EFFECT OF PRE-EMERGENCE HERBICIDE APPLICATIONS ON ENVIRONMENTALLY STRESSED COTTON

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Abstract

As weed populations with natural resistance to glyphosate have increased and spread, the need for pre-emergent herbicides has become evident. Under periods of stress, such as may be observed under extreme early or late plantings, young cotton plants may be exposed to doses of herbicides deemed safe under 'normal' conditions. Varied weather conditions in 2012 and 2013 in southeast Missouri had the potential of causing herbicide injury to young cotton plants. To simulate the varied conditions, very early and late plantings were planned. Herbicide injury and weed control were evaluated under these conditions on two soils-Tiptonville silt loam and Malden fine sandy loam. The objectives were to identify herbicides which offered the best crop safety and weed control under these conditions and whether the crop could recover to produce quality fiber and high yield. Seven herbicide treatments were selected with applications at labeled and 2x rates at proper timings. In, 2014 some stunting and stand loss was observed on Tiptonville site. Nine of 60 soil x timing x treatment displayed stunting with most occurring when cotton was planted on sand early. NDVI measurements were highest for late plantings overall, and on Tiptonville compared to Malden in 2015. Best palmer amaranth control was achieved on Malden early, with lower control ratings occurring on the Tiptonville soil regardless of timing. Yields were highest on the Tiptonville soil when planted late combining both years. Gin Turnout was better on Tiptonville early while treatments cotton on Malden sandy loam late delivered the lowest gin turnouts. NDVI measurements could be a useful indicator of herbicide induced stress. Background noise, i.e., soil readings early in the season must be eliminated for better interpretations. Later plantings on sand and earlier on loam may minimize injury but may reduce gin turnout.

Introduction

The use of pre-emergent herbicides declined as adoption of glyphosate resistant crops gained popularity in the late 1990s and early 2000s. As weed populations with natural resistance to glyphosate increased and spread, the need for pre-emergent herbicides has again become evident. Under periods of stress, such as may be observed under extreme early or late plantings, young cotton plants may be exposed to doses of herbicides deemed safe under 'normal' conditions. Will McCarty, Mississippi State University Cotton Extension Specialist, wrote in 2002 that "all pre-emergence herbicides can damage young cotton or reduce or destroy a stand if a high concentration of the herbicide comes in contact with the germinating seed or young seedling. Tolerance depends upon soil type, organic matter content and amount and timeliness of rainfall the first two weeks after planting." Vigorous early season growth is necessary for early fruiting and early crop maturation (Askew, et al., Hayes et al.).

Due to a warm dry spring in 2012, many Missouri cotton producers were able to plant early. Herbicides normally incorporated by rain, may have instead have been concentrated near the soil surface and contacted seedlings in high enough dosages to slow or even stop development. In 2013, however, the spring was cool and damp and many acres of cotton were planted later than normal. Due to higher than normal precipitation, early pre-plant and pre-emergent herbicides may have dissipated enough to allow for weeds to begin germinating before or shortly after cotton was planted, reducing their effectiveness.

Materials and Methods

Two trials were initiated at each of two locations at the University of Missouri FDRC Lee (Tiptonville silt loam) and Rhodes (Malden fine sandy loam) farms. Seven pre-emergence or early pre-plant treatments were selected and applied at 1x and 2x the labeled rates for each soil type. Pre-plant treatments were applied at least 21 days before planting, while all pre-emergence treatments were applied within 48 hours after planting. Herbicides, rates and application timings are shown in Table 1. Cotton was planted in four 7.62 m rows spaced 0.97m apart. Three rows received herbicide application with the fourth serving as a check row. Studies were arranged as a randomized complete block with an additional untreated plot in each replication.

Table 1. Herbicide application rates (1X) and timings for Pre-emergence stress study.

Herbicide	1X Rate ($Kg\ ai\ ha^{-1}$)		Application Timing	
Active Ingredient	Loam	Sand	Loam	Sand
Pyroxasulfone	0.06	0.042	PRE	PRE
Fluridone	0.22	0.22	PRE	PRE
+Fomesafen	+0.14	+0.14		
Acetochlor	1.43	1.35	PRE	PRE
Fomesafen	0.28	0.28	21DPP	PRE
s-Metolachlor	1.42	1.07	PRE	PRE
Fluometuron	1.68	1.12	PRE	PRE
Prometryn	2.69	1.79	PRE	PRE

Results and Discussion

2014 Results

Herbicide injury in the form of stand reduction and stunting was most noted with applications of 2x rates of prometryn on Tiptonville loam for both planting dates (Table 2) in 2014. Prometryn also caused some stunting of cotton plants at both locations and planting timings, but only significant stunting on Tiptonville loam for both herbicide application rates at the early planting date and when applied at a 2x rate at the late planting timing. No significant stand reduction was noted at the Rhodes Farm location for the early planted study. No numerical stand reduction was noted at Rhodes Farm for the late planted study for any herbicide treatment.

Table 2. Estimated Stand reduction from herbicide treatments to early and late planted cotton in 2014 at University of Missouri FDRC Lee and Rhodes Farms†

Herbicide	Herbicide	Stand (% of Untreated) Early		Stand (% of Untreated) Late		Stunting Early		Stunting Late	
Active Ing.	Rate	Lee[1]	Rhodes[2]	Lee[3]	Rhodes[4]	Lee[5]	Rhodes[6]	Lee[7]	Rhodes[8]
Pyroxasulfone	1X	80[a]	100[a]	87.5[a]	n/a	2.5[c]	0[a]	0[b]	2.5[a]
Fluridone +Fomesafen	1X	100[a]	100[a]	100[a]	n/a	0[c]	0[a]	0[b]	0[a]
Acetochlor	1X	100[a]	100[a]	100[a]	n/a	0[c]	2.5[a]	0[b]	2.5[a]
Fomesafen	1X	100[a]	100[a]	100[a]	n/a	0[c]	0[a]	0[b]	0[a]
s-Metolachlor	1X	100[a]	100[a]	100[a]	n/a	0[c]	10.0[a]	0[b]	0[a]
Fluometuron	1X	100[a]	100[a]	100[a]	n/a	0[c]	0[a]	2.5[b]	0[a]
Prometryn	1X	100[a]	97.5[a]	100[a]	n/a	10[b]	5[a]	2.5[b]	2.5[a]
Pyroxasulfon	2X	100[a]	97.5[a]	100[a]	n/a	0[c]	5[a]	0[b]	5[a]
Fluridone +Fomesafen	2X	100[a]	100[a]	100[a]	n/a	0[c]	2.5[a]	2.5[b]	5[a]
Acetochlor	2X	100[a]	97.5[a]	100[a]	n/a	0[c]	0[a]	0[b]	5[a]
Fomesafen	2X	100[a]	100[a]	100[a]	n/a	0[c]	0[a]	0[b]	2.5[a]
s-Metolachlo	2X	100[a]	100[a]	100[a]	n/a	0[c]	15.0[a]	0[b]	0[a]
Fluometuron	2X	100[a]	100[a]	100[a]	n/a	0[c]	5.0[a]	0[b]	2.5[a]
Prometryn	2X	60[b]	100[a]	72.5[b]	n/a	22.5[a]	0[a]	32.5[a]	0[a]

†Values with the same letter are not significantly different within each column
[1]Ratings taken 50 Days after Emergence (DAE). [2]37 DAE [3]38 DAE [4] No Stand reduction observed
[5]50 DAE [6]37 DAE [7] 38 DAE [8] 29 DAE

For the early planting on Tiptonville loam, seed cotton yields ranged from 1230 kg ha-1 to 1876 kg ha-1. Differences in yield were not statistically significant. However, there were differences in gin turnout with the low rate of acetochlor being significantly lower than the untreated check. Herbicide treatment did not significantly affect the seed cotton yield or gin turnout at any of the other planting dates or locations.

A location by treatment interaction was found to significantly affect yield (Table 3). Yields ranged from 813 kg ha-1 with the low rate of prometryn on Malden fine sandy loam up to 1412 kg ha-1 on Tiptonville loam when the low rate of acetochlor was applied. Pyroxasulfone at the 2x rate on Tiptonville loam yielded similar to the best yielding treatment, but was significantly higher than the same treatment on Malden fine sandy loam. Prometryn at the 1x rate yielded significantly lower than the same treatment on Tiptonville loam and the untreated check plots for both locations. However, the 2x rate yielded better on Malden fine sandy loam than on Tiptonville loam.

Table 3. 2014 seed cotton yield mean separation location by treatment interaction.

Herbicide Active Ingredient	Herbicide Rate	Seed Cotton Yield ($kg\ ha^{-1}$)† Lee	Rhodes
Pyroxasulfone	1X	965.77CDE	947.16CDE
Fluridone +Fomesafen	1X	1134.57ABCD	1187.27ABCD
Acetochlor	1X	1411.94A	1056.28BCDE
Fomesafen	1X	959.07BCDE	1183.15ABCD
s-Metolachlor	1X	1125.51ABCDE	1279.73AB
Fluometuron	1X	995.2BCDE	1146.37ABCD
Prometryn	1X	1261.32ABC	813.03E
Pyroxasulfone	2X	1407.76A	896.38DE
Fluridone +Fomesafen	2X	1224.21ABCD	1010.41BCDE
Acetochlor	2X	1270.47BC	1167.12ABCD
Fomesafen	2X	1093.67BCDE	930.08CDE
s-Metolachlor	2X	1240.03ABC	939.71CDE
Fluometuron	2X	1139.85ABCD	1055.20BCDE
Prometryn	2X	981.88CDE	1173.33ABCD
Untreated	-	1123.52ABCDE	1226.85ABC

†Values with the lame letters are not statistically different throughout the table

2014 and 2015 Combined Results

NDVI measurements were added to the study for 2015 after a colleague noticed substantial differences while calibrating instruments in one of these studies. NDVI measurements in 2015 showed higher values for late plantings on either soil. NDVI measurements were higher for cotton on Tiptonville loam soil at either timing compared to the same timing on fine sandy loam (Table 4).

Table 4. NDVI LS Means for cotton planted on and Tiptonville loam and Malden fine sandy loam at two timings in 2014 and 2015.

Soil	Timing	NDVI LS Means
Tiptonville Loam	Late	0.6107^{A}
Malden Sand	Late	0.3805^{B}
Tiptonville Loam	Early	0.3413^{C}
Malden Sand	Early	0.2438^{D}

Crop stunting was noted in both years. In 2014, every product tested displayed stunting for at least one soil/timing/rate combination with the exception of products that contained fomesafen at the 1x rate (Reflex and Brake F2). Only the 1x rate of prometryn on loam early and 2x on loam at either timing was significant. In 2015, only 9 of 60 possible combinations had significant stunting-which included on untreated plot, and 1x rates of prometryn, s-metolachlor, and 2x rates of pyroxasulfone and s-metolachlor. All were on sand with the exception of 2x Prometryn (both soils and timings).

Early season Palmer amaranth control was dependent on Timing X Treatment, and Soil. All treatments provided significantly higher weed control than untreated checks. Early plantings had numerically higher control of Palmer amaranth. Palmer control was also noted as being better on the Malden fine sandy loam compared to the Tiptonville loam soil. In both of these instances, higher control ratings may have been due to 1) less emergence early in the season and 2) competition. The dominant weed on the fine sandy loam was crabgrass. Treatments that controlled the crabgrass tended to have more Palmer. Treatments that did not control crabgrass had little Palmer emergence due to competition.

Palmer control later in the season was influenced by soil type with control best on the Malden fine sandy loam. Control was also affected by treatment. 1x acetochlor and both rate of prometryn had significantly less palmer control than all other herbicide treatments. The prometryn results are not surprising as in 2014 this treatment significantly reduced crop stand. As a result, there was less crop competition as the season progressed compared to other treatments and Palmer emerged and control was rated lower. Lower control from acetochlor could not be explained as easily.

Seed Cotton yield was affected by soil and timing. Highest seed cotton yield was observed on the Tiptonville loam when cotton was planted late. Other planting location x timings were significantly lower (Table 5). Gin turnout was for 2015 only and was influenced by soil x timing x treatment. Early applications on Tiptonville loam had highest turnout with the exception of 1x Fomesafen, prometryn, and Fluometuron. All treatments on fine sandy loam late were similar to the 2x fluridone + fomesafen early on sand- the worst numerical turnout.

Table 5. Seed Cotton LS Means for two planting timings on two soils in 2014 and 2015.

Soil	Timing	Seed Cotton Yield (lb/ac) LS Mean
Tiptonville Loam	Late	3002.6[A]
Tiptonville Loam	Early	2615.6[B]
Malden Sand	Early	2541.9[B]
Malden Sand	Late	2423.2[B]

Summary

NDVI measurements may prove to be beneficial for detecting herbicide stress in cotton. However, our methods need to be refined and our timing of measurements altered to minimize the influence of soil type on the results. It is believed that the measurements from the sand were lower due to 1) lower amount of vegetation and 2) lower reflectance of a sandy soil vs a loam soil. Our measurements were taken while holding a sensor over the crop row. Smaller plants at the time of measurements would have resulted in more readings taken from the soil and not plant canopy. If plants had been of the same size on both soils when readings were taken, results would still be skewed by the reflectance of the different soil types.

Later planting on sand and earlier planting on loam may result in less chance of injury based on these results. Conversely, gin turnout may be lower under these conditions than when compared to early planting on Malden fine sandy loam and late on the Tiptonville loam. Yield was shown to be higher statistically on Tiptonville loam late than other soil/timing combinations, with both loam timings being numerically higher than either timing on the fine sandy loam.

Palmer amaranth control was best when planted early. This may be due to less emergence at earlier planting dates when soils are cooler. However, we observed in 2015 that the early planting date was too early. Cotton that did emerge did not grow well. As the soil warmed and weeds began to emerge, the herbicides had lost effectiveness and the cotton crop had lost vigor. The crop was quickly out competed. The late Tiptonville loam study surpassed the growth stage of the early Tiptonville loam study which was terminated due to poor growth and heavy weed pressure.

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