Effect of Sheep Grazing on Soil Carbon and Nitrogen in Dryland Cropping Systems

Joy L. Barsotti, Upendra Sainju and Andy Lenssen
USDA-ARS, Sidney, MT
Cliff Montagne and Patrick Hatfield
Montana State University - Bozeman

Introduction

- Extensive tillage and N fertilization in the last several decades to increase crop yields has resulted in reduced soil and environmental quality due to increased soil erosion and acidification, N leaching, CO_2 and N_2O emissions and loss of soil organic matter.
- Integrated crop-livestock is an alternative practice that could reduce N fertilization rates and restore soil fertility and organic matter because of increased C and nutrient cycling.
- Sheep grazing has been known as an inexpensive and effective method of weed and pest control.
- Little is known about the effects of sheep grazing and cropping systems on soil C and N under dryland cropping systems in the northern Great Plains.

Objectives

1. Examine the amount of spring wheat grain and alfalfa and pea/barley yields harvested and spring wheat biomass residue returned to the soil in 2010 and 2011 in southwest MT.
2. Determine the effects of fallow management and cropping sequence on soil total C, total N, NH_4-N, and NO_3-N contents at the 0-120 cm depth from 2009 through 2011.

Materials and Methods

Treatments:
Three fallow management practices for weed control (main plot):
- Sheep grazing (GRAZ)
- Chemical or herbicide application (CHEM)
- Mechanical or tillage (MECH)

Three cropping sequence (split-plot):
- Continuous alfalfa (CA)
- Continuous spring wheat (CSW)
- Spring wheat-pea/barley hay-fallow (W-P/B-F)

Design: Randomized complete block with 3 replications. Each phase of the cropping sequence present every year.
Plot size: 91.4 m X 15.2 m

Sheep stocking rate: 29-153 sheep d ha^{-1}

Crop Management
Nitrogen fertilizer was applied at 201 kg N ha^{-1} to spring wheat and at 78 kg N ha^{-1} to Austrian winter pea/hay barley mixture. No N fertilizer was applied to the alfalfa or fallow phase.

P or K fertilizers were not applied due to adequate levels.

Figure 2. Soil total Carbon at 0-120 cm depths affected by cropping sequence from 2009 through 2011.

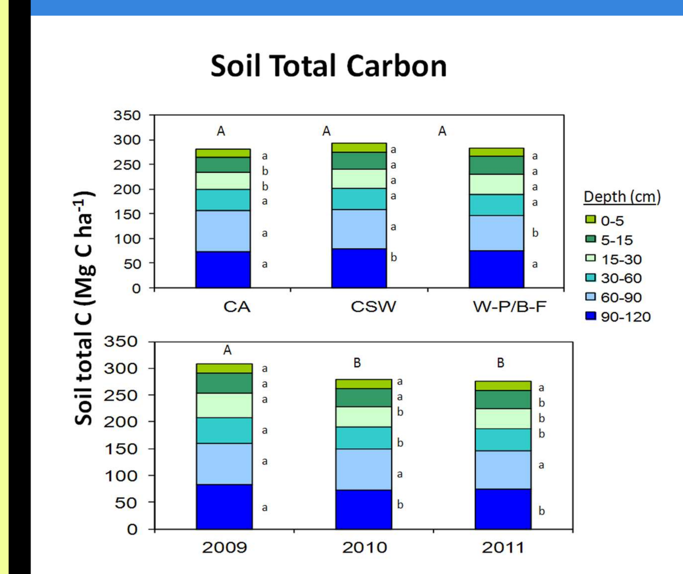


Figure 3. Soil total Nitrogen at 0-120 cm depths affected by cropping sequence from 2009 through 2011.

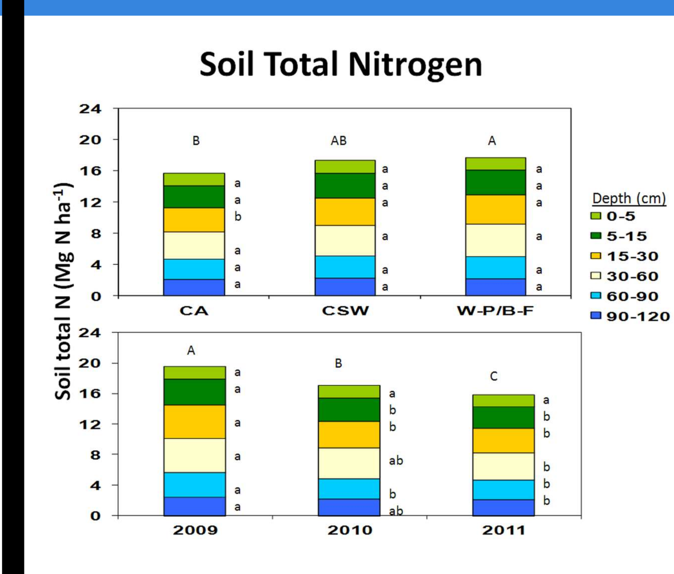


Figure 4. Soil NH_4-N content at 0-120 cm increments for years 2009 through 2011.

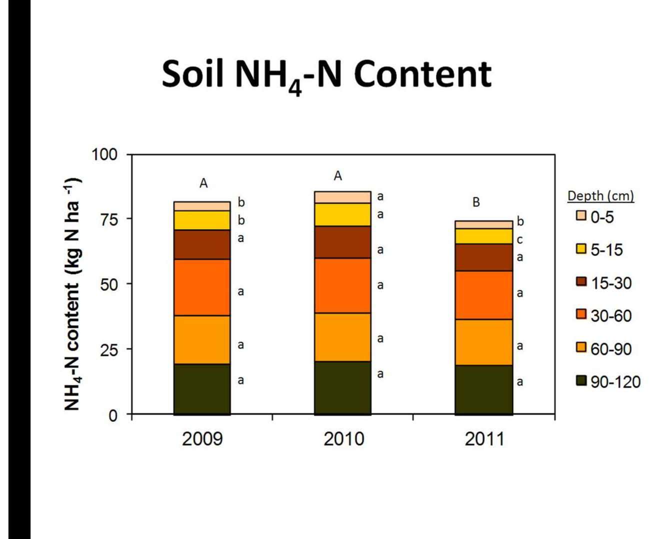
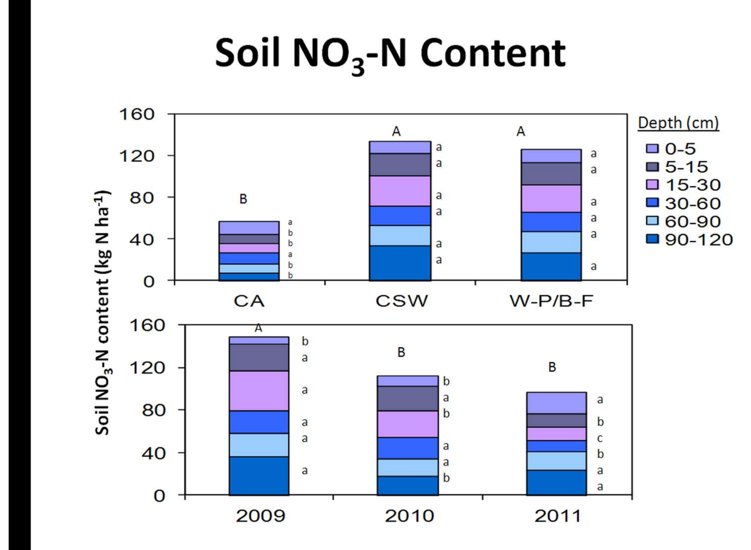


Figure 5. Soil NO_3-N at 0-120 cm depths affected by cropping sequence from 2009 through 2011.



Grain and Biomass Yields

Table 1. Spring Wheat:

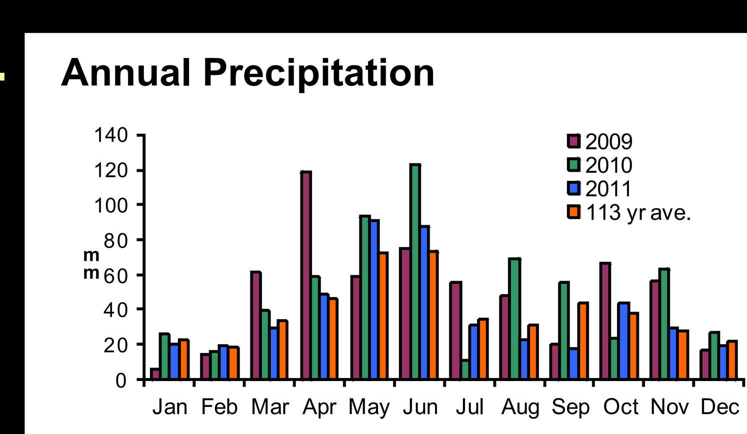
Cropping Sequence	Grain yield	Biomass yield	C content Grain	C content Biomass	N content Grain	N content Biomass
	-----Mg ha^{-1}----		----Mg C ha^{-1}---		----kg N ha^{-1}----	
CSW	2.31b	5.06b	0.98b	2.15b	31.6b	68.5b
W-P/B-F	3.55a	7.37a	1.51a	3.14a	48.2a	100.2a

Table 2. Hay:

Cropping Sequence	Biomass yield 2010	Biomass yield 2011	Biomass C content 2010	Biomass C content 2011	Biomass N content 2010	Biomass N content 2011
	-----Mg ha^{-1}----		----Mg C ha^{-1}---		----kg N ha^{-1}----	
CA (alfalfa)	-----	7.07a	----	3.1a	----	182.1a
W-P/B-F (pea/barley hay)	6.56	7.01a	2.8a	2.9a	100.8	86.8b

Results and Discussion

Figure 1.



- Spring wheat grain and biomass yields were greater in W-P/B-F than in CSW but annualized yields were lower (***Table 1***)
- Pea/barley and alfalfa biomass hay were similar in W-P/B-F and CA (***Table 2***)
- Soil total C content was greater in CSW and W-P/B-F than in CA at 5-30 cm due to greater amount of biomass residue returned to the soil (***Figure 2***)
- Similarly soil total N was higher in spring wheat than CA probably due to greater N substrate resulting from biomass residue (***Figure 3***)
- Soil NH_4-N had greater concentrations in 2009 and 2010 than 2011 (***Figure 4***), likely because of greater than average precipitation (***Figure 1***)
- Significantly lower soil NO_3-N was seen in CA than CSW and W-P/B-F because of greater root biomass using soil water and associated soluble N at 0-120 cm (***Figure 5***)
- No significant differences were observed between fallow management practices in terms of yield, soil total C and N concentrations
- Both total soil C and N declined from 2009 to 2011, regardless of treatments

Conclusions

- Fallow management had little influence on soil carbon and nitrogen.
- Sheep grazing may be used to sustain crop yields and soil and environmental quality compared to tillage and herbicide application of weed control.
- Long-term experiments are needed to accurately estimate soil C and N sequestration rates because of their high variability.
- Soil total C and N were greater in CSW and W-P/B-F at 5-30 cm depth and NO_3-N at 5-120 cm depth than CA.

We gratefully acknowledge:

- Jillian Hatfield, Ashlee Johnson, Megan Schertling, Nick Sainju, Thomas O'Neill, Erin Nix, Devon Ragen, Paramjit Karam Singh, and Evelyn Konigsberg for assistance in sample collection and Rene' France for aiding in sample analysis. Dr. Hayes Goosey and Dr. Zachary Miller were instrumental in farm management and research coordination.
- USDA/ARS/NPARL for the use of analytical instruments and laboratory equipment.
- Montana State University, Animal and Range Department, and Nutrition Center for the use of office and laboratory.
- Funding for this project was provided by USDA CSREES ICGP - 0002154.

APRIL 2012

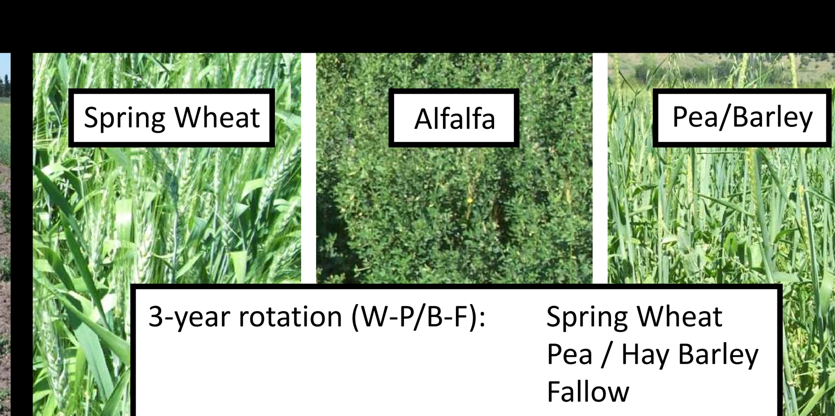
Soil sampled to 0-120 cm depth.

Divided into 0-5, 5-15, 15-30, 30-60, 60-90, and 90-120 cm depths.

Analyzed for total C, total N, NH_4-N and NO_3-N concentrations.

Soil Sampling

Fallow Management



Cropping Sequence

Plot Layout