Cutting management of multipurpose tree legumes: effects on green herbage production, leaf retention and water-use-efficiency during the dry season in Timor, Indonesia

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Abstract

Edible herbage production and water-use-efficiency of three tree legumes (*Leucaena leucocephala* cv. Tarramba, *L. pallida* x *L. leucocephala* (KX2) and *Gliricidia sepium*), cut at different times of the year (February, April, June and uncut) were compared in a semi-arid area of Timor Island, Indonesia. Cutting in the early and mid dry-season (April and June) resulted in higher total leaf production ($P< 0.05$) and water-use-efficiency ($P< 0.05$), than cutting late in the wet-season (February) or being left uncut. For the leucaena treatments removing leaf in the early to mid dry-season reduced transpiration, saving soil water for subsequent regrowth as evidenced by the higher relative water contents of leaves from these treatments. This cutting strategy can be applied to local farming conditions to increase the supply of feed for livestock during the dry season.

Media summary

A cutting strategy to maximize green herbage production was developed to help West Timor farmers provide feed for their livestock during the long dry-season.

Key Words

Cutting management, tree legumes, semi-arid, dry-season forage supply.

Introduction

The majority of Timor Island, in the eastern region of Indonesia, has a semi-arid tropical climate, typified by a 4-6 months wet season and 6-8 months dry season. Under such conditions, the availability and quality of feed becomes a major constraint to ruminant livestock production during the dry season. Local farmers use tree legumes such as leucaena (*Leucaena leucocephala*), gliricidia (*Gliricidia sepium*) and sesbania (*Sesbania grandiflora*) throughout the year, but in unmanaged situations these legumes lose most of their leaves during the latter part of the dry-season, i.e. when needed most.

Given that these tree legumes are usually deep-rooted and that moisture is usually available in the deeper soil layers at the end of the wet season, it was hypothesised that removal of foliage during the earlier part of the dry season would reduce the demand upon soil moisture and so allow better plant production later in the dry season. There is some published information to support this hypothesis, including Jackson *et al*. (2000) who demonstrated that when *Grevillea robusta* was heavily pruned, the water requirement of the tree was reduced; St?r *et al*. (1998) who suggested that cutting forage trees at different seasons and at different stages of development might influence subsequent re-growth capacity; and Roothaert and Paterson (1997) who established that cutting *Calliandra calothyrsus* 6 months before the end of dry-season was associated with maximum yield in the semi-arid lowland environment of Kenya.

This paper presents results of an experiment conducted on Timor Island to determine the effects of cutting management strategies on biomass production, leaf retention and water-use-efficiency of three tree legumes, with the aim of increasing dry season productivity.

Methods

Study site

The experiment was carried out under field conditions at the Lili Livestock Research Station of the East Nusa Tenggara Assessment Institute for Agricultural Technology, Indonesia, from December 2001 to October 2002. The site is 39 km east of Kupang City at 10^{o} 05'S and 123^{o} 52'E, at an altitude of 60 m asl. The soil is a vertisol (4.9% sand, 49.6% silt and 45.5% clay), with pH of 7.7. During the period of the study, daily minimum and maximum temperatures ranged from 14 to 26^{o}C, and 27 to 39^{o}C, respectively. Rainfall was 1000 mm during the study period, with the last rainfall occurring in late March 2002. The mean relative humidity ranged from 62 to 97% (Naibonat Meteorology Station).

Treatments and experimental design

Three tree legumes comprising *L. leucocephala* cv Tarramba, the F1 hybrid (*L. pallida* x *L. leucocephala* (KX2)), and *G. sepium,* were planted in a 3x4 factorial design (3 legumes, 4 cutting regimes) with 3 replications. The cutting regimes were - February (late wet-season), April (early dry-season) and June (mid dry-season). There was an uncut control. Each treatment plot consisted of 3 rows spaced at 2.5 m, with each row containing 7 plants spaced at 0.5 m. Measurements were taken on the five trees in the centre row of each plot. Seedlings of the three species were established in September 2001 and transplanted to the field plots in December 2001.

Above ground dry matter accumulation was measured by cutting the trees to a height of 50 cm for each cutting treatment, and to ground level at final harvest. Soil moisture was measured at 20 cm depth intervals in the soil profile by the gravimetric method at 2 monthly intervals. Soil samples were taken at a distance of 25 cm from the base of the trees in each plot. Relative water content (RWC) was measured by incising the youngest fully expanded leaves. Two leaf sections (1x1 cm for gliricidia and 2 leaflets for leucaena) were taken from trees in each plot and placed in Eppendorf tubes which were then sealed; the procedures of Barrs and Weatherly (1962) were then followed. Water-use-efficiency (WUE) was calculated as biomass retained (kg/ha) divided by total water use, i.e. initial soil moisture content, plus rainfall, minus final soil moisture content (mm). Because rainfall was negligible after April, water losses in the form of run-off, evaporation and deep drainage, were assumed to be inconsequential and were not measured.

Statistical analysis

Data were subjected to analysis based on a 3x4 factorial design by GLM procedure in Statistical Analysis System V.8 program (SAS Inst. Co. NC-USA). Means were compared using LSD's.

Results and discussion

Biomass production and water-use-efficiency

There were no significant interactions between the legume and cutting treatments for cumulative leaf production, retained leaf or WUE. Cumulative retained leaf production from December 2001 to October 2002 of all three tree legumes was maximised by cutting in the early (April) to mid (June) dry season. These treatments also led to the highest retention of leave at the end of the dry season for the leucaena treatments, produced the highest leaf:stem ratios (data not presented), and led to the best WUE for edible forage production (Tables 1, 2 & 3).

If the production strategy was specifically targeting forage supply for the late dry season then the early dry season (April) cut was best for the *Leucaena* accessions (Table 2). Data suggested that this strategy minimised transpiration losses during the early to mid dry season so that late season forage could be produced and retained on the trees. In contrast, gliricidia produced most late dry season forage when cut in the mid dry season (June). This strategy disrupted the flowering process in gliricidia, effectively keeping the tree in a vegetative state. All other cutting treatments resulted in heavy flowering and leaf fall in gliricidia. In gliricidia, therefore, mid dry season was the best time to cut to provide herbage to animals during the late dry season.

Leucaena spp. were able to provide moderate amounts of late dry season feed when left uncut, but this strategy forgoes the benefits of forage from earlier harvests. The February cutting treatment (mid wet-season) was also associated with the poor leaf retention; and higher proportions of woody biomass (data not shown).

WUE was higher in both leucaena accessions than in gliricidia ($P<0.05$) (Table 3), largely due to gliricidia producing fewer leaves and most of these leaves then senescing during the dry-season. WUE was highest for the April and June cutting treatments, presumably because canopy reduction reduced transpiration (Jones *et al*.,1998) and demand upon soil water, with that 'saved' water then used for regrowth later in the dry season, eventually leading to improved water-use-efficiency.

Table 1. Cumulative leaf production over the period of December 01 – October 02

	Cumulative leaf produced (kg DM/ha)				
Species	February cut	April cut	June cut	Uncut	Average
L. leucocephala	1,190	4,170	4,700	1,310	2,840[y]
Leucaena - KX2	1,640	4,340	4,630	2,320	3,230[y]
G. sepium	260	2,260	2,300	20	1,210[x]
Average	1,030[a]	3,590[b]	3,880[b]	1,220[a]	

Table 2. Leaf retained at final harvest (October 02) following different cutting treatments

	Total leaf retained (kg DM/ha)				
Species	February cut	April cut	June cut	Uncut	Average
L. leucocephala	994	1,387	880	1,307	1,142[x]
Leucaena - KX2	1,528	3,006	2,441	2,318	2,323[y]
G. sepium	159	0	610	18	197[z]
Average	894[a]	1,464[b]	1,310[ab]	1,214[ab]	

Table 3. Water-use-efficiency of cumulative leaf production for different cutting treatments

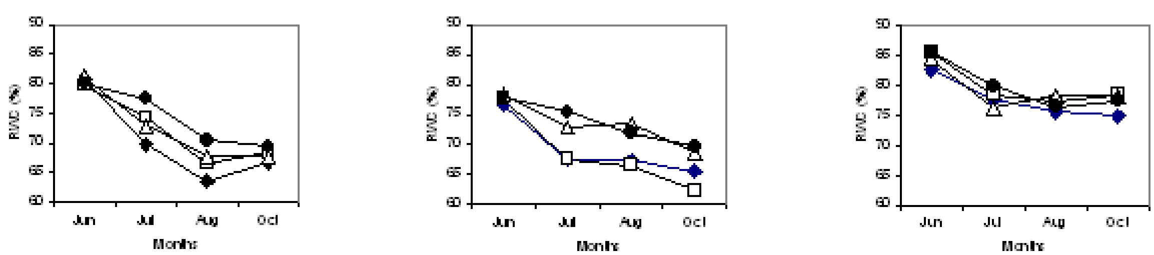
WUE (kg DM/ha/mm water)					
	February cut	April cut	June cut	Uncut	Average
L. leucocephala	3.1	11.4	11.1	3.2	7.2^{y}
Leucaena –KX2	4.0	12.9	9.4	6.6	8.2^{y}
G. sepium	0.9	6.1	5.6	0.03	3.2^{x}
Average	2.7^{a}	10.1^{b}	8.7^{b}	3.3^{a}	

^{y,x,z} – superscripts with different letters in the same column indicate significant differences ($P \leq 0.05$)
^{a,b} - superscripts with different letters in the same row indicate significant differences ($P \leq 0.05$)

Relative water content

Relative water content of the leaves declined steadily with the onset of drought stress, from June to October. The June (mid dry-season) cutting treatment maintained the highest RWC for both the leucaena treatments, whereas the uncut and February (mid wet-season) cutting treatments had the lowest RWC (Figures 1&2). For gliricidia, there was no significant difference in RWC among the cutting treatments.

The values of RWC at the time of greatest water stress (just prior to leaf senescence) for the leucaena treatments (62-70%) were lower than for gliricidia (75-78%), indicating that these cultivars were able to tolerate greater degrees of moisture stress than gliricidia.



(1) (2) (3)

Figure 1. Relative water content (RWC) of (1) *L. leucocephala,* (2) leucaena KX2, and (3) gliricidia for different cutting treatments - (♦) uncut, (□) Feb. cut, (Δ) April cut, (•) June cut

Conclusion

The data showed that cutting early and mid dry-season increased the annual production of leaf from all three tree legumes at least three-fold and resulted in the best WUE. The timing of pruning had a comparatively smaller effect on the availability of leaf at the end of the dry season.

Acknowledgement

The authors wish to acknowledge the funding support of ACIAR for the project '*Leucaena Management in West Timor and Cape York* (AS2/2000/157)', and AusAID support for the Australian Development Scholarship (ADS) provided to the first author.

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