Mineral Concentrations of Forages for Livestock in Nebraska and South Dakota

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Summary and Implications

Forage samples from Nebraska and South Dakota submitted to Ward Laboratories, Inc. from 2012–2019 were analyzed for mineral concentrations. Samples were categorized by forage species, quality based on protein content, and mineral concentration based on requirements for lactating beef cows. The data indicate that copper and zinc are frequently deficient across all species and levels of forage quality, emphasizing the need for supplementation. Except for magnesium, macro-mineral deficiencies are less likely to occur when feeding high quality forages in Nebraska and South Dakota. Corn feedstuffs are particularly likely to result in mineral deficiencies if fed without mineral supplementation. High protein annual small grain forages are more likely to have high tetany ratios than other forages. Forage mineral analysis can assist in determining whether or not supplementation is required and at what level. Forage mineral analyses is one component of developing a livestock mineral management strategy, in conjunction with livestock health and performance records, and overall ranch goals.

Introduction

Proper mineral nutrition is essential for strong immune systems, reproductive performance, and calf weight gain in beef cattle. Forages are the major component of beef cow diets in Nebraska and South Dakota. Moreover, mineral concentration in forages is highly variable due to differences in soil type, environmental conditions, species, and maturity. Laboratory analyses provide critical information that producers can use to compare mineral concentration in forages to beef cow requirements and develop appropriate supplementation strategies.

Procedure

Forage samples (n = 4,986) were submitted to Ward Laboratories, Inc. for mineral analysis from 2012–2019 by customers in Nebraska and South Dakota. Samples were sorted into eight forage categories (alfalfa, alfalfa grass mix, annual small grain forages, corn silage, corn stalks, earlage, perennial grass, and warm season annual grass) and classified into quality groups based on protein content. Samples were also categorized as deficient, ideal, or greater than maximum tolerable level based on mineral content in relation to nutrient requirements of a lactating beef cow in accordance with Nutrient Requirements of Beef Cattle (2016). Tetany ratios (seen below) were calculated and potential copper antagonisms identified.

$$\frac{K\% \times 256}{(Ca\% \times 499) + (Mg\% \times 823)}$$

Results

Data in Table 1 shows the percentage of forage samples within each category that are below animal requirements, could contribute to copper deficiency due to high sulfur or molybdenum, and/or are potentially tetany prone.

In general, macro-minerals including calcium (Ca), phosphorous (P), magnesium (Mg), sulfur (S) and potassium (K) were positively correlated with protein content of the forage (Table 2). These results suggest that macro-mineral deficiencies are more likely to occur in poor quality forages with lower protein concentrations.

A high percentage (75%) of perennial grass samples with less than 12% protein were deficient in phosphorous and magnesium. A high percentage of all corn feedstuffs (earlage, stalks, and silage) contained low levels of magnesium. Additionally, 59% corn silage and 100% of earlage samples contained low levels of Ca. These are important minerals for lactating cows and supplementation should be considered when utilizing these feedstuffs. Annual small grain forages with protein concentrations greater than 19% in Table 1 had a high percentage of samples (81%) with high potassium concentrations, and 59% of samples that would be considered tetany prone. These results would suggest that supplementation of Ca and Mg would be advisable if these forages were to be fed to lactating cows.

Micro-minerals including manganese (Mn), zinc (Zn), copper (Cu) were not correlated with protein content in all forage types. However, for Zn and Cu there were fairly strong positive correlations with protein content in perennial grasses, annual small grain forages, and warm season annual grasses. Many forage samples, regardless of species or quality, did not meet zinc and copper requirements for cows. A large proportion of earlage and corn silage samples also had concentrations below the manganese requirement. Although required in smaller quantities, micro-mineral supplementation is critical to reproduction, immune function, and general health.

Table 3 highlights the range in mineral concentrations of forages with moderate protein concentrations and quality. In general, reported data shows variation of mineral concentrations both greater than and less than the required level, and highlights the need for laboratory analysis to determine if mineral requirements can be met by forages alone and if not met by forages alone, analysis will help to determine the supplementation level that is needed.

Table 1. Percent of forage samples within each category that would be considered to result a defeciency[1] if not supplemented

	Concentration of mineral below animal requirement							Potential influence on copper absorption				
	Calcium	Phosphorous	Magnesium	Sulfur	Iron	Manganese	Zinc	Copper	Sulfur	Molybdenum	Iron	Potassium	Tetany Ratio
Type (Range % CP)	< 0.3 %	< 0.2 %	< 0.2 %	< 0.15 %	< 50 ppm	< 40 ppm	< 30 ppm	< 10 ppm	0.3–0.5%	2 -5 ppm	250–1000 ppm	>3.0%	> 2.2
Alfalfa													
Utility (< 16%)	0	29	38	22	3	53	75	81	5	18	28	9	2
Fair (16 to 17.9%)	0	16	17	2	0	57	84	80	9	17	27	18	0
Good (18 to 19.9%)	0	8	8	0	0	32	86	66	8	34	60	18	0
Premium (20 to 21.9%)	0	4	4	1	0	34	90	68	23	17	47	32	0
Supreme (≥ 22%)	0	0	2	1	0	24	64	62	21	30	57	63	0
Alfalfa grass mix	1	50	39	29	0	35	84	84	7	54	37	65	1
Perennial grass													
Low (< 5%)	12	100	94	86	0	36	100	100	0	50	45	0	0
Fair (5 to 8.9%)	5	86	80	57	0	17	90	98	1	32	26	1	1
Good (9 to 12.9%)	4	62	75	15	0	16	74	86	6	40	37	4	4
Premium (≥ 13%)	0	13	23	0	0	22	80	80	29	9	38	33	1
Annual small grains													
Fair (< 9%)	55	48	94	87	0	49	83	95		10	37	3	44
Good (9 to 12.9%)	30	13	83	19	0	11	62	97	3	11	50	19	32
Premium (13 to 18.9%)	11	2	44	0	0	8	25	92	8	17	33	28	15
Supreme (≥ 19%)	7	2	39	0	0	0	15	70	27	22	45	81	59
Annual warm season grass													
Low (< 5%)	7	57	74	90	0	67	78	89	0	0	33	3	3
Fair (5 to 8.9%)	7	59	5	94	0	32	80	94	0	5	42	6	3
Good (9 to 12.9%)	13	31	5	40	0	17	32	93	6	24	43	10	2
Premium (≥ 13%)	2	17	0	5	0	22	39	94	11	29	56	42	17
Corn feedstuffs													
Earlage	100	3	100	100	8	100	100	100	0	0	0	0	0
Corn stalks	21	84	78	10	0	28	75	94	0	0	66	3	7
Corn silage	59	16	79	87	0	69	84	96	0	1	15	2	4

[1]Assumes requirement for a lactating cow, which has greater Ca, P, and Mg requirements than a gestating cow, but micro mineral requirements would be similar. Categorization does not take into account bioavailability of the mineral in the forage.

Dark gray shading greater than 75% of samples may have resulted in a deficiency. Light gray shading between 50 and 75% of samples may have resulted in a deficiency

Table 2. Correlation of forage crude protein with mineral concentration

	Pearson correlation Coefficient							
	Ca	P	Mg	S	K	Mn	Zn	Cu
Alfalfa	**0.28**	**0.18**	**0.25**	**0.63**	0.10	**0.18**	**0.21**	**0.24**
Alfalfa grass mix	**0.69**	**0.62**	**0.55**	**0.80**	**0.69**	-0.14	0.13	0.18
Perennial grass	**0.55**	**0.71**	**0.50**	**0.67**	**0.74**	-0.06	**0.30**	**0.50**
Annual small grains	**0.38**	**0.62**	**0.55**	**0.82**	**0.62**	**0.37**	**0.54**	**0.60**
Annual warm season	**0.18**	**0.49**	**0.59**	**0.80**	**0.37**	0.15	**0.40**	**0.28**
Earlage	0.10	**0.44**	**0.32**	**0.70**	0.10	0.33	0.39	-0.29
Corn Stalks	0.08	**0.78**	**0.48**	**0.86**	**0.44**	0.38	0.23	0.40
Corn Silage	**0.54**	**0.39**	**0.52**	**0.72**	**0.50**	**0.32**	**0.40**	**0.14**
	P-value							
Alfalfa	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.09	**<0.01**	**<0.01**	**<0.01**
Alfalfa grass mix	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.39	0.43	0.26
Perennial grass	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.25	**<0.01**	**<0.01**
Annual small grains	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**
Annual warm season	**<0.01**	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.07	**<0.01**	**<0.01**
Earlage	0.22	**<0.01**	**0.04**	**<0.01**	0.56	0.29	0.2	0.35
Corn Stalks	0.44	**<0.01**	**<0.01**	**<0.01**	**<0.01**	0.10	0.34	0.10
Corn Silage	<0.01	**<0.01**	**<0.01**	**<0.01**	**<0.01**	<0.01	<0.01	0.01

Table 3. Commonly observed[1] range of mineral concentrations[2]

	Calcium, %	Phosphorous, %	Magnesium, %	Sulfur, %	Manganese, ppm	Zinc, ppm	Copper, ppm
Lactating beef cow requirement	0.30	0.20	0.2	0.15	40	30	10
Good annual small grains (9 to 12.9% CP)	0.21–0.56	0.20–0.36	0.12–0.21	0.13–0.22	43–116	20–38	4–8
Good annual warm season grass (9 to 12.9% CP)	0.27–0.86	0.13–0.25	0.25–0.43	0.12–0.18	29–127	25–45	5–9
Good perennial grass (9 to 12.9% CP)	0.39–0.86	0.13–0.25	0.13–0.23	0.12–0.27	25–126	12–45	2–13
Good alfalfa (18 to 19.9% CP)	1.19–1.82	0.21–0.32	0.21–0.35	0.19–0.28	30–69	14–35	3–16
Fair alfalfa (16 to 17.9% CP)	1.10–1.76	0.19–0.32	0.20–0.32	0.16–0.28	24–55	17–30	5–11
Utility alfalfa (< 16% CP)	0.81–1.66	0.15–0.34	0.16–0.31	0.13–0.25	17–75	10–45	1.8[3]–19
Alfalfa Grass Mix	0.57–1.29	0.13–0.29	0.13–0.33	0.10–0.29	21–91	11–36	4–10

1 Average—or + one standard deviation

2 Bioavailability of minerals in forages is highly variable. Based on Nutrient Requirements of Beef Cattle by the National Research Council (2016) the following bioavailability can be assumed: 50% of calcium (Ca), 68% of phosphorus (P), 10–37% for magnesium (Mg) in hay and grass diets. Availability of manganese, zinc and copper are highly variable in forages. Availability of copper is decreased by the presence high amounts of antagonists, such molybdenum, iron, and sulfur, in the diet.

3 Minimum value, one standard deviation below average was negative

Conclusions

High protein forages, such as alfalfa and premium quality grass forages in this data set are less likely to be deficient in macrominerals. While some forages may provide adequate copper and zinc, these microminerals are likely to be deficient regardless of forage quality and species. Earlage and corn silage-based diets are specifically of concern for mineral deficiencies. High protein annual small grain forages are more likely than other forages to be tetany prone. Mineral analysis of forages is a tool that can be used when consulting with Extension professionals and other consultants to ensure beef cattle mineral requirements are being met to optimize production and performance.

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