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NEW MEXICO FORAGE MINERAL SURVEY

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ABSTRACT: Forage minerals were surveyed across New Mexico to enhance Extension ruminant nutrition education programs by measuring mineral content and mineral variation of forages on New Mexico rangelands. New Mexico has nine major land resource areas. Seven of the areas are divided into two to four subresource areas. Forage samples were collected at two locations within each subresource area in fall and late winter of 2001 and 2002. Approximately 100 g of forage was hand-plucked at each location. Following collection, air-dry forage samples were sent to a commercial laboratory and analyzed for calcium, phosphorous, magnesium, potassium, sodium, sulfur, aluminum, cobalt, copper, iron, manganese, molybdenum, selenium, and zinc. The average concentration and range, respectively, for each mineral were: calcium (0.46%; 0.13-1.59%), phosphorous (0.07%; 0.01-0.18%), magnesium (0.09%; 0.03-0.36%), potassium (0.37%; 0.09-1.38%), sodium (0.05%; 0.01-0.57%), sulfur (0.10%; 0.03-0.29%), aluminum (1059 ppm; 147-5820 ppm), cobalt (0.46 ppm; 0.01-3.57 ppm), copper (12.6 ppm; 2.0-50.2 ppm), iron (876 ppm; 113-7450 ppm), manganese (75.5 ppm; 14.2-222 ppm), molybdenum (1.12 ppm; 0.09-2.90 ppm), selenium (0.10 ppm; 0.03-1.05 ppm), and zinc (23.7 ppm; 5.1-75.0 ppm). Forage mineral concentration varied greatly, both within and across major land resource areas of New Mexico. In most cases, average mineral concentrations were higher in the fall than in late winter. Primary consideration should be given to phosphorous, potassium, magnesium, copper, sodium, sulfur, and zinc in New Mexico mineral nutrition educational efforts. The observed magnitude of variation in forage mineral concentration highlights the importance of site-specific forage analysis to develop cost-effective mineral supplementation programs. However, in the absence of site-specific forage mineral analysis, these results provide a valuable foundation for addressing mineral supplementation in New Mexico Extension education by providing general guidelines from which to make recommendations.

Key Words: Forage, Mineral, Extension

Introduction

Livestock have requirements for water, energy, protein, vitamins, and minerals. Grazing cattle are expected to acquire the majority of required nutrients (other than water) from forage. New Mexico range forages may be seasonally deficient in required nutrients; therefore, supplemental nutrients must be provided to meet production goals. Nutrient supplementation can be costly and, in the interest of maximizing profitability, should be approached strategically. Informed decisions about mineral supplementation to grazing livestock require knowledge of the dynamic nature of forage mineral concentration and animal requirements. Animal requirement guidelines such as *Nutrient Requirements of Beef Cattle* (1996) have been published. However, dietary mineral content for animals grazing on specific sites is challenging to pinpoint. It is important for producers to identify the minerals that are most likely to be deficient and hamper performance.

This survey was conducted to develop a general measure of mineral content and variation in forages on New Mexico rangelands in order to aid producers in nutritional management of range livestock.

Materials and Methods

New Mexico has nine major land resource areas. Seven of the nine major resource areas are further divided into two to four subresource areas. In an effort to best represent the rangelands of New Mexico, two locations within each subresource area were identified for sampling (i.e., 42 locations statewide) and marked using global positioning technology. Forage samples were collected in the fall (mid-October through mid-December) and late winter (February through early March) of 2001 and 2002. Not all locations were sampled four times because of snow cover or lack of forage production. Fall samples were collected to represent mineral content at the end of the growing season, while late winter samples were collected to represent mineral content after plants had become completely dormant. Forage samples were collected while plants were becoming dormant or during dormancy because it is during this period that forages are least likely to supply adequate minerals to meet the requirement of grazing livestock.

Approximately 100 g of forage was hand-plucked at each location to best represent selectivity of grazing beef cattle. Following collection, air-dry forage samples were sent to a commercial laboratory (SDK Laboratories, Hutchinson, KS) and analyzed for calcium, phosphorous, magnesium, potassium, sodium, sulfur, aluminum, cobalt, copper, iron, manganese, molybdenum, selenium, and zinc using inductively coupled plasma procedures.

Results and Discussion

The only mineral measured to exceed the NRC (1996) requirements for beef cattle in all forage samples was iron (Table 1 and 2). In most cases, minerals were measured in higher concentration in the fall (Table 3) than in late winter (Table 4) when the forage was completely dormant. This is expected due to weathering and leaching losses that commonly occur during winter. The range in concentration for each mineral measured exceeded ninefold. Iron was the only mineral that was measured to be above the concentration that might be considered problematic.

Macrominerals

Calcium. Calcium concentration was below the NRC (1996) requirement for a gestating beef cow in 23% of samples and below the requirement for a lactating beef cow in 34%. The majority of fall and late winter samples contained sufficient calcium to meet the requirements of a gestating beef cow.

Phosphorous. Phosphorous content of all samples was below the requirement (NRC, 1996) for all classes of beef cattle. However, average forage phosphorous content in the fall was substantially higher than in late winter.

Potassium. Forage potassium concentration was below the NRC (1996) requirement for a gestating beef cow in 83% of samples and for a lactating beef cow in 89% of samples. But, phosphorous concentration was sufficient in at least one sample from six of the regions sampled in the fall. In late winter, as a result of normal decline in forage potassium leading into dormancy, less than 2% of samples was deficient in potassium for a gestating beef cow.

Magnesium. Magnesium concentration was below the NRC (1996) requirement for a gestating beef cow in 77% of samples, and below the requirement of a lactating beef cow in 97%. Magnesium was observed to be higher in the fall than late winter in most cases; however, the magnitude of difference between fall and late winter was not as great for magnesium as for phosphorous and potassium. In the fall, average magnesium concentration from five of the regions sampled were not sufficient to meet the requirement of a gestating beef cow, but only two of those regions were insufficient, on average, to meet the requirements of growing cattle. In late winter, average magnesium content for all regions was not sufficient for a gestating beef cow, and ranged from 20 to 50 percent of the requirement for a lactating beef cow. Magnesium absorption is compromised when dietary potassium or nitrogen concentrations are high (Greene et al., 1983). Usually, neither of these antagonists is high enough to significantly hinder magnesium absorption in cattle on dormant New Mexico range.

Sodium. Sodium concentration of samples collected from different locations was observed to vary greatly. Sodium concentration was substantially less than required (NRC, 1996) for a gestating or lactating beef cow in 91% and 93% of samples, respectively. However, sodium was recorded to exceed those requirements at four locations. At three of the four locations with sufficient sodium, the concentration was more than threefold the requirement. At almost all other locations sodium content was substantially less than the requirement. Although sodium concentration of forage is usually low, other than a few exceptions, it is important not to overlook the contribution drinking water makes to dietary sodium intake. For example, if an 1100-pound cow drinks 8 gallons of water that contains 150 mg/L of sodium, approximately 40 percent of the sodium requirement is fulfilled by the drinking water.

Sulfur. Sulfur content was below the NRC requirement for beef cattle in 92% of samples, and average sulfur concentration was observed to be lower in the late winter than fall in all regions. Sulfur concentration exceeded the requirement in at least one sample from four of the regions sampled in the fall, and from two of the regions sampled in the late winter. In late winter, sulfur concentration most commonly fell between 40 and 70 percent of the requirement for a beef cow. As with sodium, sulfur in drinking water often significantly contributes to the dietary supply of the mineral. For example, if an 1100-pound cow drinks 8 gallons of water containing 300 ppm of sulfates, 24 percent of the sulfur requirement will be supplied by the drinking water alone. However, excessive dietary sulfur, in drinking water or from supplemental feed sources can also reduce the absorption of copper or potentially cause polioencephalomacia (Underwood and Suttle, 1999). Sulfur is considered toxic when it exceeds 0.4 percent of the diet (NRC, 1996), and performance may be suppressed at levels as low as 0.25 percent of the diet (Zinn et al., 1997).

Microminerals

Aluminum. Aluminum concentration in forages did not follow the pattern of being higher in the fall than late winter like most other minerals measured. Extremely high aluminum values (greater than 3000 ppm) are likely the result of soil contamination of the forage sample. Aluminum toxicity has been reported (Underwood and Suttle, 1999), but is usually not a concern with grazing ruminants.

Cobalt. Cobalt concentration was below the NRC requirement (1996) for beef cattle in 8% of samples, but was not uniformly higher in the fall than late winter. In the fall, only two of the regions had at least one sample that was insufficient to meet the cobalt needs of a beef cow. However, in late winter seven of the regions sampled had at least on sample that was deficient in cobalt.

Copper. Copper concentration was deficient in 40% of samples overall, yet 89% of fall samples contained sufficient copper to meet the requirements of beef cattle (NRC, 1996). Samples collected in late winter were generally 20 to 50 percent less than fall samples, with deficient samples recorded for every region. The magnitude of deficiency in the late winter was marginal, with regional average values ranging from 74 to 104 percent of the requirement. The determination of copper content in the diet or in grazed forage has no diagnostic value in ruminants unless other elements that are antagonistic to copper availability are analyzed concurrently (Underwood and Suttle, 1999). More specifically, sulfur intake and the ratios of copper:molybdenum and iron:copper should be evaluated.

Iron. The iron content of all samples was sufficient to meet the NRC (1996) requirement of beef cattle. In fact, in five of the regions sampled in the fall and seven of the regions sampled in the late winter, at least one sample was collected that exceeded 1000 ppm, which is considered to be toxic to beef cattle. Iron:copper ratios of less than 50:1, 50:1 to 100:1, and greater than 100:1 are considered low, marginal and high risk for antagonism problems

(Underwood and Suttle, 1999). Using these risk categories 49% of samples were low risk, while 19 and 32% were classified as marginal and high risk, respectively. These findings indicate that iron may impact copper availability in many areas of the state.

Manganese. Forage manganese content was below the NRC (1996) requirement for a beef cow in only 16% of samples; however, it was sufficient to meet the substantially lower requirement of growing cattle in more than 98% of samples. Average manganese concentration for all regions sampled in the fall and late winter exceeded the requirement of beef cattle. Although average values were considered sufficient, some individual samples had insufficient manganese concentrations. Manganese concentration was measured to be less than the requirement for a beef cow in only three of the regions sampled in the fall, but seven of the regions sampled in the late winter had at least one sample considered deficient.

Molybdenum. Molybdenum is not an essential mineral required by mammals. Molybdenum can reduce copper absorption (Underwood and Suttle, 1999), and is considered toxic when dietary concentration exceeds 5 ppm (NRC, 1996). The highest molybdenum value recorded was less than 3 ppm, and 90% of samples contained less than 2 ppm. Molybdenum concentration was higher in the fall than late winter in most cases. Copper concentration exhibited the same general seasonal pattern, so that the ratio of copper to molybdenum was not drastically different between fall and late winter. It is recommended that the potential for copper depletion resulting from molybdenum interaction be evaluated using the copper:molybdenum ratio. Ratios greater than 3:1, 1:1 to 3:1, and less than 1:1 are classified as low, marginal, and high risk, respectively (Underwood and Suttle, 1999). Using the copper:molybdenum ratio, 95% of samples were classified as low risk, and the remaining 5% as marginal risk. These findings indicate that molybdenum is not a widespread copper antagonist issue within New Mexico.

Selenium. Selenium concentration was highly variable, and was below the NRC (1996) requirement for beef cattle in 92% of samples. Selenium concentration was deficient for beef cattle in at least one sample from four of the regions sampled in the fall, and from seven of the regions sampled in late winter. Average regional selenium content was not consistently different between fall and late winter. The Arizona and New Mexico Mountains, Southeastern Arizona Basin Range, and High Intermountain Valleys regions were noticeably lower in average forage selenium content than other regions.

Zinc. Zinc concentration was below the NRC (1996) requirement for beef cattle in the 77% of samples. More specifically, average regional zinc concentration was above the requirement for only three of the regions sampled in the spring, and was never sufficient in the late winter.

Implications

Forage mineral concentration varied greatly. Most minerals were in lower concentration in late winter than fall. In New Mexico, primary consideration should be given to phosphorous, potassium, magnesium, copper, and zinc when developing a mineral supplementation program for cattle because forage samples were almost always deficient. Selenium concentration was highly variable and should also be considered. Site-specific water analysis should be incorporated when interpreting the potential importance of low forage sodium and sulfur concentration at specific locations. Calcium, cobalt, and manganese were less frequently observed to be deficient, but should not be completely disregarded.

The observed magnitude of variation in forage mineral concentration highlights the importance of site-specific forage analysis to develop cost-effective mineral supplementation programs. In the absence of site-specific forage mineral analysis, the results of this survey may serve as a general guide.

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Table 1. Percentage of samples for each macromineral not meeting NRC (1996) requirement for gestating and lactating beef cows.

	Gestating	Lactating
Macromineral	--------------%--------------	
Calcium	23	34
Phosphorus	100	100
Potassium	83	89
Magnesium	77	97
Sodium	91	93
Sulfur	92	92

Table 2. Percentage of samples for each essential micromineral not meeting NRC (1996) requirement for beef cattle.

Micromineral	--------%-------
Cobalt	8
Copper	40
Iron	0
Manganese	16
Selenium	47
Zinc	77

Table 3. Average fall forage mineral concentration from New Mexico major land resource areas.

	Mineral Concentration										
Item	WP[a]	ND[b]	AN[c]	SA[d]	SD[e]	RM[f]	HV[g]	CP[h]	HP[i]	Low	High
Number of samples	6	2	8	4	10	4	0	15	12		
Calcium, %	0.60	0.39	0.49	0.29	0.48	0.47		0.56	0.56	0.16	1.59
Phosphorus, %	0.08	0.14	0.11	0.06	0.08	0.10		0.07	0.08	0.03	0.18
Potassium, %	0.76	1.21	0.53	0.30	0.61	0.39		0.52	0.46	0.13	1.38
Magnesium, %	0.17	0.18	0.10	0.05	0.12	0.10		0.10	0.09	0.04	0.32
Sodium, %	0.15	0.27	0.03	0.02	0.03	0.08		0.03	0.03	0.01	0.57
Sulfur, %	0.15	0.26	0.11	0.08	0.13	0.10		0.13	0.11	0.06	0.29
Aluminum, ppm	772	316	571	636	1204	1445		951	1127	202	3330
Cobalt, ppm	0.17	0.34	0.25	0.12	0.48	0.97		0.40	0.44	0.01	1.91
Copper, ppm	13.2	10.4	13.8	16.9	15.7	29.3		17.5	20.9	4.3	50.2
Iron, ppm	580	325	507	417	932	1390		816	909	113	3490
Manganese, ppm	81	52	71	68	124	83		92	65	31	202
Molybdenum, ppm	1.49	0.96	1.66	1.69	1.28	2.18		1.30	1.46	0.55	2.90
Selenium, ppm	0.13	0.22	0.05	0.04	0.13	0.13		0.13	0.11	0.04	0.65
Zinc, ppm	19.3	23.9	51.7	20.9	26.2	35.6		29.9	30.4	9.3	75.0

[a]WP=New Mexico and Arizona Plateaus and Mesas. [b]ND=San Juan River Valley, Mesas, and Plateaus. [c]AN=Arizona and New Mexico Mountains. [d]SA=Southeastern Arizona Basins and Range. [e]SD=Southern Desertic Basins, Plains, and Mountains. [f]RM=Southern Rocky Mountains. [g]HV=High Intermountain Valleys. [h]CP=Pecos-Canadian Plains and Valleys. [i]HP=Southern High Plains.

Table 4. Average late winter forage mineral concentration from New Mexico major land resource areas.

	Mineral Concentration										
Item	WP[a]	ND[b]	AN[c]	SA[d]	SD[e]	RM[f]	HV[g]	CP[h]	HP[i]	Low	High
Number of samples	11	3	7	4	12	8	2	16	10		
Calcium, %	0.43	0.35	0.28	0.25	0.37	0.37	0.47	0.53	0.54	0.13	1.14
Phosphorus, %	0.04	0.04	0.05	0.05	0.06	0.08	0.07	0.05	0.06	0.01	.0.13
Potassium, %	0.28	0.19	0.20	0.23	0.28	0.26	0.21	0.22	0.21	0.09	1.01
Magnesium, %	0.10	0.06	0.06	0.04	0.07	0.09	0.10	0.10	0.07	0.03	0.36
Sodium, %	0.10	0.04	0.03	0.03	0.03	0.09	0.03	0.03	0.03	0.01	0.57
Sulfur, %	0.11	0.13	0.06	0.07	0.10	0.09	0.09	0.09	0.09	0.03	0.26
Aluminum, ppm	843	532	486	452	1041	1706	1172	1766	1033	147	5820
Cobalt, ppm	0.39	0.04	0.42	0.11	0.38	1.10	0.66	0.60	0.41	0.01	3.57
Copper, ppm	9.6	7.5	8.0	10.4	7.4	8.0	9.5	9.6	8.8	2.0	28.6
Iron, ppm	729	504	565	319	718	1833	1074	1282	846	136	7450
Manganese, ppm	49	42	49	56	97	87	69	76	51	14	222
Molybdenum, ppm	0.87	1.30	0.38	1.42	0.67	1.55	0.98	0.59	0.76	0.09	2.89
Selenium, ppm	0.12	0.15	0.04	0.06	0.10	0.13	0.07	0.22	0.18	0.03	1.05
Zinc, ppm	12.5	25.4	14.0	17.6	16.9	20.0	25.1	19.1	17.4	5.1	52.7

[a]WP=New Mexico and Arizona Plateaus and Mesas. [b]ND=San Juan River Valley, Mesas, and Plateaus. [c]AN=Arizona and New Mexico Mountains. [d]SA=Southeastern Arizona Basins and Range. [e]SD=Southern Desertic Basins, Plains, and Mountains. [f]RM=Southern Rocky Mountains. [g]HV=High Intermountain Valleys. [h]CP=Pecos-Canadian Plains and Valleys. [i]HP=Southern High Plains.