Animal Agriculture and the Environment

Phosphorus requirements of lactating cows

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Nitrogen and phosphorus contamination of ground and surface water are the leading environmental issues facing dairy farmers in Maryland, Virginia, and Pennsylvania. When total phosphorus inputs to a farm or watershed exceed exports, phosphorus accumulates in soil, and may runoff, contaminating water resources. Phosphorus inputs to dairy farms include fertilizer, imported feeds, and dietary mineral supplements, and phosphorus is exported in animal products and cash crops. Long term solutions to the problem of phosphorus losses from a farm or across a watershed must address this imbalance between inputs and exports.

Reducing the amount of phosphorus in manure through nutrition is a powerful, cost effective approach to reducing potential phosphorus losses from dairy farms. Intake of phosphorus by dairy cows has been shown to have significant impact on phosphorus excretion. Better understanding of the phosphorus requirements of dairy cows, and reducing the phosphorus content of diets to true requirements will reduce phosphorus excretion, a critical step in addressing this nutrient imbalance.

Several studies indicate a direct link between phosphorus intake and phosphorus excretion. A Florida study shows this link most clearly. Twelve cows were fed diets containing one of three levels of phosphorus (.3%, .41%, .56% of dietary DM). Excretion increased linearly with increasing intake, and nearly all of the difference in phosphorus intake with the high phosphorus diet compared to the low phosphorus diet was excreted.

Phosphorus requirements for dairy cattle in the U.S. are published by the National Research Council (NRC), and are based on research reviewed by panels of scientists. Other countries publish their own requirements, based on the same research data. There is variation among nutrient requirement publications from around the world, and published recommendations do change as our base of knowledge expands. The current NRC publication recommends the highest feeding levels for phosphorus of any country, and include the biggest safety factors.

Despite the fact that published phosphorus requirements in this country are based on rigorously reviewed scientific studies and include generous safety factors, overfeeding is common. The 1989 NRC phosphorus requirement for lactating dairy cows is about .41% of diet DM, but phosphorus content of rations in the field typically averages .5% or greater, 20-40% more phosphorus than required.

Phosphorus is often fed to dairy cattle in excess of published requirements because high phosphorus diets are commonly believed to improve reproductive performance. This perception likely originates from the observation that severe phosphorus deficiency impairs reproductive performance in cattle.

The original studies that established this link between phosphorus deficiency and impaired reproduction were primarily with range cattle, and dietary phosphorus concentrations of less than .25% of the dietary DM were necessary to cause impaired reproductive performance. This dietary concentration is far below the concentration found in most feedstuffs in modern dairy rations even without supplementation, and in all of these studies, the phosphorus deficient diets that caused impaired reproduction were also deficient in energy and other minerals. The

impaired reproduction was attributed to lack of phosphorus, but may have been due to deficiencies of these other nutrients as well.

Although severe phosphorus deficiency may impair reproductive performance, there is no research data to suggest a benefit from feeding phosphorus to dairy cows in excess of NRC requirements. In fact several studies reported no impact of dietary phosphorus concentrations of .33 to .35% of dietary DM on days open, services per conception, or calving interval.

A recent study by researchers in Wisconsin serves as an example of the studies indicating no effect on reproductive performance of phosphorus supplementation. Forty-eight cows were assigned at calving to low or normal phosphorus diets (.35% vs. .5% of dietary DM). With the data from the first year of this two year, ongoing study summarized, milk yield, 4% fat corrected milk, and dry matter intake were not affected by phosphorus intake. Days to first estrus were 8 days longer for cows on the low phosphorus diet but days to first service, conception rate, services per conception, and pregnancy rates were not different. These were high producing cows, averaging 65 to 70 pounds of milk through the first year of the study.

Legislation has been passed in Maryland that may outlaw the application of manure to soils that have very high phosphorus concentrations. Most dairy farms produce more manure phosphorus than their crops require, and phosphorus-based plans will require that the excess manure be exported so that excess phosphorus is not applied and allowed to accumulate. Under this and similar laws, many farmers simply will not be able to apply manure on their farms because of high soil phosphorus concentrations. The sooner farmers begin to reduce soil phosphorus concentrations to acceptable levels on their farms the better off they will be. Reducing phosphorus intake to reduce phosphorus excretion is the most powerful, cost effective tool farmers have to achieve this goal.

The impact of reducing phosphorus intake on farms under phosphorus-based nutrient management can be estimated several ways. We developed a spreadsheet at Virginia Tech that predicts phosphorus excretion. Given allocation of manure to crops, and estimated nutrient uptake by those crops, we can calculate acreage required to land-apply manure.

We used this spreadsheet to evaluate a dairy farm milking 100 cows with different cropping strategies, and found that phosphorus intake has a tremendous impact on acreage required for disposal of manure on a phosphorus basis. Acreage required to dispose of manure generated by the herd increases by about 60% as phosphorus intake increases from .4% to .55%. Alternatively, given a fixed land base and different cropping strategies, we calculated the maximum number of milking cows supported by that land base. As phosphorus intake by the herd increases from .4 to .55%, herd size that can be accommodated with phosphorus-based manure application decreases by 35%.

We do need additional research in several areas to better understand the phosphorus requirements of high producing dairy cows. Key questions include the availability of phosphorus to lactating cows from various sources, and the question of just how low we can go with dietary phosphorus in high producing dairy cows without impairing reproductive efficiency. Answering this second question will require large numbers of high producing cows.

But most importantly, more education of producers and their advisors is needed now to reduce overfeeding of phosphorus. The perceived impact of phosphorus deficiency on reproductive performance far exceeds the actual effect, and overfeeding is not of benefit. For farmers, reducing phosphorus intake to published requirements makes sense environmentally and economically. It would be difficult to overstate the economic implications of phosphorus-based nutrient management for livestock farms throughout the Chesapeake Bay watershed, and the importance of refining rations to reduce phosphorus excretion and subsequent land application of

phosphorus.