Effect of age of forage tree legumes at the first cutting on subsequent production

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Abstract

In a tropical environment with a distinct dry season the tropical tree legumes *Calliandra calothyrsus, Sesbania grandiflora, Leucaena leucocephala* and *Gliricidia sepium* were planted widely spaced at varying times to achieve a range of ages (13, 15, 17, 19 and 21 months) at first cutting. Subsequently, trees were harvested at a height of 100 cm every three months and leaf and wood dry weight, and branch number was recorded.

Many of the *Sesbania grandiflora* trees died before the end of the experiment. In the other species both leaf and wood yields were positively related to age at first cutting. This relationship was stronger for *Leucaena leucocephala* and *Gliricidia sepium* than for *Calliandra calothyrsus* and yield differences persisted over the duration of the experiment.

Resumen

Las leguminosas arbóreas Calliandra calothyrsus, Sesbania grandiflora, Leucaena leucocephala *y* Gliricidia sepium *fueron plantadas, en un medio ambiente tropical con una estación seca distintiva, a una densidad amplia y a diferentes tiempos a fin de lograr una rango de edades (13, 15, 17, 19 y 21 meses) al primer corte. Posteriormente, los árboles fueron cosechados a una altura de 100 cm cada tres meses y se registró el peso seco de la hoja y la madera, as como el número de ramas.*

Muchos de los árboles de Sesbania grandiflora *murieron antes de finalizar el experimento. El rendimiento de hoja y madera de las otras especies estuvo positivamente relacionado con la edad al primer corte. Esta relación fue más fuerte con* Leucaena leucocephala *y* Gliricidia sepium *que con* Calliandra calothyrsus *y las diferencias en el rendimiento se mantuvieron hasta el final del experimento.*

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Introduction

The productivity of tree legumes is greatly influenced by cutting management. Of the various aspects of cutting management for tree legumes, cutting interval and cutting height have been studied in a number of experiments.

Some tree species such as *Sesbania grandiflora* (Ella *et al.* 1989) can not withstand repeated cutting, while others may not tolerate a very low cutting height (e.g. Lazier 1981 for *Codariocalyx gyroides*). Often cutting height has little effect on yield of tree species (Ferraris 1979; Pathak *et al.* 1980), but a positive relationship between cutting height and yield has been reported in some instances (Krishna Murthy and Mundegowda 1982). While total yield of tree legumes increases with longer cutting intervals, the proportion of leaf declines (Guevarra *et al.* 1978; Ella *et al.* 1989).

When comparing the productivity of different tree legumes, a common management regime is usually employed. This was the case in a previous experiment by this group (Ella *et al.* 1989) where the cutting height was 100 cm while cutting intervals and plant densities were varied. In this earlier study, trees were first cut when the slowest growing species had reached a height of more than 100 cm. At that time the fastest growing species, *Sesbania grandiflora*, was already higher than 5.5 m and it was suspected that this first cut may have disadvantaged the fastest growing species. No information has, however, been published which clarifies the effects of the age of the trees at the first cut on subsequent yields, and an experiment was designed to investigate this factor.

Materials and methods

The experiment was conducted at the Balai Penelitian Ternak at Gowa, South Sulawesi, Indonesia, between April 1984 and January 1987.

Prior to the experiment the site was used for communal grazing and the pasture consisted of very low growing native grass with traces of native legumes, mainly *Desmodium triflorum*. The soil has been described by D. McLeod (personal communication) as a well drained alluvial silty clay of pH 6, and classified as a typic ustifluvent (USDA Taxonomy). An omission nutrient trial (Samsayr Bahar personal communication) had shown the soil to be deficient in P (phosphorus) and S (sulfur) but no response to trace elements was measured.

Average yearly rainfall at Gowa is 2700 mm with a 5-6 months dry season when rainfall is less than 100 mm/month. Rainfall was average in 1984 and 1986, while 1985 was an unusually dry year (Figure 1).

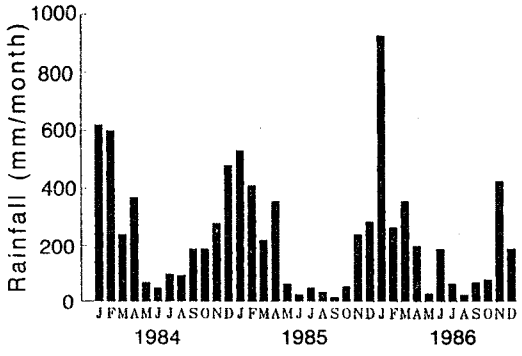

Figure 1. Monthly rainfall (mm) at Gowa, South Sulawesi from 1984 to 1986.

Treatments and design

Four tree species, (*Leucaena leucocephala* cv. Cunningham, *Sesbania grandiflora* (local source), *Calliandra calothyrsus* (local source) and *Gliricidia sepium* (local source)), were planted in the field at varying times to achieve a range of ages at the first harvest (13, 15, 17, 19 and 21 months) for each species. Subsequently, trees were harvested at approximately three-monthly intervals.

It had been intended to achieve a range of ages from 4 to 12 months at the first harvest. However, the severe dry season in 1985 (Figure 1) resulted in the cessation of tree growth. It was then decided to delay the first harvest until the following wet season, rather than to risk tree death by cutting in the dry season. The harvest was further delayed by heavy rain in late December and early January 1986, and did not take place until February 1986. While this resulted in a tree age of 13-21 months, trees had not grown for approximately 6 months during the dry season and tree size was correspondingly smaller.

The experiment was arranged as a split-plot design with the five different age groups as the main plots and the tree species as sub-plots. Each treatment was replicated five times and replications constituted blocks. Tree rows were 20 m long with five trees per row giving 4 m between trees. The distance between rows was also 4 m. This spacing was chosen to avoid the confounding effects of density.

Establishment

Prior to the experiment the site was cultivated with a disc plough and harrowed. Fertilizer was applied after planting at rates of 45 kg/ha P, 100 kg/ha S and 60 kg/ha K (potassium) in the form of triple superphosphate, elemental S and muriate of potash, respectively.

Seed of all species was pregerminated and on March 15, 1984 sprouted seeds were planted into 12 cm diameter plastic pots filled with soil collected from the site. Inoculum was applied at planting: *L. leucocephala* with CB 81, *S. grandiflora* with a mixture of CB 905/3023, *C. calothyrsus* with CB 756 and *G. sepium* with a mixture of CB 3057/3059. The seedlings were grown in a shade house until June 6, 1984, when 25 trees of each species were transplanted into the field. Seed of *Gliricidia sepium* did not germinate well and this species was established directly into the field site, also on June 6, by cuttings. Cuttings were taken from 1-2 year old trees, and were 30 cm long and 3-3.5 cm in diameter.

Subsequently, this planting procedure was repeated at two-monthly intervals on August 6, October 6, December 6, 1984 and February 6, 1985.

Trees were watered daily during the first month of establishment and the plots were periodically sprayed with Dalapon to control graminaceous

weeds, and other herbaceous weeds were removed from the plots by hand weeding. This weed control program ensured that competition was kept to a minimum.

Measurements

On February 20, 1986 the trees in all plots were cut to a height of 100 cm above the ground. This gave ages to first cutting of 13, 15, 17, 19 and 21 months. The harvested material was separated into leaf, stem and pods, and dried. Post harvest data collected included the number of side branches at cutting height that were greater than 5 mm in diameter. Subsequent harvests to 100 cm were made on May 15, 1986 (H2), August 4, 1986 (H3), October 28, 1986 (H4) and January 20, 1987 (H5).

Results

Leaf production

At the first harvest, there was no significant ($P > 0.05$) interaction between species and age, therefore only the main effects of age and species are presented (Table 1). The leaf yield of all species increased with increasing age, but there was no significant difference between the 13 and 15 month treatments. The yield difference was greatest between the 19 and 21 month treatments. *Sesbania grandiflora* and *C. calothyrsus* had a higher leaf production ($P < 0.05$) than *G. sepium* and *L. leucocephala*.

Table 1. Main effects of age and species on dry weight of leaf and wood (kg/tree) at harvest 1

Age effects		
Age (mth)	Leaf	Wood
13	0.35	0.47
15	0.40	0.60
17	0.71	1.53
19	1.35	3.50
21	2.11	6.79
LSD (0.05)	0.22	1.39
Species effect		
Species	Leaf	Wood
C. calothyrsus	1.18	2.96
S. grandiflora	1.22	3.62
L. leucocephala	0.66	2.18
G. sepium	0.88	1.55
LSD (0.05)	0.26	0.83

In the next four harvests (H2-H5) no significant difference in leaf production occurred between treatments in *S. grandiflora* (Figure 2). In *C. calothyrsus*, the older trees tended to have a higher yield than the younger ones (Figure 2) but this was significant ($P < 0.05$) only between the 21 and 13 month treatments in harvests 3 and 4. In *L. leucocephala* leaf yields at all harvests were substantially higher in the 21 month treatment than in the 13 month treatment ($P < 0.05$), but not between the 13 and 15 month treatments or between the 17 and 19 month treatments. *Gliricidia sepium* exhibited no differences or only small differences in leaf production between the 13, 15 and 17 month treatments at all harvests, however, the 21 month treatment had a much higher ($P < 0.05$) leaf yield.

Data are also presented to show cumulative leaf yields (Figure 3). The 21 months treatments of *C. calothyrsus* and *S. grandiflora* had a higher leaf yield at their first harvest than any other treatment at 21 months after planting. However, their subsequent yields were not higher than those of other treatments. On the other hand, the yield advantage of the older treatments of *L. leucocephala* and *G. sepium* increased with time.

Wood production

At the initial (first) harvest, wood yield was positively associated with age (Table 1). *Sesbania grandiflora* had a significantly ($P < 0.05$) higher wood yield than *L. leucocephala* and *G. sepium*.

For the following 4 harvests (H2-H5), the differences in wood production between species and treatments were almost identical to those recorded for leaf production (data not presented).

Number of side branches

The number of side branches which developed in the various treatments was higher in the 19 and 21 months treatments than in the younger treatments in *C. calothyrsus*, *L. leucocephala* and *G. sepium*, but not in *S. grandiflora* (Figure 4).

Discussion

Both leaf and wood yield were positively related to tree age for all species at the first harvest. At this harvest, leaf yields were highest in *S. grandiflora* and *C. calothyrsus*. Evans and Rotar (1987)

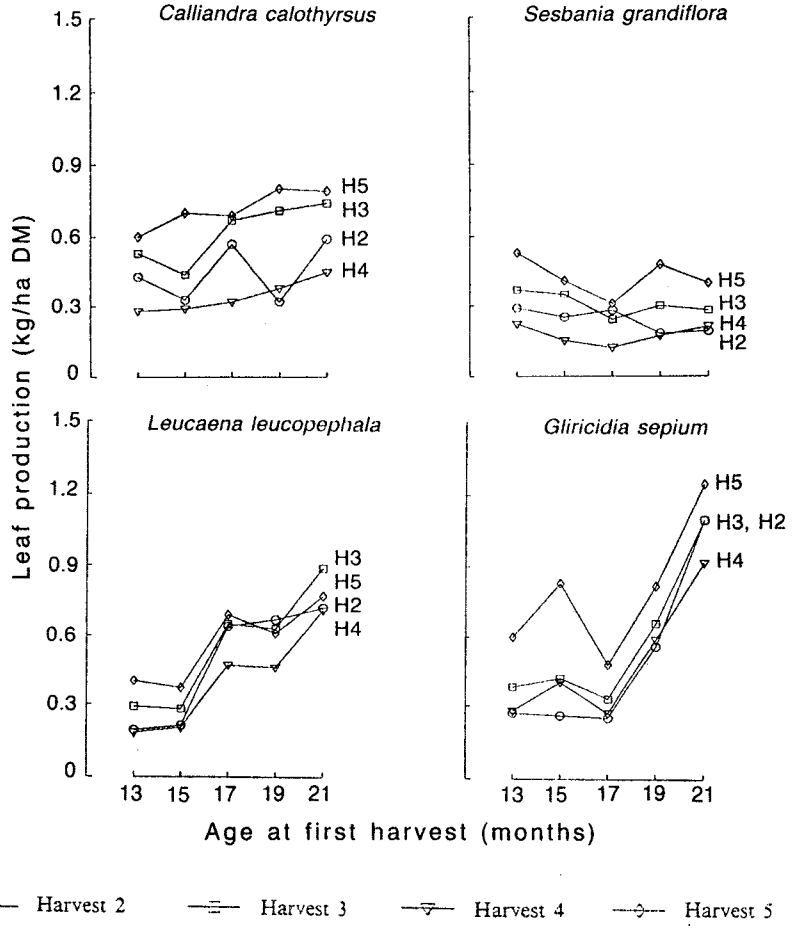

Figure 2. Effect of age of trees at first cutting (13, 15, 17, 19 and 21 months) on leaf dry matter yield (kg/tree) at four subsequent harvests.

reported that *S. grandiflora* produced 0.6 kg leaf/tree when cut 6 months after planting. This yield was higher than the 0.4 kg/tree recorded in the current study 13 months after planting. *L. leucocephala* had the lowest leaf yield for all species at the first cut, but the initial slow growth of this species is well documented (Dijkman 1950; Lesleighter and Shelton 1986).

The regrowth of *S. grandiflora* was much lower than that of the other species after the first harvest and this poor tolerance to cutting has been reported previously (Ella *et al.* 1989; Horne *et al.* 1986). This result contrasts with that of Takahashi and Ripperton (1949) who found that *S. grandiflora* yielded well even after repeated cuttings. In their experiment, the first cut was performed at 4 months, which is some 9 months earlier than in the experiment reported here.

In the other three species, the yield at subsequent harvests was generally positively related to age at first cutting, although differences between treatments were much less in *C. calothyrsus* than in *L. leucocephala* and *G. sepium*, and there were no differences or only small differences between the 13, 15 and 17 month treatments.

Little information concerning the effects of the age of the tree at first harvest on subsequent yields has been published. Harris (1978), in a review on the effects of defoliation on pasture plants, listed several factors which may influence the ability of plants to regrow. These are residual leaf area, carbohydrate and other reserves, the rate of recovery of root growth and nutrient and water uptake and the quantity and activity of meristems remaining. The older trees, which were larger at the first harvest, would be expected to have more

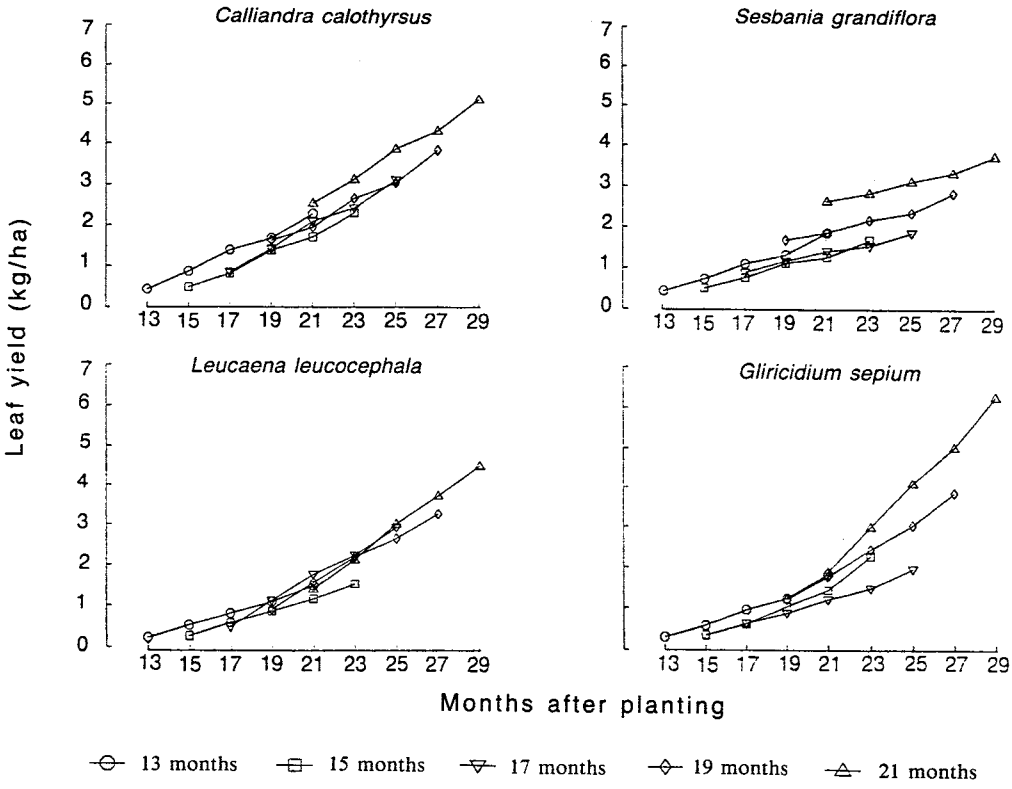

Figure 3. Effect of age of trees at first cutting on cumulative leaf dry matter yield (kg/tree).

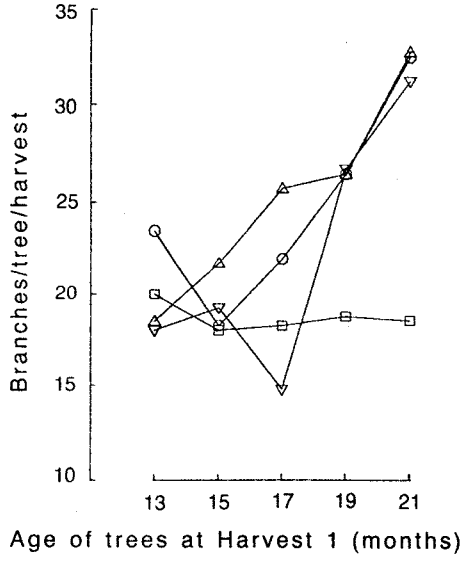

Figure 4. Effect of age of trees at first cutting on branch number (mean of harvests 2-5).

stored reserves than younger, smaller trees, and this greater amount of reserves may have been responsible for greater regrowth since little or no leaf remained after cutting. Similarly, Pathak and Patil (1980) reported that felled *L. leucocephala* trees gave high coppicing which was linearly related to their basal diameter. Isarasanee *et al.* (1984) investigated the effect of size of woody framework on leaf production and suggested that early regrowth was mainly supported by movement of carbohydrate.

In the current study the higher yield of older trees was also related to branch number. Peres and Melendez (1980) reported that *L. leucocephala* cut at 30 cm formed fewer buds (89) than those cut at 50 cm (112 buds), and the latter had a higher leaf production at the subsequent harvest.

The yield difference between the younger and older trees in the present study persisted over the 5 harvests taken in this experiment. The positive effect of delaying the time to first cutting suggests that the integration of perennial tree legumes with

annual or short-lived tree/shrub legumes such as *Cajanus cajan* and *Codariocalyx gyroides* would be beneficial. These faster-growing, shorter-lived species could be used as the initial feed source and the perennial trees left uncut and allowed to develop before they take over as the main feed supply.

Further experiments are needed to investigate the most appropriate defoliation systems for the various tree and shrub legumes.

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