**Two Approaches for Palmer Amaranth Control: we need multiple approaches**

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**Two Approaches for Palmer Amaranth Control:**

**we need multiple approaches**

The **research objectives** are to evaluate:

* herbicide options for management of large Palmer amaranth plants (2nd year); and
* investigate utility of late-terminated cereal rye for reducing herbicide inputs for Palmer amaranth management.

This proposal was developed based on the priorities outlined by the DSB in their request for proposals as well as conversations with soybean farmers, ag business, and DE Department of Agriculture’s Noxious Weed Program. The first objective is a continuation of 2018 research. The second objective is building upon results from a completed DSB project. This research will benefit Delaware’s soybean growers and the soybean industry by understanding the effectiveness of potential options when spraying large Palmer amaranth plants and expand the options of non-chemical strategies to help control plants with few to no herbicide options. These projects were designed to address weed control in terms of effectiveness, adaptability to Delaware’s specific needs, as well as resistance management.

**Progress to date:**

The **first objective** is examining the effectiveness of strategies to control Palmer amaranth that is larger than recommended.

This experiment used soybeans with the following herbicide-tolerance traits: Liberty Link (LL27GT); 2,4-D-resistant (not included); dicamba-resistant (Xtend) and Roundup Ready (Xtend).

Soybeans were drilled no-till in 7-inch rows on June 3. The research area was sprayed with glyphosate plus Liberty before planting to eliminate any emerged weeds. Outlook was applied after planting at 12 fl oz to provided limited control of annual weeds.

Large Palmer amaranth plants, 14-16 inches tall, were treated July 12 with dicamba plus glyphosate, Enlist Duo (2,4-D choline+glypohsate), Reflex plus glyphosate and Liberty as single as well as sequential applications (Table 1). Dicamba and Reflex were applied as a tankmixture with glyphosate. Flexstar GT is a prepackaged mixture of fomesafen (Reflex) and glyphosate with proprietary adjuvants. Sequential applications were made July 25. In addition, the sequential treatments included Cobra (lactofen) to assess the potential benefit of including herbicides with additional modes-of-action. Fomesafen label does not allow more than one application so it was not used as part of a sequential application. This objective will also examine if the order in which herbicides are applied influenced control.

Plots were evaluated for Palmer amaranth control. Treatments with Enlist herbicide had no soybeans and therefore lacked crop competition, reducing control as compared with treatments where soybeans were present. At harvest, five female Palmer amaranth plants were measured for height, clipped at the ground level for recording biomass, and threshed to determine seed production. Plots were harvested to determine impact of treated Palmer amaranth plants on yield. However, using multiple varieties did not allow comparison of yields across the various herbicide programs.

**Results**

Palmer amaranth control with a single POST application did not provide complete control, with 83% control from Flexstar GT being the highest (Table 1). Some plants that appeared to be initially controlled by Flexstar GT recovered (72% control 4 weeks after treatment, data not shown). Dicamba plus glyphosate had only 2 plants per plot as compared to over 25 plants per plot with the other single POST applications, but those surviving plants also had the highest seeds/plant (2,233) though not significantly different.

Sequential applications of Liberty and dicamba plus glyphosate provided 93% and 87% control respectively (Table 1). Sequential applications with PPO herbicides Reflex, Cobra, or Flexstar provided similar level of Palmer amaranth control as a single application. Adding Cobra with sequential applications did not improve overall control.

Weed seeds per plant were quite variable (not significantly different), relatively few seeds, and ranged from 0 to 2,233 (Table 1). The soybeans were drilled in 7-inch rows presumably increasing soybean competitiveness and helping to limit Palmer amaranth seed production.

There were no yield differences among treatments with the same soybean variety (data not present). Herbicide treatments that caused soybean leaf burn (Cobra) did not impact soybean yield, nor did they delay soybean maturity.

Based on results from two years, sequential applications of dicamba, 2,4-D choline or Liberty are needed to control larger Palmer amaranth plants. Provided Palmer amaranth plants are not taller than 17 inches, excellent control can be achieved with sequential applications of dicamba, 2,4-D choline or Liberty. Sequential applications of PPO herbicides, or including Cobra with sequential applications did not improve control.

Additional research is needed to better understand the seed contribution of plants surviving herbicide applications.

**Table 1. Treatments for objective 1.**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Soybean |  | P.amarnth |  | P.amarnth |  | P.amarnth |  |
|  |  |  | 8/3/2019 |  | 8/3/2019 |  | 9/27/2019 |  | 9/27/2019 |  |
| Trt |  |  | Stunting |  | Control |  | Plants |  | Seeds |  |
| No | First Applicationa | Second Applicationa | % |  | % |  | #/plot |  | #/plant |  |
| 1 | dicambab+glyphosate | None | 0.0 | b | 79 | de | 2 | c | 2233 | a |
| 2 | Enlist Duoc | None |  |  |  |  |  |  |  |  |
| 3 | Liberty | None | 0.0 | b | 80 | de | 49 | a | 1983 | abc |
| 4 | Reflex+glyphosate | None | 0.0 | b | 75 | e | 30 | ab | 1885 | abc |
| 5 | Flexstar GT | None | 0.0 | b | 83 | cde | 25 | abc | 1827 | abc |
| 6 | dicamba+glyphosate | dicamba+glyphosate | 0.0 | b | 87 | a-d | 1 | c | 0 | c |
| 7 | Enlist Duo | Enlist Duo |  |  |  |  |  |  |  |  |
| 8 | Liberty | Liberty | 0.0 | b | 93 | ab | 7 | bc | 1799 | abc |
| 9 | Reflex+glyphosate | glyphosate | 4.0 | b | 80 | de | 22 | bc | 1544 | abc |
| 10 | Flexstar GT | glyphosate | 3.3 | b | 77 | e | 19 | bc | 1680 | abc |
| 11 | dicamba+glyphosate | dicamba+glyphosate+Cobra | 15.0 | a | 90 | abc | 1 | c | 58 | bc |
| 12 | Enlist Duo | Enlist Duo+Cobra |  |  |  |  |  |  |  |  |
| 13 | Liberty | Liberty+Cobra | 15.0 | a | 93 | ab | 10 | bc | 869 | abc |
| 14 | Reflex+glyphosate | glyphosate+Cobra | 18.3 | a | 83 | cde | 18 | bc | 2092 | ab |
| 15 | Flexstar GT | glyphosate+Cobra | 16.7 | a | 87 | bcd | 15 | bc | 1379 | abc |
| 16 | None | None | 0.0 | b | 0 | f | 24 | bc | 1625 | abc |
| 17 | Liberty+Enlist One |  |  |  |  |  |  |  |  |  |
| 18 | Authority Elite fbd Reflex+glyphosate | | 2.3 | b | 96 | a | 0 | c | 0 | c |
| 19 | dicamba+Cobra | dicamba+glyphosate | 16.3 | a | 92 | abc | 0 | c |  |  |
| 20 | Cobra+glyphosate | FlexstarGT |  |  |  |  |  |  |  |  |
|  | LSD P=.05 |  | 5.114 |  | 9.562 |  | 25.255 |  | 2072.12 |  |
|  | CV |  | 50.3 |  | 7.17 |  | 101.72 |  | 89.77 |  |
| Treatment Prob(F) | |  | 0.0001 |  | 0.0001 |  | 0.0160 |  | 0.3005 |  |

aSingle herbicide application will be made to 12 to 14 inch tall Palmer amaranth plants; sequential applications were treated with the second application 13 days later.

bdicamba formulation is Xtendimax; UD research has not shown any difference in Palmer amaranth control among the various formulations.

c=Enlist Duo is a combination of glyphosate plus 2,4-D choline

dfb= followed by (application will be applied 7 days later as a sequential applications).

The **second objective** addresses the potential of cereal rye to reduce herbicide input for Palmer amaranth control.

This study examined level of rye biomass and herbicide strategy. Rye cover was terminated 1) 4 wks before planting, 2) 2 wks before planting, or 3) 2 days after planting (DAP). Herbicide strategy included timing of residual herbicide application and/or postemergence application. Residual herbicides were applied with the burndown treatment or at soybean planting; and postemergence applications were Liberty alone (no residual control) or in combination with residual herbicides. Treatments are listed in Table 2.

This study was conducted in a field naturally infested with pigweed species. Cereal rye was planted in the fall of 2018 at 2 bu/A and due to slow growth 40 lbs of N was applied in the spring. Soybeans were planted on May 22, and preemergence herbicides applied within 24 hours.

This trial was not designed to compare various herbicides; rather this trial is focusing on approaches to weed control. We used metribuzin plus Valor for the soil-applied residual treatment, which has provided very consistent control for Palmer amaranth. Based on previous research the postemergence combination of fomesafen (Reflex or Flexstar GT) and s-metolachlor (Dual Magnum) has been more consistent than either herbicide alone. In addition to consistent weed control, the use of two effective herbicide mechanism of action is recommended to delay the development of herbicide-resistance.

Plots were rated visually for weed control. Soybeans were harvest at crop maturity.

**Results**

Control of cereal rye was excellent at all termination timings at 89% or greater (Table 2). The presence and level of a cereal rye cover crop directly influenced Palmer amaranth control, providing control at 2 DAP (79%) and 2wks EPP (43%) versus 4wks EPP (0%). Adding residual herbicides also resulted in improved control 2 DAP (90%) and 2wks EPP (84%) versus 4wks EPP (50%). Waiting until after planting to apply residual herbicides instead of at burndown improved control for the 4wks EPP timing (90% vs 71%).

Adding postemergence herbicides had marginal effects on Palmer amaranth control, however morningglory control was improved with the addition of Reflex at all three timings. Burndown fb EPOST application of Liberty plus Reflex plus FirstRate provided excellent control of all species when rye was terminated 2 DAP and 2wks EPP. It was also a good treatment (82%) for Palmer amaranth at the 4wks EPP termination timing.

BD only and BD plus Residual at the 4wks EPP termination timing provided poor annual grass control. All other treatments provided excellent control.

This study will be repeated in 2020.

Table 2. Cereal rye termination and approaches for residual herbicide treatments.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | Rye | | Palmer Am | | Palmer Am | | Morningglry | | Morningglry | | Ann. grass | |
| Trt. | Termination |  | % Control | | % Control | | % Control | | % Control | | % Control | | % Control | |
| No. | Timinga | Herbicide Program | 5/30/2019 | | 7/04/2019 | | 7/28/2019 | | 7/04/2019 | | 7/28/2019 | | 7/04/2019 | |
| 1 | 4wks EPP | Burndown (BD) only | 99 | a | 0 | d | 0 | g | 0 | i | 0 | j | 0 | c |
| 2 | 4wks EPP | Residualb at BD | 99 | a | 53 | c | 50 | ef | 23.3 | h | 47 | hi | 60 | b |
| 3 | 4wks EPP | Residual at BD fb POSTd (+Rc) | 99 | a | 67 | b | 71 | cd | 66.7 | f | 68 | def | 99 | a |
| 4 | 4wks EPP | Residual at BD fb POST (-R) | 99 | a | 60 | bc | 60 | de | 43.3 | g | 53 | ghi | 99 | a |
| 5 | 4wks EPP | BD fb residuals at planting fb POST (+R) | 99 | a | 90 | a | 90 | ab | 81 | cde | 72 | de | 94 | a |
| 6 | 4wks EPP | BD fb POST (+R) (2nd trifoliate) | 99 | a | 91 | a | 82 | bc | 93 | abc | 78 | cd | 99 | a |
| 7 | 2wks EPP | Burndown (BD) only | 98.3 | ab | 50 | c | 43 | f | 26.7 | h | 47 | hi | 95 | a |
| 8 | 2wks EPP | Residual at BD | 99 | a | 86 | a | 84 | abc | 46.7 | g | 40 | i | 99 | a |
| 9 | 2wks EPP | Residual at BD fb POST (+R) | 98.3 | ab | 92 | a | 90 | ab | 89.7 | abc | 88 | abc | 99 | a |
| 10 | 2wks EPP | Residual at BD fb POST (-R) | 99 | a | 86 | a | 84 | abc | 68.3 | ef | 63 | efg | 99 | a |
| 11 | 2wks EPP | BD fb residuals at planting fb POST (+R) | 94.7 | cd | 96 | a | 95 | ab | 97.7 | ab | 93 | ab | 99 | a |
| 12 | 2wks EPP | BD fb POST (+R) (2nd trifoliate) | 89 | e | 95 | a | 94 | ab | 99 | a | 96 | a | 99 | a |
| 13 | 2 DAP | Burndown (BD) only | 92.3 | d | 87 | a | 79 | bc | 68.3 | ef | 57 | fgh | 99 | a |
| 14 | 2 DAP | Residual at BD | 96.3 | abc | 97 | a | 90 | ab | 75.7 | def | 53 | ghi | 99 | a |
| 15 | 2 DAP | Residual at BD fb POST (+R) | 95 | cd | 99 | a | 99 | a | 98.3 | a | 81 | bcd | 99 | a |
| 16 | 2 DAP | Residual at BD fb POST (-R) | 95.7 | bc | 99 | a | 90 | ab | 85 | bcd | 72 | de | 99 | a |
| 17 | 2 DAP | BD fb residuals at planting fb POST (+R) | -- |  | -- |  | -- |  | -- |  | -- |  | -- |  |
| 18 | 2 DAP | BD fb POST (+R) (2nd trifoliate) | 92.3 | d | 99 | a | 99 | a | 98 | ab | 95 | ab | 99 | a |
| 19 | 2wks EPP | BD fb EPOST | 94 | cd | 99 | a | 94 | ab | 94 | ab | 77 | cde | 99 | a |
| 20 | 4wks EPP | BD fb EPOST | 99 | a | 94.7 | a | 88 | ab | 88 | abc | 82 | bcd | 98 | a |
| 21 | Untreated | None | 0 | f | 86.7 | a | 85 | abc | 70 | ef | 50 | ghi | 99 | a |
|  | LSD P=.05 |  | 2.61 |  | 11.68 |  | 13.85 |  | 11.43 |  | 12.62 |  | 5.03 |  |
|  | Standard Deviation | | 1.58 |  | 7.08 |  | 8.4 |  | 6.93 |  | 7.65 |  | 3.05 |  |
|  | CV |  | 1.72 |  | 8.61 |  | 10.58 |  | 9.62 |  | 11.53 |  | 3.31 |  |

Treatments 15 and 17 are identical; included only to show factorial arrangement of treatments.

Abbreviations: BD= burndown; DAP= days after planting; EPP= early pre-plant; fb= followed by; POST=postemergence; +R is with residual herbicides; -R is Liberty application alone

aTermination treatment is a tankmixture of glyphosate plus 2,4-D choline.

bResidual herbicide is a tankmixture of metribuzin plus Valor

cPostemergence residuals will be a tankmixture of Liberty plus Reflex; treatments applied at 2nd trifoliate also included FirstRate

dPostemergence treatments were made 4 weeks after planting unless noted