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# Crop Rotation Planning for Dairy Farms

Crop rotations can benefit dairy farms in many ways. An effective crop rotation meets the feed needs of the operation, improves crop yields, reduces pest problems, and effectively uses on-farm nutrients. Because the resources and needs of dairy farms differ, the best crop rotation for each farm also will vary. As farms expand and forage and nutrient management requirements change, crop rotations also can be refined and improved. Because many factors can influence crop rotations, planning decisions are often complex. The objective of this fact sheet is to review some potential benefits of crop rotations and provide some guidelines for using them as a tool to address various production problems.

## OBJECTIVES

A well-functioning crop rotation on a dairy farm should do the following:

- Meet the feed needs of the operation
- Grow crops adapted to the soils and climate
- Match the labor availability of the operation
- Minimize pesticide use through IPM practices
- Effectively use nutrients from manure
- Minimize soil erosion

In most cases, a single rotation will not accomplish all of these objectives. In these situations, you must set priorities and use a rotation system that addresses the most important issues first and does at least an acceptable job on the others. For example, long hay rotations that conserve soil nutrients may conflict with the need to grow corn. Another conflict might occur between long corn rotations, which are attractive from a labor standpoint, and the need to minimize pesticide inputs.

## ESSENTIAL COMPONENTS

When developing or modifying a crop rotation to meet some of the goals and resource limitations on a particular operation, consider the following steps:

*Estimate feed requirements:* Estimate forage and grain needs for at least the next three years as carefully as possible. This will be particularly important if the size of the herd will be increasing. For example, if 20 cows will be added to the herd next year and if each cow will consume 50 pounds of forage dry matter per day, you will need 365,000 pounds, or approximately 180 tons, of additional dry matter. Where will that feed come from? What plans should be made today to produce and store that feed?

*Estimate production:* Develop an estimate of forage and grain production from *realistic* yield estimates and *accurate* crop acreage estimates. For a corn/hay grower, this summary should tell you approximately what your annual feed production will be for hay, haylage, high moisture corn grain, and corn silage. Using overly optimistic yields or inaccurate acreage can lead to large differences between expected and actual production. This in turn can lead to an imbalance between the feed inventory and the actual feed requirements of the herd, which may require a change in the ration when one feedstuff is used up before the others. Yield estimates can be verified to some extent by comparing silo capacities with the acreage required to fill them. Yield estimates also can help to identify areas where improvements in crop management are necessary.

*Adjust ration if necessary:* If it is impractical or expensive to produce some of the crops required for the ration, then consider adjusting it to accommodate feedstuffs that can be

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produced economically. Examples of this include substituting barley for corn on farms where corn is not well adapted, or using more corn silage on farms where corn is well adapted and hay production is expensive.

*Match crops to soils:* The soils on a farm will determine the crops that can be grown there most easily. Alfalfa, small grains, and soybeans grow better than corn on shallow or droughty soils. On poorly drained fields, corn grows better than alfalfa or barley. Trying to produce crops that are not well adapted to your soils leads to low yields, high production costs, and a high land requirement to meet production goals.

*Credits for rotations:* Rotational credits are an important component of crop rotation planning. For example, corn crops planted following soybeans frequently produce yields about 8 to10 percent greater than those planted following corn. Corn crops planted following hay require much less N and insecticides, are more drought tolerant, typically have fewer problems with perennial weeds, and produce yields about 10 to 15 percent greater than those planted following corn. Crop consultants can provide useful services in helping producers take full advantage of rotational credits for corn production as well as for other crops.

*Flexibility:* Each operation must maintain some flexibility in its rotation to allow it to adjust to short-term variations in crop production or feed requirements. If alfalfa winterkilling is severe, for example, then rations may need to be adjusted accordingly in the short-term while new hayfields are reseeded and the old stands are rotated to corn.

*Use of no-tillage:* Many producers use crop rotation as a way to facilitate the use of no-tillage. No-till crop production has several advantages for dairy producers: it can help to meet conservation requirements without reducing row crops; it can reduce labor requirements; and it can facilitate some intensive rotation systems such as double-crop corn following hay, rye, or barley, and short corn/alfalfa rotations. By carefully planning rotations, no-till can be used successfully in selected situations such as planting no-till corn into fall-killed sods, no-till rye or alfalfa into corn silage stubble, or no-till corn into soybean residue.

## ROTATIONS AS A TOOL TO ADDRESS PRODUCTION ISSUES

On some dairy farms, large changes in the crop rotation may be necessary to address production-related issues without compromising the other goals of the rotation. More often, however, only minor changes are needed. Listed below are some examples of how changes in crop rotations can improve some common dairy farm production problems:

*Feed shortages:* If a farm has a shortage of one feed and a surplus of another, crop rotation planning with attention to acreage and yields should be instituted. Long-term changes in feed rations to meet soil production capabilities also should be evaluated.

*Forage quality:* Low forage quality due to poor timing of the hay harvest may be the result of a crop rotation problem. Although conservation plans often require long hay rotations on farms with highly erodible land, other conservation practices such as increasing no-tillage and planting cover crops can lead to shorter corn/alfalfa rotations with less hay acreage. This can increase the legume content of the hay and improve the timeliness of the harvest because of the reduced acreage.

*Efficient N use:* Farms with a high proportion of their corn in the third or later year of a rotation may have to rely on substantial off-farm N sources. Shorter (3-year) corn rotations can reduce this need because the more frequent hay crops will replenish the N content of the soils. Interrupting a long corn rotation with a year of soybeans also can reduce external N needs and avoid pest buildups as well.

*Corn rootworm pressure:* If corn rootworms develop into a serious problem that continually requires insecticide treatment, crop rotations should be considered to limit the buildup of these pests. Shorter rotations or corn/soybean rotations can help reduce both insecticide needs and the corn rootworm beetle populations in an area for succeeding years.

*Triazine-resistant or perennial weed problems in corn:* A buildup of triazine-resistant or perennial weeds in corn often can be controlled effectively by shorter rotations. Perennial weeds are best controlled by rotating the field either to small grain crops, enabling the weeds to be controlled in the late summer, or to hay where frequent cuttings and fall-kill prior to rotation are effective means of control.

*Inconsistent corn performance caused by drought stress:* In areas where drought stress limits corn yields and profitability, including more drought-tolerant crops such as barley, wheat, soybeans, and sorghum in the rotation will provide a more stable and diverse crop mix. In addition, rotated corn is more drought tolerant than corn planted following corn. Both of these factors will improve the consistency of grain crop production on drought-prone fields. Some adjustment of the dairy ration to include more small grains or sorghum may be necessary to make these rotation adjustments.

*Poor performance of no-till corn:* Some dairy farmers limit the use of no-till corn because of a history of poor performance. This may be caused by a number of factors, but both the crop rotation and the timing of no-till in the rotation could influence potential success. No-till can become more difficult in the later years of long corn rotations due to heavier amounts of residue, increased weed problems, and compacted soils. Using no-till selectively on first year fields can help to avoid many of these problems. No-tilling soybeans into some corn fields and then following with no-till corn again also can be successful.

*Too much N for crop mix:* On farms with a large amount of manure to spread, standard corn/alfalfa rotations may need to be altered to use up the manure. More corn may be required in the rotation. If the growing season is long enough, doublecropping rye with either corn or forage sorghum can remove large amounts of N. Applying manure to alfalfa also is an option, but this probably will lead to shorter stand life and more weeds in the hay crop.

## EXAMPLE

Making a rotation change usually will cause many changes in the operation. Consider the following example: A grower is using a 4-year corn/4-year alfalfa rotation on his 300-acre farm and would like to reduce his pesticide and fertilizer use, increase his potential for no-till, improve the drought tolerance of his cropping system, and maintain profitability. One possible suggestion would be to substitute soybeans for the third year of corn and then no-till the corn following the soybeans rather than continue with the chisel/disk tillage system currently in use. To evaluate this alternative, you must estimate the potential changes in crop production, profitability, input use, labor requirements, and nutrient management. Although estimates will differ from farm to farm, our example is based on the following assumptions:

1. Corn yields increase with rotation by 8 percent, and first corn yields average 120 bu/A or 20 T/A.
2. Soybeans average 40 bu/A, and alfalfa averages 2.5 T/A in the establishment year and 5 T/A thereafter.
3. All corn planted following corn requires a soil insecticide.
4. Soybeans can be custom planted for $14.60/acre.
5. Soybeans can be custom harvested for $24.10/acre and stored for $0.05/bushel.
6. Available manure (approx 500,000 gallons of liquid dairy manure) can meet the needs of approximately one-half of the corn crop in the existing rotation.
7. The corn silage harvest will total 1,000 tons in both rotations, and the remainder will be harvested for shelled corn.

Changes in the production of commodities and their values are listed in Table 1. Note that corn yields are higher and silage acres are fewer in the changed rotation, and that the combined values of the commodities produced remains nearly the same. In Table 2, the recommended rates of soil insecticides and N, P, and K fertilizer for both rotations indicate that less insecticide and N are required when soybeans are added to the original rotation. The amount of P and K used is similar for both rotations.

**Table 2. Fertilizer and insecticide use summary for 300-acre sample farm.**

| Input | C-C-C-C-A-A-A-A | C-C-S-C-A-A-A-A |
|---|---|---|
| N fertilizer (lbs N) | 4,869 lb | 1,260 lb |
| P fertilizer (lbs $P_2O_5$) | 6,950 | 6,936 |
| K fertilizer (lbs $K_2O$) | 30,998 | 30,963 |
| Insecticide | 900 | 300 |

## ECONOMIC ANALYSIS

An economic tool that can be used to compare the profitabilities of different crop rotations is *partial budgeting.* Partial budgeting allows you to examine the profitability of incremental changes in the production technology, the size or scale of the operation, or the product mix. A partial budget contains only those income and cost items that will change if the proposed change is undertaken. Only the changes in income and expenses are used for a partial budget analysis, not the total values. The final result is an estimate of the increase or decrease in profit attributable to the change. Decreased revenues and increased costs are subtracted from increased revenues and decreased costs to identify the net effect of the change. The four questions used in preparing a partial budget are:

1) What new or additional cost(s) will be incurred?

2) How much current income will be lost or reduced?

3) What new or additional income will be received?

4) Which current cost(s) will be reduced or eliminated?

The first two questions identify changes that will reduce profit by increasing costs or reducing income. The second two questions identify changes that will increase profit by increasing income or reducing costs.

In the case of our example, the new or additional costs that may be incurred (question 1) include the costs of additional field operations, pesticides, seed, fertilizer, and harvesting for soybeans, along with the change in planting and herbicide costs resulting from the change from min-till to no-till fourth-year corn.

Corn income will be reduced because of reduced acreage (question 2), but the income from the soybeans (question 3) will counteract this loss. All the costs of producing third-year

**Table 1. Crop production summary for 300-acre sample farm.**

| Crop | C-C-C-C-A-A-A-A Rotation | Acres | Yield | Value | C-C-Sb-C-A-A-A-A Rotation | Acres | Yield | Value |
|---|---|---|---|---|---|---|---|---|
| Corn silage | 1,000 tons | 54.5 | 18.3 T/A | $23,000 | 1,000 tons | 51.2 | 19.5 T/A | $23,000 |
| Shelled corn | 11,000 bushels | 95.5 | 115.1 bu/A | $33,000 | 7,200 bushels | 61.3 | 117.4 bu/A | $21,600 |
| Soybeans | | | | | 1,500 bushels | 37.5 | 40.0 bu/A | $10,500 |
| Alfalfa | 619 tons | 150.0 | 4.1 T/A | $61,900 | 619 tons | 150.0 | 4.1 T/A | $61,900 |
| Total | | | | $117,900 | | | | $117,000 |

corn will need to be subtracted, along with the tillage, planting, and herbicide costs for min-till fourth-year corn (question 4). Assuming a first-year corn yield of 120 bu/A and a soybean yield of 40 bu/A, the change in profit when switching from a C-C-C-C-A-A-A-A to a C-C-S-C-A-A-A-A rotation is shown in Table 3.

To a large extent, the potential profitability of making the change depends on the relative corn and soybean yields (Table 4). If corn yields are high relative to those of the soybeans, then the change in profit may be negative. If soybean yields are high relative to corn, then the change in profit will be positive.

Finally, because all decisions also have non-economic aspects, it is important to consider possible intangible factors. One change that will result from a rotation change will be labor requirements at various times during the cropping season. A large proportion of our sample farm's acreage is devoted to the production of alfalfa, and historically this has meant large labor requirements during May, June, August, and September. The first alfalfa cutting often competes with corn planting, so shifting some planting to June for soybeans will save some time in May. The harvest also will be spread out, reducing labor requirements in September. The shift to

**Table 3. Partial budgeting analysis.**

Proposed Change: 4-year corn, 4-year alfalfa rotation to 2-year corn, 1-year soybean, 1-year corn, 4-year alfalfa rotation

| | | |
|---|---|---|
| ====> | add | 37.5 acres of no-till soybeans |
| | add | 37.5 acres of no-till corn |
| | subtract | 75.0 acres of min-till corn |

| Additional Costs | Price or Cost | Amount | Total | Additional Income | Price or Cost | Amount | Total |
|---|---|---|---|---|---|---|---|
| no-till soybean planting | $14.60/A | 37.5 A | $547.50 | soybeans | $7.00/bu | 1,500.0 bu | $10,500.00 |
| soybean seed | 17.40 | 37.5 | 652.50 | | | | |
| P | 9.24 | 37.5 | 346.50 | | | | |
| K | 4.48 | 37.5 | 168.00 | | | | |
| no-till soybean herbicides | 37.20 | 37.5 | 1,395.00 | | | | |
| soybean harvest | 24.10 | 37.5 | 903.75 | | | | |
| soybean storage | $0.05/bu | 1,500.0 bu | 75.00 | | | | |
| no-till corn planting | $14.30/A | 37.5 A | 536.25 | | | | |
| no-till corn herbicides | 24.30 | 37.5 | 911.25 | | | | |
| **Reduced Income** | | | | **Reduced Costs** | | | |
| shelled corn | $3.00/bu | 3,803.0 bu | $11,409.00 | corn min-tillage | $21.00/A | 75.0 A | $1,575.00 |
| | | | | min-till corn planting | 12.90 | 75.0 | 967.50 |
| | | | | corn seed | 26.30 | 37.5 | 986.25 |
| | | | | N | $0.27/lb | 3,597.0 lb | 971.19 |
| | | | | starter (12-36-12) | $10.00/A | 37.5 A | 375.00 |
| | | | | min-till corn herbicides | 16.00 | 75.0 | 1,200.00 |
| | | | | rootworm insecticide | 11.50 | 37.5 | 431.25 |
| | | | | corn harvest | 24.40 | 37.5 | 915.00 |
| | | | | corn drying | $0.20/bu | 4,550.0 bu | 910.00 |
| Total of additional costs and reduced income | | | $16,944.75 | Total of additional income and reduced costs | | | $18,831.19 |
| | | | | less | | | ($16,944.75) |
| | | | | Change in profit | | | $1,886.44 |

**Table 4. Change in profit for various corn and soybean yield combinations when soybeans are included in a corn-alfalfa rotation.**

| Soybean Yield (bu/A) | Corn Yield (bu/A) | | |
|---|---|---|---|
| | 100 | 120 | 140 |
| 30 | +$1,046 | -$840 | -$2,595 |
| 40 | +$3,756 | +$1,886 | -$71 |
| 50 | +$6,381 | +$4,613 | +$2,757 |

**Table 5. Monthly labor requirements (in hours).**

| Month | Rotation with Third-Year Corn | Rotation with Custom-Planted Third-Year Soybeans | Rotation with Farmer-Planted Third-Year Soybeans |
|---|---|---|---|
| March | 39 | 39 | 39 |
| April | 75 | 29 | 29 |
| May | 300 | 282 | 282 |
| June | 210 | 175 | 219 |
| July | 83 | 80 | 80 |
| August | 152 | 152 | 152 |
| September | 290 | 284 | 284 |
| October | 0 | 0 | 15 |
| November | 35 | 23 | 23 |
| Total | 1,184 | 1,064 | 1,123 |

soybeans can have a significant impact on labor, especially if the soybeans are planted and harvested by a custom operator. Table 5 compares the estimated labor requirements for a rotation with corn in the third year and one with third-year soybeans.

Our example demonstrates the possibility of making a change in the crop rotation and achieving all of the desired improvements. Less N and insecticides were purchased, the cost of production was reduced, the value of the commodities produced remained about the same, the on-farm labor needs were reduced, the potential for no-till planting increased, and the rotation became more drought tolerant because of the soybeans and rotated corn.

In some cases, improvements in one aspect of a cropping system may lead to undesirable consequences in another area. For example, if our farm had excess manure, adding soybeans to the rotation might negatively affect nutrient management, and the economic benefit of the change would be reduced or eliminated because the residual N credit from the soybeans would not be valuable to the farmer. Also, on highly productive soils with high corn yields, switching some acres to soybeans might not be economical.

All components of the cropping system need to be considered to make crop rotation planning successful. Rotational changes can be evaluated effectively by using good cost and yield production estimates and the partial budgeting technique described above. Adjusting rotations after careful evaluation can be an excellent method of addressing many dairy farm crop production problems.

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