# Dietary Phosphorus as Related to Clinical and Reproductive Performance in Cattle

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### Summary

During a 10-year period, 96 Hereford females were individually fed diets in which dietary phosphorus (P) ranged from 10 to 35g P/day, 9 to 13g P/day, 6g P/day or less. Symptoms of P deficiency developed within 12 months in animals fed 6g P/day or less. The clinical changes were body weight loss, reduced feed intake, decreased blood and urine P levels, bone depletion, reproductive failure and finally death. Cows showed evidence of recovery within 2 months after receiving 12g or 19g P/day.

Thirty-four Holstein cows in their second lactation were individually fed P levels for one year that were 60, 80, or 105R of NRC requirements. Feed intake, body weight, milk production, % protein in milk, and blood and urine P levels were reduced in cows receiving diets containing 60% of NRC requirements. Reproduction was not affected by P levels.

Results indicate that 12g of P/day for a 450 kg beef cow, or P equal to 80% of NRC requirements for a 592 kg high-producing dairy cow, are adequate. Phosphorus deficiency seldom occurs in a simple uncomplicated form.

### Introduction

The importance and known functions of phosphorus (P) in cattle are well established (1, 6). Phosphorus deficiency has been reported to be widespread and a common nutritional problem in cattle (6, 9). There are conflicting reports in the literature concerning the influence of dietary P for reproduction, growth, feed intake, milk production, blood P. values and mineral imbalance (1-5, 7, 8). There is also disagreement concerning the P levels necessary for normal health. This research defines adequate levels of dietary P, the clinical symptoms and reproductive performance associated with P deficiency in cattle.

### Materials and Methods

Ninety-six Hereford heifers were individually fed different levels of P for 10 years. Their mature weight averaged 450 kg. The basic diet consisted of alfalfa, wheat straw, beet molasses and molasses dried beet pulp. The amounts were varied to maintain adequate nutrition. The various dietary P levels (Table 1) were obtained by top dressing the basal diet with monosodium phosphate. The experiment was divided into four phases: I, growing (1-2 years); II, mature (3-5 years); III, half of cows fed diets 1 and 2 were transferred to diet 3 (6-7 years); and IV, recovery (8-10 years).

TABLE 1. Phosphorus intake in g/day, percent protein, and Ca: P ratio in cows given different amounts of dietary P.

| | g of P/day/Cow Diets | | | Protein % Diets | | | Ca: P (ratio) Diets | | |
|---|---|---|---|---|---|---|---|---|---|
| **Phases*** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| I | 21 | 6 | — | 16 | 16 | — | 2 | 8 | — |
| II | 35 | 11 | — | 14 | 13 | — | 3 | 8 | — |
| III | 35 | 9 | 6 | 11 | 11 | 11 | 2 | 6 | 8 |
| IV | 19 | 12 | — | 13 | 13 | — | 4 | 6 | — |

*Phases: I, growing (2 yrs); II, mature (3 — 5 yrs); III, Half of cows from diets 1 and 2 were transferred to diet 3 (6 — 7 yrs); IV recovery (8 — 10 yrs).

Thirty-four high producing dairy cows, each pregnant with their second calf, (592 kg average weight) were individually fed a basal ration of alfalfa hay, corn, molasses dried beet pulp, soybean hulls and urea (limited to less than 1% of diet) for one lactation. The basal ration contained 60% of National Research Council (NRC) (7) requirements and the other two diets 80 and 105% of NRC requirements were developed by top dressing rations with monosodium phosphate. Diets were altered for individual cows according to milk production. Animals were fed to voluntary intake.

The beef and dairy cows were tied to individual stalls for feeding, and had access to open sheds with free stalls when not tied. A vitamin-mineral supplement and water was provided free choice. Feed consumption was measured and recorded daily. Feed composition was carefully monitored by periodic chemical analyses during the experiment. The Herefords were bred by bulls and the dairy cows were artificially inseminated.

Animals were weighed and blood, urine and feces samples were analyzed. Milk from the dairy cows was weighed daily and analyzed for fat, protein and phosphorus.

### Results and Discussion

There were no detectable differences in beef cow response

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TABLE 2. Body weights (kg) average daily intake (kg of DM) and reproductive performance of cows given different amounts of dietary P.

| Phases* | Body Weights (kg) Diets 1 | 2 | 3 | Daily Intake Dry Matter (kg) Diets 1 | 2 | 3 | Reproduction Calving (%) Diets 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| I | 156 | 158 | — | 3.6 | 3.6 | — | — | — | — |
| II | 435 | 421 | — | 7.9 | 7.9 | — | 100 | 94 | — |
| III | 500 | 488 | 408 | 6.6 | 6.6 | 6.1 | 80 | 95 | 13**<br>100** |
| IV | 478 | 490 | — | 7.1 | 7.1 | — | 100 | 96 | |

*Phases are: I, growing (2 yrs); II, mature (3 — 5 yrs); III, half of cows from diets 1 and 2 were transferred to diet 3 (6 — 7 yrs); IV recovery (8 — 10 yrs), see table 1.

**Failure and recovery of reproduction on diet 3 (6 — 7 yrs).

during phase I (growth and maturation) and phase II (mature - 3½ gestations), Table 2.

Body weights did not differ significantly between diets 1 and 2. Body condition scores were consistent with body weights. There was no significant difference in feed intake between the two diets during the first two phases (Table 2).

The percentage of protein and Ca:P ratio are shown for all four phases (Table 1). Data on the Ca:P ratio indicate that any confounding effect due to the wide ratios was small or insignificant. The reduction in grass of P in diet 2, phase III, was due to adjustments in energy and protein concentration in the diet. There was adequate energy and protein for all phases except when animals voluntary intake decreased as a result of low P (Table 2).

During phase III, when some animals were placed on diet 3 (6 g P/day or less) they began developing clinical signs after 6 to 12 months. These cows consumed significantly less feed throughout phase III. Weights of cows fed the different diets did not differ significantly until calving in year 7, although their weight (diet 3) tended to decrease during year 6. These changes persisted through phase III. Necropsied animals from diet 3 were extremely emaciated due to inappetance caused by the stress of low P diet. Symptoms of P deficiency varied among animals, especially on diet 3.

Depraved appetite tended to occur more frequently among cows on diet 3. Significantly less urinary P was excreted as dietary P levels decreased (diet 1—45.2 mg P/100 ml, diet 2—.49 and diet 3 approximately 0). Blood P was significantly lower in diet 3.

During phase III (year 7), 87% of the cows on diet 3 failed to breed during the regular season (Table 2). This was a major factor in deciding to increase the dietary level of P in diet 3 of phase IV (Table 1). Cows on diets 1 and 2 had excellent calving performance throughout the experiment.

In phase IV, cows on diet 3 regained their appetite, gained weight and appeared clinically normal when P levels were increased from 12 to 19 g P/day. After two months, all cows previously on diet 3 successfully rebred. These data indicate that dietary phosphorus of 12 g P/day is adequate for 450 kg beef cows, which is approximately 30% below the levels commonly recommended (8). Body stores of P allow seasonal variation in P intake if the average can be maintained at 12 g P/day. These conclusions are also supported by field research (5).

The dairy cows fed 60% NRC requirements for P showed the same general clinical syndrome as the beef animals fed 6 g P/day or less. Cows fed 80% or 105% of NRC requirements did not show clinical symptoms. Feed intake and body weight were significantly reduced in the cows fed 60% of the NRC requirements (Table 3). Serum P of the cows on the 60% level was significantly lower than the 80% and 105% levels (Table 3). The urine level tended to be lower (.36 mg of P/100 ml) in the 105% diet. The P level of urine from cows on the 80% diet was highly variable and averaged slightly higher than the urinary P level of the 60% diet.

The average daily fat corrected milk (FCM) was significantly lower for the 60% diet from week 18 through week 42 of lactation than the FCM from the other two diets. Milk from cows receiving the 60% diet had a significantly lower protein concentration after six weeks of lactation (Table 3).

Reproductive performance (Table 3) suggests that reproductive efficiency tended to be higher for the 60% diet, a trend that is difficult to explain unless it was related to the lower milk production in the 60% diet. Results indicate that P deficiency per se will not affect reproduction until malnutrition occurs.

After a year, dairy cows fed 60% of NRC requirements for P showed reduced feed intake, lower body weight, decreased milk production, and had low serum and urine level but no hemoglobinruia. The 80% P level appeared adequate for high producing cows during the period of this experiment.

TABLE 3. Average daily feed intake (Mcal of DE), body weight (kg), fat corrected milk/day (kg), % protein in milk, serum phosphorus (mg/100 ml) and reproduction for dairy cows on 3 different P levels.

| | Dietary P as % NRC 60 | 80 | 105 |
|---|---|---|---|
| Feed Intake (Mcal of DE) | 50.3 | 65.3 | 66.1 |
| Body Weight (kg) | 565.0 | 621.0 | 591.0 |
| Serum Phosphorus (mg/100 ml) | 3.6 | 5.0 | 5.1 |
| Fat Corrected Milk (kg) | 17.3 | 22.2 | 21.2 |
| Percent Protein in Milk | 3.14 | 3.35 | 3.34 |
| Parturition to Pregnancy (days) | 82.0 | 135.0 | 87.0 |
| Breeding/Conception | 1.3 | 1.9 | 1.5 |

**References**

1. Agricultural Research Council: 1980 Commonwealth Agric. Bureaux., England, Gresham Press. 2. Call, J.W., J.E.Butcher, J.L. Shupe, et. al.: 1986, Am. J. Vet. Res., 47:475-481. 3. Carstairs, J.A., D.A. Morrow & R.S. Emry: 1980, J. Animal Sci., 51:1122-1130. 4. Kincaid, J.K., J.K. Hillers & J.D. Cronrath: 1981, J. Dairy Sci., 64:754-758. 5. Marsh, H., K.F. Swingle, R.R. Woodward, et. al.: 1959, Mont. Agr. Exp. Sta. Bul. No. 549, Bozeman, MT. 6. Maynard, .A., J.K. Loosli, H.E. Hintz & R.G. Warner: 1979, Animal Nutrition, 7th Edition, McGraw-Hill Book Company, p. 1-602. 7. National Research Council: Nutrient Requirements of Dairy Cattle: 1978, 5th revised ed., National Academy of Sciences, Washington. 8. National Research Council: 1984, Nutrient Requirement of Beef Cattle, Washington, D.C., National Academy Press. 9. Underwood, E.J., 1981, London, England, CAB Books.