FARMING PRACTICE
COVER AND CATCH CROPS

IMPACT: CROP YIELD

Reference 40

Tonitto, C; David, MB; Drinkwater, LE 2006 Replacing bare fallows with cover crops in fertilizer-intensive cropping systems: A meta-analysis of crop yield and N dynamics AGRICULTURE ECOSYSTEMS & ENVIRONMENT, 112, 58–72. 10.1016/j.agee.2005.07.003

Background and objective

Diversified crop rotations using cover crops to provide a variety of ecosystem functions, including biological N fixation (BNF), could maintain yields while reducing N losses. Although leguminous plants used as green manures are capable of fixing N in quantities which exceed cash crop demand, the prospect of replacing significant quantities of Haber-Bosch N with BNF is widely viewed as impractical due to yield reductions. Likewise, the practice of replacing bare fallows with non-leguminous cover crops in systems receiving Haber-Bosch N is generally deemed not economically viable. Objectives: 1) How does the replacement of Haber-Bosch N with legume-derived N affect yield? 2) How does the management of a non-leguminous cover crop affect yield? 3) How do the N dynamics in conventional versus diversified agroecosystems differ? Here, only results regarding the effect of legume green manures on yields are reported.

Search strategy and selection criteria

They searched the literature by using electronic databases, including BIOSIS, Agricola, and Web of Science. The Science Citation Index was used to identify papers citing some of the key early papers that fit our parameters. Finally, citation lists from relevant, recent literature reviews were also used to obtain studies. For some studies, Data Thief1 software was used to extract needed data from figures. When they came across studies that met selection criteria, but did not report the values needed in the paper, the author(s) were contacted. Studies compiled in our legume covercrop yield database had the following characteristics: (1) winter legume cover crop followed by an unfertilized cash crop compared to the control, (2) cash crop production every year, (3) no manure or other N additions applied during any phase of the diversified rotation, and (4) cover crop biomass incorporated into the soil or killed before crop planting, with no biomass removal. They excluded studies if legume treatments had excessive applications of inorganic N fertilizer or if the green manures were being compared to a zero N control. Only legume cover crops are considered for this analysis (cash crop after non-legume cover crops is fertilized, so non-legume cover crop were removed in our analysis).

Data and analysis

A meta-analysis was conducted to analyze the response of yield and soil N status in legume and non-legume cover crop systems compared with conventional systems, using MetaWin version 2.1 software. Because nearly all of the studies we used did not report any measure of variance or the number of replicates, we conducted an unweighted meta-analysis. Although a more rigorous weighted analysis is possible with known variance and replicates for each study, the statistical significance of our unweighted meta-analysis is enhanced by the calculation of confidence intervals (CI). After a mean effect size was calculated, a bias-corrected 95% confidence interval was generated by a bootstrapping procedure (5000 iterations) using the MetaWin software.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
35	Conventional and diversified systems	Fertilization using cover crops as green manure (with distinction between legume and non-legume)	Bare soil with mineral-N fertilization	Metric: Crop yield; Effect size: Logarithm of ratio of considered metrics in system with fertilization with legume cover crops as green manure to the considered metrics in systems with bare soil and N fertilization.	50

Results

- Legume-fertilized systems averaged a 10% decline in yield relative to inorganically-fertilized systems with reccomended N level and a winter bare fallow.
- When considering all conventional fertilizer levels tested, the change in yield under legume systems relative to high applications of fertilizer was not statistically different from the trends for recommended fertilization. However, compared to low inorganic fertilizer application, legume systems averaged a 5% yield improvement. As a result, the overall effect size under all fertilizations tested was a 7% decline in yield in legume relative to conventional systems.
- Some of the variation in yield response can be understood by characterizing legume N inputs. Legume N inputs varied from 8 to 350 kg N ha1 in a fairly continuous distribution, with 50% of the studies having 50–150 kg N ha1 inputs. The distribution of legume-derived N inputs observed in this review indicated legume N inputs were generally 28% lower than recommended inorganic fertilizer applications. There was no statistical difference in crop yield between conventional systems applying recommended fertilizer N and diversified systems where legume N inputs ranged from 110 to 180 kg N ha1, a rate comparable to recommended inorganic fertilizer applications.
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Factors influencing effect sizes

- Soil type : NA
- Tillage : NA
- Climate : NA
- Cover crop phenology : NA
- Mineral fertilisation rate : compared to low inorganic fertilizer application, legume systems averaged a 5% yield improvement. As a result, the overall effect size under all fertilizations tested was a 7% decline in yield in legume relative to conventional systems.

Conclusion

On average, the legume-fertilized crops averaged 10% lower yields than conventional N-fertilization. However, yields under green manure fertilization were not significantly different relative to conventional systems when legume biomass provided at least 110 kg N ha1. No effect was observed for non-legume cover crops.