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Phosphorus on the dairy from feed grains and by-products

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Phosphorus (P) is an important plant nutrient for growing dairy forages. Unfortunately, many dairies have more P excreted and stored in manure than they can use during a crop year. Soils have the ability to store moderate over-applications of P for future crop production, but continued over-application can lead to losses of P to surface water.

Much of the P brought onto the dairy is in livestock feeds. Proper ration balancing giving credit to the P in all feeds, developing rations to consistently meet animal requirements, and avoiding the use of "insurance" supplementation are good for the environment and the producer's bottom line.

An example of phosphorus in feeds

Let's look at a 400-cow dairy and the potential for concentrating P on the farm. If we assume a requirement for P of 0.4% and animals eat 50 pounds of dry matter daily, we need 0.2 pounds P per animal per day. This times 400 cows and 365 days shows the dairy will have 29,200 pounds of P in feeds each year. If cropping on the farm removes 35 pounds P per acre per year, the dairy needs 835 acres of cropland to utilize this phosphorus, or more than two acres per cow!

The good news is that not all that P hits the ground in manure. A dairy cow will absorb about 20% of feed P to support her body maintenance and production needs. That means 80% is excreted by the cow. Seems like a lot, but 45-60% is indigestible without special extraction prior to feeding. Animals fed deficient or marginally deficient diets absorb more P, so over-feeding this nutrient reduces the absorption rate and adds more P to the manure (Morse, 1992).

Farm balance case studies

Developing a whole farm balance where nutrients in feed, fertilizer, bedding, and animals brought onto the farm are balanced against nutrients exported in meat, milk, animals, sold feeds, manure is a useful process to plan how to better match manure nutrients to crop uptake.

A project in 1992 looked at whole farm balances for three dairies and a beef operation in an Oregon watershed listed as water quality-impaired due to P. The dairies each milked about 100 cows, raised their own heifers, produced part of their forages, and grew crops for sale.

Not surprisingly, much of their imported P came from feeds brought on the farm (Table 1).

Table 1: Phosphorus imported onto livestock operations (Washington County, Oregon, 1992)

	total P	feed P	% feed P
dairy 1	3,383	2,400	71%
dairy 2	13,321	6,500	49%
dairy 3	10,354	5,700	55%
cow-calf beef	1,040	1,000	96%

Much of the significant farm-to-farm variation in this study was due to the amount of feeds raised on the farm and the amount of crops sold off the farm. For example, dairy #2 with only 49% imported in feed sold seed crops off the farm. Phosphorus-laden fertilizers were used on the crops and were a major source of imported P in this case.

Even with more intense cropping, feed P is still a major contributor to P accumulation (Gamroth, 1992).

Typical phosphorus levels in feeds

Most species require P in the diet at 0.16 to 0.40% of ration dry matter. Many of our traditional feed sources contain adequate or abundant P for supporting animal growth and milk production. Table 2 shows typical P values. All feeds, especially by-products, vary in nutrient content. It is wise to analyze each feed ingredient to know its nutrient content, including P.

Table 2: Phosphorus content of selected feeds.

	% P (dry matter basis)
legume hay	0.26%
cool season grass	0.23%
cereal silage	0.31%
corn silage	0.26%
corn grain	0.30%
barley grain	0.39%
oast	0.40%
soybean meal	0.70%
canola meal	1.10%
distillers grains	0.83%
brewers grains	0.67%
almond hulls	0.13%
whole cottonseed	0.60%
wheat bran	1.18%
wheat midds	1.02%
soy hulls	0.17%

With adequate to high levels of P in animal feeds, it is common to see P fed at levels above requirements. A recent survey of dairy herds in Virginia showed that P could be reduced by 45% if diets were formulated to meet NRC requirements (Sink et al., 2000.) The average P fed in 33 surveyed herds was 0.49%, while calculated requirements averaged only 0.34%. Not only could herds in the survey reduce the P in manure by 71% by formulating rations more precisely, but

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they would also save $800 to $1,500 per year in feed costs.

Conclusion

As animal units increase relative to land managed it will become more important to evaluate and manage the whole farm balance. This management involves reducing P imports and increasing P exports.

Reduce P brought onto the farm

• Test soils and target manure applications to reduce purchased P fertilizers.

• Balance rations often to precisely meet P requirements by production stage. Don't ignore the P provided in by-product feeds. Avoid free-choice and ready-to-use minerals not matched to feeds.

• Plant appropriate varieties for greater yields of high-quality forages or cereal grains.

Increase P sent off the farm

• Maintain an efficient herd for best conversion of feed to animal product.

• Develop a manure management system that allows for export of manure off-farm. Composting dries the product, reduces volume, and is more acceptable to users. Lagoon sludge is rich in P.

• Consider planting crops for sale that pull P out of soils.

• Avoid death loss. Dispose of mortalities off-farm when possible.

• Contract graze with other producers when forage is more than sufficient for farm needs.

Strategies to increase nutrient export from the dairy

By Mike Gamroth and Troy Downing

As livestock operations continue to grow, it is becoming more common to find production situations where manure generated on the farm contains more nutrients than can be used by crops grown on the farm. Another way of saying this is that the farm has more manure produced by the animals than they have land for disposal. Soils have the ability to store moderate over-applications of nitrogen, phosphorus, and potassium for future crop production, but continued over-application leads to losses of nutrients to surface water.

There are strategies to lower the amount of nutrients applied on the farm and many livestock operations may have to use these in the future. What choices are there?

1) Reduce N, P, and K imported in feeds and fertilizers by properly balancing rations for animals and properly planning applications to crops.

2) Reduce N losses from manure to better balance the ratio of N to P in manure making it worth more as a fertilizer to surrounding farms.

3) Export N, P, and K off the farm after some processing.

4) Increase crop uptake through improved varieties and higher yields.

5) Increase the land used for application. This will be an added cost of production.

6) Reduce animal numbers. This will reduce farm income in most cases.

Increasing sales of crops off the farm and increasing milk and/or meat sales are also techniques to help bring a farm into balance.

Given that most producers are land-limited and they don't want to buy land or sell animals, this paper will look at the options for exporting nutrients off the farm as:

• Separated solids from a mechanical separator
• Solids from a settling basin separator
• Dry scrape manure (compost)

There have been a number of surveys to determine the efficiency of mechanical separation and the nutrient content of separated manure solids. A study of 51 mechanical separators in 1995 showed the following:

• Average dry matter was 19.3%

• Average separator efficiency was 21%

• N content of separated solids averaged 1.22% and most of the samples ranged from .9% to 1.5% DM. This is equivalent to 12.9 to 21.5 lbs. of N per cow with an average of 17.5 lbs. per cow per year.

• P content of separated solids ranged between .09% and .83% DM with an average of .21% P. This is equivalent to 1.3 to 11.6 lbs. of P per cow with an average of 3 lbs. per cow per year.

• K content of separated solids averaged .46% and most samples ranged between .24% and .68% DM This is equivalent to 3.5 to 9.7 lbs. of K per cow with an average of 6.6 lbs. per cow per year.

So the nutrient content of solids is quite variable. A Washington State University study found results that were just as variable. It is important to test the content of separated solids for better nutrient management planning.

"Composting and exporting most manure deposited in housing has the potential to remove around 90% of the nutrients excreted. This requires special handling equipment and facilities and the addition of a carbon source like wood chips or straw. Even after the import of the carbon source, it is possible to significantly cut down the number of acres required for using P or other nutrients on the farm."

Newer squeeze-type separators appear to increase separation efficiency. If you double separator efficiency, you most likely more than double P removal because the first material out of a separation system will be the coarse bedding which is low in nutrients.

Allowing gravity to pull out solids in designed settling basins achieve greater solids and nutrient removal rates. Data from a California study of settling basins showed basins varied between 25 and 60% in removal of solids.

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The separator study by WSU reported two gravity separators with solid capture rates of about 60% with sand bedding. However, sand is very dense and the P content of the solids was only 0.15 %.

Composting and exporting most manure deposited in housing has the potential to remove around 90% of the nutrients excreted. This requires special handling equipment and facilities and the addition of a carbon source like wood chips or straw. Even after the import of the carbon source, it is possible to significantly cut down the number of acres required for using P or other nutrients on the farm.

Increasing nutrient export is a good tool for the land-limited operation, but this is only one tool needed to balance nutrients more precisely.

Since P is most often the most limiting nutrient to land application, an example follows on how a dairy farm might achieve a better P balance through better feed management and P export options:

A 300-cow dairy growing grass silage would need 428 acres to balance P excretion with grass uptake. Based on recent data, the average dairy in Oregon can reduce phosphorus imports by about 11 lbs./cow/year through more precise feeding. This dairy would need 94 acres less to balance P using this better feed management. (428-94 = 334 acres).

If the dairy separated manure solids with a conventional side hill liquid-solid separator, they would reduce manure P another three lbs./cow/year and reduce the cropland required by another 26 acres. (428-94-26 = 308 acres)

Using a more efficient screw-type separator would reduce manure P by about seven lbs./cow/year instead of three lbs. for a side hill. This would reduce needed acreage by 56 rather than 26 (428-94-56 = 274 acres).

Notice that mechanical separation doesn't reduce the P applied very much. If this producer chose to use gravity settling basins instead of mechanical separators, the operation would need about one half the acreage for balance compared to an operation using P feed management alone. (428-94-172 = 162 acres).

And finally, if this dairy composted 90% of its manure and sent it to other farms, it would only require about 34 acres to dispose of the remaining manure or one acre for about 10 cows.

Exporting can help balance nutrients on livestock operations, but it is best used along with better feed and fertilizer management to limit nutrient importation. When exporting nutrients, a producer will likely have more investment in equipment, facilities, and labor than on operations with adequate land for nutrient use.