Cover crops can mitigate no-tillage-induced labile phosphorus stratification

Reid W. Barker[1,2], Matthew J. Helmers[2], Marshall D. McDaniel[1]

1: Iowa State University | Department of Agronomy
2: Iowa State University | Ag. & Biosystems Engineering

INTRODUCTION

- Reduced tillage, especially no-till, can stratify soil P (i.e., concentrate P on soil surface).
- Phosphorus stratification poses a problem for water quality and may affect its availability to crops.
- **Research Question: quantify soil P stratification of a long-term (12-year), factorial no-tillage (NT) and cereal rye cover crop (CC) experiment.**
  1. Hypothesis 1 (H1): NT alone would increase soil P stratification (compared to disc tillage).
  2. Hypothesis 2 (H2): Cover crops will increase soil P stratification (compared to winter fallow).
  3. Hypothesis 3 (H3): CCs combined with NT will not alleviate and may even further exacerbate soil P stratification.

METHODS

- A 2×2 factorial (with tillage and cereal rye cover crop) was established in 2010 in Northeast Iowa near Gilmore City, Iowa.
- Treatments
  CPWF → Chisel-Plow + Winter Fallow
  CPCC → Chisel-Plow + Cereal Rye Cover Crop
  NTWF → No-tillage + Winter Fallow
  NTCC → No-tillage + Cereal Rye Cover Crop
- Soil Sampling & Analyses
  - Depths: 0-2.5, 5-10, 10-15, 15-20, 20-25 cm
  - Analyzed for 6 soil P measurements:
    - ✓ Water extractable-P (**H_2O-P**)
    - ✓ Bicarbonate extractable-P (**BEP**)
    - ✓ Mehlich 3-P (**STP**)
    - ✓ Microbial biomass P (**MBP**)
    - ✓ Anion exchange extractable-P (**AER-P**)
    - ✓ Total-P (**TP**)
  - Soil P Stratification Index calculated as: $P_{strat} = \frac{\bar{x}_{P0-5}}{\bar{x}_{P5-25}}$

RESULTS & DISCUSSION

- All P measurements were stratified (Figures 1-3).
- No-till increased P stratification by 45% compared to conv. tillage (NTWF vs CPWF). This is similar finding to many No-till studies and supports H1. Figure 4.
- Cover crops alone, also increased P stratification by 41% compared to no cover (CPCC vs CPWF). Supports H2, but only a few studies have also shown this. Figure 4.
- Cover crops, when paired with NT (NTCC), reduced labile P stratification by 13-32% compared to No-till without cover crop. Likely due to increased soil microbial activity, changes in soil pH, and enhanced mobility of labile P. Figure 4.

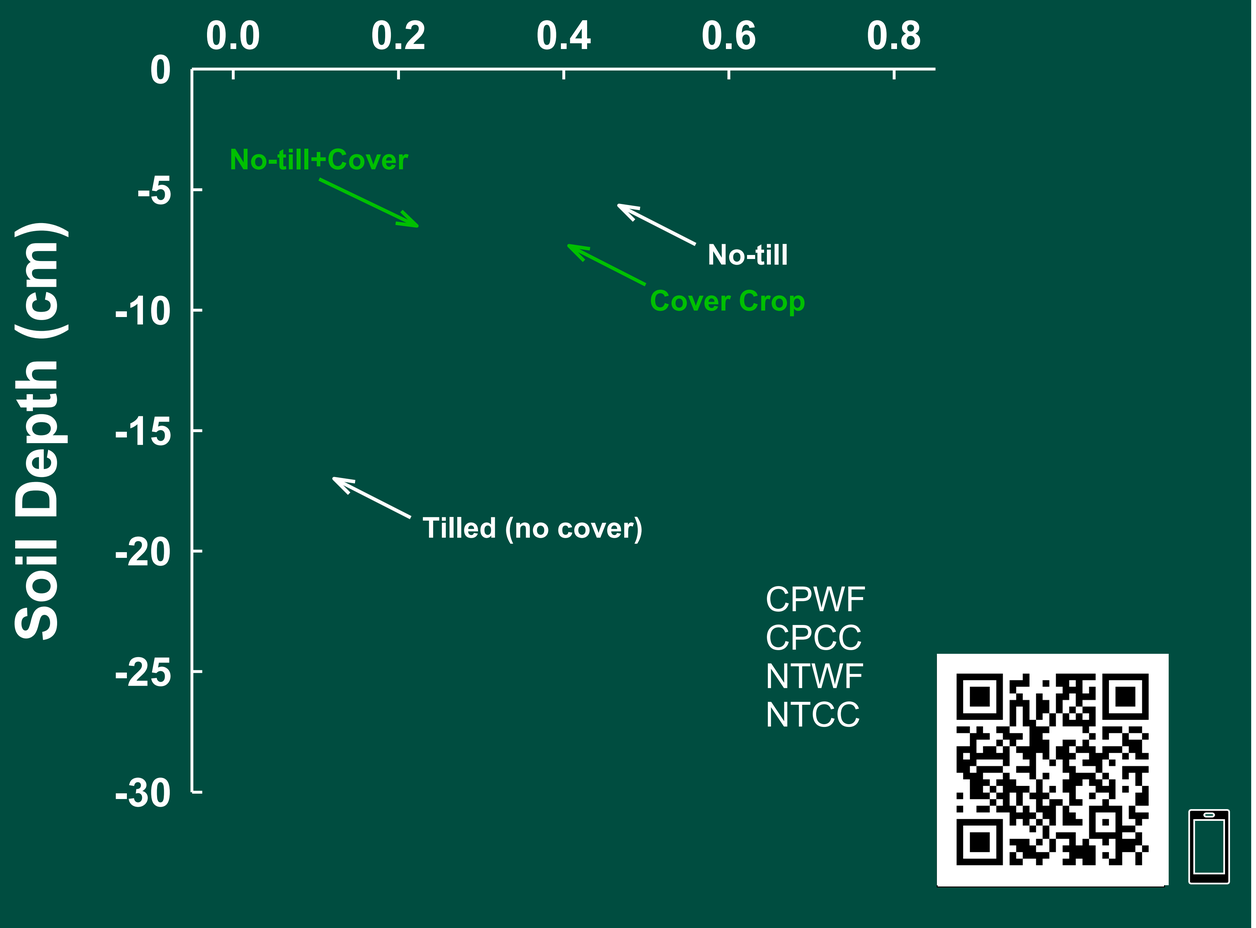
CONCLUSION

Cereal rye winter cover crops alleviate no-till induced P stratification. In addition to all the other benefits provided by cover crops, combining them with no-till is a good solution to P stratification and provide other agroecosystem services.

ACKNOWLEDGEMENTS

Special thanks to the Helmers and McDaniel Labs for their help in facilitating this research. In addition, we thank the Iowa Department of Agriculture and Land Stewardship as well as the Brent and Cindy Hart Professorships for funding this research

Cover crops can mitigate no-tillage-induced labile P stratification.



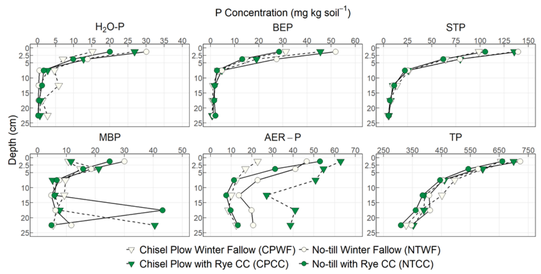


Figure 1. Mean soil phosphorus (P) concentrations by depth in the soybean crop phase (n = 4). All soil P measures are expressed in mg P per kg of dry soil.

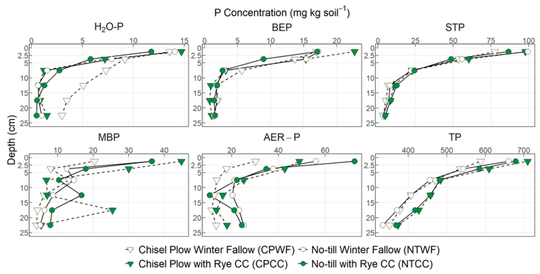


Figure 2. Mean soil phosphorus (P) concentrations by depth in the maize crop phase (n = 4). All soil P measures are expressed in mg P per kg of dry soil.

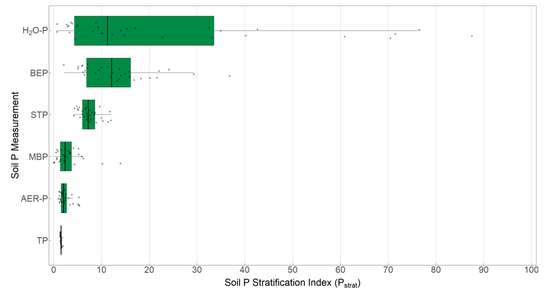


Figure 3. Soil phosphorus stratification indices (P_{strat}) for each soil P measurement (n=32).

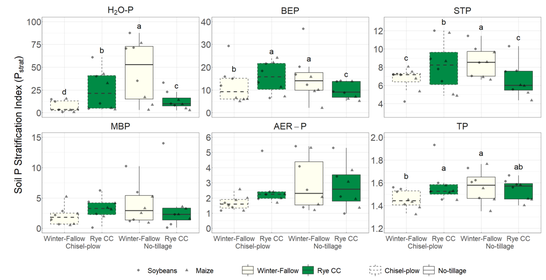


Figure 4. Soil phosphorus stratification index (P_{strat}) across both soybean and maize crop phase. Mean shown with letters indicate significant (p-value < 0.1) difference among means (n = 8).

Table 1. Three-way ANOVA *p*-values† on phosphorus stratification index (P_{strat}) of multiple soil P measures (Corresponds to Figure 4).

Source of Variance	Water Extractable P (H_2O-P_{strat})	Sodium Bicarbonate-extractable P (BEP_{strat})	Mehlich III Soil Test P (STP_{strat})	Microbial Biomass P (MBP_{strat})	Anion Exchange Resin P ($AER\text{-}P_{strat}$)	Total P (TP_{strat})
Crop Phase (Phase)	0.058*	**0.004****	0.103	0.535	0.558	**0.015***
Tillage (Till)	**0.048****	0.566	0.777	0.643	0.186	0.326
Cover Crop (CC)	0.716	0.844	0.537	0.927	0.333	0.281
Phase × Till	0.268	0.621	0.298	0.974	0.611	0.933
Phase × CC	0.731	**0.022****	0.199	0.332	0.738	0.749
Till × CC	**0.004****	**0.055***	**0.019****	0.310	0.226	0.084*
Phase × Till × CC	0.657	0.480	0.833	0.853	0.251	0.724

†: * = marginally significant at <0.1, ** (and **bold**) = significant at <0.05

Main Figure (*Center*). Normalized labile P concentrations of combined measures of H_2O-P, BEP, and M3P (the 3 labile P measures that had treatment effects).