Impact of simulated rainfall on atrazine wash off from roller crimped and standing cereal rye residue onto the soil

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Introduction

The application of soil residual herbicides at cover crop termination is often recommended as part of an integrated weed management strategy[1,2,3]. Previous research suggests that cover crop biomass accumulation significantly reduces the amount of herbicide that reaches the soil[3]. Once intercepted by cover crops, herbicides can only move to the soil with rainfall. To date, limited research has been published on the effect of rainfall on herbicide wash off from cover crops onto the soil.

Hypothesis and Objectives

Hypothesis

1. Less atrazine will reach the soil underneath rolled cereal rye compared to standing cereal rye at the time of application.
2. Atrazine applied to rolled cereal rye will become more readily available in the soil relative to when applied to standing cereal rye.

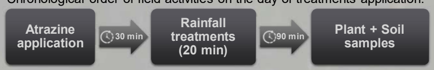
Objectives

1. Determine the amount of atrazine that reaches the soil at the time of application.
2. Determine the amount that is washed out from standing and roller crimped cereal rye after rainfall simulation.

Materials and Methods

- Field trial was conducted in May of 2022 at the Throckmorton Purdue Agricultural Center, Lafayette, IN.
- Cereal rye was planted on 10/01/2021 at 67 kg ha^{-1}
  - Average cereal rye biomass in May of 2022 was 3,591 kg ha^{-1}
- Experimental design: split-plot with 4 replications (3 by 3 m plots)
  - Rainfall volume: 0, 12.5, and 25 mm – main plot
  - Cover crop orientation: standing, roller crimped, and fallow – subplot
- Cereal rye was roller crimped one day before rainfall simulation
  - Cereal rye at flag leaf stage (average plant height: 50 cm)
- Atrazine was sprayed at 2,241 g ai ha^{-1} to all plots.
- Rainfall simulation started 30 minutes after atrazine application and lasted for 20 minutes.

Chronological order of field activities on the day of treatments application:



- Rainfall simulator structure (Figures 1, 2, and 3):
  - Nozzles were positioned 2.4 m above crop canopy
  - Each boom containing one nozzle rotated 45° back and forth to simulate rainfall droplet impact on the plant surface

Nozzle specifications for each rainfall treatment:

Rainfall treatment	Nozzle	PSI	GPM
25 mm	AI 8006	30	0.52
12.5 mm	AI 8003	30	0.26

Ultra coarse droplet size >622 microns (ASABE Standard S572.1)

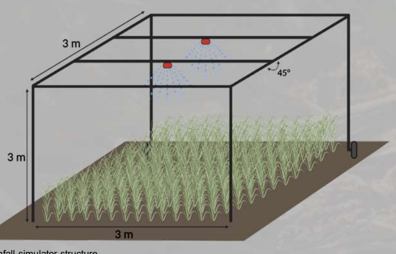


Figure 1: Rainfall simulator structure.

Data Collection and Analysis

- Samples:
  - 4 plant samples (2 whole plants each) per plot – after rainfall
  - Soil: one composite sample per plot (10 soil cores) – after rainfall
- Atrazine concentrations measured from all samples in a UHPLC
- Ground cover (%) – ImageJ software
- Data analysis: Proc GLIMMIX procedure of SAS. Means were separated using Tukey's HSD or Fisher's protected LSD ($P \leq 0.05$).

Rainfall Simulator

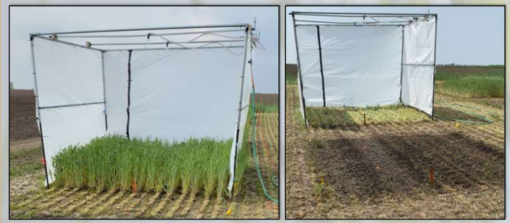


Figure 2: Cereal rye orientation treatments – standing (left) and roller crimped (right).

Figure 3: Water wagon was used to supply water to the rainfall simulation. Windshield wiper motor was used to rotate (45°) the booms with nozzles.

Results

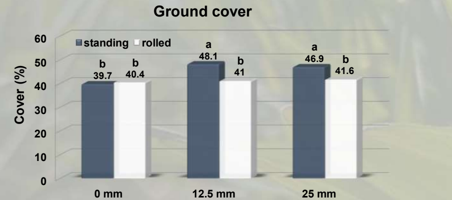


Figure 4: Ground cover. Data represents the average ground cover from 4 replicates of each cover crop and rainfall treatments. Bars with the same letter are not significantly different according to Tukey's HSD ($P < 0.05$).

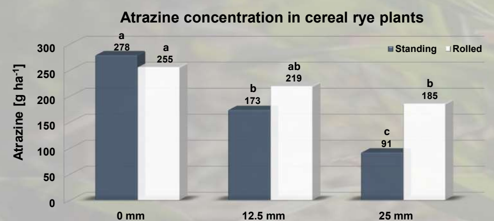


Figure 5: Concentration of atrazine in standing and roller crimped cereal rye plants that were subjected or not to rainfall simulation. Data represents the average concentration of atrazine from 4 composite samples collected per plot and across all rainfall and cover crop orientation treatments (24 plots). Bars with the same letter are not significantly different according to Fisher's protected LSD ($P < 0.05$).

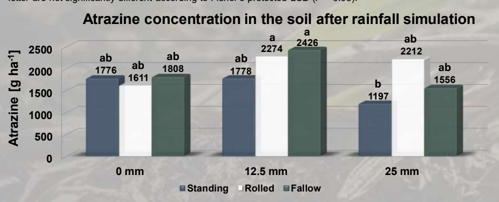


Figure 6: Concentration of atrazine in the soil (0–5 cm depth) of plots with or without cereal rye and subjected or not to rainfall simulation. Data represents the average concentration of atrazine (one composite sample of 10 soil cores) per plot and across all rainfall and cover crop orientation treatments (36 plots). Data were log-transformed before analysis. However, back-transformed original mean values are presented. Bars with the same letter are not significantly different according to Fisher's protected LSD ($P < 0.05$).

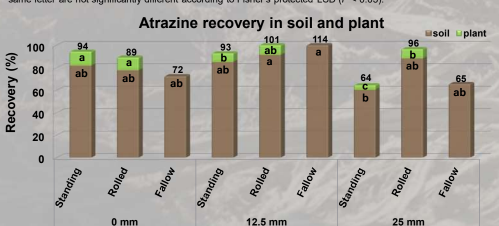


Figure 7: Percentage of atrazine recovered in the soil and plant relative to applied. Data represents the average atrazine recovery from 4 replicates of each cover crop and rainfall treatments. Soil data were square-root transformed before analysis. However, back-transformed original mean values are presented. Bars with the same letter within soil or plant data are not significantly different according to Fisher's protected LSD ($P < 0.05$).

Results and Discussion

- The use of roller crimper did not increase the ground cover relative to the cereal rye that was left standing (Figure 4).
- 25 and 12.5 mm of rainfall reduced atrazine concentrations from the standing cereal rye residue by 67 and 38%, respectively, compared to the standing cereal rye that was not subjected to rainfall (Figure 5).
- Atrazine measured in cereal rye plants that were roller crimped and subjected to 25 mm of rainfall was 102% greater than that measured in standing cereal rye under the same rainfall treatment (Figure 5).
- Only 28% of the atrazine initially intercepted by the roller crimped cereal rye was washed out from the plant residue after 25 mm of rainfall, compared to rolled cereal rye under 0 mm rainfall (Figure 5).
- After 25 mm of rainfall, more atrazine was observed in the soil under roller crimped cereal rye compared to standing cereal rye and fallow control (Figure 6) → Atrazine was slowly released onto the soil during rainfall under roller crimped cereal rye (Figure 8).
- All the atrazine applied was recovered in the soil and plants from roller crimper and fallow treatments after 12.5 mm of rainfall, whereas only 64% was recovered in the soil and plants from standing treatment after 25 mm of rainfall (Figure 7).

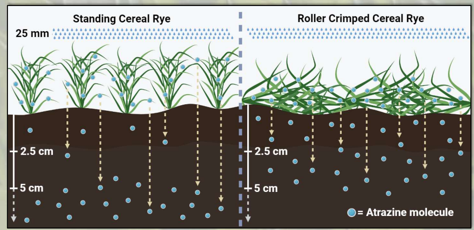


Figure 8: Rainfall effect on atrazine leaching within the top 5 cm of soil as influenced by cover crop orientation.

Conclusions and Implications

- **Data from this research suggests that:**
  - Roller crimped cereal rye residue is acting as a slow release mechanism for atrazine onto the soil during rainfall.
  - More than 25 mm of rainfall are required to wash off the majority of the atrazine initially intercepted by the roller crimped cereal rye.
- **Practical implications:**
  - Under a heavy rainfall event, the roller crimped cereal rye residue protects the soil and reduces herbicide leaching to the groundwater.
  - Reduced atrazine concentrations in the soil caused by herbicide interception by cereal rye is likely to impact weed control efficacy.
  - The slow release of the residual herbicide can be a concern for crop safety depending on the residual herbicide used (e.g. sulfentrazone injury in newly emerged soybean).

Future Research

- Trial will be repeated in 2023.
- Investigate the influence of different timings, volumes, and frequencies of rainfall on atrazine wash off from cereal rye residue onto the soil.

Acknowledgement

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INDIANA CORN Marketing Council

References

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