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Basche, AD; Miguez, FE; Kaspar, TC; Castellano, MJ; 2014 Do cover crops increase or decrease nitrous oxide emissions? A meta-analysis JOURNAL OF SOIL AND WATER CONSERVATION, 69, 471-482. 10.2489/jswc.69.6.471

Background and objective

There are many environmental benefits to incorporating cover crops into crop rotations, such as their potential to decrease soil erosion, reduce nitrate (NO₃) leaching, and increase soil organic matter. Some of these benefits impact other agroecosystem processes, such as greenhouse gas emissions. In particular, there is not a consensus in the literature regarding the effect of cover crops on nitrous oxide (N₂O) emissions. The objectives of this study were to use a meta-analysis approach to: 1) examine the relative impact of cover crops on N₂O emissions; 2) determine what management and environmental factors contribute to variability in cover crop effects on N₂O emissions. Here, only results regarding the effect of green manures on N₂O emissions are reported.

Search strategy and selection criteria

A literature review utilizing electronic databases Google Scholar and Web of Science was conducted with the following search string: "nitrous oxide emissions or greenhouse gas emissions and cover crops or green manures or catch crops." This combination of key terms resulted in approximately five thousand papers. To reduce the number of papers included in the meta-analysis, the following criteria were applied: 1) Studies in which the cover crop is not harvested and is grown between the harvest and planting of cash crops. 2) Studies reporting N₂O measurements. 3) Studies with a control treatment varying only in the inclusion of a cover crop and keeping all other management practices such as tillage and N additions equal. 4) Studies that provided enough information (standard errors, standard deviations, coefficients of variation, etc.) about experimental error either in the published paper or in information that was provided by the authors when contacted to allow for an estimate of within study variance. 5) Studies published before December of 2012.

Data and analysis

The statistical analysis was performed using the MIXED procedures of SAS (SAS Institute 2010). Finally, a sensitivity analysis was performed in order to test the robustness of the data-base and overall conclusions.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
26	Arable crops	Cover crops (legume/non-legume; incorporated/surface)	Bare soil with the same treatments than in the intervention	Metric: N ₂ O emissions; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	81.25

Results

- There was a significant interaction between the type of cover crop and N rate. When no additional N is applied (zero mineral-N application rate), legumes exhibited higher N₂O emissions than non legume species.
- In general, legumes typically resulted in positive LRRs, while the LRRs for non legume and biculture species were close to zero. Statistical analysis revealed that there was a significant difference at the p < 0.10 level in response ratios between the legume, cover crop type nonlegume and biculture groups.
- The analysis indicated that the highest LRRs were data points measuring during the cover crop decomposition period.
- In the analysis, N₂O emissions for studies that incorporated cover crop residues into the soil were significantly higher than those for studies that left the residues on the soil surface.
- NULL

Factors influencing effect sizes

- N fertilisation rate : Especially when no additional N is applied (zero N application rate), legumes exhibited negative effects, compared to the bare-soil control. Fertilized plots had positive LRRs, and nonfertilized plots had negative LRRs.
- Period of Nitrous Oxide Measurement : The highest LRRs were data points measuring during the cover crop decomposition period. Data points based on measurements made across an entire year had an average response ratio close to zero compared to the other periods of measurement.

Conclusion

The use of green manure increased N₂O emissions using legume cover crops, while no effect was observed with non-legume cover crops.