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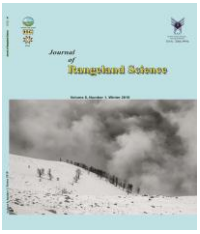

**Research and Full Length Article:**

# Effect of Growth Stage on the Macro Mineral Concentrations of Forbs and Grasses in a Semi-arid Region of Sudan

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**Abstract.** Changes in mineral concentrations with maturity often reflect increases in the proportion of stem to leaf with stems showing lower mineral concentrations than young leaves. The objective of this research was to assess the status of the macro mineral elements, Na, K, P, Ca and Mg in the dominant native species during the flowering and seed set stages of plant growth. This experiment was conducted at El Obeid Research Station Farm at Bannu area, Sheikan Locality, North Kordofan State, Sudan, over 2012/2013 seasons. The data indicated a higher content of macro minerals in forbs compared with grasses. Flowering stage showed higher concentrations of macro minerals compared with the seed set stage. It was concluded that the rangelands of North Kordofan State, containing a mixture of grasses and forbs, are good sources of macro minerals. It was considered that macro elements content in forbs and grasses in the study area is adequate for sheep, especially during the stage before plants set their seeds.

**Key words:** Macro-minerals, Flowering stage, Seed set stage

## Introduction

Sudan is a large country with an area of 1.88 million $Km^2$, and has the second largest animal population in Africa consisting of 52.08 million sheep, 43.44 million goats, 41.76 million cattle and 4.62 million camels (MARF, 2013). The majority of animal wealth is concentrated in western Sudan (40%), followed by central Sudan (23%) (MARF, 2011). Minerals are divided into two groups, macro-minerals, those that are required at 0.1% or more in the diet, and micro-minerals, are those that are required at very small amounts measured in part per million (ppm). Macro minerals include calcium, phosphorus, sodium, potassium, chlorine, sulphur and magnesium. Micro minerals include iron, copper, cobalt, manganese, zinc, iodine and others. Mineral deficiencies can lead to decreased growth and reproduction (Hajer *et al.,* 2014). Ruminants grazing forages in severely mineral-deficient areas may even be more limited by mineral deficiency than by a lack of energy or protein (McDowell and Conrad, 1977). Mineral imbalances in soils and forages are responsible for low production and reproduction among grazing livestock. As grazing livestock are not usually presented with mineral supplements apart from common salt, they depend upon forages for their requirements. However forages seldom completely satisfy all mineral requirements (Pastrana *et al.,* 1991). Mineral intakes of livestock are influenced by the factors that determine the mineral content of plants and their seeds. The concentrations of minerals in plants depend mainly on plant genotype, soil environment, climate and stage of maturity. Leguminous species are generally much richer in macro-elements than grasses growing in comparable conditions, whether temperate or tropical (Pastrana *et al.,* 1991). Small ruminant production represents the principal economic output, contributing a large share of the income of farmers (Ben Salem and Smith, 2008). Goats are important source of milk and meat for small farmers, fetch income locally and can be sold in local markets, to cover small cash expenditures (Devendra, 1985). Moreover, some areas of the tropics are known to be deficient in certain minerals, and the seasonal movement of sheep under nomadic or transhumant systems minimizes the effect of localized deficiencies. Underwood (1981) stated that mineral imbalance arises in an animal because the mineral content of its food is either deficient or in excess. It was also reported that sodium (Na) mineral content of food is either deficient or in excess. Rick (2007) reported that sodium (Na) together with chlorine (Cl) occurs as sodium chloride (NaCl) salt and it functions in amino acid and glucose transport and muscle contractions. Sodium deficiency occurs in tropical Africa and the inland parts of Australia (Underwood, 1981). Mineral deficiencies in goats in many countries are caused by low or variable contents due to soil, season, maturity of plants and low digestibility; where mineral supplementations were applied correctly (Hajer *et al.,* 2014). The objective of this study was to assess the status of the macro mineral elements Na, K, P, Ca, and Mg in the dominant native species during the flowering and seed set stages of plant growth at Sheikan Locality, North Kordofan State, Sudan.

## Methods and Methods

### Study area

This study was conducted at Bannu area at Sheikan Locality, North Kordofan State over 2012/2013 seasons (Fig. 1). The average annual rainfall is about 300mm, consisting of storms of short duration between July and September with the highest rainfall generally occurring in August. During the rainy season, forage biomass is suitable to provide sufficient feed for animals, but

during the dry season forage is scarce and small quantities of grain are also fed to animals (MARF, 2009).

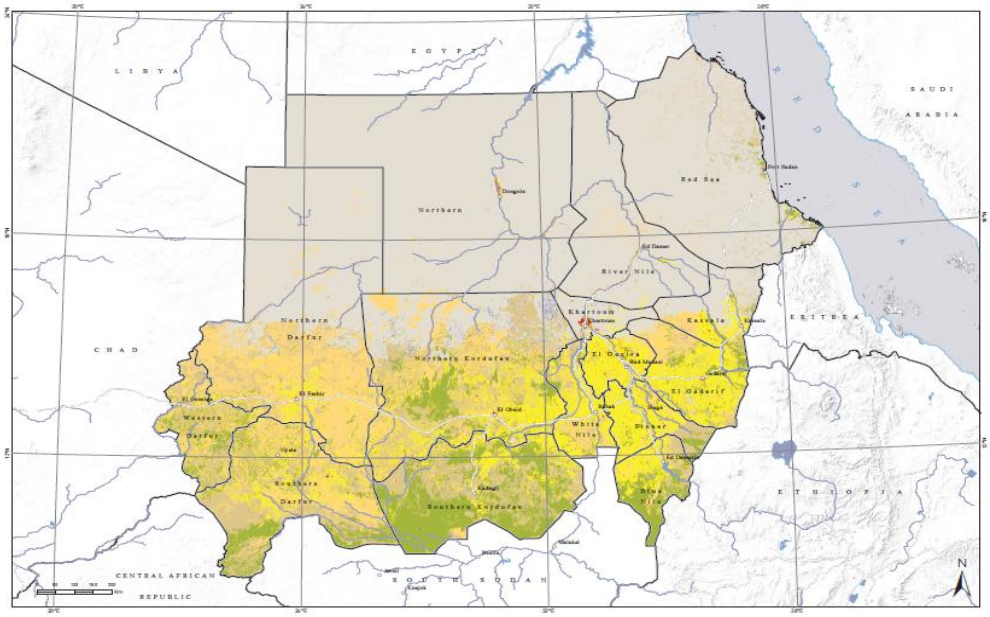


**Fig. 1.** The study area

## Sampling and experimental study

Sampling periods corresponded to two different stages of growth namely flowering (mid-rainy season) and seed set (early dry season) of 2012 and 2013. A total of 29 plant species (21 forbs and 8 grasses) were collected from the rangelands. Plants' shoots (leaves and stems) were picked randomly by hand according to the botanical composition of the diet selected by sheep as determined by bite count technique (Bjugstad *et al.*, 1970). Sheep were monitored for three days at flowering and at seed set stages, where the number of bites from each plant species was counted (Sahar, 2013). Similar materials were collected for analysis. Inductively Coupled Plasma Emission Spectrometer (ICP) was used to determine minerals. Data was analysis using SAS package (GLM Procedure).

## Results

Tables 1 and 2 illustrate the levels of the macro-minerals Na, K, P, Ca and Mg of some plant species of the rangeland of North Kordofan over the two stages of growth for forbs and grasses, respectively. Flowering stage showed higher concentrations of K, P and Ca compared with the seed set stage. There were significant differences ($P<0.05$) in the content of macro-minerals over the two stages of growth namely flowering and seed set. Also a higher content of macro-minerals was found in forbs compared with grasses.

There was great variation between species for Concentrations of macro-elements in both forbs and grasses. For example, Result of forbs at flowering stage for Na concentration showed that *Ipomoea belpharosepala* and *Blepharis linariifolia* with average values of 12156 and 127 (mg/kg) had higher and lower Na content, respectively (Table 1). The same trend with lower values were observed in seed set stage.

Mineral requirements of sheep from national research council (NRC, 1985) is presented in Table 3. According NRC (1996) the concentrations in forage needed to meet requirements of sheep for Na, Ca P, Mg, K and S were (0.09-0.18), (0.20-0.82), (0.16-0.38), (0.12-0.18), (0.50-0.80) and (0.14-0.26) percent, respectively (Table 3).

**Table 1.** Concentrations of macro-elements Na, K, P, Ca and Mg (mg/kg) for some forbs at flowering and seed set stage

| Scientific name | Flowering stage (mg/kg) | | | | | Seed set stage (mg/kg) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Na | K | P | Ca | Mg | Na | K | P | Ca | Mg |
| *Colocynthis citrullus* | 212 | 13863 | 1823 | 9948 | 2666 | 275 | 11854 | 1167 | 7907 | 1733 |
| *Seddera spp.* | 1433 | 11660 | 1328 | 21824 | 3593 | 4673 | 13485 | 1614 | 18997 | 4608 |
| *Polygala erioptera* | 473 | 22692 | 1654 | 18858 | 3247 | 625 | 12596 | 2049 | 6461 | 2486 |
| *Crotalaria spp.* | 280 | 21462 | 1854 | 12640 | 2426 | 178 | 14767 | 1043 | 8292 | 1501 |
| *Requenia obcordata* | 235 | 16049 | 1517 | 9656 | 2631 | 389 | 17829 | 1606 | 9051 | 2658 |
| *Justicia kotschyi* | 203 | 27631 | 2011 | 31457 | 18277 | 230 | 28632 | 2063 | 18694 | 10340 |
| *Blepharis linariifolia* | 127 | 21445 | 1581 | 18578 | 3978 | 102 | 15860 | 1295 | 17604 | 2650 |
| *Ipomoea sp.* | 10142 | 24012 | 2509 | 9194 | 4437 | 3084 | 26609 | 2581 | 9172 | 6197 |
| *Tephrosia spp.* | 669 | 18548 | 1504 | 10002 | 3173 | 172 | 14897 | 1319 | 11818 | 3524 |
| *Tribulus terrestris* | 1507 | 20173 | 2049 | 26132 | 5606 | -- | -- | -- | -- | -- |
| *Corchorus olitorius* | 808 | 22394 | 1703 | 13950 | 3669 | 388 | 15200 | 2301 | 20378 | 3459 |
| *Indigofera aspera* | 671 | 41579 | 2369 | 24604 | 11755 | -- | -- | -- | -- | -- |
| *Acanthus spp.* | 665 | 15139 | 1696 | 11038 | 3813 | 613 | 20019 | 1838 | 12186 | 4746 |
| *Indigofera spp.* | 410 | 20191 | 1795 | 26752 | 5277 | 260 | 16176 | 1240 | 14524 | 2592 |
| *Solanum dubium* | 294 | 29652 | 2320 | 15361 | 6684 | 158 | 25396 | 1451 | 14516 | 4538 |
| *Dicoma tomentosa* | 181 | 19597 | 2272 | 9748 | 4081 | -- | -- | -- | -- | -- |
| *Farsetia longifolia* | 594 | 15831 | 1870 | 18057 | 4673 | -- | -- | -- | -- | -- |
| *Ipomoea belpharosepala* | 12156 | 19010 | 2536 | 7524 | 3382 | 8079 | 21194 | 1483 | 9199 | 3727 |
| *Acanthospermum hispidum* | -- | -- | -- | -- | -- | 407 | 29131 | 1180 | 11733 | 4689 |
| *Abutilon glaucm* | -- | -- | -- | -- | -- | 748 | 22719 | 1769 | 24015 | 6383 |
| Total Means | 1726 | 21163 | 1910.6 | 16407 | 5187 | 1274 | 19148 | 1625 | 13409 | 4114 |

**Table 2.** Concentrations of macro-elements Na, K, P, Ca and Mg (mg/kg) for grasses at flowering and seed set stage

| Scientific name | Flowering stage (mg/kg) | | | | | Seed set stage (mg/kg) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Na | K | P | Ca | Mg | Na | K | P | Ca | Mg |
| *Echinochloa colonum* | 2718 | 25962 | 1415 | 3863 | 4345 | 1319 | 21958 | 697 | 5531 | 3690 |
| *Eragrostis tremula* | 11606 | 11926 | 1689 | 3905 | 2244 | 11397 | 11894 | 1221 | 3552 | 2535 |
| *Schoenefeldia gracilis* | 3412 | 16114 | 1199 | 3994 | 2031 | 1091 | 15606 | 705 | 3658 | 1994 |
| *Cenchrus biflorus* | 280 | 23633 | 1101 | 6086 | 2417 | 1448 | 20262 | 706 | 4080 | 2608 |
| *Chloris virgata* | 299 | 22480 | 1209 | 3694 | 3553 | -- | -- | -- | -- | -- |
| *Dactyloctenium aegyptium* | 3256 | 10673 | 1229 | 5121 | 2219 | -- | -- | -- | -- | -- |
| *Cyperus spp.* | 632 | 17332 | 867 | 6175 | 3250 | 1282 | 20535 | 1017 | 6914 | 2708 |
| *Aristida mutabilis* | 195 | 11324 | 1194 | 2972 | 1703 | -- | -- | -- | -- | -- |
| Total Means | 2800 | 17431 | 1238 | 4476 | 2720 | 3307 | 18051 | 869 | 4747 | 2707 |

**Table 3.** Mineral requirements of sheep from National Research Council (NRC, 1985)

| Nutrient | Sheep mineral requirement (% diet dry matter) |
|---|---|
| Sodium | 0.09-0.18 |
| Calcium | 0.20-0.82 |
| Phosphorus | 0.16-0.38 |
| Magnesium | 0.12-0.18 |
| Potassium | 0.50-0.80 |
| Sulfur | 0.14-0.26 |

## Discussion

Mineral concentrations in plants generally reflect the capability with which the soil can supply absorbable minerals to the roots. However, plants react to insufficient supplies of available minerals in the soil by limiting their growth, reducing the concentration of the deficient elements in their tissues or, more commonly, by reducing growth and concentration simultaneously. The extent of a particular response varies with different minerals, different plant species as well as with the soil and climatic conditions. Nevertheless, the primary reason for mineral deficiencies in grazing animals is that the soils are inherently low in plant-available minerals (Alloway, 2004).

According NRC (1996) the concentrations in forage needed to meet requirements of beef cattle for P, Ca, Mg, Na and K were 1.9 g/kg, 3.2 g/kg, 1.15 g/kg, 672 mg/kg and 5.76 g/kg, respectively. Grusak (2001) reported that the concentrations in forage needed to meet requirements of sheep for P, Ca, Mg and K were 0.2%, 0.5%, 0.2% and 1.0%, respectively. The requirement of sheep according to NRC (1985) for Na ranges between 0.09- 0.18% (Table 3), so our results indicate that Na is adequate to meet sheep requirements. Also the same result was found by Abdel Moniem *et al.* (2014) who reported a high sodium concentration at the flowering stage and a low concentration during the seed setting stage. Out of the 19 forbs collected at flowering stage and analyzed for P, only 8 reached the 0.2% concentration considered adequate for sheep. This agrees with Cook and Fadlalla (1987) who reported a deficiency of phosphorus in the diets of grazing animals in South Kordofan, Sudan, reflected in concentrations in range plants varying from 0.18% in the rainy season to 0.09% in the dry season. Calcium concentrations were adequate exceeding the 0.5% level in all plants, similarly Mg was also sufficient (>0.2%) in all plants except one; while K values exceeded the 1.0% reference level for adequacy in all plants. In the present study the concentrations of minerals was adequate for the requirements of grazing sheep particularly those not yet at peak productivity level. A slight correction in the mineral content of feed, with the addition of salts containing one or two of the main elements (i.e. Ca and P) may be sufficient. A similar result was obtained by Coates *et al.* (1990) who reported that phosphorus concentrations of crop and forage plants declined markedly with advancing maturity, although the decline was less in legumes than in grasses. Concentrations of many other elements also decline, but rarely to the same extent as those of phosphorus. Such changes often reflect increases in the proportion of stem to leaf and old to new leaves, with stems and old leaves having lower mineral concentrations than young leaves (Minson, 1990).

Ca deficiency is most likely to occur in areas of high rainfall and humidity. Abundant rainfall seems to have an adverse, probably leaching effect, on P. Mg is often deficient in young grass, tropical forage, straw and other low-quality forages and a deficiency of Mg can reduce the digestibility and intake of forage. During long periods of P deficiency, this mineral may become deficient in the rumen of sheep, leading to reduced microbial growth efficiency and at times digestibility and intake of forage (Leng, 1990). This is probably due to slightly different adaptations and feeding habits, although these two animal species (sheep and goats) have a same type of digestive system. Goats prefer more browsing, while sheep are grazing lower forages. It has been observed that browsed forages have higher mineral contents than lower forage and grasses. Also as forages mature and dry up, their mineral concentration declines. The rate of this decline is higher in grasses than that of browsed forage plants as reported by Hajer *et al.* (2014).

## Conclusion

It was concluded that the mineral nutrition of livestock at this region was at the marginal deficient level. This concentration may change abruptly to severe deficient levels at any time and may result in decreasing effective minerals particularly at dry season due to decrease in the levels of essential minerals in forages which are considered as the main reason for poor animal performance.

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# اثر مراحل مختلف رشد بر غلظت مواد معدنی پر مصرف در گیاهان پهن برگ و گندمیان در منطقه نیمه خشک سودان

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**چکیده.** تغییرات غلظت مواد معدنی با رشد گیاه، اغلب در ساقه نسبت به برگ دیده می‌شود. غلظت مواد معدنی در ساقه کمتر از برگ‌های جوان می‌باشد. هدف از این پژوهش، ارزیابی وضعیت عناصر معدنی پر مصرف از قبیل سدیم، پتاسیم، فسفر، کلسیم و منیزیم در مراحل مختلف رشد گونه‌های غالب بومی در طول گلدهی و تشکیل دانه بود. این آزمایش در مزرعه تحقیقاتی ال عبید در منطقه بانو، محل شیکان، شمال کردفان دولت سودان، در فصول مختلف و بین سال‌های ۱۳۹۰ الی ۱۳۹۱ انجام شد. داده‌ها نشان داد که غلظت مواد معدنی پر مصرف در گیاهان پهن برگ در مقایسه با گیاهان گندمیان بیشتر است. همچنین در مرحله گلدهی غلظت مواد معدنی پر مصرف در مقایسه با مرحله تشکیل دانه بالاتر است. نتیجه گرفته می‌شود مراتع شمالی کردفان، حاوی مخلوطی از گیاهان پهن برگ و گندمان، منابع خوبی از مواد معدنی پر مصرف برای تالیف دام‌ها می‌باشد. همچنین نتایج نشان داد عناصر پر مصرف در پهن برگان و گندمیان در منطقه مورد مطالعه برای گوسفند و به خصوص در مرحله قبل از تشکیل دانه کافی می‌باشد.

**کلمات کلیدی:** عناصر پر مصرف، مراحل رشد، مرحله تشکیل دانه