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GROWTH PERFORMANCE AND BIOMASS PRODUCTION OF FOUR TYPES OF LEGUMINOUS TREE SPECIES IN THE COCONUT TRIANGLE

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ABSTRACT

Since forage production is seasonal in the coconut triangle, growing of fodder legumes under coconut could extend the grazing season of the year. This research was carried out to study the performance, biomass productivity and the nutritive value of four types of leguminous tree species in the coconut triangle. Seedlings of four leguminous fodder species Acacia auriculiformis (Acacia), Gliricidia sepium (Gliricidia), Leucaena leucocephala (Leucaena) and Calliandra calothyrsus (Calliandra) were established in double rows under coconut at 2m x 1m between and within row spacing in a Randomized Complete Block Design with four replicates. Height and girth parameters were measured in the seedlings of the four species from three months up to 15 months of age. According to the growth trial, Acacia had the highest basal stem girth and height ($P<0.05$) followed by Calliandra, Gliricidia, and Leucaena. Gliricidia had a mean height of one meter and girth of 0.5 meters after 15 months of age. Leucaena had the slowest growth at field compared to the other three fodder trees during the study period. However, Gliricidia and Leucaena were found to be better in nutritional composition having higher crude protein and ash contents compared to Acacia and Calliandra. Growing Leucaena and Calliandra under coconut trees significantly improved the annual yield of coconut as well ($P<0.05$).

Key words: *Growth performance, biomass production, leguminous trees*

INTRODUCTION

Forage tree legumes are considered as high quality forage for livestock. The special feature with the legumes is the ability to fix atmospheric nitrogen into plant proteins and it is the largest and cheapest source of nitrogen for crops. Most commonly used fodder tree legumes come from the genera Acacia, Albizia, Calliandra, Desmanthus, Desmodium, Gliricidia, Leucaena, Prosopis and Sesbania (Brewbaker, 1986).

In many parts of the world forage tree legumes are cultivated as field borders, fence lines or in home gardens. These are harvested under cut and carry system and used as a supplement with low quality roughage such as crop residues. Establishment period of legumes can be more than one year and generally legume trees are uncut until they reach a height of 1-1.5 meters (Stur *et al*., 1994). These are considered as important sources of nutrients such as proteins, minerals and fibre. However, the optimum dietary level of leguminous forage on dry matter basis is 30-50% (Devendra, 1993) as those are high protein diets and also contain anti nutritive factors like condensed tannin, mimosine and lignin.

Forage production is somewhat seasonal in the coconut triangle of Sri Lanka but the requirement of forage/feed by animals is more or less uniform throughout the year. Therefore, it is possible to grow fodder legumes to extend the grazing season of the year. Cultivation of Leguminous fodder trees (Nitrogen fixing trees) in coconut lands helps to enhance the fertilizer status in soil, reduce soil erosion and rehabilitate soil in marginal coconut lands. These forage legumes are also used as supportive trees for vine intercrops like pepper and vanilla. Liyanage *et al.* (1990 & 1993) found that Acacia species would produce a higher wood and bio mass yield compared to Calliandra, Gliricidia and Leucaena when grown under coconut. However, with respect to forage quality Acacia species are of low nutritive value (Norton, 1994). This research was carried out to study the growth performance, biomass production and nutritive value of four types of leguminous tree species namely Acacia, Calliandra, Gliricidia and Leucaena, when grown under coconut in the coconut triangle.

MATERIALS AND METHODS

Location and experimental design

Approximately 1.5 ha of land at the Rathmalagara estate, Madampe in the low country intermediate zone (08^0 02 N, 79^0 50 E, 35 m altitude) was selected for this study. The mean annual rainfall and ambient temperature were 1,660 mm and 23.8^0-30.4^0 C, respectively. The soil type was Red Yellow Podzolic (Ultisols) with pH around 5.2. The leguminous fodder tree species were established in a 45 year old Tall x Tall coconut stand with a density of 137 trees per ha, transmitting 60% photo-synthetically active radiation (1050 uE M^2S^{-1}) on clear days (Liyanage *et al.*, 1993).

Study I

Initially, field was mapped, ploughed and harrowed. Sixteen coconut squares (size: 8m x 8m) in alternate coconut rows were prepared. One month old uniform size poly bag seedlings of leguminous fodder tree species namely *Acacia auriculiformis, Gliricidia sepium, Leucaena leucocephala* and *Calliandra calothyrsus* (Treatments) were established in 30 cm deep planting holes in the coconut squares following a Randomized Complete Block Design with four blocks and five replicates (the fifth being the control). Thus with four squares assigned to the control, there were 20 coconut squares prepared. Within one coconut square sixteen seedlings of one species were planted in rows having the spacing of 2 m between row and 1 m within the row. Coconut squares of the control blocks were kept vacant without establishing fodder tree species. Initially, one kilogram of goat manure was applied for each seedling after one month of field planting and thereafter, continued each quarter. Coconut palms were fertilized annually with the Adult Palm Mixture (APM) recommended by the Coconut Research Institute (CRI), Lunuwila, Sri Lanka (CRI Advisory Circular No. 01; 2004). Quarterly, the field was slashed and weeded. Height and girth of the above leguminous fodder tree species were measured every three months for 15 months. Annual Coconut yield was also recorded during the study period bymeasuing bimonthly nut yield from the palms within the square.

Study II

In conjunction with study I, biomass production of leguminous fodder trees cultivated under coconut at Rathmalagara Estate, Madampe was also studied. A field with mature trees (aged more than 25 years) of *Acacia auriculiformis, Gliricidia sepium, Leucaena leucocephala* and *Calliandra calothyrsus* in the estate was selected to study the biomass production of fodder tree legumes. The above fodder legumes were also planted in the spacing (2mx1m) between and within rows with four replicates per each fodder species (same as in study I). Biomass production of the above trees was measured by obtaining the weight of wood and edible portions (twigs & leaves) at the time of lopping. Lopping height was one meter while lopping frequency was once per year. Total biomass yield and total edible yield (fresh weight basis) were collected during the annual pruning for 2 years. To determine the nutritive value of the fodder tree species leaf samples were collected, oven dried and stored in paper bags for further analysis. During the analysis all the samples were ground to pass through 1 mm mesh using a laboratory mill and analyzed for dry matter (DM), crude protein, crude fibre, ether extract and ash (AOAC 1995).

Analysis of Data

Analysis of variance procedure was carried out to test the mean differences among the four species with respect to height, girth and biomass measurements (study I) and coconut yield (study II) using General Linear Model Procedure in SAS software (SAS, 1999). Duncan's New Multiple Range test was used to compare the means of four species at $\alpha=0.05$ (Snedecor and Cochran, 1986).

RESULTS AND DISCUSSION

Growth of leguminous fodder species

Table 1 shows the mean height (cm) of leguminous fodder trees established at the Rathmalagara estate, Madampe. Leucaena attained a significantly faster growth rate compared to other species ($P<0.05$) within the first three months after establishment. However, after 6 months, Acacia displayed a significant increase in growth reaching about 2.5m in height at 15 months of age ($P<0.05$). These results are in agreement with the findings of Liyanage *et al.* (1990). Calliandra recorded the second highest growth of 1.9 m after 15 months of age while the slowest growth was recorded by Leucaena ($P<0.05$).

Table 1. Height of leguminous fodder trees under coconut cultivation

Fodder species	Mean height (cm)*				
	3 months	6 months	9 months	12 months	15 months
Acacia	24^a	101^a	161^a	223^a	249^a
Gliricidia	24^a	67^b	86^b	105^b	101^b
Leucaena	30^b	56^b	63^c	66^c	80^c
Calliandra	18^a	73^b	138^d	17^d	188^d

*Means having different superscripts in a column differ significantly ($P<0.05$).

Palmer *et al.* (1989) stated that Calliandra had a better drought tolerance ability compared to Leucaena. Therefore, Calliandra may be more suitable under coconut at low country intermediate zone. In contrast, Liyanage *et al.* (1990) observed that Calliandra had the slowest growth in low country intermediate zone two years after planting compared to other fodder species. However, in this study Acacia and Calliandra had faster growth rates compared to Gliricidia and Leucaena.

Girth is an essential growth parameter for estimating the fuel wood potential of fodder trees (Liyanage *et al.*, 1990). Table 2 shows that in this study, initially up to 6 months Gliricidia attained significantly higher basal girth and Acacia had the lowest girth ($P<0.05$). But with the maturity Acacia displayed a significant ($p<0.05$) increase in the basal girth compared to the other species. The basal girth of Gliricidia and Calliandra were not significantly different after 12 months of age. Leucaena had the slowest growth in this experiment compared to the other fodder species ($P<0.05$). This may be partly because of some damage caused by grazing cattle to Leucaena seedlings during the study resulting in low recovery rate. In contrast Liyanage *et al.* (1993) observed that Leucaena developed to a better height and stem girth compared to Gliricidia two years after planting.

Table 2. Girth of leguminous fodder trees under coconut cultivation

Fodder species	Mean girth (mm)*				
	3 months	6 months	9 months	12 months	15 months
Acacia	8^{c}	2^{b}	38^{a}	59^{a}	81^{a}
Gliricidia	12^{a}	26^{a}	36^{a}	42^{b}	46^{b}
Leucaena	10^{b}	$18^{b,c}$	22^{b}	26^{c}	27^{c}
Calliandra	9^{b}	17^{c}	31^{b}	41^{b}	49^{b}

*Means having different superscripts in a column differ significantly ($P<0.05$).

Biomass production

According to table 3, the weight of wood and edible portion (twigs & leaves) per tree per year seems higher in Calliandra while the lowest weight was in Gliricidia, however, those differences were not significant ($P<0.05$). It was observed during this study that Acacia and Leucaena did not withstand severe pruning compared to Gliricidia and Calliandra. Therefore, when Acacia and Leucaena were pruned, a mature branch was left without pruning until the new branches appeared. The number of Acacia and Leucaena trees survived after complete pruning was approximately 50% lower compared to the other two species. Therefore, it is advisable to leave a mature branch without pruning until the new branches are grown. According to Stur *et al.* (1994), plant re-growth after defoliation is supported by residual leaf area and stem and root reserves. Leaving enough residual leaf area would be important to reduce length of lag phase after defoliation (Stur *et al.*, 1994) and plant death. Stewart and Simons (1994) noted that Gliricidia re-sprouts vigorously after lopping and also withstands repeated lopping.

Table 3. Biomass production (kg/tree/year, wet weight basis) of leguminous fodder trees aged 25 years at Rathmalagara Estate, Madampe*

Fodder species	Weight of wood	Weight of edible portion (twigs & leaves)	Total biomass
Acacia	15.8	6.9	22.7
Gliricidia	9.5	4.5	14.0
Leucaena	12.4	5.9	18.3
Calliandra	13.0	14.0	26.9

*Means within columns are not significantly different (P>0.05).

In a similar study, Liyanage *et al.* (1993) found that *Acacia auriculiformis* produced a higher wood mass (31.6 kg per tree) than Leucaena, Gliricidia and Calliandra after 4 years of planting while Calliandra produced the lowest (8.2 kg per tree). In addition, *Acacia auriculiformis* and *A. mangium* have produced the highest total bio mass of 54.1 kg per tree and 43.9 kg per tree, respectively four years after planting. However, according to Table 3, Acacia and Calliandra appeared to have faster growth compared to Gliricidia and Leucaena producing higher total biomass though not significant compared to the other two species even after 25 years of age (P>0.05). Lack of significance could be partly due to larger standard errors associated with the means. In contrast, Liyanage *et al.* (1993) observed that Gliricidia had the highest coppicing rate producing 6.4 shoots per tree 6 months after initial pruning (17 months of age) whereas, Leucaena and Acacia had the lowest coppicing rate of 1.6 and 1.8 shoots per tree, respectively. However, in this study, production of shoots in Gliricidia tended to decrease with age resulting in lower mean weight of wood. Ella *et al.* (1989) also found that Gliricidia had a lower proportion of wood than Leucaena and Calliandra.

Proximate composition of fodder species

The proximate analysis conducted on the fodder species have indicated that Gliricidia and Leucaena leaf meals were higher in crude protein content (Table 4). Similar results have been reported by Liyanage *et al.* (1993). Low crude protein content in Calliandra may be attributed to insufficient light conditions available under coconut. According to Seresinghe and Pathirana (1999), Calliandra provenance La Puerata (109/94) also had a crude protein content of 17% when cultivated in the low country wet zone, Sri Lanka. In general crude protein content of Calliandra is around 22% (Wiersum and Rika, 1992). Crude fibre content was found to be the highest in Acacia followed by Gliricidia, Leucaena and Calliandra. Dynes and Schlink (2002) obtained a value of 23.6-36.6% for crude fibre in *Acacia aneura* when they studied the potential of Australian species of Acacia for livestock. The lowest ash content was recorded for Acacia (6%) compared to the other three species.

Table 4. Proximate composition of leguminous fodder tree leaves (dry weight basis) at Rathmalagara Estate, Madampe (%)*

Fodder species	DM	CP	CF	EE	Ash
Acacia	94	14	39	10	6
Gliricidia	93	22	26	9	8
Leucaena	98	22	26	7	7
Calliandra	93	13	25	10	8

*DM=dry matter; CP=crude protein; CF=crude fat; EE=ether extract.

Acacia species are generally of low nutritive value (Norton, 1994). It could be used as a feed for livestock by supplementing with other specific feeds like molasses (McMeniman and Little, 1974).

Growth of coconut with intercropping

Effect of leguminous fodder trees on coconut when intercropping is performed is a vital criterion in the sustainability of coconut based livestock farming system. Table 5 shows the mean coconut yield per tree per year in the experimental site at Rathmalagara Estate. Differences among Acacia, Gliricidia and control plots were not significantly different ($P>0.05$). However, growing Leucaena and Calliandra under coconut seems to improve the yield of coconut plantation in this ecological zone significantly ($P<0.05$). Further studies must be conducted analyzing at least five years of nut yield records to scientifically establish the differences among the four fodder species with respect to improvement of coconut yield.

Table 5. Mean coconut yield when intercropped with different fodder legumes at Rathmalagara Estate, Madampe

Fodder species	Mean coconut yield*	
	nuts/palm/year	nuts/ha/year$^{\$}$
Leucaena	129^{a}	20,640^{a}
Calliandra	108^{ab}	17,280^{a,b}
Acacia	87^{bc}	13,920^{b,c}
Control	80^{c}	12,800^{c}
Gliricidia	79^{c}	12,640^{c}

*Means not sharing the same superscript in a column differ significantly ($P<0.05$).

$Yield per ha (hectare) was calculated based on 160 palms per hectare (Liyanage *et al.*, 1993).

Liyanage *et al.* (1993) reported a mean coconut yield of 73-79 nuts per palm per year when intercropped with above legume fodder trees compared to control plots which had an average value of 62 nuts per palm per year (15-26% increase in yield). They further noticed that nitrogen fixing trees were capable of enabling coconut trees to maintain yields during the dry season and they have exerted a greater yield advantage during the wet season when compared with those in the control plots.

CONCLUSIONS

Cultivation of leguminous fodder trees such as Acacia, Calliandra, Gliricidia and Leucaena in coconut lands helps to enhance the feed availability to ruminants in coconut lands. Acacia and Calliandra had a faster growth rate compared to Gliricidia and Leucaena in this study. However, Gliricidia and Leucaena are quality fodder species compared to Acacia and Calliandra when nutrient composition was considered. Leucaena and Calliandra were found to increase coconut yield when intercropping is practiced, but further research for a longer duration is recommended to prove these results. In overall, the above four species have shown the potential to be successfully grown under coconut cultivation to extend the grazing season in coconut triangle where forage production is found to be seasonal.

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