# Grazing management effect on mineral content of grasses: Case of two veld types of the Eastern Cape, South Africa

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**Key words**: Forage quality; herbaceous biomass; management practice; mineral concentration; veld type.

**Abstract**

This study examined the impact of three distinct grazing management strategies on the mineral composition of bulked native herbaceous forages within the sourveld and sweetveld ecosystems of South Africa's Eastern Cape province. The grazing management treatments examined were communal continuous (CC), holistic planned grazing (HPG), and commercial rotational (CR), each implemented across both veld types. Herbaceous forage samples were harvested from transects distributed along the lower, middle, and upper slopes of each site. Bulked, ground herbaceous forages were analysed for macro-elements (K, Ca, Mg, and P) and micro-elements (Fe, Zn, Mn, and Cu). Results highlighted notable differences between sourveld and sweetveld forages, with sourveld exhibiting higher macro-nutrient levels while sweetveld displayed elevated micronutrient concentrations, except for Mn. In sourveld areas, grazing management significantly affected ($P < 0.05$) the concentration of both macro and micro-elements except Zn. Additionally, the year (season) exerted significant effects ($P < 0.05$) on levels of Ca, K, Mg, Cu, Fe, and Zn, though not on P and Mn. Noteworthy interactions were observed, such as the influence of management practice by year by landscape position on P levels, and management by year on Zn and Mn levels. In sweetveld areas, management practices significantly impacted ($P < 0.05$) the levels of Ca, K, Mg, Cu, Zn, and Mn. Overall, grazing management practice and yearly (seasonal) variations emerged as the primary factors influencing forage mineral status. The analysis indicated deficiencies in P and Cu across both veld types, implying insufficient levels to meet ruminant animal requirements. Moreover, other elements potentially displayed marginal to deficient supplies, particularly in areas with continuous grazing. Consequently, supplementation may be necessary in both veld types. Future research could explore animal blood serum mineral levels to devise practical supplementation regimes aimed at averting potential deficiencies.

## Introduction

There are two main types of rangeland tenure and usage in South Africa: communal land, which is owned by the government but managed through the chief, and the title deed land, which is mainly private ranching. Two major grazing systems have been practiced, namely continuous grazing (mostly practiced in communal tenure), and rotational grazing (mainly practiced in the commercial ranching and conservation farms). Over the last few decades, holistic planned grazing (HPG) has been introduced in a few commercial farm and communal areas in an attempt to maintain the natural balance between the livestock and rangeland resources for sustaining livestock production and associated values. Recent studies suggest that vast communally used rangelands in South Africa have degraded (Kwaza *et al*. 2020; Mlaza *et al.* 2023) with implications on mineral provision, both in time and space. However, the changes in forage minerals in the communal land in relation to other management (including rotational or HPG) have not been investigated. The objectives of this study were to determine the mineral content of bulked herbaceous forage samples in three grazing systems along a landscape gradient over time.

**Methods**

The study was conducted in two rangeland types across a precipitation gradient, sweetveld and sourveld in the Eastern Cape, South Africa. Sweetveld sites in Enock Mgijima local municipality experience a relatively dry climate with sourveld sites in Raymond Mhlaba local municipality receiving ~1000mm mean annual rainfall. Three communal - continuous grazing camps (CC), three communal - holistic planned grazing camps (CHPG) and two commercial ranches with rotational grazing (CR) were selected in the sweetveld. In the sourveld, two CC grazing lands, two CR grazing and two commercial ranches with HPG (CRHPG) were selected. Each camp or farm was divided into three major landscape positions (upper, middle and lower), and two 100 m x 10 m permanent plots ~50 m apart for data collection were established in each landscape unit. Forage samples were collected over two years; in the first year, during end of the dry season (sweetveld – 2016; sourveld – 2017), and towards the end of the growing season the following year. Forage samples were taken from ten 0.25 $m^2$ quadrats per plot, harvested at stubble height, bulked and oven-dried. The samples were milled and mineral elements were analysed using dry ashing (Method 6.1.1) (ALASA, 1998) at Western Cape Department of Agriculture, Enselberg Laboratories, South Africa. The experimental design consisted of nine treatment combinations in each rangeland type (3 camps/farms and 3 landscape positions). Data were analysed separately for the two rangeland types using the Mixed Model procedure of SAS (2007) testing the effects of grazing management, landscape position and seasonal variation.

**Results**

**Effect of grazing management practices on mineral concentration**

All forage mineral contents except Zn were significantly influenced by grazing management (Table 1). Forage Ca and P were higher ($P < 0.001$) in CR and CRHPG farms, K ($P <0.01$) in CR farms and Mg ($P < 0.001$) in CC farms. Of the micro elements, forage Cu and Fe contents were highest in CR farms and Mn had the order of CR > CC > CRHPG farms. In the sweetveld, grazing management significantly influenced ($P < 0.001$) Ca, K and Mg concentrations. Forage Mn, Cu and Zn were highest in CC camps (Table 1).

Table 1: Mineral concentrations of forage samples from three grazing management systems in the sourveld and sweetveld study areas.

| Mineral | Sourveld | | | Sweetveld | | |
|---|---|---|---|---|---|---|
| | CC | CRHPG | CR | CC | CHPG | CR |
| Ca (%) | 0.26±0.01[b] | 0.32±0.01[a] | 0.32±0.01[a] | 0.25±0.01[b] | 0.24±0.01[c] | 0.32±0.01[a] |
| P (%) | 0.06±0.01[b] | 0.11±0.01[a] | 0.13±0.01[a] | 0.11±0.01[a] | 0.10±0.01[a] | 0.11±0.01[a] |
| K (%) | 0.69±0.04[b] | 0.69±0.04[b] | 0.86±0.04[a] | 0.59±0.04[b] | 0.48±0.04[c] | 0.84±0.04[a] |
| Mg (%) | 0.13±0.00[a] | 0.08±0.00[b] | 0.10±0.00[b] | 0.10±0.00[b] | 0.08±0.00[c] | 0.12±0.01[a] |
| Mn ($mgkg^{-1}$) | 169.6±10.9[b] | 58.8±10.9[c] | 229.1±10.9[a] | 50.2±1.62[a] | 43.4±1.62[b] | 46.1±1.99[ab] |
| Cu ($mgkg^{-1}$) | 2.16±0.12[b] | 2.24±0.12[b] | 2.66±0.12[a] | 2.88±0.09[a] | 2.59±0.09[a] | 2.51±0.11[a] |
| Fe ($mgkg^{-1}$) | 281.8±27.3[b] | 263.8±27.3[b] | 442.7±27.3[a] | 667.6±44.38[a] | 585.1±44.38[ab] | 499.4±54.4[b] |
| Zn ($mgkg^{-1}$) | 28.0±1.26[a] | 27.0±1.26[a] | 26.9±2.16[a] | 36.0±1.68[a] | 28.9±1.68[b] | 32.1±2.06[ab] |

Means with different superscripts differ significantly (*P < 0.05*)

***Effect of year (season) on mineral concentration***

Significant differences (P < 0.0001) in forage mineral concentrations of Ca, K, Mg, Fe, Cu and Zn were found between years in both sourveld and sweetveld. Sourveld forages had lower concentrations in Year 1 (2017) compared to Year 2 (2018) (Table 2). Phosphorus and Mn were not influenced by year, but P showed a significant interaction of management practice x year x landscape position (P<0.05). In the sweetveld, all macro elements (Ca, P, K and Mg) were greatly influenced (P < .0001) by year with higher P, K, Ca and Mg in Year 2 (Table 2)

Table 2: Mean concentration of macro and micro-minerals by year in sweetveld and sourveld forages.

| Mineral | Sourveld | | | Sweetveld | | |
|---|---|---|---|---|---|---|
| | Year 1 | Year 2 | SE | Year 1 | Year 2 | SE |
| Ca (%) | 0.27 | 0.33 | 0.01 | 0.24 | 0.30 | 0.01 |
| P (%) | 0.09 | 0.11 | 0.01 | 0.07 | 0.14 | 0.05 |
| K (%) | 0.56 | 0.94 | 0.03 | 0.43 | 0.84 | 0.03 |
| Mg (%) | 0.09 | 0.11 | 0.00 | 0.08 | 0.12 | 0.04 |
| Mn ($mgkg^{-1}$) | 15.05 | 39.53 | 1.76 | 47.70 | 45.42 | 1.43 |
| Cu ($mgkg^{-1}$) | 1.71 | 3.00 | 0.10 | 1.87 | 3.46 | 0.77 |
| Fe ($mgkg^{-1}$) | 249.44 | 409.48 | 22.26 | 496.67 | 671.35 | 39.14 |
| Zn ($mgkg^{-1}$) | 148.94 | 156.05 | 8.90 | 20.26 | 49.43 | 1.48 |

***Effect of landscape position on mineral concentration***

Landscape position significantly affected (P < 0.001) K, Cu and Zn concentrations in the sweetveld, with higher levels found in the upper slopes. Management and landscape interactions influenced mineral concentrations, with upper slopes of CR farms having higher K, Mg, Cu, Zn and Mn, while CC and CHPG had highest Zn concentrations in the lower slopes, and K, Mg and Mn highest in CHPG middle slopes.

**Discussion**

Phosphorus concentration was inadequate for grazing animals in both veld types, and across all management systems. This was likely due to the stage of plant maturity, as P levels typically decrease with advancing maturity (Beyene and Mlambo 2012), particularly when forages are harvested in the dry season and towards the end of the rainy season. The slight increase in P content in Year 2 may have been caused by more seed in the forages harvested towards the end of the growing season. A study by Kwaza (2018) in the sourveld also found inadequate P levels in the forages of the same veld. The deficiency of P in forages of South African rangelands was previously recorded by Drewes *et al*. (1999). Calcium deficiency may be of concern in CHPG camps, as forages should contain at least 0.27 % for beef cattle (NRC, 2000). The K concentration in sourveld forages exceeded the recommended level for grazing animals (McDowell 1996; NRC 2000), a similar finding to that of Kwaza (2018). Magnesium levels were deficient for grazing animals in both veld types, especially in holistic managed camps and farms. Previous studies, such as Drewes *et al*. (1999), noted Mg deficiencies in Eastern Cape rangelands. The deficiency in Mg could be due to soils with higher amounts of K (Prabowo *et al*. 1991). High soil K can compete with Mg for uptake, reducing Mg availability and causing Mg deficiency in forages. Variations in Mg levels in the different management systems could be partially clarified in terms of the proportion of leaf and stem fractions that were collected for mineral analysis, especially during the dry season where a higher proportion was stem. Beyene and Mlambo (2012) found that most grass species generally meet micro-nutrient requirements, but Zn levels in CHPG were inadequate. In the communal rangelands especially where sheep are grazed, supplementation of Zn needs to be kept under review. The levels of forage Zn did not vary by season, unlike Ramirez *et al*. (2001) who reported variations in forage Zn by season.

The concentration of Cu levels in the forages were below the required 6-12 $mgkg^{-1}$ (NRC, 2000) potentially leading to deficiency. This may be due to the high levels of Fe in the soil as the forages had above the recommended levels of Fe for grazing animals (NRC, 2000). Grazing pressure and grazing systems (CC and CHPG) in sweetveld may have contributed to low Cu levels, potentially due to high Fe and Mn levels. Beyene and Mlambo (2012) found elevated Fe concentrations in bulked range forages harvested from a variety of soil types. Complex interactions between soil properties, land management practices, landscape position, grazing intensity, and seasonal changes affect both the soil's mineral content and the plant's ability to absorb and accumulate these nutrients.

**Conclusion**

It can be concluded that the forages in the two veld types generally meet ruminant mineral requirements, except for P and Cu. Forage Ca, Fe, Mn and Zn are sufficient. However, K and Mg in communal holistic managed rangelands need monitoring. Supplementation may be required, and further studies on animal blood mineral levels are recommended to ensure animals have the right nutrients and to detect potential health issues.

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