Effects of Root-Zone Glyphosate Exposure in Two Ditch Species

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Introduction

Glyphosate is one of the most widely used herbicides globally (Pollegioni et al. 2011), and its use has steadily intensified, with amounts applied in the United States doubling in half a decade, from 41,000-t in 2001 to 84,000-t in 2007 (Grube et al. 2011). Glyphosate is applied to agricultural fields at the beginning of the growing season to eliminate undesirable vegetation before planting with crops. Additionally, fields planted with glyphosate-resistant crops receive repeated glyphosate applications throughout the growing season.

In addition to the documented negative effects of glyphosate exposure on nontarget vegetation through drift or by-spray (Dalton and Boutin 2010), nontarget vegetation in edge-of-field ditches are also exposed to aqueous glyphosate in the root zone following soil infiltration during precipitation events (Vereecken 2005).

Objectives

This experiment explored the effects of aqueous glyphosate in agricultural runoff at environmentally-relevant concentrations on agricultural ditch plant species in a controlled laboratory experiment. investigated if root-zone glyphosate exposure affects two agricultural ditch plant species in a dose dependent relationship.

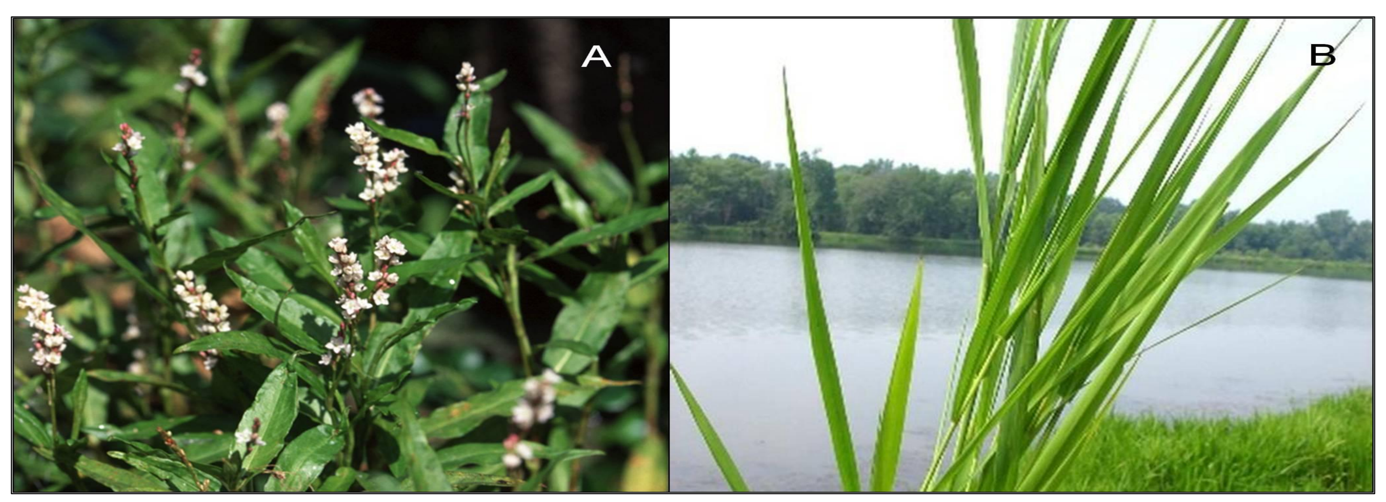

Figure 1. *Polygonum hydropiperoides* (A) and *Panicum hemitomon* (B) were studied in this experiment.

Materials and Methods

- *Polygonum hydropiperoides* and *Panicum hemitomon* and four glyphosate concentrations (0, 10, 1000, 10000 mg L^{-1} glyphosate) were arranged in a 2x4 randomized block design.
- Each treatment was replicated by six *P. hemitomon* plants (N = 24) and 10 *P. hydropiperoides* plants (N = 40).
- Glyphosate solution (100 mL) was introduced to the top of the substrate (sand) and allowed to infiltrate for two hours, then the substrate was rinsed with 500 mL deionized water.
- The study was terminated on Day 21.
- Plants were divided into above- and below-ground tissue, dried in an oven at 70°C, and dry weights were recorded. These dry weights were used to calculate the root-to-shoot ratio.
- Survivorship was calculated.
- Treatment effects were determined using a one-way analysis of variance (ANOVA). Significant differences were followed by Tukey's post-hoc comparisons. Differences were considered significant α<0.05.

Figure 2. Layout of plants in the laboratory.

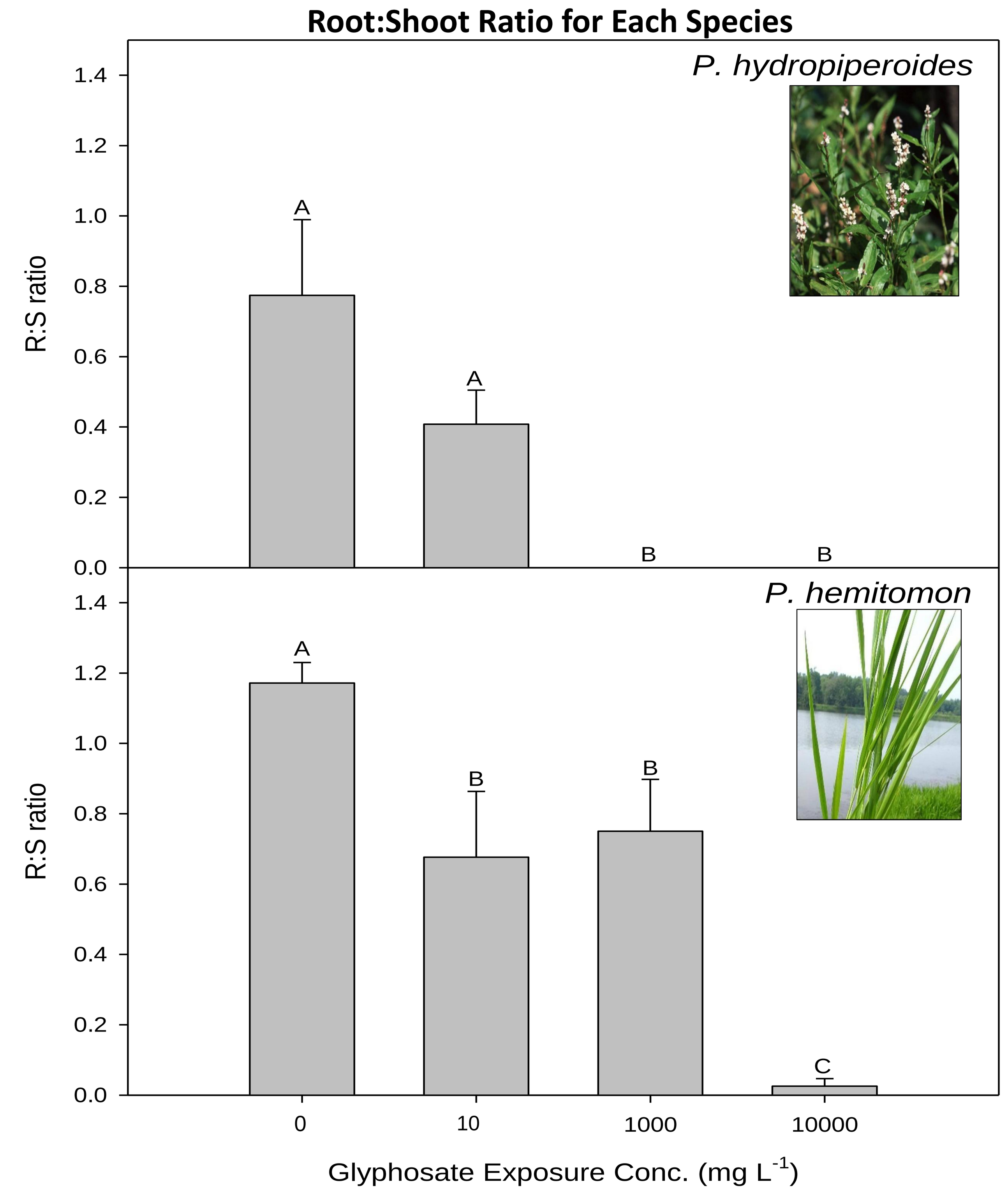

Figure 3. Calculated root:shoot ratios from dried and divided plant biomass for each species across the four glyphosate treatments. Values represent the mean ± SE for 10 and six replicates for *P. hydropiperoides* and *P. hemitomon*, respectively. Letters indicate significant differences across glyphosate treatments (p<0.05).

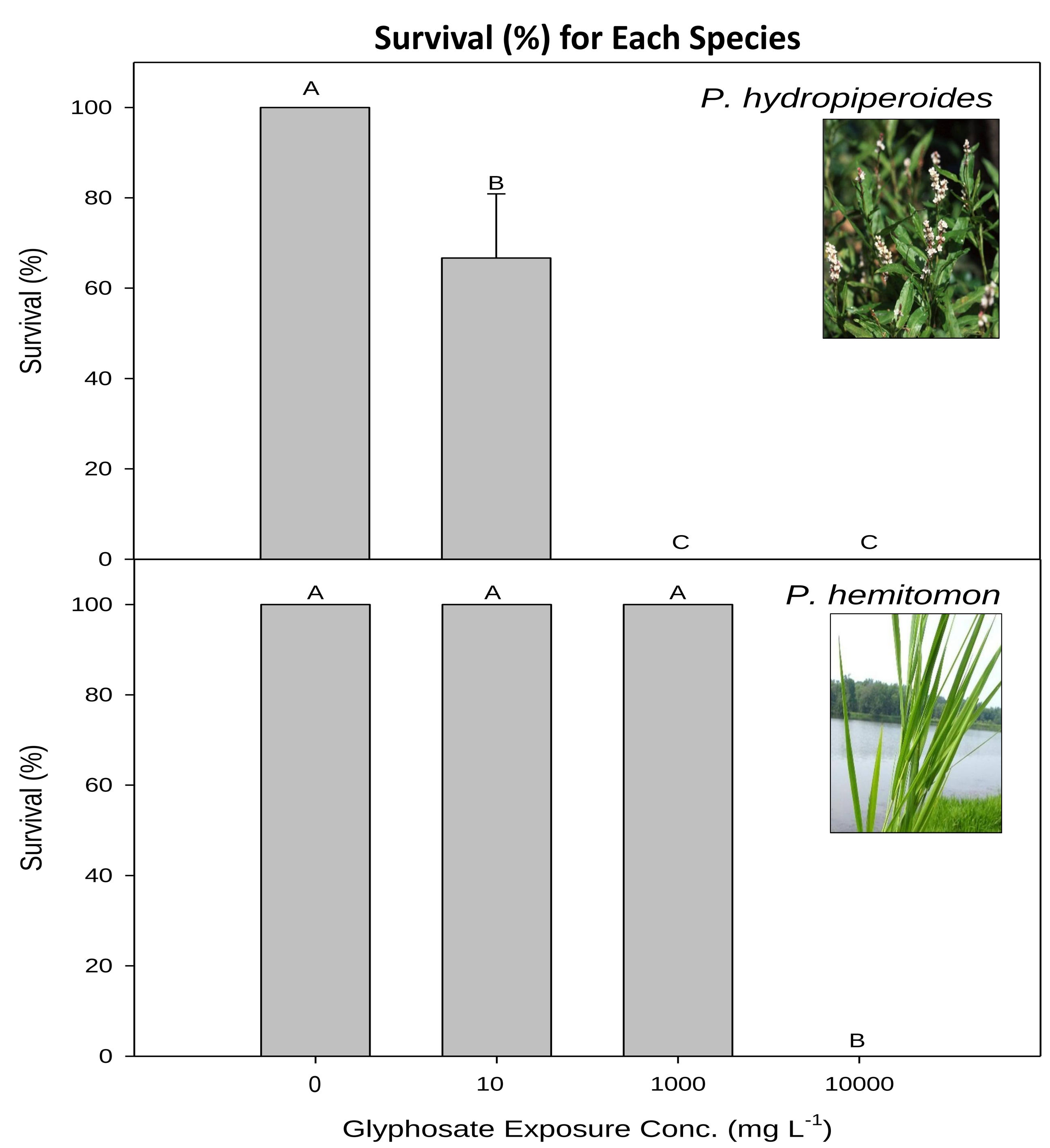

Figure 4. Calculated survival (%) at study termination for each species across the four glyphosate treatments. Values represent the mean ± SE for 10 and six replicates for *P. hydropiperoides* and *P. hemitomon*, respectively. Letters indicate significant differences across glyphosate treatments (p<0.05).

Results

Root:Shoot Ratio

- Root:shoot ratio decreased with increasing glyphosate concentration in *P. hydropiperoides* (F = 8.856, p = 0.000) and *P. hemitomon* (F = 13.00, p = 0.000) (Figure 3).
- In *P. hydropiperoides*, the root:shoot ratios for the 0 and 100 mg L^{-1} treatments were significantly greater than 1000 and 10000 mg L^{-1} treatments (α<0.05).
- In *P. hemitomon*, all treatments differed significantly, except for between the 10 and 1000 mg L^{-1} treatments (α<0.05).

Survival

- Glyphosate exposure affected survival in *P. hydropiperoides* (F = 38.698, p = 0.000) and *P. hemitomon* (F = 30.675, p = 0.000) (Figure 4).
- In *P. hydropiperoides*, the 1000 and 10000 mg L^{-1} treatments were significantly less than the 0 and 10 mg L^{-1} treatments, respectively (α<0.05).
- In *P. hemitomon*, the 10000 mg L^{-1} treatment was significantly less than the 0, 10, and 1000 mg L^{-1} treatments (α<0.05).

Conclusions

- Both *P. hydropiperoides* and *P. hemitomon* were negatively affected by root-zone glyphosate exposure in a dose dependant manner.
- Root:shoot ratios decreased with increasing glyphosate concentration in both species.
- Survival in each species was affected differently by the glyphosate treatments. In both *P. hydropiperoides* and *P.hemitomon*, the highest glyphosate concentration resulted in total mortality. *P. hemitomon* had greater survival than *P. hydropiperoides* at the two lowest concentration treatments.
- *P. hemitomon* may be better able to withstand the stress imposed by root-zone glyphosate exposure.
- Agricultural ditches share many of the same functions as wetlands, including transformation of many contaminants and providing habitat for plants and animals (Pierce and Pezeshki 2010).
- A recent literature review identified plant coverage as the most important variable affecting pesticide removal from ditches (Stehle et al. 2011).
- Vegetated agricultural ditches are an inexpensive area strategy to remove contaminants from field runoff.

Literature Cited

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