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104 - ASSESSING PHOSPHORUS AND POTASSIUM FEEDING ON OREGON DAIRIES

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Introduction

Over the last decade, numerous field studies and surveys have reported overfeeding of phosphorus (P) to lactating dairy cows. In a field survey, Dou et al. (2003) reported that Northeastern dairy producers were feeding 0.44% P, which was 26% above the level recommended by the NRC (National Research Council, 2001) for 72 lb milk/d. Satter and Wu (1999) reported an average of 0.48% P in dairy rations based on a telephone survey of university extension personnel, nutrition consultants, and feed industry personnel. Much of the overfeeding has been attributed to a 1951 publication in which, Hignett and Hignett observed that P improved conception rate in dairy cattle. However, this improvement in conception rate was relative to cows consuming P deficient diets (less than 0.25%). Therefore, over the last 50 years the importance of the concentration of dietary P on reproductive performance has been overemphasized. Recent studies have shown no beneficial effect on reproduction when recommended dietary P concentrations are exceeded (Wu and Satter, 2000; Lopez et al., 2004).

The most recent edition of Nutrient Requirements of Dairy Cattle (NRC, 2001) reduced dietary P requirement to 0.34% compared to 0.38% P (NRC, 1989) for a cow producing 70 lb milk/d. The reduction in dietary P was initiated because of the negative impact P can have on the environment. Of all of the essential dietary minerals for dairy cattle, P represents

the greatest potential risk for environmental damage via pollution of surface water (NRC, 2001). The concentration of P in the feces is positively correlated to the concentration of P in the diet (Morse et al., 1992). Therefore, feeding P in excess of requirement will result in a greater amount of P being excreted. Recycling of P to crops, at rates greater than crop needs, allows P to accumulate in soil; increasing the amount of P available to potentially enter surface water. Thus, managing dietary P levels to reduce P excretion should minimize environmental contamination.

When applied in excess, some nutrients accumulate within the plant instead of the soil. One such nutrient is K and forges have the ability to consume K in luxury amounts (Brady and Weil, 1999). When excess K is applied to soil, this excess K is mirrored within the forage. Although K is not an environmental concern, it has been implicated in the incidence of metabolic disease around the time of calving. Since forages are the primary feed ingredients of the prepartum cow's diet, the use of high K forages increases the incidence of milk fever (Horst et al., 1997), which can lead to other metabolic diseases (Curtis et al., 1983). In 1998, Crill reported that Oregon dairy producers were overfeeding K by 2.5-fold in prepartum diets.

Field Study Description

A field study consisting of 37 Oregon dairy farms was conducted from July 2002 to July 2003. Participating farms were located in the western region of Oregon and were divided in two regions based upon geographic location of farms: valley (V) and coast (C). Valley comprised 17 farms residing in the Willamette Valley and located in Benton, Clackamas, Marion, Lane, Linn, Polk, Washington and Yamhill counties. The remaining 20 farms were located on the coast of Oregon in Coos and Tillamook counties. In addition to geographic location, farms were classified as either small (S) or large (L). Farms with herd size smaller then the herd size median, for each region, were classified as S. Likewise, farms with herd size larger than herd size median, for each region, were classified as L. Each farm was visited on three separate occasions to collect data. Data collection included: ration information, for both lactating and dry cows, individual feed ingredients as well as fecal and urine sample from the lactating and dry cow group. Individual feeds, fecal matter and urine were analyzed for P and K.

Overall, average herd size was 339 cows and ranged from 50 to 1650, with an average of 277 acres receiving manure. Producers were divided into groups based on geographic region (V or C) and herd size (S or L). Characteristics of these groups are summarized in Table 1.

Field Study Results

Feeding practices were similar for region and herdsize, therefore results are presented as an overall average of the participating farms as shown in Table 2. A difference in feeding practice between herdsize was expected since L herds are more apt to use professional services, such as nutritionist, compared to S herds. In addition, V herds were expected to have lower dietary P due to more consistent rations since C herds graze more often.

Table 1. Characteristics of participant farms.

	Coast		Valley	
	Small	Large	Small	Large
Number of farms	10	10	8	9
Herd size, cows	101	278	198	800
Milk Yield, lbs/d	56.5	64.9	77.7	78.3
Grazing (months)	7.8	6.7	4.8	2.4
Total acres receiving manure	171	292	209	428
Acres/Cow	1.69	1.05	1.06	0.54

Oregon dairy producers were feeding 0.40% P (DM basis) to lactating dairy cattle (Table 2). On average, these farms fed P 18% above the NRC (2001) recommendation for the given milk yield (68 lb/cow/d). The range in P feeding was 0.32 to 0.50%. Although P was being overfed, the magnitude of overfeeding was less than observed by other field studies. A Northeast field study conducted during 2002 found that dietary P concentrations ranged from 0.29 to 0.65% with a mean of 0.44%, which was 26% above the NRC recommendation for the given milk yield. Sink et al. (2000) reported dietary P content of 0.49% on Virginia dairies.

Dietary P content of the dry cow diet was 0.31%. On day 240 of gestation, dietary P requirement is 0.22% and increases to 0.26% near parturition (NRC, 2001). Therefore, Oregon dairy producers are overfeeding P to dry cows by 19 to 41%. Dry cows constitute only 12 to 17% of the dairy herd; nevertheless, feeding as close to recommendations is ideal for all dairy cattle despite stage of lactation.

Table 2. Concentrations of P and K in diets fed to lactating and dry cows, and concentrations of P and K in feces and urine.

	Lactating	Dry
Diet P, % DM	0.40	0.31
Fecal P, % DM	0.90	0.90
Urine P, mg/dl	2.58	1.73
Diet K, % DM	1.71	1.99
Fecal K, % DM	0.59	0.73
Urine K, mg/dl	0.98	11.3

Average fecal P concentration of lactating cow samples was 0.92% (DM basis) and mean urinary P was 2.58 mg/dl (Table 2). Wu et al. (2001) reported similar values for lactating cows consuming 0.39% P during a controlled experiment. Nearly all (>99%) P is excreted in the feces, which gives dairies the opportunity to export P off the farm. In contrast, the majority (≈83%) of K is excreted in the urine, resulting in few alternatives to exporting K off the farm.

Oregon producers are overfeeding K to both the lactating and dry cows. Average K content of lactating diets was 1.71% and dry cow diets averaged 1.99% (DM basis). Potassium feeding recommendations for lactating diets is approximately 1.0%, whereas dietary K should be limited to 0.62% or less in the dry cow diet (NRC, 2001). Oregon producers were overfeeding K by 58% in lactating diets and over 300% in dry cow diets. Because of the implications of K and metabolic disease in dry cow diets, we expected to see lower levels than that

fed to lactating cows. In 1998, average K in prepartum diets fed in Oregon was 1.67% (Crill, 1998).

Conclusions

Phosphorus is being overfed in lactating cow rations, but not to the extent reported in other states. A potential problem may exist with the limited land base which receives manure. The inability to apply manure at agronomic rates leads to accumulation of soil P and the potential for surface water damage. This should be of concern since the majority of Oregon producers reported surface water borders farm property.

Potassium continues to be overfed in the diets of both lactating and dry cows. Of particular concern is the increase in overfeeding that has occurred in dry cow diets over the last 5 years. The ability to grow low K forages for dry cow rations will continue to challenge the industry.

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TABLE 1. Phosphorus Requirements of Livestock

Type and Class of Animal	P Requirement % of diet dry matter	Comments
Beef Cattle (adapted from NRC,1996)		
Lactation	0.16%	90 d postpartum, 9 lb milk/d
Dry, pregnant, 1100 lb	0.19%	Last 3rd of pregnancy
Pregnant heifers, 900 lb	0.23%	Last 3rd of pregnancy
Steers, 550 lb, 1.5 ADG	0.24%	% P increases with increased % TDN
Steers, 1000 lb, 3.0 ADG	0.20%	
Dairy Cattle (NRC, 2001)		
Replacement heifers	0.27%	550 lb, 2 lb ADG,
Dry cows	0.23%	
Lactating cows	0.38%	120 lb milk, 90 d-in-milk
Horses (Perry et al., 2003)		
Maintenance	0.17%	Mature horses
Yearling	0.24%	12 mo old, moderate growth
Light work	0.22%	Western and English pleasure; equitation, etc.
Lactating mares	0.34%	Foaling to 3 months
Pigs (NRC, 1988)		
Sows, lactation	0.6% total P 0.35% available P	
Sows, pregnant	0.6% total P 0.35% available P	
Growing pigs, 22-44 lb	0.6% total P 0.32% available P	
Growing pigs, 110-242 lb	0.4% total P 0.15% available P	
Poultry (NRC, 1994)		
Leghorn laying hens	0.25% nonphytate P	
Leghorn chicks, 0-6 wk	0.40% nonphytate P	
Leghorn chicks, 6-12 wk	0.35% nonphytate P	
Leghorn chicks, 12-18 wk	0.30% nonphytate P	
Leghorn pullets, 18-Lay	0.32% nonphytate P	
Broiler chicks, 0-3 wk	0.45% nonphytate P	
Broiler chicks, 3-6 wk	0.35% nonphytate P	
Broiler chicks, 6-8 wk	0.30% nonphytate P	
Sheep (Kellems and Church, 2002)		
Ewes, maintenance, 154 lb	0.25%	
Ewes, pregnant	0.20%	Last 6 wk of gestation
Ewes, lactation	0.34%	
Replacement lambs, 66 lb	0.25%	

TABLE 2. Phosphorus Concentrations and Some Comparative Availabilities* of Various Dietary Phosphorus Sources

		Animal Species			
		Poultry	**Pigs**	**Horses**	**Cattle**
P Source	**% P**	***---P % Availability---***			
β tricalcium phosphate	20	100	---	---	75
Dicalcium phosphate	18.5	105-115	100	58	75
Sodium tripolyphosphate	25	95-102	---	58	75
Fish meal	2.2	100	95	---	---
Corn gluten meal	0.5	35	---	---	---
Yellow corn	0.28	35	---	---	---
Soybean meal 44	0.65	25	31	---	---
Barley	0.36	---	30	---	---
Cool season grass hay & silages	0.23-0.36	---	---	45	64
Legume hay & silages	0.28-0.36	---	---	45	64
Concentrates	variable	---	---	30	70
Canola meal	1.22	---	---	---	---
Wheat bran	1.29	---	---	---	---
Wheat mill run	1.13	---	---	---	---
Corn gluten feed	0.82	---	---	---	---
Whole cottonseed	0.58	---	---	---	---
Wheat straw	0.05	---	---	---	---

*Affected by physiological state and age of animal, total available P in the diet, and interactions with calcium and other minerals.

Figure 1. Phytate, the chemical form of much of the phosphorus in grains.