The Effect of Energy Beets in a Crop Rotation

Mike Ostlie, Jasper Teboh, Szilvia Yuja, and Ezra Aberle

Energy beets are a potential new crop for central North Dakota. Energy beets are a type of sugar beet that have been bred for use in ethanol production. Past data has indicated that dryland energy beet yields in central North Dakota can be significant. Theory suggests that energy beets would be a good fit in rotations due to its deep taproot which can mine subsurface water and nutrients, and it is a crop that is more salt tolerant than most current North Dakota crops. There are no energy beet processing facilities in North Dakota as of this writing.

A crop rotation study was established in 2014 to evaluate how energy beets would affect cropping systems in central North Dakota. The study was conducted through 2017 and consisted of four crop rotations as follows:

1) Wheat ➡ Energy Beet ➡ Corn ➡ Soybeans
2) Wheat ➡ Soybean ➡ Corn ➡ Soybeans
3) Wheat ➡ Energy Beet ➡ Corn
4) Continuous Energy Beets

Each crop in the rotation was present each year (12 treatments), and replicated four times. Each plot was divided into a conventional till and no-till portion. The effect of previous crop was analyzed for the 2015-2017 growing seasons. Tables were assembled for each crop in the study to view the effect of the crop sequence from each crop's perspective.

Energy beets

Energy beets were not affected by crop rotation from a yield or quality perspective (Table 1). Energy beets were preceded by either wheat or energy beets (no rotation). It was expected that energy beet production would drop without rotating to a different crop. Due to the lack of energy beet production proximate to Carrington, few leaf and root diseases were observed during the course of the study. Cercospora leaf spot was detected with very low incidence in plots with continuous beets. The lack of pathogen pressure is likely a key reason that there was no drop in energy beet performance in the absence of rotation. Continuous beets would not be a recommended practice for long-term sustainability.

Table 1. The effect of crop rotation on the yield and quality of energy beets.									
Rotation[b]	Previous Crop	Beet Weight	Yield	Sugar[a]	Crude Protein	Phosphorous	Potassium	Dry Matter	Nitrogen[a]
		lb/beet	ton/ac	%	%	%	%	%	%
1	Wheat	1.46	19.83	15.75	3.75	0.093	0.69	28.67	0.323
2	Wheat	1.45	20.57	16.71	4.07	0.092	0.67	30.45	0.383
3	Beet	1.48	20.62	17.28	4.11	0.081	0.63	29.88	0.381
Mean		1.46	20.34	16.58	3.98	0.089	0.663	29.667	0.362
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)		35.3	32.1	24.6	30.3	42.8	30.3	29.4	25.5

[a] calculated on current moisture, all other nutrients calculated on a dry matter basis

[b] rotations consist of 1) wheat->beet->corn->soybean, 2) wheat->beet->corn, and 3) beet->beet->beet

Energy beet performance was affected by tillage practice. Conventionally-tilled plots performed better than no-till plots for the duration of the study (Table 2). A big reason for this was due to established stand. There were generally less plants/ac in the no-till plots compared to the tilled. This is likely due to a poor seed bed from harvest activity disturbance and harder soils associated with the first years of no-till production. As a result of fewer plants/ac, the average size of the beet was larger in the no-till plots. The conventionally-tilled plots had higher protein (and nitrogen) content, while the no-till plots had greater phosphorus concentration.

Table 2. The effect of tillage practice on the yield and quality of energy beets.									
Treatment	Tillage	Beet Weight	Yield	Sugar[a]	Crude Protein	Phosphorous	Potassium	Dry Matter	Nitrogen[a]
		lb/beet	ton/ac	%	%	%	%	%	%
1	No-till	1.74	16.97	15.47	2.74	0.108	0.70	33.04	0.278
2	Conv. Till	1.19	23.71	16.95	4.72	0.082	0.58	28.54	0.457
	Mean	1.47	20.34	16.21	3.73	0.10	0.64	30.79	0.37
	LSD (0.05)	0.3	3.1	NS	0.81	0.026	NS	NS	0.062
	C.V. (%)	35.3	32.1	24.6	30.3	42.8	30.3	29.4	25.5

Corn

Corn quality was affected by crop rotation. Corn harvest moisture was higher in rotations that contained energy beets as the previous crop (Table 3). Corn protein was also higher in rotations that contained energy beets. It should be noted that when energy beets preceded corn, there were severe phosphorous deficiency symptoms on the corn leaves in 2015 and 2016. This was indicated by moderate to high levels of purple leaves prior to the V5 growth stage. These deficiency symptoms did not carry over to affect yields. It is known that sugar beets do not host mycorrhizae, which assist with phosphorous uptake. Fewer mycorrhizae in the soil is a likely reason there would be early-season phosphorous deficiency symptoms in the corn.

Table 3. The effect of crop rotation on the yield and quality of corn.

Rotation[a]	Previous Crop	Moisture	Test Weight	Yield	Starch	Protein
		%	lb/bu	bu/ac	%	%
1	Beet	16.45	56.07	156.2	71.43	8.84
2	Soybean	15.54	56.33	159.2	71.57	8.58
3	Beet	16.05	56.28	165.7	71.50	8.91
Mean		16.01	56.23	160.4	71.50	8.78
LSD (0.05)		0.43	NS	NS	NS	0.28
C.V. (%)		4.7	1.3	15.1	0.9	5.5

[a] rotations consist of 1) wheat->beet->corn->soybean, 2) wheat->soybean->corn->soybean, and 3) wheat->beet->corn

Corn following energy beets (left) and corn following soybean (right).

Tillage practice affected corn yield and moisture (Table 4). Harvest moisture was higher in the conventional-till plots, but this could be related to the higher yields in those plots as well. Corn quality was not affected by tillage. With a longer duration of study (5 or more years), it would be expected that the no-till plots will perform more similarly to conventional-till plots.

Table 4. The effect of tillage practice on the yield and quality of corn.						
Treatment	Tillage	Moisture	Test Weight	Yield	Starch	Protein
		%	lb/bu	bu/ac	%	%
1	No-till	15.77	56.29	152.1	71.57	8.68
2	Conv. Till	16.26	56.15	168.6	71.43	8.87
	Mean	16.02	56.22	160.4	71.50	8.78
	LSD (0.05)	0.35	NS	11.4	NS	NS
	C.V. (%)	4.7	1.3	15.1	0.9	5.5

Soybean

Soybean yield was affected by crop rotation. Soybeans benefited from energy beets in the rotation (Table 5). The four-year crop rotation with energy beets yielded better than the four-year rotation where a second soybean year substituted energy beets. Soybean production in the three-year rotation with energy beets trended higher than the no-beet rotation, but was statistically similar.

Table 5. The effect of crop rotation on the yield and quality of soybeans.						
Rotation[a]	Previous crop	Moisture	Test Weight	Yield	Protein	Oil
		%	lb/bu	bu/ac	%	%
1	Corn	12.67	59.19	66.1	35.21	16.74
2	Corn	12.68	58.94	57.9	35.07	16.65
3	Wheat	12.69	59.04	62.0	34.92	16.82
Mean		12.68	59.06	62.0	35.07	16.74
LSD (0.05)		NS	NS	5.2	NS	NS
C.V. (%)		10.3	2.6	14.5	1.7	2.2

[a] rotations consist of 1) wheat->beet->corn->soybean, 2) wheat->soybean->corn->soybean, and 3) wheat->beet->corn

Soybeans were affected by tillage practice (Table 6). No-till soybeans had higher harvest moisture, and lower yields. No-till soybeans also had higher grain protein content but lower oil content. Similar to corn, it is expected that a longer study duration would result in fewer differences between the tillage systems.

Table 6. The effect of tillage practice on the yield and quality of soybeans.

Treatment	Tillage	Moisture	Test Weight	Yield	Protein	Oil
		%	lb/bu	c	%	%
1	No-till	13.08	59.12	59.0	35.24	16.56
2	Conv. Till	12.29	59.00	65.1	34.89	16.91
	Mean	12.69	59.06	62.0	35.07	16.74
	LSD (0.05)	0.62	NS	4.2	0.34	0.22
	C.V. (%)	10.3	2.6	14.5	1.7	2.2

Wheat

Wheat was not affected by tillage practice, but was affected by crop rotation. Wheat performed better following soybeans than following corn (Table 7). Wheat would not typically be recommended following corn, but it is a better agronomic sequence to prepare for energy beets in a three-year rotation. Wheat moisture was higher and test weight was lower following corn. Grain protein, surprisingly, was not affected by previous crop. Having beets in the rotation did not influence wheat production (comparing treatments 1 and 2).

Table 7. The effect of crop rotation on the yield and quality of wheat.

Rotation[a]	Previous Crop	Moisture	Test Weight	Yield	Protein
		%	lb/bu	bu/ac	%
1	Soybean	16.15	58.74	59.5	14.26
2	Soybean	15.08	59.52	60.3	14.51
3	Corn	17.42	57.14	54.4	14.69
Mean		16.22	58.47	58.1	14.49
LSD (0.05)		1.36	1.18	3.9	NS
C.V. (%)		14.6	3.5	11.8	6.7

[a] rotations consist of 1) wheat->beet->corn->soybean, 2) wheat->soybean->corn->soybean, and 3) wheat->beet->corn

Summary

Energy beets were not affected by the different rotations used in this study. Meanwhile, soybean yields were higher in a four-year rotation with energy beets, and corn and wheat yields were unaffected by a rotation with energy beets. Further data are being collected and analyzed to quantify water use differences by the different rotations as well as model development for energy beet growth and development in central North Dakota.

Partial funding for this project was provided by the USDA National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.