International Research Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) Vol. 2(10) pp. 445-450, October 2012
Available online http://www.interesjournals.org/IRJAS

Full Length Research Paper

Fodder potential of leaves and pods of planted *Leucaena diversifolia* and *L. leucocephala* species in semi-arid Botswana

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Abstract

The two species, *L. diversifolia* and *L. leucocephala,* were planted on-farm to provide supplementary feed for sheep. The plant material analysed was on the third cycle of harvesting. The objective was to investigate the nutritional value of the leaves and pods, with a view to establishing a long term strategy for on-farm provision of crude protein source. The investigation involved laboratory analysis of CP, NDF, ADF, ADL, IVDMD, OM, ash and condensed tannin. Mineral analysis included Ca, Mg, K, Na and P according to the procedure of AOAC (1996). CP, ADF and NDF were significantly higher in pods than in leaves ($p<0.0001$) while IVDMD was significantly higher in leaves ($p<0.0001$). ADL did not differ significantly between the leaves and the pods, being 12.72 and 12.92 g/100 g of dry matter for *L. diversifolia* and 11.03 and 11.92 g/100 g of dry mater for *L. leucocephala* suggesting that pods will be equally acceptable to animals. With the exception of Na, both pods and leaves had more than adequate amounts of the minerals Ca, Mg, K and P to meet the requirements for ruminants. With their ease of drying and storing pods have great potential as dry season fodder. *Leucaena* can be grown in Botswana with leaves providing crude protein during the wet season and pods providing dry season fodder as part of diversifying sources of livestock feed and promoting self-sufficiency.

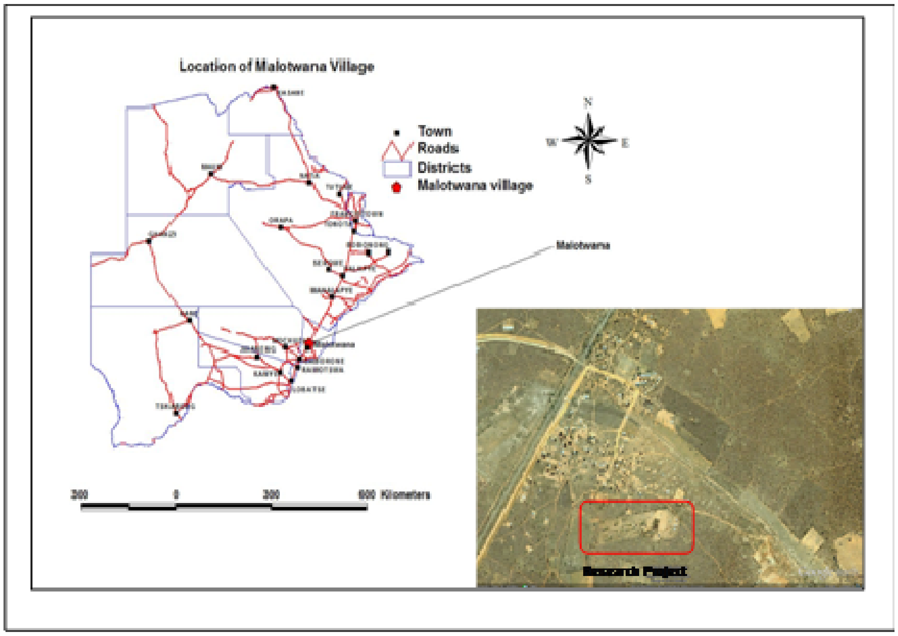
Keywords: Nutritional value, On-farm planting of supplementary feed, requirements for ruminants, easy of drying, Botswana.

INTRODUCTION

Livestock in Botswana are dependent on the range where they feed mainly on *Cenchrus ciliaris* which is both low in crude protein and with a content which declines with maturity (Aganga and Omphile, 2006). The need to find complementary fodder crops to support livestock is therefore paramount if farmers are to be provided with a potential solution to the shortage of nutritious feed. *Leucaena* can be planted to provide crude protein and is frequently employed in the tropics (Stewart and Dunsdon 1998; Shelton and Brewbaker 1994). Leaves of the species from plantations have been analysed and found to contain high crude protein ranging between 12.72 and 31 g/100 g of dry matter (Felker et al; Aregheore 2002) and the species has been shown to improve livestock production, both as part of range planting intervention and under cut-and-carry practice (Shelton and Brewbaker 1994). The objective of this study was to investigate the nutritional composition of leaves and pods of two on-farm planted species of *Leucaena,* namely *L. diversifolia* and *L. leucocephala,* as potential supplements in rearing livestock in Botswana.

MATERIALS AND METHODS

Seeds for planting material were obtained from the Grassland Research Institute in the Republic of South Africa and were planted at Malotwana Silvopastoral Farm



in Botswana in 1993 in a 2 species x 3 spacing randomised complete block design replicated five times. The village lies at latitude 24° 20' S, longitude 26° 05' E and falls between altitudes 940 and 950 m a.s.l. The tree crops were harvested at the age of 2.5 years and thereafter every two years.

Sampling Procedure

At the final harvest, in May 2000, separate samples of leaves and pods from the four most central trees in each plot were collected and mixed thoroughly, with 250 g being placed in carefully labelled sampling bags for oven drying. There were 60 samples comprising 15 pod and 15 leaves samples for both *L. diversifolia* and *L. leucocephala*. Samples were dried in a forced-fan air oven at 70°C for 48 hours. Oven-dried plant material was ground, using a stainless steel mill, and passed through a 1 mm sieve. The ground samples were labelled and stored in airtight plastic jars, until taken for analysis of *in vitro* dry matter digestibility, fibre analysis and mineral content. The analysis was carried out at the Botswana College of Agriculture laboratory in accordance with the procedures of AOAC (1996). The analysis involved determination of NDF, ADF and ADL according to the modified Van Soest *et al* (1991) procedure used in the ANKOM^{220} fibre analyser.

The condensed tannin contents of the leaves and the pods were determined using the procedures of Makkar (1999). Aqueous acetone made up of 70% acetone and 30% distilled water was used for tannin extraction. Butanol-HCL reagent and ferric solution were used for tannin determination using a spectrophotometer.

Samples were digested in a Kjeldatherm Gerhardt digestion block. A Gerhardt Vapodest distillation titrator was used to determine the nitrogen percentage which was multiplied by 6.25 to obtain the crude protein content in g/100. The digest was used for analysis of the minerals calcium (Ca) and magnesium (Mg), using an Atomic Absorption Spectrometer (GBC 908 AA). A Ciba-Corning Flame Photometer 410 was used to measure sodium (Na) and potassium (K) as described by AOAC (1996). Phosphorus (P) was measured using a UV1601PC UV visible spectrometer (ILSA (Pty) Ltd). Organic matter (OM) and ash were determined by ashing samples in a Gallenkamp muffle furnace at 550°C for four hours. *In vitro* dry matter digestibility was determined using an Ankom Daisy incubator (Tilly and Terry 1963). The rumen fluid was obtained from a fistulated cow from the Department of Agricultural Research Station in Sebele, Gaborone, Botswana.

Analysis of data

The data were entered in Microsoft Excel and analysed using the SAS statistical package (2000). They were subjected to analysis of variance and means were separated using the Student-Newman-Keuls Test.

$Y_{ijkl} = \mu + B_i + P_j + T_k + P\,S_{jk} + PIB(P+T)_{ijk} + e_{ijkl}$

Y_{ijkl} = nutrient content

μ = expected overall mean

B_i = variation effect due to blocks i = 1, 2, 3, 4, 5

Table 1. Nutritional composition of leaves and pods of *L. diversifolia* and *L. leucocephala* (g/100 dry matter

Parameter	Spacing	*L. diversifolia*		*L. Leucocephala*	
		Leaves	Pods	Leaves	Pods
ADF	5.0	36.44 ± 6.28	36.11 ± 6.31	34.11 ± 5.01	32.80 ± 5.55
	6.3	31.79 ± 6.76	33.42 ± 5.40	26.98 ± 6.74	35.48 ± 6.44
	8.3	27.40 ± 9.48	40.28 ± 6.46	28.44 ± 7.41	34.94 ± 6.61
Mean		**31.88b**	**36.60a**	**29.84b**	**34.40a**
ADL	5.0	15.92 ± 7.37	13.66 ± 2.83	9.73 ± 5.94	11.04 ± 2.83
	6.3	12.12 ± 2.01	11.27 ± 2.48	10.68 ± 4.41	12.28 ± 2.95
	8.3	10.13 ± 3.04	13.83 ± 3.34	12.68 ± 5.31	11.90 ± 3.44
Mean		**12.72a**	**12.92a**	**11.03a**	**11.74a**
Ash	5.0	5.72 ± 1.10	4.90 ± 0.44	7.37 ± 1.02	5.62 ± 0.31
	6.3	5.23 ± 1.48	5.05 ± 0.37	7.22 ± 1.14	5.72 ± 0.50
	8.3	6.49 ± 1.08	5.36 ± 1.47	7.50 ± 0.89	6.40 ± 1.53
Mean		**5.81a**	**5.10b**	**7.36a**	**5.92b**
CP	5.0	16.17 ± 2.27	18.00 ± 2.49	17.18 ± 4.15	19.24 ± 3.32
	6.3	15.48 ± 3.63	17.53 ± 2.86	17.83 ± 4.49	20.01 ± 3.00
	8.3	17.12 ± 4.02	17.01 ± 2.53	16.30 ± 2.86	19.91 ± 3.42
Mean		**16.26b**	**17.51a**	**17.11b**	**19.72a**
IVDMD	5.0	76.62 ± 2.55	68.36 ± 3.83	81.36 ± 3.06	72.92 ± 3.77
	6.3	75.13 ± 5.37	72.01 ± 4.31	82.45 ± 2.69	72.81 ± 3.19
	8.3	77.08 ± 1.59	67.67 ± 3.34	83.45 ± 3.33	74.42 ± 4.30
Mean		**76.28a**	**69.34b**	**82.28a**	**73.39b**
	5.0	34.62 ± 8.04	39.14 ± 4.25	34.35 ± 6.85	39.50 ± 3.93
NDF	6.3	33.13 ± 4.87	36.39 ± 6.49	34.67 ± 6.62	37.42 ± 5.81
	8.3	36.09 ± 6.19	38.39 ± 5.72	34.04 ± 6.90	38.99 ± 3.49
		34.61b	**37.97a**	**34.36b**	**38.64a**
OM	5.0	94.24 ± 1.16	95.10 ± 0.45	92.63 ± 1.02	94.38 ± 0.31
	6.3	94.77 ± 1.48	94.92 ± 0.36	92.92 ± 1.05	94.28 ± 0.50
	8.3	93.51 ± 1.08	94.48 ± 1.45	92.50 ± 0.89	93.66 ± 1.52
Mean		**94.17b**	**94.83a**	**92.68b**	**94.11a**
CT	5.0	2.43 ± 0.57	2.82 ± 1.78	1.84 ± 0.66	2.49 ± 1.46
	6.3	2.07 ± 0.67	2.42 ± 0.91	1.81 ± 0.33	2.12 ± 0.62
	8.3	1.63 ± 0.57	1.89 ± 0.69	2.69 ± 2.04	2.16 ± 0.73
Mean		**2.04b**	**2.38a**	**2.12b**	**2.25a**

Means followed by a different letter **ab** along the row show significant differences between leaves and pods P<0.05.±SEM

P_j = effect due to the j^{th} part j = 1, 2, 3, 4
T_k = effect due to using the k^{th} spacing k = 1, 2, 3
PT_{jk} = the interaction due to planting the j^{th} part at the k^{th} spacing.
$PIB(P+T)_{ijk}$ = random error, ~ $N(0, \sigma^2)$
e_{ijkl} = sampling error effect ~ $N(0, \sigma^2)$
l = number of runs l = 1, 2, 3, 4, 5 runs
k = 1, 2, 3 corresponding to low (8.3 x 5 m), medium (6.3 x 5 m) and high (5.x 5 m) density spacings respectively.
H_o: No difference between mean concentration of a given element in leaves and pods of plants of the same species: i.e. H_o:μ_1-μ_2 = 0 vs. H_1: μ_1 -μ_2 ≠ 0.

RESULTS AND DISCUSSION

The results of nutritional analysis are presented in Table 1 and those of mineral composition in Table 2 shows, both species had higher mean values for pods than leaves with respect to all parameters apart from IVDMD and ash content, though in some instances this was not the case in low density spacings. For example, at low

Table 2. Mineral composition of leaves and pods of *L. diversifolia* and *L. leucocephala* in g/100 g of dry matter

Parameter	Spacing	*L. diversifolia*		*L. leucocephala*	
		Leaves	*Pods*	*Leaves*	*Pods*
Ca	5.0	0.97 ± 0.36	0.27 ± 0.09	0.80 ± 0.42	0.53 ± 0.19
	6.3	0.87 ± 0.36	0.36 ± 0.15	1.08 ± 0.37	0.54 ± 0.17
	8.3	0.95 ± 0.55	0.43 ± 0.17	1.23 ± 0.43	0.50 ± 0.16
Mean		**0.93a**	**0.36b**	**1.04a**	**0.52b**
K	5.0	0.55 ± 0.36	0.49 ± 022	0.75 ± 0.22	0.60 ± 0.19
	6.3	0.50 ± 0.40	0.68 ± 0.37	0.48 ± 0.26	0.51 ± 0.22
	8.3	0.46 ± 0.19	0.89 ± 0.58	0.58 ± 0.40	0.63 ± 0.21
Mean		**0.50b**	**0.69a**	**0.61a**	**0.58a**
Mg	5.0	0.38 ± 0.07	0.24 ± 0.05	0.68 ± 0.10	0.35 ± 0.06
	6.3	0.34 ± 0.11	0.26 ± 0.07	0.56 ± 0.17	0.42 ± 0.13
	8.3	0.38 ± 0.19	0.31 ± 0.07	0.69 ± 0.08	0.32 ± 0.06
Mean		**0.37a**	**0.27b**	**0.64a**	**0.36b**
Na	5.0	0.0027 ± 0.0014	0.0037 ± 0.0023	0.0029 ± 0.0016	0.0031 ± 0.0021
	6.3	0.0022 ± 0.0008	0.0038 ± 0.0017	0.0027 ± 0.0010	0.0034 ± 0.0020
	8.3	0.0026 ± 0.0013	0.0034 ± 0.0020	0.0025 ± 0.0012	0.0035 ± 0.0019
Mean		**0.0025b**	**0.0036a**	**0.0027b**	**0.0034a**
P	5.0	0.15 ± 0.05	0.23 ± 0.05	0.20 ± 0.07	0.28 ± 0.06
	6.3	0.17 ± 0.06	0.22 ± 0.04	0.20 ± 0.06	0.22 ± 0.06
	8.3	0.20 ± 0.08	0.23 ± 0.07	0.16 ± 0.05	0.26 ± 0.06
Mean		**0.17b**	**0.23a**	**0.19b**	**0.25a**

Means followed by a different letter **ab** along the row show significant differences at $p<0.05$ between parts of same species ± SEM

density plantings the ADF content was marginally higher in the leaves of both species than in their pods. In contrast to all the other measures of nutritional composition apart from ash content, the IVDMD for both species was significantly greater in leaves than in the pods. However, with the values of 69.34 and 73.39 g/100 for *L. diversifolia* and *L. leucocephala* respectively, pods compared well with *M. sativa* (59 to 66 g/100) (Aganga and Tshwenyane 2003, Mupanga *et al* 1999).

CP which is not readily available from forage for livestock in arid zones (Rubanza *et al*, 2003), was significantly greater in the pods of both species than in their leaves (P<.0001). Since CP is largely concentrated in the seed (Nyambati *et al* 1996), pods, which are readily accepted by animals unprocessed, will need to be harvested while immature. This will ensure that kraal manure does not become the source of viable seed that will germinate and lead to species invasion on the farm land or the range. Likewise, farmers need to be aware that unless dried in very small quantities leaves are highly susceptible to mould. This contrasts with pods which are easy to dry and maintain their quality over relatively long periods of storage (at least three months without deterioration). This indicates their further advantage as dry season fodder despite their lower IVDMD. Also of importance is the finding that the condensed tannin content of both leaves and pods was lowest from trees in low density plots. This suggests that where there is less competition for nutrients, the tannin content may be lower in edible fodder and therefore low density planting should be recommended. Also worth noting is that ADL, which is a measure of acceptability of feed (Sandoval-Castro *et al* 2005), was not significantly different between leaves and pods.

Mineral Composition of Leaves and Pods of Leucaena

Table 2 shows the mineral composition of the leaves and pods of the two species. The mean values for Ca and Mg are significantly higher in the leaves than in the pods, although the extent to which this is so varies considerably with spacings. For K, Na and P mean values are significantly higher in the pods than in the leaves. However, both pods and leaves had more than the minimum 0.24 g/100 calcium content required for livestock maintenance (Norton 1994). The high calcium content of both leaves and pods of these species is particularly important in the light of the widespread deficiencies in range feed.

Pods of *L. diversifolia* contained significantly higher quantities of potassium than the leaves ($p<.0001$) (0.69 and 0.50 g/100 respectively). In contrast, for *L. leucocephala* the difference was not significant ($p = 0.1697$), with values of 0.61 and 0.58 g/100 for leaves and pods respectively. This can be explained by the fact that immature *L. diversifolia* pods have a high concentration of potassium which is being translocated from the leaves to the young pods. Since *L. leucocephala* produces pods earlier in the season than *L. diversifolia,* the potassium content of pods and leaves were at equilibrium in equally mature parts. Of importance is the fact that both the leaves and pods of the two species had potassium values above the minimum requirement of 0.5 g/100 g of dry matter for livestock (Underwood and Suttle 2004).

The high Ca content of pods and leaves of both species is most gratifying as this mineral is very important in the bone development of lambs and lactating ewes. It also improves the appetite of animals and leads to higher mass gain than when deficiencies of the mineral are present (Underwood and Suttle 2004). The calcium concentration in both parts far exceeds the minimum required for livestock maintenance and the leaves exceeds the values found in *M. sativa* of 0.88 g/100 (Aganga and Tshwenyane 2003). Currently deficiencies in the mineral must be met through supplementation with dicalcium phosphate which cost P570.00 (US$91.67) for a 50 kg bag whis is expensive for resource-poor farmers. It is also used to supplement phosphorus. Through the use of pods and leaves farmers can considerably enhance the availability of both minerals in the diet of their livestock.

CONCLUSIONS

Leaves and pods of these hardy exotic species far exceed the minimum crude protein requirement for livestock and are comparable in content to the commonly-used protein source, *M. sativa.* Pods of both species, although more tanniferous, have a higher protein content and dry more easily than the leaves, and could be part of dry season fodder on-farm.

Growing trees on-farm can contribute to sustainable agriculture through the provision of crude protein, which is a major limiting factor to animal production.

Tree fodder production of such hardy species can be incorporated in integrated agricultural production to provide formulation for feed for dairy cattle to increase milk production and can be mixed with bran to produce nutritious pellets.

RECOMMENDATIONS

Farmers should be encouraged to plant Leucaena on-farm to meet crude protein needs for their livestock Investigation of the optimal harvesting time for the pods of *Leucaena* spp. is needed so that seeds are both retained in pods and are immature at harvest to ensure that the protein content is maintained at a high level and that self-seeding on-farm or the range is avoided.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the guidance of Dr J. M Theron University of Stellenbosch, Prof A. A. Aganga of Botswana College of Agriculture and Dr B Moseki of University of Botswana who supervised the PhD of which this paper is an extract. My husband, Mr D. G.Walker and our children, Alister and Alison funded the study.

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