CROPPING SYSTEM EFFECTS ON SOIL BIOLOGICAL CHARACTERISTICS IN THE GREAT PLAINS

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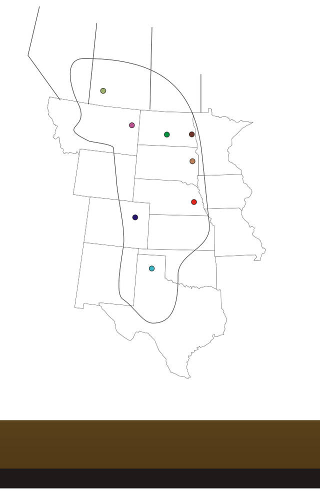


INTRODUCTION

Soil biota mediate important ecosystem processes within cropping systems. Through their affect on energy flow, nutrient cycling, and water infiltration and storage, soil biota influence both agricultural productivity and environmental quality, and therefore warrant careful consideration when evaluating the sustainability of cropping systems.

From 1999 to 2002, a multi-location study in the Great Plains was conducted to evaluate a number of physical, chemical, and biological properties proposed for assessing soil quality. Objectives of the study were to:

- Quantify temporal dynamics of soil quality attributes in established cropping systems,
- Assess soil quality attributes between treatments of contrasting management intensity, and
- Evaluate recently developed methods for assessing soil quality.

This study allowed for the evaluation of management impacts on a consistent set of soil biological properties across multiple locations over time.

METHODS

Soil sampling protocol

- Depths: 0-7.5, 7.5-15, and 15.0-30 cm.
- Frequency: pre-plant (PP), peak biomass (PB), post-harvest (PH) (1999 to 2002).
- Grass check-plots were sampled at Fargo, Mandan, Mead, and Sidney (for reference only).

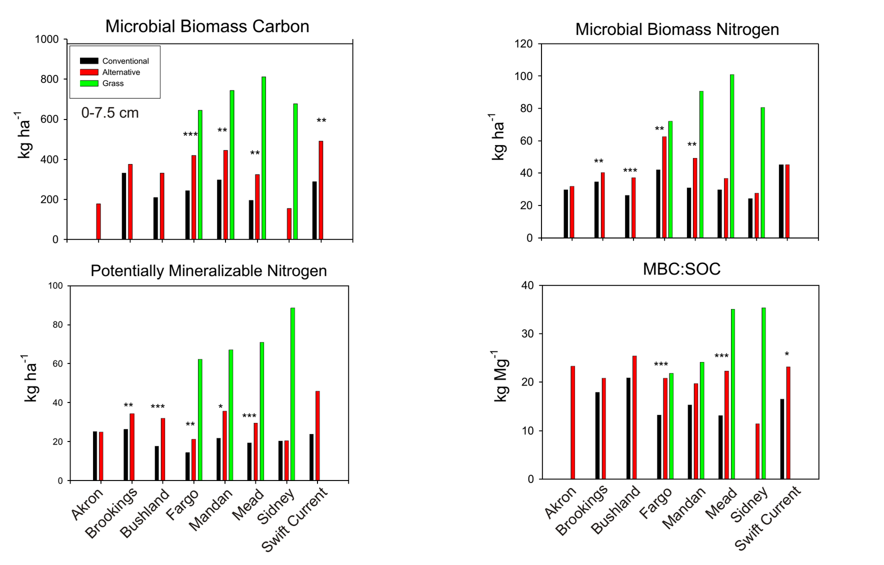
Laboratory analysis

- Microbial biomass C and N (microwave irradiation).
- Soil organic C for MBC:SOC ratio.
- Potentially mineralizable N (PMN) (anaerobic incubation).
- Total glomalin and water stable aggregates (WSA) (1 to 2 mm aggregates).
- Fatty acid methyl esters (FAME) (MIDI standard protocol).

Statistical analyses

- PROC MIXED within location analysis by depth.
- Regression analysis to identify management, climatic, and sampling factors affecting soil biological properties.
- Principal component analysis (PCA) of FAME.

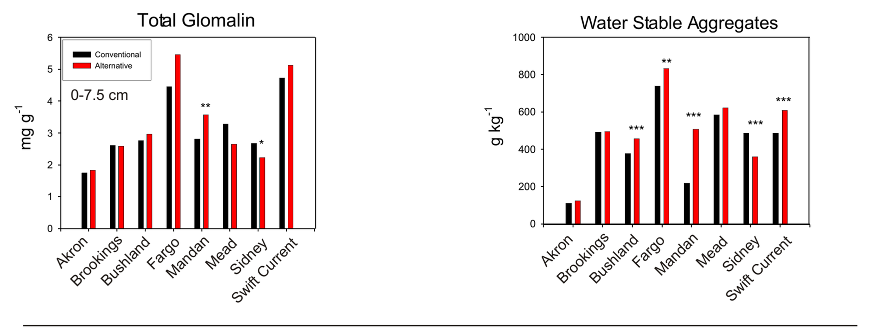
MICROBIAL BIOMASS, PMN



*, **, *** Values between conventional and alternative treatments within a property and soil depth significantly different at P=0.1, 0.05, and 0.01, respectively.

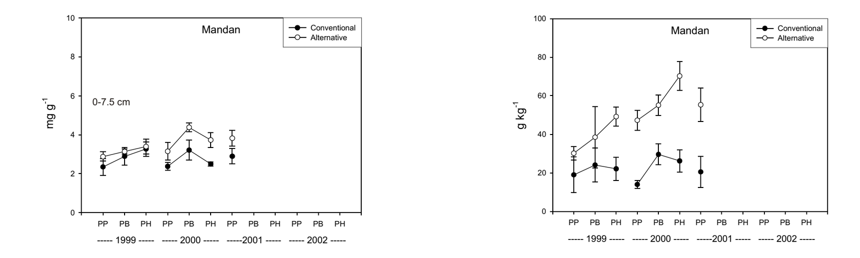
Microbial biomass C and N were greater in alternative cropping systems than conventional cropping systems at Fargo, Mandan, Mead, and Swift Current.
Alternative cropping systems possessed greater PMN than conventional cropping systems at Brookings, Bushland, Fargo, Mandan, and Mead.

GLOMALIN, WSA



*, **, *** = Difference between conventional and alternative treatments significant at P=0.1, 0.05, and 0.01, respectively.

Management effects on total glomalin were limited to Mandan and Sidney, where contrasting trends between treatments were observed.
Four of eight locations had greater water stable aggregates in the alternative cropping system.
Total glomalin was the measure chosen in this study because of the ease of analysis for the large number of samples assayed. However, other fractions of glomalin, particularly the immunoreactive fraction, might be more important in influencing aggregate stability than total glomalin.



Total glomalin and aggregate stability differed between treatments at multiple time periods at Mandan, especially during the fallow period of the conventional treatment (2000).

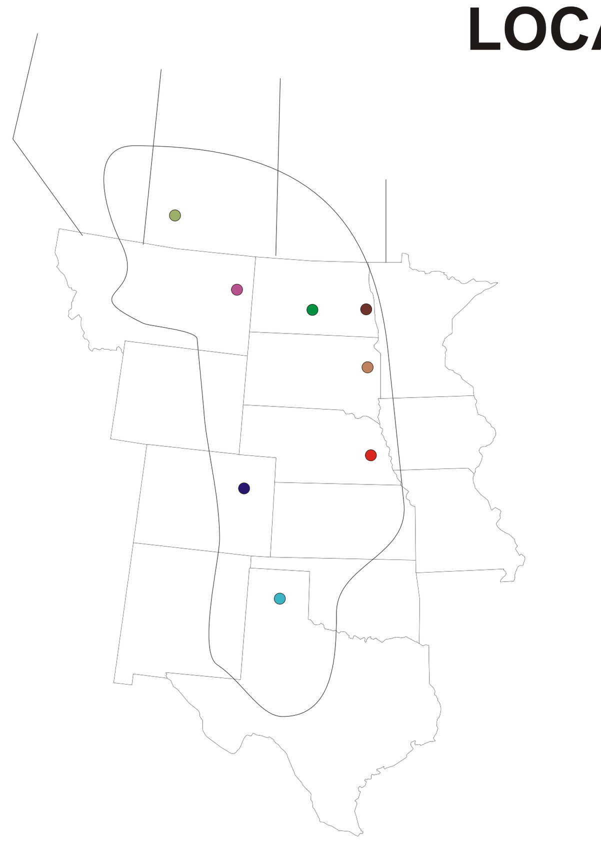
DISCUSSION

Collectively, findings from this evaluation indicate there is merit in pursuing alternative management practices to enhance biological indicators of soil quality. Specifically, management systems characterized by increased cropping intensity, greater cropping diversity, and/or reduced tillage enhanced most soil biological properties evaluated in this study. Improved status of soil biological properties can enhance nutrient cycling and residue decomposition.

Temporal variation in soil biological properties in this study underscored the importance of interpreting results in the context of climatic and treatment attributes unique to the time soil samples are collected.

Systems comparisons such as this can play an important role in redefining best management practices for improving soil quality and creating more sustainable cropping systems.

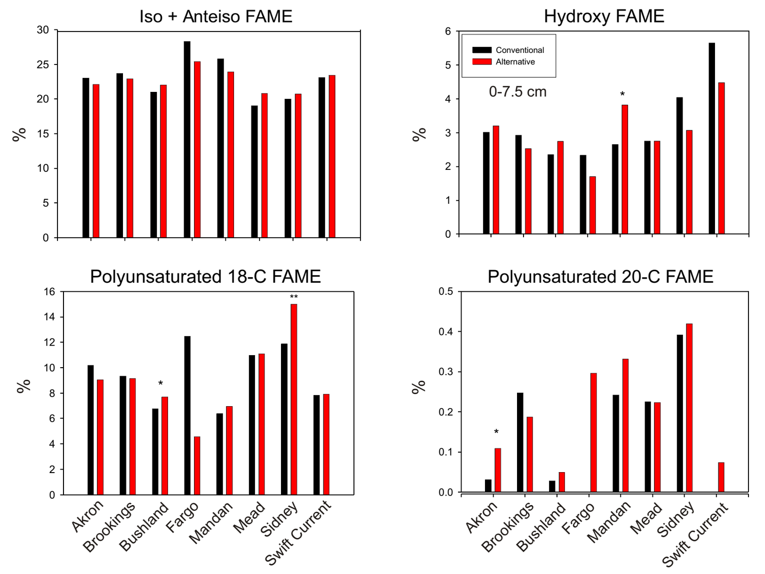
LOCATION DESCRIPTIONS



Location/ MAP;MAT*	Trt	Tillage	Rotation
Akron	C	Sweep plow	WW-F
(42 cm; 9°C)	A	No-till	WW-C-M
Brookings	C	Fall chisel, spring disk	CC
(58 cm; 6°C)	A	Fall chisel, spring disk	C-SB-SW/A-A
Bushland	C	No-till	WW-SG-F
(47 cm; 13°C)	A	No-till	CWW
Fargo	C	Moldboard plow, disk, S-tine	FP-D
(54 cm; 5°C)	A	No-till	FP-D
Mandan	C	Tandem disk, chisel plow	SW-F
(43 cm; 6°C)	A	No till	SW-WW-SF
Mead	C	Tandem disk, harrow	CC
(77 cm; 11°C)	A	Tandem disk, harrow	C-SB-SG-O/CL
Sidney	C	Tandem disk	CSW
(31 cm; 9°C)	A	No till	CSW-F
Swift Current	C	Chisel plow w/sweeps	SW-F
(36 cm; 4°C)	A	Chisel plow w/sweeps	SW-L

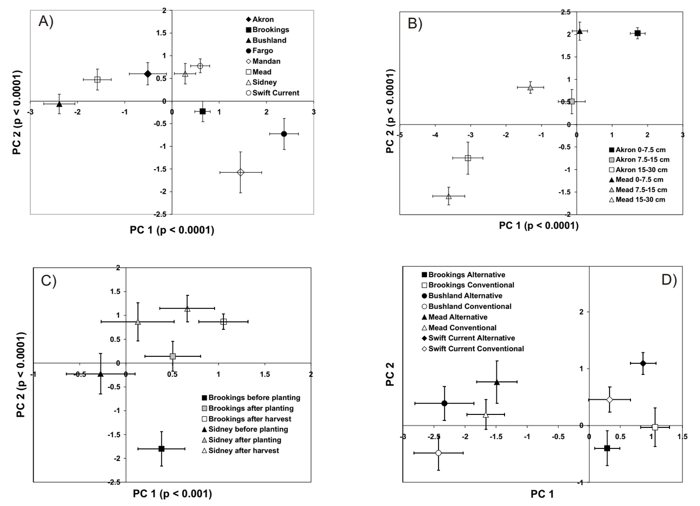
* Abbreviations: MAP = Mean annual precipitation, MAT = Mean annual temperature, C=conventional, A=alternative, A=alfalfa, C=corn, CC= continuous corn, CL=clover, CSW = continuous spring wheat, CWW=continuous winter wheat, D=durum wheat, F=fallow, FP= field pea L=lentil, M=millet, O = oats, SB= soybean, SF=sunflower, SG = sorghum, SW= spring wheat, WW=winter wheat. (see poster #930 by Varvel et al. for additional detail).

FAME PROFILES



Biomarkers for microbial groups: Hydroxy FAME = gram negative bacteria; Iso + Anteiso FAME = gram positive bacteria; Polyunsaturated 18-C FAME = fungi; Polyunsaturated 20-C FAME = protozoa (Vestal and White, 1989; Zelles et al., 1995).
§ *, ** = Difference between conventional and alternative treatments within a depth significant at P=0.05 and 0.01, respectively.

Consistent trends in individual FAME biomarkers between treatments were not common across locations, indicating a strong site-specific effect on soil biota composition.



FAME profiles were highly dependent on location (A).
Sampling depth had a dominant influence on FAME profiles at all locations. Akron and Mead are shown as examples (B).
Locations where FAME profiles were analyzed for more than one sampling time yielded significant time effects (C).
Four locations Brookings, Bushland, Mead, and Swift Current were significantly different between treatments in PC 1 or 2 (D).

REGRESSION ANALYSIS

	- - - - Model with maximum adjusted r^2 - - - -			Best two component model	
Parameter	Adj r^2	Variables	# variables	Adj r^2	Variables
		0 to 7.5 cm			
MBC	0.161	D, F, L, R, S, T	6	0.10	D, T
MBN	0.146	D, F, N, R, S, T	6	0.08	F, T
PMN	0.107	F, L, N, R, T, S	6	0.06	F,S
WSA	0.59	D, F, L, N, R, S, T	7	0.40	F, S
TG	0.42	D, L, N, R, S, T	6	0.18	S, T

D = maximum tillage depth, F=presence (1) or absence (0) of fallow in the rotation, L= presence (1) or absence of legume (0) in the rotation, N = total number of species included in rotation cycle, R = mean annual precipitation, S=sampling time and year of sampling, T = mean annual temperature.

Management, climatic, and sampling factors explained little variance associated with microbial biomass C and N and PMN. A major source of variation in water stable aggregates and total glomalin was sampling time.

ACKNOWLEDGEMENTS

We acknowledge the contribution of numerous support personnel at each of the research locations for maintenance of research plots and assistance with field sampling and sample processing. We thank S. Siragusa for data collection and summarization, M. West for guidance with statistical analyses, and J. Gross and K. Eystad for assistance with the poster.

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