INFLUENCE OF DIETARY PHOSPHORUS LEVEL ON GROWTH AND REPRODUCTION OF GROWING BEEF HEIFERS

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SUMMARY

An experiment was conducted to study the effect of two levels of dietary phosphorus (either .12 or .20% dry basis) on growth and reproductive performance of growing beef heifers. Experimental duration as from 525 to 772 days in length, depending on slaughter date of individual animals. The experiment consisted of a phosphorus depletion phase (270 days), an adaptation period to the basal phosphorus supplementation diet (10 days) and a phosphorus supplementation phase (ranging from 245 to 492 days in length). The experimental period was 245 days of phosphorus supplementation phase for nonpregnant and 3 weeks postpartum for pregnant heifers.

Results of the study suggest that .12% phosphorus (dry basis) does not optimize growth response in young growing heifers as heifers fed .20% P outgained ($P < .05$) heifers that received the lower phosphorus level during the 210 day <u>ad libitum</u> feeding period of the phosphorus supplementation phase. Heifers fed the .20% phosphorus level also tended to consume more feed and be more efficient in its utilization.

Although phosphorus insufficiency has been reported to lower reproductive performance in beef cattle, in the present study, .12% phosphorus was not detrimental to onset of puberty or conception rate. Results herein may suggest that for a limited time .12% phosphorus is adequate to maintain reproductive performance in young heifers.

INTRODUCTION

The importance of phosphorus in ruminant diets worldwide is well established and is probably the nutrient (except salt) most frequently given as a supplement to grazing ruminants. Almost every phase of performance in beef cattle production has been reported to be depressed by a deficiency of phosphorus, such as voluntary feed intake, feed efficiency, growth, body condition and all aspects of reproduction.

To date, a considerable volume of research has been published on the requirements of phosphorus in beef cattle nutrition; however, there is no clear consensus on the requirements of this mineral element in ruminants. The objective of the present study was to compare the influence of two dietary levels (.12 and .20%, dry basis) of phosphorus in a long-term study on growth and reproduction in growing beef heifers.

MATERIALS AND METHODS

The duration of the present experiment ranged from 525 to 772 days. The experiment consisted of a phosphorus depletion phase (270 days), an adaptation period to the basal phosphorus supplementation diet (10 days) and a phosphorus supplementation phase (ranging from 245 to 492 days in length; common experimental endpoint was day 245 of phosphorus supplementation phase for nonpregnant and 3 weeks postpartum for pregnant heifers).

Fifteen weaned Angus heifers, 7 to 8 months of age, initially weighing 352 lb, were housed under dry lot conditions on concrete floors in a covered barn and allowed ad libitum intake of a low phosphorus diet (Table 1) during the 270 day phosphorus depletion phase.

At the end of this period, heifers were allowed a 10 day adaptation period to the basal phosphorus supplementation diet (Table 1). In the phosphorus supplementation phase of the experiment, heifers (averaging 462 lb) were allotted randomly (seven animals/group) to one of two dietary levels of phosphorus: (1) continuation of low phosphorus (LP) basal diet containing .12% phosphorus (dry matter basis), or (2) high phosphorus (HP) diet, consisting of basal diet supplemented to provide .20% total phosphorus (Table 1). Basal diets fed during the course of the experiment were formulated to be low in phosphorus yet provide adequate energy, protein, other minerals and vitamins to obtain approximately 1.1 lb/day gain. Calcium to phosphorus ratios in the phosphorus supplementation phase ranged from 3.1:1 in the HP diet, 5.2:1 in the LP diet and 6:1 for the P depletion diet.

Heifers were group-fed ad libitum their respective treatment diets for the initial 210 days of the phosphorus supplementation phase. Feed intake was then restricted in at attempt to control body condition in order to minimize potential calving difficulties. Throughout this period, feed intake was recorded daily for each group. Feed offered was periodically sampled for chemical analyses. Heifers were weighed at 2 week intervals at 8 am prior to feeding.

All heifers were bred naturally during a 120 day exposure to a single fertile bull (from day 94 to 214 of the supplementation phase). Heifers had access to the bull twice daily during the breeding period. Ovarian activity of heifers was monitored monthly for follicle and luteal structures by rectal palpation from day 85 to 239 of the supplementation phase (six palpations total). After the final palpation, two heifers from both LP and HP groups were diagnosed as nonpregnant and were slaughtered on day 245 of the supplementation phase.

Remaining pregnant heifers (five per group; 10 total) were maintained until 3 weeks postpartum at which time they were slaughtered. Calving occurred between day 387 (birth of first calf) and 471 (birth of last calf) of the phosphorus supplementation phase. Calves were weighed at day of birth and 3 weeks of age.

TABLE 1. COMPOSITION OF BASAL DIETS FED DURING PHOSPHORUS DEPLETION AND SUPPLEMENTATION PHASES (DRY BASIS)[a]

	Amount	
Ingredient	Depletion phase	Supplementation phase
Citrus pulp	30.0	35.0
Cottonseed hulls	30.0	17.5
Soybean hulls	-	20.0
Coastal Bermudagrass hay ground, pelleted	15.5	-
Cardboard paper, ground	10.5	11.0
Cane molasses	10.0	10.0
Animal fat	-	2.5
Urea	2.0	2.0
Mineral premix	2.0	2.0
Vitamin A and D	+	+
TOTAL	100.0	100.0

[a]Average phosphorus content of basal diet; phosphorus content varied from .11 to .13% during course of supplementation phase, dry-matter basis. Monofos™ (Pitman-Moore, Mundelein, IL) was added to the basal diet at the expense of cane molasses to achieve .20% *total* phosphorus in supplemented diet.

RESULTS AND DISCUSSION

Average daily gain of heifers during the 270 days phosphorus depletion phase was .42 lb/day. Gains similar to those observed in this phase have been reported elsewhere. Signs of pica (abnormal appetite) exhibited by excessive wood chewing were observed in all heifers during the phosphorus depletion phase; however, this behavior was not seen during the phosphorus supplementation phase in either treatment group.

After receiving the phosphorus supplemented diet for 28 days, HP heifers had higher ADG than unsupplemented controls. The HP heifers continued to gain faster throughout the 210 day period. Decrease in average body weight of heifers seen in both treatment groups from day 127 to 140 of the phosphorus supplementation phase was likely associated with the introduction of the bull.

Total gain (lb) and ADG (lb/day) were greater ($P<.01$) for HP than LP heifers (Table 2) over the 210 day ad libitum feeding period of the phosphorus supplementation phase. The total gain and ADG values represent a 20% benefit to phosphorus supplemented heifers. The HP heifers consumed more feed (11%) and

TABLE 2. INFLUENCE OF DIETARY PHOSPHORUS LEVEL ON TOTAL GAIN, AVERAGE DAILY GAIN, TOTAL DRY-MATTER INTAKE AND FEED:GAIN OF HEIFERS DURING 210-DAY AD LIBITUM FEEDING PERIOD OF PHOSPHORUS SUPPLEMENTATION PHASE

	Dietary phosphorus level, % DM		
Item	.12	.20	SEM[a]
Total gain (lb)[b]	451	565	22.88
Average daily gain (lb)[b]	2.16	2.68	0.112
Total dry-matter intake (lb)	33196	37341	-
Feed:gain	10.51	9.44	-

[a] Standard error of the mean.
[b] LP and HP means differ ($P<.01$).

also tended to be more efficient (10%) than LP heifers (Table 2).

The higher ADG values exhibited during the ad libitum feeding period of the phosphorus supplementation phase (i.e., 2.16 and 2.68 lb/day for LP and HP heifers, respectively) compared to that of the phosphorus depletion phase (.42 lb/day) are probably associated with such factors as compensatory gain and differences in acceptability in diet formulations between the two experimental phases.

Table 3 shows the influence of dietary phosphorus and date of palpation on ovarian volume estimated by rectal digital measurements. Only the first four of the six palpations were used in statistical analysis, as the final two palpations were performed only for pregnancy diagnosis. Heifers were 18 to 19 months of age at the time of first palpation (October 14, 1983). There was no dietary phosphorus level palpation date interaction ($P>.10$). Dietary phosphorus also had no effect ($P>.10$) on either right, left or total ovarian volume (i.e., right plus left ovarian volume).

Prior to the initial palpation, no estrous behavior was observed in heifers of either treatment group. Only 1 of 14 heifers had a corpus luteum (CL) at the initial palpation. Three heifers in each group were found with 4 mm or larger follicles during this initial palpation. Also, all heifers were regarded as having prepubertal uteri initially, with the exception of the HP heifer with the CL. By the third palpation, six heifers in each group had normal cycling uterine tonus and also possessed CL.

Puberty of heifers can be influenced by many factors, including hormones, genetics, environment and nutrition. Perhaps the reduced body weight per day of age during the phosphorus supplementation phase had effect on the low sexual activity observed in all heifers (heifers 462±3 lb and 16 to 17 months of age at initiation of the phosphorus supplementation phase). Age and weight of the heifers in this study are considered within the range of values (7 to 18 months of age and 440 to 990 lb) suggested as normal for initiation of puberty in heifers. Molybdenum was added to the basal diet (Table 1) at the rate of 5 ppm (dry basis). Phosphorus depletion and supplementation basal diets analyzed 4.30 and 4.70 ppm, respectively (Table 1). A recent report indicated that molybdenum induced infertility and low conception rates in cattle fed 5 ppm DMB. These authors reported that low copper status induced by high molybdenum levels was associated with depressed growth rate and impaired reproductive performance; however, they point out that altered secretion of luteinizing hormone suggests that molybdenum may have an early effect on the hypothalmic-pituitary axis. Copper levels in the present trial, 13.8 and 14.9 ppm for the basal phosphorus depletion and supplementation diets, respectively, were above recommended levels of 8 ppm and may have provided some protection against high dietary molybdenum levels.

Five of seven heifers in the HP group were found to be pregnant and six of seven in the LP group. Birth weight of calves were greater ($P<.10$) from HP than LP dams (Table 4). One calf was stillborn in the HP group and another HP calf died during the 21-day postpartum period unrelated to treatments. All five calves born to LP heifers survived the 21-day period following parturition. The HP calves gained more weight (Table 4) than LP calves (15.7 vs. 12.2 kg, respectively) over the 21-day postpartum period; however, the HP least square mean is based on only three calves. Similarly, calf ADG was greater for HP calves (Table 4). This could possibly be related to increased milk yield from HP heifers; however, this variable was not quantified.

There appears to be wide variation in defining minimum phosphorus requirements for the various phases of reproduction in female beef cattle. Phosphorus deficiency is accepted as a major nutritional factor depressing reproductive efficiency in mammals. In some studies, ovarian function and fertility of bovine females appear to be quite sensitive to phosphorus intake, whereas other work has failed to show a diminished reproductive performance of animals on low phosphorus diets. Results of the present experiment would suggest agreement with the latter proposition that low dietary phosphorus in heifers per se did not affect reproductive performance through breeding and gestation. This may not be true for more than one reproductive cycle.

TABLE 3. INFLUENCE OF DIETARY PHOSPHORUS LEVEL AND TIME OF PALPATION OF RIGHT, LEFT AND TOTAL OVARY VOLUME

Item	Palpation Date								
	10/14/83 LP[b]	(85)[a] HP[b]	11/10/83 LP	(112) HP	12/16/83 LP	(148) HP	1/16/84 LP	(179) HP	SEM[c]
Right ovary (mm^3)[d]	1937	2959	2560	4738	4062	3403	6841	8775	1048.3
Left ovary (mm^3)[e]	1751	1463	4147	3561	2832	4794	6061	5170	874.2
Total volume (right ± left) (mm^3)	3688	4422	6707	8299	6894	8197	12902	13945	1053.3

[a]Day of phosphorus supplementtion phase.
[b]LP (low phosphorus; .12% P, dry matter basis); HP (high phosphorus; .20%, dry-matter basis).
[c]Standard error of the mean.
[d]Quadratic period effect ($P<.05$).
[e]Linear period effect ($P<.01$).

TABLE 4. INFLUENCE OF DIETARY PHOSPHORUS LEVEL ON CALF BIRTH WEIGHT, CALF WEIGHT CHANGE AND CALF AVERAGE DAILY GAIN FROM PARTURITION TO 3 WEEKS POST-PARTUM (21-DAY PERIOD)[a]

Item	Dietary phosphorus % DM		
	.12	.20	SEM[b]
Calf birth weight (lb)[c]	49.9	59.2	3.52
Calf weight change (lb)	26.8	34.5	3.76
Calf average daily gain (lb)	1.28	1.65	0.18

[a]Means are based on the following number of animals per treatment group: 5 and 5 for LP and HP groups, respectively, for calf birth weight; 5 and 3 for LP and HP groups, respectively, for calf weight change and calf average daily gain over the 21-day period from day of birth to 3 weeks postpartum.
[b]Standard error of least square mean.