PERFORMANCE OF *GLIRICIDIA SEPIUM* SEEDLINGS AND CUTTINGS ON IMPROVEMENT OF SOIL PHYSICAL PROPERTIES

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SUMMARY

The Andigama soil series, which is widespread in the Coconut Triangle, is known to be of poor physical characters restricting the growth and yield of coconut in the Intermediate zone of Sri Lanka. In this study, effects of Gliricidia sepium, seedlings and cuttings were compared with respect to their contribution on the improvement of soil physical properties of Andigama series.

G. sepium seedlings and cuttings were established in a 45 years old coconut plantation in double rows of 2 m x 1 m and arranged in a randomized block design with four replicates. Distribution and interaction of roots of Coconut and G. sepium and their effect on soil physical properties such as gravel distribution, texture profile, bulk density, aeration capacity, total available water and readily available water fraction were measured four years after establishment of the trial.

The results showed that the root growth of coconut and G. sepium seedlings and cuttings in Andigama series was limited upto 125 cm depth by the adverse soil physical properties of AB and B horizons. Further, roots of Gliricidia seedlings and cuttings tolerated adverse soil conditions and

proliferated throughout the soil profile, resulting enhanced coconut root growth. Moreover, Gliricidia seedlings were more effective than cuttings in improving soil physical conditions. However, Gliricidia cuttings improved the moisture status of Andigama series better than seedlings. Due to the physical and moisture improvement, coconut root growth in AB horizon was significantly (P<0.0001) increased by Gliricidia seedlings compared to cuttings and control. The highest coconut root growth was observed in AB horizon of Gliricidia seedlings grown plots. Overall results showed that improved soil physical conditions of plots where G. sepium seedlings were grown induced coconut roots proliferation more effectively than G. sepium cuttings.

INTRODUCTION

Due to the low income level from coconut monoculture and fluctuating prices. high priority is being given to optimize land and other resources for increasing productivity of coconut. Numerous studies have been undertaken to achieve this task by adopting several agronomic practices, especially, by improving fertility status of soil (Liyanage and Jayasundara, 1991; Liyanage et. al., 1993). However, very little attention has been given to the possibility of improving coconut production in marginal lands by introducing multipurpose tree species.

G. sepium has a great potential as a multipurpose tree in agroforestry systems (Liyanage and Jayasundara, 1991) and may be useful in improving gravelly soil such as Andigama series, which occur in large extents in the Low Country

Intermediate Zone of Sri Lanka. Furthermore, comparative studies of *Gliricidia* seedlings with cuttings on improving gravelly soil such as Andigama series (Red Yellow Podzolic) have not been undertaken. Hence, clear differentiation and identification of the effect of *Gliricidia* seedlings and cuttings on the improvements of adverse soil physical conditions such as poor aeration capacity and low availability of water in marginal soils such as Andigama series is important to improve coconut production. The objective of this study was to compare the effect of *Gliricidia* seedlings and cuttings on the improvement of soil physical properties of Andigama series.

MATERIALS AND METHODS

The experiment was established during December 1990 at Rathmalagara Estate, Madampe in the Low Country Intermediate Zone (08° 02 N, 79° 50 E 35 m altitude) of Sri Lanka in the Andigama soil series. The mean annual rainfall and ambient temperature were 1660 mm and 23.8 - 30.4 C°, respectively.

Gliricidia cuttings and seedlings were established 2.0 x 1.0 m apart in double rows in a 45 years old coconut plantation. The were arranged in randomized complete block designed with four replicates. Two pits (1.5 m x 2 m x 2 m) were opened between rows of *Gliricidia* and coconut palm to study root distribution pattern and soil physical properties three distinct soil horizons namely A, AB, and B corresponding to 0-15, 15-50, 50-100 cm depths, respectively.

Soil core samples ($25\ cm^3$) were taken within the distance of 1.5 m from the base of *Gliricidia* towards the manure circle of coconut palm, and upto 1.5 m depth to represent A, AB and B horizons of Andigama Series. Live roots of Gliricidia and coconut roots in each core sample were separated and their weights taken after drying at 105°C for 24 hrs in the oven and total root mass of coconut, *Gliricidia* seedlings and cuttings and calculated for each horizon. Root system of *Gliricidia* seedlings and cuttings was exposed by using a power sprayer (Arimitsu-CS-26KB) to study root distribution pattern of both crops in the soil profile.

Hundred centimetre diameter circle around *Gliricidia* seedlings and cuttings was selected for the analysis of soil physical properties.

Samples were taken from each horizon upto 1.3 m depth for the analysis of texture and percentages of gravel size classes. Undisturbed soil samples were taken for bulk density and water holding capacity (WHC) determination.

Sieves of different mesh sizes (12, 5, 3 and 2 mm) were used to determine the percentage of gravel sizes. Undisturbed soil core samples were taken using steel core samplers which are 7.5 cm in diameter and 5 cm in height for bulk density and 4.5 cm in diameter and 3.5 cm in height for WHC determination. Soils in core sampler for WHC determination were transferred to aluminum rings (4.5 x 3 cm) for water relation measurements.

These samples were then saturated and water retention measurements were taken using standard pressure plate apparatus for different suction intervals ranging from 1 kPa to 1500 kPa. The gravimetric water content at each suction level was estimated and converted to the volumetric water content using the corresponding bulk densities. The mean values of volumetric water content between 10 kPa an 100 kPa suction was used to calculate the percentage of readily available water fraction of all three soil horizons of Andigama series. Moisture depletion pattern was also determined as a percentage of available water under different suction increments.

Hydrometer method was used for texture analysis. Total porosity was obtained using bulk density and particle density values. Particle density was assumed ad 2.65 g/cm^3. Total porosity was used as the volumetric water content at saturation corresponding to zero suction level. Pores in which no water held at 10 kPa (Diameter 0.03 mm) were estimated as macro pores and rest as micro pores.

RESULTS

Root distribution of coconut and *Gliricidia sepium*

Mean total values of root mass of coconut within the distance between *Gliricidia* seedlings and cuttings and manure circle of the palm in each horizon of Andigama series are shown in Table 1.

Table 1. Distribution of coconut roots in Gliricidia and control plots

	A	AB	B
	<————	g/m^3	————>
Coconut only (Control)	12765	10150	5605
G. sepium seedlings	13439	19355	6766
Cuttings	11876	12634	7378
CV %	12.28	10.51	12.35
LSD	3115	2949	1625
Significance	NS	***	NS

Results showed that coconut root proliferation decreased with increasing depth of soil profile. The root growth of coconut in the control was significantly higher ($P<0.0001$) in the A horizon compared to AB and B horizons. Results also showed that the lateral root growth of coconut was higher than the vertical growth which was confined up to 125 cm depth.

Mean total values of root mass of *Gliricidia* seedlings and cuttings in different horizons of Andigama series towards manure circle of coconut palm are shown in Fig. 1a, 1b and 2. Root growth of *Gliricidia* seedlings and cuttings throughout the soil profile was limited upto 1.25 m depth 1.5 m distance away from the stem. Results indicate that significantly ($P<0.001$) higher root mass was produced by *Gliricidia* cuttings compared to seedlings in A (3166 g/m^3) and AB (414 g/m^3) horizons. However *Gliricidia* seedlings penetrated more roots upto the B horizon (451 g/m^3) compared to cuttings. Coconut root distribution in Gliricidia seedlings and cuttings plots showed that coconut root growth was significantly higher (P<0.001) with Gliricidia seedlings in AB horizon compared that with the control (Table 1). However, coconut root mass in B horizon was higher in *Gliricidia* cuttings than seedlings plots.

Particle size and bulk density

Data in Tables 2 and 3 shows the effect of *Gliricidia* seedlings and cuttings on percentage of gravel size classes and primary soil particles in each horizon of Andigama series. Results showed that percentage of gravel size class (12, 12-5, 5-3, and 3-2 mm) significantly (P>0.001) decreased due to particles fragmentation by roots growth of *Gliricidia* seedlings and cuttings in AB and B horizons of the soil profile. Overall results revealed that roots of *Gliricidia* cuttings were more effective in breaking down gravel particles (>12 & 12-5 mm) in AB horizon than *Gliricidia* seedlings. However roots of *Gliricidia* seedling was more effective than cutting in breaking down larger gravel particles in the B horizon. The fragmentation of larger particles lead to an increase in the percentage of small particles (3-2 mm) significantly (P<0.001) in AB & B horizons. Anyway root configuration (Fig. 1a and 1b) did not show a vast difference between *Gliricidia* seedlings and cuttings throughout the soil profile. The fragmented gravel particles by root *Gliricidia* significantly reduced the bulk density of AB (P 0.001) and B(P<0.001) horizons compared to the control. Moreover, *Gliricidia* seedlings reduces the bulk density of each horizon compared to the roots of cuttings (Table 2).

Furthermore, roots growth of *Gliricidia* seedlings and cuttings increased sand fraction throughout the soil profile compared to the control, which resulted in increase aeration capacity (Table 3). These changes significantly (P<0.0001) reduced the clay fraction in plots of *Gliricidia* seedlings and cuttings. Also *Gliricidia* cuttings were found to be effective than seedlings in reducing clay fraction. Physical disintegration of larger gravel particles by roots of Gliricidia seedlings and cuttings also significantly (P<0.001) change the silt content of soil profile (Table 3).

Table 2. Effect of *Gliricidia* seedlings and cuttings on gravel sizes and bulk density

	<—Gravel sizes (%)—>				
Treatment	<12	12-5	5-3	3-2	Bulk density
Horizon A					
Coconut only (control)	0	0.3	0.3	0.2	1.43
G. sepium seed.	0	0.3	0.3	0.1	1.41
G. sepium cut.	0	0.2	0.25	0.15	1.42
CV %	-	10.7	7.4	17.7	6.0
LSD	-	-	-	-	-
Significance	-	NS	NS	NS	NS

Horizon AB					
Control	14.7	32.3	12.5	4.2	1.60
G. sepium seed.	10.6	20.9	14.4	5.6	1.43
G. sepium cut.	9.6	20.2	18.1	8.8	1.45
CV %	24.3	20.8	29.2	16.0	4.89
LSD	2.5	9.3	2.9	0.7	0.06
Significance	**	*	*	**	**
Horizon B					
Control	28.3	41.3	14.4	3.9	1.62
G. sepium seed.	12.1	36.4	24.4	13.9	1.33
G. sepium cut.	20.9	43.9	11.4	12.1	1.55
CV %	16.6	14.2	20.4	19.6	4.46
LSD	4.6	14.4	15.3	5.9	0.16
Significance	**	NS	NS	**	**

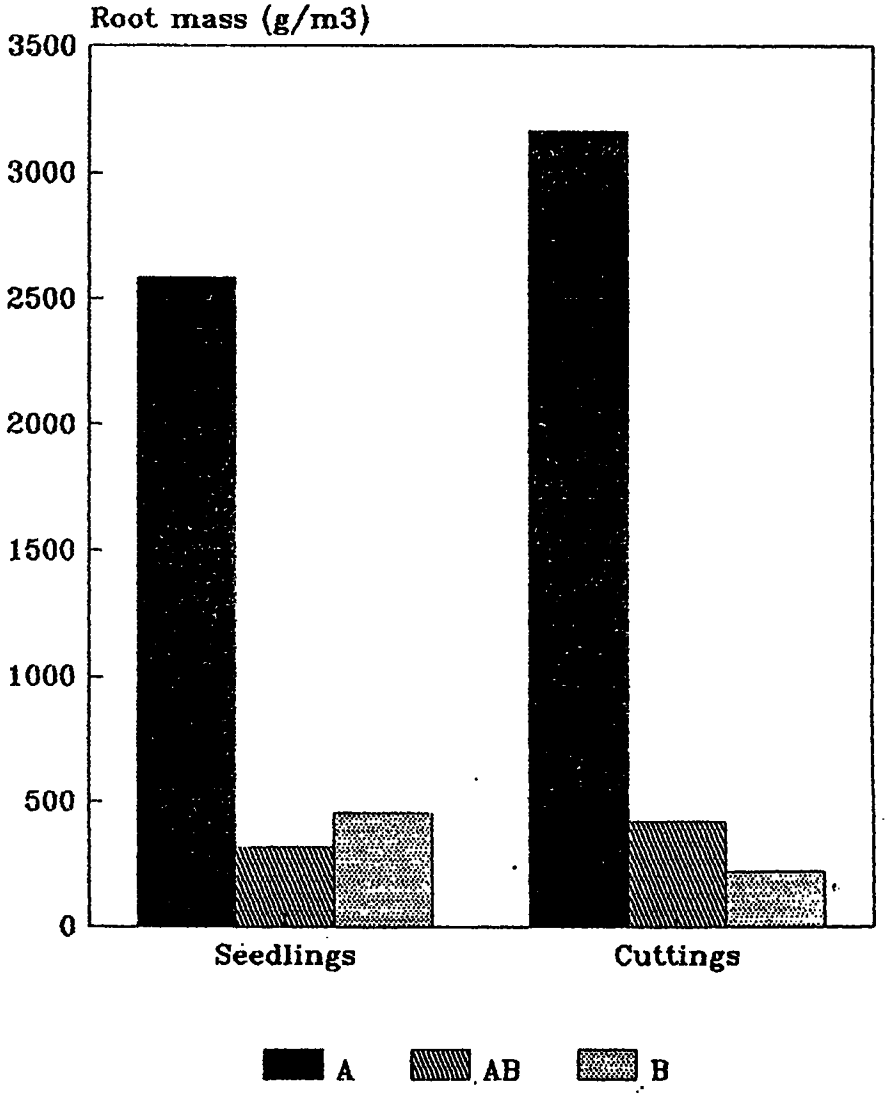
Table 3. Effect of *Gliricidia* seedlings and cuttings on soil particle size and water retention

	<—Primary particles (%)—X			—Volumetric (%)	
Treatment	Sand	Silt	Clay	FC	PWP
Horizon A					
Coconut only (control)	76.8	7.2	14.1	13.2	8.7
G. sepium seed.	86.5	4.7	13.5	9.6	2.2
G. sepium cut.	78.5	8.3	13.4	19.0	4.1
CV %	1.3	10.1	12.4	3.87	10.5
LSD	1.8	1.9	0.9	1.1	1.1
Significance	***	***	***	***	***

(a) Gliricidia Seedling (b) Gliricidia Cutting

Fig.1. Root distribution of coconut, <u>Gliricidia Sepium</u> seedling and cuttings in Andigam series

Fig.2 Root distribution of *Gliricidia*



In Andigama series

Horizon AB					
Control	73.2	9.5	16.0	14.3	10.3
G. sepium seed.	82.0	5.2	13.0	16.0	4.4
G. sepium cut.	83.6	7.0	11.3	20.8	4.5
CV %	3.2	2.9	4.1	4.8	10.8
LSD	3.9	1.6	1.4	1.6	1.4
Significance	**	**	***	***	***
Horizon B					
Control	63.4	10.6	24.2	18.1	14.3
G. sepium seed.	82.6	7.0	11.1	14.9	7.1
G. sepium cut.	78.4	15.2	8.5	16.6	8.5
CV %	1.2	10.9	2.9	4.5	4.3
LSD	1.8	2.4	0.9	1.5	0.9
Significance	***	***	***	**	***

Pore size distribution

Result (Table 4) indicated that total porosity of soil in each soil horizon increased significantly ($P<0.001$) as a result of root growth of *Gliricidia* seedlings and cutting. The aeration capacity in each horizon of *Gliricidia* grown plots increased significantly (For A & 0.0001; and for AB & B, $P<0.01$) compared to that of the control. Moreover, results revealed that roots of *Gliricidia* seedlings were more effective in increasing aeration capacity in each horizon than the cuttings. The higher proportion of clay and silt fraction (Table 4) also led to a larger amount of micropores, which enhances moisture retention significantly ($P>0.0001$) at field capacity and permanent wilting percentage of soil (Table 3).

Table 4. Effect of *Gliricidia* seedlings and cuttings on pore size distribution

Treatment	Total porosity	Macroporosity	Microporosity
	<————	(%)	————>
Horizon A			
Coconut only (control)	41.3	28.1	13.2
G. sepium seed.	54.4	44.8	9.6
G. sepium cut.	48.8	29.8	19.0
CV %	5.0	7.0	8.4
LSD	4.9	4.7	2.4
Significance	**	***	***
Horizon AB			
Control	36.9	22.6	14.3
G. sepium seed.	45.9	29.6	16.0
G. sepium cut.	45.4	24.6	20.7
CV %	3.9	6.9	11.6
LSD	3.4	3.6	4.0
Significance	**	*	*
Horizon B			
Control	41.7	23.6	18.1
G. sepium seed.	46.9	32.0	14.9
G. sepium cut.	42.2	25.6	16.6
CV %	4.7	15.2	13.4
LSD	4.1	8.4	4.5
Significance	**	*	NS

Total and readily available water

Results in Fig. 3a & 3b, showed that total available water retention capacity of Andigama series was significantly improved by (P<0.001) by *Gliricidia* seedlings and cuttings. Soils around cuttings showed the highest available water retention in each horizon compared to the control and seedlings. Result in Fig. 3b illustrates the increase of readily available water fraction as a percentage of the control of each treatment. Growth of Gliricidia cuttings resulted in an increase in readily available water fraction throughout the soil profile, while Gliricidia seedlings tend to reduce it in a horizon even than the control.

DISCUSSION

Root growth and distribution of coconut and Gliricidia in the A horizon were found to be significantly (P<0.001) higher than in the AB & B horizons of Andigama series. Root distribution of both coconut and Gliricidia was limited upto 125 cm depth due to adverse soil physical condition. Vidhana Arachchi *et al.*, (1994) reported that the occurrence of hard, compact iron stone gravel layer in Andigama series at a depth of 30-75 cm from the surface hinders root penetration seriously. Senevirathna and Kendaragama (1993) also found that the highest root growth of Leucaena leucocephalla and *G. sepium* was observed in upper layers and gradually decreased with increasing depth of soil profile on a Rhodustalf of the upper slope of the catena.

Fig. 3a Effect of *Gliricidia sepium* on total available water fraction

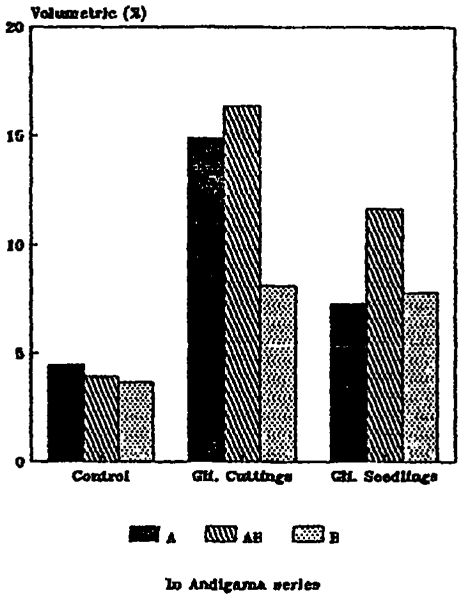
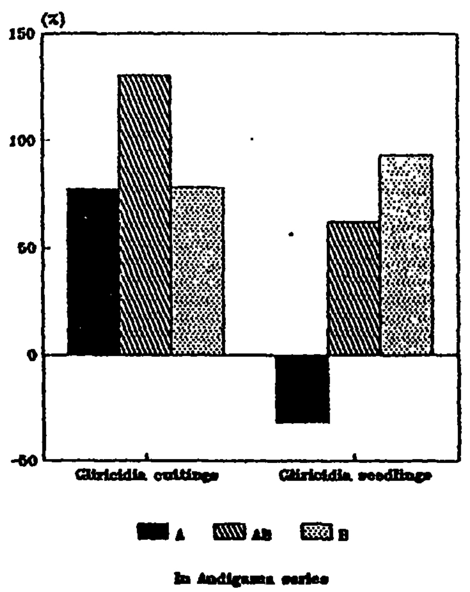


Fig. 3b Percentage increase of readily available water fraction of the control



Further, results showed that roots of *Gliricidia* seedlings and cuttings improved the adverse soil conditions such as high compaction, low aeration capacity and available water throughout the soil profile of Andigama series. This may be due to the root penetration ability of *G. sepium*. Gunasena et al., (1991) also observed that *G.sepium* led to reduce bulk density and increase the infiltration capacity of soil. In addition, Cobbina (1994) confirmed that *G. sepium* has a deep root system and it has the ability to reserve a larger amount of carbohydrates in their roots. High amount of carbohydrates could the adequate energy required for root penetration.

Due to improved soil conditions, coconut root growth was significantly (P>0.001) increased especially in the AB horizon of Andigama series. Moreover, results indicated that *G. sepium* seedlings were more effective than cuttings in enhancing coconut root growth throughout the soil profile of Andigama series. Russel (1973); Atwell (1988) and Brady (1990) explained that loose soil with optimum aeration capacity and available water enhances plant root growth and their physiological functions. Moreover, Senevirathna Banda and Sangakkara, (1994) reported that the perennial tree hederrows induced moisture extraction from deeper soils due to the presence of a tap root.

CONCLUSION

Results indicated that *G. sepium* cuttings were more effective in increasing readily available water throughout the soil profile and decreasing the particle size from 12 mm to 5 mm compared to *G.*

sepium seedlings. In addition, roots of *G. sepium* seedlings effectively penetrated to B horizon of soil profile and reduced its bulk density and increased aeration capacity compared to cutting. Nevertheless, seedlings reduced readily available water in A horizon due to increase of aeration capacity itself. Overall results showed that improved soil physical conditions of plots where *G. sepium* seedlings were grown induced coconut root proliferation more effectively than G. sepium cuttings. Ultimate results concluded that both *G. sepium* seedlings and cuttings improved soil physical conditions of Andigama series resulted in increasing coconut root growth and proliferation.

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