ha^{-1} at 165 kPa and a single flood nozzle per row middle delivering 140 L ha^{-1} at 210 kPa.

Data collection and statistical analysis

Data for cotton necrosis, chlorosis, and growth reduction was collected at 7 days after (DA) POST 1, 14 DA POST 1, POST 2, POST 3, and 105 to 120 DAP (late season). Weed control ratings were performed 7 DA POST 1, 14 DA POST 1, POST 2, POST 3, and late season. Weed control and cotton injury were estimated visually on a 0 to 100 scale according to Frans and others (1986), where 0= no weed control or no plant injury and 100= complete weed control or plant death, respectively. All plots were machine-harvested using a modified two-row John Deere cotton harvester and weighed to determine seed cotton yield. In the glufosinate-based experiment, seed cotton samples were collected and subjected to ginning and HVI testing to determine lint percentage and fiber qualities, respectively. Yield of non-treated control plots were unhavestable due to weed pressure. Therefore, data for these plots was not included in statistical analysis. Data for cotton necrosis, chlorosis, growth reduction, weed control, and yield were subjected to analysis of variance using the PROC MIXED procedure of SAS (version 9.2). Herbicide treatments were a fixed factor, whereas locations and replications were treated as random. Means were separated using Fisher's Protected LSD at $p < 0.05$.

Results and Discussion

Necrosis was greatest 7 days after POST 1 in both glyphosate- and glufosinate-based systems. Likewise, at this timing, growth reduction was most significant. However, necrosis and growth reduction were greater when residual herbicides were applied in combination with glufosinate. In the glufosinate-based system, glufosinate alone caused 5% necrosis. Necrosis was increased 3 and 4% when pyrithiobac was applied at 48 and 85 g ai ha^{-1}, respectively. The addition of *s*-metolachlor and acetochlor to glufosinate also increased necrosis observed (19 to 23%). Furthermore, necrosis caused by acetochlor plus pyrithiobac (20%) was equivalent to acetochlor alone (19%). However, the addition of pyrithiobac to *s*-metolachlor did increase injury. Compared to *s*-metolachlor alone (23%), pyrithiobac in combination with *s*-metolachlor increased necrosis 3 to 4%. Likewise, growth reduction was greatest when *s*-metolachlor and pyrithiobac were applied in combination (20%) and was greater than either herbicide applied alone (16%). Moreover, the addition of pyrithiobac to acetochlor (19%) increased cotton growth reduction compared to acetochlor alone (15%). Similar to necrosis, glufosinate alone caused the least amount of growth reduction.

In the glyphosate-based system, overall cotton injury was less than in the glufosinate-based system. As expected, glyphosate alone produced the least amount of necrosis (1%). The addition of residual herbicides, however, did increase necrosis. *S*-metolachlor, acetochlor, and pyrithiobac alone increased necrosis 13, 11, and 2%, respectively. Furthermore, *s*-metolachlor plus pyrithiobac (16 to 18%) was more injurious than *s*-metolachlor alone (14%).

However, the addition of pyrithiobac to acetochlor did not increase necrosis. Similar to necrosis, growth reduction was minimized by applications of glyphosate alone (0%). *S*-metolachlor in combination with glyphosate increased growth reduction to 6%. Further reduction in cotton growth was observed when acetochlor and pyrithiobac were mixed with glyphosate (12 to 15%). However, equivalent growth reduction was noted when pyrithiobac was applied at 48 and 85 g ai ha^{-1} alone or in combination with *s*-metolachlor/acetochlor.

In general, glufosinate-based systems were more effective for control of Palmer amaranth, mostly due to the presences of GR Palmer amaranth at research sites. However, the addition of residual herbicides had varying effects depending on the primary POST product used (glufosinate or glyphosate). In glufosinate-based systems, glufosinate alone controlled 86% of Palmer amaranth at POST 3. The addition of a single residual herbicide increased control of the weed (91 to 93%). However, the greatest control was achieved by combinations of residual herbicides (95 to 96%). In the glyphosate-based system, glyphosate alone provided 73% control of Palmer amaranth. Contrary to results when glufosinate was used POST, *s*-metolachlor and acetochlor in combination with glyphosate provided no benefit in control of Palmer amaranth (71%). However, when pyrithiobac was tank mixed with glyphosate, control improved 15 to 16%. Furthermore, combinations of *s*-metolachlor /acetochlor with pyrithiobac (88 to 91%) provided equivalent control of Palmer amaranth to pyrithiobac alone (86 to 87%).

Cotton lint yield followed a trend comparable to Palmer amaranth control. In glufosinate-based systems, lint yield was similar across all herbicide treatments. In these trials, lint yield ranged 1155 to 1254 lb./acre. On the other hand, in the glyphosate-based system, differences in lint yield were observed between herbicide treatments. Lint yield totaled 959 lb./acre when glyphosate was applied alone. Similar to Palmer amaranth control, the addition of *s*-metolachlor or acetochlor offered no benefit in lint yield. However, the addition of pyrithiobac improved lint yield approximately 14 to 18%. Likewise, lint yield in plots receiving *s*-metolachlor /acetochlor plus pyrithiobac were equivalent to plots receiving pyrithiobac alone.

In conclusion, it appears pyrithiobac can enhance injury of cotton by *s*-metolachlor. In both glufosinate- and glyphosate-based systems, necrosis caused by *s*-metolachlor plus pyrithiobac was greater than *s*-metolachlor alone. However, the increase in necrosis was very slight (2 to 4%). Contrarily, the addition of pyrithiobac to acetochlor did not increase necrosis. A typical effect of pyrithiobac on cotton is growth reduction. General field observations found that cotton sprayed with pyrithiobac was often shorter and had less leaf area compared to cotton not receiving pyrithiobac POST. Therefore, it is possible that plants with reduced leaf area would appear to have a greater percentage of necrosis. Furthermore, plants not sprayed with pyrithiobac are quicker to recover from foliar burn caused by POST herbicides. This is the likely explanation for why necrosis caused by glufosinate plus pyrithiobac was greater than glufosinate alone. From a weed control stand point, residual herbicides provided an advantage in both POST herbicide systems. However, in the glufosinate-based program, adequate control of Palmer amaranth was achieved by glufosinate plus *s*-metolachlor /acetochlor (92 to 93%). In the glyphosate-based system, the addition of *s*-metolachlor or acetochlor to glyphosate provided no benefit in control of the weed. In contrast, pyrithiobac added to glyphosate increased Palmer amaranth control 15 to 16%. Likewise, where glyphosate was applied POST, lint yield was greatest in plots that received pyrithiobac alone compared to *s*-metolachlor or acetochlor alone. Thus, pyrithiobac emerged as a critical weed control component in the glyphosate-based program. In the glufosinate-based system, lint yield was equivalent in plot receiving *s*-metolachlor or acetochlor alone or pyrithiobac plus *s*-metolachlor /acetochlor. Because there was only a minimal benefit to Palmer amaranth control and no yield advantage, pyrithiobac seems less crucial in glufosinate-based herbicide programs compared to *s*-metolachlor and acetochlor.