The Effects of Burning on Mineral Contents of Flint Hill Range Forages

JIMMY E. UMOH, LENIEL H. HARBERS, AND ED F. SMITH

Abstract

The mineral status of Flint Hills bluestem forage was assessed monthly between 1975 and 1976. Results indicated that magnesium, potassium, and manganese were adequate for optimum performance of range cattle during spring and summer, but that magnesium and potassium were low in late fall and winter. Concentrations of calcium, iron, and zinc, highest in spring, were higher throughout the year than established nutrient requirements. Burning significantly decreased phosphorus and iron and increased magnesium. The low levels of phosphorus and potassium during fall and winter do not affect animal performance.

Most of the many minerals essential for animal life normally are present and metabolically available in adequate amounts in pasture so only those likely to be deficient are important to range managers. Pasture, the main source of feed for ruminants, varies widely in mineral content because many factors influence minerals including seasons, soil, cultural or management practices, and stage of plant growth.

Higher phosphorus (P) in winter and spring grasses than in summer and fall grasses have been reported (Melville and Sears 1953, Reith et al. 1964), while calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) peak about September then decline to their lowest in winter (Walker et al. 1953, Hemingway 1962, Karn and Clanton 1976). Blincoe and Lambert (1972) reported that advancing season did not influence copper (Cu) or zinc (Zn) contents of crested wheatgrass from April to July in northern Nevada. Cu deficiency was reported in the Netherlands at the end of the grazing season (Hartmans 1969), while Fleming (1970) found Zn content of perennial ryegrass *(Lolium perenne* L.*)* increased until late September and then declined.

Management practices, such as range burning, also greatly affect mineral status of forages. Range burning has been used to increase protein in forages (Campbell and Cassady 1951, Smith and Young 1959) and apparent digestibility coefficients of dry matter and crude fiber (Smith et al. 1960, Grelen and Whitaker 1973).

Burning also is believed to benefit plant growth by increasing organic matter, mineral elements, and nitrogen in the soil (Metz et al. 1961, Ahlgren and Ahlgren 1960). The widespread practice of burning in late winter increases protein and P in new growth, but the benefit lasts only until May when the young-leaf stage ends (Campbell and Cassady 1951, Duvall and Whitaker 1964).

Glendening et al. (1952) reported mineral contents of prairie grass, mostly bluestem of Kansas. Their work, covering April, July, and winter months of 3 years, showed some minerals deficient. A wide variety of plants grow under range conditions, and management, stage of maturity, precipitation, and location all affect the nutrient composition of range plants. It seemed to us that a monthly assessment of mineral composition of Flint Hills range forages was essential to establish possible deficiencies or excesses of minerals for grazing stock, so we investigated effects of grazing season and pasture burning on the mineral contents of Flint Hills range forage hand clipped monthly for 12 months.

Research assistant and professors of animal science, Kansas State University, Manhattan. J. Umoh now is senior research fellow, National Animal Production Research Institute, Ahmadu Bello University, Zaria, Nigeria.

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Experimental Area and Methods

The study area was the Flint Hills, tallgrass prairie 5 miles northwest of Manhattan, Kansas. Nutritive value of the range plants is high from May 1 to October 1. Warm-season grasses start to mature in July and develop seed heads by August.

Main grass species, big and little bluestem (*Andropogon gerardii* Vitman and *A. scoparius* Michx.) (Herbel and Anderson 1959), form from 50 to 60% of the vegetation. Three other warm-season grasses, Indiangrass (*Sorghastrum nutans* (L.) Nash), switchgrass (*Panicum virgatum* L), and sideoats grama (*Bouteloua curtipendula)* (Michx.) Torr.), comprise another 10 to 20%. The range area elevation is 400 m. Annual precipitation varies from 63.5 to 92 cm with most of it coming as summer rain (Rao et al. 1973).

Nine pastures totalling 199 ha were selected for burned and nonburned treatments in 1975. Five of the nine were burned in late spring (April 22, 1975). In the spring of 1976, the same areas were burned April 23. Burning in 1976 was sporadic because most of the pasture had turned green by late April.

Some of the pastures were grazed during the summer season each year by Hereford and Hereford × Angus steers distributed evenly among the pastures. The steers remained on the pastures between May and October, when they were removed for finishing in the feedlot. Polled Hereford beef cows with calves grazed the remaining pastures year-round at a stocking rate of 0.35–0.44 cows/ha.

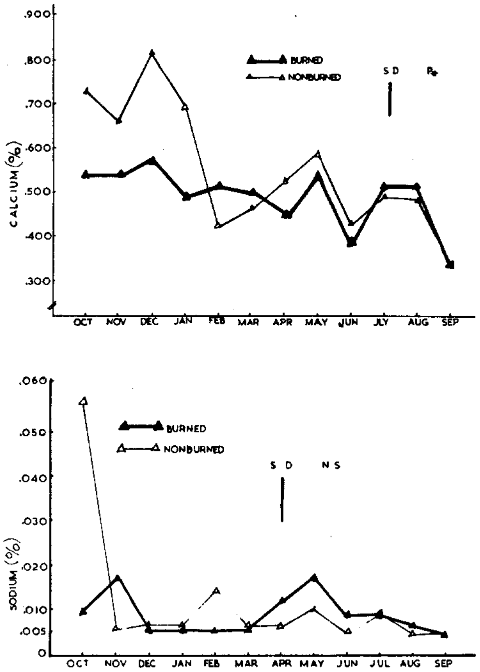
Hand-clipped forage samples were collected at 10 random locations every month, between October 1975 and September 1976, from one burned and one nonburned pasture. The sample areas measured 1800 cm^2 each and samples were cut to 2.5 cm above ground level. Each set of ten samples was bulked, subsampled, and dried immediately after harvest at 55° C in a forced-air oven for 2 days, then ground through a 0.5-mm mesh screen in a Wiley mill. Calcium, phosphorus, sodium, potassium, magnesium, copper, manganese, and zinc were determined from the samples by standard A.O.A.C. (1970) methods and atomic absorption spectrophotometry. The data were subjected to analysis of variance, with treatments (burned and nonburned) and monthly effects as the main inputs.

Results and Discussion

Mineral contents of forages are given in Table 1 and Figures 1 and 2. Each element is considered separately below.

Calcium (Ca)

Calcium contents of winter and spring pastures were significantly ($P<0.05$) higher than contents of fall and summer pastures, although the monthly variations were small ($CV = 14.6\%$) (Fig. 1). Burning had no significant effect on the Ca content, although Ca



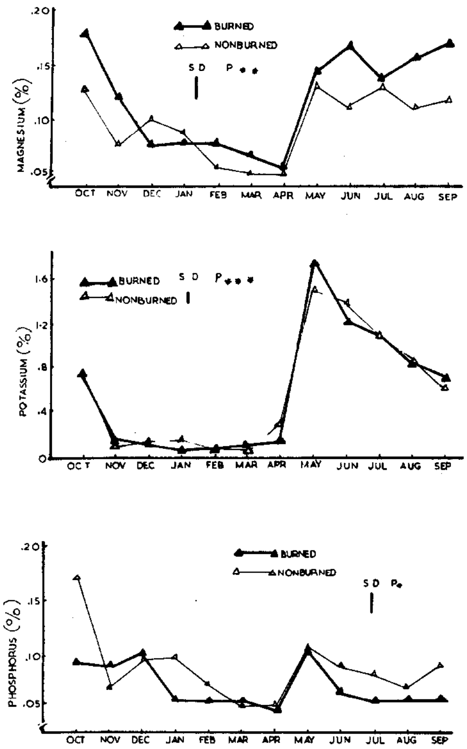


Fig. 1. *Macro element contents of burned and nonburned pastures. Monthly variation (SD) and level of significance are shown as NS = Not significant, * = P <0.05, ** = P <0.01 and *** = P <0.001.*

content of the nonburned pasture trended higher (Table 1).

A mean of 0.52% Ca (ranging from 0.342 to 0.819% Ca) is higher than the NRC (1976) Ca requirement of 0.30 to 0.44 (% DM) for growing and finishing beef cattle, and our data confirm those of Glendening et al. (1952), who reported 0.57 and 0.41% Ca content for bluestem prairie of Kansas during April and July, respectively. So grazing stock should not require any Ca supplementation even during winter when Ca content is low.

Phosphorus (P)

The mean P content of pasture was 0.082%, with a range of 0.058 to 0.171% P (Fig. 1), which is below the NRC (1976) 0.18 to 0.22% requirement for growing and finishing cattle. Phosphorus supplementation of pastures was needed throughout the year, with a possible exception in May. Earlier work had shown P content of bluestem prairie grass variable with results similar to ours (Glendening et al. 1952).

Although significantly higher (P<0.05) values were recorded during winter and spring than in other seasons, the month-to-month variation did not indicate a consistent pattern (CV = 20.4%). Melville and Sears (1953) observed similar trends in New Zealand when they separated grasses from clover swards and found higher P contents in both grass and clover swards in winter

Table 1. Mean mineral content of burned and unburned bluestem pasture forage and level of significance between the two treatments.

	Nonburned	Burned	*F*-value	
Calcium (%)	.554	.494	3.73	NS[1]
Phosphorus (%)	.091	0.74	5.99*[2]	
Magnesium (%)	.097	.120	8.55*[2]	
Sodium (%)	.012	.009	0.40	NS
Potassium (%)	.608	.601	0.05	NS
Iron (gm/kg)	.327	.285	5.54*[2]	
Copper (gm/kg)	.005	.005	0.28	NS
Manganese (gm/kg)	.041	.045	0.70	NS
Zinc (gm/kg)	.033	.032	0.57	NS

[1]NS = Not significant
[2]* = (P<0.05)

and spring growth than in summer and autumn. Burning in our studies significantly (P<0.05) decreased P content of the pasture (Table 1).

The P content of esophageal fistula forages from the pastures averaged 0.255% (ranging from 0.160–0.420), showing that range animals recycle P (Umoh 1977). Bath et al. (1956) and Lesperance et al. (1960) have shown that salivary contamination significantly modifies the composition of feed samples and may explain the lack of response to P by cattle grazing Flint Hills pastures (Drake 1964).

Magnesium (Mg)

The range of 0.052 to 0.178% Mg, with a mean of 0.108% meets the NRC (1976) requirement of 0.06 to 0.15% Mg for growing and finishing cattle. Burning significantly (P<0.05) increased Mg content over the nonburned pasture (Table 1), with differences among seasons highly significant (P<0.05) (Fig. 1). Magnesium was highest during the spring and summer growing period and lowest during winter dormancy. Thus the decline in Mg at maturity agrees with earlier work of Rauzi et al. (1969) for blue grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.), although they noticed no similar effect in wheatgrass (*Agropyron* spp.).

Potassium (K)

No specific minimum K requirement has been established, but NRC (1976) suggests 0.6 to 0.8% of ration DM for growing and finishing cattle. As the K content of forages varied from 0.087 to 1.79% during different months, the NRC suggestion would be met only during certain months. K declined steadily and consistently throughout summer from its high (1.8%) in spring to its lowest (0.08%) in winter (Fig. 1). Earlier reports quoted K content of bluestem at 0.51% in mature plants and 1.35% in immature plants (NRC 1976) and 0.50 to 1.02% in bluestem prairie hay and 0.09 to 0.30% in winter grass (Glendening et al. 1952). So, cattle would have adequate K from the forage diets except on grass of winter ranges (Karn and Clanton 1976). Native grasses contain low K, which decreases as the grasses mature. Burning pasture did not affect K content significantly (Table 1).

Sodium (Na)

Neither burning nor seasonal variation significantly effected Na content of forages (Table 1 and Fig. 1), but the monthly trend was highly irregular (CV = 100.4%).

A mean of 0.01% Na (ranging from 0.005 to 0.18%) was far below the Na requirement of 0.13% in the total DM ration for lactating cows (ARC 1965), or 0.25% and 0.5% salt for growing and finishing cattle and for lactating cows, respectively (NRC 1976). The pasture contained adequate Na only in spring when 0.18% was recorded, and similar low values have been reported for other grass species. Long et al. (1970) recorded 0.03% Na for *Brachiaria* sp. and 0.07% Na for *Chloris gayana,* although Fleming and Murphy (1968) reported higher Na values (0.2 to 0.3%) in tall fescue *(Festuca arundinacea)* and timothy *(Phleum pratense)* and 1.2% in perennial ryegrass in Ireland. Applied fertilizer may have contributed immensely to Fleming and Murphy's high values. Mineral contents, particularly of Na, of different grass species and varieties of the same species vary widely (Lehr 1960), which may partially explain our Na. Still, year round salt supplementation of Flint Hills range, as practiced, seems appropriate for grazing livestock.

Iron (Fe)

Our mean Fe content of forages was 0.306 g/kg (ranging from 0.13 g to 0.616 g/kg), with the highest in spring and lowest in summer after plants matured (Fig. 2). Similar declining Fe with plant maturity had been reported earlier for bromegrass (*Bromus* spp.) (Loper and Smith 1961), although Stewart and Holmes (1953), studying the effect of N on micronutrient contents of mixed sward, reported that Fe increased as the season advanced. Rauzi et al. (1969) reported that Fe content of western wheatgrass (*Agropyron* spp.) remained fairly constant during the growing season.

Although beef cattle require Fe, the minimum has not been established (NRC 1976). Fe present in most U.S. cattle feeds (0.08 to 0.8 g/kg) is considered adequate for beef cattle. Van Campen (1970) gave Fe requirements as 0.03 g/day for calves and 0.05 to 0.06 g/day for mature cattle, values far below those we found. Kirchgessner (1965) reported that meadow grass's lowest Fe content was higher than the optimum for cattle. Other workers also have shown Fe in grasses and clovers far higher than the requirements for grazing stock.

Burning of the pasture significantly ($P<0.05$) reduced the Fe concentration in the forages (Table 1).

Manganese (Mn)

The Mn of forages was adequate for cattle. The mean of 0.043 g/kg (ranging from 0.021 to 0.081 g/kg) is higher than the 0.001 to 0.01 g/kg Mn recommended for beef cattle (NRC 1976). However, increases in dietary Ca and P raise Mn requirements, so one must know Ca and P levels in the diet.

Neither burning nor season significantly affected the Mn content of forages, although the highest value was recorded late in summer, probably because Mn concentrates more in plant stems than in other plant parts (Fig. 2). Fleming (1963) showed that Mn concentrates in stems more than in other parts of perennial ryegrass, alfalfa (*Medicago* spp.), red clover *(Trifolium pratense),* Ladino clover (*Trifolium repens* L.), and bromegrass (*Bromus* spp.), and more at senescence when the ratio of stem to leaf is greater than earlier in the plant's life.

Zinc (Zn)

Pasture burning had no significant effect on Zn content (Table 1), but the seasonal variation was significant ($P<0.05$) (Fig. 2). Zn was higher in spring than at other times (Fig. 2). Its mean value of 0.032 g/kg Zn (ranging from 0.019 to 0.045 g/kg) was higher than the recommended Zn requirement of 0.01 to 0.03 g/kg for cattle (NRC 1976) and about the same as the 0.02 to 0.03 g/kg given for best cattle performance by Van Campen (1970). Thus, the forages examined contained Zn adequate for cattle performance except when diets contain high Ca that may depress Zn availability.

Copper (Cu)

The Cu content of forages seemed adequate for grazing stock. The mean of 5 mg/kg (ranging for 2 to 10 mg/kg) equalled the minimum (5 mg/kg) given for most domestic species (Van Campen 1970; NRC (1976) gives a Cu requirement for growing and finishing cattle of 4 mg/kg.

Burning had little effect on Cu, but seasonal variation was highly significant ($P<0.001$) (Fig. 2). Cu rose from March to a peak in May, then declined from June to its lowest in winter.

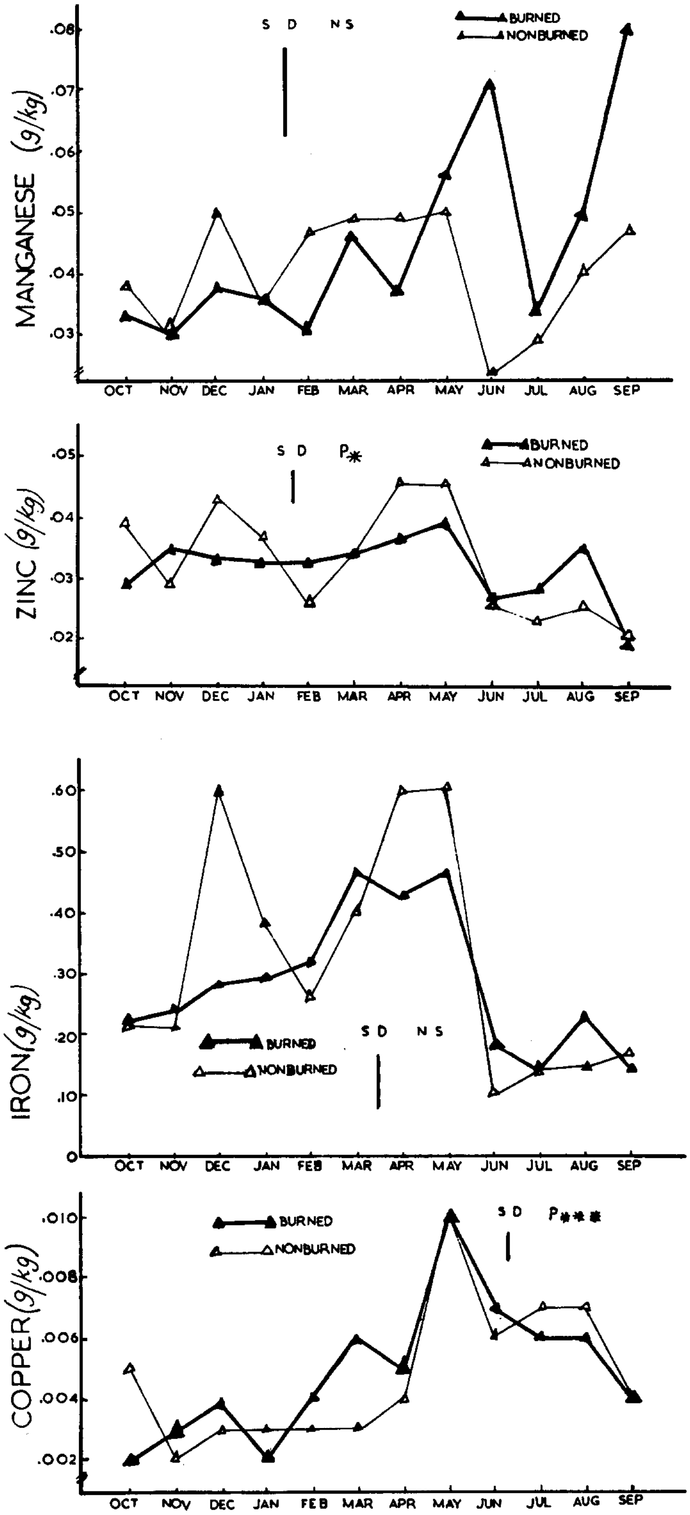


Fig. 2. *Micro element contents of burned and nonburned pastures. Monthly variation (SD) and significance are shown as NS = Not significant, * = P <0.05, and *** = P <0.001.*

Summary and Conclusions

Data from our study indicate that mineral imbalances and/or deficiencies for grazing animals are related to season of year and pasture burning. However, big and little bluestem, the dominant species of the prairie we studied, having unfavorable ratios of one element to another does not mean that other prairie species will be the same. If we had analyzed separately the different grass species occurring in the range, our results likely would have differed.

During winter and spring months, P and Mg levels were similar, averaging about 0.08% each, but in summer, the Mg (0.15%) was significantly higher than P (0.062%). Similar differences were recorded for Mn and Zn, both having about the same concentration and trend throughout spring, but Mn then almost doubling Zn (Fig. 2). This raises the question about the botanical composition of sward, mineral concentration in different plant parts, and possible species selection by grazing stock attempting to correct mineral imbalances.

The Ca:P ratio is important in animal nutrition and the recommended ratio lies within the limits of 2.0 to 0.5 (Ensminger 1955). The ratio we found (about 6.0:1) is below the 7:1 cattle tolerate (NRC 1976). The only season when the Ca:P ratio was as low as 4:1 was in spring.

NRC (1976) recommendations are for high-energy rations to contain at least 0.22% P and growing rations, 0.18% P. The forages we examined did not contain enough P except in spring. Low P in pasture and other roughage feeds is widespread, particularly in semiarid regions where P content of plants generally decreases markedly with maturity and is deficient in cattle subsisting for long periods on mature dried forages without supplements.

The mineral analyses suggest that animals grazing Flint Hills pastures may suffer deficiencies in P, Na, and Cu when they depend on pastures for their mineral needs. However, selective grazing, well known in cattle, may at least partially correct the deficiency. Recycling minerals also may be important because supplementing cows on pasture with P, K and Cu did not improve cow or calf performance for Pruitt et al. (1979, 1980).

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