Dryland Residue and Soil Nitrogen Fractions as Influenced by Long-term Tillage and Cropping Sequence

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Introduction

Nitrogen sequestration in soil and crop residue is needed to reduce its loss through leaching, volatilization, surface runoff, erosion, and N_2O (a greenhouse gas) emission. In contrast, N mineralization is needed to optimize N availability for plant growth so that the cost and rate of N fertilization can be reduced. While the conventional tillage with wheat-fallow system (STW-F) reduces soil N storage (Haas et al., 1957), reduced tillage and increased cropping intensity can increase dryland soil N fractions (Sherrod et al., 2003; Sainju et al., 2006, 2007). In the northern Great Plains, limited information exists on the long-term effects of tillage and cropping sequence on soil N fractions. This study provided a unique opportunity to evaluate the 21-yr effects of tillage frequency and cropping sequences on dryland soil N storage and N mineralization potential and availability in the northern Great Plains.

Objective

To examine the 21-yr influence of combinations of tillage frequency and cropping sequence on mean dryland crop biomass (stems + leaves) returned to the soil every year, surface residue N, and soil total N (STN), particulate organic N (PON), potential N mineralization (PNM), microbial biomass N (MBN), NH_4-N, and NO_3-N contents at 0- to 5- and 5- to 20-cm depths in semiarid eastern Montana.

Treatments

1. No-tilled continuous spring wheat (NTCW),
2. Spring-tilled continuous spring wheat (STCW),
3. Fall- and spring-tilled continuous spring wheat (FSTCW),
4. Fall- and spring-tilled spring wheat-barley (1984-1999) followed by spring wheat-pea (2000-2004) (FSTW-B/P), and
5. Spring-tilled spring wheat-fallow (STW-F).

The STW-F is the conventional farming system. Treatments were arranged in randomized block design with four replications. The experiment was started by Aase and Pikul (1995) in 1983. Crop biomass was measured from 1984 to 2004 and soil surface residue and N fractions were measured in 2004.

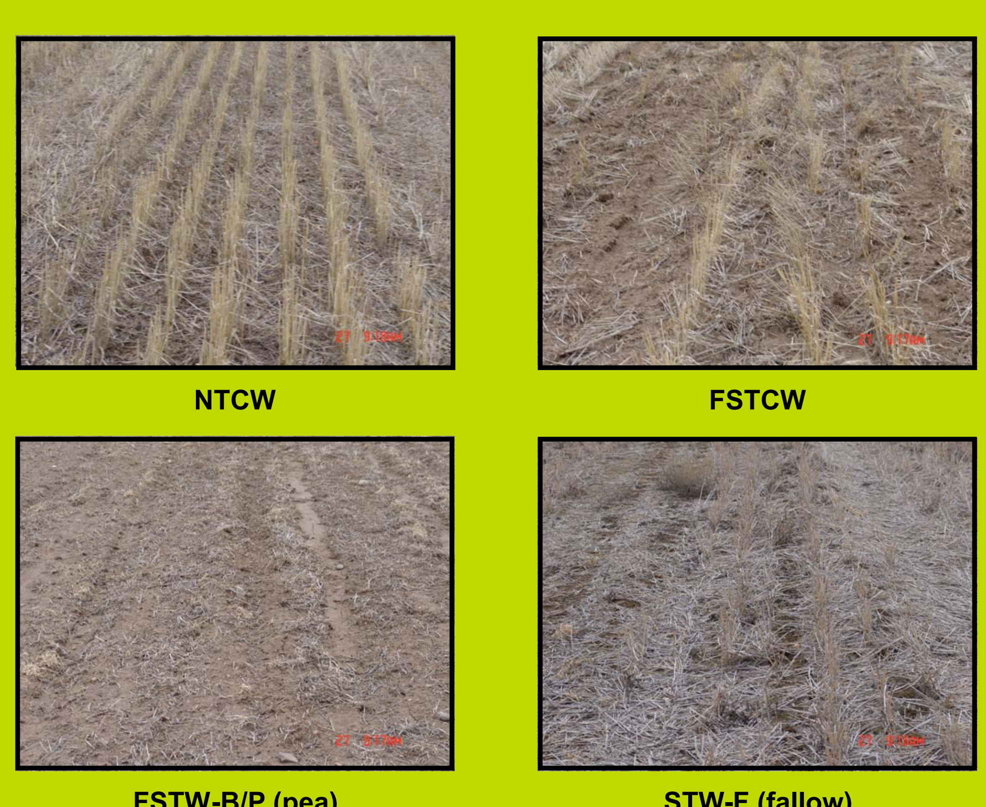

Fig. 1. Crop residue cover in wheat phase of NTCW and FSTCW, pea phase in FSTW-B/P, and fallow phase in STW-F in October 2004.

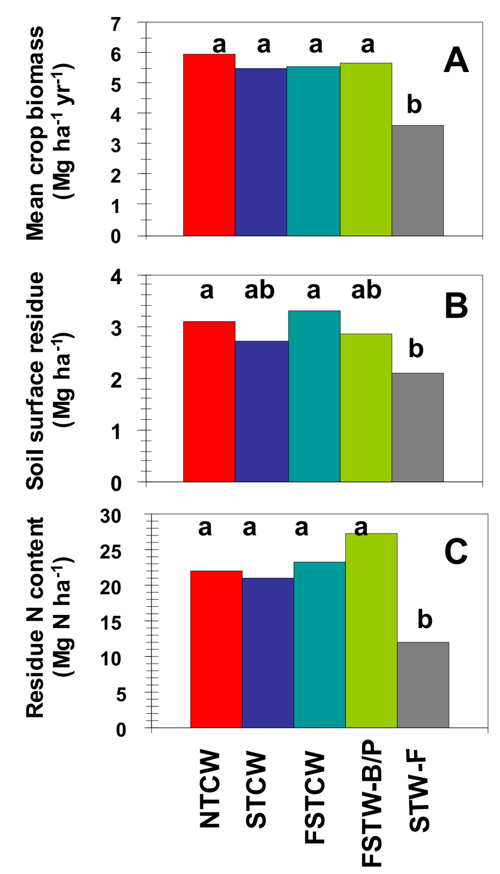

Fig. 2. Effects of tillage and cropping sequences on (A) mean annualized crop biomass returned to the soil from 1984 to 2004, (B) soil surface residue amount, and (C) residue N content in 2004. NTCW = No-tilled continuous spring wheat, STCW = Spring-tilled continuous spring wheat, FSTCW = Fall- and spring-tilled continuous spring wheat, FSTW-B/P = Fall- and spring-tilled spring wheat-barley (1984-1999) followed by spring wheat-pea (2000-2004), and STW-F = Spring-tilled spring wheat-fallow.

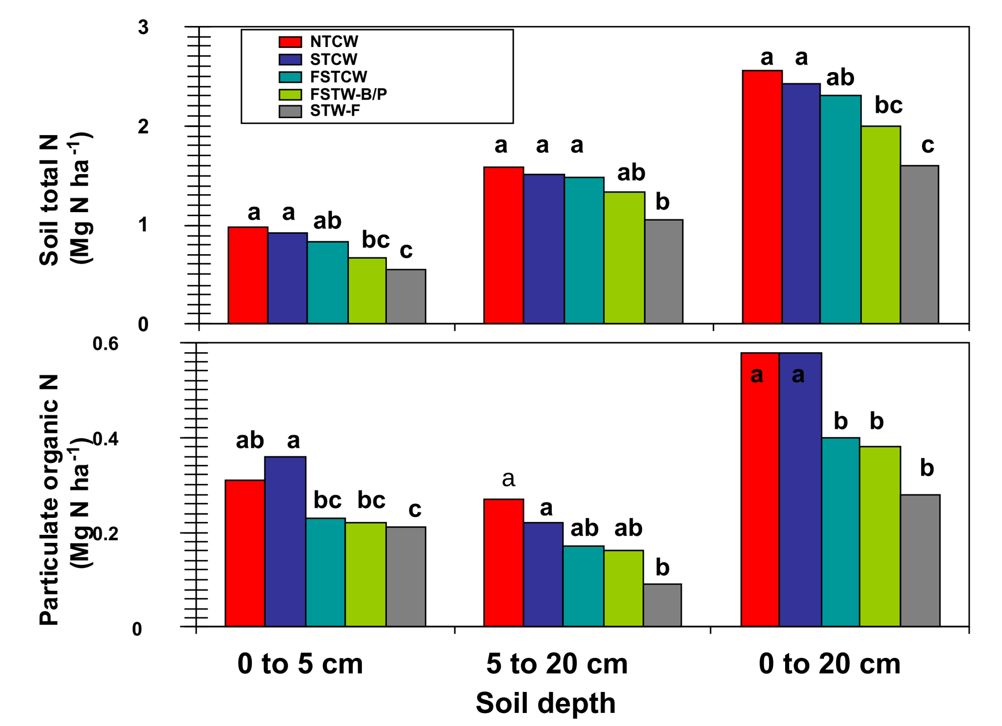

Fig 3. Effects of tillage and cropping sequences on soil total N and particular organic N contents at the 0- to 20-cm depth in 2004.

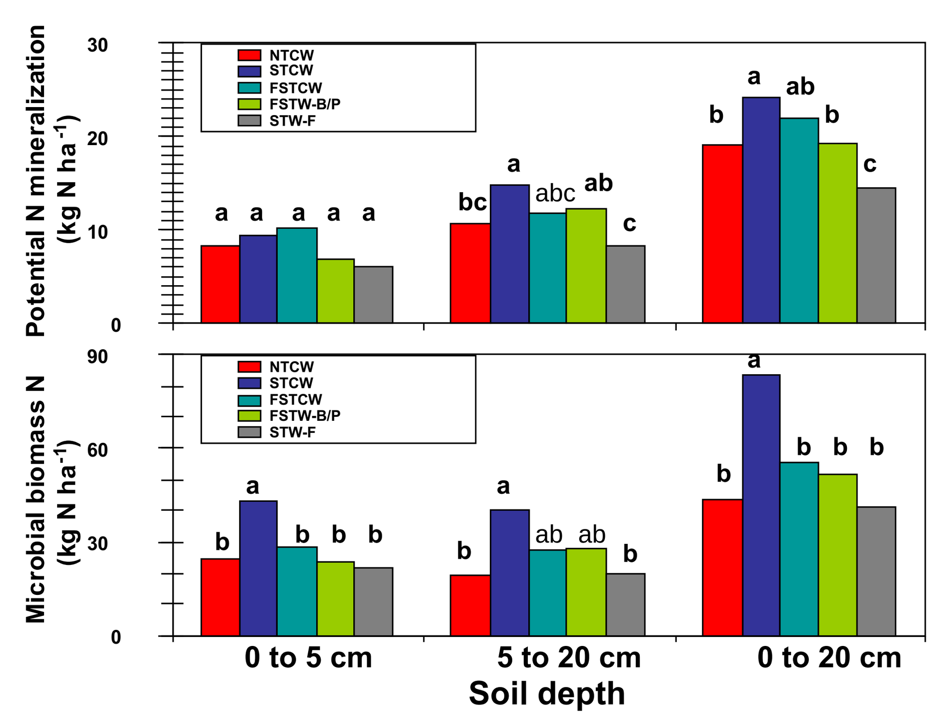

Fig. 4. Effects of tillage and cropping sequences on soil potential N mineralization and microbial biomass N contents at the 0- to 20-cm depth in 2004.

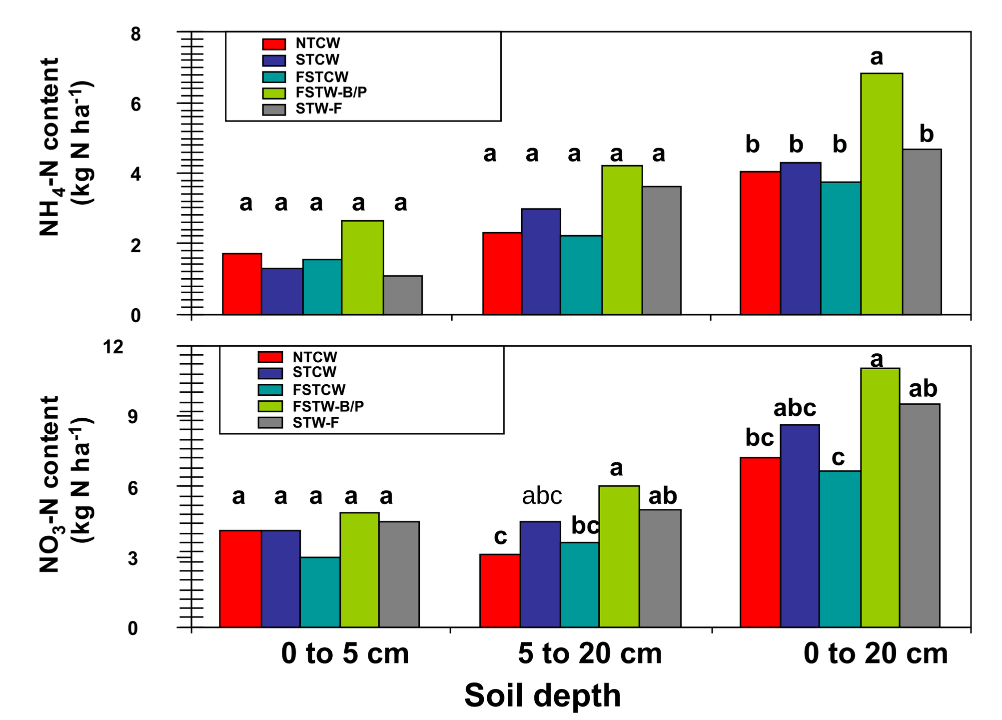

Fig. 5. Effects of tillage and cropping sequences on soil NH_4-N and NO_3-N contents at the 0- to 20-cm depth in 2004.

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Results & Discussion

Mean annualized crop biomass returned to the soil was 53 to 66% greater in NTCW, STCW, FSTCW, and FSTW-B/P than in STW-F (Fig. 2). As a result, soil surface residue amount and N content were 30 to 127% greater in other treatments than in STW-F. The STN was greater in NTCW and STCW than in FSTW-B/P and STW-F (Fig. 3). The PON was greater in NTCW and STCW than in STW-F. The PNM was not different between treatments at 0 to 5 cm but was greater in STCW than in NTCW at 5 to 20 cm (Fig. 4). The MBN was greater in STCW than in NTCW. The NH_4-N content was not different between treatments at 0 to 5 and 5 to 20 cm but was greater in FSTW-B/P than in other treatments at 0 to 20 cm (Fig. 5). Similarly, NO_3-N content was not different between treatments at 0 to 5 cm but was greater in FSTW-B/P than in NTCW and FSTCW at 5 to 20 and 0 to 20 cm.

Conclusions

- Although STW-F produced 117 to 124% more crop biomass than other treatments during the crop year, absence of crop during fallow reduced mean annualized biomass in STW-F than in other treatments. This resulted in lower soil surface residue and N content.
- Reduced tillage with continuous nonlegume cropping increased soil N storage, probably due to less soil disturbance and residue with higher C/N ratio.
- Spring tillage with continuous nonlegume cropping increased potential N mineralization and microbial biomass N compared with other treatments, likely a result of residue incorporation into the soil.
- Increased tillage frequency, followed by inclusion of legumes, such as pea, in the crop rotation increased NH_4-N and NO_3-N contents at the subsurface layer, possibly due to mineralization of pea residue with higher N content as a result of tillage.
- Long-term reduced tillage with continuous nonlegume cropping can be used to store N in the northern Great Plains compared with the conventional STW-F. With NTCW, N storage can be increased by as much as 46 kg N ha^{-1} yr^{-1}.
- Nitrogen fertilization rate can be reduced with the inclusion of legume in the crop rotation.

References

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