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Department of Agronomy

Impact of Cropping Systems on Net Nitrogen Mineralization Rate

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Introduction

Goal

This research is aimed to estimate the spring net N mineralization rate, and determine the impact of cropping systems on N mineralization rate.

Why?

Nitrogen fertilizer is an expensive input for managing crop land and yet the added nitrogen is not all taken up by plants. Under some management systems, a large amount of mineralized N may be leached from the soil, negatively impacting the surface-water systems. But under alternative management systems, the nitrogen could be slowly mineralized to a plant-available form and less likely to be leached. Thus, better predictions of N mineralization rates are essential to improve management decisions for cropping systems.

Research questions

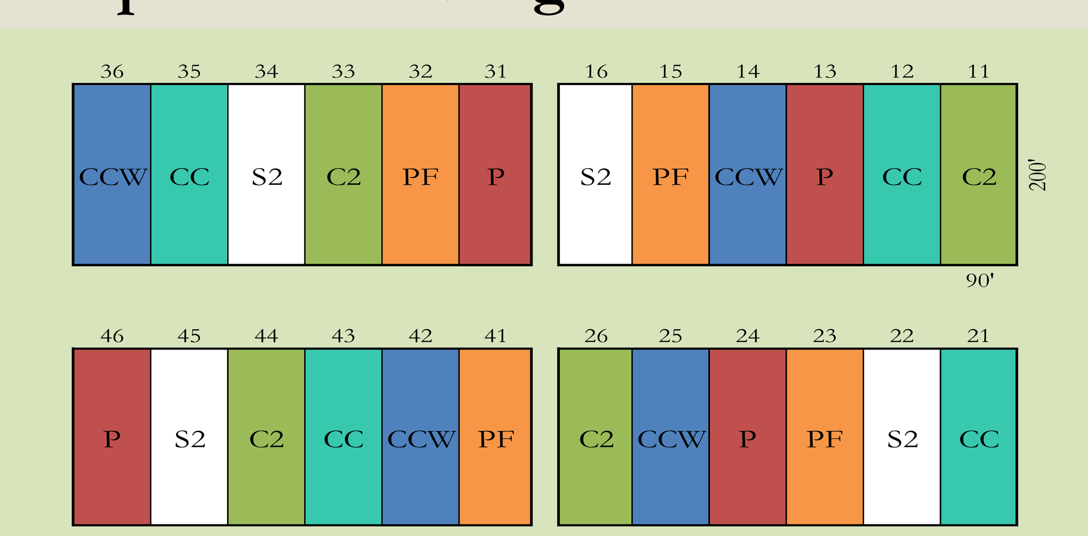
(1) Does the cropping systems have impact on the net N mineralization rate?

(2) Does the presence of decomposing plant residues influence the rate of mineralization?

(3) What characteristics of soil and plant residues affect the net N mineralization rate?

Method

Experimental design



CC: continuous corn
C2: corn in corn-soybean rotation
CCW: continuous corn with a winter rye cover crop
P: unfertilized perennial prairie
PF: fertilized perennial prairie
S2: soybean in corn-soybean rotation

Figure 1: Randomized complete block design of field plots located near Ames, Iowa.

Treatments

Soil sample collected per plot was split into two - half of the soil sample was kept in its original (WR) and in the other half most visible plant residues were removed (WOR).

Measurements

Net nitrogen mineralization rate

Soil samples were incubated for 30 days, and were leached with 5 m*M* $CaCl_2$ every 5 days. Net N mineralization rate was determined as the amount of inorganic N accumulated over the 5-day period.

Soil characteristics

Soil total C and N, particle size analysis (Gee and Bauder, 1986), 2 *M* KCl-extractable NO_3^- and NH_4^+.

Plant residues characteristics

Plant residue concentration, total C and N.

Results

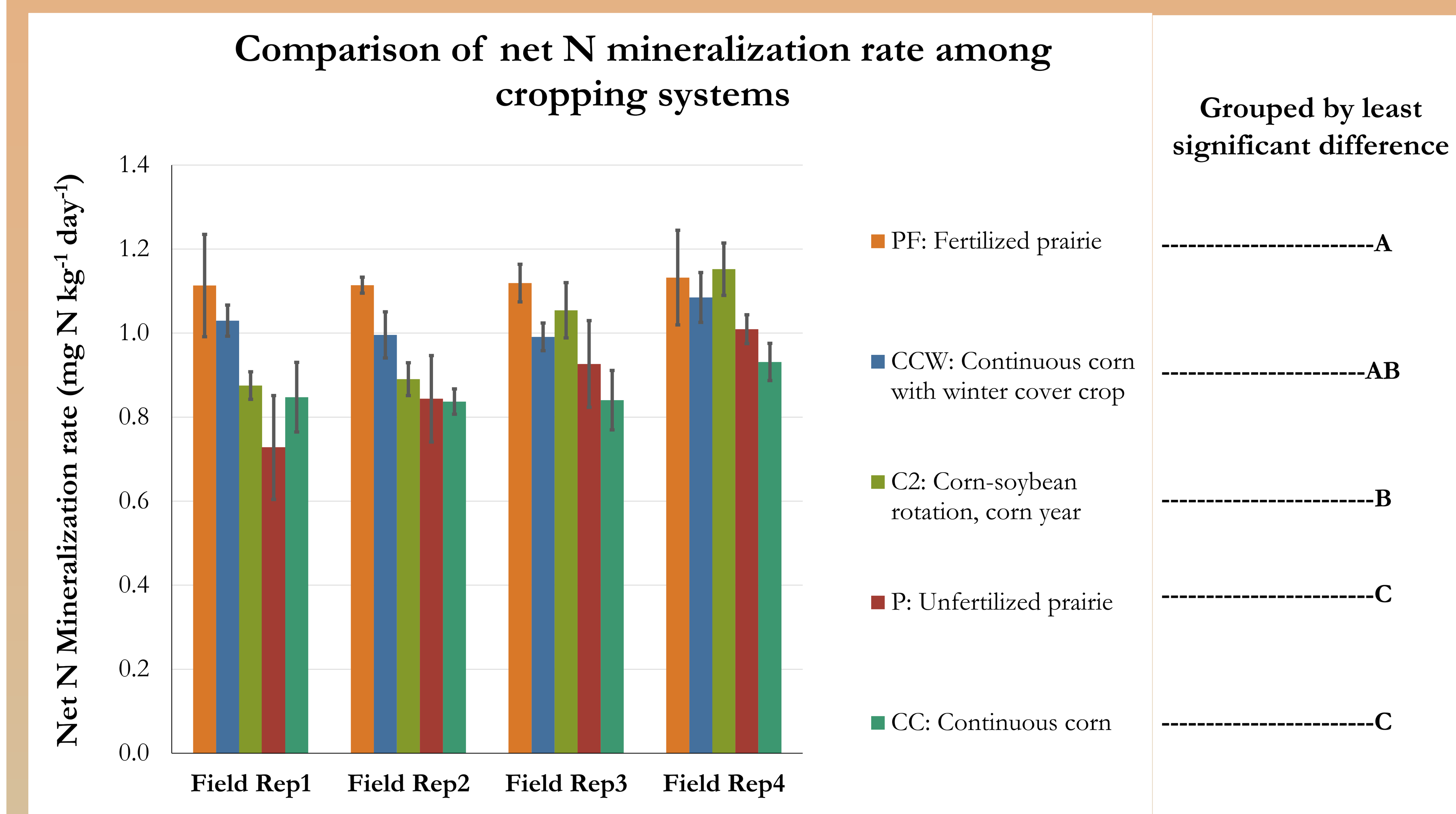


Figure 2: Comparison of net N mineralization rate among cropping systems. By pooling all four field replications to compare net N mineralization rate among cropping systems, the ANOVA $p < 0.01$. Then, based on the least significant difference analysis ($\alpha<0.05$), the net N mineralization rate in the 5 cropping systems has the order: fertilized prairie (mean=1.12 mg N kg^{-1} soil day^{-1}) ≤ continuous corn (mean=1.03 mg N kg^{-1} soil day^{-1}) ≤ corn-soybean rotation (mean=0.99 mg N kg^{-1} soil day^{-1}) < unfertilized prairie(mean=0.88 mg N kg^{-1} soil day^{-1}) ~ continuous corn (mean=0.86 mg N kg^{-1} soil day^{-1}).

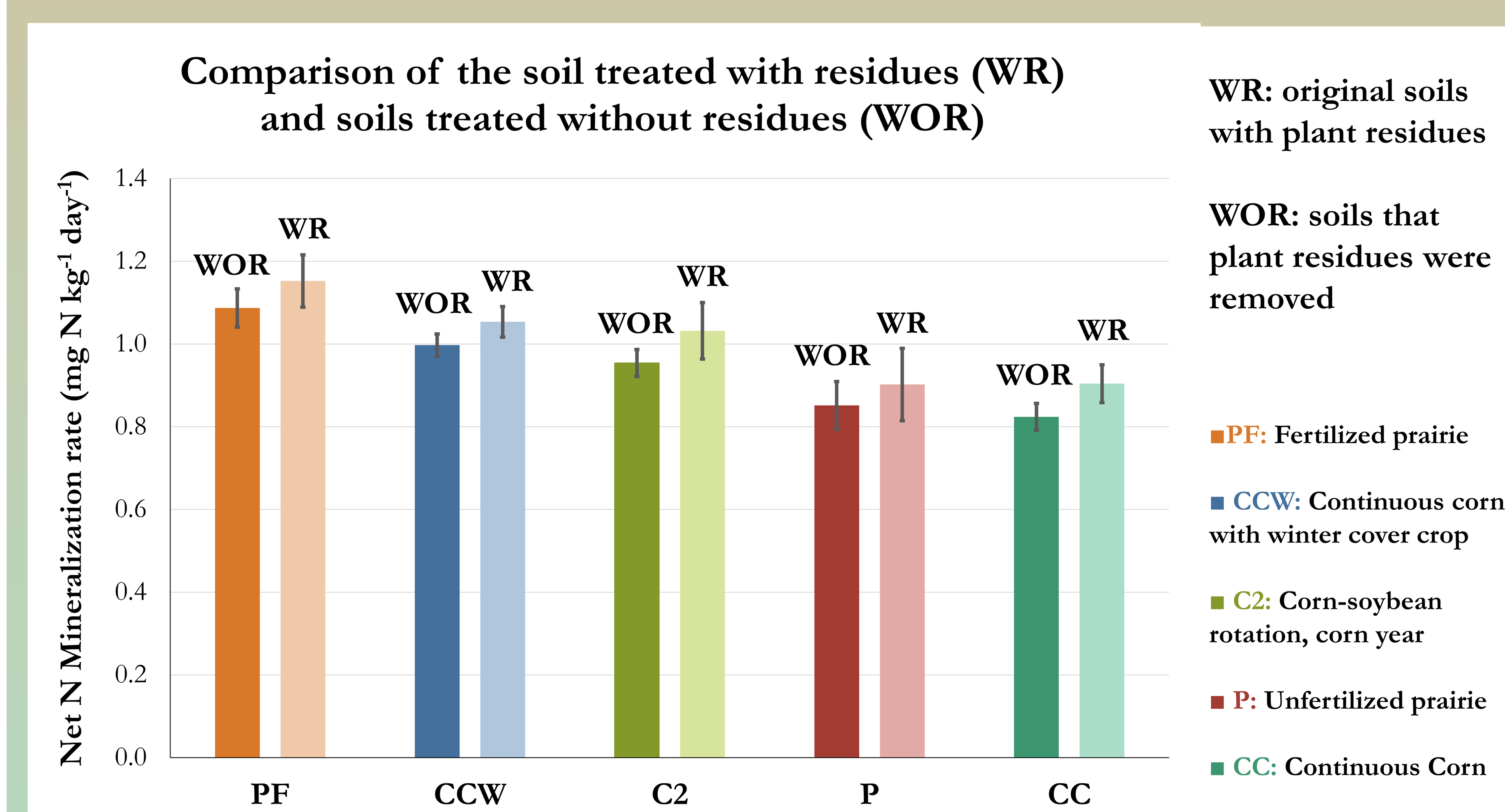


Figure 3: Comparison of the soil treated with residues (WR) and soils treated without residues (WOR). When data from all five cropping systems were lumped, the net N mineralization rate was significantly larger in the presence of plant residues than in their absence ($p = 0.05$).

Soil Characteristics	ANOVA: *p*-value	Plant Residue Characteristics	ANOVA: *p*-value
Soil C/N ratio	0.089	Plant residue C/N ratio	0.620
Soil Total C	0.005	Plant residue total N	0.666
Soil Total N	0.001	Plant residue total C	0.996
Clay content	0.054	Plant residue concentration in soil	0.002
Pre-incubation Nitrate	0.559		
Pre-incubation Ammonium	0.082		

Table1: ANOVA test: Effect of soil/plant residues characteristics on net N mineralization rate. The *p*-value indicates the possibility to reject the hypothesis that the soil or plant characteristics have an impact on net N mineralization rate. With >90% confidence, the effect of soil C/N ratio, soil total C, soil total N, clay content, ammonium and plant residue/soil weight ratio on the net N mineralization rate was significant.

Results

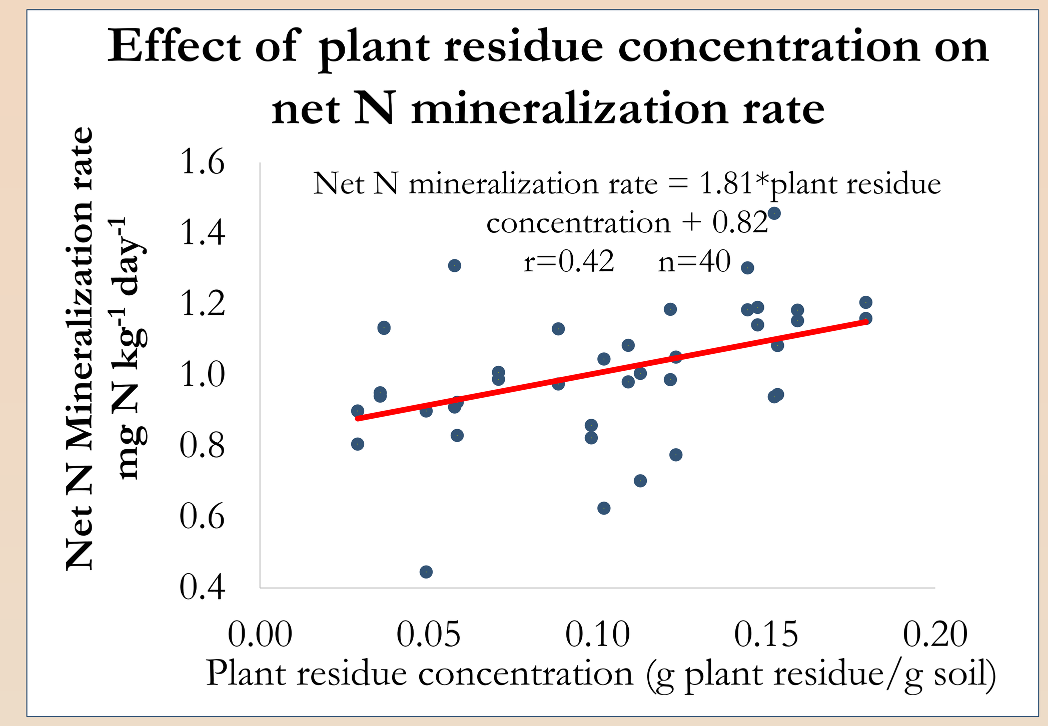


Figure 3: Effect of plant residue concentration on the net N mineralization rate.
The concentration of plant residue in the soil had a positive effect on the net N mineralization rate (ANOVA, p=0.02).

Conclusions

(1) The net N mineralization rates were different among the cropping systems (ANOVA, p<0.01). Based on the least significant difference analysis ($\alpha<0.05$), the net N mineralization rate in the 5 cropping systems had the order:

fertilized prairie ≤ continuous corn with winter cover crop≤ corn-soybean rotation < unfertilized prairie ~ continuous corn.

(2) The presence of decomposing plant residues had a significant effect on net N mineralization rate. With 95% confidence, the net N mineralization rate was larger in the presence of plant residues (mean=1.01 mg N kg^{-1} soil day^{-1}) than in their absence (mean=0.94 mg N kg^{-1} soil day^{-1}).

(3) With more than 90% confidence, the individual effects of plant residue concentration, soil C/N ratio, soil total C, soil total N, clay content, ammonium and plant residue concentration on the net N mineralization rate were significant.

References

Stanford, G. and S. Smith. (1972) Nitrogen mineralization potentials of soils. *Soil Sci. Soc. Am. J.* 36: 465-472.

Carpenter-Boggs, L. et al. (2000) Soil nitrogen mineralization influenced by crop rotation and nitrogen fertilization. *Soil Sci. Soc. Am. J.* 64:2038–2045.

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