MISSISSIPPI SOYBEAN PROMOTION BOARD
PROJECT NO. 30-2015 (YEAR 1)
2015 Final Report

Title: Effect of New Multiple Herbicide Resistant Soybean Technologies on Control of Herbicide Resistant Weeds and Soil Microbial Parameters

PI: Vijay Nandula; vijay.nandula@ars.usda.gov

EXECUTIVE SUMMARY

Results from this study clearly indicate that the new 2,4-D and dicamba formulations registered for use on 2,4-D and dicamba-resistant soybean, respectively, provide a viable alternative for controlling Glyphosate-Resistant (GR) as well as wild types of troublesome pigweeds such as Palmer amaranth and tall waterhemp, and other broadleaf weeds such as common ragweed.

Applications of these herbicides must be made to pigweeds that are 4 inches or less in height to achieve maximum benefit.

Results indicate that the new 2,4-D + glyphosate formulation does not significantly impact the activities of soil microorganisms linked to nutrient cycling in the soybean rhizosphere.

BACKGROUND AND OBJECTIVES

Widespread distribution of glyphosate-resistant weeds in soybean-growing areas across Mississippi has economically affected soybean planting and follow-up crop management operations. New multiple herbicide crop (including soybean) technologies with associated formulations will soon be commercialized.

The objectives of the planned research are to determine efficacy of new 2,4-D and dicamba formulations alone and in combination with one or more additional herbicide modes of action on herbicide resistant weeds, and to determine the impact of these formulations on soil microbial communities involved in nutrient cycling. Greenhouse studies will be initiated to evaluate interaction of new herbicide formulations with current herbicides and to achieve a broader and deeper understanding of the impact of new crop technologies on soil microbial properties. Results/data from the above research will greatly aid in the adaptation of new multiple herbicide resistant soybean germplasm in Mississippi soybean cropping systems.

Objectives

1. Determine efficacy of new 2,4-D and dicamba formulations alone and in combination with one or more additional herbicide modes of action on herbicide resistant weeds;

2. Determine the impact of dicamba and 2,4-D alone and in combination with glyphosate on soil microbial communities involved in nutrient cycling.

REPORT OF PROGRESS/ACTIVITY

Objective 1

Glyphosate resistant (GR) and susceptible (GS) Palmer amaranth, GR and GS tall waterhemp, and GR and GS common ragweed plants were treated with dicamba (1 pint/A Engenia formulation from BASF Crop Protection) and 2,4-D choline salt (4.75 pints/A Enlist Duo formulation, Dow AgroSciences; 2,4-D (1.064 kg ae/ha) + glyphosate (1.13 kg ae/ha)). Visual assessments of plant response were taken 21 d after treatment (DAT) on a scale of 0 (no injury) to 100 (complete plant mortality).

All pigweed plants (GR and GS, Palmer amaranth and tall waterhemp) were completely controlled when treated with 2,4-D at ≤5 inches in height (Table 1, Figures 1A-D). When pigweed plants were treated with 2,4-D at a height of 10 inches, two GR Palmer amaranth populations, GR2 (Figure 2A) and GR3, were completely controlled, but 13 % of plants from a third GR Palmer amaranth population, GR1, survived, though severely injured. A GR waterhemp population was also severely injured, but 7% of treated plants survived (Figure 2B).

Dicamba was applied only to ≥10-inch pigweeds. As with 2,4-D, two GR Palmer amaranth populations, GR1 and GR2, were completely controlled (Figures 3A-B) , but a third GR population, GR3, had 100% survival (Figure 3C). Similarly, a GR waterhemp population had 80% survival 3 WAT (Figure 3D).

GR pigweed populations, Palmer amaranth and waterhemp, which survived dicamba at 10-inch height at the time of treatment did not put out new healthy growth even by 8 WAT. Plants remained injured or began to starve towards attrition (Figure 4).

GR and GS common ragweed, 4- to 6-inches in height at the time of treatment, were completely controlled by both 2,4-D (Figure 5A) and dicamba (Figure 5B).

The above results clearly indicate that the new 2,4-D and dicamba formulations registered for use on 2,4-D and dicamba-resistant soybean, respectively, provide a very viable alternative for controlling GR as well as wild types of troublesome pigweeds such as Palmer amaranth and tall waterhemp, and other broadleaf weeds such as common ragweed. Herbicide applications must be made to pigweeds that are 4 inches or less in height.

Table 1. Response of glyphosate-resistant (GR) weed species to 2,4-D and dicamba. Survival rating is based on presence of an actively growing apical or lateral meristem. Percent control rating is based on visible injury to plants.

Population	Weed species	Height (inches)	Herbicide	# Plants treated	# Plants survived	Survival %	Control %
GR1	Palmer amaranth	≤5	2,4-D	15	0	0	100
GR2	Palmer amaranth	≤5	2,4-D	15	0	0	100
GR3	Palmer amaranth	≤5	2,4-D	15	0	0	100
GR	Tall waterhemp	≤5	2,4-D	15	0	0	100
GR1	Palmer amaranth	≥10	2,4-D	15	2	13	90
GR2	Palmer amaranth	≥10	2,4-D	15	0	0	100
GR3	Palmer amaranth	≥10	2,4-D	15	0	0	100
GR	Tall waterhemp	≥10	2,4-D	15	1	7	95
GR	Common ragweed	4-6	2,4-D	15	0	0	100
GR1	Palmer amaranth	≥10	Dicamba	15	0	0	100
GR2	Palmer amaranth	≥10	Dicamba	15	0	0	100
GR3	Palmer amaranth	≥10	Dicamba	15	15	100	80
GR	Tall waterhemp	≥10	Dicamba	15	12	80	40
GR	Common ragweed	4-6	Dicamba	15	0	0	98

Figure 1A. GR1 Palmer amaranth (left) treated with 2,4-D at ≤5 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS Palmer amaranth with untreated plant in the back.

Figure 1B. GR2 Palmer amaranth (left) treated with 2,4-D at ≤5 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS Palmer amaranth with untreated plant in the back.

Figure 1C. GR3 Palmer amaranth (left) treated with 2,4-D at ≤5 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS Palmer amaranth with untreated plant in the back.

Figure 1D. GR tall waterhemp (left) treated with 2,4-D at ≤5 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS tall waterhemp with untreated plant in the back.

Figure 2A. GR2 Palmer amaranth (left) treated with 2,4-D at ≥10 inch height of plants, 3 WAT. Untreated plant in the back. Tray on right indicates GS Palmer amaranth with untreated plant in the back.

Figure 2B. GR tall waterhemp (left) treated with 2,4-D at ≥10 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS waterhemp with untreated plant in the back.

Figure 3A. GR1 Palmer amaranth (left) treated with dicamba at ≥10 inch height of plants, 3 WAT. Untreated plant in the back. Tray on right indicates GS Palmer amaranth with untreated plant in the back.

Figure 3B. GR2 Palmer amaranth (left) treated with dicamba at ≥10 inch height of plants, 3 WAT. Untreated plant in the back. Tray on right indicates GS Palmer amaranth with untreated plant in the back.

Figure 3C. GR3 Palmer amaranth (left) treated with dicamba at ≥10 inch height of plants, 3 WAT. Untreated plant in the back. Tray on right indicates GS Palmer amaranth with untreated plant in the back.

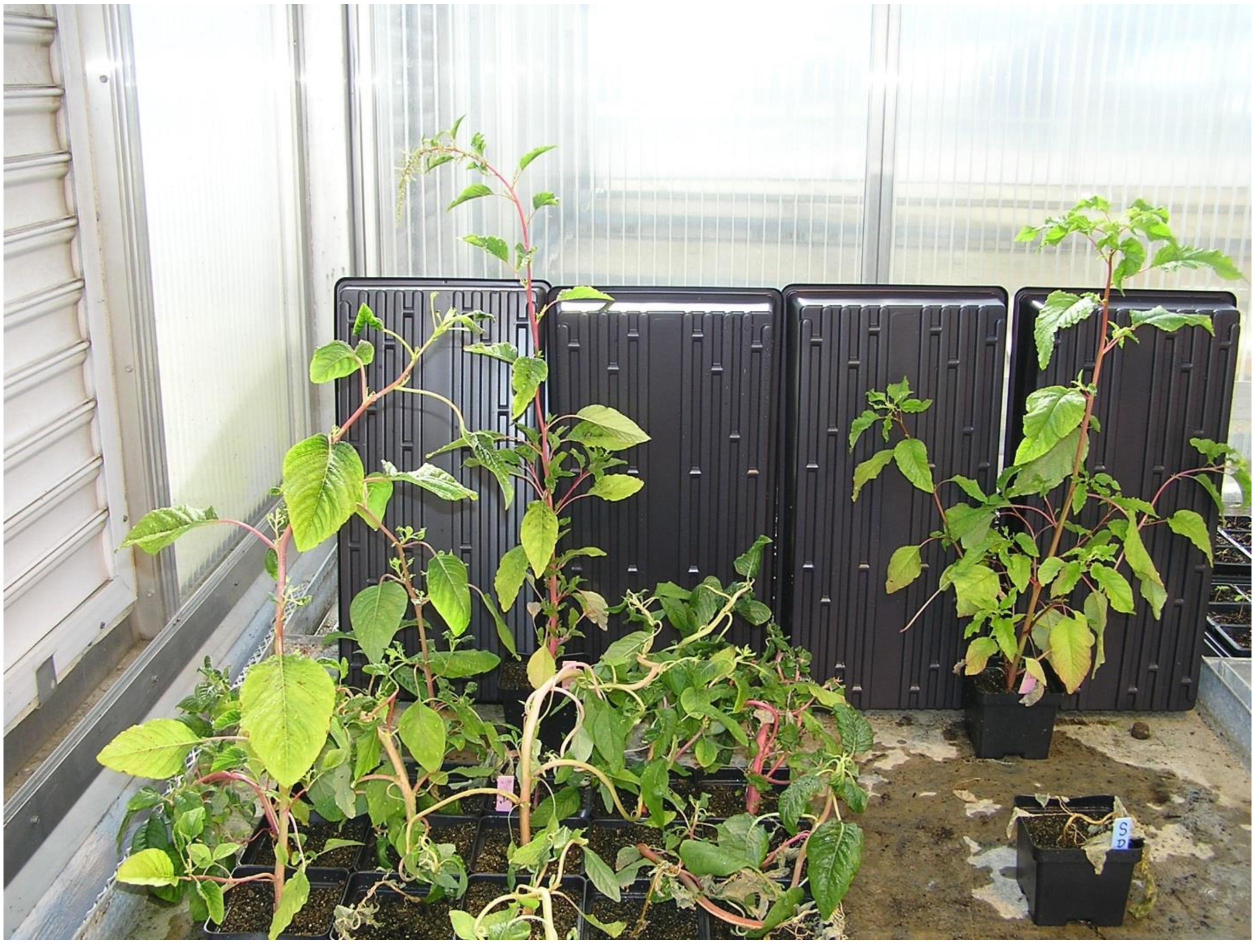

Figure 3D. GR tall waterhemp (left) treated with dicamba at ≥10 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS waterhemp with untreated plant in the back.

Figure 4. GR Palmer amaranth and waterhemp treated with dicamba at ≥10 inch height of plants, 8 WAT.

Figure 5A. GR common ragweed (left) treated with 2,4-D at 4-6 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS common ragweed with untreated plant in the back.

Figure 5B. GR common ragweed (left) treated with dicamba at 4-6 inch height of plants, 3 WAT. Untreated plant in the back. Pot on the right indicates GS common ragweed with untreated plant in the back.

Objective 2

A greenhouse experiment was conducted in February of 2016 using 2,4-D resistant soybeans grown in sandy loam and clay loam soils. Plant treatments included no herbicide application, glyphosate alone (1.13 kg ae/ha), and 2,4-D (1.064 kg ae/ha) + glyphosate (1.13 kg ae/ha) (4.75 pints/A of Enlist Duo). Rhizosphere soil was collected from plants at 1, 3, 7, 14, and 30 days after herbicide application and assayed for microbial enzyme activities linked to phosphate mineralization (phosphatase), nitrogen mineralization (N-acetylglucosaminidase (NAGase)), and organic matter turnover (β-glucosidase and cellobiohydrolase). ANOVA was conducted to determine if there were any significant differences between herbicide treatments in the two soil textures.

2,4-D + glyphosate did not significantly impact the activities of NAGase or cellobiohydrolase in the rhizosphere of soybean plants grown in either sandy loam (Figure 6C and 6D) or clay loam (Figure 7C and 7D) soils at any of the time points measured. Phosphatase activities also did not differ significantly between treatments in either soil texture for most of the experiment (Figure 6A and 7A). One exception was observed 14 days after herbicide application in sandy loam soils, when phosphatase activity in the rhizosphere of 2,4-D + glyphosate treated plants was significantly lower than untreated plants ($p=0.022$). However, this effect was transient and phosphatase activity had recovered to non-treated levels by the end of the experiment.

β-glucosidase activity in the rhizosphere was largely unaffected by herbicide application in either soil texture (Figure 6B and 7B). The only statistically significant difference occurred 7 days after application in clay loam soils, when β-glucosidase activity was 17% higher in 2,4-D + glyphosate than in untreated plants ($p=0.042$). However, this difference was small compared to the variability between rhizosphere samples at other time points and not likely to be biologically relevant.

Overall, microbial activities varied greatly between samples. However, there was no consistent impact of herbicide application on microbial activities between sandy loam and clay loam soil textures. Most differences in rhizosphere activity observed between herbicide treatments were not statistically significant and were transient in nature.

These results indicate that the new 2,4-D + glyphosate formulation does not significantly impact the activities of soil microorganisms linked to nutrient cycling in the soybean rhizosphere.

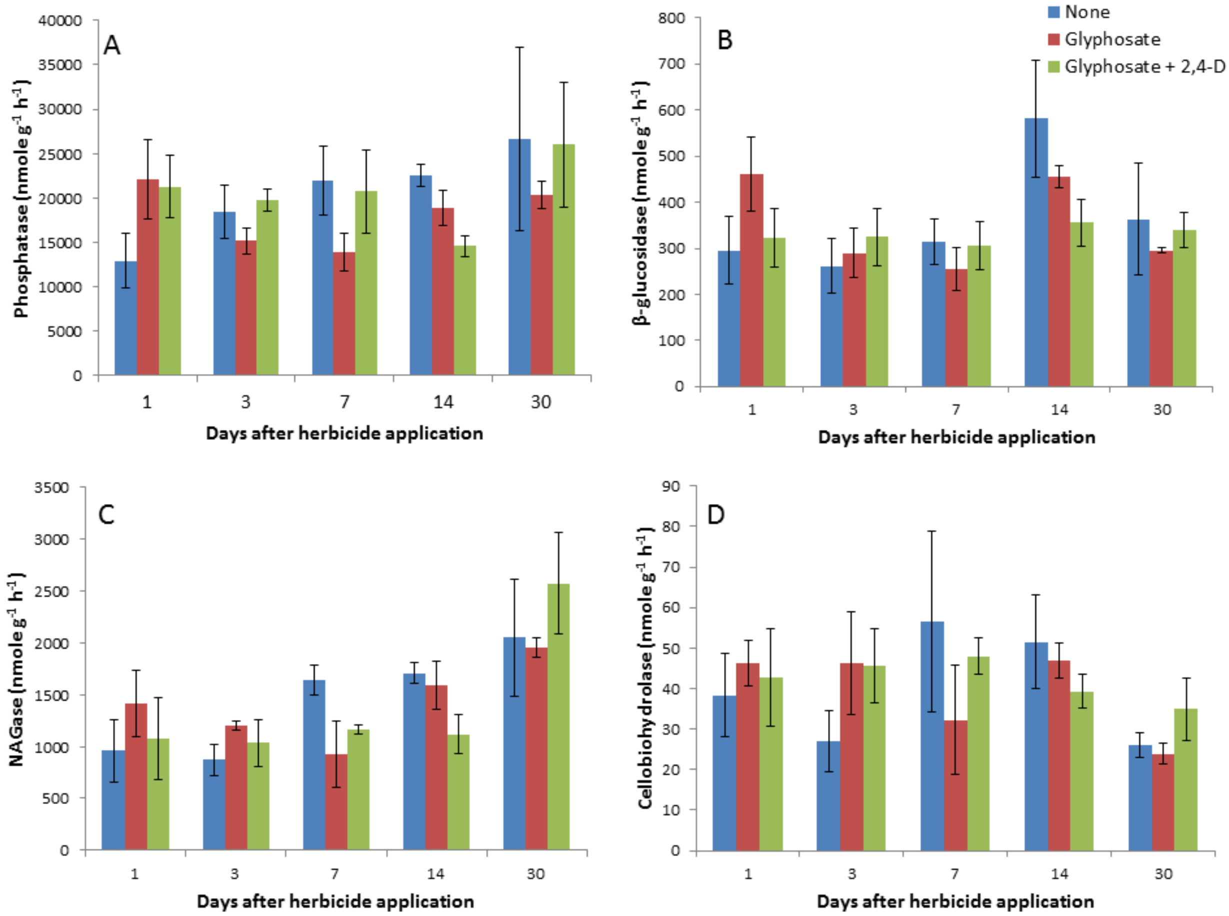

Figure 6. Mean ± standard error of phosphatase (A), β-glucosidase (B), N-acetylglucosaminase (NAGase) (C), and cellobiohydrolase (D) activities in the rhizosphere of untreated, glyphosate treated, or glyphosate + 2,4-D treated soybean plants grown in a sandy loam soil. The data from each treatment represents three replicates, with each replicate being composed of the pooled rhizosphere soil from four plants, for a total of 12 soybean rhizospheres collected per treatment and time point.

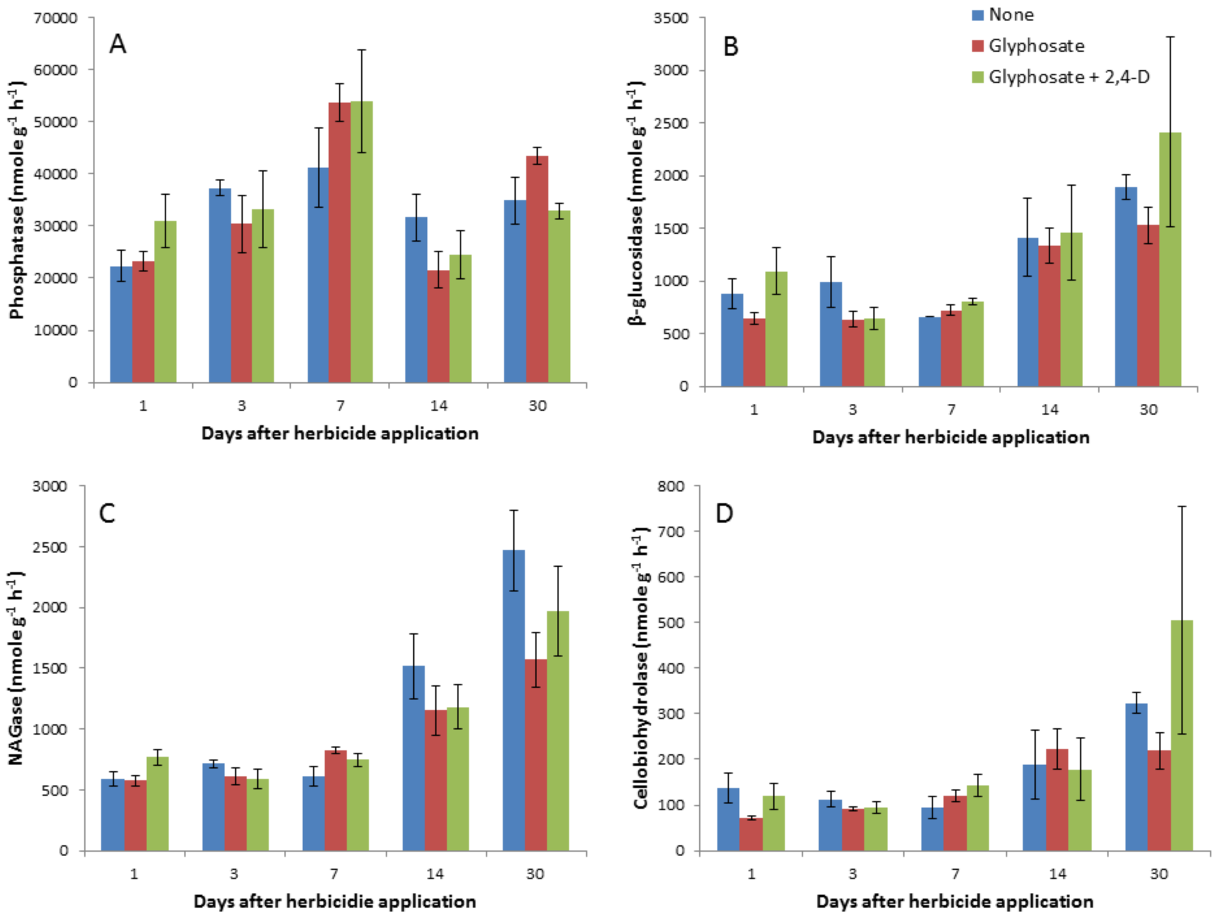

Figure 7. Mean ± standard error of phosphatase (A), β-glucosidase (B), N-acetylglucosaminase (NAGase) (C), and cellobiohydrolase (D) activities in the rhizosphere of untreated, glyphosate treated, or glyphosate + 2,4-D treated soybean plants grown in a silty clay loam soil. The data from each treatment represents three replicates, with each replicate being composed of the pooled rhizosphere soil from four plants, for a total of 12 soybean rhizospheres collected per treatment and time point.