Effects of Supplementing High Levels of Cu, Co, Mn, and Zn After Calving on Productivity of Two-Year-Old Cows

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When cow management, health and nutrition are adequate, supplementation of trace minerals at high levels is not beneficial and may in fact be detrimental to reproductive performance.

Summary

A two-year study evaluated effects of supplementing Cu, Co, Mn and Zn at levels above NRC recommendations on reproduction and trace minerals in liver of two-year-old cows. Cows (n=236) were assigned to one of three treatments at calving: (1) no supplemental trace minerals, (2) organic complex (4-Plex®) and (3) inorganic. Minerals were supplemented at the same level for both supplemental treatments. Supplemental treatments increased the number of open cows compared to controls. The organic treatment increased days to conception in 1994, but not in 1995. Calf performance was not different among treatments. Liver Cu levels increased for both supplemental treatments.

Introduction

Trace mineral research and feed industry recommendations in the past five years have been directed toward feeding higher levels of trace minerals because of pharmacological responses observed in feedlot receiving cattle studies. Furthermore the response has been greater for organic sources when compared to inorganic sources of the minerals. The two-year-old cow with her nutritional stresses from calving to breeding may respond to pharmacological levels of trace minerals. Therefore, the objective of this study was to determine if a combination of Cu, Co, Mn and Zn in an organic or inorganic form fed only from calving to breeding at higher than NRC recommendations alters: pregnancy rate, subsequent calving date, calf performance, and liver biopsy and serum concentrations of trace minerals.

Procedure

A study was conducted at the University of Nebraska, West Central Research and Extension Center (WCREC), North Platte over two years using 236 (127 in 1994, 109 in 1995) crossbred two-year-old MARC II cows (1/4 Angus x 1/4 Herford x 1/4 Simmental x 1/4 Gelbvieh). Each year cows were developed as yearlings in drylot and fed ground alfalfa hay, corn silage, and dry rolled corn to reach a target weight of 650 lb before a 40-day breeding season. The bred heifers grazed native range during the summer and fall. They were fed grass and alfalfa hay plus dicalcium phosphate and salt during the winter until calving.

The calving season started in early February and lasted until the end of March. After calving the cows were randomly assigned to one of three mineral-protein treatments. The three treatments investigated were: (1) control (no supplemental trace minerals), (2) organic complex (4-Plex®) and (3) inorganic trace minerals. The control supplement consisted of soybean meal and dicalcium phosphate. The organic supplement consisted of the control plus (4-Plex®): copper lysine, cobalt glucoheptonate, manganese methionine, and zinc methionine. The inorganic supplement consisted of the control plus copper sulfate, cobalt carbonate, manganese sulfate and zinc sulfate. Supplemental elements were fed at the same daily level for organic and inorganic treatments: Cu (125 mg), Co(25 mg), Mn (200 mg) and Zn (360 mg). The heifers were tagged for identification of treatment groups and weighed approximately 48 hours after calving. Cows and calves were moved to a small pasture (with sparse grass). Cows had ad libitum access to grass hay (8% CP) from calving to breeding. All cows were individually fed the mineral-protein or protein supplement with corn twice a week to meet protein and energy requirements (NRC 1984). Cows received 3.5 lb of cracked corn and 3.5 lb of supplement at each feeding. The control cows received corn and soybean-meal supplement. Cows in the organic and inorganic treatments received corn, soybean-meal and mineral supplement.

Table 1. Trace elements consumed in the diet.

Element	Control[a]	Org & Inorg[b]	NRC[c]
		mg/day	
Cu	51	176	80
Co	8	33	0.8
Mn	945	1,145	320
Zn	165	525	240

[a] Trace element intake based on analysis of hay samples and dry matter intake of 17.6 lb/day estimated by indigestive markers plus amount provided by base supplement (Cu=7, Co=.45, Mn=57, Zn=21 mg/day).
[b]Org=Organic source of elements and Inorg= inorganic source of elements formulated to contain equal amounts of elements.
[c]NRC=National Research Council (1996) recommendations based on 17.6 lb DM intake.

Table 1 shows the trace elements consumed in the diets of the treatments. The mean concentration of elements in the hay was: Cu 5 mg/kg, Co 0.8 mg/kg, Mn 111 mg/kg and Zn 18 mg/kg. A random sample of cows

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was used each year to determine intakes of hay using chromium oxide boluses. Intakes were calculated and averaged 17.6 lbs of dry matter per day. The soybean meal supplement in the control diet contained a base amount of the four trace minerals. The mineral supplements added higher levels of trace elements to the diet. Cows in the control treatment received a total of 51 mg of Cu, 8 mg of Co, 945 mg of Mn and 165 mg of Zn per day from the hay and soybean meal supplement. Cows in the organic and inorganic supplement received a total of 176 mg of Cu, 33 mg of Co, 1,145 mg of Mn and 525 mg of Zn. Table 1 shows the intake of trace minerals relative to NRC recommendations based upon 17.6 lb of dry matter intake per day. The average feeding period per cow was 60 days.

Liver biopsies were performed to obtain liver samples for trace element analysis. Blood was also collected to compare concentration of trace elements in serum verses liver tissue. Liver biopsies were taken at four times: two weeks before calving (Feb. 5), after calving (start of feeding period), end of feeding period (May 15), and mid summer (July 7). The four biopsy times evaluated change of liver stores over the feeding period. Fifteen cows per treatment per year were randomly selected and biopsies taken on the same cows on all collection dates. Liver, serum, and feed samples were analyzed at the University Veterinary Diagnostic Center for trace minerals. The analysis of mineral concentrations in liver biopsies, serum and feeds was determined with simultaneous/sequential ICP/AES interfaced with an ultrasonic nebulizer.

On May 15, cows and calves were moved to the Gudmundsen Sandhills Laboratory for summer pasture. On May 20, bulls with chin ball markers were placed with the cows and breeding dates were recorded for the first 40 days of the 70-day breeding season. Cows were examined for pregnancy on August 31 and October 5 to determine fetal age and day of conception. Day of conception was calculated by breeding dates, two pregnancy exams, and subsequent calving dates.

Health records were recorded for the calves and cows for the entire year. Cow and calf weights and condition scores on cows were taken at calving, April 4, May 15, and August 31 (weaning).

Table 2. Reproduction of 2-Year-Old Cows on Trace Mineral Supplementation.[a]

	Treatment		
Year	Control	Organic	Inorganic
1994			
No. of cows	43	42	42
No. open after 70 days breeding	0	6	5
Day of conception[b]	June 10[d]	June 21[c]	June 7[d]
(Second Calving date)	(March 22)	(April 1)	(March 19)
1995			
No. of cows	37	36	36
No. open after 70 days breeding	0	5	6
Day of conception[b]	June 18	June 17	June 23
(Second Calving date)	(March 30)	(March 29)	(April 4)
Pooled over years			
No. of cows	80	78	78
No. open	0[e]	11[f]	11[f]
Calf gain (April-May)	54 lb.	53 lb.	52 lb.
Calf wt. at weaning	405 lb.	405 lb.	401 lb.

[a]Treatment by year interaction for mean day of conception (P<.001).
[b]Day of conception estimated by two palpations and confirmed by calving date.
[c,d,e,f]Means with unlike superscripts within a row differ (P<.01).

Results

Mineral treatments increased (P<.01) number of open cows (Table 2). Treatment affected number of open cows (P<.01). Over the two years there were 11 cows open in each mineral supplemented groups. Number of open cows was not different for mineral sources. There was a treatment by year interaction for day of conception (Table 2). The cows in 1994 bred earlier than the cows in 1995. The control and the inorganic cows conceived earlier than the cows fed organic mineral (P<.01) in 1994. However in 1995 there was no difference in day of conception among treatment groups (P>.05).

There were no differences in calf gain from April to May. Calves in each treatment gained about 53 lbs and there were no differences in calf health. Weaning weights were similar among treatments. There were no differences for cow weights or condition scores among treatments.

The trace mineral concentrations in the liver were different between treatments for Cu (P<.01) with organic and inorganic being greater than the control (Table 3). The organic and inorganic groups were not different from each other at any biopsy date (P>.05). The Cu level for the control cows was higher initially at the start of supplementation. The reason the control cows were higher in liver Cu was because of the random allocation of cows to that treatment. At the end of the feeding period, cows fed minerals had increased their liver Cu level nearly three times (P<.01). A fourth biopsy was taken at mid summer to determine the pasture affects on the trace element levels in the liver. The control cows had higher liver Cu in July than the May 15 biopsy date (P<.01). The organic and inorganic cow's liver Cu decreased for the July 7 biopsy (P<.01). Source of mineral did not influence Cu concentrations in liver biopsy samples. Serum Cu concentrations did not differ for treatment or at any of the collection dates. Therefore, serum is a poor indicator of Cu status. The data suggest that organic sources are not advantageous when protein and energy nutrition is adequate.

Liver Mn was not different by treatment or biopsy time. Liver Zn levels were highest after calving (start of

Table 3. Least square means for liver trace element analysis by biopsy time.

ppm	Start Supp March 15	End Supp May 17	Mid Summer July 7
Cu[a]			
Control	67^c	75^c	91^c
Organic	48^b	184^b	144^b
Inorganic	43^b	174^b	144^b
Zn[d]			
Control	131	98	96
Organic	137	112	107
Inorganic	134	102	99
Mn			
Control	10	11	9
Organic	12	10	9
Inorganic	11	10	10

[a]Biopsy treatment by time interaction.
[b,c]Means with unlike superscripts within a column differ (P<.01).
[d]Biopsy time (P<.01).

supplementation) and decreased significantly by May. This was interesting that liver Zn was lower in May after the feeding period. Zinc may not have been used by the animal because it was tied up with another trace element in the diet such as Cu. Zinc is stored in other tissues such as the pancreas at higher levels than liver. This might explain why there were no differences for Zn by treatment time. Manganese liver levels did not differ after supplementation or after the cows went to grass. The levels in the liver are in the normal range. The liver is not a good storage site for Mn. Bone stores more Mn than liver, therefore, it is possible that the sampling technique failed to give an accurate measurement of Mn in the cow. There is no data for liver Co because of the analysis techniques used. Cobalt could not be detected in the liver tissue.

Mineral supplementation increased the number of open cows. The cows were not deficient for Cu, Zn, Mn or Co as evidence by excellent reproductive performance for the control cows. Trace elements in excess may cause sub-clinical toxicities, such as reduced reproductive performance. Therefore, since the base forage contained adequate levels of trace minerals, the additional levels fed may have caused the reduction in reproductive performance.

The study suggests that with the imposed management and nutrition, the combinations of trace elements fed at high levels reduced reproductive performance in beef cows. Trace mineral supplementation should be looked at as a function of health management and nutrient intake. When nutritional management and nutrient intakes are low a response may be seen to feeding higher levels of trace minerals. However, when nutrition and health are closely watched a positive response to higher trace mineral levels probably will not be seen. The trace minerals supplemented individually may not have caused a decrease in reproduction. Based upon hay analysis and amounts of minerals in supplement, elements were not overfed according to NRC maximum tolerable levels. Cobalt was the only element close to reaching the maximum tolerable level of 50 mg/day. Cobalt in the mineral supplement groups was fed at a level of 33 mg/day. Therefore additional research is needed to identify specific elements, levels, and biological mechanisms involved so reduced performance caused by overfeeding trace minerals can be avoided.

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