Dryland Soil Carbon Dynamics under Alfalfa and Durum-Annual Forage Sequences

Barley hay

Fallow

Foxtail millet

Durum

Alfalfa

Barley/Austrian winter pea hay

Introduction

In forage cropping systems, aboveground biomass is usually harvested for animal feed. Therefore, belowground biomass (root) becomes the sole source of C to maintain soil organic matter and sustain soil quality and productivity. Since soil C content increases with increase in crop residue returned to the soil (Sainju et al., 2009), it is not known if the removal of aboveground biomass maintains soil quality. In dryland cropping systems in the northern Great Plains, lands are kept under fallow for one or more years to conserve soil water and stabilize crop yields. This reduces soil organic matter level and quality due to reduced crop residue returned to the soil and increased mineralization (Peterson et al., 1998; Sainju et al., 2007). Since durum production can return aboveground crop residue to the soil after grain harvest, little is known about soil C dynamics in durum-forage cropping sequences.

Objectives

- Examine the amount of **above- and belowground crop residue C** returned to the soil from 2002 to 2005 in alfalfa and durum-annual forage sequences.
- Determine the effect of four years of cropping sequence on **soil total C** (STC), **particulate total C** (PTC), **microbial biomass C** (MBC), and **potential C mineralization** (PCM) at the 0-120 cm depth under dryland cropping systems in the northern Great Plains.

References

Peterson, G.A., A.D. Halvorson, J.L. Havlin, O.R. Jones, D.G. Lyon, and D.L. Tanaka. 1998. Reduced tillage and increased cropping intensity in the Great Plains conserve soil carbon. Soil Tillage Res. 47:201-218.

Sainju, U.M., T. Caesar-TonThat, A.W. Lenssen, R.G. Evans, and R. Kohlberg. 2007. Long-term tillage and cropping sequence effects on dryland residue and soil carbon fractions. Soil Sci. Soc. Am. J. 71:1730-1739.

Sainju, U.M., A.W. Lenssen, T. Caesar-TonThat, and R.G. Evans. 2009. Dryland crop yields and soil organic matter as influenced by long-term tillage and cropping sequence. Agron. J. 101:243-251.

Materials and Methods

Experiment was conducted from 2002 to 2005 in eastern Montana. Five cropping sequences in randomized block design with three replications:

1. Continuous alfalfa (CA)
2. Durum-barley hay (D-B)
3. Durum-foxtail millet hay (D-M)
4. Durum-Austrian winter pea/barley hay (D-P/B)
5. Durum-fallow (D-F)

Soil samples were collected at the 0-120 cm depth in October 2005. Samples were analyzed for soil total C (STC), particulate total C (PTC), microbial biomass C (MBC), and potential C mineralization (PCM).

Results and Discussion

- Belowground crop residue C was greater but aboveground residue C was lower in alfalfa than in other treatments (**Fig. 1**). This is due to the harvest of aboveground growth for forage in alfalfa.
- Soil total C content was greater in CA than in D-B at the 0-15 cm depth but was greater in D-B and D-M than in CA at 15-60 cm (**Fig. 2**). At 0-120 cm, total C was greater in D-F than in D-P/B.
- Particulate total C was also greater in CA than in other treatments at 0-15 cm but varied with treatments at other depths (**Fig. 3**). At 0-120 cm, particulate total C was greater in D-P/B than in other treatments, except in CA.
- Potential C mineralization was greater in CA than in most other treatments at all depths (**Fig. 4**).
- Microbial biomass C was greater in D-P/B than in D-B at 30-60 cm but was greater in CA than in D-B at 60-120 cm (**Fig. 5**). At 0-120 cm, microbial biomass C was greater in CA than in D-B.
- Greater C fractions in CA than in other treatments suggest that belowground C inputs (roots and rhizodeposition) may play a greater role in soil C dynamics than aboveground biomass, since aboveground biomass was absent but root and rhizodeposit C was greater in CA than in other treatments (**Fig. 1**).
- Greater C input due to increased crop yield as a result of increased soil water conservation due to fallow may have increased C sequestration in D-F. Greater potential C mineralization and microbial biomass C in CA than in other treatments suggests that alfalfa may improve soil quality due to greater microbial biomass and activity as a result of greater root biomass and rhizodeposition C.

Conclusions

Root biomass and rhizodeposit C are main C inputs in the forage production system, since aboveground biomass is harvested for forage. Because of greater root biomass and rhizodeposit C, followed by undisturbed soil condition, **alfalfa may improve soil quality compared with annual forages due to increased microbial biomass and activity.**

Although total C input was lower, increased C fractions in alfalfa compared with other cropping sequences suggest that **belowground biomass (root and rhizodeposit) may play a greater role in soil C dynamics than aboveground biomass**.

Durum followed by barley hay reduced soil C fractions compared with durum followed by other annual forages, probably due to lower C inputs.

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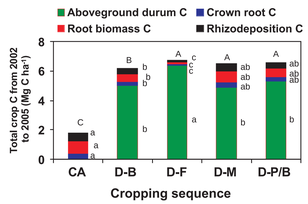

Fig. 1. Total crop residue C returned to the soil from 2002 to 2005 as influenced by cropping sequence. Bars followed by lower case letter in the right within a set and upper case letter at the top (total depth) are not significantly different.

Cropping Sequences for all Figures:

CA = continuous alfalfa
D-B = durum-barley hay
D-F = durum-fallow
D-M = durum-foxtail millet hay
D-P/B = durum-Austrian winter pea/barley hay

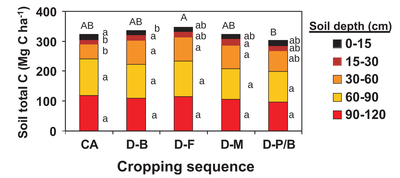

Fig. 2. Soil total (organic + inorganic) C content at the 0-120 cm depth in 2005 as influenced by cropping sequence. Bars followed by lower case letter in the right within a set and upper case letter at the top (total depth) are not significantly different.

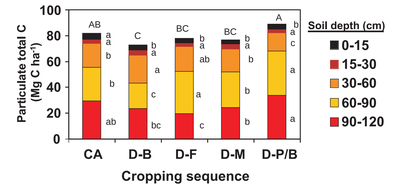

Fig. 3. Soil particulate total (organic + inorganic) C content at the 0-120 cm depth in 2005 as influenced by cropping sequence. Bars followed by lower case letter in the right within a set and upper case letter at the top (total depth) are not significantly different.

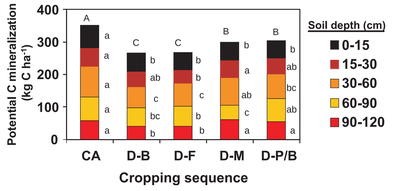

Fig. 4. Soil potential C mineralization at the 0-120 cm depth in 2005 as influenced by cropping sequence. Bars followed by lower case letter in the right within a set and upper case letter at the top (total depth) are not significantly different.

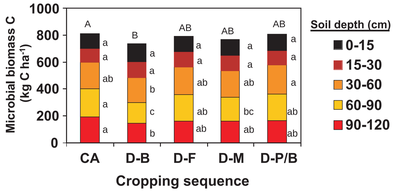

Fig. 5. Soil microbial biomass C at the 0-120 cm depth in 2005 as influenced by cropping sequence. Bars followed by lower case letter in the right within a set and upper case letter at the top (total depth) are not significantly different.