LEUCAENA AS A MULTIPURPOSE TREE FOR COCONUT PLANTATIONS IN SRI LANKA

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Received March 1992

LIYANAGE, M. de S., JAYASUNDARA, H.P.S. & GUNASEKERA, T.G.L.G. 1993. *Leucaena* as a multipurpose tree for coconut plantations in Sri Lanka. A series of experiments on *Leucaena leucocephala* conducted at the Coconut Research Institute of Sri Lanka revealed its adaptability under coconut in different agro-climatic zones. The highest biomass yield (13.4 $t\ ha^{-1}\ y^{-1}$) was obtained in the Dry Zone on Entisols with a pH of 6.0 indicating its adaptability to non-acid soils in dry area. In another trial, application and incorporation of 30 *kg* palm $^{-1}$ fresh loppings of *Leucaena* as a green manure around the palm showed that nutrients released from its decomposition could provide the entire nitrogen and about 20% of phosphorus and potassium requirements of an adult palm. The beneficial effects of *Leucaena* on soil physico - chemical properties were demonstrated by a substantial improvement on Ultisols in terms of increased organic carbon content (45%) and water holding capacity (82%) and reduced bulk density (3%) over the control. The enhanced earthworm activity in *Leucaena* plots further indicated its significant role in soil improvement. Fresh *Leucaena* loppings placed in a quarter circle trench around low yielding palms on degraded Utisols resulted in 29% increase in nut production and 51% increase in copra yield compared with those in control plots. *Leucaena* (cv. K 636) grown in the avenues between coconut rows and along the boundary fence in the Intermediate Zone proved to be a potential source of drought feed for cattle raised under coconut. During the dry season feeding up to 6 *kg* of fresh loppings of *Leucaena* mixed with (*Gliricidia sepium*) in 1:1 ratio to supplement the low quality roughage such as rice straw given at 10 kg^{-1} head $^{-1}$ day $^{-1}$ resulted in live weight gains of cattle in the range of 306 to 680 *g* head $^{-1}$ day $^{-1}$. In another trial to estimate fuelwood value, *Leucaena* (cv. K 8) grown under coconut in double rows produced the highest wood yield (5.17 $t\ ha^{-1}$) three years after planting. The coconut palms also benefited most from the double row system as indicated by 8-13% increase in nut and 7-8% increase in copra over control plots without *Leucaena*. These results suggest that *Leucaena* could play a significant role in raising the productivity of coconut lands in Sri Lanka.

Key words: *Leucaena* - green manure - biomass yield - coconut palms - fodder soil improvement - fuelwood - agro-ecological zones

LIYANAGE, M. de S., JAYASUNDARA, H.P.S. & GUNASEKERA, T.G.L.G. 1993. *Leucaena* sebagai pokok pelbagai bagi ladang pokok kelapa di Sri Lanka. Satu series kajian yang di jalankan oleh Institut Penyelidikan Kelapa, Sri Lanka, pada zon agroiklim yang berbeza, menunjukkan *Leucaena leucolephala* dapat tumbuh di bawah pokok kelapa. Tanah jenis Entisols di Zon Kering, p.H 6.0, telah memberikan hasil biojisim yang tertinggi (13.4 $t\ ha^{-1}\ tahun^{-1}$). Pada plot ujian yang lain, 30 *kg Leucaena* segar yang di pangkas dan digunakan sebagai baja. Pembebasan nutrien semasa penguraian *Leucaena* dapat menampung segala keperluan nitrogen pokok kelapa yang matang semasa proses penguraian *Leucaena,* dan menyumbang hampir 20% fosforus dan potassium. Sifat fisio-kimia tanah jenis Ultisols yang ditanam dengan *Leucaena* dapat memperbaiki kandungan karbon organik (45%), kapasiti memegang

air (82%) dan mengurangkan ketumpatan pukal (3%), berbanding dengan plot kawalan. Kehadiran cacing di dalam plot *Leucaena* telah membaikkan keadaan tanah. Pokok kelapa yang tumbuh pada tanah usang Ultisols yang kurang berhasil dapat meningkatkan pengeluaran buah kelapa dan kopra sebanyak 29% dan 51% masing-masing apabila di tambah dengan bahan pangkasan *Leucaena* yang segar. *Leucaena* (cv. K 636) yang tumbuh antara barisan pokok-pokok kelapa dan sempadan Zon Perantaraan dapat di gunakan sebagai sumber makanan bagi binatang-binatang ternakan semasa musim kering. Semasa musim kering, campuran 6 *kg* pangkasan *Leucaena* dengan *Gliricidia sepium* pada ratio 1:1 merupakan penganti bahan kasar makanan berkualiti rendah seperti batang padi bagi binatang-binatang ternakan. Di mana berat badan binatang-binatang ternakan ini telah bertambah dari 306 kepada 680 *g* binatang $^{-1}$ hari $^{-1}$, apabila di beri makanan sebanyak 10 *kg* binatang $^{-1}$ hari $^{-1}$. Dalam plot ujian yang lain, yang digunakan untuk menganggarkan nilai kayu api *Leucaena* (cv. K 8) yang tumbuh di bawah dua barisan pokok kelapa memberikan hasil kayu sebanyak 5.17 *t ha* $^{-1}$ tiga tahun selepas di tanam. Pokok kelapa yang di tanam dengan teknik ini menunjukkan peningkatan dari segi peratus pengeluaran biji kelapa dan kopra sebanyak 8-13% dan 7-8% masing-masing berbanding dengan plot kawalan yang tumbuh tanpa *Leucaena*. Keputusan-keputusan ini menunjukkan *Leucaena* dapat memainkan peranan yang penting dalam meningkatkan pengeluaran ladang kelapa di Sri Lanka.

Introduction

Leucaena leucocephala is a fast growing leguminous tree widespread throughout Southeast Asia. Although the exact date of its introduction to Sri Lanka is not well documented, it is believed that *Leucaena* was brought into the country in the 1970's. Coconut (*Cocos nucifera*) on the other hand has a long history in this country dating back to the 5th Century BC and is certainly the most extensively cultivated plantation tree crop, occupying about 400,000 *ha* of arable land. It has been shown that in India *Leucaena* grows well under coconut shade (Vioayakumar *et al.* 1986).

Since 1980, the Coconut Research Institute has investigated the potential of nitrogen fixing tree species such as *Leucaena* in coconut plantation. In contrast to *Gliricidia sepium*, propagation of *Leucaena* by seed is perhaps the most convenient and reliable method of establishment. Use of *Leucaena* seedlings is particularly beneficial to coconut plantations as they develop a deep root system which does not interfere with coconut roots. Being more effective in drawing and recycling nutrients from deeper layers of soil, hardier and coppicing more vigorously than *Gliricidia*, *Leucaena* tolerates repeated pruning and consistently produces a high biomass yield over a longer period (Proverbs 1986).

Preliminary trials on *Leucaena* under coconut have shown that it is capable of producing a satisfactory biomass and wood yield under coconut palms (Liyanage *et al.* 1983). Therefore, research on *Leucaena* under coconut has been intensified since 1984 to explore its potential uses in relation to coconut plantations.

Although *Leucaena* has proven itself as a potential source of green manure for agricultural crops (NAS 1977) and in alley cropping (Wilson *et al.* 1986), as a high protein supplementary feed for cattle and as a renewable source of fuelwood in many other Asian countries, the multipurpose uses of this species and its increased utilization in coconut plantation have not been well recognized.

This paper discusses the results from a series of field experiments to evaluate the potential role of *Leucaena* in coconut plantations of Sri Lanka.

Materials and methods

Estimation of biomass yield of Leucaena under coconut

The experiment was conducted under mature plantations of 45 - 50*y* old representing three agro-climatic zones (Wet, Intermediate, Dry) and two soil types (Ultisols, Entisols). Double rows of *Leucaena* (cv. K636) seedlings raised in polybags were planted after six weeks in pits of 30 × 30 × 30 *cm* The planting holes were spaced 2.0 *m* between and 0.9 *m* within the rows giving a planting density of 1900 trees ha^{-1}. Prior to planting, 60*g* NPK fertillzer mixture were added to each planting hole. One year after planting, trees were lopped to a height of 1.0 *m* and thereafter repeated four times a year, to estimate biomass yield over a period of 2 1/2 *y*. The experimental layout was a randomized block design with four replicates.

Role of Leucaena as a green manure for coconut palms

The experiment was conducted in the Wet Zone on an Ultisol under a 40-*y*-old coconut plantation. Six-week-old polybagged *Leucaena* seedlings were planted in double rows at a spacing of 2 × 0.9 *m*. A randomized design with three replicates and nine palms per plot was used. *Leucaena* was lopped one year after planting at 1 *m* height and thereafter every six months. Fresh leaf material (30 *kg*) was incorporated to a depth of 20 *cm* in a radius of 2 *m* around each palm during the rainy season. Foliar analysis was done on a dried sample of *Leucaena* to determine NPK contents.

Use of Leucaena foliage for soil improvement in coconut plantations

The experiment was conducted in a 50-*y*-old low yielding plantation (4446 nuts $ha^{-1}\ y^{-1}$) on Ultisols in the Dry Zone. Treatments included opening quarter, half and full circle trenches of 30 *cm* width and 30 *cm* depth, 30 *cm* away from the bole of the palm. The quantity of leaves placed in trenches was 30, 60 and 120 *kg* for quarter, half and full trenches respectively. Plots without trenches were included as controls. A randomized design with three replicates was used and there were nine effective palms per plot. Nut and copra yields were taken at two-monthly intervals for three years. Six months after incorporation, soil samples were taken at 30 *cm* depth for physical and chemical analyses. Earthworm activity was determined by application of formalin into soil in a given area.

Use of Leucaena as a supplementary fodder for cattle raised under coconut

This unreplicated trial was conducted in a 45 - *y* - old mature plantation with a density of 137 palms ha^{-1} in the Intermediate Zone, receiving rainfall of 1700 $mm\ y^{-1}$. Double rows of *Leucaena* (cv. K636) were established in the coconut

avenue 2.0×1.0 *m* apart along with a mixed pasture stand consisting of *Brachiaria miliiformis* and *Pueraria phaseoloides*. In addition, alternate trees of *Leucaena* and *Gliricidia* were established 1.0 *m* apart along the fence enclosing the paddocks. Cattle belonging to Jersey × Local crosses were fed with *Leucaena* foliage and rice straw during the dry season and pasture during the wet season. Live weight gains of cattle were recorded weekly.

Fuelwood value of Leucaena under coconut

In this trial, *Leucaena* (cv. K 8) was established in the avenue of a 45-y-old coconut plantation, in double rows 2.0 × 0.5 *m* apart with 2240 trees ha^{-1} and single rows with 1120 trees ha^{-1}. The experiment was laid out in a randomized block design with four replicates. Three years after planting, trees were cut back to a height of 1.0 *m* to estimate fuelwood production. The quality of wood was assessed by measuring the specific gravity and heating value of oven-dried samples. Nut and copra yield records were maintained throughout the experiment.

Results and discussion

Fresh biomass yields of *Leucaena* estimated three years after planting in the first experiment are given in Table 1. It has been shown that the highest biomass yield of 13.4 $ha^{-1}\ y^{-1}$ was obtained in the Dry Zone on Entisols with a pH of 6.0. These results indicated that while *Leucaena* has a wide adaptability it is more suitable to dry areas with non-acid light soils. Results from the second experiment (Table 2) demonstrated that the application of 30 *kg* palm $^{-1}\ y^{-1}$ of fresh *Leucaena* loppings to a depth of 20 *cm* in a 2 *m* radius around the palm could supply the total nitrogen and 20% of phosphorus and potassium requirements of the palm per annum, amounting to a saving of 40% on the cost of fertilization of coconut palms. This has significant economic implications in terms of reduction in cost of production of coconuts. The potential of *in-situ* planting of *Leucaena* as a green manure for coconut palms has also been reported by Vioayakumar *et al.* (1986). The efficiency of *Leucaena* foliage as a green manure may be attributed to its rapid decomposition accompanied by low lignin content. Substitution of inorganic fertilizer either entirely or partially with *Leucaena* foliage would be beneficial, especially for the coconut smallholders who seldom use inorganics for palms.

Table 1. Performance of *Leucaena* under coconut in different agro-climatic zones

Agro-climatic zone	Annual rainfall (*mm*)	Rainy days	Soil type	pH	Biomass yield ($t\ ha^{-1}\ y^{-1}$)	
					Fresh	Dry
Wet	2700	137	Ultisol	5.1	9.6	2.88
Intermediate	1900	128	Entisol	5.5	10.8	3.24
Dry	1300	110	Entisol	6.0	13.4	4.02

Source: Liyanage & Jayasundera 1987.

Table 2. Effect of *Leucaena* on nutrient supply

Fertilizer source	Nutrient analysis (*g*)		
	N	P_2O_5	K_2O
Leucaena foliage 30 *kg* palm $^{-1}$ *y* $^{-1}$	360	30	180
Inorganic fertilizer 3 *kg* palm $^{-1}$ *y* $^{-1}$	360	180	960

Source: Liyanage 1987 (unpublished), Coconut Research Institute, Sri Lanka.

Results from the experiment in which *Leucaena* foliage was placed in trenches (Table 3) show that placement of 30 *kg* of fresh foliage in quarter circle trenches around the palm increased nut and copra yield of palms after two years. The rehabilitation of low yielding palm was largely attributed to the improvement of Ultisols in terms of reduced bulk density and increased organic carbon content and water holding capacity (Table 4a). The enhanced earthworm activity (Table 4b) in *Leucaena* added plots is a reflection of the improvement in physical structure of Ultisols.

Table 3. Effect of incorporating *Leucaena* in trenches on the yield of coconut palms (after 2 years)

Treatments	Nuts palm $^{-1}$ *y* $^{-1}$	Copra content (*g* nut $^{-1}$)
30 kg *Leucaena* in 1/4 trenches	62.0	202.8
60 kg *Leucaena* in 1/2 trenches	58.7	174.4
120 kg *Leucaena* in full trenches	54.5	192.0
Control (without *Leucaena*)	47.8	174.2

Source: Gunasekera 1989.

Table 4a. Effect of *Leucaena* loppings on soil improvement (Ultisols)

Treatments	Organic carbon (%)	Bulk density (*g cm* $^{-3}$)	Water holding capacity (*mm m* $^{-1}$)
With *Leucaena*	1.21	1.40	75.8
Without *Leucaena*	0.83	1.47	41.5

Source: Liyanage & Jayasundera 1987.

Table 4b. Effect of *Leucaena* on earthworm activity

Treatments	Population (no. *m* $^{-3}$)	Wormcast (no. *m* $^{-2}$)	weight *g m* $^{-2}$
With *Leucaena*	163	418	32
Without *Leucaena*	112	336	25

Source : Liyanage & Jayasundara 1987.

In another trial, *Leucaena* in double rows and along fence mixed with *Gliricidia* produced a fresh biomass yield of 7.19 and 2.0 *t ha*$^{-1}$ respectively (Table 5). Feeding up to 6 *kg* of fresh *Leucaena* along with 10 *kg* rice straw head^{-1} day^{-1} during the dry season produced satisfactory liveweight gains of cattle in the region of 306 to 680 *g* head day at the end of first and fourth years respectively. These results indicated that *Leucaena* foliage could be used as a supplementary fodder to alleviate feed shortages, especially during the dry season for cattle raised under coconut. This is of immense benefit to coconut smallholders with limited grazing land to feed their cattle.

Table 5. Fodder production of *Leucaena* in the coconut/ pasture/cattle integrated system

Component	Fresh fodder yield (*t ha*$^{-1}$ *y*$^{-1}$)
Leucaena, double rows in the avenue	7.19
Leucaena + *Gliricidia* along fence	2.0

Source: Liyanage & Fernando 1991.

Results given in Table 6 revealed that *Leucaena* grown in double rows performed better than single rows in terms of dry wood yield giving 5.17 *t ha*$^{-1}$. The wood had a specific gravity of 0.53 and heating value of 4200 *K cals kg*$^{-1}$ which makes it a renewable source of fuelwood to be grown under coconut. In addition, there was an improvement in both nut and copra yields of palms over those in control plots. Here again, double rows of *Leucaena* produced a greater yield advantage on palms than single rows.

Table 6. Fuelwood production of *Leucaena* under coconut (3 *y* after planting)

Treatment	Sundried wood production (*t ha*$^{-1}$)	Coconut Production	
		Nuts *ha*$^{-1}$ *y*$^{-1}$	Copra *t*$^{-1}$ *ha*$^{-1}$ *y*$^{-1}$
Leucaena in double rows	5.17	11088	1.92
Leucaena in single rows	4.49	10384	1.90
Control (without *Leucaena*)	0	9728	1.78

Source: Gunasekara & Liyanage 1989.

Conclusions

These studies and observations show that *Leucaena*, which is well adapted to the non-acid Entisols and performs well under coconut shade, can serve as an alternative species to *Gliricidia* in the dry regions. The multiple uses of *Leucaena* for improving coconut plantation were amply demonstrated by the fact that it serves as a useful green manure for substituting inorganic fertilizer, improvement on physico-chemical properties of Ultisols, as a source of high protein supplemen-

tary feed for cattle, and as a fuelwood for household cooking and heating purposes. It is often argued that *Gliricidia* supports used for black pepper under coconut sometimes compete with coconut and pepper for plant nutrients and soil moisture. In this situation *Leucaena* can be used as a possible support tree for training pepper vines.

For these reasons, there is a need to create an awareness among local farmers on the potential use of *Leucaena* for agricultural systems associated with coconut. One disadvantage for the popularization of *Leucaena* is that currently it suffers damage from a psyllid (*Heteropsylla cubana*). Evaluation of germplasm for biological screening of psyllid resistant lines has already begun. Preliminary observations suggest that *L. diversifolia, L. pallida* and *L. esculenta* show a certain degree of tolerance to psyllid damage, particularly during the dry season.

Acknowledgements

The authors are grateful to the Director, Coconut Research Institute of Sri Lanka for permission to present the data. The assistance given by the Agronomy Division staff in maintaining the trials and collection of data is much appreciated. Finally, we thank H. M. W. S. Athauda for typing the manuscript.

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