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Multi-Elemental Analysis of Sandhills Meadow Hay

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Summary

Sixty-six meadow hay samples were collected from 11 cooperating producers in Cherry, Brown, Rock and Holt counties during the two years of this survey. The objective was to develop a database that could be used to predict sampling and supplementation strategies for elements. Analyzed elements were found to be in sufficient quantities to meet the gestating beef cows requirement in most of the samples collected, when hay is fed as the sole diet to beef cows. In all but one sample, Mn was found to exceed the optimal dietary requirement for beef cattle. Many of the hay samples contained levels of Mo shown to reduce Cu availability in the presence of high S. Regression equations to predict element levels and supplementation strategies could not be developed for this data base with the current number of samples.

Introduction

Traditionally, ranches in the Sandhills of Nebraska feed meadow hay to cows during the winter. Trace element composition of meadow hay varies. To determine if, when and where trace element supplementation is necessary, it is important to characterize the trace element concentrations in the hay. If the variation in trace element content of hay among location and years can be predicted, ranch managers and advisors may develop appropriate strategies for sampling hay and preventing trace element deficiencies. Our objective was to develop a data base of trace element content of meadow hay from various locations over two years. The data base could be used to predict needs for sampling and supplementation strategies.

Procedure

Hay samples (n = 66) were collected with a hay sampling probe from 11 cooperating producers in Cherry, Brown, Rock and Holt counties in north central Nebraska during the fall of 1993 and 1994. Cooperating ranches were identified by the county extension educators and participation was on a voluntary basis. The selected hay samples represented the diversity of hay harvested within that county for that year. Only one set of samples was received from one ranch in Brown county, the analysis was completed but it was removed from the statistical analysis due to a lack of replication.

Lab Analyses

All hay samples were ground through a 1 mm screen and analyzed by Near Infrared Spectroscopy for the macro nutrients (CP, TDN, etc.). The samples were then analyzed for mineral concentrations by inductively coupled argon plasma emission spectroscopy (ICP).

Statistical Analysis

Statistical analysis was performed using Least Square Means and the Stepwise Regression procedures in SAS.

Results

Figure 1 shows the number of samples and the approximate location of the ranch. Calcium (Ca) and iron (Fe) concentrations were not different ($P < .10$) for ranch, county or year and remained at about .64% $\pm$ .21 and 130 $\pm$ 87 ppm of the forage dry matter, respectively. Statistical differences ($P < .05$) occurred between ranches and between years for copper (Cu), zinc (Zn), manganese (Mn), molybdenum (Mo), phosphorus (P), magnesium (Mg) and potassium (K). Table 1 shows the range of element concentrations within a county by year, typical range of values commonly found in forages and the NRC recommended levels for beef cattle. It was not possible to identify ranches that were consistently low or high for a particular element, because

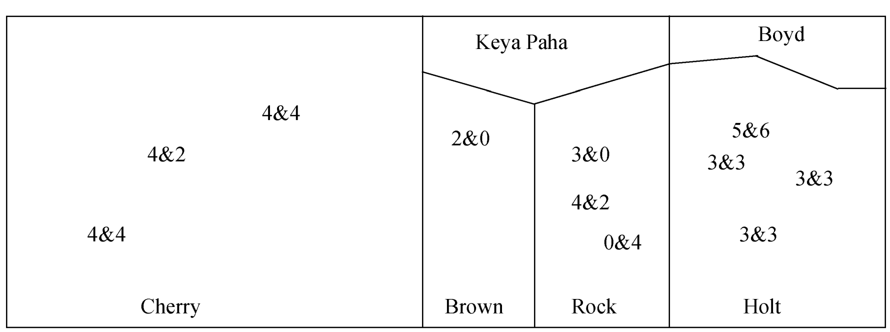

Figure 1. Sandhills Meadow Hay Project Cooperative Ranches, 1993 and 1994.[1]

[1]The first number is the number of samples collected in 1993 followed by the number of samples collected in 1994.

of the wide range of values for a particular element and the variation among samples were not consistent within a ranch. A greater than normal rainfall and below normal temperature in 1993 and near normal rainfall and temperature in 1994 may have accounted for some of the difference between years.

Copper was highest in ranches sampled in Cherry county and higher in 1993 than in 1994 in ranches sampled in Cherry and Rock counties (Table 2 and Table 3). Only one hay sample collected during the two years had a Cu concentration below 4 ppm, which is considered to be the low end of the optimum range for dietary intake (Table 1). However, the Mo concentrations in the hay sampled in 1994 were near the maximum tolerable dietary level. However, these maximum dietary levels were established with analytical equipment that may under-estimate the Mo concentration.

Because of some interactions that occur in the rumen between Mo and Cu, the relatively high level of Mo may decrease the availability of the Cu to the animal. The normal Cu:Mo ratio should be about 3:1. The ratios, among ranches sampled, were 1.5:1 for Cherry county and about 1:1 for Rock and Holt counties. However, the Cu:Mo interaction also requires sulphur (S), which was not measured in this study. Copper, Mo and S form an insoluble complex in the rumen and is unavailable for absorption in the small intestine. Thus, with the high levels of Mo, available Cu may not be adequate in the hay especially if S is also high.

Zinc was not different (P = .08) by county when averaged over the two years, but was higher in 1993 than in 1994 in Cherry and Holt counties. Fifteen of 66 samples collected during the 2 years had Zn concentrations lower than 20 ppm, the minimum value in the optimal range. These samples were from a variety of ranches from each county. Twenty to 40 ppm Zn is considered to be the optimal range for performance and the mean for each county was within this range.

All but one sample collected from all ranches in both years had a Mn value that exceeded the desired range of 20 to 50 ppm of the dry matter. The Mn concentrations were higher (P < .05) from ranches sampled in Rock and Holt counties. No performance depression would likely occur from feeding these higher levels, because the animals homeostatic control mechanisms will not allow absorption.

Cobalt was below the ICP detection limit for about half the samples in this study. However, the detection limit was at .5 ppm and about half the samples were between .5 and 1 ppm. The beef cattle requirement is about .10 ppm in the diet dry matter. Thus, it is safe to assume that the low Co is a detection limit problem and that in most cases, Co deficiency will not be a problem on the ranches sampled.

Phosphorus concentrations were in the normal range of published values for grass hay in Nebraska. However, the ranches sampled in Holt county were lower during both years than those in Rock county and lower than those in Cherry county in 1993. Cattle requirements for P varies with stage of growth and production. Phosphorus in the hay sampled was near the requirement for beef cows during gestation, but is on the low end of the optimum range for lactation if hay is fed as the sole diet.

Table 1. The range of elemental concentrations of hay by county, year, typical values[a] and beef cattle recommendations[b].

Element	Year	Cherry	Rock	Holt	Typical Range	NRC
Zn, ppm	93	20.5 - 72.7	17.0 - 28.5	17.0 - 42.0	20-80	20-40
	94	17.2 - 22.1	16.8 - 28.5	18.6 - 43.3		
Cu, ppm	93	6.82 - 20.45	5.68 - 9.09	4.55 - 7.95	4-8	4-10
	94	3.61 - 11.05	4.70 - 7.43	4.10 - 8.71		
Mn, ppm	93	52.3 - 253.4	69.3 - 148.9	64.8 - 280.7	40-200	20-50
	94	30.1 - 165.9	51.5 - 239.9	61.3 - 346.2		
Mo[c], ppm	94	4.00 - 8.19	4.77 - 7.01	3.95 - 7.03	.5-3.0	—
P, %	93	.132 - .823	.089 - .389	.085 - .284	.1-.3	.2-.3
	94	.105 - .254	.107 - .389	.086 - .340		

[a] Range of element levels common in forage, Livestock Feeds and Feeding (Church, 1991).
[b] Recommendations, National Research Council Nutrient Requirements for Beef Cattle (1984).
[c] Mo was only analyzed in 1994.

Table 2. Element concentrations for hay samples by county.

Element	Cherry	Rock	Holt	S.E.
Cu, ppm	9.42[a]	6.70[b]	6.47[b]	.93
Zn, ppm	26.1[a]	25.5[a]	27.5[a]	2.0
Mn, ppm	85.9[a]	111.9[b]	131.5[b]	13.27
Mo, ppm	6.10[a]	6.09[a]	6.11[a]	.40
P, %	.25[a]	.29[a]	.15[b]	.03
Mg, %	.17[ab]	.19[b]	.16[a]	.01
K, %	1.07[a]	1.63[b]	1.26[a]	.12

[ab]Means in a row with different superscripts are different (P < .05).

Table 3. Mean element concentrations within county by year.

County	Year	Cu, ppm	Zn, ppm	P,%
Cherry	93	12.21[a]	32.6[b]	.34[c]
	94	6.61[b]	19.6[a]	.16[ab]
Rock	93	7.10[b]	23.0[a]	.28[bc]
	94	6.31[b]	28.0[ab]	.30[bc]
Holt	93	6.33[b]	31.3[b]	.15[a]
	94	6.61[b]	23.8[a]	.15[a]

[abc] Means in a column with different superscripts are different (P < .05).

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In all samples collected, Mg and K concentrations were within or exceeded the normal range to be considered adequate in the diet if hay is fed as the sole diet.

In an attempt to build prediction equations to determine under what conditions trace element supplementation may be necessary, stepwise regression analysis was used. We thought that since the average harvest date was 6 weeks later in 1993 than in 1994, some of the variation could be accounted for by an increase in physiological maturity. We used ADF as an indicator of this, and found it to have the best relationship to Mo (highest R^2). When only other nutrients were included in the model, P and Mg predicted Cu concentration best (R^2 = .41). When building prediction equations, it is best to use as few variables as possible. Adding more variables to the model, in this case, did not improve the R^2 significantly; therefore, only 2 variable models are presented (Table 4). Also a R^2 of less than .70 is considered to be a weak indicator. Other 2 variable models are: Ca and Cu to predict Zn (R^2 = .37), Fe and Cu to predict Mn (R^2 = .41), TDN and ADF to predict Mo (R^2 = .25) and Cu and K to predict P (R^2 = .54). Table 4 gives the best 2 non-nutritive or Near Infrared Spectrophotometry determined variables to predict the elemental concentrations. Even when all the variables measured were included in the model, reliable prediction equations could not be calculated.

Table 4. Shows the best 2 variable model and R^2 for predicting the element content of hay using ranch, county, year and NIR[a] measured nutrients as the independent variable.

Element	Model	R^2
Cu	county and year	.22
Zn	year and TDN[b]	.27
Mn	ranch and ADF[c]	.16
Mo	month and ADF[c]	.28
P	county and year	.20

[a] NIR = Near Infrared Spectrophotometry
[b] TDN = Total Digestible Nutrients
[c] ADF = Acid Detergent Fiber

In conclusion, the results of this study indicate that hay samples should be analyzed for Cu and Mo and a Cu:Mo ratio calculated on an annual basis until a given ranch can determine under what conditions supplementation is necessary. Zinc and P analysis should also be completed on ranches which have marginal levels for the desired performance. There is not enough data in the current data base to build reliable prediction equations. So, until more information is available, the best indicator of the element concentration of a hay sample, is a lab analysis for that element.

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