

Soil Health Assessments in Biofuel Cropping Systems

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- The term **soil health** refers to a holistic perspective on how a soil functions in the agricultural ecosystem, with particular emphasis on biological processes.
- Healthy soils are resilient to external impacts that might negatively affect the productivity and stability of the soil ecosystem.

Objective

To assess the impacts of biofuel cropping systems on soil health, we measured short-term CO₂ evolution (soil respiration), organic carbon (OC), total nitrogen (TN), particulate organic matter (POM), and water-extractable organic carbon and nitrogen (WEOC and WEON) in soils under both annual and perennial cropping systems managed for biomass production.

Materials & Methods

➤ **The experiment** was established in 2008 near ISU. All plots are tile drained and receive no tillage.

➤ **The experimental treatments for this study (Fig. 1) were:**

- continuous corn (**CC**),
- continuous corn with a rye cover crop (**CCW**),
- unfertilized reconstructed multispecies prairie (**P**),
- and fertilized, multispecies, reconstructed prairie (**PF**).



Fig. 1

➤ **Soil sampling:** Composite samples from each plot were collected from the 0-15 cm depth at six times, i.e., in April and November in 2016, 2017, and 2018.

➤ **Soil analyses:** Soil properties were determined, e.g., soil CO₂ respiration (using the Solvita technique) (Fig. 2), OC, TN, POM, WEOC, and WEON.



Fig. 2. Measuring soil CO₂ respiration using the Solvita technique (CO₂-C evolved during 24-h incubation at uniform water content).

➤ **Soil health Index (similar to the Haney SHI):**

$$\text{SHI} = (\text{CO}_2\text{-C}/\text{OC}/\text{TN}) + (\text{WEOC}/100) + (\text{WEON}/10)$$

Results

- Over all years, **soil CO₂ respiration** in the fertilized perennial cropping systems (PF) was significantly greater than that in other cropping systems (Fig. 3). Respiration was greater in the continuous corn with cover crop treatment (CCW) than in the continuous corn treatment (CC).
- Over all years, **particulate organic matter (POM)** in the diverse perennial cropping systems (P and PF) was significantly greater than that in annual cropping systems (CC and CCW) (Fig. 4).

- **Soil organic carbon** concentration was greater in the fertilized perennial system than in the unfertilized perennial system or the annual cropping systems (Fig. 5).

- **Water-extractable carbon** concentrations were greatest in the fertilized perennial cropping system than in all other systems (Fig. 6).

- **Water-extractable organic nitrogen** did not vary with cropping systems – within seasons (Fig. 7), but fall WEON values were greater than spring values.

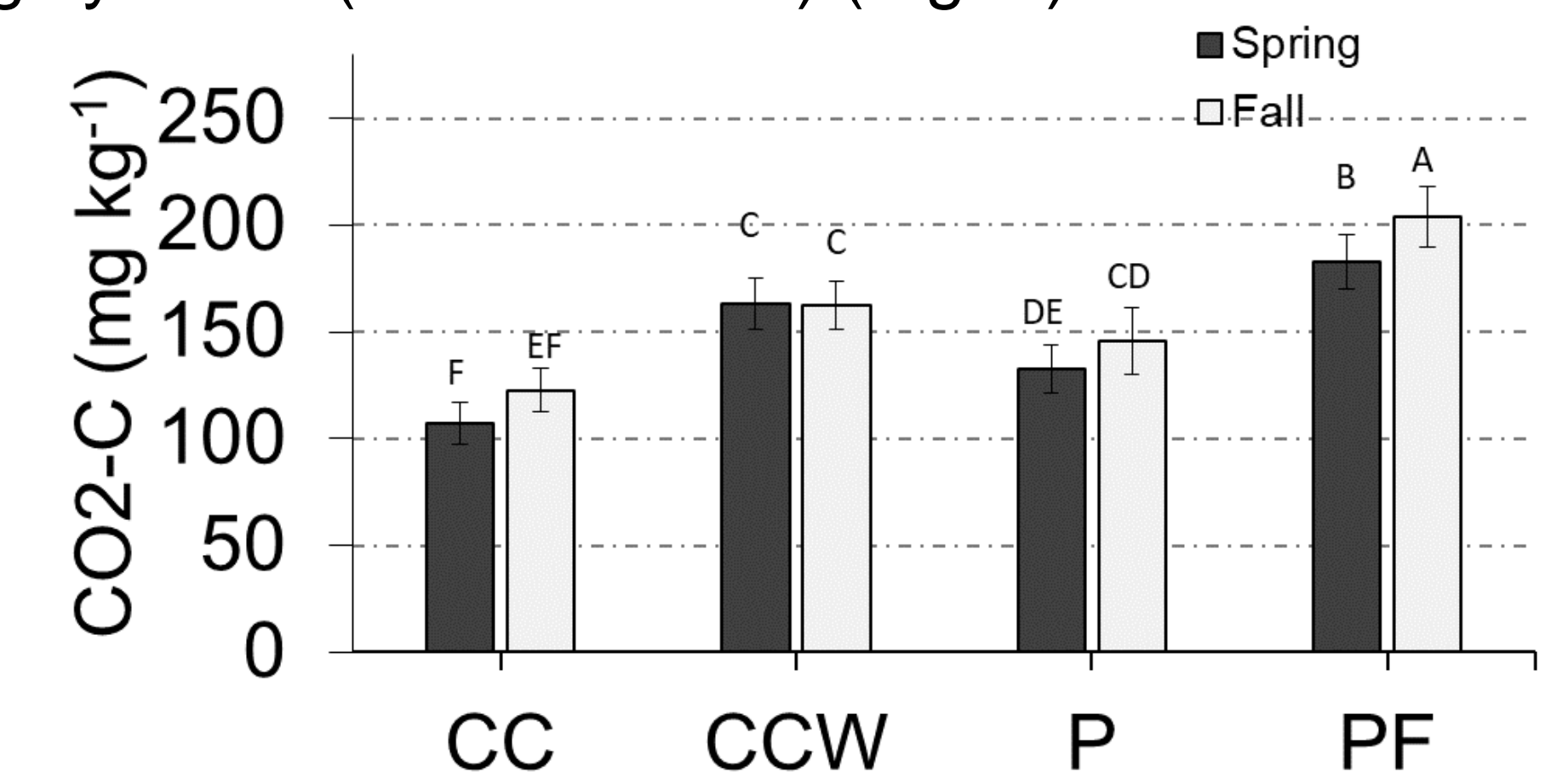


Fig. 3. Soil CO₂ respiration (24-h) in annual (CC and CCW) and perennial (P and PF) cropping systems.

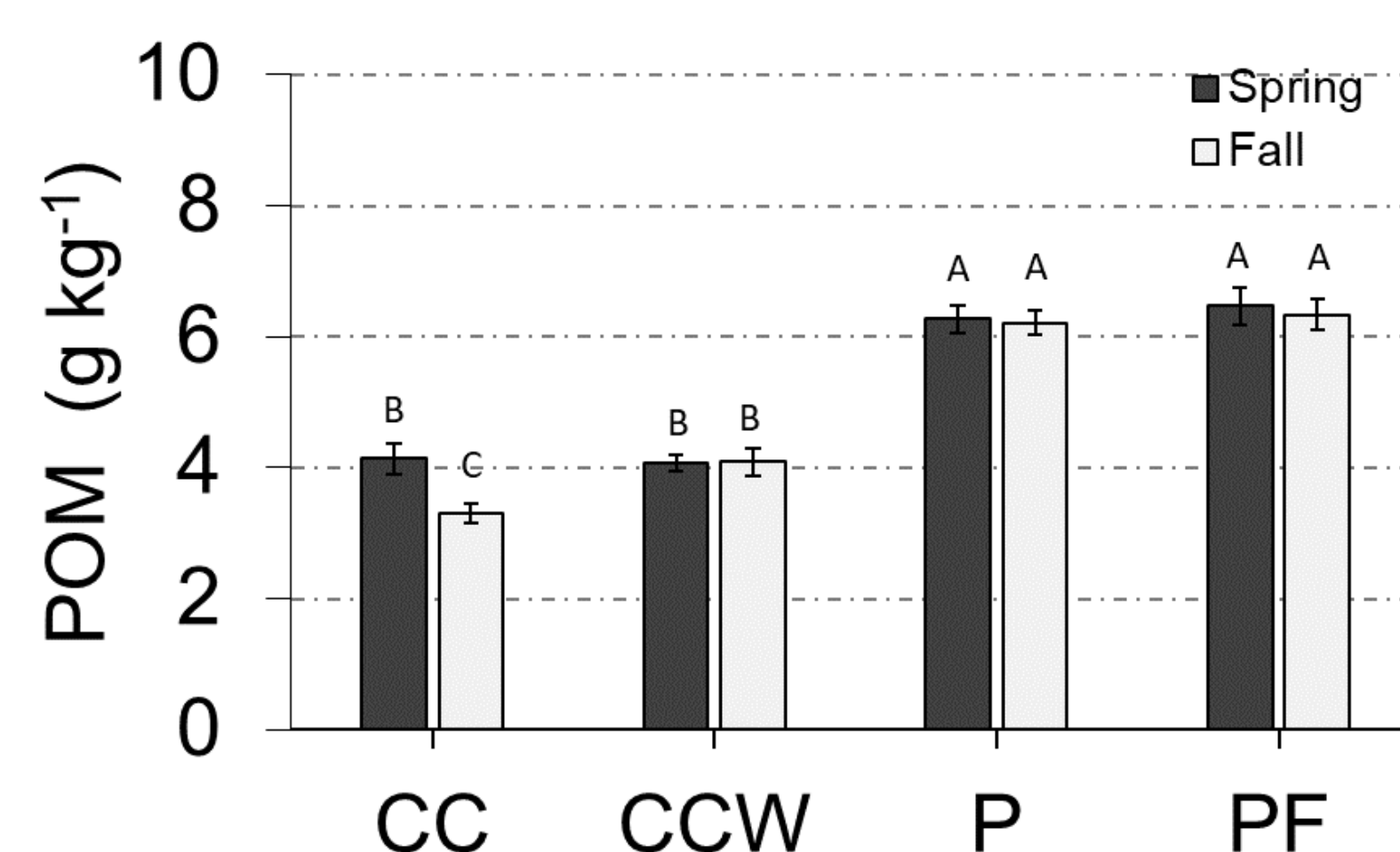


Fig. 4. Particulate organic matter (POM) concentration in annual (CC and CCW) and perennial (P and PF) cropping systems.

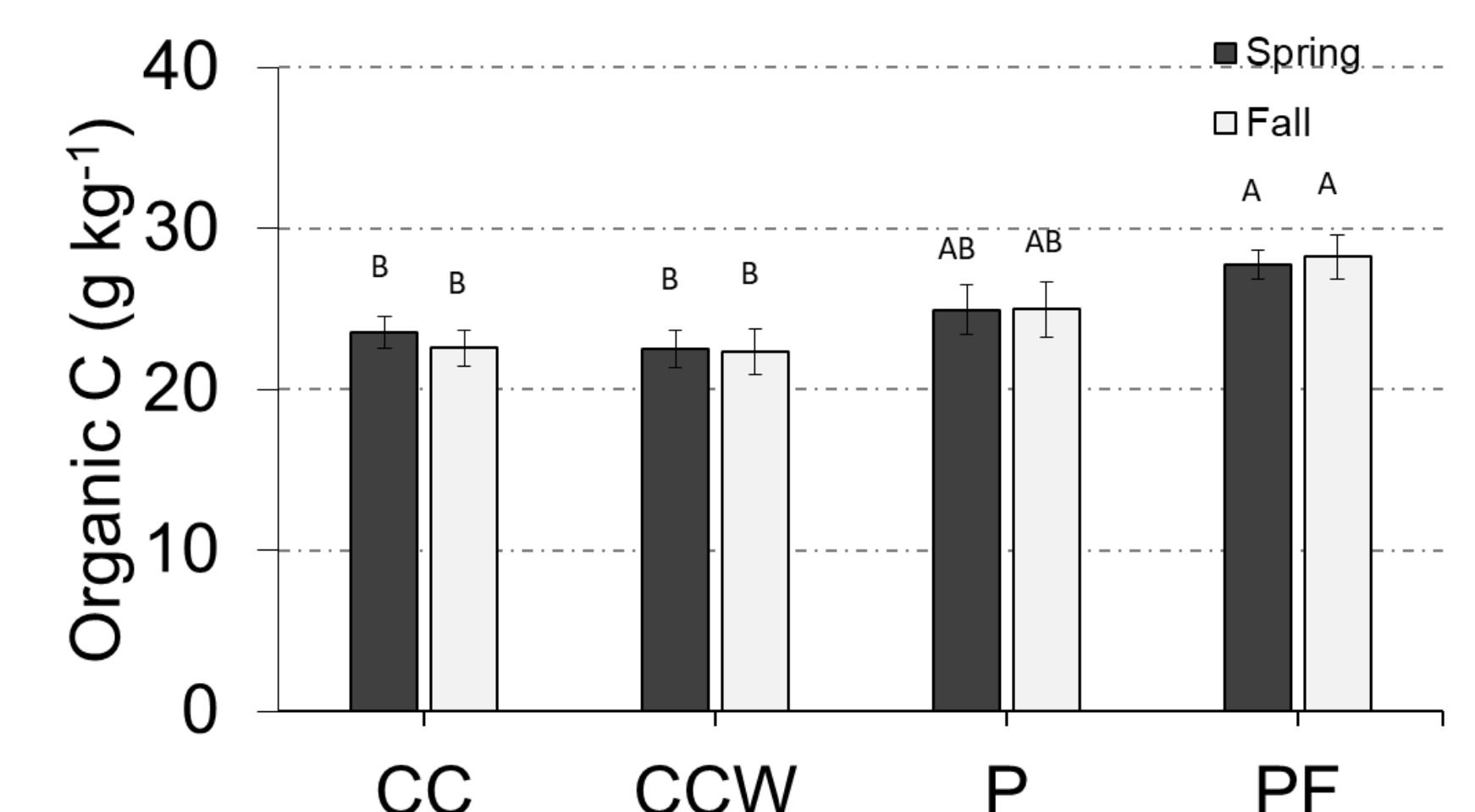


Fig. 5. Soil organic carbon concentration in annual (CC and CCW) and perennial (P and PF) cropping systems.

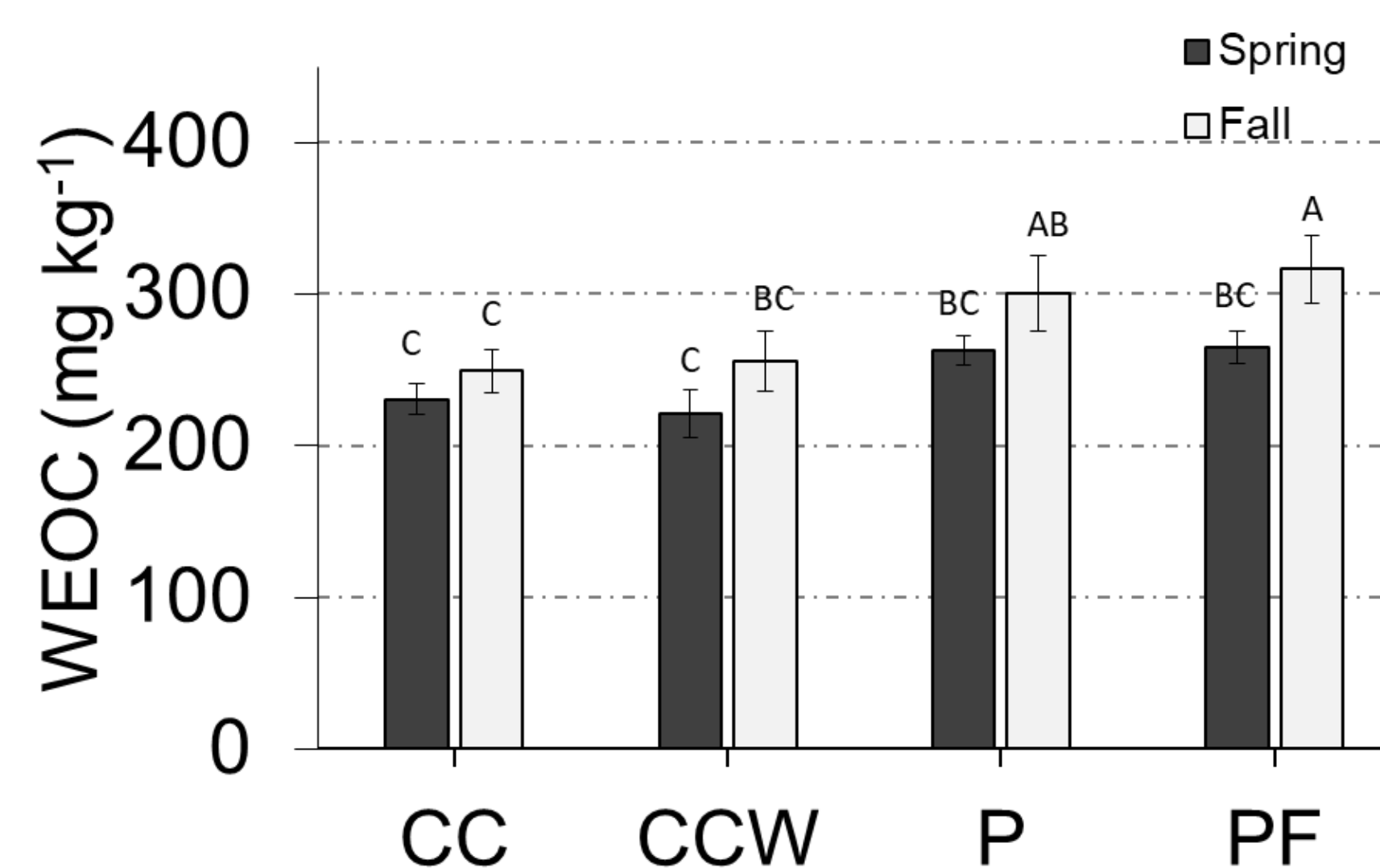


Fig. 6. Water-extractable organic carbon concentration in annual (CC and CCW) and perennial (P and PF) cropping systems.

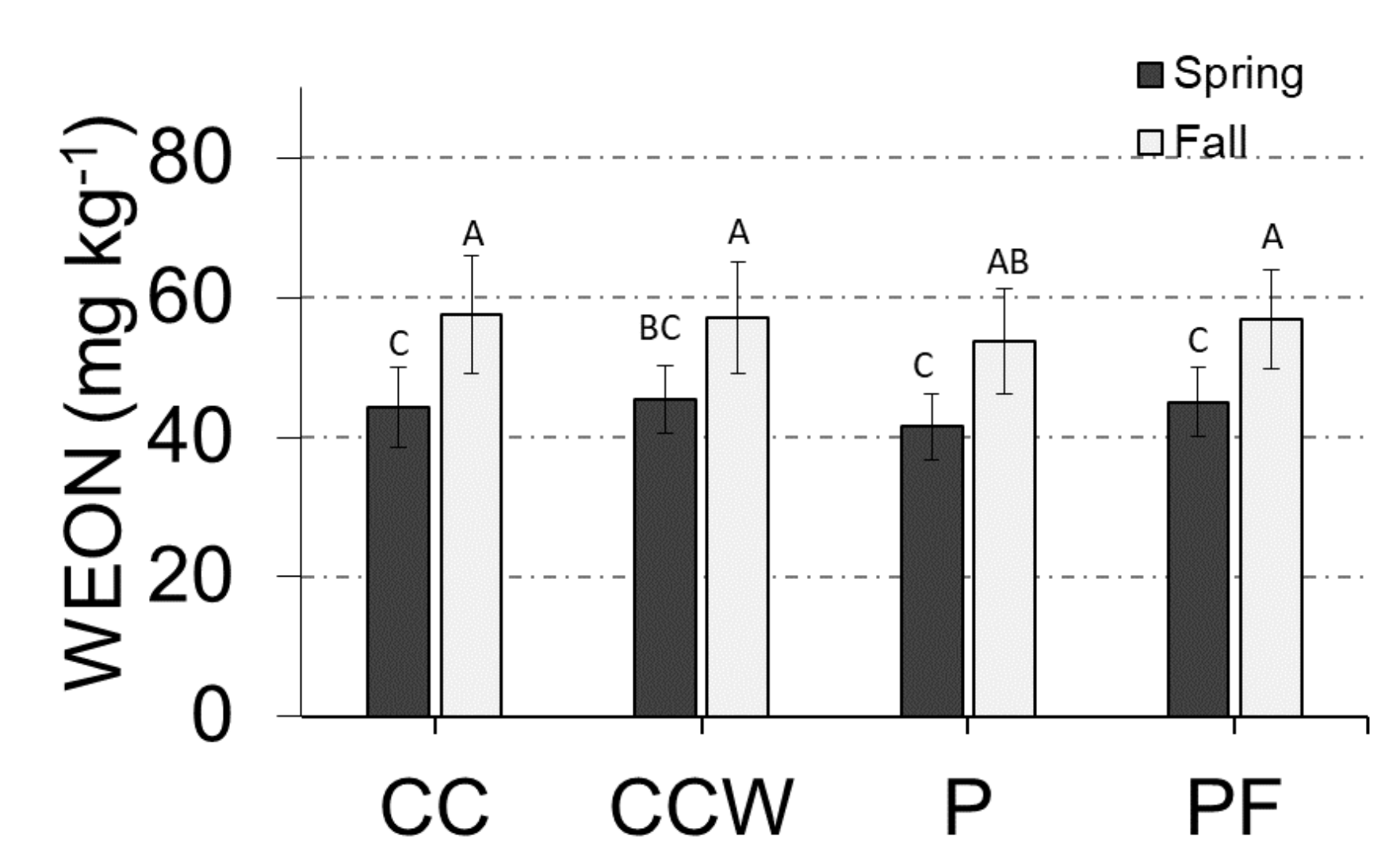


Fig. 7. Water-extractable organic nitrogen concentration in annual (CC and CCW) and perennial (P and PF) cropping systems (spring data for 2016 and 2017 only).

Soil Health Index (SHI)

The Soil Health Index (data for spring are based on 2016 and 2017 data only) for the fertilized perennial treatment (PF) in fall sampling was significantly higher than that of the other treatments (Fig. 8). The continuous corn treatment with a cover crop (CCW) had higher Soil Health Index values than the unfertilized prairie treatment (P).

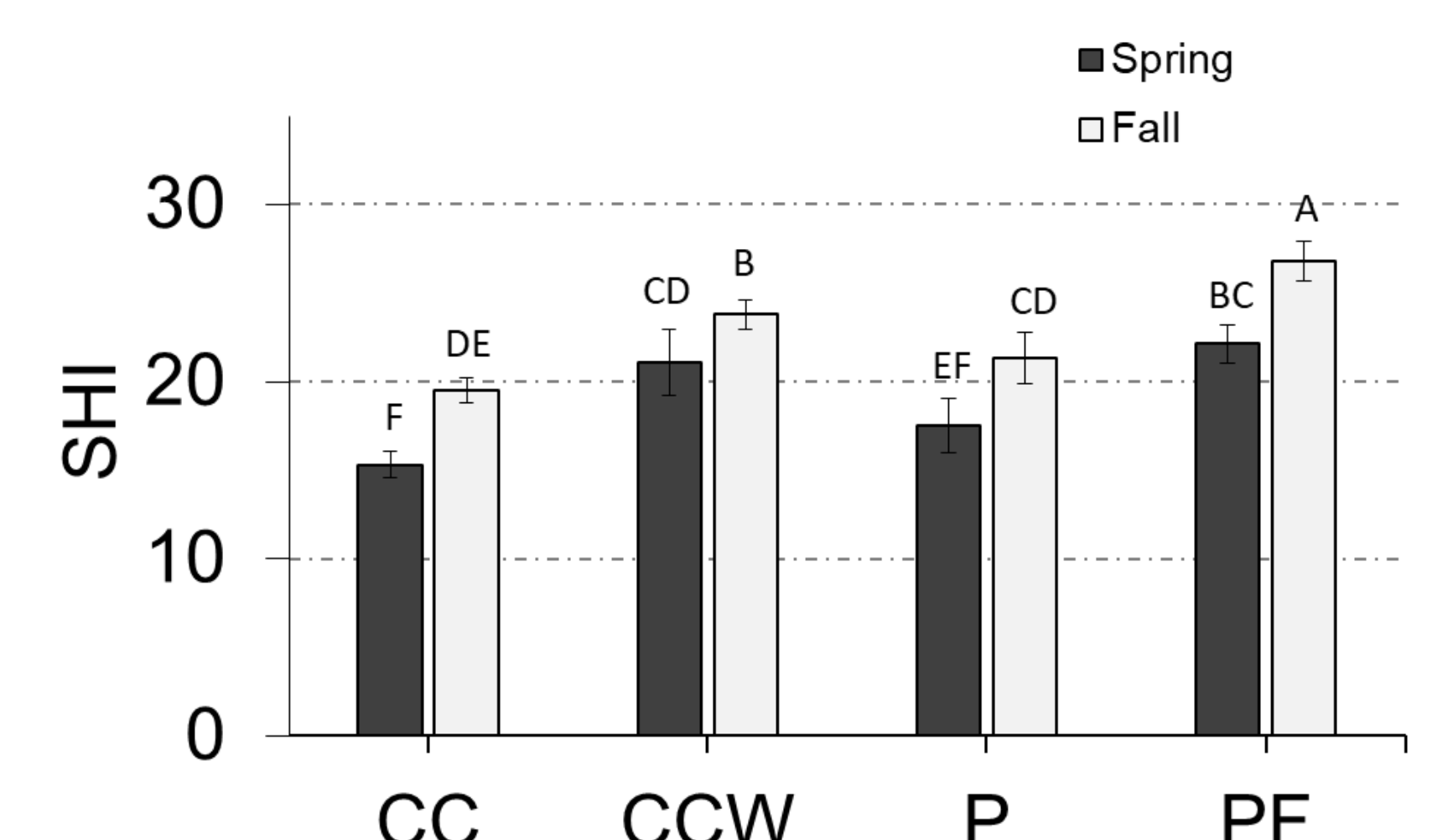


Fig. 8. Haney Soil Health Index (SHI) under four biofuel cropping systems.

Conclusions

Compared to soil supporting the annual bioenergy crops (maize in the CC and CCW treatments), soil in the fertilized, multispecies, reconstructed prairie cropping system had significantly greater CO₂ respiration rates, greater concentrations of POM, more water-extractable organic carbon, and a higher soil health index. Most soil health indicators were higher for fall-collected samples than for samples collected in the spring of each year.

Acknowledgments

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