# EFFECTS OF TRACE MINERAL SUPPLEMENTS ON PERFORMANCE OF FEEDLOT STEERS

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## Story in Brief

Response of steers to trace minerals was examined in a 218 d feedlot trial using 72 crossbred steer calves (501 lb initially) in 12 pens. Control steers received no supplemental Co, Cu, Mn or Zn; 4-Plex® steers received organic forms of these minerals; steers received only inorganic forms of these four minerals. The 95% concentrate diet consisted of whole corn, cottonseed meal, urea, and 5% cottonseed hulls. Co, Cu, Mn and Zn of the control diet were .08, 4.3, 20, and 26 ppm; supplemented diets had 2.8, 13.9, 22, and 40 ppm; NRC recommends .02, 8, 40, and 30 ppm. During the first 104 d and averaged over the total trial, diet did not alter performance. But during the last 114 d, ADG was greater for steers receiving trace minerals, intake tended to be lower for 4-Plex® than inorganic steers, and feed: gain was slightly better for 4-Plex® than inorganic or control steers. Carcass characteristics did not differ. Added trace mineral tended to increase Cu in blood and liver and Zn in blood. Compared with steers fed inorganic forms, 4-Plex® steers had higher liver Co. Liver Mn was notably low. Apparently, these newly weaned calves had adequate stores of these trace minerals for normal feedlot performance for several months but rate of gain stalled later when minerals were not added. The 7% efficiency advantage for steers fed 4-Plex® over steers fed inorganic minerals late in the study may reflect a metabolic advantage or simply dietary inadequacy of inorganic minerals.

(Key Words: Steers, Performance, Trace Minerals.)

## Introduction

Trace mineralized salt and commercial trace mineral supplements often do not supply as much copper, cobalt, manganese, and zinc as recommended by the NRC (1984). Additionally, certain consultants have questioned whether trace minerals even need to be supplemented to diets for finishing cattle. Proof that growing and finishing cattle will benefit from supplementation with these

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trace minerals is based largely on measurements other than performance. In addition, sources of these trace minerals range from the oxides and sulfates, some of which have limited availability, to organic forms chelated with amino acids or protein which usually are more useful to animals. Most of the studies in the literature have compared inorganic with organic forms of minerals at a specific level of supplementation and have not tested whether either is needed or beneficial. The purpose of this experiment was to evaluate the need for supplementing diets for rapidly growing feedlot steers with four trace minerals (cobalt, copper, manganese and zinc) and to compare the benefits on performance from supplementing at levels recommended by the NRC (1984) with either an organic or inorganic form of these minerals.

## Materials and Methods

***Animals.*** English X Exotic, crossbred, spring-born calves (n=72) were weaned from two commercial cow herds at Oklahoma State University in October 1994. The cattle were vaccinated with modified live virus 4-way respiratory and 7-way clostridial vaccines at weaning. On November 21, 1994 these cattle were transported 280 miles (5 hours) to the Panhandle State University research facility at Goodwell, OK. Upon arrival, the cattle were weighed, revaccinated and treated with Ivomec pour-on® for parasite control. On November 22, 1994 (d 0) the cattle were stratified into four weight blocks and assigned randomly to one of three treatments.

Pelleted protein supplements were formulated based on urea and cottonseed meal utilizing either 1) no supplemental copper, cobalt, manganese or zinc, 2) organic (Zinpro 4-plex®) forms of these minerals, and 3) inorganic forms (sulfate form) of these minerals at the same concentration as provided by the organic form. Cobalt, Cu, Mn and Zn concentrations of the control diet were .08, 4.3, 20, and 26 ppm; supplemented diets had 2.8, 13.9, 22, and 40 ppm; NRC recommends .02, 8, 40, and 30 ppm. All other minerals were supplemented to meet or exceed requirements estimated by the NRC (1984). The steers were housed in twelve partially covered pens with covered feed bunks. Each treatment had four pens and 24 calves (6 calves per pen). The cattle were implanted with Synovex-S® on d 30 and reimplanted with Revalor-S® on d 99.

***Diets.*** Isonitrogenous and isocaloric diets (Table 1) were available free choice. The basal ingredients included whole shelled corn (84.4%), cottonseed hulls (5.0%) and a supplement pellet (10.6%). All ingredients were analyzed at a commercial laboratory for dry matter, crude protein, calcium, phosphorous, potassium and trace minerals. These diets differed only in the form or presence of these four trace minerals.

***Data Collection and Analysis.*** Prior to starting the trial, liver biopsy and blood samples were obtained from 24 of the calves to assess trace mineral status. All calves were weighed and feed samples taken on roughly 28 d intervals. All steers were slaughtered at Excel Corporation, Dodge City, KS after being fed for 218 days. Carcass data were collected after a 48 hr chill. Immediately prior to slaughter, blood and hair samples were obtained from each calf. Blood samples and liver tissue were obtained from each steer during processing at the packing plant. All blood and tissue samples were analyzed at the Michigan State Diagnostic Laboratory. For statistical analysis, comparisons of interest were 1) whether supplementing with these four supplemental minerals averaged across the two forms produced any response compared with the unsupplemented steers, and 2) whether responses differed due to the form of supplemental trace minerals.

## Results and Discussion

***Cattle Performance.*** Performance data are summarized in Table 2. Average daily gain was calculated for the entire period on a carcass adjusted (dressing percentage of 62%) basis. Period gains (d 0 to 104 and d 104 to 218) were calculated by regressing individual shrunk weights collected monthly against time. Rate of gain, feed intake, and feed efficiency were not affected by the presence or form of TM supplementation during the first 104 days on feed. Failure of supplemental trace minerals to influence performance may reflect adequate stores of these minerals at the start of the feeding period or overestimation of requirements for these trace minerals.

During the second half of the trial, however, steers receiving supplemental trace minerals had greater (P=.03) daily gains than unsupplemented steers. Feed intake tended to be greater during the second period (P=.09) and over the total trial (P=.08) for steers supplemented with inorganic than with the organic form of these minerals, but ADG was not different between the two forms of TM supplementation. Equal rate of gain with slightly lower feed intake means that steers supplemented with 4-plex supplemented steers tended to have slightly improved feed efficiencies when compared with steers receiving no supplemental trace minerals or inorganic trace minerals. Averaged over the total trial, feed efficiency did not differ statistically due to TM supplementation although a numeric and economic advantage from supplementation of either form was evident. Relatively poor performance by all cattle in the first period tended to mask effects on feed efficiency. The more rapid gain of supplemented steers in the second period probably reflects a deficiency of one or more of these trace minerals.

The lack of performance response to trace mineral supplementation during the first half of the trial probably reflects initial status of these cattle.

Mineral status of cattle from other regions of the country or not given supplemental minerals prior to weaning may be inadequate. Mineral status at the start of feeding period is probably the key factor determining when performance will be depressed due to a trace mineral deficiency.

***Carcass Characteristics.*** Carcass data are summarized in Table 3. Carcass characteristics did not differ due to TM supplementation. The cattle had a mean 746 lb carcass, dressed 62.7% and graded 34.3% choice. Liver condemnation rate averaged 18.9%. Considering the small number of steers in this study, one should not expect to detect differences in carcass measurements. Only by combining data from numerous studies can carcass changes be assessed.

***Blood and Liver Mineral Concentrations.*** At the start of the trial, blood concentrations of calcium (Ca), copper (Cu), magnesium (Mg), phosphorus (P), zinc (Zn), sodium (Na) and potassium (K) all were above the minimums suggested by both Puls (1988) and Michigan State Diagnostic Laboratory (Table 4) suggesting that these steers had adequate status for these minerals. Additionally, liver concentrations of Ca, Cu, iron (Fe), Mg, P, Zn, cobalt (Co), Na, sulfur (S) and K all were above the suggested minimum values (Table 5). The only minerals that fell below the suggested minimums were for Fe in blood and Mn in liver. These results indicate that at the start of the trial, these steers had adequate mineral status except possibly for Mn. Certainly, cattle from various regions of the country where forages may be deficient in minerals and from ranches where growing calves and their dams do not receive supplemental mineral may enter the feedlot deficient in one or more trace minerals.

At the end of the feeding period blood and liver data indicated that most measured minerals for supplemented and unsupplemented cattle were adequate. Lower than recommended concentrations were noted for Cu in blood and Fe, Mn, and Na in liver samples. Blood Cu concentrations, classified as deficient for all cattle, was lower at the end than at the start of the trial; concentrations decreased less ($P<.04$) for steers that received supplemental trace minerals. Final liver Cu also was lower ($P<.05$) for unsupplemented cattle but remained numerically above the initial concentration of these steers. Although blood Fe suggested a deficiency at start of the trial, blood concentrations were higher at the end and were increased to a greater degree when trace minerals were supplemented even though none of the supplements provided iron. In contrast, liver concentrations of iron dropped ($P<.05$) below initial levels to levels considered deficient for all cattle at the end of the study.

Although neither blood nor liver concentrations of magnesium changed significantly during the trial, blood Mg tended to increase while liver Mg decreased. Liver Mg decreased to a lesser ($P<.01$) extent with inorganic than organic supplementation even though Mg was not provided in either supplement. Liver and blood concentrations of P were not significantly affected over the duration of the trial, but final blood P levels were greater (P<.05) for organic than inorganic supplemented cattle but was not different from control. Final liver Mn concentrations were numerically greater than initial levels for all cattle but remained consistently below the concentrations recommended.

Blood Zn levels increased from the start to the end of the trial, increasing to a greater (P=.08) degree in supplemented than unsupplemented cattle with no difference due to trace mineral source. Liver Zn levels decreased for all groups from start to finish. Liver Co levels decreased over the course of the trial with organic supplemented cattle decreasing (P<.01) to a lesser degree than cattle supplemented with inorganic cobalt. Blood Sodium levels changed very little during the trial whereas liver Na decreased to a level considered deficient for all cattle; levels and changes were not influenced by trace mineral supplementation or source. Liver S levels tended to increase during the trial with no differences due to treatments. Blood K levels increased for all cattle by the end of the trial, with concentrations increasing to a greater (P<.05) extent in supplemented than unsupplemented cattle. Liver K decreased slightly with the concentrations remaining higher (P<.03) for steers receiving inorganic minerals than those receiving 4-plex.

In summary, except for Cu, blood minerals increased or did not change from initiation to termination of the trial. Liver mineral concentrations were more erratic; P, Mn and S increased while other minerals decreased. The major impacts of mineral supplementation on final mineral concentrations were for Cu, which was increased in mineral supplemented cattle but decreased in unsupplemented cattle. The only impacts of mineral source were for liver Co, which was much greater with supplementation with 4-plex, and a trend for higher Mn with 4-plex. Although Co status appeared adequate, liver concentrations of Mn suggest that it was in the marginal to deficient category. Whether the slight improvement in Mn status with 4-plex is responsible for the trend for improved feed efficiency in the last half of the feeding period for cattle receiving 4-plex is unclear. Note, however, that even with supplementation, the dietary concentration of Mn with both 4-plex and inorganic minerals at 22 ppm remained below the amount suggested as required by NRC (1984) for growing cattle (30 ppm).

The decision to use an organic or inorganic source of trace minerals should be based on cattle performance and economics. Extensive data with nonruminants and some with ruminants indicates that organic forms usually are better absorbed; therefore, less mineral needs to be fed when the mineral is organic than when it is in the inorganic form. This difference might be important for avoiding adverse effects on ruminal fermentation and when one considers environmental impact of animal wastes. With current prices and regulatory practices, for a given cost, more mineral can be supplied from an inorganic than an organic form. Nevertheless, total cost even for organic forms of minerals should be less than $1 per ton of feed, a minor cost relative to the sacrifice in animal efficiency observed with mineral deficiencies. Even among inorganic minerals forms, usefulness differs, with generally greater biological availability from the sulfate than the oxide form.

Although weaned calves may not require trace mineral supplements for adequate performance for the first 100 days in the feedlot, other cattle deficient at the start may respond immediately to supplementation. Until some less costly methods are developed for determining mineral status at the start of a feeding period, supplementation is more economical than assessment. For large feedlots, analysis of liver samples gathered at necropsy of cattle that have been fed for several months should prove useful to assess trace mineral status of cattle and thereby of the finishing diet. Considering that feedlot diets can be supplemented to recommended levels with inorganic trace minerals for less than 20 cents per ton of feed, trace minerals are economical insurance. And until more definitive requirements are established, NRC (1984) recommendations should be used as minimum concentrations.

## Acknowledgements

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## Literature Cited

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**Table 1. Supplement composition.**

| Ingredient | Control | Organic | Inorganic |
|---|---|---|---|
| Cottonseed meal, % | 44.52 | 44.52 | 44.52 |
| Corn, % | 26.52 | 25.03 | 26.29 |
| Limestone, % | 13.65 | 13.65 | 13.65 |
| Potassium chloride, % | 5.65 | 5.65 | 5.65 |
| Urea, % | 5.65 | 5.65 | 5.65 |
| Salt, % | 2.82 | 2.82 | 2.82 |
| Dical, % | .75 | 0.75 | .75 |
| 4-Plex, % | 0 | 1.49 | 0 |
| Rumensin-80, g/ton | 1763 | 1763 | 1763 |
| Tylan-40, g/ton | 961 | 961 | 961 |
| Vitamin A-30, g/ton | 627 | 627 | 627 |
| Vitamin E-50, g/ton | 570 | 570 | 570 |
| Sodium selenite, g/ton | 128 | 128 | 128 |
| EDDI, g/ton | 5 | 5 | 5 |
| Cobalt carbonate, g/ton | 0 | 0 | 5 |
| Copper sulfate, g/ton | 0 | 0 | 471 |
| Manganese sulfate, g/ton | 0 | 0 | 645 |
| Zinc sulfate, g/ton | 0 | 0 | 952 |

**Table 2. Feedlot performance of steers supplemented with inorganic, organic (Zinpro 4-plex®) or no trace minerals**

| Item | Control (1) | Inorganic (2) | 4-Plex (3) | SEM | 1 vs 2&3 P= | 2 vs 3 P= |
|---|---|---|---|---|---|---|
| Live weight, lb | | | | | | |
| Start | 501 | 501 | 502 | 3.25 | .91 | .97 |
| Day 218 | 1157 | 1193 | 1180 | 18.61 | .21 | .60 |
| ADG, lb | | | | | | |
| Day 0 to 104 | 2.96 | 3.05 | 2.83 | .12 | .90 | .19 |
| Day 104 to 218 | 3.15 | 3.40 | 3.46 | .10 | .03 | .70 |
| Day 0 to 218 | 3.10 | 3.24 | 3.13 | .09 | .40 | .36 |
| Intake, lb | | | | | | |
| Day 0 to 104 | 14.2 | 14.5 | 13.8 | .27 | .99 | .12 |
| Day 104 to 218 | 19.4 | 20.2 | 19.1 | .37 | .57 | .09 |
| Day 0 to 218 | 16.8 | 17.2 | 16.5 | .23 | .91 | .08 |
| Feed: Gain | | | | | | |
| Day 0 to 104 | 4.24 | 4.22 | 4.34 | .07 | .67 | .28 |
| Day 104 to 218 | 5.48 | 5.27 | 4.90 | .18 | .13 | .21 |
| Day 0 to 218 | 4.83 | 4.71 | 4.68 | .10 | .29 | .82 |

**Table 3. Carcass characteristics of steers supplemented with inorganic, organic Zinpro 4-plex® or no trace minerals**

| Item | Control (1) | Inorganic (2) | 4-Plex (3) | SEM | 2 & 3 vs 1 P= | 2 vs 3 P= |
|---|---|---|---|---|---|---|
| Hot weight, lb | 735 | 758 | 748 | 12.15 | .22 | .56 |
| Dress, % | 62.5 | 62.9 | 62.7 | .36 | .52 | .63 |
| Marbling Score | 290 | 297 | 276 | 13.5 | .83 | .27 |
| Choice, % | 33.3 | 39.2 | 30.8 | 9.8 | .93 | .56 |
| Select, % | 54.2 | 60.8 | 60.0 | 9.9 | .56 | .93 |
| Standard, % | 12.5 | 0.0 | 9.2 | 5.2 | .21 | .21 |
| Backfat, in | .39 | .46 | .40 | .03 | .37 | .14 |
| KPH, % | 2.0 | 2.2 | 2.2 | .10 | .06 | .96 |
| Yield grade | 2.5 | 2.7 | 2.4 | .12 | .66 | .13 |
| REA, $in^2$ | 13.0 | 13.4 | 13.6 | 13.4 | .20 | .62 |
| Liver condemned, % | 16.7 | 21.7 | 18.3 | 7.9 | .74 | .78 |

**Table 4. Blood concentrations of minerals (ppm) at the start of the experiment and at the end of the experiment 204 days later for steers fed no supplemental Zn, Mn, Co, and Cu or fed these minerals from inorganic or organic (Four-Plex) sources based on pen means.**

| Mineral | Ca | Cu | Fe | Mg | P | Zn | Na | K |
|---|---|---|---|---|---|---|---|---|
| Initial Means | 96.43 | 1.12 | 1.09 | 20.68 | 73.96 | 0.81 | 3,151 | 188 |
| Control | 95.48 | ***.70***[x] | 2.07[xy] | 22.35 | 76.86 | 1.01 | 3,133 | 332[x] |
| Inorganic | 94.65 | ***.75*** | 2.47 | 21.78 | 72.96[b] | 1.08 | 3,090 | 367 |
| Four-plex | 96.22 | ***.73*** | 2.75 | 21.65 | 76.68[a] | 1.14 | 3,115 | 372 |
| Supplement ($P<$) | .96 | .04 | .01 | .27 | .12 | .08 | .16 | .05 |
| Source ($P<$) | .17 | .53 | .16 | .85 | .03 | .33 | .29 | .76 |

[x] Differs ($P<.05$) from mean of cattle fed supplemental minerals.

[y] Change from initial value was greater ($P<.05$) when added minerals were fed.

[a,b] Means with different superscipts differ ($P<.05$).

Values in intalics fall below minimums suggested by Puls (1988) and Michigan State Diagnostic Laboratory.

**Table 5. Liver concentrations of minerals (ppm) at the start of the experiment and 204 days later for steers fed no supplemental Zn, Mn, Co, and Cu or fed these minerals from inorganic or organic (Four-Plex) sources based on pen means**

| Mineral | Ca | Cu | Fe | Mg | Mn | P | Zn | Co | Na | S | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial means | 735 | 135.4 | 324 | 664 | ***6.79*** | 10,845 | 208 | 1.176 | 4,225 | 7164 | 11,326 |
| Control | 115 | 111 | ***125*** | 607 | ***7.94*** | 11,788 | 106.1 | .54 | ***1,690*** | 7719 | 9,898 |
| Inorganic | 115 | 162 | ***124*** | 622[a] | ***7.88*** | 11,725 | 104.4 | .45[b] | ***1,712*** | 7551 | 9,964[a] |
| Four-plex | 111 | 151 | ***107*** | 599[b] | ***8.12*** | 11,365 | 101.1 | .83[a] | ***1,718*** | 7350 | 9,486[b] |
| Supplement (p <) | .49 | .22 | .28 | .51 | .85 | .44 | .41 | .18 | .58 | .17 | .29 |
| Source (p<) | .21 | .78 | .10 | .01 | .54 | .32 | .47 | .01 | .91 | .35 | .03 |

[a,b] Means with different superscipts differ (P<.05).
Values in italics fall below minimums suggested by Puls (1988) and Michigan State Diagnostic Laboratory.