Nitrous oxide in the inland Pacific Northwest

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For those interested in understanding farming's impact on climate change, nitrous oxide is an important piece of the picture. This is because nitrous oxide is a powerful greenhouse gas (298 times more powerful than carbon dioxide, over a 100-year time frame). And nitrous oxide from agricultural soils is a significant contributor to agriculture's direct greenhouse gas emissions, as estimated through inventories of such emissions. In all three Pacific Northwest (PNW) states (WA, OR, and ID), it has been estimated that nitrous oxide from soils accounts for 40% to 50% of direct greenhouse gas emissions from agriculture. However, these estimates rely on "default" assumptions about nitrous oxide emissions that were developed from global data—and a review of existing experimental data in the inland PNW suggests that these defaults may not be appropriate in our region.

Nitrous oxide emissions occur in agricultural soils (and also in nonagricultural soils) when microbes in the soil transform nitrogen from one form to another, specifically during the processes of nitrification and denitrification. However, more nitrous oxide is produced under some conditions than others—for example, when nitrogen is added to soils (as in most farming systems) and when oxygen in soils is limited (for example, when soils are saturated with water from rainfall or melting snow).

Most work on nitrous oxide in the PNW has been done since 2000, and there's not an overwhelming quantity of data. However, existing data suggest that emissions from most inland PNW croplands may be on the low side compared to other regions of the United States and world (Figure 1). The data in Figure 1 were collected as part of the ongoing webinar series on PNW Agriculture and Climate Change, supported by REACCH.

On the left is the Intergovernmental Panel on Climate Change (IPCC)'s "Tier 1 emissions factor," indicating that in the absence of more specific data, it should be assumed that 1% of nitrogen applied as fertilizer is emitted as nitrous oxide. This number is based on a global review of nitrous oxide emissions data in agricultural systems. In recognition of the high amounts of variability in the data, they suggest an uncertainty range of 0.3% to 3% (shown in the graph with the error bars). Immediately to the right of the IPCC Tier 1 emissions factor are data from several conventional and no-till dryland cropping rotations in Bozeman, MT. The next two measurements are from dryland winter wheat in WA. At the far right are two measurements from irrigated systems, representing measurements in a sweet corn–sweet corn–potato rotation.

IMPACT

A review of published season-long (or longer) nitrous oxide emissions values in the inland PNW suggests that emissions may be on the low side compared to other regions of the United States and world. If ongoing research confirms this, it suggests that any efforts to reduce nitrous oxide emissions through management should focus on strategies that offer strong co-benefits, such as raising yields or saving water.

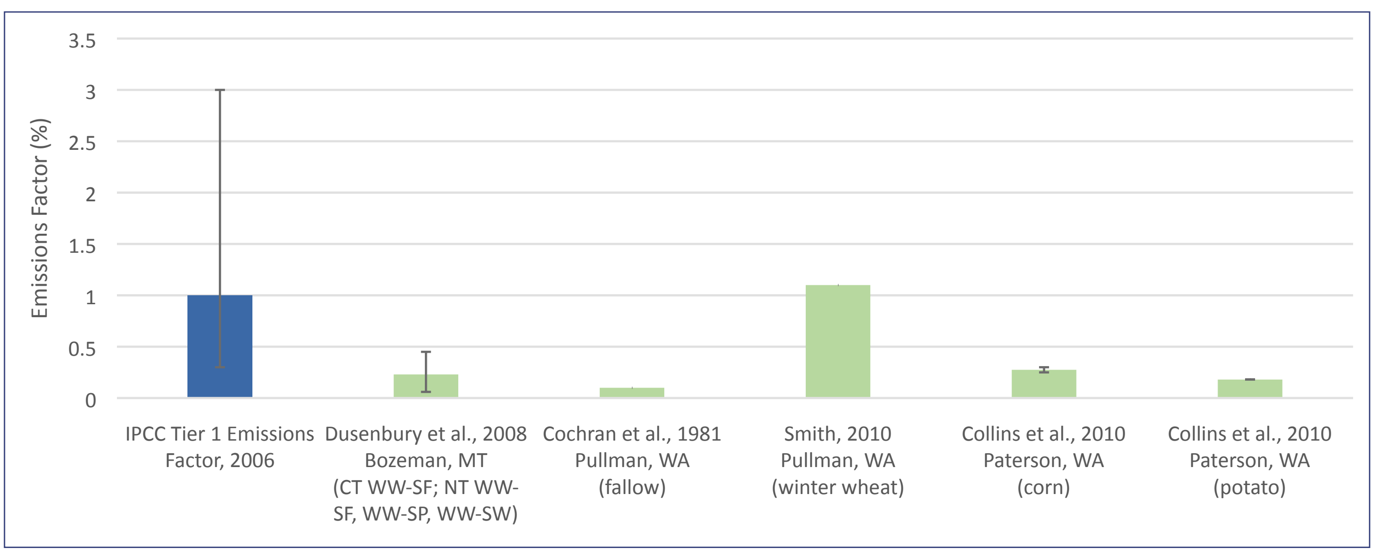

Figure 1. *Intergovernmental Panel on Climate Change (IPCC) Tier 1 emissions factor compared to existing published experimental data collected under field conditions in Montana and the inland PNW. Experimental measurements are for two years (Dusenbury et al. 2008), 41 days (Cochran et al. 1981), or growing season (Smith 2010 and Collins et al. 2010). Error bars on this graph represent uncertainty range (IPCC) and ranges across multiple crop rotations and nitrogen levels (for Dusenbury et al. 2008) or years (Collins et al. 2010). IPCC Tier 1 emissions factor is from DeKlein et al., 2006.*

Published modeling results also suggest that emissions are on the low side compared to IPCC estimates (Figure 2). For detailed explanation of both graphs, see the webinar "Nitrous Oxide Emissions in inland Pacific Northwest Cropping Systems" at csanr.wsu.edu/webinars/pnw-ag-and-climate-change/.

Ongoing work in the PNW, through the REACCH project, the Site-Specific Climate-Friendly Farming project, and others, will either confirm or refute this tentative conclusion. Methods being used include experimental efforts using sophisticated flux towers along with the chamber methods that are captured in the data described earlier, as well as modeling efforts. These multiple strategies are being used to try to overcome difficulties that result from the event-based and localized nature of nitrous oxide emissions, which makes it difficult to accurately capture field-level emissions.

The answers that we get will likely have implications for how we might mitigate nitrous oxide emissions in the inland PNW. If emissions are fairly low, one implication is that any efforts to reduce nitrous oxide emissions through management should focus on strategies that offer strong co-benefits, such as raising yields or saving water. This is because with lower overall emissions, any strategies that reduce greenhouse gas emissions will also have relatively smaller incentives (whether through carbon credits or some other structure), so strong co-benefits will likely be important for adoption.

References

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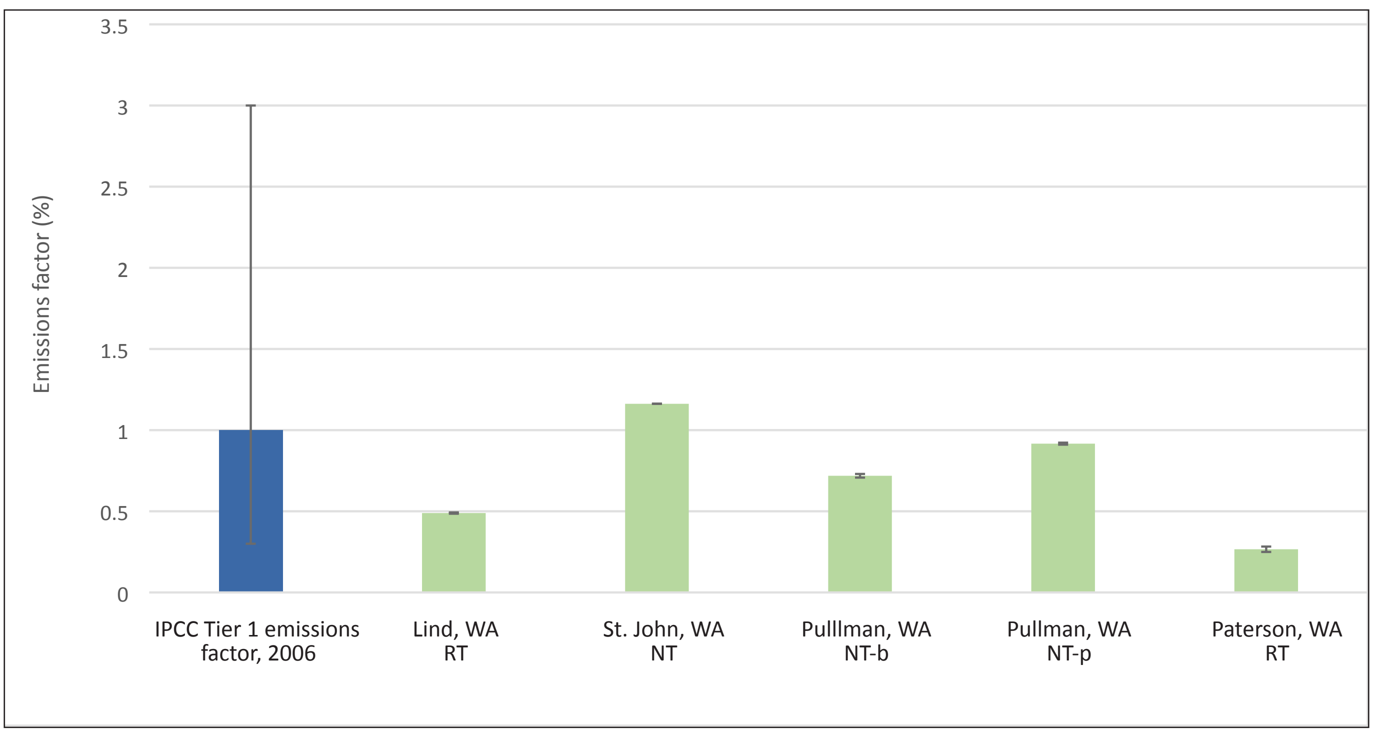

Figure 2. *Intergovernmental Panel on Climate Change (IPCC) Tier 1 emissions factor compared to published modeling results for the inland PNW. Modeling results are annual nitrous oxide emissions, averaged over 30 years, simulated by CropSyst and expressed as a percentage of applied nitrogen, for reduced tillage (RT) and no-till (NT) crop rotations at four locations in eastern WA. Pullman NT-b has barley in rotation; Pullman NT-p has peas in place of barley. Error bars for IPCC emissions factor represent uncertainty range. Error bars for CropSyst values represent range between low oxidation and high oxidation boundaries. The results summarized here are from De Klein et al. 2006 (IPCC data) and Stockle et al. 2012.*