Crop Rotation

Crop rotation means changing the crop planted in a field from year to year. In the U.S. Midwest, it is common for grain growers to practice a two-year crop rotation by alternating between corn and soybeans in a given field each year.

2-year, 3-year, and 4-year crop rotations

Research at Iowa State University's Marsden Research Farm compared two-, three-, and four-year rotations: corn/soybeans (CS); corn/soybeans/oats (CSO); and corn/soybeans/oats+alfalfa/alfalfa (CSOA).

Fossil fuel use in diesel fuel equivalents:

- Two-year CS: 25 gallons/acre
- Three-year CSO: 10 gallons/acre
- Four-year CSO: 11 gallons/acre

Corn yield comparison:

- Two-year CS: 194 bushels/acre
- Three-year CSO: 199 bushels/acre
- Four-year CSOA: 202 bushels/acre

Soybean yield comparison:

- Two-year CS: 50 bushels/acre
- Three-year CSO: 55 bushels/acre
- Four-year CSOA: 57 bushels/acre

Profitability, as % of two-year CS net return to management:

- Two-year CS: 100%
- Three-year CSO: 103%
- Four-year CSOA: 91%

Reference:

Energy and Economic Returns by Crop Rotation. September 2012. Ann M. Johanns, Craig Chase, and Matt Liebmann. Iowa State University Extension. www.extension.iastate.edu/agdm/crops/html/a1-90.html (accessed 8/12/13).

In order to gain maximum benefits from crop rotation, you need a rotation sequence that is longer than two years. Multi-year rotations break up weed cycles as well as insect life cycles and certain disease cycles, reducing the damage these cause to crops. Including legumes in the rotation can create the conditions that lead to improved soil structure and fertility, which over the long term leads to increased crop yields with fewer purchased inputs. Having a more diverse array of crops growing spreads out financial risk because a single crop failure will not be so disastrous (1). These benefits are seen by organic farmers who are required to use multi-year crop rotations, but the same benefits also happen on non-organic farms that use long crop rotations.

In spite of the fact that longer rotations can be as productive or even more productive per acre than two-year rotations, the vast majority of agricultural acres in the Midwest are in a two-year rotation. Part of the reason is that in two-year rotations, fossil fuel inputs substitute for the higher labor inputs required for the three-

and four-year rotations (2). Lots of farmers choose the two-year rotation and accept the relatively small reduction in per-acre profitability in order to operate many more acres with less labor.

How can a landowner make it possible for the future land owners or operators to use a three- or four-year crop rotation? Beyond the higher labor requirement, there are costs in the form of background management and machinery ownership to deal with a complex multi-crop system *(see Complexity Costs text box)*. Retiring farmers or landowners could consider giving the future farm operator a credit for all or part of the higher management costs he or she will have from using a long rotation. The choice to include a longer rotation partly comes down to the determination of the landowner and farm operator. Long rotations that reduce fertilizer and pesticide expenses are an easier decision to make in years when grain prices are low. It takes a stronger commitment to stick to it in years when grain prices are high, when it's really tempting to let go of the long rotation in favor of a large profit from planting all acres to corn *(see Corn & Soybean Profitability text box)*.

If the future operator will not own the land, you should consider a long-term lease arrangement to ensure that the farm operator can maintain a three- to four-year crop rotation system. You can specify multi-year rotations in the terms of

Complexity Costs

Calculations of costs of operating an organic farming system show an estimated $117/acre higher cost for background management + dealing with system complexity + machinery ownership + other factors, as compared to a conventional corn and soybean system *(see Organic Costs text box in the Organic Certification section)*. We'll call this total cost the "complexity" cost.

Some of that complexity cost has to do with management time and labor spent in dealing with organic certification requirements, but a portion of the complexity cost has to do with managing a larger variety of crops and owning or hiring the different types of machinery to deal with those crops (Delbridge et al.). Those costs for crop rotation management and machinery ownership would also apply to a conventional farm with a rotation longer than two years.

If we estimate that 50% of the total complexity cost for an organic system would apply to a non-organic four-year rotation:

$117/acre total complexity cost /2 = $58.50/acre in complexity cost for non-organic four-year rotation.

(Round to $59/acre)

Reference:

A whole-farm profitability analysis of organic and conventional cropping. 2013. Timothy A. Delbridge, Carmen Fernholz, Robert P. King, William Lazarus. *Agricultural Systems*. http://dx.doi.org/10.1016/j.agsy.2013.07.007

a lease. Use land rental rates that are in line with typical rates in your area, that reflect the crop production potential of your soil, and that give the farmer sufficient profit potential so that she or he will be able to stick to the longer rotation in good years and bad years. Your local NRCS office can help you find those appropriate rates. If the future operator will also be the owner, you can use deed restrictions or covenants to ensure that the land will be treated the way you want. See Conservation Financing for more details about these tools for farm transitions.

Crop Rotation

	- Column	+ Column	
Qualitative Benefits of the Practice	**Cost of Implementation and Potential Income Loss**	**Potential Income Gain and Reduced/Avoided Costs**	**Your Judgment: Value Per Acre of This Practice on Your Land**
Lowers risk of disease, insect, and weed problems Improves soil structure and fertility Increases species diversity Spreads out workload Spreads out financial risk Reduces purchased synthetic fertilizer inputs **The numbers in this table are broad estimates, and you should adjust them for your farm's conditions.**	Cost of dealing with the complexity of a long crop rotation system: $59/acre *(See Complexity Cost text box in this section)*	$6/acre/year average greater net return for 3-year rotation than for 2-year rotation (1) Plow-down value of alfalfa in providing nitrogen to the next cash crop: $96/acre of alfalfa that will be followed by corn *(See Alfalfa Nitrogen Credit text box in Perennial Forage section)* Plow-down value of alfalfa in providing nitrogen to the second-year cash crop: $30/acre of corn or small grain in second year following alfalfa *(See Alfalfa Nitrogen Credit text box in Perennial Forage section)* $8.60/acre/year gain in fertilizer value of soil by saving 4.1 tons/acre/year from soil erosion; cumulative over years *(See Value of Saving Soil text box in this section)* Benefit to society: approximately $20/acre/year gain in water quality value of soil by saving 4.1 tons/acre/year of soil from erosion *(See Value of Saving Soil text box in this section)*	Potential income gain and costs avoided: + Potential income loss and costs to pay: - Your judgment on value to your farm of qualitative benefits: + Value to society or environment: + Add up the total net value per acre per year: Multiply by a time frame (5 years? 10 years?) Total value over time:

References:

(1) **Rotation.** In *Organic Risk Management: Tools for Managing Pest and Environmental Risks to Organic Crops in the Upper Midwest*. 2010. Editors: Kristine M. Moncada and Craig C. Sheaffer. www.organicriskmanagement.umn.edu/ (accessed 8/27/13)

(2) **Energy and Economic Returns by Crop Rotation.** September 2012. Ann M. Johanns, Craig Chase, and Matt Liebmann. Iowa State University Extension. www.extension.iastate.edu/agdm/crops/html/a1-90.html (accessed 8/12/13).

Further Resources:

Ag Decision Maker, Whole Farm Decision Tools. Iowa State University Extension and Outreach. www.extension.iastate.edu/agdm/decisionaids.html
This online toolbox, created by Iowa State Extension, helps farmers answer hundreds of "what if" questions about their operations and about possible new enterprises. Worksheets are available to evaluate production decisions, marketing decisions, machinery questions, etc.

Value of Saving Soil

Soil lost due to erosion in the Corn Belt of the U.S. Midwest (2007 average numbers):

Water erosion = 3.9 tons/acre/year (1)
Wind erosion = 0.2 tons/acre/year (2)
Total erosion = 4.1 tons/acre/year

The loss rate on your land may be lower or higher, depending on how steep the slopes of the fields are, the cropping system, soil type, and various other factors. To find out the expected rate of soil erosion on your land, contact your local Natural Resources Conservation Service (NRCS) office to ask them for an estimate. Find your local NRCS office: http://offices.sc.egov.usda.gov/locator/app?agency=nrcs

Plant nutrient value of saving soil:

The value of the plant nutrients nitrogen (N), phosphorus (P), and potassium (K) provided by one ton of soil is equal to about $2.10 of purchased fertilizers, in 2012 dollars (3).

If good soil conservation practices are followed:
4.1 tons/acre/year of soil saved x $2.10/ton = about $8.60/acre/year in plant nutrients.

A couple of things to note:
- This is a cumulative savings over years because those tons of soil provide those nutrients *every* year. As minerals and organic matter in the soil gradually break down, the nutrients contained in them become available to plants.
- This calculation only accounts for major nutrients: nitrogen, phosphorus, and potassium. Soil also provides minor, but important, nutrients like sulfur, magnesium, calcium, boron, and others.

Water quality improvement value of saving soil:

The Natural Resources Conservation Service estimates that compliance with conservation standards results in $4.96 in off-farm water quality benefits for every ton of soil saved, in 2007 dollars (4).

continued on next page …

Value of Saving Soil, continued: (pg. 2)

If good soil conservation practices are followed:
$4.96/ton in benefits x 4.1 tons/acre/year saved = $20.34/acre/year in water quality benefits (Round to $20/acre/year)

References

(1) **Water Erosion on Cropland, by Region and Year.** NRCS. In *2007 National Resources Inventory, Soil Erosion.* www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/nra/nri/?cid=nrcs143_013656

(2) **Wind Erosion on Cropland, by Region and Year.** NRCS. In *2007 National Resources Inventory, Soil Erosion.* www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/nra/nri/?cid=nrcs143_013655

(3) **Value of Soil Erosion to the Land Owner.** August, 2012. Mike Duffy, Iowa State University Extension. www.extension.iastate.edu/agdm/crops/html/a1-75.html (accessed 6/11/13)

(4) **Interim Final Benefit-Cost Analysis for the Environmental Quality Incentives Program (EQIP)**. January 2009. USDA Natural Resources Conservation Service. www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_007977.pdf

Corn & Soybean Profitability

When making decisions about future land use, it's important to get the full picture of what the costs and the benefits of those decisions will be. One important number to estimate is the potential loss of net income per acre from a cash grain crop if something other than cash grain will be grown.

There are many tools available to help estimate what cash crop values might be. Grain prices change over time, so you can't know future prices for sure; but you can use past averages to make your estimate. Because corn, soybean, and other grains are handled as commodities in the stock market, the prices of these tend to be similar all over the country at any given time. Production costs and typical yields change a lot from place to place, though, so profitability is not the same all over. The Economic Research Service (ERS), part of the USDA, is a good source of average data on costs of production and profits from crops (1,2).

If you want a quick and easy estimate of profit per acre from a grain crop, open the ERS report for your crop (1); find the column for your region of the country (2); and use the "Value of production less total costs listed" number. That's the average amount of profit per acre from that crop after production costs, labor, and farm overhead costs are subtracted from the total value of the grain. You should look at more than one year, because crop yields and prices can change greatly from year to year.

- ERS estimated 2011 profit from Heartland CORN: $247.50/acre/year
- ERS estimated 2012 profit from Heartland CORN: $146.87/acre/year
- Average of 2011 and 2012 CORN: $197.20/acre/year

- ERS estimated 2011 profit from Heartland SOYBEAN: $206.12/acre/year
- ERS estimated 2012 profit from Heartland SOYBEAN: $216.75/acre/year
- Average of 2011 and 2012 SOYBEAN: $211.44 /acre/year

You can calculate a specific estimate of crop prices, production costs, and profits for your own land. A retiring farmer will most likely know what current grain prices are, the long-term average yields for any field, and may have a fairly good estimate of production costs per acre. If those numbers are not known, though, here are some places to look up average numbers:

continued on next page ….

Corn & Soybean Profitability, continued (pg 2)

Yields:

National Agricultural Statistics Service, Statisics by State:
www.nass.usda.gov/Statistics_by_State/ (3)

Click on your state. On your state's page, click on "County Estimates." Then choose a crop report. You will get a table of information on that crop's acreage and yield by county.

It can be easy to get lost in the NASS web site, though. If you have trouble, contact your local Natural Resources Conservation Service (NRCS) office to ask about average crop yields for your county. Find your local NRCS office:
http://offices.sc.egov.usda.gov/locator/app?agency=nrcs

Grain Prices:

The Department of Agricultural and Applied Economics at the University of Wisconsin-Madison has a nice, accessible web page that lets you find prices for a variety of crop and livestock products, by month and by year (4). You may want to use an average of several years, since prices change a lot from year-to-year.

Production costs:

Use the "Total Costs Listed" number for the crop from the same ERS tables mentioned above (1).

Example Corn & Soybean Profit Calculations:

Note: The following corn and soybean calculation examples use 2011 numbers for Chickasaw County, Iowa (3). The grain prices in 2011 were significantly higher than the average prices of the previous 5 years, and yields were good in 2011, so profits from corn were very high. You would not expect to see this same level of profit every year, but it's an example of why farmers can be very tempted to break away from a longer rotation in favor of growing corn.

continued on next page …

Corn & Soybean Profitability, continued (pg 3)

Example of profit per acre calculation for corn:

- 2011 corn yield: 188.8 bushels/acre (3)
- December 2011 corn price: $5.86 / bushel (4)
- Production Costs in 2011 for Heartland corn: $636.39 /acre (1)
- Calculate: (Yield x Price) – Production Cost = Profit
- 188.8 bu./ac. X $5.86/bu. = $1,106.87 /acre gross income
- $1,106.87/ac. Income - $636.39/ac. Production Cost = $469.98/acre profit

Example of profit per acre calculation for soybean:

- 2011 soybean yield: 51.4 bushels/acre (3)
- December 2011 soybean price: $11.50 / bushel (4)
- Production costs in 2011 for Heartland soybeans: $409.81 / acre (1)
- Calculate: (Yield x Price) – Production Cost = Profit
- 51.4 bu./ac. X $11.50/bu. = $591.10/acre gross income
- $591.10/ac. Income - $409.81/acre Production Cost = $181.29/acre profit

Again, remember, this example reflects 2011 yields and prices which were both high. This level of profit will not be seen every year.

Throughout the remainder of this publication we'll be using corn and soybean profit per acre figures from the University of Minnesota (5). These figures include government payments for corn and soybean production and are averages for the years 2008-2012:

- CORN profit = $310.47/acre/year
- SOYBEAN profit = $149.70/acre/year
- Average profit = $230.09 (Rounded to $230/acre/year)

continued on next page …

Corn & Soybean Profitability, continued (pg 4)

References

(1) **Commodity Costs and Returns**. June 2013. USDA Economic Research Service. www.ers.usda.gov/data-products/commodity-costs-and-returns.aspx#.UfvbrY3U98E (accessed 8/30/13).

(2) **Agricultural Resource Management Survey (ARMS): Resource Regions**. September 2010. USDA Economic Research Service. http://webarchives.cdlib.org/sw1wp9v27r/http://ers.usda.gov/briefing/arms/resourceregions/resourceregions.htm (accessed 8/30/13).

(3) **Statisics by State**. USDA National Agricultural Statistics Service (NASS). www.nass.usda.gov/Statistics_by_State/. (accessed 8/30/13).

(4) **Prices of Grains, Livestock Products, and Hay**. Brian Gould. In Understanding Dairy Markets: Your Source for Market Information and Price Risk Management Principles. University of Wisconsin, Madison – Department of Agricultural and Applied Economics. http://future.aae.wisc.edu/tab/feed.html#65 (accessed 8/30/13).

(5) **What does it take to earn a living on the farm?** April, 2013. Gary Hachfeld, University of Minnesota Extension. http://swroc.cfans.umn.edu/prod/groups/cfans/@pub/@cfans/@swroc/documents/asset/cfans_asset_440374.pdf (accessed 8/06/13)