Impact of Weeds and Nitrogen on Nitrous Oxide Emissions

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Introduction

Nitrous oxide (N_2O) emissions increase with high rates of nitrogen (N) fertilizer and in high soil moisture environments. Weeds compete for excess N and water in the soil, and as a result, they may reduce N_2O emissions while growing. However, after weeds are killed emissions may increase as weeds decay and surface residues increase soil moisture and encourage N cycling. This research investigates how a 'weed-free' preemergence plus postemergence (PRE + POST) herbicide program and a 'weedy' POST-only herbicide program impact N_2O emissions at two different N rates.

Objectives

1. To determine if weeds reduce N_2O emissions while growing and/or increase emissions after termination
2. To compare how herbicide management strategy (PRE + POST vs. POST-only) influences N_2O emissions
3. To determine if N rate affects how weeds influence N_2O emissions

Materials & Methods

2x2 factorial treatment structure	**Greenhouse** (Spring 2013, Fall 2013, Spring 2014)	**Field** (Summer 2013 and 2014)
+Weeds (POST-only)	100 plants m^{-2} Powell amaranth (*Amaranthus powellii S.Wats.*) POST: glyphosate at 0.86 kg a.e. ha^{-1}	Powell amaranth seeded + naturally occurring weeds POST: glyphosate at 0.86 kg a.e. ha^{-1}
-Weeds (PRE + POST)	no weeds seeded	PRE: acetochlor at 2.63 kg a.i. ha^{-1} POST: glyphosate at 0.86 kg a.e. ha^{-1} + acetochlor at 1.57 kg a.i. ha^{-1}
+N	200 kg N ha^{-1} as ammonium nitrate	225 kg N ha^{-1} as urea
-N	0 kg N ha^{-1}	0 kg N ha^{-1}

- N applied at time of weed seeding/PRE application
- 10-15 cm tall weeds killed with POST herbicide, and weed residues left to decompose on the soil surface

Gas samples were collected from static sampling chambers in each plot daily, semi-weekly, or weekly from planting to 4 weeks past POST application. Samples were removed at 0, 20, 40, and 60 min, and gas chromatography was used to determine the concentration of N_2O in each sample. N_2O fluxes were generated by linear regression of the four samples within collection timings. N_2O emissions for the periods before and after weed termination were determined by linear interpolation of the fluxes between sampling days and numerical integration using Simpson's rule (Jarecki *et al.*, 2009)*.

Emissions data from the greenhouse and field trials were analyzed separately using a PROC Mixed procedure in SAS 9.3. *weed*, *N*, and *weed*N* were treated as fixed effects while *trial* was random. Means were separated using Fisher's Protected LSD at α = 0.05.

Results

There was no *weed*N* interaction effect on N_2O emissions in either the greenhouse (p=0.0927) or the field (p=0.4359). The graphs at right show the main effects of weed management and N rate on N_2O emissions.

Weeds did not have an effect on N_2O emissions in the field trials (Fig. 1c), but in the greenhouse weeds significantly increased emissions from 1.3 to 2.6 mg N_2O-N m^{-2} after termination, and total emissions were higher in +W treatments (Fig. 1a).

N_2O emissions were consistently higher at the higher N rate for all phases of the greenhouse and field studies (Figs. 1b and 1d).

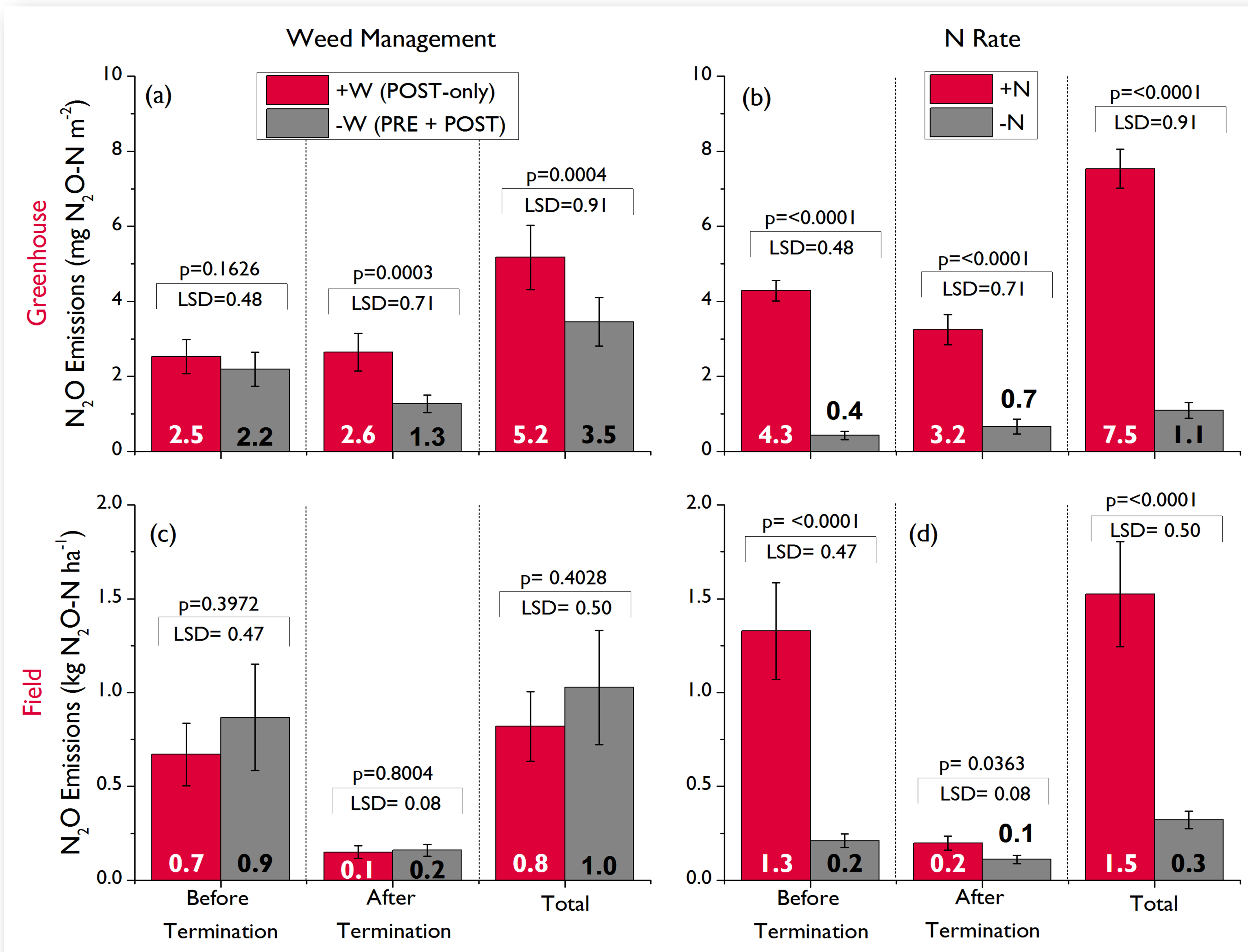

FIGURE 1. Main effects of weed management and N rate on N_2O emissions for the greenhouse and field studies. Error bars represent the standard error of the mean.

An effect of weed management was detectable in the greenhouse trials. Figure 2a shows how N_2O fluxes varied among the different treatments over time using the third greenhouse trial as an example. Note especially the period after POST application, where treatments with weeds (in red) had higher fluxes than those without weeds (in black).

Ancillary CO_2 flux data (Fig. 2b) shows that weeds consumed CO_2 prior to termination, but the soil released CO_2 as the weeds decomposed. This trend, which was not observed in the field, suggests that in the greenhouse we were able to more clearly detect how weed growth and decomposition impacted N_2O emissions.

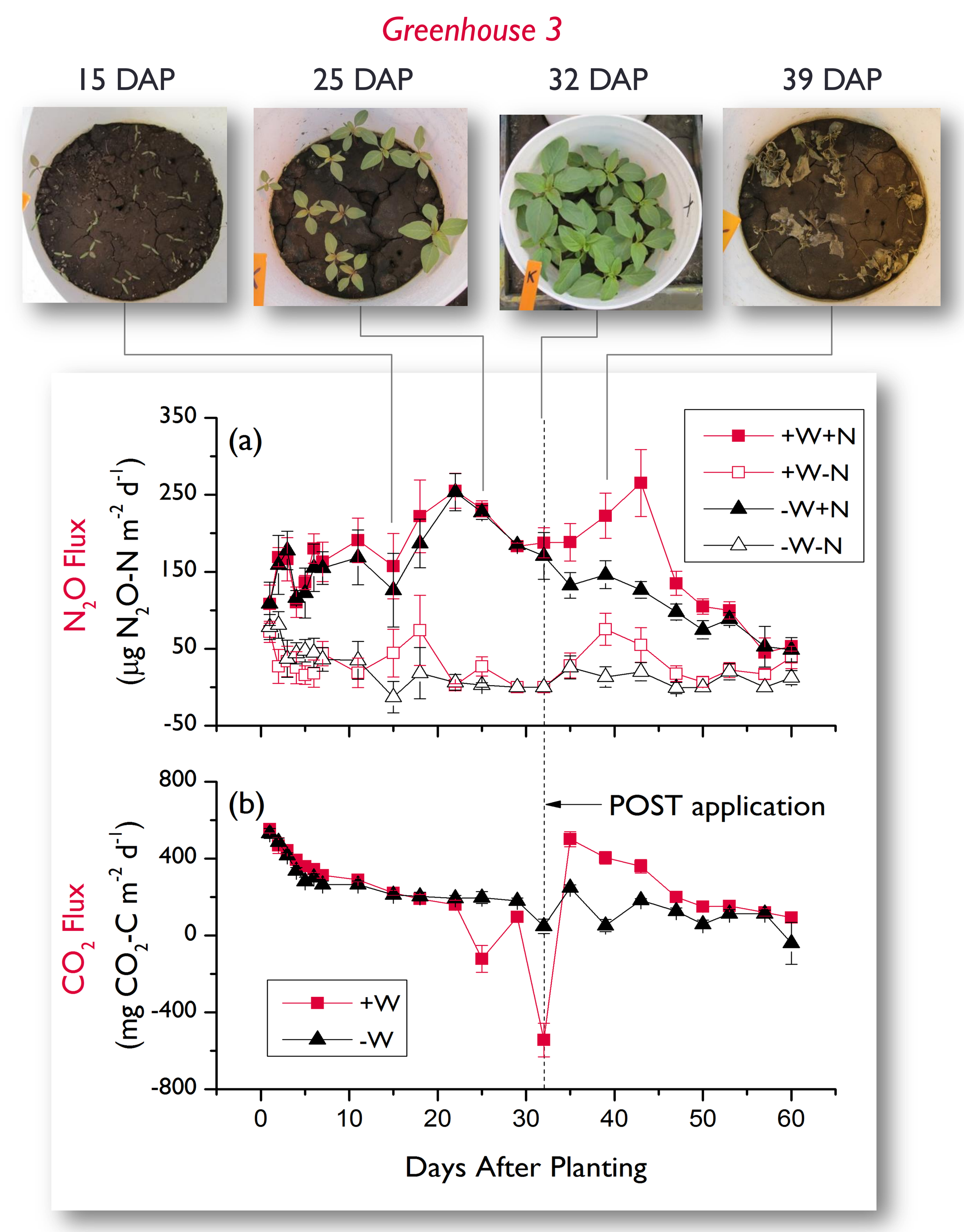

FIGURE 2. N_2O and CO_2 flux data from the third greenhouse trial, along with corresponding pictures of the weeds at various points in the study. The vertical dashed line shows when weeds were terminated.

Conclusions

We hypothesized that weeds would reduce N_2O emissions while growing and increase emissions after termination. While there was no effect of weeds on N_2O emissions before termination, weeds increased emissions after termination in the greenhouse studies. The ability to detect an influence of weeds in the greenhouse rather than in the field was likely due to fewer biotic and abiotic variables. In both the greenhouse and the field studies, high levels of N significantly increased N_2O emissions, which is consistent with previous research. Our results suggest that N rate is a more important factor than weed management in influencing N_2O emissions at the field scale. However, the decision to use a PRE + POST versus a POST-only herbicide management strategy is still important as an agronomic consideration to maximize yield.

Acknowledgements

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*Reference: Jarecki *et al.* 2009. Agriculture Ecosystems & Environment 134: 29-35.

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