

N₂O Emissions from Soybean as Influenced by Herbicide Management Strategy and Row Width

Rebecca R. Bailey, Thomas R. Butts, Vince M. Davis

Nitrous oxide (N₂O) is a harmful greenhouse gas produced when there is high soil moisture and increased concentrations of soil nitrate (NO₃⁻). Management practices that alter the availability of water in the soil, therefore, can directly influence N₂O emissions. This research evaluates the impact of weed management and row width on N₂O emissions in soybean. In the absence of preemergence (PRE) herbicides, weeds compete with soybean for available soil moisture and nitrate, and may reduce N₂O emissions relative to a weed-free environment. However, after weeds are killed with a postemergence (POST) herbicide, the dead weed residues remaining on the soil surface act as a carbon and nitrogen source which may stimulate N₂O emissions. Soybean row width is known to influence weed growth and biomass accumulation, with wider rows often resulting in more weed biomass. As a result, row width may further impact soil water and nitrate availability, and ultimately, N₂O emissions. A study was conducted in 2013 and 2014 at Arlington Agricultural Research Station near Arlington, WI (43.30 N, 89.32 W). A 2x2 factorial treatment structure of weed management (PRE + POST vs. POST-only) and row width (38- or 76-cm) was arranged in a RCBD with four replications. On May 14, 2013 and May 22, 2014 soybean was planted at a target population of 322, 000 seeds ha⁻¹, and PRE herbicides were applied within a day of planting. In 2013, POST applications were made 50 days after planting (DAP) if following a PRE and 31 DAP for POST-only treatments, while in 2014 all POST applications were made 42 DAP. N₂O emissions were measured from static gas sampling chambers placed within each plot. Samples were collected at least weekly starting 14 DAP until mid-September. Since different years and treatments had varying POST application timings, emissions data before termination were normalized to a 28 day span while emissions after termination were normalized to an 81 day span. Data were compared using a mixed model procedure in SAS 9.3 with *weed*, *width*, and *weed*width* treated as fixed effects and *year* and *rep(year)* as random. Means were separated with Fischer's Protected LSD at $\alpha = 0.05$. Yield data were also compared using the same mixed model procedure. POST-only treatments had lower N₂O emissions than PRE + POST treatments before termination, but otherwise there was no significant effect of *weed*, *width*, or *weed*width* on N₂O emissions either before termination, after termination, or for the full study at $\alpha = 0.05$. Soybean yield was not influenced by *width* or *weed*width* ($p=0.6018$ and $p=0.5825$, respectively), but yield for PRE + POST treatments (4270 kg ha⁻¹) was significantly higher than yield for POST-only treatments (3620 kg ha⁻¹) ($p=0.0007$). These results indicate that while weed management strategy may not be an effective means to mitigate season-long N₂O emissions from soybean, use of a PRE herbicide is still recommended to increase soybean yield.

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Introduction

Emissions of nitrous oxide (N₂O), a potent greenhouse gas, are positively correlated to increased soil nitrate, soil moisture, carbon availability, and temperature. We hypothesized that compared to a ‘weed-free’ preemergence plus postemergence (PRE + POST) management system, weeds competing with soybean for nitrate and water in a ‘weedy’ POST-only system would reduce N₂O emissions while growing. Conversely, after weeds were terminated by POST herbicides, emissions would increase as the weed residues supplied nitrate and carbon to the soil. We expected this effect to be heightened at a wide row width (78-cm) compared to a narrow row width (36-cm) since soybean canopy closure occurs later in wider rows and weeds can accumulate more biomass.

Objectives

- To determine if weeds reduce N₂O emissions while growing and/or increase emissions after termination.
- To compare N₂O emissions from PRE + POST and POST-only weed management strategies in soybean.
- To evaluate if row width has an impact—or further influences an effect of weed management—on N₂O emissions.

Materials & Methods

- Trials conducted in 2013 and 2014 in Arlington, WI.
- 2x2 factorial treatment structure in RCBD with 4 replications:

Row width (cm)	Weed Management	
	PRE + POST	POST-only
38	PRE: S-metolachlor + fomesafen + metribuzin @ 1.22 + 0.27 + 0.42 kg ai ha ⁻¹ , respectively	S-metolachlor + fomesafen + glufosinate @ 1.22 + 0.27 + 0.59 kg ai ha ⁻¹ , respectively
76	POST: glufosinate @ 0.59 kg ai ha ⁻¹	

- PRE applied at planting. In 2013, POST applied 50 days after planting (DAP) if following a PRE, or 31 DAP for POST-only. In 2014, POST applied 42 DAP for both treatments.
- Prior to POST application, weed biomass collected from POST-only treatments (2014) and compared by row width with Student’s t-test.
- Gas samples collected weekly from static chambers placed in each plot starting 14 DAP until mid-September.



- 4 gas samples collected hr⁻¹ on sampling days.
- Concentration of N₂O in each sample determined by gas chromatography, and linear regression of concentration over time generated N₂O flux.
- Average daily fluxes compared for the period before weed termination, after termination, and for the full study. Additionally, fluxes compared by sample timings (soybean growth stages).

- N₂O flux and yield data analyzed with PROC Mixed procedure. Fixed effects: *weed*, *width*, *weed*width*. Random effects: *year*, *rep (year)*. Means separated with Fisher’s Protected LSD at α=0.05.

Conclusions

We hypothesized that weeds would reduce N₂O emissions before termination and increase emissions after termination. Although weeds reduced emissions at the sample timing immediately prior to POST application, average N₂O fluxes were comparable for PRE + POST and POST-only herbicide management strategies before termination, after termination, and for the full study. Similar to other research, weed biomass was greater in the 78- vs. 38-cm rows, but row width did not influence N₂O emissions. Soybean yield was 650 kg ha⁻¹ higher in the PRE + POST vs. the POST-only treatments. These results indicate that although herbicide management strategy does not significantly influence N₂O emissions from soybean, the use of a PRE herbicide is still important to prevent soybean yield loss.

Results

Weed biomass collected at the POST timing was 67 vs. 31 g m⁻² in the 76- vs. 38-cm rows, respectively (p=0.0384). However, N₂O emissions were not influenced by *weed*width* or *width* either before termination, after termination or for the full duration of the study. Interestingly, we observed that POST-only treatments had lower fluxes on the sampling day immediately prior to POST application (p=0.0023, Fig. 2), but this was the only incidence where *weed* influenced N₂O fluxes, and overall, average fluxes from PRE + POST and POST-only treatments were comparable for all periods of the study (Fig. 1). Soybean yield was significantly higher in the PRE + POST vs. the POST-only treatment. Results are summarized in Table 1.

Table 1. P-values for tests of fixed effects on average N₂O fluxes for different periods of the study and soybean yield.

Factor	N ₂ O Fluxes			Yield
	Before termination	After termination	Total	
<i>weed</i>	0.1537	0.7189	0.2409	0.0007
<i>width</i>	0.4828	0.5102	0.3615	0.6018
<i>weed*width</i>	0.7846	0.8124	0.9260	0.5825

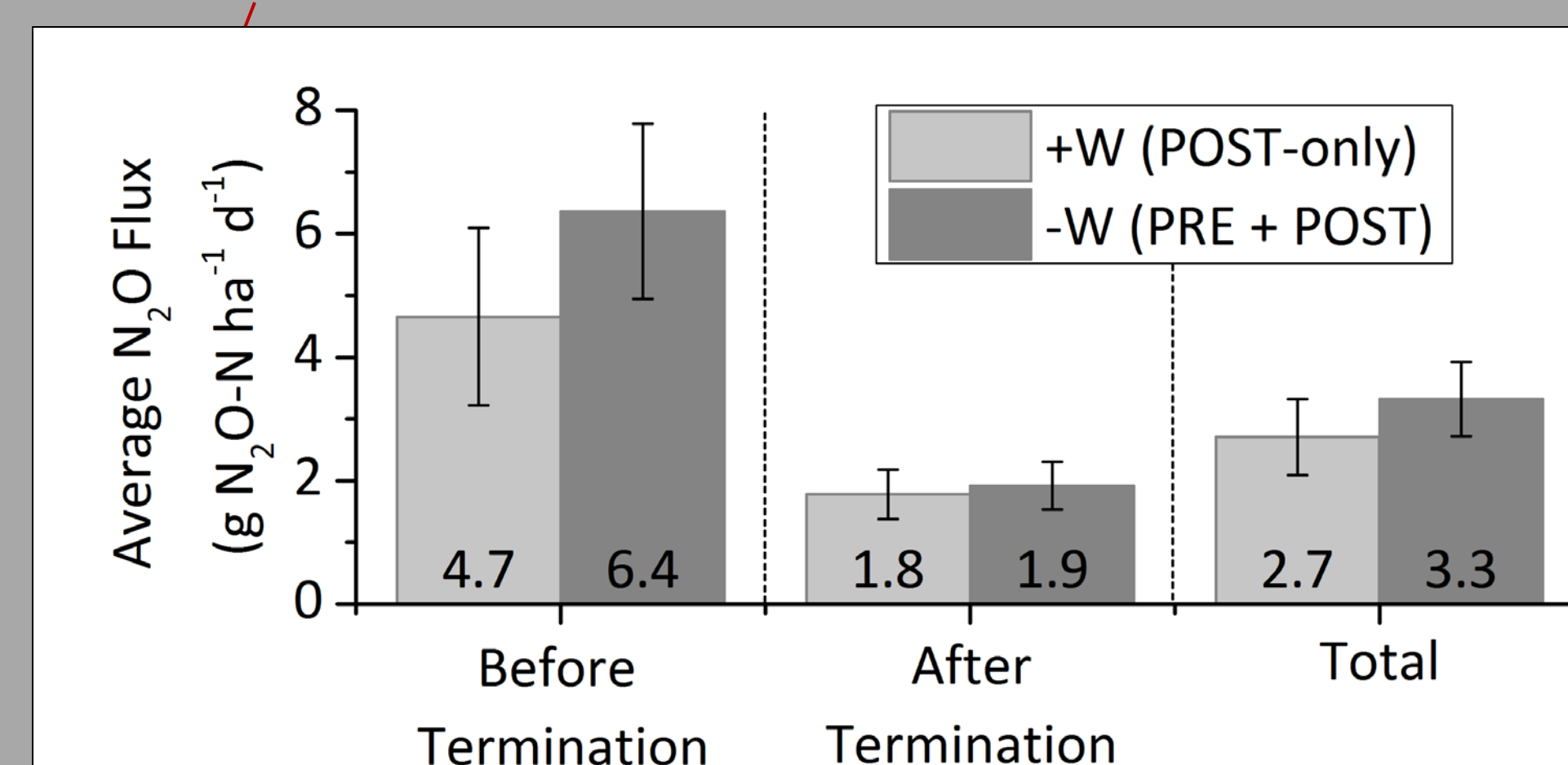


Figure 1. Average N₂O fluxes by *weed* for each study period combining two years of data. Error bars represent standard error of the mean.

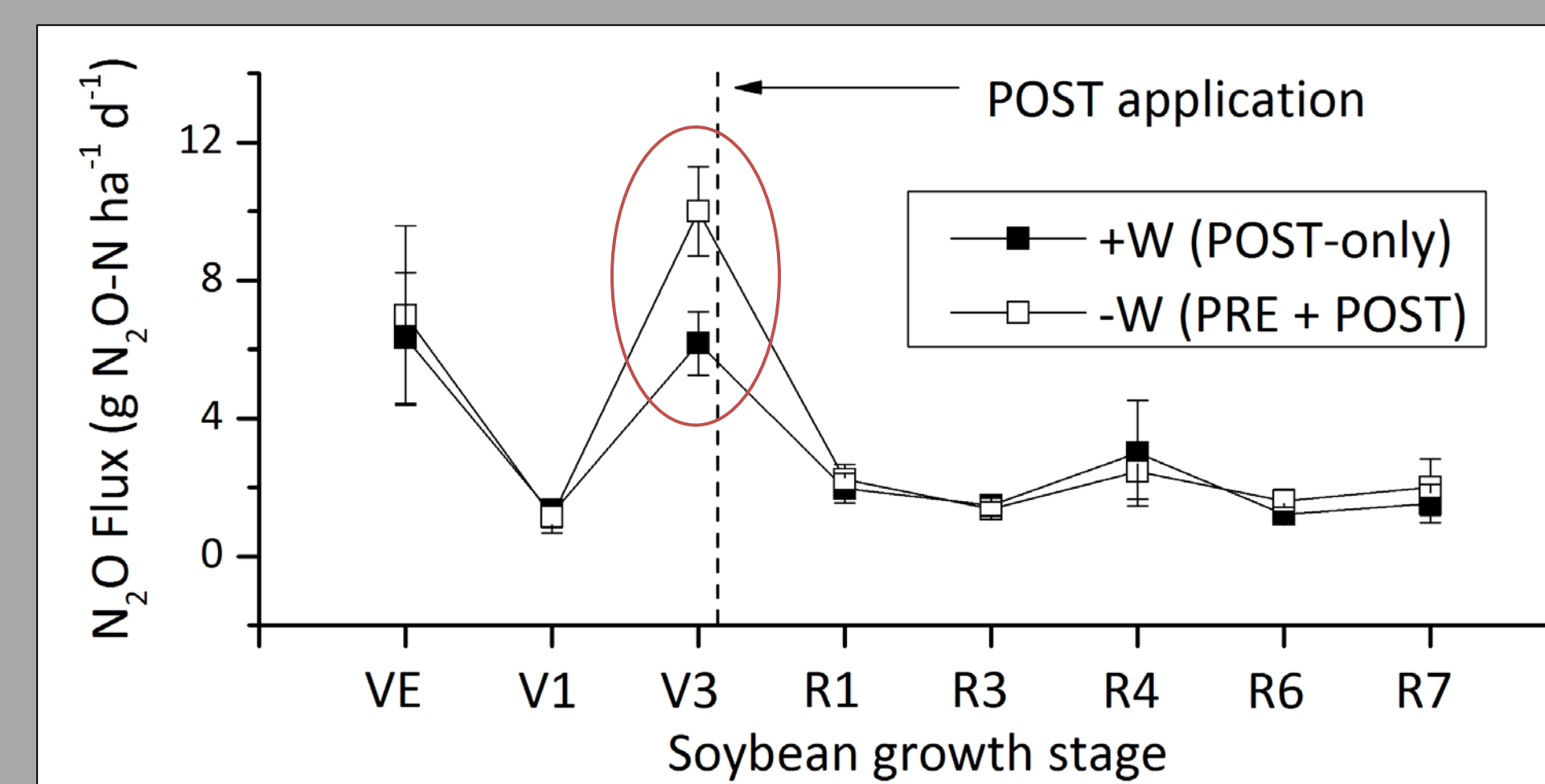


Figure 2. N₂O fluxes by *weed* across both years for sample timings corresponding to soybean growth stage. Error bars represent standard error of the mean.

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