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Mineral composition of certain *Atriplex* species and *Cassia sturtii*

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Abstract
The objective of this study was to quantify the macro and trace mineral concentrations of *Atriplex canescens*, *A. halimus*, *A. nummalaria* and *Cassia sturtii* at two different sites in South Africa. Statistically significant differences in Ca, P, Mg, Se, Zn and Mn concentrations occurred between plants and sites. Calcium, Mg, Zn and Mn were present in sufficient concentration to meet nutrient requirements of small ruminants, but P was deficient at Lovedale, Northern Cape and Se at Hatfield, Gauteng. The *Atriplex* spp. have in general higher macro- and trace mineral concentrations at both sites than *C. sturtii*.

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Introduction
Some *Atriplex* species can, in theory, measure up to the requirements of a production ration according to their chemical composition. However, the relative poor production results of small stock browsing *Atriplex* species can be attributed to the fact that plant material is unpalatable or unacceptable to them, or that intake for productive purposes is inadequate (Wilson, 1966). The purpose of this study was to evaluate the interspecies and area variation for macro- and trace mineral concentrations between *Atriplex canescens*, *A. halimus*, *A. nummularia* and *Cassia sturtii*.

Materials and Methods
Leaves of *Atriplex canescens* (Pursch.) cv. Santa Rita (Fourwing Saltbush) (Origin: North America), *A. halimus* L. (Origin: Asia, Mediterranean), *A. nummularia* L. (Oldman Saltbush) (Origin: Australia) and *Cassia sturtii* (Origin: Australia) were collected from two experimental sites differing in ecological conditions. Site one was at the Experimental Farm of the University of Pretoria, Gauteng, South Africa (coordinates 025°15'28.9" E, 25°45'03.6" S). It is a summer rainfall area with a precipitation of 650 mm per annum. The soil type is a Hutton form (MacVicar *et al*., 1977), well drained, slightly acidic and consists of a good nutrient status. The Hutton type is a deep clay-loam soil with approximately 25% clay and an effective depth of 600 mm+. According to soil analysis, the soil $pH_{(H_2O)}$ was 5.7, the P status and K status were 250 and 200 mg/kg respectively while Ca, Mg and Na status were 800, 400 and 40 mg/kg, respectively.

Site two was at the farm Lovedale in the Kenhardt district, Northern Cape province, South Africa (coordinates 019°44'0.57" E, 29°18'58.8" S). It is a summer rainfall area with an average annual rainfall of approximately 130 mm. According to MacVicar *et al*. (1977), the soil type is also a Hutton form, slightly alkaline and consists of a good nutrient status ($pH_{(H_2O)}$ 8.4, P, K, Ca, Mg and Na status of 14, 337, 3445, 136 and 179 mg/kg, respectively).

Sample material randomly collected for each species (three samples per species per site with two replications) was from approximately five year old plants. Samples of each plant of the same species in each replication was kept apart and not pooled. Samples were dried in a force draught oven for 24 hours at 60 °C and milled through a 1 mm screen of a Beaver mill for chemical analysis to determine qualitative characteristics.

Atomic absorption spectrophotometry was used to determine Ca, Mg, Zn, Cu and Mn concentrations according to AOAC (2000). Phosphorus concentration was determined colorimetrically (Parkinson & Allen, 1975) and Se concentration by using a hydride generator attached to an atomic absorption spectrophotometer (Perkin-Elmer 2380).

A model was tested for each of the dependant variables. An analysis of variance with the Proc GLM model (SAS, 1994) was used to determine the significance between species, locations and first order

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interactions for the dependant variables. The level of significance between least square means (LSM) was tested with the Bonferroni's test (Samuels 1989).

Results and Discussion

The macro- and trace mineral concentrations are presented in Table 1. *Atriplex halimus* had a higher Ca concentration at Hatfield then at Lovedale (P < 0.05), which does not correspond with the very high Ca concentration of the soil at Lovedale. *Atriplex canescens* also had a higher Ca concentration than *A. nummularia* at Lovedale (P < 0.05). This contradicts the reports of both Smit & Jacobs (1978) and Khalik *et al.* (1986) who reported higher Ca concentrations in *A. nummularia* than in *A. canescens*. All the species exceeded the Ca requirements for goats (>1.38 g/kg), irrespective of site (NRC, 1981).

The P concentration of *A. nummularia* at both sites was higher than the concentrations in the other plants (P < 0.05), except for *A. canescens* at Lovedale. Except *A. canescens*, higher P concentrations were noted for all the plants at Hatfield compared to Lovedale (P < 0.05). This is in accordance with the higher P soil values of Hatfield. Concentrations of P found in this experiment were higher than the values reported by Khalil *et al.* (1986) for *A. nummularia* and *A. canescens*, but lower than those reported for the same species by Jacobs & Smit (1977). Except for *C. sturtii*, *Atriplex* spp. at Hatfield supplied enough P for maintenance requirements of small stock (>1.6 g/kg) (NRC, 1985). Although ruminants can tolerate a relatively wide Ca : P in the diet (Underwood & Suttle, 1999), the very wide Ca:P ratios in this study (>10:1) may cause a reduction in P bioavailability and a P deficiency could occur (Underwood & Suttle, 1999).

The Mg concentrations of both *A. canescens* and *A. halimus* were higher then those of *A. nummularia* and *C. sturtii* at both sites (P < 0.05), with higher levels at Hatfield compared to Lovedale (P < 0.05), except for *C. sturtii*. This correlates well with the higher Mg soil concentration at Hatfield. According to the NRC (1981) Mg requirements of goats are well below the reported values.

Table 1 Mineral composition of major and trace elements in leaf material of *Atriplex canescens*, *A. halimus*, *A. nummularia* and *Cassia sturtii* at two different sites (DM basis)

Site	Minerals	Species			
		A. canescens	*A. halimus*	*A. nummularia*	*Cassia sturtii*
Hatfield	Ca (g/kg)	20.6_1^a (± 4.3)*	21.5_2^a (± 3.7)	15.6_1^a (± 1.9)	15.5_1^a (± 2.3)
	P (g/kg)	1.9_1^a (± 0.2)	1.92_2^a (± 0.3)	2.5_2^b (± 0.3)	1.5_2^a (± 0.1)
	Mg (g/kg)	16.1_2^c (± 3.4)	20.3_2^c (± 4.3)	9.7_2^b (± 1.0)	2.0_1^a (± 0.1)
	Se (µg/kg)	39_1^a (± 20)	22_1^a (± 8)	21_1^a (± 8)	19_1^a (± 4)
	Zn (mg/kg)	110_2^c (± 18)	103_2^c (± 27)	60_2^b (± 15)	22_1^a (± 2)
	Mn (mg/kg)	170_2^b (± 59)	395_2^c (± 49)	153_2^b (± 59)	37_1^a (± 2)
Lovedale	Ca (g/kg)	20.3_1^b (± 1.8)	11.5_1^{ab} (± 2.5)	10.9_1^a (± 3.2)	14.5_1^{ab} (± 1.0)
	P (g/kg)	1.6_1^{ab} (± 0.1)	1.4_1^a (± 0.1)	1.6_1^b (± 0.1)	0.8_1^a (± 0.1)
	Mg (g/kg)	8.3_1^{bc} (± 0.4)	10.4_1^c (± 0.4)	3.0_1^a (± 0.4)	1.2_1^a (± 0.1)
	Se (µg/kg)	257_2^a (± 60)	105_2^a (± 20)	401_2^a (± 180)	314_2^a (± 33)
	Zn (mg/kg)	13_1^a (± 1)	11_1^a (± 2)	14_1^a (± 6)	13_1^a (± 6)
	Mn (mg/kg)	91_1^a (± 8)	116_1^a (± 6)	62_1^a (± 21)	40_1^a (± 6)

[abc]Means within a row for the same mineral followed by the same letter are not significantly different (P > 0.05)
[1,2]Means within a column, for the same mineral in different locations followed by the same number are not significantly different (P > 0.05)
*Standard deviation

Although no significant differences in Se concentrations were noted between the different plants at both sites, large differences occurred between the two sites (P < 0.05). The Se requirements of small stock are >100 µg/kg DM (NRC, 1985). The concentrations of all the plants at Lovedale will fulfil in these requirements, but not the plants at Hatfield.

The concentration of Zn of the different plants at Lovedale did not differ significantly, but differences occurred at Hatfield, where the *Atriplex* spp. had higher values than *C. sturtii* (P < 0.05). The Zn concentrations were also higher at Hatfield than at Lovedale (P < 0.05), most probably due to the calcareous soils at Lovedale. The inverse relationship between Ca and Zn is well noted (Underwood & Suttle, 1999). The Zn concentrations of plants at Lovedale were marginally above the Zn requirements for goats (10 mg/kg) (NRC, 1981).

The Mn concentrations of the *Atriplex* spp. at Hatfield were higher ($P < 0.05$) than the Mn concentration of *C. sturtii*. No differences were noted for Lovedale. Except for *C. sturtii*, differences occurred between the two sites for all the *Atriplex* spp. ($P < 0.05$). The lower Mn concentrations at Lovedale may be due to the high Ca concentration in those soils (McDonald *et al*., 2002). According to the NRC (1985) sufficient Mn was present in all samples to meet the requirements of small stock.

Conclusion

The Ca, Mg, Zn and Mn concentrations were present at sufficient levels to fulfil in the requirements of small stock. The P concentration of all plants at Lovedale was marginal in terms of requirements and the Ca:P ratios of all plants may present a problem in terms of P utilization. Supplementation of P should be considered if these plants, irrespective of site, are being utilized by ruminants. Shortages of Se may occur at Hatfield and supplementation could be necessary. The *Atriplex* spp. had considerably higher macro- and trace mineral concentrations at both sites than *C. sturtii*.

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