Sheep Grazing Influence Soil Microbial and Particulate Organic Carbon in Dryland Cropping Systems

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Introduction

- Sheep grazing during fallow is an effective and inexpensive method of weed and pest control compared with herbicide application and tillage.
- Tillage and fallow can expose soil to erosion and herbicide application can contaminate soil, water, and air, all of which can increase risks to human and animal health.
- Sheep grazing may influence soil C fractions by returning C inputs to the soil through feces and urine.
- Little information exists on the effect of sheep grazing on soil C fractions in dryland cropping systems.

Objectives

- Quantify the effects of weed management practices (sheep grazing, tillage, and herbicide application) and cropping sequences (continuous spring wheat [CSW] and spring wheat-pea/barley mixture hay-fallow [W-P/B-F]) on soil microbial biomass C (MBC), potential C mineralization (PCM), and particulate organic C (POC) from 2009 to 2011 in southwestern Montana, and
- Identify if sheep grazing for weed control can be a viable option for improving soil health and quality compared with tillage and herbicide application in dryland cropping systems.

Treatments

Location: Bozeman, Montana

Duration: 2009-2011

Treatments:

Three weed management practices (sheep grazing, tillage, and herbicide application) as the main plot and

Two cropping sequences (continuous spring wheat [CSW] and spring wheat-pea/barley mixture hay-fallow [W-P/B-F]) as the split plot.

Design: Randomized complete block

Replication: 3

Crop residue: Removed by machine in tillage and herbicide application treatments and by sheep grazing in the grazing treatment.

Results and Discussion

- MBC at 0-5 cm was greater with tillage on CSW than most other treatments from 2009 to 2011 (***Fig. 2***) due to the incorporation of residue of higher C/N ratio into the soil.
- POC at 0-5 cm was greater with sheep grazing on W-P/B-F and at 15-30 cm was greater with grazing on CSW than other treatments (***Fig. 3***). At 5-15 cm, POC was greater with herbicide application on CSW than other treatments.
- Return of C inputs through feces and urine to the soil through sheep grazing increased POC only at some depths. Nondisturbance of soil increased POC the surface layer on CSW. Similarly, increased crop residue returned to the soil increased POC on CSW and than W-P/B-F at some depths.
- PCM was not affected by treatments.
- Return of more nonlabile than labile portion of organic matter through feces and urine probably reduced MBC but increased POC with sheep grazing compared with other weed management practices.
- Both PCM and POC at all depths declined with year from 2009 to 2011 (***Figs. 4 and 5***). The rate of decline was greater for 15-30 cm than for other depths (***Table 1***). Removal of crop residue with herbicide application and tillage treatments and sheep grazing with the grazing treatment likely reduced PCM and POC from 2009 to 2011.

Conclusions and Recommendations

- Sheep grazing had little impact on microbial and mineralizable C compared with tillage and herbicide application for weed control.
- Continuous cropping increased microbial and particulate organic C compared with crop-fallow system at some depths.
- Sheep grazing may increase coarse organic matter fraction compared with other weed management practices in dryland cropping systems in the long run.

Fig. 1. *From left, white-faced sheep grazing on crop residue during fallow; an aerial view of the experiment in Bozeman, Montana; soil sampling with a probe truck, and pea/barley mixture hay and spring wheat.*

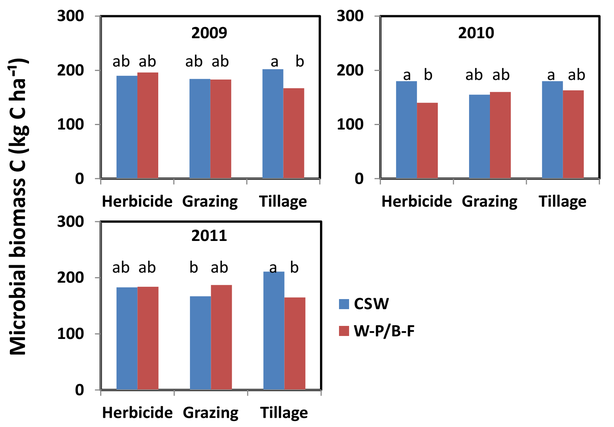

Fig. 2. *Microbial biomass C at the 0-5 cm depth from 2009 to 2011 as influenced by weed management and cropping sequence. Herbicide = weed management by herbicide application, grazing = weed management by sheep grazing, tillage = weed management by tillage, CSW = continuous spring wheat, and W-P/B-F = spring wheat-pea/barley mixture hay-fallow.*

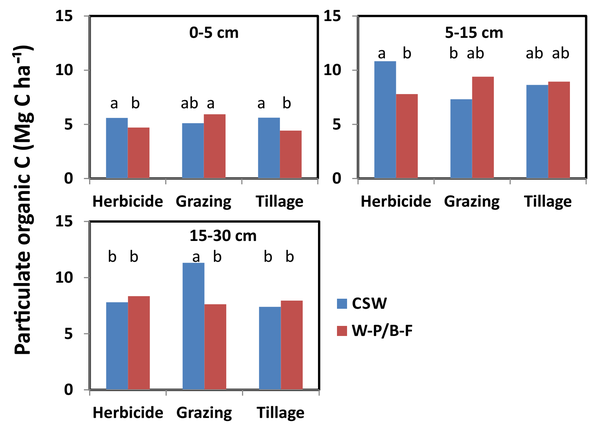

Fig. 3. *Particulate organic C at the 0-30 cm depth averaged across years as influenced by weed management and cropping sequence. Herbicide = weed management by herbicide application, grazing = weed management by sheep grazing, tillage = weed management by tillage, CSW = continuous spring wheat, and W-P/B-F = spring wheat-pea/barley mixture hay-fallow.*

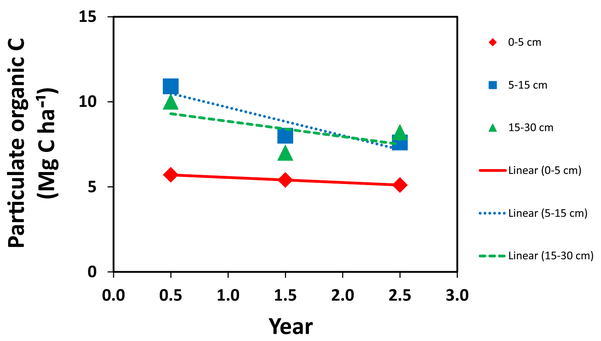

Fig. 5. *Relationship between particulate organic C (POC) at the 0-30 cm depth with year. Regression coefficients are shown in* ***Table 1.***

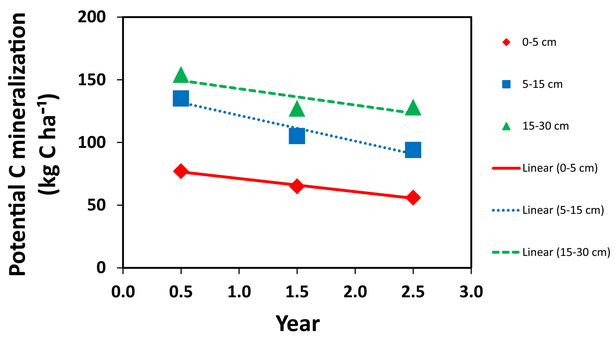

Fig. 4. *Relationship between potential C mineralization (PCM) at the 0-30 cm depth with year. Regression coefficients are shown in* ***Table 1.***

Table 1. *Regression coefficients for the relationships between potential C mineralization (PCM) and particulate organic C (POC) at various depths with year for* ***Figs. 4 and 5****.*

† Units are kg C ha $^{-1}$ for PCM and Mg C ha $^{-1}$ for POC.

‡ Units are kg C ha $^{-1}$ yr $^{-1}$ for PCM and Mg C ha $^{-1}$ yr $^{-1}$ for POC.

Parameter	Soil depth	Intercept†	Slope‡	R^2	P
PCM (kg C ha^{-1})	0-5 cm	82	-11	0.99	0.02
	5-15 cm	142	-21	0.93	0.06
	15-30 cm	156	-13	0.72	0.35
POC (Mg C ha^{-1})	0-5 cm	5.8	-0.3	0.99	0.01
	5-15 cm	11.3	-1.7	0.84	0.26
	15-30 cm	9.8	-0.9	0.36	0.59