2 Pruning treatments of *Leucaena leucocephala* in alley cropping systems

2.1 Introduction

The use of *Leucaena leucocephala* (leucaena) in various agroforestry systems has been extensively researched in tropical countries. These agroforestry practices are mostly based on cut-and-carry systems and include fodder banks, tree plots on wastelands, border or dense lines, and tree stands in home gardens. The trees are usually harvested and not grazed directly in the field. The cut leaf material (fodder) may be used to supplement low quality roughage (e.g. crop residues) to improve intake, palatability, and nutritive value of the whole ration. Fodder refers to stems, shoots (including soft shoots and stems of woody plants that can be utilized by game and cattle), as well as fruit, pods and seed (Gutteridge & Shelton, 1994; Gutteridge, 1995).

Leucaena is also often intercropped with a range of food or fodder crops; a system referred to as alley cropping or (hedgerow) intercropping. Different cutting methods are used for the harvesting of leucaena and different cutting heights have been used, the most common being regular pruning to a hedgerow. The leaf yield is often used as a green manure (ploughed into the soil before planting of intercrops), mulch (layering the green material on the soil surface) or animal feed. These practices are reported to have a beneficial effect on the quality and yield of the alley crop, as well as an ameliorating effect on the soil (Brewbaker, MacDicken & Withington, 1985; Brewbaker, 1987). The latter has been attributed to the nitrogen fixing ability of leucaena and the build-up of organic matter in the soil.

From available literature it would appear that yields obtained from harvesting leucaena depend on cutting regime and cutting height. Yields reported vary from 4 to 80 t/ha across the climatological spectrum (Blair, Catchpoole & Horne, 1990; Brewbaker, 1987; Tejwani, 1987; Furoughbakhch, 1992). Wood biomass production was the highest when leucaena was grown alone (Korwar, 1995).

Yields have generally been reduced when the trees were cut to low stubble heights. As the pruning height increased, the yield of adjacent rows of crops fell. The best compromise for most situations lies in the range of 60 to 100 cm (Ezenwa & Cobbina, 1991; Paterson, Dzowela, Akyeampong, Niang & Otsyina, 1995; Kheertisena & Gunawardana, 1996). Alley widths (the space between the tree rows) used have ranged from a narrow 2.5 m up to 9 m, with a preferred width of 4 m (Brewbaker, 1987).

Harvest interval has played a significant role in determining forage yield and quality and different results are reported. Low hedge management with two to four month cutting intervals is standard practice. Less frequent harvesting resulted in significantly higher yields, due to the fact that more woody material was produced. The hypothesis is that, in general, total yield (leaf + stem) increases with longer cutting intervals but is associated with a decrease in leaf:stem ratio (Brewbaker *et al*, 1985; Brewbaker, 1987, Gutteridge, 1988; Ella, Jacobsen, Stür and Blair,1989; Calub, 1996).

Confirmed by these results, general guidelines as set by Brewbaker *et al* (1985), could serve as a recommendation for the implementation of a leucaena harvesting system:

- Harvest plants only after they are well established, usually six months.
- Cut the growth back to 20-30 cm to stimulate coppicing and increase yield in later harvests.
- The optimal time to harvest is at a branch height of 1-1.5m.

In cut-and-carry systems, hedge management is preferred. Trees should be cut at a height of 80-100 cm and cut low again after two or three years. Hedges should be maintained at a height above 60 cm (Brewbaker, 1987), to ensure the retention of some green foliage and to minimize possible stress from cutting too low.

In light of the above results, the response of leucaena to different pruning treatments was studied under local conditions. The purpose of the trial was to determine what effect pruning might have on the total forage yield over a full growing season, compared with no pruning, and whether the traditional method of pruning (hedgerow) would produce higher yields or not.

2.2 Materials and methods

An alley cropping field experiment was conducted on the Hatfield Experimental Farm of the University of Pretoria (Table 1).

Table 1 Site description on Hatfield Experimental Farm

Locality	28°16'E, 25°45'S
Altitude	1372 m
Av. annual rainfall	709 mm
Av. max. and min. temp.	30°C (Jan), 2°C (Jun)
Soil type	Sandy clay (37 % clay), Hutton, homogenous to a depth of 0.66 m after which it becomes gravelly (MacVicar, Loxton, Lamprechts, Le Roux, De Villiers, Verster, Merryweather, Van Rooyen & Von M. Harmse, 1977).

The study was laid out in a 2x3x3 factorial randomized complete block design with five replications, involving two alley widths (3m and 6m), three pruning treatments (Table 2), and a split plot for three alley crops (maize, grain sorghum, fodder sorghum). Tree-spacing within the row spacing was 1 m. Blocking was done across the length of the plot, on an east-west axis, based on previously observed differences in growth (Lindeque, 1997). Statistical analysis did not compare yields between the two years, as treatments were adapted by experience after the first harvest season.

Table 2 Pruning treatments applied to *L. leucocephala* in the alley cropping trial

S1	Control - no pruning
S2	Pruning to a single stemmed tree (± every 6 weeks), clearing the undergrowth up to 1 m. In 1998 the interval was changed to 8 weeks.
S3	Hedgerow (± every 4 weeks), cut back to 1m height and ±0.75 m width

An existing leucaena stand, planted at a tree density of 3 333 trees per ha, was used. Before the start of the 1996/1997 growing season, the trial was converted to an alley cropping trial by removing selected alternate rows. The plant populations of the 3m and 6m treatments were 3333 and 1667 trees per ha respectively. Pruning of the trees started in November 1996 and was repeated at fixed intervals thereafter, until April 1998 (Figure 1 & 2).

Except for the first harvest, yields of the different pruning treatments were applied as a mulch between the alley crops. No irrigation or fertilizer was applied. Trees of the S1 treatment were harvested at the end of the growing season to compare the full season's growth with the accumulated forage yield of the pruned trees (Figure 3).

The prunings were weighed in the field to assess the total fresh yield. Except for the first harvest, forage yield consisted of leaf and young, green stems. Wood yield was only measured with the final harvest of the 1996/1997 season. Representative samples for the determination of dry mass yield and dry mass concentration were taken at each harvest and dried at 60° C for 24 hours, before being weighed again. The same samples were used to separate the yield into leaf and stem material. In 1996/1997, samples were taken only from the 3m alleys. In 1997/1998, samples were taken from both alleys. Data was analyzed using PROC GLM (1996/1997 and 1997/1998) and PROC ANOVA (1997/1998) of the SAS Program (Statistical Analysis Systems, 1994). Significant differences were taken at $P \leq 0.05$.

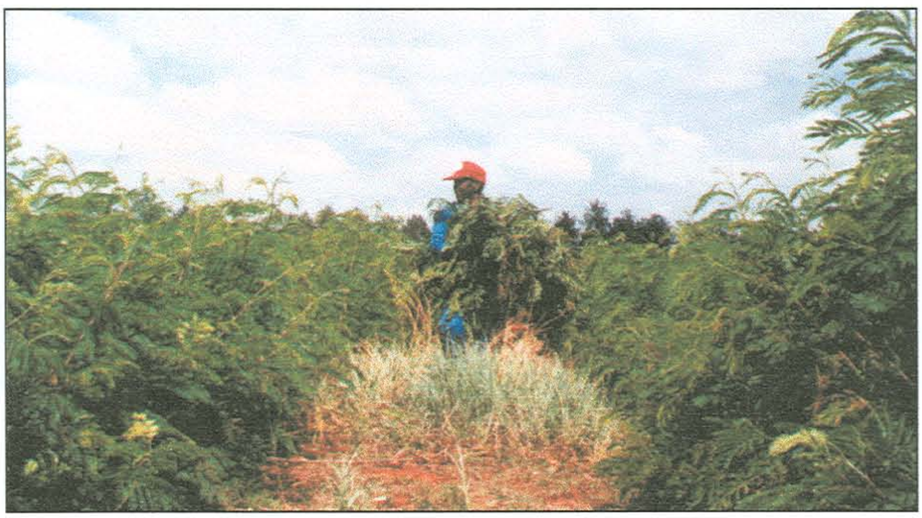

Figure 1 Trees were pruned manually. Unpruned trees in foreground.

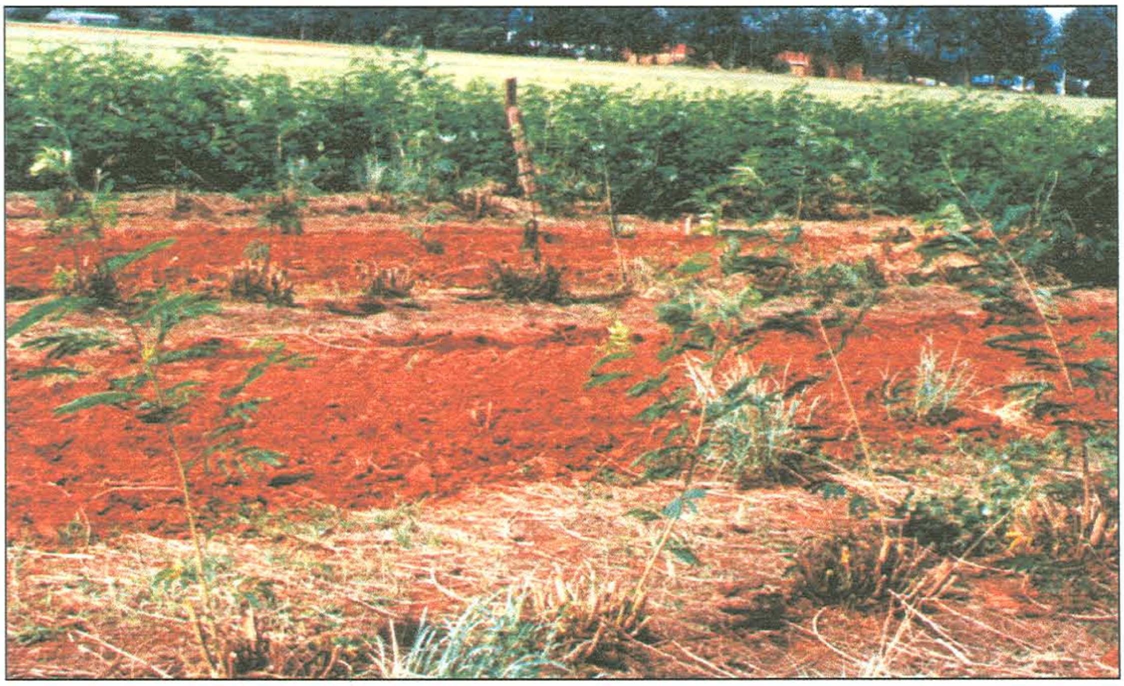

Figure 2 First pruning of S2. Hedgerows of S3 in background.

Figure 3 Development of the stems in S2. Unpruned trees of S1 in background.

2.3 Results and discussion

2.3.1 1996/1997 Season

Total yield

The highest total yield per individual tree was obtained from the S2 treatments (Table 3), while S3 and S1 had similar yields. Only the S2 treatment had significantly different yields between the row widths, whereas the yields obtained from the 3 m and 6 m alleys did not differ in the S3 treatment. Within the 3 m alleys, S2 produced the highest yield, with the second highest yield obtained from S3. This was also the case in the 6 m alleys. The 3 m alleys had a higher yield per ha. The highest total yield per ha was obtained from the S2 treatment (23.448 t/ha).

Table 3 Total yield of *L. leucocephala* as affected by spacement and pruning treatment

Treatment	kg/tree		t/ha	
	3m	6m	3m	6m
S1	4.549†	-	15.162†	-
S2	7.035†*	10.518*♦	23.448*†	17.534*♦
S3	5.445†	6.702♦	18.148†	11.172♦
R^2	0.939	0.939	0.978	0.978
CV	14.681	14.681	8.803	8.803
	* Significant differences between alley widths † Significant differences between pruning treatment in 3m alley ♦ Significant differences between pruning treatments in 6m alley		* Significant differences between alley widths † Significant differences between pruning treatment in 3m alley ♦ Significant differences between pruning treatments in 6m alley	

Forage yield

The forage yield of S1 tended to be low compared to other treatments (Table 4). As the soft, green young stems were not separated from leaf material, this could explain the relatively high value for S2, where, after six weeks of growth, longer (and, therefore, heavier) stems were harvested than after four weeks on S3.

Table 4 Total forage yield of *L. leucocephala* as affected by pruning treatment

Treatment	kg/tree	t/ha
	3m	3m
S1	0.857	2.856
S2	4.742	15.805
S3	3.537	11.789

Wood yield

Wood production was only assessed with the final harvest of the season. During the season only the odd twig thicker than 6 mm was pruned and these were discarded. S1 tended to have the highest wood yield (± 82% of total biomass per tree), which could be expected as the stems were left to grow undisturbed through the season (Table 5). Brewbaker (1987) reported results from undisturbed tree growth, while in alley cropping systems the trees are pruned early and frequently, resulting in the reduction in stem production (Keerthisena & Gunawardana, 1996). "Wood" yield obtained from S2 and S3, represented twigs *just* not qualifying as shoots, which might be better described as kindling.

Table 5 Total wood yield of *L. leucocephala* as affected by pruning treatment

Treatment	kg/tree	t/ha
	3m	3m
S1	3.692	12.305
S2	2.293	7.643
S3	1.908	6.359

2.3.2 1997/1998 Season

Total yield

In this season, the highest total yield per individual tree was obtained from the S3 treatment (Table 6). The yields obtained were nearly double those of the previous year, due mainly to the increased harvest frequency (6 harvests, compared to 4 in 1997). Only the S1 treatment had significantly different yields between the row widths. Within the two alley widths respectively, all three pruning treatments differed significantly. The total yield of the S1 harvest was lower in the 3m alley than the previous season. This may be mainly attributed to the fact that less stem material was produced on this treatment (± 56 % of total yield, compared to ± 82 % during 1997). Lindeque (1997) reported total seasonal yields of 8-11.5 t/ha, consisting of 75 % woody material and 25 % shoots.

The total yield from the S2 treatment was lower after four harvests were taken in 1998, compared to three in 1997. Harvesting of treatments 2 and 3 started earlier in the 1997/1998 season, resulting in the first harvest at an earlier stage, and therefore harvesting of softer material. Six harvests, compared to four in 1996/1997, were taken from the S3 treatment, the last cutting taken almost a month and a half later than in 1996/1997. This resulted in higher yields being recorded.

The highest total yield per ha was obtained from S3 where both alley widths produced a higher yield than any of the other treatments. The yields per ha of S1 did not differ significantly between the two row widths, although the yields per ha obtained from S2 and S3 differed significantly ($P \leq 0.05$) between row widths.

Forage yield

The highest forage yield per tree was obtained from S3 (Table 7). The two additional harvests compared to the 1997 season yielded more leaf material. The yield obtained from S3 was much higher than S2 (167% in the 3m alley and 122% in 6m). Yield per ha tended to be higher at the 3m spacing and when applied as green manure or mulch, the rate of application per unit area is even higher.

Table 6 **Total yield of *L. leucocephala* as affected by spacement and pruning treatment**

Treatment	kg/tree		t/ha	
	3m	6m	3m	6m
S1	2.799*†	5.373*♦	9.329†	8.957♦
S2	5.471†	6.646♦	18.235*†	11.079*♦
S3	11.579†	12.020♦	38.593*†	20.037*♦
R^2	0.971	0.971	0.988	0.988
CV	10.071	10.071	7.995	7.995
	* Significant differences between alley widths † Significant differences between pruning treatment in 3m alley ♦ Significant differences between pruning treatments in 6m alley LSD = 0.956		* Significant differences between alley widths † Significant differences between pruning treatment in 3m alley ♦ Significant differences between pruning treatments in 6m alley LSD = 1.837	

Table 7 **Total forage yield of *L. leucocephala* as affected by espacement and pruning treatment**

Treatment	kg/tree		t/ha	
	3m	6m	3m	6m
S1	0.933	3.110	3.110	5.184
S2	3.501	4.318	11.669	7.198
S3	9.350	9.607	31.164	16.015

Table 8 **Total wood yield of *L. leucocephala* as affected by espacement and pruning treatment**

Treatment	kg/tree		t/ha	
	3m	6m	3m	6m
S1	1.866	6.219	6.219	10.367
S2	1.970	2.328	6.566	3.881
S3	2.229	2.413	7.429	4.022

Wood yield

The highest wood yield per tree in this season was obtained from the 6m alleys in treatment S1 (Table 8). The yields obtained from S2 and S3 were relatively similar. Again, the "wood" yield from these two treatments, consisted essentially of lignified twigs (kindling), while the wood obtained from S1 were large enough to use for fuel wood.

2.4 Discussion

It is generally confirmed that the total yield obtained from leucaena will increase with lower harvesting or cutting frequencies (Brewbaker *et al.,* 1985, Stür, Shelton & Gutteridge, 1994 and Lindeque, 1997). Lower cutting frequencies resulted in higher yields containing a larger percentage of woody material, while higher cutting frequencies resulted in lower yields, containing forage of a better quality. Lindeque (1997) also observed higher yields obtained with the first cutting than with subsequent cuttings. If the aim is fuel wood production, a pruning regime should not be followed. Without any pruning, there would be a small, once off, forage harvest at the end of the season, but the wood yield would be sufficient for fuel wood (logs) purposes. Pruning to a single stemmed tree resulted in the formation of a long stem that could be used for construction or fence-making purposes, while the shorter, multi-stemmed woody growth of a hedgerow would be more suitable for fuelwood (kindling) purposes, with slightly lower yields. The forage yields of both S2 and S3 pruning treatments provided a regular supply of fodder, green manure or mulch throughout the season, depending on the specific site conditions.

From this study it may be concluded that yield and the contribution of yield components can be manipulated by using different pruning methods. No pruning results in a low, once-off forage yield, while the wood yield can be used for fuelwood. Pruning to a single stemmed tree may appear laborious, but the advantages lie in the fact that crops or pasture could then be planted nearer to the trees, without shading, in addition to producing more versatile wood and a higher yield of shoots. Hedgerow treatments would be relevant to both labour intensive small scale farming enterprises and mechanized larger scale operations, as it is indeed a labour intensive procedure. However, the very high forage yield obtained may well justify the effort.

2.5 References

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