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SHORT NOTE [NOTA CORTA]

EFFECT OF MATURITY ON THE MINERAL CONTENT OF HAIRY VETCH (*Vicia villosa*)

[EFECTO DE LA MADUREZ DE *Vicia villosa* SOBRE SU CONTENIDO MINERAL]

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SUMMARY

This study was conducted in Naivasha, Kenya over a period of 15 weeks to determine the effect of maturity on mineral content in hairy vetch (*Vicia villosa* Roth). Immediately after field preparation, 60 plots 2 x 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 10 g of seed evenly drilled to 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. They were harvested at 6, 8, 10, 12 and 14 weeks after seed emergence in sequential manner beginning with block 1 to 5, each time leaving a stubble height of 5 cm. Levels of most elements examined were not strongly influenced by advancing maturity of *V. villosa*. P, Na and Mg levels remained fairly constant with advancing maturity of the legume. Their overall means at the end of the study were 36.8, 160.4 and 17 g kg^{-1} DM respectively. Concentration levels of Mn and Zn also followed the same pattern over the study period. Levels of K however increased sharply from 29.4 at 6 to 42.1 g kg^{-1} DM at 14 weeks. Copper levels increased marginally (4.4%) from 7.67 at 6 to 8.01 mg kg^{-1} DM at 14 weeks. The changes in Ca levels with age of the legume were inconsistent. This inconsistency was also reflected in the determined Ca:P ratios. This study has shown that, relative to ruminant mineral requirements, *V. villosa* has adequate macro-elements. The levels of trace elements however, fell below the desired limits for ruminants. It was concluded that, advancing age of *V. villosa* did not have significant effect on tissue concentration of most essential minerals.

Key words: Ruminant diets; macro and micro-minerals; smallholder farms.

RESUMEN

El estudio se realizó en Naivasha, Kenya por 15 semanas para evaluar el efecto de la madurez sobre el contenido mineral de *Vicia villosa* Roth. Después de preparar el área, 60 parcelas de 2 x 2 m^2 fueron delimitados y asignados a 5 bloques in un diseño de bloques al azar. En cada parcela se sembraon 10 g de semilla en 5 hileras de 2 m con una separación de 30 cm. Se cosechó a las 6, 8, 10, 12 7 14 semanas post emergencia, cortando a una altura de 5 cm. La mayoría de los elementos analizados no fueron influenciados por la edad de *V. villosa*. P, Na y Mg permanecieron constants con una concentración promedio al final del studio de 36.8, 160.4 y 17 g.kg^{-1} DM respectivamente. Mn y Zn siguieron un patron similar. El K sin embargo se incrementó de 29.4 en la semana 6 a 42.1 g.kg^{-1} DM en la semana 14. Cu incrementó marginalmente de 7.67 a 8.01 mg.kg^{-1} DM. Los cambios en la concentración de Ca no siguieron un patron definido. En relación a las necesidades de los rumiantes, *V. villosa* tiene un aporte adecuado de macro elementos. Los niveles de micro elementos son menores a los deseables para dietas de rumiantes. Se concluyó que no hubo un efecto de la edad de *V. villosa* sobre la concentración de la mayoría de sus minerales.

Palabras clave: Forraje para rumiantes, macro y micro-minerales; sistema de producción.

INTRODUCTION

Ruminant livestock production in the tropics is largely dependent on forages (Martin 1993). Consequently their performance is often determined by the nutrient profiles of these forages (Blaxter, 1978). Most of the common feed resources in the tropics are characterized by deficiencies of essential nutrients (particularly protein, energy and minerals) leading to low animal performance (McDonald *et al*., 1988; Mukasa – Mugerwa *et al*., 1992). These deficiencies are attributed to many edaphic factors. Temperature, soil moisture, soil nutrients and age at harvest are the primary causes of the forage being poor in nitrogen (N), digestible energy and minerals (Elliott and McMeniman, 1987). All plants depend upon the soil for their supply of mineral nutrients and grazing animals obtain the majority of their mineral nutrients from plants grown on these soils. In Kenya, declining soil fertility has been cited as one of the major causes of the present feed inadequacy on smallholder farms (Muriuki, 2003) and therefore poor performance of ruminant livestock (Omore *et al.*, 1996) further compounded by low economic status of many households. Inability of farmers to offer mineral supplements is partly attributed to lack of information on mineral profiles of most of the available feed resources. This therefore calls for generation of information that not only provides the general mineral profiles of feed resources but also establishes the relationship between individual elements and advancing plant maturity. Such studies should also take into consideration other important factors when recommending appropriate forages for cultivation on smallholder farms. Earlier studies have shown that grasses have higher extraction capacity for K, Mg, Na, Mo, Co, Mn and Cr, whereas legumes showed higher extraction for Ca (Piasentin, *et al*., 1998). On many smallholder farm soils, nitrogen (N) is the most limiting element (Nandwa, *et al*., 2000). Since primary minerals are not reservoirs of N and fertilization with N fertilizer is restricted by high cost, use of N fixing crops holds a promise. Common vetch (*Vicia sativa* L) and hairy vetch (*V. villosa* Roth) are annual legume species, widely grown for both livestock and soil fertility improvement (Caballero, 1993; Chowhurry, *et al*., 2001). The value of *Vicia spp* as protein supplements for ruminant livestock is also widely recognized (Alzueta, *et al*., 2000; Hadjipanayiotou and Economides, 2001). As a green manure cover crop vetches have gained popularity for their reputed beneficial ability to fit well into cereal rotations and grass pastures (Sattell, *et al*., 1998). These aspects of *Vicia spp* are particularly relevant to smallholder resource – poor farms in Kenya. Available literature has clearly shown that, while many previous studies dwelt on yield (caballero, 1993) and quality (Gohl, 1981), little information is available on mineral status of *V. villosa* Roth, especially under Kenyan conditions. The current study was conducted to examine the influence of advancing *V. villosa* age on its tissue mineral content.

MATERIALS AND METHOD

This study was conducted in Naivasha, Kenya over a period of 15 weeks. Due to the prevailing weather conditions at the time (dry season), a moderate irrigation (6 h irrigation per week) was applied to ensure sufficient soil moisture. The objective was to determine the effect of advancing plant maturity on mineral content of hairy vetch (*V. villosa* Roth). A 0.5-acre plot was demarcated from within a 10 – acre experimental field, and thoroughly prepared according to the standard agronomic guidelines for sown pastures establishment. Before planting, representative soil samples were taken for mineral profiling. Sixty plots of 2 x 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 10 g of seed were sown with each row receiving exactly 2 g of evenly distributed seeds (approx. 80% viability). 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 legume was harvested at 6, 8, 10, 12 and 14 each time weeks after seedling emergence in a sequential manner beginning with block 1 to 5, leaving a stubble height of 5 cm. The harvested fresh matter was weighed and representative herbage grabs (per plot) were made, chopped into 2 cm pieces, mixed thoroughly and then 2 composite samples of about 500 g each were taken for chemical and mineral analysis (AOAC, 1990). Sodium (Na) and Potassium (K) were determined by flame photometry (Dvoirbak, 1970). 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 data was analyzed using appropriate procedures of SAS (2002). Bi-variate correlations were done using SAS (2002).

RESULTS

Naivasha receives a bimodal rainfall with an annual mean of about 650 mm. Although mean temperature is about 18^{o}C, daily values range from 7 to 27^{o}C. The soils at the experimental site are generally imperfectly to poorly drained, very deep, dark grayish to brown, silt loam to clay loam, developed on sediments from volcanic ashes (Jaetzhold and Schmidt, 1982). The chemical soil analyses done during the first weeks of the trial indicated that the areas' soils are slightly alkaline (pH about 7.4) and chemically fertile (Table 1). The results showed that, the soils are sufficient in Nitrogen (N; 0.27%) and Phoshorus (P; 113 mg kg^{-1} DM)(Table 1). The textural composition was about 18% sand, 44% silt and 38% clay. Results showed that fresh matter yield (FMY) of *V. villosa* increased significantly from 3.7 at 6 weeks to 48.4 ton FMY ha^{-1} at 14 weeks. On dry matter (DM) basis, the mean yield at 6 and 14 weeks were 0.5 and 9.5 ton DMY ha^{-1} respectively. This represented DM accumulation rate of 160.7 kg ha^{-1} d^{-1}. The mean neutral detergent fibre (NDF) and acid detergent fibre 6 and 14 weeks was 321.7 and 384.9 g kg^{-1} DM respectively, representing an increase of 19.65%. Similarly, concentration of acid detergent fibre increased by 23.4% from 260.7 at 6 weeks to 321.7 g kg^{-1} DM at 14 weeks. The mean crude protein (CP) content at 6 weeks was 204.4 g kg^{-1} DM and also varied with age at harvest. In Table 2 mean macro- and micro – mineral levels in hairy vetch (*V. villosa* Roth), harvested at different maturity stages are presented.

P, Na, Mg, Mn and Zn levels remained relatively constant with advancing maturity of the legume. K and Cu increased marginally from 29.4 g kg^{-1} DM and 7.67 mg kg^{-1} DM at 6 to 42.1 g kg^{-1} DM and 8.01 mg kg^{-1} DM at 14 weeks, respectively. The changes in Ca concentration with age in *V. villosa* were however inconsistent. This was evidenced by the inconsistency observed in Ca:P ratios (Table 2). The correlations between mineral elements and with advancing maturity of *V. villosa* were also investigated. The results showed that Na was strongly and positively correlated with age of the legume (r = 0.898; P < 0.05), DMY (r = 0.932; P < 0.05), CP (r = 0.932; P < 0.05) and ADF content (r = 0.884; P < 0.05). K also showed strong correlation with ADF (r = 0.915; P < 0.05). Strong, but negative correlation was also observed between Na and Cu (r = - 0.942; P < 0.05). The results further showed that though most of the other correlation coefficients were high, they were however not significant.

Table 1. Chemical characteristics of soils at the experimental site

Element	N	Mean ± S. D	s. e	C. V	Comment
Soil pH	4	7.38 ± 0.05	0.026	0.704	*Medium alkaline*
Total Nitrogen (g kg^{-1} DM)	4	2.7 ± 0.01	0.005	3.774	*Adequate*
Organic matter g kg^{-1} DM)	4	19.9 ± 0.08	0.041	4.041	*Moderate*
Phosphorus (mg kg^{-1} DM)	4	113 ± 1.51	0.756	13.382	*Adequate*
Potassium (g kg^{-1} DM)	4	34.7 ± 0.09	0.047	2.724	*High*
Calcium (g kg^{-1} DM)	4	216 ± 0.57	0.283	2.619	*High*
Magnesium (g kg^{-1} DM)	4	42.2 ± 0.21	0.105	4.96	*High*
Manganese (g kg^{-1} DM)	4	9.7 ± 0.46	0.228	46.935	*Adequate*
Copper (mg kg^{-1} DM)	4	9.6 ± 0.11	0.055	11.456	*Adequate*
Iron (mg kg^{-1} DM)	4	438 ± 1.33	0.665	3.035	*Adequate*
Zinc (mg kg^{-1} DM)	4	82.3 ± 0.17	0.165	4.084	*Adequate*
Sodium (g kg^{-1} DM)	4	19.5 ± 0.06	0.299	3.071	*Adequate*
Elec. Cond. MS/cm	4	1.05 ± 0.04	0.204	3.888	*High*

Table 2. Content of macro- (%) and micro-minerals (mgkg^{-1} DM) in hairy vetch (*Vicia sativa* Roth)

		Harvest age (in weeks)					Overall			Requirements	
Mineral element	N	6	8	10	12	14	Mean	s.e	CV	Heifer[a]	Cow[b]
P (g kg^{-1} DM)	12	3.3	3.8	3.6	3.6	4.1	3.68	0.01	8.02	2.4	3.0
K (g kg^{-1} DM)	12	29.4	37.6	41.5	38.9	42.1	37.91	0.23	13.5	4.4	4.4
Na (g kg^{-1} DM)	12	12.6	11.6	18.1	18.1	19.8	16.04	0.17	22.9	0.7	0.7
Ca (g kg^{-1} DM)	12	19.4	16.4	8.3	12.1	14.4	14.12	0.19	29.9	3.5	3.2
Mg (g kg^{-1} DM)	12	1.8	1.8	1.7	1.5	1.7	1.7	0.01	7.2	1.5	1.8
Cu (mg kg^{-1} DM)	12	7.67	8.01	8.31	8.8	8.01	8.161	0.21	5.2	9	10
Mn (mg kg^{-1} DM)	12	46.1	69.3	64.1	60.0	49.3	57.76	4.39	17.1	10	16-21
Zn (mg kg^{-1} DM)	12	63.3	86.1	70.2	61	66.3	69.28	4.44	14.3	30	28-48
Ca : P ratio		6:1	4:1	2:1	3:1	4:1	4:1			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; Soil nitrogen : Phosphorus ratio in the trial site was 235:1

DISCUSSION

Vetches are well known group of legumes with high crude protein content (Alzueta, *et al*., 2000). Their mineral contents have also been fairly studied in temperate regions (Hadjipanayiotou and Economdes, 2001; Gohl, 1981). The obtained mean values for P, K, Ca and Mg (Table 2) were comparable to the 3.3, 30.7, 12.1 and 3.0 g kg^{-1} DM reported by Rayburn (1994) and Sirois (1995) in legume forages. The 13, 44 and 18 mg kg^{-1} DM values reported by the same authors for Cu, Mn and Zn, respectively in legume forages are also consistent with the findings of this study (Table 2). The mean 3.68 g P kg^{-1} DM recorded in this study was slightly lower than the 5.7 and 4.8 g kg^{-1} DM reported by Hadjipanayiotou and Economdes (2001) for Common vetch (*V. sativa* L) and Narbon vetch (*V. narbonensis*) in Cyprus, respectively. It was however higher than the 3.1 g kg^{-1} DM reported by Kariuki *et al*. (1999) in Napier grass. The observed high P and Ca in *V. villosa* compared to Napier grass, agreed with Andrew and Robbins (1969) who stated that apart from the high N content, tropical legumes generally maintained higher P and Ca compared to tropical grasses. Results showed that mineral concentration in *V. villosa* herbage varied with advancing plant maturity. The concentration change patterns were however inconsistent, which seemed to be at variant with earlier assertions that, as plants mature, mineral content declines (McDowell, 1985). Results however showed that, concentration of micro-elements in herbage materials harvested between 12 and 14 weeks compared to those harvested between 6 and 8 weeks. This was found to concur with earlier observation that copper, zinc, iron, cobalt and molybdenum are the most common elements affected by plant maturity (Underwood 1981). According to this author, there is a rapid uptake of trace mineral during early growth and a gradual dilution as the plant matures. This therefore suggests that in *V. villosa* forage production optimum mineral concentration should be taken into account. Results further showed that, with respect to ruminants' mineral requirements, *V. villosa* has mineral content well above the suggested requirement limits for dairy cattle (Table 2; ARC, 1984), except for Cu. They were also found to be above the required limits for beef cattle (NRC, 1996; Rayburn, 1994; Sirois, 1995) except for Cu (10 mg kg^{-1} DM) and Mg (2 g kg^{-1} DM). The Cu and Mg deficiency in *V. villosa* herbage may have been due to the soil high pH (Table 1). From the results it was observed that, mineral levels in Naivasha soils seemed adequate for fodder production. It has however been shown that high pH restricts uptake of mineral elements by cultivated fodder crops. Mitchell (1957) monitored the change in mineral concentration of red clover and ryegrass when soil pH was increased from 5.4 to 6.4 by liming. Herbage cobalt concentrations were reduced from 2.2 to 1.2 mg kg^{-1} DM and 3.5 to 1.2 mg kg^{-1} DM, and manganese from 580 to 400 mg kg^{-1} DM and 1400 to 1300 mg kg^{-1} DM on a dry basis, for the red clover and ryegrass, respectively. Zinc and copper also tend to decrease with increasing soil pH (Mitchell, 1957). Concentration of K and Na were found to exceed the maximum tolerance limits of 30 and 7 g kg^{-1} DM, respectively for lactating beef cattle (NRC, 1996). Relative to ruminant animal requirements for production in the tropical grassland ecosystems (McDowell, 1985), the Ca:P ratios recorded in this study were quite acceptable.

CONCLUSION

The results revealed that, relative to ruminant animal requirements for production in the tropics, *V. villosa* has adequate mineral content, except for Cu and Mg. It was therefore concluded that, in addition to being a rich source of N, *V. villosa* has a potential for substantially increasing mineral content of ruminant livestock diets on smallholder farms in Kenya. This in turn will have an additive effect on animal performance on these farms. However, since low concentration of Cu and Mg was noted, it is therefore suggested that, supplementary source of Cu and Mg be offered regularly to ruminant livestock on *V. villosa* based diets to prevent Cu and Mg deficiencies related ailments. It is recommended that supplementation of minerals during periods, such as dry season, when concentrations in herbage are below those required by ruminant livestock is necessary to maintain optimum animal performance on-farm.

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