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Effect of Maturity on the Mineral Content of the Giant *Commelina benghalensis*

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Abstract: This study was conducted in Naivasha, Kenya over a period of 15 weeks to determine the effect of maturity on mineral content in *Commelina benghalensis (Giant var M)*. Immediately after field preparation, representative soil samples were taken for mineral profiling. Thereafter, 60 plots of 2×2 sq. m size were demarcated and allotted to 5 similar blocks of 12 plots each in a randomized complete block design. Each plot received a total of 50 vines (15 cm long with 3 nodes each) evenly planted in 5 rows (2 m length and 30 cm apart). All the plots were planted on the same day and kept weed free throughout the study. The forage was harvested at 6, 8, 10, 12 and 14 weeks after planting (excluding the 1st 7 days considered as rooting period) in sequential manner beginning with block 1 to 5, each time leaving a stubble height of 5 cm. From each plot, representative herbage grabs were made, chopped into 2 cm pieces and mixed thoroughly. Two composite samples of about 1 kg each were then taken for dry matter determination and mineral analysis through the standard procedures. Results showed wide variations in the plant tissue concentration change patterns of different mineral elements over the study period. From the results, it was noted that P and Mg levels recorded a marginal decline of 0.6 and 13.8% respectively between 6 and 14 weeks. This represented decline rates of 8.93 and 7.14 mg kg^{-1} DM d^{-1}. On the contrary, K registered a 31.39% increase from 6.18 at 6 to 8.12% at 14 weeks. Sodium and Ca recorded 35.19 and 49.78% drop in concentration over the same period. The level of Cu was fairly consistent throughout the study. That of Mn was observed to be inconsistent. Zinc levels however showed rapid decline 66.68% over the study period. From the results presented it was concluded that, macro-mineral content in *Commelina benghalensis* significantly decreased with advancing age of the forage. Trace elements, though were not significantly affected by age, their concentration occurred in quantities below ruminant livestock requirements suggesting the need for trace mineral supplementation. It was further concluded that, owing to high macro-mineral content, the giant *Commelina benghalensis* has a potential for enhancing the levels of essential minerals in the diets of ruminant livestock on smallholder farms in Kenya.

Key words: Commelinaceae, smallholder farms, macro-elements, micro-elements, ruminants

INTRODUCTION

Today, many stakeholders are implicating deficiencies of various mineral elements, inadequate vitamin intake and energy-protein imbalances as major contributors to poor performance of dairy stock on smallholder farms in Kenya[1]. Availability of these nutrients largely depends on their voluntary intake from feed offered or grazed. On smallholder farms, majority of ruminant livestock entirely depend on poor quality tropical grass forages and crop residues for major part of the year. Most of these feeds are deficient of the required nutrients[2] and it is these deficiencies that are limiting dairy production on these farms[3]. This is further aggravated by farmers' inability to formulate balanced rations, which is partly attributed to lack of feed resource quality related information[4]. The perennial feed shortage on smallholder farms in Kenya, therefore calls for development of cost effective and sustainable strategies to enhance production and utilization of the available feed resources. In addition, there is urgent need to deliberately and innovatively broaden feed resource base through identification, evaluation and domestication of the many potential naïve native forages for future use at farm level. Of the large variety of potential, but unexploited, naïve native forages present in topical ecosystems,

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Commelinaceae family is the largest and most successful[5,6]. Several species of this family, are reported to be relished by grazing ruminant animals[7-10]. However, lack of literature on the yields and nutritive values indicates that, these forages are poor studied. This information is essential if they are to be used efficiently. The current study was conducted to examine the mineral concentration flux with advancing age of *Commelina benghalensis* as one of the promising commelinaceae species for use as ruminant livestock feed in Kenya.

MATERIALS AND METHODS

This study was conducted in Naivasha, Kenya over a period of 15 weeks to determine the effect of advancing plant maturity on mineral content of *Commelina benghalensis*. The 0.5-acre plot demarcated from within a 10-acre experimental field, was thoroughly prepared according to the standard agronomic guidelines for pastures establishment. However, before planting, representative soil samples were taken for mineral profiling. Sixty plots of 2×2 sq. m size were then demarcated and allotted to 5 similar and randomly distributed blocks of 12 plots each in Randomized Complete Block (RCB) design. During each planting, 5 rows of 2 m length, 30 cm apart and 10 cm deep were drilled on each plot and a total of 50 vines (15 cm long with 3 nodes each) were planted with each row receiving exactly 10 evenly distributed vines. All the plots (N = 60) were planted on the same day and kept weed free throughout the trial. Within each block, guard rows of 30 cm width were provided between plots. Between blocks, 60 cm wide weed free guard rows were also provided. The forage was harvested at 6, 8, 10, 12 and 14 weeks after planting (excluding the 1st 7 days considered as rooting period) in a sequential manner beginning with block 1 to 5, leaving a stubble height of 5 cm. From each plot, representative herbage grabs were made, chopped into 2 cm pieces and mixed thoroughly. Two composite samples of about 1 kg each were then taken for dry matter determination and mineral analysis[11]). Sodium (Na) and Potassium (K) were determined by flame photometry and nitrogen was analyzed calorimetrically on a flow analyzer (Kjeldahl method). Phosphorus (P) was determined by spectrophotometery. Calcium (Ca), Magnesium (Mg), Manganese (Mn), Copper (Cu) and Zinc (Zn) were determined by AAS (Atomic absorption spectrophotometer). The recorded data was stored in MS-excel and analyzed using ANOVA and GLM procedures of SAS[12]. Bi-variate correlations were done using SAS[12].

RESULTS

In Table 1, the mean concentration levels of both macro-and micro-mineral elements in *Commelina benghalensis* plant tissue are presented. Results showed wide variations in the concentration change patterns of different mineral elements over the study period. From the results, it was noted that, P and Mg concentrations did not change appreciably with advancing maturity of the forage. The two elements recorded a marginal decline of 10.6 and 13.8% between 6 and 14 weeks respectively. This represented decline rates of 8.93 and 7.14 mg kg^{-1} DM d^{-1}, respectively.

In contrary, K registered a 31.39% increase in concentration from 6.18 to 8.12% over the same period Table 1. The results also showed that, the levels of Na and Ca decreased significantly with maturity. They recorded 35.19 and 49.78% drop in concentration respectively between 6 and 14 weeks. This represented daily decline rates of 10.18 and 20.54 mg kg^{-1} DM d^{-1}. The concentration of Cu was fairly constant throughout the harvested maturity stages. The observed changes in

Table 1: Content of macro- (%) and micro-minerals (mg kg^{-1} DM) in *Commelina benghalensis* (var M) harvest at different maturity stages

	Harvest age (in weeks)						Overall			Requirements	
Mineral	N	6	8	10	12	14	Mean	s.e	CV	Heifer[a]	Cow[b]
Phosphorus (%)	12	0.47	0.47	0.41	0.41	0.42	0.436	0.02	7.18	0.24	0.30
Potassium (%)	12	6.18	6.51	7.47	8.12	8.12	7.281	0.41	12.4	0.44	0.44
Sodium (%)	12	1.62	1.21	1.39	1.07	1.05	1.268	0.11	18.9	0.07	0.07
Calcium (%)	12	2.31	1.21	0.71	1.37	1.16	1.352	0.26	43.6	0.35	0.32
Magnesium (%)	12	0.29	0.29	0.26	0.25	0.25	0.268	0.01	7.65	0.15	0.18
Cu (mg kg^{-1} DM)	12	11.01	12.7	12.5	11.8	10.8	11.76	0.38	7.28	9*	10*
Mn (mg kg^{-1} DM)	12	76.5	107	154	91.5	89.0	103.6	13.5	29.1	10*	16-21*
Zn (mg kg^{-1} DM)	12	240	128	85.8	88.8	79.7	124.5	30.1	54.1	30*	28-48*
Ca : P ratio		5:1	3:1	2:1	3:1	3:1	3:1			Ruminants:	1:1-7:1

[a] –Mineral requirements for 300 kg heifer with an estimated gain of 500 gd^{-1}; [b]-Mineral requirements for 450 kg cow with an estimated milk yield of 10 kg d^{-1} (ARC, 1984); s. e-Standard error of the mean; CV-Coefficient of variation; N-Number of samples analyzed excluding replicates; * - Concentrations are in g kg^{-1} DM; Soil nitrogen : Phosphorus ratio in the trial site was 235:1

Mn concentrations with age of *Commelina benghalensis*, was observed to be inconsistent. Zinc level however showed rapid decline over the study period. In attempt to describe the concentration change patterns, both linear and quadratic regression lines were fitted to the data Table 2.

From the information presented in Table 3, it can be seen that patterns of concentration change in K and Mg were accurately described by linear regression line. In contrast, those of P, Ca, Cu, Mn and Zn seemed to conform to the quadratic regression curve fit. Most of the regression lines fitted were however not significant Table 2. Figure 1 illustrates the concentration change patterns of the mineral elements investigated. The Fig. clearly illustrated the existed wide variations in mineral concentration pattern aforementioned. In Table 3, correlation coefficients between mineral elements and with advancing age of *Commelina benghalensis* are presented. Results showed that most of the mineral elements examined were strongly, but inversely correlated with

Table 2: Regression lines fitted to minerals change pattern in *Commelina benghalensis* (Giant var. M)

Mineral element	Estimated Regression curve lines: Linear	R^2	Sign
Phosphorus (%)	$Y = 0.516-0.008\,X$	0.653	0.098
Potassium (%)	$Y = 4.535 + 0.275\,X$	0.927	0.009
Sodium (%)	$Y = 1.908-0.064\,X$	0.716	0.071
Calcium (%)	$Y = 2.422-0.107\,X$	0.331	0.311
Magnesium (%)	$Y = 0.328-0.006\,X$	0.857	0.024
Cu (mg kg^{-1} DM)	$Y = 12.41-0.065\,X$	0.058	0.697
Mn (mg kg^{-1} DM)	$Y = 98.85 + 0.475\,X$	0.002	0.937
Zn (mg kg^{-1} DM)	$Y = 304.36-17.99\,X$	0.714	0.072
	Quadratic		
Phosphorus (%)	$Y = 0.647-0.037X + 0.002X^2$	0.771	0.230
Potassium (%)	$Y = 2.941 + 0.621X-0.173X^2$	0.948	0.052
Sodium (%)	$Y = 2.368-0.164X + 0.005X^2$	0.740	0.260
Calcium (%)	$Y = 7.252-1.157X + 0.053X^2$	0.775	0.225
Magnesium (%)	$Y = 0.361-0.013X + 0.001X^2$	0.874	0.126
Cu (mg kg^{-1} DM)	$Y = 2.717-2.042X + 0.105X^2$	0.906	0.094
Mn (mg kg^{-1} DM)	$Y = -189.5 + 63.15X - 3.13X^2$	0.606	0.394
Zn (mg kg^{-1} DM)	$Y = 716.7-107.6X + 4.482X^2$	0.962	0.038

Y-Mineral element concentration (Macro - % or Micro - mg kg^{-1} DM); X-age at harvest in weeks, Sign.-Significance of the model

Table 3: Correlation coefficients of mineral contents and age at harvest of *Commelina benghalensis* (Giant var. M)

	Age	P	K	Na	Ca	Mg	Cu	Mn	Zn
Age	●								
P (%)	-0.808^{ns}	●							
K (%)	0.963^{**}	-0.920^{*}	●						
Na (%)	-0.846^{ns}	0.516^{ns}	-0.775^{ns}	●					
Ca (%)	-0.575^{ns}	0.638^{ns}	-0.571^{ns}	0.542^{ns}	●				
Mg (%)	-0.926^{*}	0.959^{*}	-0.987^{**}	0.662^{ns}	0.543^{ns}	●			
Cu (ppm)	-0.240^{ns}	0.011^{ns}	-0.168^{ns}	-0.037^{ns}	-0.571^{ns}	0.208^{ns}	●		
Mn (ppm)	0.050^{ns}	-0.415^{ns}	0.132^{ns}	0.069^{ns}	-0.790^{ns}	-0.179^{ns}	0.722^{ns}	●	
Zn (ppm)	-0.845^{ns}	0.794^{ns}	-0.843^{ns}	0.816^{ns}	0.901^{*}	0.793^{ns}	-0.31^{ns}	-0.49^{ns}	●

^{ns}-Not significant; ppm-parts per million; Age-*Commelina benghalensis* age at harvest

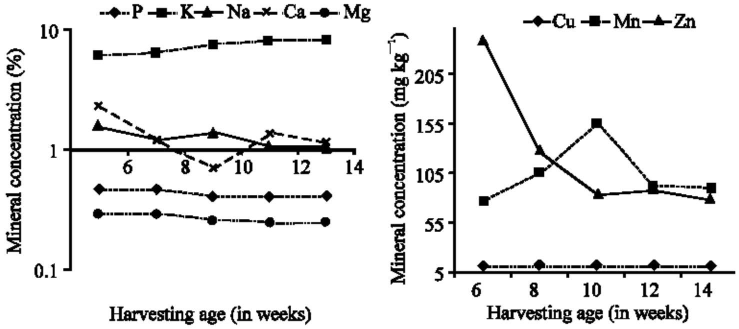

Fig. 1: Trend of mineral concentration in the *C. benghalensis* plant tissue as influenced by harvesting age

advancing maturity of the forage under study. It was observed that Copper and Mn concentration change over time, were not correlated with age of the forage.

Between mineral elements, wide correlation variations were observed. Potassium concentration change was inversely correlated with all the other elements. From the results, it was however noted that most of correlations were not significant.

DISCUSSION

The concentration levels of both macro-and micro-minerals in *Commelina benghalensis* varied widely with advancing maturity. Results showed that P declined marginally over the study period. This compared well with Perdomo, *et al.*[13]and Kariuki, *et al.* [14]both of whom reported that P levels in tropical grasses declined with grass age. The two authors also reported a similar trend of K in tropical grasses, which sharply contrasts with our observation in the current study. The results of this study showed that K concentration in *Commelina benghalensis* plant tissue increased with maturity. The concentrations of all the other elements were also observed to be significantly higher than those reported in *Sorghum almum*[15] and *Pennisetum purpureum*[14]. This was largely attributed to the ability of *Commelina benghalensis* to perennate at the vine nodes. This enables it explore large soil surface area. *Commelina benghalesis* is also able to form new shoots rapidly, which also encouraged rapid mineral uptake. Our observation seemed to concur with Coates, *et al.*[16] who stated that concentration levels of minerals in plant tissue is directly determined by several closely interacting factors. These include: 1) solubilisation of minerals fixed within the soil[17] increased plant capacity for active transport of minerals through cell membranes when water is present[18] increased root exploration of soil volume and 4) large root hair surface area[19]. The results further showed that Ca, Na and Zn levels declined with advancing maturity of the forage. This decline may be due to the effect of dilution of these elements in a great quantity of dry matter that is produced and accumulated with advancing age of *Commelina benghalensis*. The concentration levels of all macro-elements however remained significantly higher than the required limits for ruminant production[20]. The concentration of trace elements remained fairly consistent but far below the limits aforementioned[20]. This agreed with the statement by Conrad[21] that trace minerals in plants may increase, decrease or show no consistent change with stage of growth, plant species, soil or seasonal conditions. From the results, it was also observed that, except for K and Mn, concentrations of all the mineral elements were inversely correlated with advancing maturity of this forage. Most correlations were however not significant further confirming earlier assertions that concentrations of minerals in plant tissue are influenced by interplay of many factors. In this study, the observed high levels of macro-elements may have also been contributed by soil contamination during harvesting accentuated by the creeping nature of this forage.

CONCLUSION

In the context of ruminant livestock feeding, Commelinaceae is one of the poorly studied family of plants. The current study has clearly shown that *Commelina benghalensis* is a rich source of macro-mineral elements for ruminants. It is however recommended that further research be done to elucidate any deleterious effects to ruminant livestock that might be associated with such high mineral concentrations. In this forage, levels of trace elements occurred in quantities below ruminant livestock requirements suggesting the need for mineral supplementation when this forage is fed to ruminants. From the results presented it was generally concluded that age strongly influenced the concentration of macro-elements in the *Commelina benghalensis* plant tissue. It was further concluded that because of its high mineral content, *Commelina benghalesis* has a potential for enhancing the levels of essential minerals in the diets of ruminant livestock on smallholder farms. Owing to its high mineral and moisture contents, it was also concluded that this forage would be more suitable for feeding young ruminant animals such as lambs, kids and calves.

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