FARMING PRACTICE
COVER AND CATCH CROPS

IMPACT: NUTRIENT LEACHING AND RUN-OFF

Reference 28

Thapa R, Mirsky SB, Tully KL 2018 Cover Crops Reduce Nitrate Leaching in Agroecosystems:A Global Meta-Analysis Journal of Environmental Quality 47, 6, 1400-1411 10.2134/jeq2018.03.0107

Background and objective

Cover crops are well recognized as a tool to reduce NO_3^- leaching from agroecosystems. However, their effectiveness varies from site to site and year to year depending on soil, cash and cover crop management, and climate. (i) to assess the overall effect of cover crops on NO_3^- leaching and subsequent crop yields, and (ii) to examine how soil, cash and cover crop management, and climate impact the effect of non-leguminous cover crops on NO_3^- leaching.

Search strategy and selection criteria

We conducted a search of primary articles that compared NO_3^- leaching losses between cover crop and no cover crop treatments using the ISI Web of Science (Thompson Reuters) database. The following search terms were used for the literature survey: ('cover crop' *OR* '*green manure*' OR 'catch crop' *OR* '*rye*' *OR* '*oat*' *OR* '*vetch*' *OR* '*clover*' *OR* '*winter*') *AND* ('*nitrate leach*' OR 'nitrogen leach' *OR* '*leach*' OR 'drain*'). This search produced 237 articles published in scientific journals from 1931 to 2017. 238 observations from 28 studies. (i) the study compared winter cover crop treatments with no cover crop (control); (ii) NO_3^- leaching was measured during at least the cover crop growth period or for the entire year (during both cover crop and cash crop phases); (iii) cumulative NO_3^- leaching was calculated using both NO_3^- concentrations in the soil solution and the drainage volume; (iv) the study was conducted under natural field conditions (i.e., model-based simulation and indoor lysimeter studies were excluded); (v) all other factors (soil, management, and climate) for each pairwise comparison between no cover crop and cover crop treatments were the same; and (vi) the experimental design, approach, and sampling protocols were clearly described. We excluded studies in which the potential risk of NO_3^- leaching was assessed by comparing profile soil N over the cover crop season. Studies with a long history of pasture prior to the experimental year were also excluded because of the potential legacy effect of previous pasture or forage crops on NO_3^- leaching that could mask the true cover crop effect. Similarly, studies that were conducted on recently constructed drainage lysimeters or monoliths using disturbed soils were also discarded because the disturbed soil structure in these monoliths could influence drainage characteristics and, hence, NO_3^- leaching. We also excluded studies in which the treatment combinations impeded sole comparison between no cover crop and cover crop treatments.

Data and analysis

The authors used an alternative weighting technique based on experimental replications. we employed a cluster-based robust variance estimation technique (clustering on site) using the clubSandwich package to estimate robust SEs for mean effect sizes (Pustejovsky, 2017). Using robust SEs, we calculated the 95% confidence interval (CI) for the weighted natural log mean effect sizes [ln(R)]. For ease of interpretation, ln(R) values were back-transformed to mean effect sizes and expressed as percentage change in response due to cover crop treatments. The mean effect sizes for each response variable were considered significantly different from the controls ($p < 0.05$) only if the 95% CI did not include zero.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
28	Arable fields with cereal crops	Cover crop (nonleguminous, leguminous, and nonlegume–legume cover crop mixtures). Nonleguminous cover crops included both grasses and broadleaves.	No cover crops	Metric: Soil nitrate leaching; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	87.5

Results

- Most of the studies included in this meta-analysis evaluated the effectiveness of nonleguminous cover crops in reducing NO_3^- leaching (216 observations from 27 studies), whereas leguminous and nonlegume–legume cover crop mixtures were evaluated in only three studies with 9 and 13 observations, respectively.
- Compared with no cover crop controls, nonleguminous cover crops significantly reduced NO_3^- leaching by 56% (95% CI = −66 to −43%). Legumes alone or in combination with nonlegumes had no significant effect on NO_3^- leaching.
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Factors influencing effect sizes

- Soil texture : Although not significantly different, there was a trend toward greater effectiveness of nonleguminous cover crops in NO_3^- leaching reduction on coarse-textured soils (mean = −65%, 99% CI = −77 to −49%) than on fine-textured soils (mean = −43%, 99% CI = −59 to −20%).
- Cover crop species : Compared with no cover crop controls, grasses and broadleaf species reduced NO_3^- leaching by 50% (99% CI = −61 to −37%) and 67% (99% CI = −77 to −54%), respectively.
- Planting dates : Early-planted nonleguminous cover crops significantly reduced NO_3^- leaching compared with no cover crop controls (mean reduction of 64, 60, and 49% for August-, September-, and October-planted nonlegume cover crops, respectively). When planting nonleguminous cover crops after November, there was no advantage of having a cover crop on NO_3^- leaching (mean = −28%, 99% CI = −50 to 3%).

- Cover crop biomass production : Reduction in NO_3^- leaching with nonleguminous cover crops was significantly greater in the higher shoot biomass categories of 4 to 8 Mg ha−1 (mean = −74%, 99% CI = −83 to −59%) and >8 Mg ha−1 (mean = −71%, 99% CI = −80 to −58%) than in the lower biomass category of <1 Mg ha−1 (mean = −36%, 99% CI = −53 to −13%).
- Mean annual precipitation : The effectiveness of nonleguminous cover crops in reducing NO_3^- leaching decreased linearly with increase in precipitation relative to the long-term mean precipitation. In other words, nonleguminous cover crops were slightly better at reducing NO_3^- leaching in drier years (years with precipitation below the long-term average) than in wet years (years with precipitation above the long-term average).

Conclusion

There is a clear indication that nonleguminous cover crops can substantially reduce NO_3^- leaching into freshwater systems, on average by 56%. Legumes alone or in combination with nonlegumes had no significant effect on NO_3^- leaching.