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Micro Minerals Profile of Forbs and Grasses at Flowering and Seed set Stages for Grazing Ruminants in Sudan

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Abstract

This study was conducted to determine the status of some micro minerals notably iron, copper, zinc, cobalt and nickel, in forbs and grasses in plants at the flowering and seed set stages for sheep grazing on natural range land, at Sheikan Locality, North Kordofan State, Sudan in the year 2011 and 2012. 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. Samples of plants' shoots (leaves and stems) were picked randomly by hand according to diet selected by sheep and ICP was used to determine minerals. A higher concentration of micro minerals was found in forbs compared with grasses ($P < 0.05$). It was concluded that the rangelands of North Kordofan State, containing a mixture of grasses and forbs, are good sources of micro minerals at seed set stage of growth that can meet the requirements of sheep.

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Introduction

Plants must obtain a number of inorganic mineral elements from their environment for a successful growth and development of both vegetative and reproductive tissues. These minerals serve several functions such as structural components in macromolecules, cofactors in enzymatic reactions and osmotic solutes needed to maintain proper water potential to provide charge balance in cellular compartments. Trace elements are essential parts of many physiological processes such as energy production, enzyme activity, hormone production, collagen formation, vitamin and tissue synthesis, oxygen transport and other physiological processes related to health, growth and reproduction. Their deficiency causes a variety of pathological consequences such as cardiac conditions in addition to immunological and hormonal functions and metabolic defects (Suttle, 2010). Reports on clinical Zn deficiency in cattle under field conditions in Sudan are relatively rare. The concentration of Cu was found to be low in sera and tissues of various Sudanese animals raised under nomadic system. The effect of dietary supplementation during different physiological states on serum concentrations of Cu and Zn were investigated by Abo Damir., *et al.* (1988).

Voluntary intake and mineral concentrations of base feedstuffs determine the level of mineral consumption. Adequate intake of forages by grazing animals is essential in meeting mineral requirements. The concentration of minerals in plants is dependent upon interactions among many factors including soil type, plant species, stage of maturity, dry matter yield, grazing management and climate (Farhad, 2012).

The currently recognized micro-minerals include iron (Fe), zinc (Zn), manganese (Mn), copper (Cu), boron (B), chlorine (Cl), molybdenum (Mo), selenium (Se) and nickel (Ni). These minerals generally are found at concentrations less than 0.01% of dry tissue weight (Grusak 2001). The mineral nutrients, found in the soil, are dissolved in water and absorbed through the roots of plants. There are not always enough of these nutrients in the soil for a plant to grow healthy. This is why many farmers use fertilizers to add these nutrients to the soil. Some studies determined micro element status in livestock in Eastern and Western Sudan. Mineral status should also be investigated in plants. The aim of this study was to investigate the effects of the stage of growth and type of plant on the trace minerals copper (Cu), iron (Fe), Cobalt (Co), Zinc (Zn) and Nickel (Ni) at Sheikan Locality, North Kordofan State, Sudan.

Methods

Sampling involved two different types of plants (forbs and grasses) at seed set stage of plant growth (early dry season) of 2010 and 2011. A total of 27 plant species (20 forbs and 7 grasses) in the flowering stage were collected from the rangelands. A total of 22 plant species (17 forbs and 5 grasses) were collected from the rangelands at seed set stage. Plants' shoots (leaves and stems) were picked randomly by hand according to diet selected by sheep and Inductively Coupled Plasma Emission spectrometer (ICP) was used to determine minerals. Data were analyzed by using SAS package (GLM Procedure).

Results

Table 1: *Concentrations of trace elements Cu, Fe, Co, Zn and Ni in forbs and grasses at flowering stage (mg/kg).*

Scientific name	TP*	Cu	Fe	Co	Zn	Ni
Colocynthis citrullus	Forb	10.97	270	0.904	50.53	1.145
Echinocloa colonum	Grass	12.70	1562	0.985	44.71	2.812
Seddera spp.	Forb	10.11	249	0.223	29.37	1.261
Eragrostis tremula	Grass	10.24	1030	0.529	67.08	2.418
Polygala eriotera	Forb	11.46	1041	0.575	27.98	2.089
Crotalaria spp.	Forb	11.01	755	0.372	27.85	1.433
Schoenefoldia gracilis	Forb	9.58	2522	1.322	30.85	4.031
Requenia obcordata	Forb	10.29	641	0.350	22.64	1.404
Justicia kotschyi	Forb	8.10	1080	0.807	40.41	2.155
Cenchrus biflorus	Grass	7.79	1318	0.664	32.89	2.726
Sesbania sesban	Forb	10.77	231	0.387	36.26	2.183
Belpharis linarifolia	Forb	11.94	1094	0.491	35.54	1.533
Chloris virgata	Grass	8.85	579	0.682	42.26	1.816
Dactyloctenium aegyptium	Grass	6.65	2684	1.274	32.25	4.582
Ipomoea sp.	Forb	13.63	1776	0.926	38.37	2.881
Tephrosia spp.	Forb	10.60	2452	1.251	27.38	3.705
Tribulus terrestris	Forb	10.29	1738	0.999	26.77	3.191
Acacia nubica	Shrub	8.55	228	0.186	21.37	1.243
Corchorus oiltorius	Forb	11.48	1801	1.160	34.35	3.032

Indigofera aspera	Forb	8.92	534	0.312	22.55	1.001
Cyprus spp.	Grass	10.00	4813	2.272	23.26	6.568
Acanthus spp.	Forb	10.23	2616	1.301	34.59	3.708
Indigofera spp.	Forb	8.21	466	0.536	25.14	1.102
Solanum dobium	Forb	18.41	1114	0.612	60.22	2.112
Dicoma tomentosa	Forb	11.12	278	0.265	38.95	1.381
Farsetia longisclizua	Forb	6.70	412	0.426	23.82	0.961
Ipomoea belpharosepala	Forb	13.53	1937	1.155	37.04	3.437
Aristida mutablis	Grass	9.55	1124	0.579	33.93	2.035

TP* = Type of plant

Table 2: *Concentrations of trace elements Cu, Fe, Co, Zn and Ni in forbs and grasses at seed set stage (mg/kg).*

Scientific name	TP*	Cu	Fe	Co	Zn	Ni
Seddera spp.	Forb	9.72	158	0.131	24.98	1.101
Eragrostis tremula	Grass	9.72	864	0.555	43.50	2.553
Acanthospermum hespidum	Forb	11.07	826	0.763	76.28	1.692
Ipomoea belpharosepala	Forb	14.69	572	0.498	63.60	1.028
Colocynthis citrullus	Forb	9.99	223	0.327	44.11	0.662
Cyprus spp.	Grass	7.81	1897	0.966	14.21	2.756
Indigofera spp.	Forb	9.56	199	0.132	22.81	0.915
Corchorus oiltorius	Forb	11.71	337	0.281	53.36	0.985
Ipomoea sp.	Forb	12.47	697	0.378	38.87	1.195
Cenchrus biflorus	Grass	8.10	504	0.353	61.68	1.181
Abutilon glaucm	Forb	11.97	501	0.376	79.40	1.051
Tephrosia spp.	Forb	12.93	317	0.211	29.25	1.070
Echinocloa colonum	Grass	16.67	810	0.539	71.02	1.621
Belpharis linarifolia	Forb	11.38	614	0.308	33.13	1.001
Solanum dobium	Forb	15.42	801	0.493	49.44	1.584
Crotalaria spp.	Forb	11.87	348	0.181	26.08	0.643
Acacia nubica	Shrub	9.33	280	0.159	16.45	1.131
Justicia kotschyi	Forb	10.65	599	0.426	78.15	1.255
Acanthus spp.	Forb	13.08	1978	1.082	45.57	3.215
Polygala eriotera	Forb	15.48	759	0.368	37.55	1.440
Requenia obcordata	Forb	10.53	455	0.235	34.46	1.238
Schoenefoldia gracilis	Grass	6.59	301	0.180	34.27	0.978
Sesbania sesban	Forb	12.54	293	0.287	35.18	1.899

TP* = Type of plant

Table 3: *Trace mineral requirements (ppm) for Cattle and Sheep.*

Element	Beef cattle		Sheep	
	Requirement	Maximum Tolerable	Requirement	Maximum Tolerable
Co	0.10	10	0.10-0.20	10
Cu	10-15	100	7-11	25
I	0.50	50	0.10-0.80	50
Fe	50	1,000	30-50	500
Mn	20-40	1,000	20-40	1,000
Mo	NA	5	0.5	10
Se	0.10	2	0.10-0.20	2
Zn	30-40	500	20-33	750

NRC. 1996. Nutrient Requirements of Beef Cattle. (7th Ed.) National Academy Press, Washington, DC.

NRC. 1985. Nutrient Requirements of Sheep. (6th Ed.) National Academy Press, Washington, DC.

Discussion

Table 1 illustrates the concentrations of some trace elements in forbs and grasses at flowering stage while table 2 shows the concentrations of some trace elements in forbs and grasses at seed set stage. Forbs had higher trace elements concentrations than grasses. Younger leaves and leaflets contain higher levels of minerals than older mature leaves, twigs and stem parts. These levels of micro minerals are adequate to meet the NRC (1985) requirements of sheep for Co (0.10-0.20 ppm), Cu (7-11 ppm), Fe (30-50 ppm) and Zn (30-33 ppm).Variations in the contents of Fe among forages could be partly explained by forage species' differences and the level of Fe in the soil. Fe level in this study ranges between 200-2000 mg/kg which agrees with (Farhad, 2012) who stated the all the grazing pasture forages had higher levels of Fe than the critical content of Fe in animal tissues (between 30-50 mg·kg^{-1} DM). Content of Zn (22-60 mg/kg in legumes and 23-67 mg/kg in grasses) in these forages is within recommended level for sheep.

However, efficiency of Zn utilization of these forages would depend on zinc bioavailability, and its interaction with other mineral elements. Variations in the concentrations of minerals among forages in this study agreed with Hajer., *et al*. (2014) who attributed variations in the concentrations to genotypic differences, efficiency of mineral uptake and retention and stage of foliage maturity. Younger leaves and leaflets contain higher levels of minerals than mature leaves, twigs and stem parts. This result agrees with Burridge., *et al.* 1983 and Hopkins., *et al*. 1994 who reported that Fe, Cu, Zn, Co and Ni concentrations were higher in leguminous than in graminaceous species grown in temperate climates, with Cu and Zn being higher in mixed than in pure grass swards. The trace minerals requirements of sheep are: Co: 0.10-0.20 ppm, Cu: 7-11 ppm, Fe: 30-50 ppm and Zn: 30-33 ppm (NRC, 1985). For beef cattle the requirements are Co: 0.10 ppm, Cu: 10-15 ppm, Fe: 50 ppm and Zn: 30-40 ppm (NRC, 1996). Variations in the contents of Fe among grazing forages could be partly explained by forage species' differences and the influence of grazing on the level of Fe in the soil.

All the grazing pasture forages had higher levels of Fe than the critical content of that mineral in animal tissues (30-50 mg/kg DM). The Zn content in these forages was sufficient for recommended requirement for sheep. However, efficiency of Zn utilization in these forages would depend on its bioavailability, and on its interaction with other mineral elements. Forage Zn concentration was also above the requirements of ruminants in winter (Farhad, 2012). Contamination of forage samples with soil is a common cause of anomalously high cobalt and iron concentrations. The uptake and availability of trace minerals is influenced by environmental factors (soil type, soil pH, plant species, season and climate). Soil and pasture in western Sudan were deficient in Cu but livestock for the most part had adequate tissue Cu levels (Hajer., *et al*. 2014). In this investigation most of the forage samples analyzed only meet the marginal to deficient requirements of this element.

This situation may be even further complicated by high levels of dietary Fe which can be elevated by soil ingestion during grazing. It has been also found that dietary concentrations exceeding 1g Fe/kg can profoundly reduce the availability of ingested Cu (Schillhorn and Loeffler, 1990). It was suggested that the nomadic lifestyle has prevented a Cu deficiency syndrome in animals which migrate to areas rich in Cu during part of the year (Schillhorn and Loeffler, 1990). Forage Cu content declines with forage maturity, and is higher in leaf compared with stem fractions. Copper deficiencies in forages can cause poor reproduction, broken bones, weak calves, and light color hair (Farhad, 2012). The results in tables 1 and 2 indicated that the levels of micro minerals (Fe, Cu, Zn, Co and Ni) in all plant species (grasses and forbs) in this study were within the limits of the normal values (NRC, 1985) for sheep. Overall, cattle and sheep can possibly have adequate mineral nutrition in the dry season by selectively grazing among the mixture of grasses and forbs.

Conclusion

The results reported in the present study provide some information to assist in judging animal performance as related to the deficiencyof these elements. It is recommended that further studies should be done to determine the profile of trace elements in animals at slaughter in different regions of the Sudan to monitor the possible risk of livestock trace elements deficiency/poisoning by determining the highest/lowest levels ofminerals detected in animal tissue.

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