Ag Decision Maker

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Energy and Economic Returns by Crop Rotation*

With rising energy costs, input costs and variable grain prices, adjusting crop rotations could be profitable for some farm operations. Using research from the ISU Extension and Outreach Marsden Research Farm, the rotational effects on energy usage and economic returns were compared by two, three and four-year rotations. The two-year rotation included GMO corn and soybeans (C-Sb); the three and four-year rotations included non-GMO corn, soybeans and oats, and added a fourth year alfalfa crop in the four-year rotation. (C-Sb-O and C-SB-O/A-A). The energy analysis focuses on uses of energy that have a price associated with them. To successfully compare across rotations, a line was drawn to keep energy use contained to producing the crop. It does not take into account solar energy or energy consumption outside the "farm gate." Storage, hauling and handling past initial removal of the crop are not considered. These have an impact on overall energy usage and economic returns but can vary widely and would not make equal comparisons across the three rotations.

This study looks at the period from 2006-2011. A previous study by Cruse, Liebman, Raman and Wiedenhoeft takes a similar approach for 2003-2008. One major change was a switch from triticale to oats for the small-grain rotation. Figure 1 shows average yields for corn and soybeans for the three rotations. Yield gains were present for the three and four-year rotations that can be associated with the agronomic benefits of crop rotations and management practices used.

Energy Study

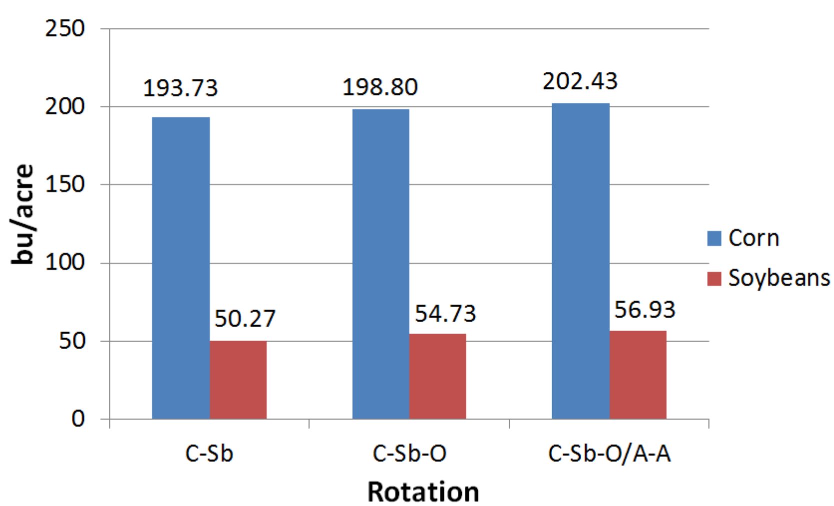
Energy use was split into five categories. Within each category, the BTU/units were applied to the actual inputs and field operations from the research farm field notes. The five categories included: seed, grain drying, field operations, pesticides and fertilizer.

There is limited information on the energy production of seeds for clover, oats and alfalfa. Previous research (Shapouri, Cruse) uses one factor for corn seed production and another for all other seeds. A similar method was used in this study as well. Factors used were 6,320 BTU/lb for corn and 1,333 BTU/lb for other seeds.

Field operations were categorized into preharvest and harvest operations, including hauling grain.

This study looks at the energy usage for grain drying in a category of its own to show the high energy requirements that drying can capture. The average reduction in moisture was 3.9 percent across the span of the study. This was multiplied by the factor of 1,620 BTU/point/bushel dried, giving a total of 6,320 BTU per bushel. This was then applied to the average yield for each rotation.

Figure 1. Average Yields by Crop and Rotation, 2006-2011



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Fuel usage for every field operation came from the publication, "Fuel Required by Field Operation," (www.extension.iastate.edu/agdm/crops/pdf/a3-27.pdf). For operations not specifically listed, the closest equivalent was used as a substitute. The energy values and sources are listed in Table 1.

Fertilizer applied was averaged across all years to give a long-term picture of energy use. Application, based on need, varied year to year. Amounts used were taken from the provided field notes. Though minor, nitrogen as an adjuvant was included in the fertilizer category.

The energy usage of herbicide and insecticide applications were based on active ingredients in the amounts applied. On the three and four-year rotations, application was done by banding, thus reducing the overall rates.

Table 1. Energy Values Used

Input	Energy Value	Units	Source
Seed – Corn	6,320	BTU/lb	Grabowski
All other seed	1,333	BTU/lb	Sheehan
N	24,500	BTU/lb	Shapouri et al. (2004)
P	4,000	BTU/lb	Shapouri et al. (2004)
K	3,000	BTU/lb	Shapouri et al. (2004)
Herbicides	101,034	BTU/lb	Bhat et al.
Insecticides	113,932	BTU/lb	Bhat et al.
Grain Drying	6,320	BTU/bu	Grabowski
Diesel	138,690	BTU/gallon	EIA

Results

The rotational results were similar to previous studies (Cruse, et. al), though at a slightly lower rate. This can be attributed to several adjustments done in the later years of the study, including reduced fertilizer application and improved pesticide efficiencies, both in the product and method of application. Another change was the switch to oats from triticale.

Figure 2 shows average energy inputs over the six-year period, with the two-year rotation clearly demanding the most energy. From 2006-2011, the three-year rotation showed the least amount of energy usage based on the parameters of the study. Figure 3 illustrates in more detail where energy is expended. The highest category for energy usage was fertilizer for the two-year rotation, whereas the three and four-year rotations show the most energy usage in field operations. Table 2 illustrates the details of percent of energy usage by category as indicated in Figures 2 and 3. In the two-year rotation, just over 60 percent of energy expenditures came from fertilizer. In the three and four-year rotations, the leading category of field operations carried 44 and 47 percent, respectively, of the energy demands.

Figure 2. Average Energy Inputs by Rotation, 2006-2011

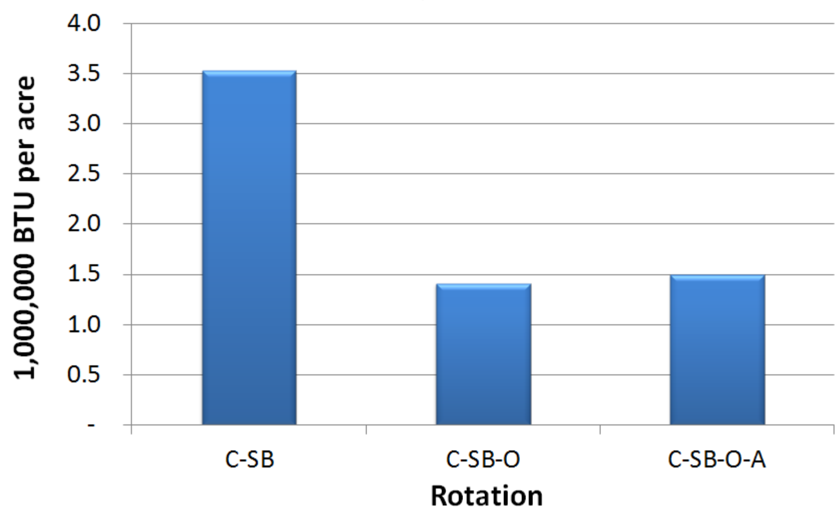
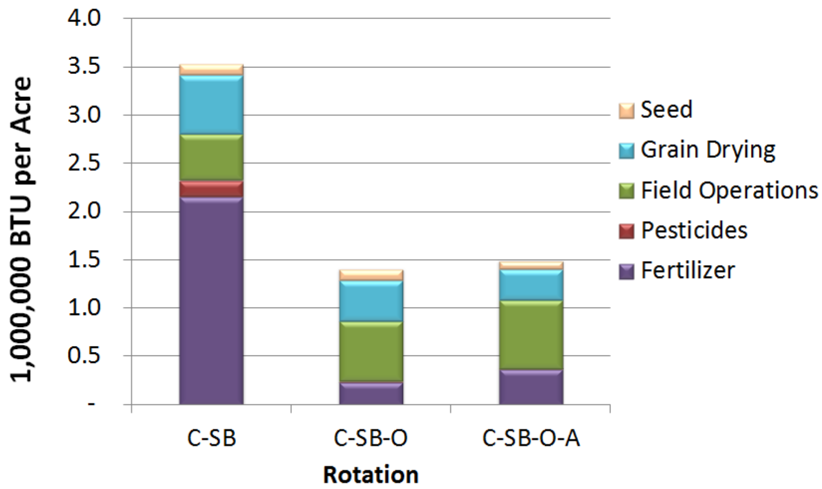


Figure 3. Distribution of Energy Inputs by Selected Energy Categories, 2006-2011



Energy use was looked at by crop as well as by rotation. In Figure 4, the two-year corn crop leads as the most energy demanding, much higher than any other crop. The two-year corn crop utilized more than twice the energy of any other crop at 5.83 million BTU, primarily due to increased herbicide and fertilizer usage. Table 3 shows the three and four-year corn rotations come fairly close to one another at 2.45 and 2.63 million BTU each. The reason for the difference in those rotations can mostly be attributed to the drying costs associated with the slightly higher corn yields in the four-year rotation.

Table 2. Percent of Energy Use by Category

	GMO	Non-GMO	
	C-SB	C-SB-O	C-SB-O-A
Seed	3%	8%	6%
Grain Drying	17%	30%	21%
Field Operations	14%	44%	47%
Pesticides	5%	1%	1%
Fertilizer	61%	17%	25%

Table 3. Total BTU by Crop

	2yr	3yr	4yr
Corn	5.83	2.45	2.63
Soybeans	1.23	1.00	1.13
Oats		0.77	1.09
Alfalfa (2nd yr)			1.14
Total Average BTU by Rotation	3.53	1.41	1.50

Figure 4. Energy Input per Crop for Individual Rotations

2006-2011 average for each rotation

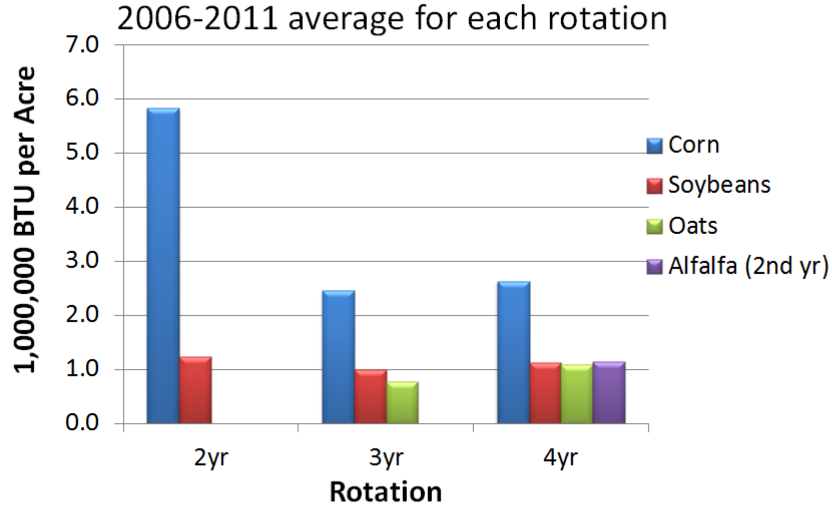
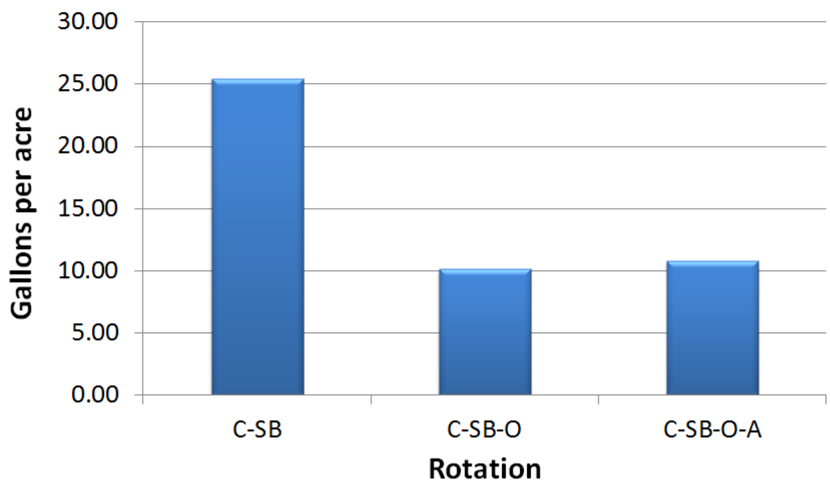


Figure 5. Energy Usage by Rotation in Diesel Fuel Equivalents, 2006-2011



Another way to look at energy usage is in diesel fuel equivalents. This is shown in Figure 5. Diesel fuel equivalents were found by taking the total BTU/rotation divided by the BTU/gallon of diesel fuel. This represents the energy consumption in an easily recognizable form, even though not all energy usage was associated with diesel fuel. The two-year rotation uses the equivalent of 25.43 gallons of diesel fuel per acre. The three and four-year rotations are both just over 10 gallons per acre.

Economic Returns

Along with energy usage, this study also compares economic returns for the three rotations. Using data from the annual publication for estimated costs of crop production for that year, the costs for production were applied to the various cost components (Duffy, et. al). Herbicide and Insecticide prices were taken from annual reports from North Dakota State University and the University of Nebraska. Annual grain prices came from the USDA National Ag Statistics Services, Iowa office. No government payments or other income were included in the study. With differences in field operations, fertilizer, and reduced pesticides, the three and four year rotations have the ability to compete with the two-year rotation in profitability as well as energy requirements.

Energy Usage by Rotation in Diesel Fuel Equivalents

	2yr	3yr	4yr
Diesel Fuel Equivalents (gal/acre)	25.43	10.16	10.80

Figure 6 shows the average return to management by crop and rotation. Figure 7 shows the average returns for the three rotations to land, labor and management, land and management, and management. The first of these categories shows the returns if the costs for land, labor and management are not included. The second takes into account the cost for labor, and the last includes all costs; what remains are the returns to management. Rotational effects of increased yields and lower input costs for the non-GMO crops make the three-year rotation result in the highest returns for this study. Table 4 gives a detailed summary of the cost and returns by crop and rotation and shows the three-year rotation having an average Return to Management of $194.03; the two-year and four-year rotations have positive returns of $187.92 and $170.97, respectively.

Figure 6. Average Return to Management by Crop and Rotation, 2006-2011

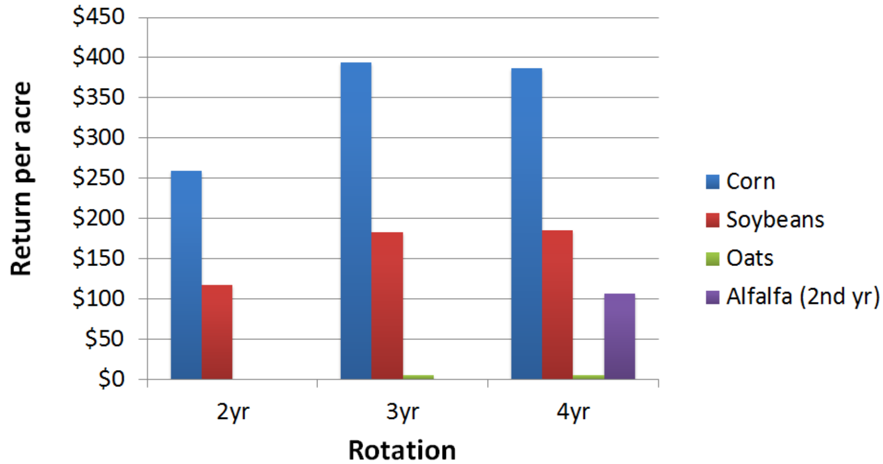


Figure 7. Average Returns to Land, Labor, and Management by Crop Rotation
2006-2011

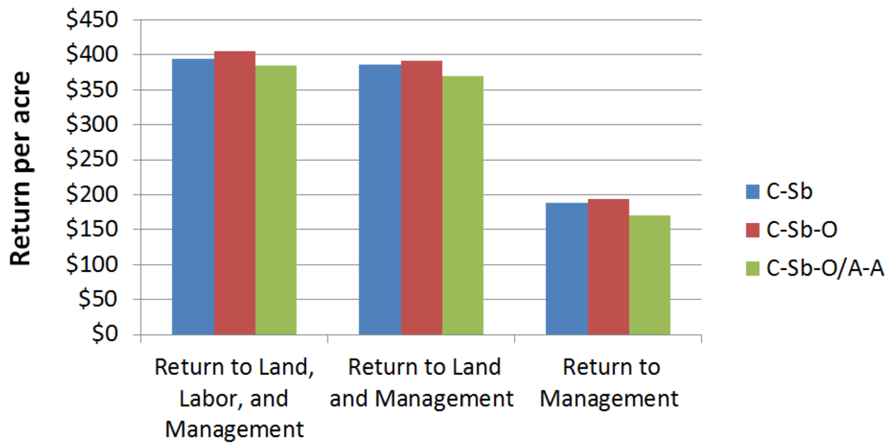


Table 4. Revenue and Returns by Crop and Rotation

	Yields	Prices	Gross Revenue	Production Cost	Return LL&M	Return L&M	Return Mgmt
C-Sb							
Corn	193.73	$4.35	$841.60	$377.27	$464.33	$457.25	$259.09
Soybeans	50.27	9.95	503.82	180.76	323.06	314.92	116.75
					$393.70	$386.08	$187.92
C-Sb-O							
Corn	198.80	$4.35	$865.19	$255.22	$609.97	$592.73	$394.57
Soybeans	54.73	9.95	549.31	158.01	392.00	380.72	182.56
Oats	97.92	2.69	256.35	129.54	212.04	203.13	4.97
Oat Straw	1.07	79.17	85.23				
					$404.67	$392.20	$194.03
C-Sb-O/A-A							
Corn	202.43	$4.35	$878.09	$275.72	$602.37	$584.75	$386.59
Soybeans	56.93	9.95	571.12	175.97	395.15	383.91	185.74
Oats	101.58	2.69	267.15	215.37	218.05	203.72	5.55
Oat Straw	1.00	79.17	79.74				
Alfalfa (1st yr)	0.74	119.47	86.52				
Alfalfa (2nd yr)	3.97	119.47	470.21	145.08	325.13	304.16	106.00
					$385.17	$369.14	$170.97

Nutrient Pricing

A portion of the cost savings in the three and four-year rotations was due to applying manure from an available livestock operation to all corn acres in the rotation. In the initial study, the only cost associated with the manure is the cost to apply. Another way to phrase this is that manure was viewed as a "waste product" that needs to be disposed of in a feasible manner.

Another second method was also applied to see how it would affect the profitability of the rotations. This involved valuing the manure based on its nutrient value. The concept behind this method was to show the cost that would have occurred had an equivalent amount of fertilizer been purchased commercially.

Manure was analyzed each year for nutrient content and these rates were used along with the cost that would have been assessed had those nutrients been purchased. Nutrient prices used were from the ISU publication for Estimated Costs of Crop Production. A third option in comparing the rotations might be to put a flat rate per ton or load on the manure rather than breaking the cost down for each nutrient. The energy usage of the animals in producing the manure is not considered. This could also be taken into consideration as far as number of animals, manure nutrient content, etc.

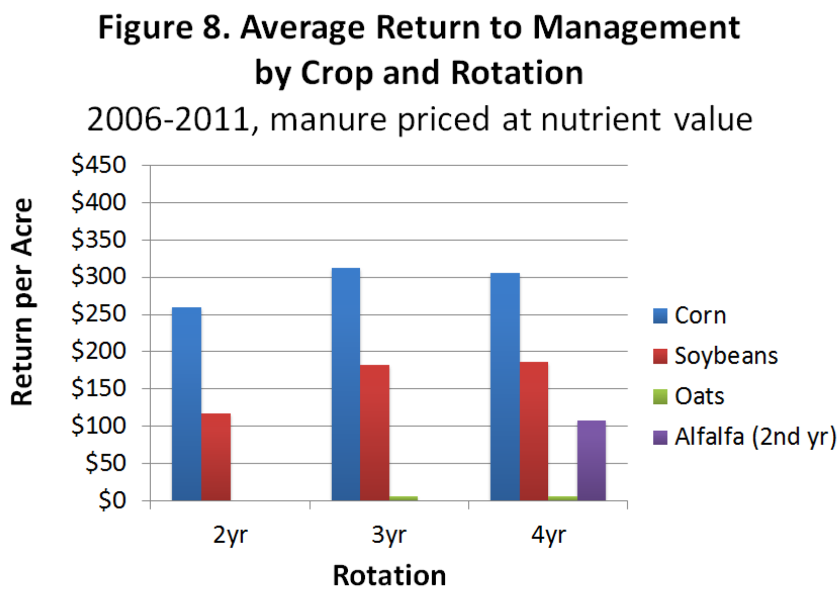
Figures 8 and 9 show the returns to land, labor and management by crop and rotation. Table 5 gives the economic data with manure priced at its nutrient value. Applying this process shows the benefits of having manure readily available and that it is a major factor in the profitability of the non-GMO rotations in this study.

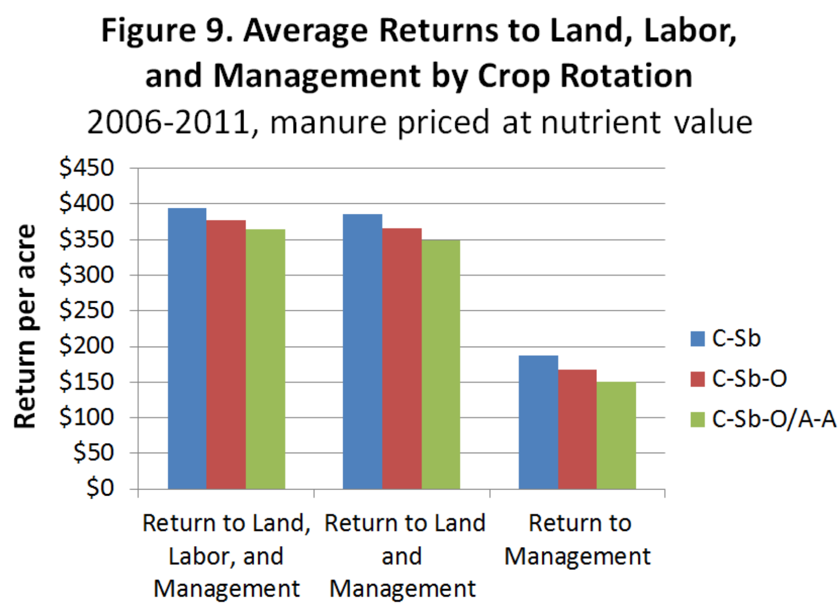
Summary

This publication has focused on the energy use and economic returns of three different crop rotations. The choice of which rotation to choose is dependent on many factors. When considering profitability and energy consumption, including a third or fourth crop may be a viable option for some operations. Other benefits might include an outlet for excess manure, reduced erosion, increased soil health and pest management.

Table 5. Revenue and Returns by Crop and Rotation, with manure priced by nutrient value

	Yields	Prices	Gross Revenue	Production Cost	Return LL&M	Return L&M	Return Mgmt
C-Sb							
Corn	193.73	4.35	$841.60	377.27	464.33	$457.34	$259.18
Soybeans	50.27	9.95	$503.82	180.76	323.06	$314.92	$116.75
					393.70	386.13	187.96
C-Sb-O							
Corn	198.80	4.35	$865.19	336.72	528.47	$511.24	$313.07
Soybeans	54.73	9.95	$549.31	157.32	392.00	$380.72	$182.56
Oats	97.92	2.69	$256.35	128.56	213.01	$204.42	$6.26
Oat Straw	1.07	79.17	$85.23				
					377.83	365.46	167.29
C-Sb-O/A-A							
Corn	202.43	4.35	$878.09	357.22	520.87	$503.26	$305.09
Soybeans	56.93	9.95	$571.12	175.97	395.15	$383.91	$185.74
Oats	101.58	2.69	$267.15	215.12	218.30	$203.97	$5.80
Oat Straw	1.00	79.17	$79.74				
Alfalfa (1st yr)	0.74	119.47	$86.52				
Alfalfa (2nd yr)	3.97	119.47	$470.21	144.11	326.10	305.22	107.06
					365.11	349.09	150.92





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