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MINERAL CONCENTRATION OF HERBAGE FROM THREE PAULOWNIA SPECIES USED FOR GOAT BROWSE

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Abstract

Goats naturally prefer a high proportion of browse in their diets. Therefore, research was initiated to investigate various silvo-pastoral production systems. In May 1997, six *Paulownia* treatments were planted in a randomized complete block experiment with six replications. Trees were between 6 and 12 cm in height at planting. Treatments included: *P. fortunei* seedlings, *P. tomentosa* seedlings, *P. elongata* seedlings, and three *P. elongata* clones. Each 4-m wide plot contained a single row of 12 trees with an intra-row spacing of 1 m. Leaf samples were analyzed from all six replications to determine mineral concentration in October 1997, and June and August 1998. Ca and P concentrations varied widely, and the Ca:P ratio exceeded the desired 2:1 with a range from 2.7:1 to 10.1:1. In October 1997, concentrations of Ca were similar in leaf laminae and petioles (1.26%), whereas P concentrations were twice as high in laminae (0.19%) as in petioles (0.09%). In October 1997, laminae from seedlings contained greater concentrations of Ca, Fe, and Zn than did laminae from clones, whereas the opposite was true for every element, with the exception of Fe, in June 1998. By

August 1998, these differences had disappeared. Regardless of sampling date and leaf part, concentrations of Ca, Mg, K, Fe, Mn and Zn were sufficient to fulfill goat nutritional requirements, whereas P concentrations were too low. Goats readily browsed *Paulownia* laminae and no clear preference trends were observed between treatments.

Keywords: Fodder tree, mineral concentration, *Paulownia*, Boer goats

Introduction

Meat goat production in the eastern United States is increasing as a result of growing demand from various ethnic groups. Because goats naturally prefer a high proportion of browse in their diets, research was initiated to investigate various silvo-pastoral production systems. The genus *Paulownia* contains several species which exhibit rapid juvenile growth and other characteristics that justify research into their potential use in meat goat feeding systems. *Paulownia* cropping systems with corn, cotton, millet, wheat, soy bean and sweet potato have been reported (Huo, 1992). Fallen, senescent *Paulownia* leaves have been used as a low-cost fodder source in rations for growing and finishing pigs (Boying, 1995). Hongfu et al. (1995) evaluated fallen *Paulowina* leaves for degradability using the nylon bag technique and concluded that their nutritive value was superior to that of rice or wheat straw. While it is known that *Paulownia* foliage can be used for feeding goats (Mueller et al., 2000), the mineral concentration of *Paulownia* herbage is not known. This research was designed to provide quantitative data on the mineral concentration of *Paulownia* as a browse plant for goats.

Material and Methods

In May 1997, six *Paulownia* entries were planted in Raleigh, NC (35 52 N 78 47 W) in a randomized complete block design with six replications. Soil at the experimental site was a clayey, kaolinitic, thermic Typic Hapludult. Soil tests revealed adequate levels of P and K and a pH of 6.2. No P, K, N or limestone was applied during the study. Treatments included *Paulownia fortunei* seedlings, *P. tomentosa* seedlings, *P. elongata* seedlings and three *P. elongata* clones (3, 5, and 13). Trees were between 6 and 12 cm tall at planting in May 1997. Each plot was 4 m wide and contained a single row of 12 trees of the same entry with an intra-row spacing of 1 m. One plot of each entry was included in each of the six blocks with entry position randomized within block. The inter-row area was clipped monthly to a 5-cm stubble during the first growing season. Herbaceous vegetation at the site consisted of white clover (*Trifolium repens*), narrow leaf plantain (*Plantago spp.*) and tall fescue (*Festuca arundinacea*).

Foliage samples were collected from the six replications three times to estimate herbage quality: 12 October 1997, 21 June 1998 and 14 August 1998. Foliage collected in October 1997 was hand-separated into leaf laminae and petioles, whereas only leaf laminae were collected in June and August 1998. Foliage samples were dried for 48 hours at 60_ C in a forced-air oven. Lamina and petiole samples were analyzed for dry matter (AOAC, 1999), for Ca, Mg, K, Fe, Mn and Zn by flame atomic absorption spectrophotometry, and for P by colorimetry. Thirty yearling halfblood Boer does were allowed to browse trees in each replicate for two days beginning at 0900 on 21 June and 14 August 1998. Statistical analysis of data was conducted using SAS (1998) for a randomized complete block design containing six treatments and six replicates.

Results and Discussion

Petioles collected from all seedlings on 12 October 1997 contained greater concentrations of Ca (P<0.01), P (P<0.05), Mg (P<0.01), and Zn (P<0.01) than petioles from clones (Table 1). In addition, Ca (P<0.02), Mg (P<0.03), and Zn (P<0.02) concentrations were greater in *P. elongata* seedlings than in *P. elongata* clones (Table 1). Greater Ca (P<0.02), Fe (P<0.01), and Zn (P<0.01) concentrations were observed in laminae from seedlings than in laminae from clones. Contrasts between *P. elongata* seedlings and *P. elongata* clones indicated that the latter contained less Fe (P<0.04) and Zn (P<0.03) than the former (Table 1). Conversely, laminae from clones collected on 21 June 1998 contained greater concentrations of Ca (P<0.02), P (P<0.02), Mg (P<0.01), K (P<0.01), Mn (P<0.01), and Zn (P<0.01) than laminae from seedlings (Table 2). Clones of *P. elongata* exhibited the same trend for K (P<0.02), Mn (P<0.01), and Zn (P<0.04) when compared to *P. elongata* seedlings (Table 2). However, by 14 August 1998, differences in mineral concentrations between seedlings and clones had disappeared, with the exception of Mn which was greater (P<0.01) in *P. elongata* clones than *P. elongata* seedlings (Table 2).

Crude protein and cell-wall concentrations and *in vitro* digestibility of *Paulownia* foliage have been reported elsewhere (Mueller et al., 2000). The most nutritionally demanding physiological stage for meat goats is that of young, growing kids (< 15 kg) and does in early lactation (NRC,1981). Nutritional requirements for Ca and P as a percentage of the ration are 0.6 and 0.3, respectively. The leaf blades and petioles of the *Paulownia* species studied in our trials provided ranges above these requirements for Ca, whereas P concentrations were lower than required. Phosphorous concentrations were especially low in petioles. In addition, Ca and P values varied widely and exceeded the desired Ca:P ratio of 2:1 to 4:1 with a range from 2.7:1 to 10.1:1. Although this range is at variance with the desired ratio, the problem can be easily corrected by prudent mineral supplementation. Finally, concentrations of Mg, K, Fe, Mn and Zn in laminae were sufficient to fulfill the nutritional requirements of goats (Haenlein, 1990) .

Animals readily browsed leaf blades, but leaf petioles were almost entirely rejected. Trees were completely defoliated by day 2, and no clear preference trends were observed among the different *Paulownia* species and clones. Thus, it is unlikely that dry matter intake would be reduced if using sound controlled grazing management practices. Therefore, the *Paulownia* species studied have the potential to play an important role in meat goat sylvo-pastoral production systems of southeastern USA.

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Table 1 - Petiole and lamina mineral concentrations for six *Paulownia* entries grown at Raleigh NC and sampled on 12 October 1997.

	Petioles							Laminae						
Paulownia	Ca	P	Mg	K	Fe	Mn	Zn	Ca	P	Mg	K	Fe	Mn	Zn
Seedlings	--------------%-------------				------mg·kg^{-1}------			--------------%-------------				------mg·kg^{-1}------		
1. *tomentosa*	1.43	0.14	0.84	2.7	124	41	39	1.81	0.18	0.67	0.93	180	39	27
2. *fortunei*	1.87	0.10	1.04	1.6	105	25	43	1.47	0.19	0.66	0.93	154	39	34
3. *elongata*	1.45	0.10	0.97	2.0	87	32	38	1.16	0.20	0.50	1.07	150	32	36
Clones														
4. *elongata* 3	.96	0.07	0.63	2.3	119	25	24	0.76	0.21	0.37	0.99	150	41	30
5. *elongata* 5	1.02	0.07	0.72	2.2	87	23	26	1.02	0.18	0.56	1.25	137	37	28
6. *elongata* 13	.92	0.07	0.59	2.4	84	24	23	1.20	0.20	0.62	1.18	132	39	27
SE	0.50	0.02	0.11	0.3	15	8.0	5.0	0.21	0.02	0.09	0.22	4.0	4.0	3.0
Treatment of contrasts														
Seedlings vs. clones (1,2,3 vs. 4,5,6)	<0.01	0.05	<0.01	*NS*[a]	*NS*	*NS*	<0.01	0.02	*NS*	*NS*	*NS*	<0.01	*NS*	0.01
P. *elongata* seedlings vs. clones (3. vs. 4,5,6)	0.02	*NS*	0.03	*NS*	*NS*	*NS*	0.02	*NS*	*NS*	*NS*	*NS*	0.04	*NS*	0.03

[a]*NS* = nonsignificant.

Table 2 - Lamina mineral concentrations for six Paulownia entries grown at Raleigh NC and sampled in 1998.

	21 June							14 August						
Paulownia	Ca	P	Mg	K	Fe	Mn	Zn	Ca	P	Mg	K	Fe	Mn	Zn
Seedlings	--------------%--------------				------$mg \cdot kg^{-1}$------			--------------%--------------				-------$mg \cdot kg^{-1}$------		
1. *tomentosa*	0.48	0.20	0.29	0.39	172	26	39	1.15	0.24	0.71	0.93	152	37	56
2. *fortunei*	0.85	0.11	0.44	0.73	178	31	33	1.03	0.27	0.61	1.04	155	34	84
3. *elongata*	0.86	0.19	0.45	0.77	203	28	40	0.87	0.18	0.49	0.9	134	25	71
Clones														
4. *elongata* 3	1.05	0.21	0.60	1.17	204	37	52	0.99	0.27	0.65	1.37	166	38	85
5. *elongata* 5	1.01	0.20	0.59	0.94	212	37	48	0.67	0.25	0.43	0.92	138	38	81
6. *elongata* 13	0.99	0.21	0.60	1.05	188	38	49	0.91	0.24	0.63	1.39	150	35	76
SE	0.13	0.009	0.07	0.08	14	2.1	3.4	0.19	0.03	0.12	0.23	20	3.2	10
Treatment of contrasts														
Seedlings vs. clones (1,2,3 vs. 4,5,6)	0.02	0.02	<0.01	<0.01	*NS*[a]	<0.01	<0.01	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
P. elongata seedlings vs. clones (3 vs. 4,5,6)	*NS*	*NS*	*NS*	0.02	*NS*	<0.01	0.04	*NS*	*NS*	*NS*	*NS*	*NS*	<0.01	*NS*

[a]*NS* = nonsignificant.