Oakes Irrigation Research Site

Carrington Research Extension Center * North Dakota State University
P.O. Box 531, Oakes, ND 58474-0531, Phone: (701) 742-2744, FAX: (701) 742-2700,
E-mail: Blaine.Schatz@ndsu.edu
Leonard.Besemann@ndsu.edu

Optimum Corn Stover Removal for Biofuels and the Environment

L. Besemann and H. Eslinger

The 2007 U.S. energy bill calls for 36 billion gallons of ethanol to be produced by 2020. In 2007 the U.S. produced 6.5 billion gallons of ethanol. If corn grain was able to supply 15 billion gallons of ethanol, 21 billion gallons of ethanol would have to come from cellulosic material (biomass) to meet the 2020 mandate. The production of 21 billion gallons of cellulosic ethanol will require 350 million tons of dry biomass. Presently, perennial grasses and corn stover are the most available. About 194 million tons of biomass is produced in U.S. production agriculture annually, with 75 million tons coming from corn stover. Therefore corn stover is being looked at to play a major role in cellulosic ethanol production.

Before we commit ourselves to using corn stover for fuel we need to study the environmental and economic consequences of this action. What effect will stover removal have on soil organic matter, soil erosion and ultimately sustainability of the land resource?

The objective of this study is to determine what rates of stover removal within different cropping systems are conducive to maintaining and possibly improving the productive capacity of the land while providing a renewable energy source.

MATERIALS AND METHODS

Rotations: Block I: 2014 - field corn, 2013 - field corn, 2012 - field corn, 2011 - field corn, 2010 - field corn, 2009 - field corn, 2008 – field corn, 2007 - field corn.

Block II: 2014 - soybean, 2013 - field corn, 2012 - soybean, 2011 - field corn, 2010 -- soybean, 2009 - field corn, 2008 - soybean, 2007 - field corn.

Block III: 2014 - field corn, 2013 - soybean, 2012 - field corn, 2011 - soybean, 2010 - field corn, 2009 - soybean, 2008 - field corn, 2007 - onion.

Soil: Embden sandy loam, Hecla sandy loam and Maddock sandy loam.

Block I: pH = 6.1; 2.1% organic matter; soil N 24 lbs/acre; soil P and soil K were very high; soil S was very low.

Block II: pH = 6.0; 2.1% organic matter; soil N 32 lbs/acre; soil P and soil K were very high; soil S was low.

Block III: pH = 6.7; 1.1% organic matter; soil N 27 lbs/acre; soil P and soil K were very high; soil S was low.

Seedbed preparation:	Strip-till May 9 with an Orthman strip-till machine.
Hybrid:	Corn: Peterson 88A97SS RIB.
Variety:	Soybean: Peterson 14R11 RR2Y.
Planting:	Block I: Corn May 10 in 30-inch rows @ 33,000 seeds/acre.
	Block II: Soybean May 27 in 30-inch rows @ 205,000 seeds/acre.
	Block III: Corn May 10 in 30-inch rows @ 33,000 seeds/acre.
Fertilizer:	Block I: Twelve lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0 via strip-till May 9. Stream-bar 10 lbs N/acre and 23 lbs S/acre as 12-0-0-26 and 60 lbs N/acre as 28-0-0 May 22. Sidedress 135 lbs N/acre as 28-0-0 June 17.
	Block II: Twelve lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0 via strip-till May 9.
	Block III: Twelve lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0 via strip-till May 9. Stream-bar 10 lbs/N acre and 23 lbs S/acre as 12-0-0-26 and 60 lbs N/acre as 28-0-0 May 22. Sidedress 135 lbs N/acre as 28-0-0 June 17.
Irrigation:	Hand move sprinkler irrigation as needed.
Pest control:	Block I: Harness (2 pt/acre) May 22, Laudis (3 oz/acre) + AAtrex 9-O (0.5 lb ai/acre) + Destiny (0.05% v/v) + AMS (1½ lbs/acre) June 3.
	Block II: Roundup Power Max (30 oz/acre) + AMS (10 lbs/100 gal) June 7. Roundup Power Max (20 oz/acre) + AMS (1 lbs/10 gal) June 25.
	Block III: Harness (2 pt/acre) May 22; Laudis (3 oz/acre) + AAtrex 9-0 (0.5 lb ai/acre) + Destiny (0.05% v/v) + AMS (1½ lbs/acre) June 3.
Remote sensing:	Remote sensing was achieved with an Opti-Sciences CCM 200 Plus chlorophyll meter and a Holland Crop Circle ACS active canopy sensor (normalized difference red edge - NDRE).
Harvest:	Block I: Hand harvested the entire length (27 feet) of rows 6 and 7 from each plot on October 17.
	Block II: Harvested with a JD 4400 combine (48 rows 108 feet long, recorded with a weigh wagon) on October 8.
	Block III: Hand harvested the entire length (27 feet) of rows 6 and 7 from each plot on October 17.

RESULTS BLOCK I (Corn/Corn) - 2014

Corn stover was removed at the 33, 67 and 100 percent removal rates in block I (corn/corn rotation). Stover removal had no significant effect on grain yield, moisture and test weight at the 95 percent confidence level. Stover removal had no effect on chlorophyll readings (Opti-Science CCM 200), Normalized Difference Red Edge (NDRE) indice (Holland Crop Circle ACS 430) and stalk nitrate-N (Table 1) at the 95 per cent confidence level. Longer term data from 2009 to 2014 is presented in Table 2. The effect on revenue for the higher yield of the 100 percent removal rate compared to the 0 percent removal rate when the cost of N, P and K are accounted for is shown in Figure 1.

RESULTS BLOCK II (Soybean/Corn) - 2014

All soybean plots were combine harvested and bulked. The soybeans yielded 51.0 bu/acre at 11.1% moisture (51.2 bu/acre @ 13 %) and had a test weight of 58.5 lbs/bu.

RESULTS BLOCK III (Corn/Soybean) - 2014

Stover removal rates of 33, 67, and 100 had no effect on grain yield, moisture or test weight (Table 3).

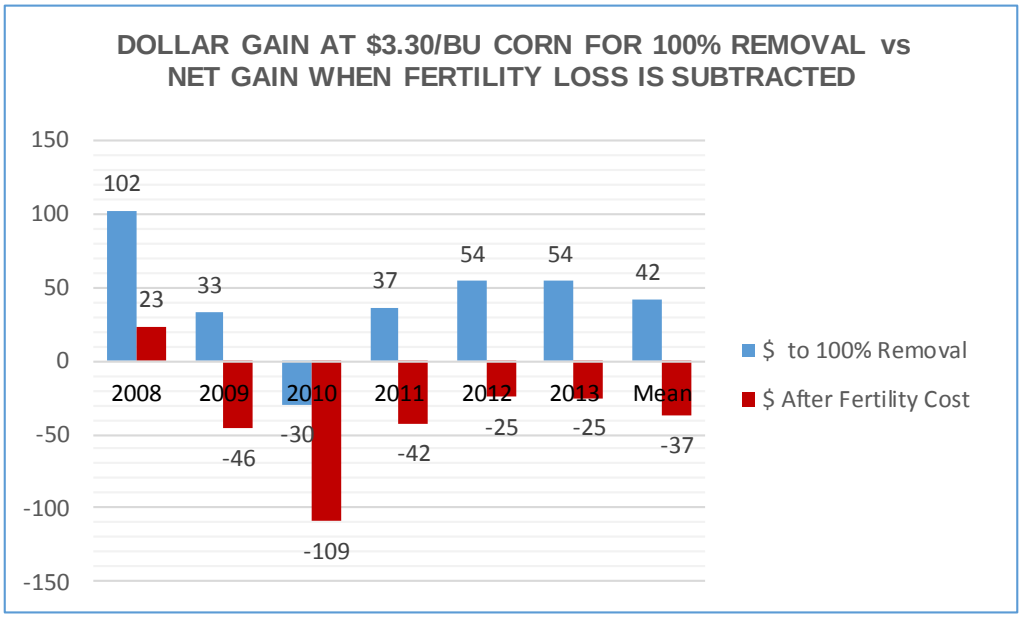

Figure 1. The net return when the fertility cost leaving the field is subtracted from the yield advantage in 100 percent removal plots compared to 0 percent removal plots for corn on corn from 2008 to 2013 (Mean) at the Oakes Irrigation Research Site.

Other corn Studies 2014

Corn hybrid performance trial – dryland
Corn hybrid performance trial - irrigated
Mosaic fertilizer-field corn
Strip-tilled corn N rate corn corn rotation
Strip-tilled corn N rate corn soybean rotation

Table 1. The affect of corn stover removal from 0 to 100% on grain yield and other agronomic parameters for corn on corn plots in 2014.

Stover Removal	Grain Yield[1]	Grain Yield 2009-14	Harvest Moisture	Test Weight	Stalk DM Removal[2]	Stalk DM Removal 2008-13	Chlorophyll Meter Reading[3]	NDRE[4]	Population	Stalk Nitrate-N	Fall soil Nitrate-N
%	bu/ac	bu/ac	%	lb/bu	------ ton/ac ------		4-Aug	4-Aug	plants/ac	ppm	lbs/ac
0	191.9	216.1	16.5	51.9	0.0	0.0	51.5	0.3346	32831	1606	18
33	208.0	221.7	15.7	52.0	2.1	2.3	51.8	0.3462	34364	1896	36
67	204.3	223.3	16.2	52.2	2.8	3.5	53.2	0.3476	34284	1850	26
100	208.3	223.8	15.9	52.4	4.4	5.3	53.1	0.3461	33558	1603	57
Mean	203.1		16.1	52.1	2.3		52.4	0.3436	33759	1738	34
C.V. (%)	4.2		5.0	2.7	6.1		2.7	1.8	3.6	15.4	48.6
LSD 0.10	11.1		NS	NS	0.18		NS	0.0078	NS	NS	22
LSD 0.05	NS		NS	NS	0.23		NS	NS	NS	NS	27

Table 1. The affect of corn stover removal from 0 to 100% on grain yield and other agronomic parameters for corn on corn plots in 2014. (continued)

Stover Removal	Seed			Emerge Date	Silk Date	Mature Date	Nutrients in stover[2]			Nutrient Value	
	Oil	Protein	Starch				N	P	K	2014[2]	2008-2014
%	----------%----------						------ lb/acre ------			---------- $/ac ----------	
0	1.8	9.4	74.2	26-May	26-Jul	25-Sep	0	0	0	0	0
33	1.7	9.1	74.5	25-May	24-Jul	24-Sep	26	2	29	24	38
67	1.8	9.1	74.4	25-May	24-Jul	24-Sep	42	2	43	37	55
100	1.7	9.2	74.6	25-May	23-Jul	24-Sep	60	3	86	62	79
Mean	1.8	9.2	74.4	25-May	24-Jul	24-Sep	32	2	40	31	
C.V. (%)	19.7	2.9	0.7	0	0	0	13.8	26.9	28.0	19.0	
LSD 0.10	NS	NS	NS	0.65	1.5	NS	6	0.6	14	7.6	
LSD 0.05	NS	NS	NS	0.80	1.9	NS	7	0.8	18	9.4	

Planting Date = May 10; Harvest Date = October 17; Previous Crop = Corn.

Fertilizer Rate lbs/acre = 242 N, 40 P_2O_5, 23 S; Irrigation = 8.0 inches.

[1] Yield adjusted to 15.5% moisture.

[2] Corn stover removed spring of 2014 from 2013 corn crop.

[3] Opti-Science CCM 200.

[4] Holland Crop Circle ACS active canopy sensor (normalized difference red edge) - NDRE.

Table 2. Corn on Corn Stover Removal - NDSU Oakes Irrigation Research Site 2009-2014.

Stover Removal	Grain Yield	Harvest Moisture	Test Weight	Chloroph Reading	Reading NDRE	Stalk Nitrate-N	Grain Protein	Silk Date	Mature Date
%	bu/ac	%	lb/bu			ppm	%		
0	216.1	21.7	54.0	54.0	0.3605	2434	8.6	7/24	9/29
33	221.7	20.9	54.6	55.1	0.3624	2931	8.5	7/23	9/28
67	223.3	20.9	54.6	56.1	0.3636	2920	8.5	7/22	9/27
100	223.8	20.3	54.9	56.1	0.3594	3143	8.6	7/21	9/27
Mean	221.2								

Table 3. The affect of corn stover removal from 0 to 100% on grain yield and other agronomic parameters for corn on soybean plots in 2014.

Previous Year Stover Removal	Grain Yield[1]	Grain Yield 2009-14	Harvest Moisture	Test Wt.	Chlorophyll[2]	NDRE[3]	Nitrate-N		Population	Seed			Emerge Date	Silk Date	Mature Date
							Stalk test	Fall Soil		Oil	Protein	Starch			
%	bu/ac		%	lb/bu	4-Aug	4-Aug	ppm	lbs/ac	plants/ac	--------%----------					
0	220.5	227.2	15.7	53.2	52.7	0.3535	1800	42	32670	2.2	9.3	73.7	25-May	23-Jul	24-Sep
33	221.3	222.4	15.6	53.4	52.1	0.3532	1428	73	33315	2.0	9.2	74.1	25-May	22-Jul	24-Sep
67	205.4	222.2	15.1	53.1	48.8	0.3481	1156	29	33073	2.1	9.2	73.9	25-May	22-Jul	24-Sep
100	222.4	225.7	15.4	53.5	54.3	0.3536	1628	89	33719	1.9	9.3	74.2	25-May	22-Jul	24-Sep
Mean	217.4		15.5	53.3	51.9	0.4	1503	58	33194	2.1	9.2	74.0	25-May	22-Jul	24-Sep
C.V. (%)	5.2		5.3	1.2	5.9	1.8	45.5	56.6	2.5	11.0	2.7	0.6	0	0	0
LSD 0.10	NS		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD 0.05	NS		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Planting Date = May 10; Harvest Date = October 17 ; Previous Crop = Soybean.

Fertilizer Rate lbs/acre = 242 N, 40 P_2O_5, 23 S; Irrigation = 8.0 inches.

[1]Yield adjusted to 15.5% moisture.

[2]Opti-Science CCM 200.

[3]Holland Crop Circle ACS active canopy sensor (normalized difference red edge) - NDRE.