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Effects of Forage Maturity on Phosphorus Digestion in Beef Cows

A.S. Leaflet R1880

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Wendy Powers, Associate Professor of Animal Science
Jim Russell, Professor of Animal Science

Summary and Implications
For environmental reasons, minimizing phosphorus excretion from cattle is of great interest. Current estimates of forage phosphorus digestibility by cattle consider that phosphorus digestibility does not change with composition of the pasture. To better estimate phosphorus (P) excretion, estimates of P digestibility for forages of different compositions are needed. Four crossbred cow/calf pairs were stocked on four pastures managed with grazing (G) or grazing with hay removal (G/H). Forage was maintained in paddocks at 50% removal. Collected pasture samples and fecal samples from cows administered chromic oxide were analyzed for P, NDF, and ADL contents. Rumen evacuations of steers were conducted to evaluate composition of consumed forage for each treatment. Forage analyzed from paddocks where steers grazed demonstrated no grazing management effects on composition, which was evidenced by no differences in composition of rumen contents of the steers. Analysis of the 13th rib bone concludes the cattle were not deficient in phosphorus. Year 1 results suggest that pastures managed under a combination of grazing and initial hay removal resulted in greater P content of the forage and concomitant increased P excretion by cows consuming that forage. There was no treatment effect for P retention, however a there was a date effect with the G treatment having higher P retention in July and September. These results verify that grazing management practices can have a substantial effect on water pollution potential.

Introduction
Pending environmental regulations in Iowa and nationally will restrict the land application of phosphorus in some areas. Phosphorus consumed by cattle is either digested and absorbed or excreted, primarily in feces. By predicting the amount of phosphorus cows are consuming and digesting from a pasture of a given maturity, producers can estimate how much phosphorus is excreted and use these estimates for assessing nutrient management strategies. Studies determining the digestibility of phosphorus contained in forages are limited. Current estimates of forage phosphorus digestibility by beef cattle (National Research Council, 1996) consider that phosphorus digestibility does not change with stage of maturity of the forage. However, in order to better estimate phosphorus (P) excretion, accurate P digestibility coefficients that are specific to stage of hay and pasture maturity are needed. The objective of this study is to determine the apparent digestibility of P for pastures at two different maturities by using a rotational stocking system with and without supplemental hay removal. The two treatments used in this study are 1) grazing (G) and 2) grazing with hay removal (G/H), which could be considered less mature because the cows were grazing the grass much more intensely throughout the grazing period.

Materials and Methods
Four pastures of approximately five acres each were used at the Iowa State University Beef Nutrition Farm in Ames, Iowa. Pasture forage consisted of smooth bromegrass (Bromus inermis) predominately. Each pasture was randomly assigned to either a gazing or a grazing/hay pasture management. The grazing/hay treatment was obtained by using a rotational stocking system utilizing 60% of the pasture for hay and 40% for grazing (G/H). This treatment consisted of four paddocks until the re growth after the hay cutting was ready and then the pasture was divided into 10 paddocks. The grazing treatment utilized 100% of a rotational stocking system (G). This treatment consisted of 10 paddocks throughout the entire grazing period. During the first month of the grazing period cows were rotated between paddocks everyday to keep ahead of the forage growth. After the first month, paddocks within each pasture were maintained to 50% forage removal.

Cows
Four groups of four cow-calf pairs were used to evaluate the effects of forage maturity on phosphorus digestion in a grazing system. Cow weight and body condition score of the sixteen crossbred cows was measured and recorded over a two-day period at the beginning of the grazing season, the conclusion of grazing, and every 28 d. Body condition score was measured using a scale of one through nine. A score of one consisted of an extremely emaciated cow and a score of nine considered an obese cow (Boyles, et. al., 1992). Calf weights were measured every 28 d.

Digestibility Trial
During three week-long periods in May, July, and September, an indigestible marker, chromic oxide, was administered to the cows (six g/d) in order to determine
mass feces voided. Feces were collected during the last three
d of the seven d period. Fecal samples were analyzed for P
(A.O.A.C. Total Phosphorus Determination Method
#973.56), NDF, ADL (A.O.A.C. Method # 973.18; adapted
for use with an instrument ANKOM Technology, Fairport,
NY), and chromium content (A.O.A.C. Method # 993.23).

**Forage Selectivity Trial**

Four fistulated steers were used to determine the forage
selection pattern of the cows. Rumen contents of the steers
were collected and analyzed in order to determine chemical
composition of consumed forage. Rumen evacuations of
each steer were performed during four periods throughout
summer grazing. Each steer was randomly assigned to a
pasture and was allowed to graze with the cows for five d.
On day six, the rumens of the steers were completely
emptied. Following evacuations, the steers were returned to
the pastures to graze for two h. Grab samples of the rumen
contents were collected. The rumen was cleaned once again,
and the steers were not allowed feed or water for two h.
Saliva samples were collected from the rumen and analyzed
total phosphorus content in order to estimate the
contribution of salivary phosphorus to total phosphorus
ingested. Collected rumen contents were analyzed for P,
NDF, and ADL content.

**Pasture Composition and Maintenance**

Pastures were maintained at 50% forage removal level
by using a rising plate meter, 8.8 lbs/yd² (4.8 kg/m²),
(Hermann et. al., 2002). Six random measurements were
collected in grazed paddocks. An initial height was obtained
followed by daily monitoring until 50% of the forage had
been removed. Cows were then moved to the next paddock
where sward heights were monitored. Following initial hay
removal from the G/H treatments, a 30-d re-growth period
was allowed before grazing occurred.

Forage samples were clipped every 28 d from each
pasture using a hand clipper. A 0.3 yd² (0.25 m²) square
made of PVC pipe was tossed randomly twice in each
paddock within the pasture. All of the clipped forage from
each pasture was compiled into a composite sample from
each pasture. The composite sample of the pasture was
analyzed for P, NDF, and ADL content.

Concurrent with the composite pasture sampling every
28 d, one 0.3 yd² (0.25 m²) square was hand clipped from
each paddock within the pasture and sorted by maturity
class (Moore et. al., 1991). Each maturity class was weighed
and the stems counted to calculate the percentage that each
maturity class represented of the total sample.

During the rumen evacuations, a 0.3 yd² (0.25 m²)
square was used to randomly sample the forage within the
paddock the steers were grazing. The equivalent of two
squares of grass were hand clipped using grass clippers.

This grass was sorted by maturity using a maturity chart
(Moore et. al., 1991). Each of the maturities was weighed,
the stems counted and recorded. All samples were analyzed
for P, NDF, and ADL content.

**Phosphorus Retention**

Using the in vitro dry matter digestibility of the
collected rumen content samples (rumen content samples
were used to simulate what the animals were actually
choosing to eat), forage intake and phosphorus retention of
each animal was calculated and compared between
treatments using the following equations.

\[
\text{Feces Production (kg)} = \frac{(\text{Chromium Intake (g)})}{(\text{Chromium in Feces (\%)/100})}/1000
\]

\[
\text{Intake (kg)} = \frac{\text{Feces Production (kg)}}{(1-\text{Digestibility of Rumen Content Samples})}
\]

\[
\text{Phosphorus Intake (g)} = (\text{Forage Intake (g) * (Forage Phosphorus (\%)/100)})/1000
\]

\[
\text{Phosphorus Output (g)} = \text{Feces Production (g) * Fecal Phosphorus (\%)}
\]

\[
\text{Phosphorus Retention (\%)} = \frac{(\text{Phosphorus Intake (g) - Phosphorus Output (g)})}{\text{Phosphorus Intake (g)}}*100
\]

**Bone Biopsies**

The cows were not supplemented with any phosphorus
during the grazing period. Bone phosphorus content can be
used as an indicator of P status in the animal (Crenshaw et.
al., 1981). Bone biopsies were performed on each cow at the
end of the grazing period to assess treatment effects on bone
status. Force need to break the bone cleanly was
determined. The bones were then de-fatted and analyzed for
total phosphorus using the method previously described.

**Results and Discussion**

Treatment did not have an effect on cow weight (G =
658 kg, G/H = 644 kg; P = 0.4344) or body condition score
(G = 5, G/H = 5; P = 0.5683). Also, there was no significant
date by treatment interaction (P >0.05).

Treatment differences occurred for P (G = 0.41, G/H =
0.48; P = 0.0087) and dry matter content (DM) (G =
33.97%, G/H = 25.65%; P = 0.0020) in the monthly pasture
samples. Dry matter differences may be attributed to greater
amounts of dead plant material in the G pastures. No
significant treatment differences (P > 0.05) were observed
for NDF (G = 63.03%, G/H = 61.95%) or ADL (G = 23.58
%, G/H = 22.86%) content in the pasture samples.

No grazing management effects were observed for
composition of the samples clipped from paddocks where
steers grazed (Table 1) however, a significant date ×
treatment interaction was observed for P (P < 0.0001) and NDF (P = 0.0002) of the rumen samples. The P content in the G pastures decreased throughout the grazing period (0.47, 0.47, 0.39, and 0.38% for May 22, May 23, July 17 and September 7 sampling dates). The P content of the G/H pastures corresponded to 0.43, 0.45, 0.72, and 0.50% for May 22, May 23, July 17, and September 7 sampling dates, respectively (P < 0.0001; Table 1). The increased P content in July may be attributed to a greater regrowth period resulting from less intensive grazing when more paddocks were made available following hay removal.

Table 2 depicts harvest date effects on the chemical compositions of each maturity class from forage samples collected in paddocks grazed by steers. Forage samples collected on July 17 contained less NDF (53.66%) than samples collected in May 22, May 23, and September 7 (62.76, 67.94, and 59.75%, respectively; P < 0.0001). Forage samples collected on July 17 and September 7 contained less ADL (12.91 and 11.54% NDF, respectively) than forages collected on May 22 and May 23 (21.71 and 21.98% NDF, respectively; P < 0.0001). Phosphorus composition differed between maturity classes (P = 0.0353, Table 2). The NDF and ADL contents were not significantly different between classes. No significant treatment or date × maturity interactions were observed for forage composition.

Fecal excretion from cows demonstrated a significant date × treatment interaction for P (P < 0.0001), NDF (P = 0.0005; Table 3). Grazing management effects were significant for P (P < 0.0001) and grams of P excreted (P < 0.0344) with the G/H pasture containing greater P concentration (Table 3). Grazing management did not show an effect on bone breaking strength or bone phosphorus content in cows (G/H = 125 mm of force, G = 117 mm of force, P = 0.7073). Bone P was not significantly different between grazing management practices (G/H = 17.08% P, G = 17.14% P; P = 0.8462).

Treatment did not have an effect on P (0.62%), NDF (46.2%), ADL (12.56%), or saliva P (1.38%) composition of rumen contents (P > 0.05). Using only one steer per pasture provided limited degrees of freedom when analyzing these data. While the data tends to show differences, there were insufficient observations to demonstrate significance.

Treatment did not show an effect for phosphorus retention in the months of July and September (July: 27% G; 14% G/H and September: 37% G; 18% G/H). The cattle on the G treatment showed a date effect for forage intake (P < 0.0001) and a treatment effect for fecal phosphorus (P < 0.0001). The cows on the G treatment had a mean excretion of phosphorus of 1.03% and the G/H treatment had a mean fecal phosphorus concentration of 1.24%. These factors show the cattle on G treatment retained more phosphorus over the course of the summer.

Overall the cows on the G/H treatment had greater P excretion and lower P retention in months when the P content of the forage was statistically higher than the G treatment. In July the cows on the G/H treatment excreted on average 82 g of P, with cows on the G treatment excreting 101 g of P. Cattle on the G treatment excreted 20% less P than cattle on pastures with supplemental hay removal. This study indicates that pasture and grazing management can play a large role in the water pollution potential of individual farms.

Acknowledgment

The authors would like to thank Mr. Rod Berryman and the Iowa State University Beef Nutrition Farm, and the Iowa State University laboratory staff of Dr. Wendy Powers for their support and assistance during this project.

References


### Table 1. Paddock composition clipped during rumen evacuations from each pasture under one of two management systems.

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<tr>
<th>Date</th>
<th>P, %</th>
<th>NDF, %</th>
<th>ADL, % NDF</th>
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<th>NDF, %</th>
<th>ADL, % NDF</th>
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<td>5/22/02</td>
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<td>5/23/02</td>
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### Table 2. Composition of maturity classes sorted from forage samples clipped during rumen evacuations from paddocks in pastures under one of two management systems.

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<th>V2</th>
<th>V3</th>
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<th>E1</th>
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aMaturity classes as described by Moore et al., 1991.

V= vegetative stage of growth
E= elongation stage of growth
R= reproductive stage of growth
Each number represents a subset of the stage of growth
The other category was for weeds, dead material, and unidentifiable parts.

bSamples are pooled across grazing management practice (P > 0.05 for % P, % NDF). Sampling date was significant for % NDF (P < 0.0001). Maturity class was significant for % P (P = 0.0353).
Table 3. Composition of fecal excretion from cows grazing pastures managed under one of two management systems.

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<th>ADL, % NDF</th>
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