Evaluating the effects of intense precipitation on the efficacy of weed management in soybeans

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The Northeast is experiencing a 71% increase in extreme precipitation events, which can increase soil-applied herbicide leaching and runoff, thereby decreasing preemergent residual herbicide efficacy. Cover crop surface residues can suppress weeds, thereby providing backup weed control when residual herbicides fail. However, cover crop surface residues increase soil moisture, which may exacerbate the loss of residual herbicides in response to extreme rain events.

Our proposed work included two research objectives investigating how extreme precipitation affects weeds and weed management efficacy.

Research Objectives:

1. Evaluate how variable precipitation influences the efficacy of residual herbicides varying in solubility.
2. Evaluate whether cereal rye surface residues can enhance weed control efficacy when used in combination with either Group 14 or Group 15 herbicides when extreme rainfall events occur.

Research Methods: To address these objectives, in Fall 2021 we established a research experiment at PSU's R.E. Larson Research Center in Rock Springs, PA comparing the following treatments in all combinations:
1) Cover crop surface residues: with and without a cereal rye cover crop
2) Herbicide: None, Group 15 (Dual II Magnum, Outlook, and Zidua) and Group 14 (Valor and Spartan) residual herbicides
3) Precipitation manipulation.
Precipitation manipulation treatments were imposed with rainfall simulators constructed by our group (see Figure 1) and included:

1. Ambient rainfall (0 inches of added precipitation, "0")
2. Intense precipitation (5 inches of rain in a single day event, "5x1")
3. Frequent precipitation (2 events of 2.5 inches of rain in one week).

Figure 1. Rainfall simulators used to impose precipitation addition treatments at PSU's research center in Rock Springs, PA.

Agronomic Management:

The experiment occurred at PSU's R.E. Larson Research Center in Rock Springs, PA and was established as a split-split plot randomized complete block design with four replications. As a split plot we applied three levels of precipitation treatments (Ambient

rainfall; Intense precipitation (5 inches) in one day; Frequent & Intense precipitation (2.5 inches of rain per event in two events in a single week).

We planted cereal rye (130 kg seed ha-1) in Fall 2021, which was then terminated in late Spring 2022 with glyphosate. Prior to cereal rye termination, above-ground biomass was collected from two 0.50 m2 quadrats per plot, sorted into cereal rye and weeds, then oven-dried, and weighed. The no cover crop plots were maintained weed-free until soybean planting with broad-spectrum herbicides. Prior to soybean planting, all plots received a burndown herbicide to kill any existing vegetation. Soybean (420,000 seeds ha-1) were planted in 30 in. rows, and standard fertility (NPK) was applied based on soil tests. At time of soybean planting, a ZRX roller-crimper system was used to flatten cereal rye in both cover crop treatments. At this time, the residual herbicides were applied.

To evaluate the effect that varying precipitation has on the efficacy of weed control tactics alone or in combination, we planted three weed species: smooth pigweed, giant foxtail, and marestail). 325 germinable seeds of both foxtail and smooth pigweed, along with 0.5 g of marestail seed plus flowering structures, were sown into a 0.5 m^2 quadrat in the center of the subplot. Because we had very unpredictable emergence of marestail, the data is not presented here.

Research Findings

How did extreme precipitation events affect weed density in the absence of herbicides?

Both extreme precipitation treatments increased pigweed density compared to the ambient precipitation control, however, we saw the highest pigweed density in the precipitation treatment in which we added 2 events of 2.5 inches of precipitation (Figure 2A). Cereal rye surface residues decreased pigweed density regardless of precipitation treatment.
The effect of extreme precipitation treatments on giant foxtail density varied based on presence of cereal rye surface residues (Figure 2B). In both extreme precipitation treatments (5x1) and (2.5x2), cereal rye surface residues increased giant foxtail density, however cereal rye surface residues had no effect on giant foxtail density in the ambient precipitation control.

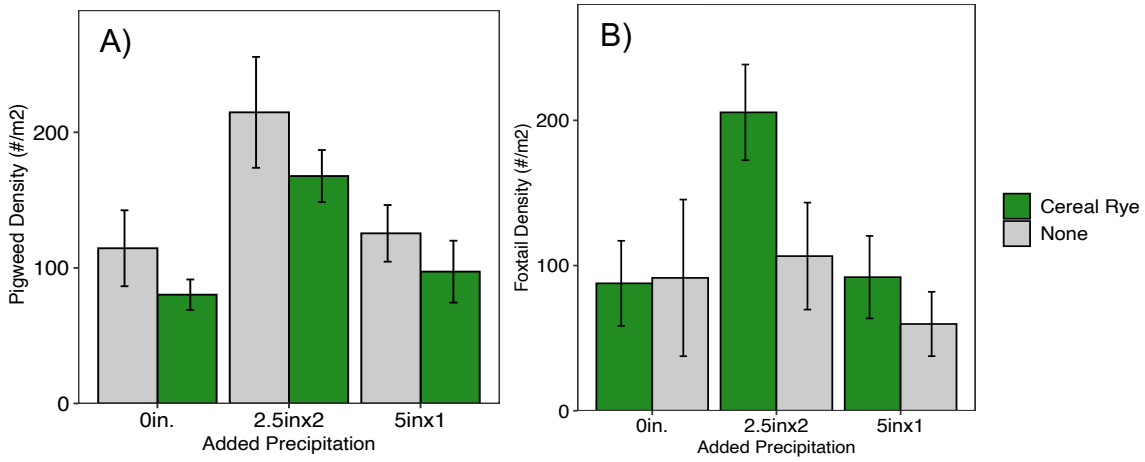

Figure 2. Density of A) Smooth Pigweed and B) Giant Foxtail in response to cover crop (Cereal rye [green bars] or None [gray bars]) and added precipitation treatments ("0"= ambient rainfall, no added precipitation; "2.5x2"= 2 events of 2.5 inches of precipitation added per event); "5x1"= five inches of added precipitation in a single day event). Data shown is from our no residual herbicide treatment. Bars represent means and standard errors.

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How did extreme precipitation events affect Group 15 control of smooth pigweed and giant foxtail?

Compared to the no herbicide control, all group 15 herbicides reduced the density of emerged pigweeds (Figure 3) and giant foxtail (Figure 4), however, we did find variation in control among the Group 15 herbicides in response to both cover crop and added precipitation treatments. Overall, we found greatest loss of Group 15 residual herbicide efficacy in response to extreme precipitation events when the more soluble Group 15 herbicide, Outlook, was combined with cereal rye surface residues.

Added precipitation had no effect on Zidua control of pigweed (Figure 3); however, both extreme precipitation treatments (2.5x2 and 5x1) decreased Outlook and Dual control regardless of cover crop treatment. However, overall Dual control of pigweed remained relatively high. Cereal rye decreased the efficacy of Outlook, the more water-soluble Group 15 herbicide, in response to extreme precipitation events. Overall, both Zidua and Dual effectively controlled pigweed when extreme precipitation events occurred. Extreme precipitation effects on group 15 control of giant foxtail were more variable (Figure 4), especially when combined with cereal rye surface residues. Extreme precipitation events tended to decrease efficacy of residual herbicides when combined with a cereal rye cover crop, however the loss of efficacy was greater in the more soluble herbicide Outlook. Overall, both Dual and Zidua remained effective across precipitation treatments, especially when no cover crop was present.

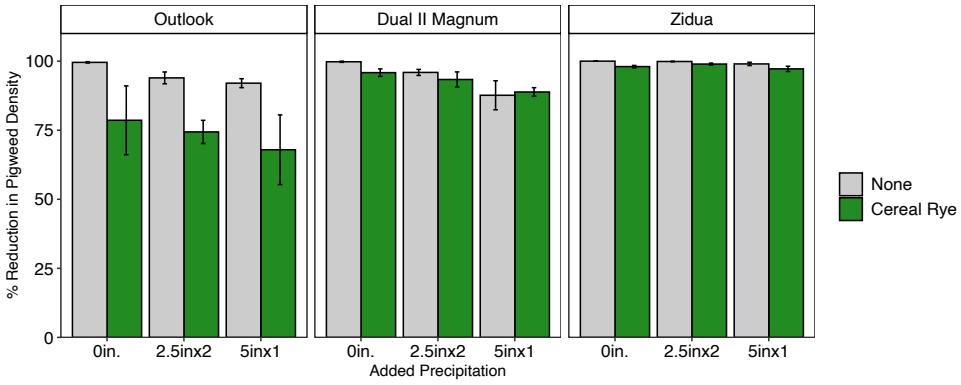

Figure 3. Group 15 herbicide effects on the % Reduction in Pigweed seedlings density (a metric of control) in response to cover crop (cereal rye or none) and added precipitation treatments (“0”= ambient rainfall, no added precipitation; “2.5x2”= 2 events of 2.5 inches of precipitation added per event); “5x1”= five inches of added precipitation in a single day event). Bars represent means and standard errors.

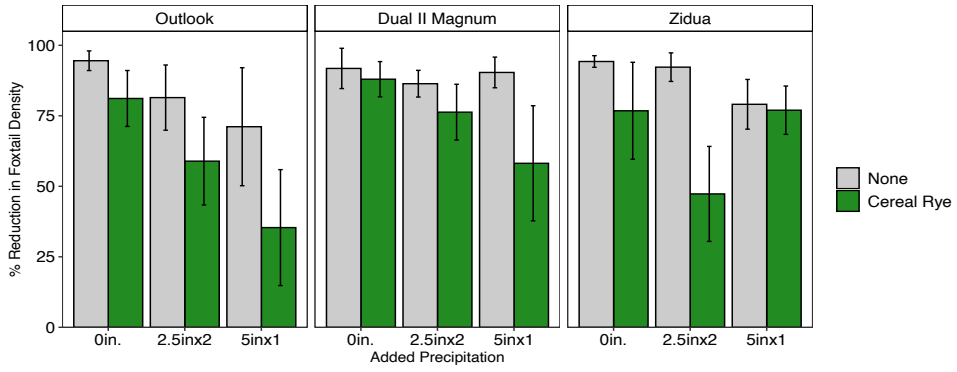

Figure 4. Group 15 herbicide effects on the % Reduction in Foxtail seedlings density (a metric of control efficacy) in response to cover crop (cereal rye or none) and added precipitation treatments (“0”= ambient rainfall, no added precipitation; “2.5x2”= 2 events of 2.5 inches of precipitation added per event); “5x1”= five inches of added precipitation in a single day event). Bars represent means and standard errors.

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How did extreme precipitation events affect Group 14 control of smooth pigweed?

Both Group 14 herbicides (Valor and Spartan) remained effective (greater than 99% control) regardless of cover crop or added precipitation treatments (Figure 5).

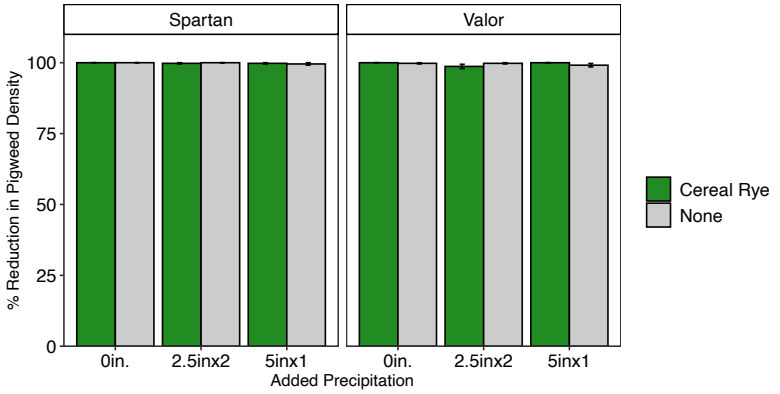
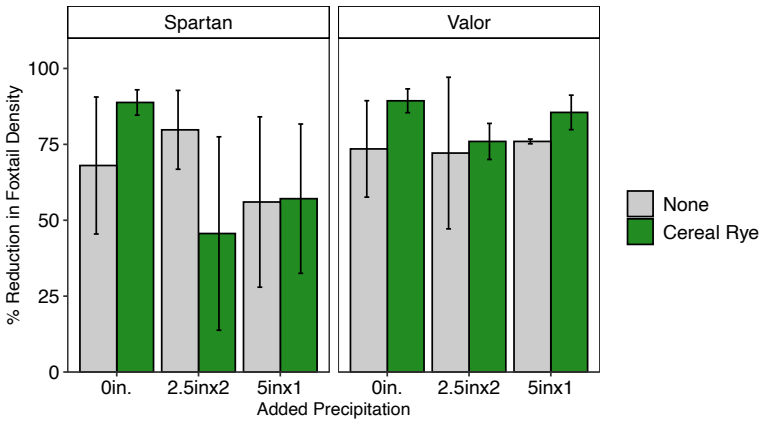


Figure 5. Group 14 herbicide effects on the % Reduction in Pigweed seedlings density (a metric of control efficacy) in response to cover crop (cereal rye or none) and added precipitation treatments ("0"= ambient rainfall, no added precipitation; "2.5x2"= 2 events of 2.5 inches of precipitation added per event); "5x1"= five inches of added precipitation in a single day event). Bars represent means and standard errors.

- Overall, we saw lower of efficacy of Group 14 residual herbicides of giant foxtail compared to pigweed (Figure 6). However, because of a high level of variability in the data, we detected no statistical differences in determining the response of Group 14 herbicides to extreme precipitation and cereal rye surface residues.

Figure 6. Group 14 herbicide effects on the % Reduction in Foxtail seedlings density (a metric of control efficacy) in response to cover crop (cereal rye or none) and added precipitation treatments ("0"= ambient rainfall, no added precipitation; "2.5x2"= 2 events of 2.5 inches of precipitation added per event); "5x1"= five inches of added precipitation in a single day event). Bars represent means and standard errors.



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Implications.

Often, integrated management tactics are highlighted as the best approach to increase the resilience of a farming system to weather variation and extreme scenarios. However, our research shows that the integrated approach (cover crop surface residues combined with residual herbicides) did not improve weed control when extreme precipitation events occurred, and may have lowered weed control efficacy in certain scenarios (e.g. when more soluble residual herbicides were used, such as Outlook). This research highlights the importance of evaluating integrated approaches across a range of environmental conditions and weather scenarios. However, it is important to note that even within our extreme rain treatments, we still saw that residual herbicides remained overwhelmingly effective. Among the Group 15 herbicides, both Zidua and Dual remained effective, providing over 80% control of pigweed, however control of foxtail was more variable especially when combined with a cereal rye cover crop. With both Outlook and Dual, we saw greater loss of efficacy with greater intensity of extreme rainfall (5x1) compared to greater frequency (2.5 x 2), and this was exacerbated when combined with cereal rye surface residues.