IRRIGATION SYSTEM EFFECTS ON SOIL CARBON AND NITROGEN UNDER SUGARBEET AND BARLEY IN NORTHERN GREAT PLAINS

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INTRODUCTION

The semiarid MonDak region at the confluence of Yellowstone and Missouri rivers in eastern Montana and western North Dakota has abundant supply of high quality water that can be used for irrigation and increase crop production. Because of increased competition of water use among municipalities, industries, and farm producers and decreased soil and water qualities due to increased erosion and chemical contamination, improved soil and water management practices are needed to use water efficiently, improve environmental quality, and sustain irrigated crop production.

Sugarbeet and malt barley are important irrigated cash crops grown in the rotation in this region. Intensive tillage used for planting, weed control, and harvest, followed by increased rate of N fertilization have reduced soil and water qualities by increasing soil erosion, organic matter mineralization, and N leaching. Studies have shown that soil organic matter mineralization increases with increased intensity of tillage (Franzluebbers et al., 1999; Sainju et al., 2005). Using reduced tillage, not only soil organic matter level can be maintained or increased (Franzluebbers et al., 1999; Sainju et al., 2005) but also crop yields can be sustained (Halvorson and Hartman, 1984; Al-Kaisi and Licht, 2004). Little is known about the use of conservation tillage, such as strip till, in sugarbeet production. Therefore, research is needed to examine if conservation tillage along with improved irrigation system can be used to maintain or increase soil organic matter, reduce soil erosion and N leaching, and sustain crop yields.

OBJECTIVE

Determine the effects of two irrigation methods [mid-elevation spray application (MESA) and low energy precision application (LEPA)] on the amount of biomass residue returned to the soil and soil organic C, total N, NH_4-N, and NO_3-N levels in conventional till sugarbeet (CTSB), strip till sugarbeet (STSB), and conventional till malt barley (CTMB).

MATERIALS AND METHODS

Two irrigation systems: MESA and LEPA. The MESA (commonly used) system consists of nozzles suspended at a height of 1.2 m above the ground and spaced at 3.0 m (Figure 1). It applies water at the rate of 24.4 L min^{-1} to or above the plant canopy, part of which could be lost due to evaporation. The LEPA system consists of nozzles suspended at a height of 0.2 to 0.5 m above the ground and spaced at 1.2 m (Figure 2). It applies water at the rate of 9.4 L min^{-1} near the ground directly to plant roots. As a result, water can be used more efficiently by plant roots using LEPA, which can increase crop yields and biomass production. Both of these systems apply equal amount of water (232 mm applied to all crops in 2004).

Location and year of experiment: Sidney, MT. 2004.

Crops: Conventional till sugarbeet (CTSB), strip till sugarbeet (STSB) (Figure 3), and conventional till malt barley (CTMB) (Figure 4).

Biomass collection: CTMB, August 2004; CTSB and STSB, October 2004.

Soil and residue sample collection: October 2004.

FIGURE 1. The mid-elevation sprinkler application (MESA) irrigation system (right) which applies water above the plant canopy.

FIGURE 2. The low energy precision application (LEPA) irrigation system which applies water near the ground directly to plant roots.

FIGURE 3. Strip-till sugarbeet (STSB) in the left and conventional till sugarbeet (CTSB) on the right.

FIGURE 4. Conventional-till malt barley (CTMB)

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CONCLUSIONS

Irrigation system did not influence crop biomass yield and C and N, residue cover, and soil C and N contents.

Biomass yield, C content, and residue cover was higher but N content was lower in conventional till malt barley than in conventional till sugarbeet and strip till sugarbeet.

Soil NH_4-N content was higher but NO_3-N content was lower in conventional till sugarbeet and strip till sugarbeet than in conventional till malt barley. Soil organic C and total N contents were similar between cropping systems.

Long-term research is needed to determine the influence of irrigation systems on biomass residue C and N returned to the soil from sugarbeet and malt barley and soil C and N contents.

RESULTS AND DISCUSSION

Crop Biomass, Carbon, and Nitrogen

Biomass yield and C and N contents in crops were not influenced by irrigation system (Table 1). Biomass yield was higher but C and N concentrations were lower in CTMB than in CTSB and STSB. As a result, C content was higher but N content was lower in CTMB than in CTSB and STSB. Because of lower N concentration, N content was also lower in STSB than in CTSB. Lower N concentration and content in STSB may have resulted from band application of N fertilizer compared with broadcast in CTSB. The C/N ratio of biomass was higher in CTMB than in CTSB and STSB. Similarly, residue cover was higher in CTMB than in CTSB and STSB, suggesting reduced soil erosion under malt barley than under sugarbeet.

Soil Carbon and Nitrogen

Irrigation method and cropping system did not influence soil organic C and total N (Table 2). It probably takes more than a year to observe significant impact of tillage and cropping system on soil organic C and total N under irrigated crops in Great Plains (Peterson et al., 1998; Halvorson et al, 2002). The NH_4-N content was higher in CTSB than in CTMB but NO_3-N content was higher in CTMB than in CTSB and STSB (Table 3). The lower NO_3-N content in CTSB and STSB than in CTMB suggests that sugarbeet requires a greater amount of N or is more efficient in N uptake than malt barley. In contrast, the higher NH_4-N content in CTSB than in CTMB suggests that N uptake by sugarbeet is greater in NO_3-N than in NH_4-N form.

Table 1. Effects of irrigation method and cropping system on biomass (stems + leaves) yields and C and N contents in sugarbeet and malt barley.

		Concentration		Content			
Treatment	Biomass Yield	C	N	C	N	C/N Ratio	Residue Cover
	Mg ha^{-1}	g kg^{-1}		kg ha^{-1}			%
Irrigation method†							
LEPA	6.45a‡	368a	18.0a	2275a	106a	20.4a	20.2a
MESA	6.40a	372a	18.3a	2314a	108a	20.3a	19.9a
Cropping system§							
CTSB	5.82b	394a	24.1a	2250b	140a	16.3b	4.8b
STSB	5.24b	396a	22.7b	2034b	120b	17.4b	5.2b
CTMB	8.20a	318b	7.6c	2599a	61c	41.8a	50.0a

† Irrigation methods are LEPA, low energy precision application; and MESA, mid-elevation sprinkler application.
‡ Numbers followed by same letter within a treatment are not significantly different by the least square means test at *P* ? 0.05.
§ Cropping systems are CTMB, conventional till malt barley; CTSB, conventional till sugarbeet; and STSB, strip till sugarbeet.

Table 2. Effects of irrigation method and cropping system on soil organic C and total N contents at the 0 to 35 cm depth.

	Soil organic C at depth (cm)			Soil total N at depth (cm)		
Treatment	0 to 5	5 to 35	0 to 35	0 to 5	5 to 35	0 to 35
	Mg ha^{-1}					
Irrigation method†						
LEPA	8.6a‡	54.3a	62.9a	0.73a	6.09a	6.82a
MESA	8.7a	55.3a	64.0a	0.73a	4.44a	5.17a
Cropping system§						
CTSB	8.6a	56.3a	64.9a	0.75a	7.05a	7.80a
STSB	8.8a	53.1a	61.9a	0.72a	4.21a	4.93a
CTMB	8.6a	55.0a	63.6a	0.72a	4.54a	5.26a

† Irrigation methods are LEPA, low energy precision application; and MESA, mid-elevation sprinkler application.
‡ Numbers followed by same letter within a treatment are not significantly different by the least square means test at *P* ? 0.05.
§ Cropping systems are CTMB, conventional till malt barley; CTSB, conventional till sugarbeet; and STSB, strip till sugarbeet.

Table 3. Effects of irrigation method and cropping system on soil NH_4-N and NO_3-N contents at the 0 to 35 cm depth.

	Soil NH_4-N at depth (cm)			Soil NO_3-N at depth (cm)		
Treatment	0 to 5	5 to 35	0 to 35	0 to 5	5 to 35	0 to 35
	kg ha^{-1}					
Irrigation method†						
LEPA	0.95a‡	7.10a	8.05a	4.92a	15.65a	20.57a
MESA	0.93a	7.05a	7.98a	4.20a	17.32a	21.52a
Cropping system§						
CTSB	0.97a	7.21a	8.18a	3.88b	13.43b	17.31b
STSB	0.92b	7.13ab	8.05ab	1.93b	12.98b	14.81b
CTMB	0.92b	6.90b	7.82b	7.88a	23.13a	31.01a

† Irrigation methods are LEPA, low energy precision application; and MESA, mid-elevation sprinkler application.
‡ Numbers followed by same letter within a treatment are not significantly different by the least square means test at *P* ? 0.05.
§ Cropping systems are CTMB, conventional till malt barley; CTSB, conventional till sugarbeet; and STSB, strip till sugarbeet.