Managing Dietary Phosphorus to Reduce Environmental Impact of Dairy Farms

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USDA United States Department of Agriculture

NRCS Natural Resources Conservation Service

Introduction

This fact sheet has been developed to support the implementation of the Natural Resources Conservation Service Feed Management 592 Practice Standard. The Feed Management 592 Practice Standard was adopted by NRCS in 2003 as another tool to assist with addressing resource concerns on livestock and poultry operations. Feed management can assist with reducing the import of nutrients to the farm and reduce the excretion of nutrients in manure.

The link between P intake and P excretion

In dairy cows, several studies indicate a direct link between P intake and P excretion (Morse et al., 1992; Wu et al., 2001; Knowlton and Herbein, 2002). Morse et al. (1992) were the first to show this link. This Florida study used twelve cows and fed diets containing one of three levels of P (.30%, .41%, .56% of dietary DM). Excretion increased linearly with increasing intake, and nearly all of the difference in P intake with the high P diet compared to the low P diet was excreted (Figure 1).

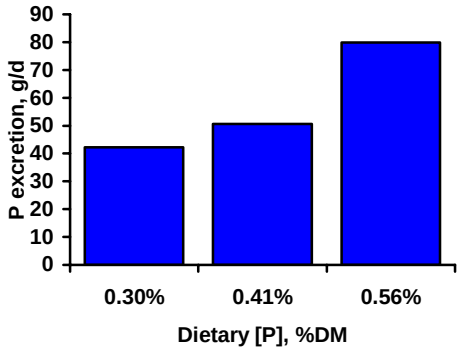

Figure 1. Effect of dietary P concentration on P excretion in lactating cows. (Morse et al., 1992)

Overfeeding of dietary P is common in the field, with overfeeding of 20 to 40% in excess of published requirements commonly observed (Sink et al., 2000). A survey conducted by Wu et al. (2003) in Pennsylvania indicates that the extent of overfeeding is less now than was indicated in these earlier surveys. Assuming that P consumed above the requirement of the animal will be excreted, reducing overfeeding of P could reduce P excretion by 20 to 40% in the dairy industry.

For farms in positive P balance, reduced overfeeding of P translates directly into improved whole farm P balance, by reducing excess imported P. Spears et al. (2003) observed a significant relationship between whole-farm P balance and herd P utilization efficiency. Cows overfed P utilize dietary P less efficiently because the excess P is not being converted into milk. Wang et al. (2000) estimated that grouping strategies that allowed diet formulation based on production reduced whole-farm P balance by 9%.

Why do we overfeed P?

Phosphorus is often fed to dairy cattle in excess of published requirements because high P diets are commonly believed to improve reproductive performance. This perception originates from the observation that severe P deficiency (< 0.25% of dietary DM) impairs reproductive performance in cattle (Eckles et al., 1932). Modern dairy rations are much higher in P even without supplementation, and in all of these deficiency studies, P intake was seriously confounded with intake of energy and other minerals.

Although severe P deficiency may impair reproductive performance, there are no research data to suggest a benefit from feeding P to dairy cows in excess of NRC requirements (~0.37%P).

In fact several studies reported no impact of dietary P concentrations of 0.33 to 0.35% of dietary DM on days open, services per conception, or calving interval (Brintrup et al., 1993; Brodison et al., 1989; Wu and Satter, 2000). A review by researchers in Wisconsin (Satter and Wu, 1999) summarized thirteen studies with 785 lactating cows fed diets low in P (0.32 to 0.40% P) or high in P (0.39 to 0.61% P).Dietary P had no effect on days to 1st estrus, days open, services per conception, days to 1st AI, or pregnancy rate. (The apparent overlap in low and high P diets is because Satter and Wu categorized treatments low or high as they were categorized in the original studies. The 0.39% “high” P diet was not in the same study as the 0.40% “low” P diet.)

Two other factors that have led dairy producers to overfeed P are undetected variation in the P content of feeds, and inconsistencies between NRC requirements and the advice dairy producers receive. Undetected variation in the P content of feeds leads to imprecise ration formulation.

Phosphorus content of forages analyzed by the Northeast DHI Forage laboratory across one year was highly variable (Kertz, 1998). Phosphorus content varied by 20-25%, and was more variable in grasses than in legumes. Despite this variation, wet chemistry analysis of forages for P content is not routinely requested, and NIR analysis of P is not accurate.

One final reason P is overfed is the inclusion of feeds in the diet that are naturally high in P. Many byproduct feeds are high in P, most notably the byproducts of corn processing and ethanol production. These are increasingly popular feed supplements for dairy cattle because of the protein and energy they supply. However inclusion of these feeds often increases the dietary P content beyond requirements.

There is no easy answer to the dilemma of high P byproducts. In the short term, producers using these feeds should remove unneeded supplemental inorganic P from diets. In the long run the true cost of the use of these high P feeds should be carefully considered. If their inclusion will cause significant nutrient imbalance and lead to difficulty meeting environmental regulations, then these feeds may not be as inexpensive as they appear.

Benefits of reduced overfeeding

Reducing P intake has both economic and environmental benefits. The impact of reducing P intake on net farm income depends upon the regulatory conditions affecting the dairy producer. If the producer is not under P-based nutrient management, and applies manure without regard to its P content, the only impact of feeding excessive P is on the feed bill (Table 1). A 100 cow herd increases their feed bill by $750 to $850/year by feeding P at 0.45% of dietary DM vs. 0.40% dietary DM, depending on milk yield and feed intake. With P at .50% of dietary DM, the feed bill is increased between $1500 and $1700/yr, and at .55%, feed costs are increased between $2250 and $2500/yr.

For the producer under mandatory P-based nutrient management, the costs of excessive P supplementation and excretion are much greater. These costs include the increased feed bill, the cost of exporting manure in excess of what can be applied to land, and the cost of purchased N fertilizer.

Table 1. Increase in annual feed costs of a 100 cow herd relative to P at .4% of dietary DM[1]

		Dietary P, % DM		
MY, lbs/d	DMI, lbs/d	.45	.50	.55
60	45.6	$754	$1500	$2260
70	48.4	$798	$1603	$2402
80	51.2	$850	$1693	$2542

[1]Assumes increased inclusion of Dicalcium Phosphate at $350/ton.

Evaluating a dairy farm milking 100 cows with different cropping strategies, we can estimate the impact P intake has on acreage required for manure application on a P basis (Table 2).

Table 2. Impact of P intake on manure disposal under P-based nutrient management

	Dietary P content			
	.40	.45	.50	.55
Acres required for land application[1]				
100 cows	91	108	126	143
Maximum cow numbers[2]				
100 acres, 50% corn 50% alfalfa	93	78	68	60
100 acres, 50% corn, 25% alfalfa 25% grass hay	86	73	63	56

[1]Assumes cropping program of 50% corn, 50% alfalfa. DMI predicted from NRC, 2001, and crop nutrient uptakes as in Van Horn (1992);
[2]Milk yield of 60 lb/d.

Acreage required to use manure to meet (but not exceed) crop removal increases by about 60% as P intake increases from 0.4% to 0.55%. Alternatively, given a fixed land base and different cropping strategies, we calculated the maximum number of milking cows supported by that land base. As P intake increases from 0.40 to 0.55%, herd size must decrease by 35% to accommodate P-based manure application.

Summary

Reducing the amount of P in manure through nutrition is a powerful, cost effective approach to reducing potential P losses from dairy farms. The current NRC requirements are based on sound, current research, and should be followed in ration formulation. Feeding rations formulated to meet without exceeding the NRC requirements will improve P utilization, reduce environmental impact, and make it easier for producers to meet regulatory obligations.

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Project Information

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