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VALUATION OF *Gliricidia sepium* PROVENANCES IN THE INTERMEDIATE ZONE OF SRI LANKA

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ABSTRACT

Seven selected *Gliricidia sepium* provenances from the Oxford Forestry Institute were evaluated for growth, soil improvement, competition with Agricultural crops and woody biomass production, in two experiments, a pure plot and an alley cropping experiment at Dodangolla Experimental Station, Kundasale in the Intermediate Zone of Sri Lanka.

The height, basal diameter and number of branches of different provenances differed, but local cutting, 17/84 and 14/84 were outstanding at the first lopping, one year after planting. The height and diameter of local cuttings were significantly better than the others due to the stage of growth and the availability of resource material. In the pure plot experiment, Acacia, the control, showed it's best performance in number of branches, which was significantly different from *G. sepium* provenances. In the alley cropping experiment, local cutting and 14/84 showed better yields of Agricultural crops compared to other provenances. The woody biomass production was very high in local cutting and 14/84, and significantly better than other provenances. All seven provenances contributed to improvement of soil Nitrogen (N) ; and significant differences were observed among the provenances only for phosphorus (P) and potassium (K). In soil improvement, 14/86, 10/86, 14/84 and local cutting were outstanding. These provenances can thus be recommended for planting for soil improvement.

After evaluating for growth, soil improvement and woody biomass production, local cutting (the best performer), 17/84, and 14/84 can be recommended as being more suitable for planting in the mid-country Intermediate Zone of Sri Lanka.

INTRODUCTION

Gliricidia sepium was introduced to Sri Lanka during the last century as a shade tree for coffee and tea plantations. It is now cultivated widely and, apart from shade, it is used for live fences, fuelwood, staking for crops and livestock fodder. More recently, it has been tested for use as a green manure and to reduce soil erosion through contour planting. Gliricidia is commonly propagated by cuttings which have excellent survival rates.

It was recognized that in Sri Lanka, as for many other tropical countries, the local land races were of restricted genetic base, of unknown origin and their genetic value remained untested. Consequently, these populations were likely to suffer a degree of degeneration and be sub-optimal. In 1984, the Oxford Forestry Institute, began exploration of the native range of Gliricidia. Following systematic genecological investigations, a set of 30 provenances, that covered the ecological amplitude of the species, was assembled. Seeds of these provenances were distributed in more than 40 tropical countries for field trials. Early results indicated that significant differences exist between provenances for wood and leaf production. Indeed, at some locations the best provenance has been shown to be more than five times as productive as the worst. A trial carried out in the Intermediate Zone of Sri Lanka at the Coconut Research Institute (CRI) in Lunuwila substantiated these findings. Moreover, the best provenance in the CRI trial was observed to produce up to three times more dry season foliage than the local land race. Gliricidia is also grown widely and appreciated in the Intermediate and Wet Zones and has been targeted by the GTZ (German Technical Cooperation) and ADB (Asian Development Bank) programmes for promotion in these areas. In fact, ADB has scheduled over 3 million cuttings of Gliricidia for distribution. This demand and the above results warrants the testing of a select group of the 30 provenances for the Intermediate and Wet Zones.

This study will test the growth and performance of a select group of provenances for wood and leaf production. Gliricidia is described as multipurpose, but in different farming systems individual trees will have different utilization priorities - for example for fuelwood, green manure or for fodder. Thus, two different systems will be tested namely;

- **Alley-cropping** -where trees are grown in alleys among agricultural crops; and
- **Woodlot** - where trees are grown in a pure plot with Acacia as control.

Within this experimental framework, the performance of seedlings versus cuttings will also be evaluated since cuttings are reputed to have shallower and more horizontal rooting systems which cause increased crop competition.

OBJECTIVES

This research has the following objectives:

- To determine the relative performance of *G. sepium* provenances/compared with the local land race.
- To evaluate the performance of selected provenances of *G. sepium* for woody biomass production.
- To study the soil improvement by *G. sepium*.

METHODS AND MATERIALS

1 Site Description

Climate and Soils

The Peradeniya University Experimental Station is located at Dodangolla in the Intermediate Zone of Sri Lanka; 367 m above mean sea level; receiving 1663 mm of rainfall annually. The soil is deep, with moderate structures and a friable consistency, containing thick clay coatings on ped faces and root channels. The parent material is granite gneiss and is well drained. The soil's physical characteristics give no major limitation for plant growth.

2 Experimental

***G.sepium* Alley Cropping Trial**

Treatments in this experiment included the following seven provenances:

- Monterrico, Guatamala	(OFI 17/84)	-	T_1
- Vado Hondo, Guatamala	(OFI 16/84)	-	T_2
- La Garita, Honduras	(OFI 10/86)	-	T_3
- Belen Rivas, Nicaragua	(OFI 14/86)	-	T_4
- Retalhulcu, Guatamala	(OFI 14/84)	-	T_5
- Sri Lankan Local	(Cuttings)	-	T_6
- Sri Lankan Local	(Seedlings)	-	T_7

They were field established in October '92. A Randomised complete Block Design with 3 replicates was used (see Figure 1).

***G.sepium* Pure Plot Trial**

Treatments in this experiment included the following seven provenances:

- Retalhuleu, Guatamala	(OFI 14/84)	$-T_1$
- Volcon Schitan, Guatamala	(OFI 1684)	$-T_2$
- Monterrico, Guatamala	(OFI 17/84)	$-T_3$
- La Garita, Honduras	(OFI 10/86)	$-T_4$
- Belen Rivas, Nicaragua	(OFI 14/86)	$-T_5$
- Sri Lankan Local	(seedlings)	$-T_6$
- Sri Lankan Local	(cuttings)	$-T_7$

The trial was established in October '92 with *Acacia auriculiformis* as the control (T_8). (see Figure 2).

In both trials, a Randomised Complete Block Design with 3 replicates was used (which consisted of 36 trees /plot).

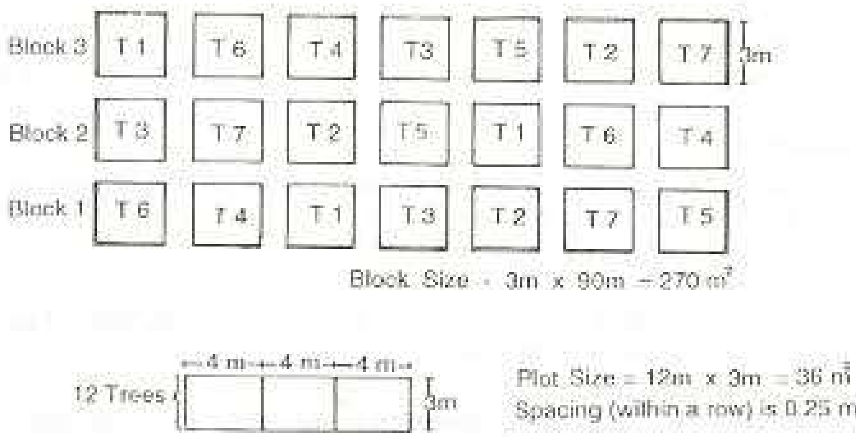

Figure 1 - Field plan for Alley Cropping

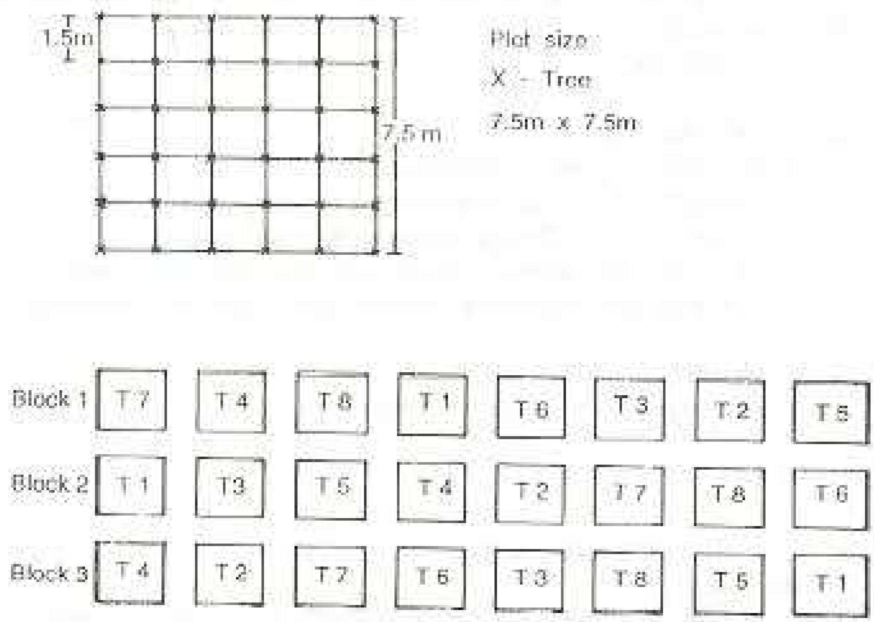

Figure 2 - Field plan for Pure Plot Trial

MEASUREMENTS

1 Morphological

Height (stem length)

Stem length, to the nearest 0.1 m, was measured to the growing point furthest from the base.

Diameter

All stems exceeding 10 mm in diameter at 0.3 m above ground level were measured. The final diameter was calculated from:

$$D^2 = (d_1^2 + d_2^2 + \ldots\ldots d_n^2) / n$$

where:

d_1 = diameter of stem 1 d_2 = diameter of stem 2

d_n = diameter of stem n

Number of Branches

At 30 cm height, stems having more than 10 mm in diameter were considered.

Diameter at Breast Height (DBH)

DBH was measured at 130 cm above ground level.

Woody Biomass Production

The dry weight of stem and branches which were more than 2 cm in diameter were taken. A regression analysis was carried out using:

$$Y = bo + b1 + D^2H$$

where:

Y = Predicted total woody biomass (g) D = Diameter (cm) at breast height

H = Total height bo = Constant

b1 = X Coefficient

2 Soil Analysis

The following measurements were taken:

- Soil pH - Determined electrometrically using a pH meter.
- Total Nitrogen - Determined using Kjeldahl method.
- Available Phosphorus - Determined using spectrophotometer.
- Exchangeable Potassium - Determined using flame photometer.

3 Yield

The yield of Agricultural crops was measured.

RESULTS

1 Alley Cropping Experiment

Height

The treatments gave no significant differences during the first month (November); however, they showed differences from the second month (December) up to lopping. Treatment 6 (local cutting) was the tallest (560 cm at 11 months old) and it was significantly better than other treatments. During the first seven months, treatment 1 (17/84) showed good performance and later it was overtaken by treatment 3 (10/86).

Treatment 5 (14/84) was the shortest of all treatments up to lopping period (Table 1).

Table 1: Height of *G. sepium* in Alley Cropping (cm)

TRT	TIME (MONTH)										
	1	2	3	4	5	6	7	8	9	10	11
T1	53.8	108	124.8	128.5	136.6	164.7	225.4	301.2	363.6	413.8	435.2 b
T2	51.9	101	112.6	114.6	117.9	138.9	175.4	272.6	329.4	375.4	396 b
T3	61.5	107.2	119	121.3	124.8	142.4	201.9	279.9	345.2	408.1	423.2 b
T4	59.9	95.9	106	107.9	110.8	130.8	183.2	264.5	336.5	371.5	395 b
T5	55.9	94.7	106.5	110.3	116.6	139	184.6	246.7	314.2	336.1	355 b
T6	79	153.8	185.8	194.3	219.5	270.3	337.3	400.3	456	508.6	557 a
T6	54.2	105.5	121.9	123.4	132.1	160.4	210.5	278.6	331.5	375.2	396.1
CV											13.49

Common letter indicates non-significance differences among provenances according to DNMRT (alpha = 0.05)

Number of Branches

There was no difference in the branch number from the first month up to lopping among the treatments. Treatment 7 (local seedlings) had 5 branches compared to other treatments which had only 3 or 4 branches. T_5 (14/84) was one of the superior provenances throughout the entire growing season (Table 2).

Table 2: Number of branches in *G. sepium* in Alley Cropping

TRT	TIME (MONTH)										
	1	2	3	4	5	6	7	8	9	10	11
T1	2.55	2.44	2.16	1.91	2.74	3.33	3.98	4.57	4.80	4.35	4.83 a
T2	2.89	2.71	2.32	2.04	2.83	4.04	4.50	4.57	4.95	3.79	4.04 ab
T3	3.91	3.44	2.79	2.09	2.69	4.58	4.27	4.01	3.79	3.46	3.75 ab
T4	3.36	3.09	2.49	2.17	2.55	3.52	3.62	3.90	4.62	3.51	3.80 ab
T5	3.10	2.26	2.16	1.93	3.41	4.66	5.45	5.67	6.44	4.43	5.04 a
T6	3.49	3.18	2.68	1.91	2.08	2.09	2.67	2.49	2.30	2.07	2.27 b
CV											30.61

Common letter indicates non-significance differences among provenances according to DNMRT (alpha = 0.05)

Basal Diameter

The treatments showed significant differences during all 11 months. Treatment 6 (local cutting) had the highest basal diameter (4.8 cm) which was significantly different to all other treatments (3.5 - 4 cm). Treatments 1 (17/84) and treatment 3 (10/86) followed treatment 6 (local cutting). Treatment 5 (14/84) had the lowest basal diameter (Table 3).

Diameter at Breast Height (DBH)

DBH showed a trend similar to basal diameter. Treatment 1 (17/84) with 3.05 cm was the most outstanding (Figure 3).

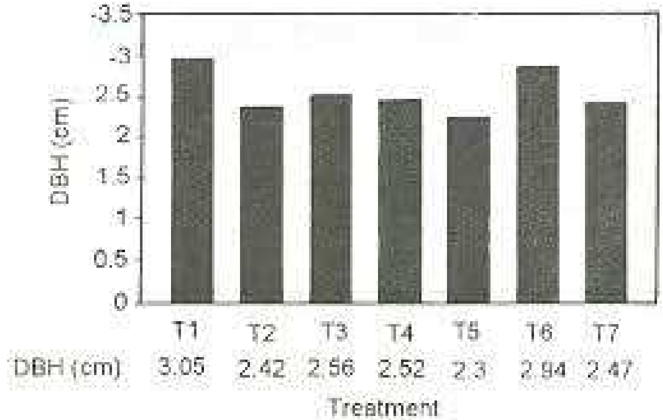

Figure 3 - DBH of *G. sepium* alley cropping in September (11th month)

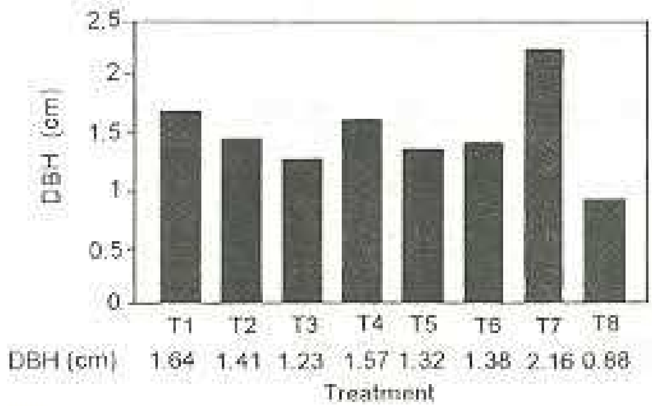

Figure 4 - DBH of *G. sepium* pure plot in September (9th month)

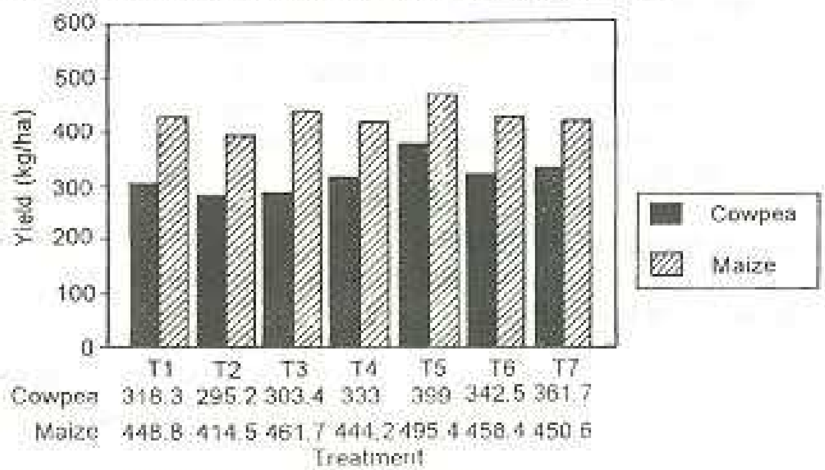

Figure 5 - Average yields of Cowpea and Maize (Kg/ha)

Biomass Production (WOOD BIOMASS)

Treatment 1 (17/84) and T_6 (local cutting) showed 0.84 kg and 1.07 kg respectively. All the other treatments showed about 0.65 kg (not significantly different); (Table 4).

Table 3: Basal Diameter of *G. sepium* in Alley Cropping

TRT	TIME (MONTH)										
	1	2	3	4	5	6	7	8	9	10	11
T1	0.77	1.43	1.52	1.51	1.69	2.21	2.19	2.83	3.24	3.73	3.88b
T2	0.60	1.22	1.40	1.44	1.54	1.67	2.15	2.69	3.14	3.59	3.72b
T3	0.83	1.33	1.59	1.65	1.78	2.04	2.32	2.79	3.19	3.70	3.85b
T4	0.78	1.27	1.47	1.48	1.45	1.73	2.05	2.66	3.22	3.55	3.69b
T5	0.73	1.93	1.31	1.37	1.48	1.67	2.00	2.57	3.19	3.40	3.55b
T6	2.65	2.78	2.81	2.82	2.97	3.12	3.37	3.86	4.21	4.62	4.79a
T7	0.84	1.32	1.45	1.49	1.61	1.74	2.03	2.74	2.07	3.50	3.64b
CV											9.27

Common letter indicates non-significance differences among provenances according to DNMRT (alpha = 0.05)

Table 4: Woody Biomass Production in *G. sepium* in Alley Cropping (dry wt in gm).

TREATMENT	WBM (grams)	CONSTANT (bo)	X - Coeff. (b1)	R^2
T1 (17/84)	837.25	27.65	0.203	0.929
T3 (10/86)	715.04	96.62	0.223	0.980
T4 (14/86)	646.00	94.28	0.222	0.991
T5 (14/84)	597.53	146.93	0.241	0.979
T6 (L/C)	*1069.90	6.27	0.221	0.972

* Woody biomass production shows significantly better than others according to DNMRT (alpha = 0.05)

2 Pure Plot Experiment

Height

Treatments showed significant differences from January to September. Among the treatments, significant differences were also recorded. Treatment 7 (local cutting) showed a significant difference compared to other treatments in its fast growth (413 cm, which was 2.5 times more than the control). The control (Acacia) was very slow growing during the last 2 months and it was the poorest performer. Treatment 1 (14/84) was the second best in ranking (262 cm) followed by T_4 (10/86), T_2 (16/84) and T_6 (local seedlings). Especially with time, T_6 (local seedlings) showed improvement (Table 5).

Table 5: Height of *G. sepium* in Pureplot (cm)

TRT	TIME (MONTH)								
	1	2	3	4	5	6	7	8	9
T1	64.49	66.62	70.51	82.95	104.64	135.93	182.54	237.87	261.91 b
T2	48.87	51.99	54.78	60.76	79.47	122.28	170.06	231.98	248.81 b
T3	50.83	53.39	53.97	60.43	72.54	99.05	134.27	169.88	188.52 b
T4	48.37	51.05	51.11	55.64	69.15	103.69	149.57	212.17	236.12 b
T5	59.82	62.07	62.24	63.19	75.51	105.88	144.92	186.07	197.97 b
T6	53.49	57.12	59.39	69.49	91.24	123.87	169.56	211.86	219.74 b
T7	94.26	125.85	109.33	157.20	209.22	252.01	331.25	404.97	413.24 b
T8	30.58	34.20	49.31	67.61	90.85	110.00	134.40	163.47	167.30 b
CV									21.81

Common letter indicates non-significance differences among provenances according to DNMRT (alpha = 0.05)

Number of Branches

A significant difference was observed over time. Treatment 3 (17/84) showed an excellent performance, averaging 5 branches, followed by T_1 (14/84) and T_5 (14/86). But just before lopping (during the 8th and 9th months) the control (*Acacia auriculiformis*) showed the best performance (14 branches) which was significantly different to all other treatments (Table 6).

Table 6: Branching of *G. sepium* in Pureplot

TRT	MONTH								
	1	2	3	4	5	6	7	8	9
T1	4.11	4.58	4.81	5.01	5.27	4.60	5.16	4.83	5.66 bc
T2	2.81	2.85	2.89	3.62	4.08	4.17	4.43	4.19	4.74 cd
T3	4.63	5.09	5.35	5.99	6.03	5.66	5.75	5.33	6.26 b
T4	2.32	2.61	2.60	3.87	3.48	2.86	2.99	2.71	3.90 d
T5	3.21	3.32	3.40	3.84	4.85	4.61	4.16	4.75	4.97 cd
T6	3.02	3.54	4.14	4.99	5.18	4.80	4.75	4.47	4.82 cd
T7	2.77	3.05	3.33	3.91	2.97	3.08	2.91	2.64	2.68 e
T8	2.68	2.82	3.44	4.85	7.23	5.96	10.65	9.54	14.7 a
CV									9.87

Common letter indicates non-significance differences among provenances according to DNMRT (alpha = 0.05)

Basal Diameter

Treatments showed significant differences for all 9 months. T_7 (local cutting) showed significant differences from other treatments and was ranked first (4.5 cm) followed by T_1 (14/84). T_8 (Acacia) showed the poorest performance (only 2 cm) which was significantly different to other treatments (Table 7).

Diameter at Breast Height

The basal diameters at breast height also showed a ranking order similar to that for basal diameters (Figure 4).

Table 7: Basal Diameter of *G. sepium* in Pureplot (cm)

	1	2	3	4	5	6	7	8	9
T1	1.23	1.33	1.39	1.46	1.74	2.16	2.53	2.76	3.29 b
T2	1.02	1.12	1.17	1.20	1.31	1.80	2.25	2.53	2.88 bc
T3	1.00	1.06	1.09	1.12	1.23	1.60	1.95	2.33	2.61 c
T4	1.00	1.09	1.12	1.16	1.27	1.66	2.19	2.57	2.87 bc
T5	1.30	1.19	1.21	1.12	1.29	1.64	2.03	2.30	2.62 c
T6	1.06	1.15	1.16	1.22	1.32	1.71	2.02	2.19	2.63 c
T7	2.64	2.71	2.76	2.81	2.96	3.36	3.74	3.90	4.45 a
T8	0.35	0.41	0.48	0.59	0.85	1.14	1.46	1.94	14.7 d
CV									11.39

Common letter indicates non-significance differences among provenances according to DNMRT (alpha = 0.05)

3 Soil Analysis.

Alley Cropping Experiment

The assumption was made that along the block, the initial nutrient status had no gradient. For pH and Nitrogen (N) no significant differences were observed. The treatments showed significant differences among themselves for Phosphorus (P) and Potassium (K) at the 11th month. For P, treatment 6 (local cutting) showed an excellent performance (which was significantly different), followed by treatments 3 (10/86), 4 (14/86) and 5 (14/84). For K, treatments 6 (local cutting) and 4 (14/86) showed better performances, followed by T_1 (17/84).

Although treatments did not show any significant differences among themselves for N, their contribution of N to the soil was very high (40 mg N/ 100 gm soil) compared to the initial status of the soil N (Table 8

Table 8: *G. sepium* Alley Cropping - Soil Status (11 months)

TREATMENT	pH	N(%)	P (mg/kg)	K (meq/100G)
17/84 (T1)	4.73	0.11	13.5 bc	0.67 b
16/84 (T2)	4.83	0.10	13.0 cd	0.44 c
10/86 (T3)	4.76	0.12	14.0 b	0.46 c
14/86 (T4)	4.86	0.16	13.5 bc	0.82 a
14/84 (T5)	4.80	0.10	12.5 d	0.45 c
L.cutting (T6)	5.00	0.14	16.0 a	0.82 a
L.seedling(T7)	4.90	0.10	12.5 d	0.64 b
INITIAL	5.02	0.08	12.5	0.82
CV			3.15	3.03

Common letter indicate non significant differences among provenances according to DNMRT (alpha = 0.05)

***Gliricidia Sepium* Pureplot**

Again, the assumption was made that along the block the initial nutrient status had no gradient. For pH and Nitrogen (N) no significant differences were observed. For potassium (K) and phosphorus (P) significant differences were observed. Treatment

1 (14/84) and treatment 4 (10/86) showed significant differences for P compared to all the other treatments and treatment 6 (local seedlings) performed the worst - at the 9th month. For K, all treatments showed significant differences compared to the control; and treatment 7 (local cutting) showed the highest performance which was significantly different from other treatments.

When compared to the initial status of the soil, after 9 months the improvement of soil N was considerable (by about 40 mg/ 100 g of soil) and statistically significant. The control, Acacia, fixed the highest amount of N (80 mg/ 100 g soil) compared to the other treatments (Table 9).

Table 9: *G. sepium* Pureplot - Soil status (9 months)

TREATMENT	pH	N (%)	P (mg/kg)	K (meq/100)
14/84 (T1)	4.93	0.12	10.5 a	1.44 c
16/84 (T2)	4.76	0.13	9.0 b	1.53 bc
17/84 (T3)	4.73	0.14	9.0 b	1.52 bc
10/86 (T4)	5.03	0.14	10.5 a	1.50 bc
14/86 (T5)	4.86	0.12	8.5 b	1.55 b
L.seedling (T6)	4.80	0.14	6.5 c	1.53 bc
L.cutting (T7)	4.93	0.14	10.0 a	2.10 a
Acacia (T8)	4.93	0.16	10.0 a	1.08 d
INITIAL	5.03	0.08	8.2	1.00
CV			3.93	3.28

Common letter indicates non significant differences among provenances according to DNMRT (alpha = 0.05)

4 Yield of Agricultural Crops.

Cowpea (MI 35)

The yield showed no significant differences except that of T_5 (14/84), having 399 kg/ha (Figure 5).

Maize (Badhra)

The yield of T_5 (14/84) showed the highest yield of 495.4 kg/ha, although no significant difference was observed (Figure 5).

DISCUSSION

The growth of the local cutting was found to be the best in both pureplot and alley cropping. It showed fewer branches but, due to its height and best diameter at breast height, it performed well in the production of woody biomass. Usually cuttings make shallow horizontal roots along the top soil. Those roots are strong and active compare to seedlings and get all the nutrients required from the soil. The performance of seedlings was a little better during the later stage (just before lopping). This was due to their adaptation to the environment at a later stage after being transferred to the field from the nursery.

The number of branches and the rate of girth growth at 30 cm height dropped suddenly from April to May and in some cases from May to June. This was due to the effect of the drought which occurred during that period.

For biomass production, a positive correlation was found between cross sectional area and biomass. Wood biomass is the most useful measure of yield in species grown for fuelwood production. Leaf and pod biomass were excluded from the OFI biomass studies for two reasons. Firstly, there are major seasonal changes. Most of the species lose their leaves in the dry seasons. This makes measurement at a single point in time almost meaningless, especially as the phenology of each species is different and they lose their leaves at different times. Secondly, the timing (phenology) of foliage production, as well as the partitioning of dry matter between different parts of the tree, can be manipulated by the adoption of particular lopping regimes.

The improvement of soil N (significantly different compared to the initial status of soil N) by *G. sepium* was clearly observed - this resulting from its N fixing ability. Since *G. sepium* is a legume, the soil P was also improved relative to its initial status.

CONCLUSION

The growth of local cutting was the best compared to all other provenances - namely OFI 14/84, 17/84, 10/86, 14/86, 16/84 and local seedlings which were used for this experiment.

Next to local cutting, the provenances 10/86, 14/84, and 14/86 contributed well to improving the soil. Local cutting and 17/84 can be recommended for good woody biomass production.

Local cutting, 14/84 and 17/84 can be recommended as suitable provenances for the Intermediate Zone of Sri Lanka (especially in mid-country) when the growth, biomass production, soil improvement and less competition with agricultural crops, are considered.

A better performance of 14/84 could be achieved in pure plots than in alley cropping, although it showed a higher yield of agricultural crops in the alley cropping experiment. The provenance 17/84's performance was good in alley cropping compared to the pure plot experiment, so it can also be recommended for alley cropping in the mid-country Intermediate Zone of Sri Lanka.

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