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Research Article

REGENERATION POTENTIAL OF *GLIRICIDIA SEPIUM* (JACQ.) KUNTH EX WALP. AS A FUELWOOD SPECIES

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ABSTRACT
Dendrothermal energy generation has been identified as one of the best options due to its potential as a low cost and locally available environmentally sound energy source. However, this potential has not been exploited by the people in most of the potential areas which hinder the further expansion of dedicated fuel wood production. With this background, a study was undertaken to evaluate the potential of *Gliricidia* cultivation in dry zone for bio-energy generation. *Gliricidia* can be used as a biomass energy source to fulfill the future electricity demand. It is needed to optimize fuelwood yield of *Gliricidia* for dendro thermal power generation. In this study 2 factors (Height of pruning with 2 levels as 1 m and 1.5 m and number of branches remaining after pruning with 2 levels as 5 branches and allow all branches to grow naturally) were evaluated by using fresh and dry weight of *Gliricidia* stems over 6 month (May 2015 – November 2015) in an open field experiment (2 factor factorial experiment) at Nawagaththegama $DL_{1.}$ The results showed that the main effects are significant while none of interactions are significant. So, it can be concluded that highest biomass yield is given by *Gliricidia* with the pruning height of 1.5 m while they are allowing to naturally grow. It is about 11.2 tons/ha. Regeneration potential of *Gliricidia* is high at 5 months. So, *Gliricidia* trees can be successfully harvested in 5 month intervals. It is better, if the growth of Gliricidia can be measured at 6, 7, 8 months after pruning while calculating economics of keeping 4, 5, 6, 7, 8 months under field conditions.

Keywords: *Dendro Thermal Power, Gliricidia, Biomass Energy, Fuelwood, Regeneration*

INTRODUCTION
The three traditional major cash crops in Sri Lanka are tea, rubber and coconut which were introduced during colonial period. Since then number of other crops were immersed as cash crops such as pepper, cinnamon, cardamom, sugarcane etc. But none of them could come to the position of fourth cash crop of Sri Lanka.

Sri Lanka took the decision to introduced *Gliricidia* as the country's fourth plantation crop based on a cabinet memorandum of the Ministry of Plantation Industries. Scientific name of Gliricidia is *Gliricidia sepium* (Jacq.) Kunth ex Walp. It is widely known as wetahiriya, wetamara, ladappa, nanchi, sevana, kolapohora, makulatha and albesia (Gunasena, 1997).

Gliricidiais a versatile multipurpose tree species introduced to Sri Lanka in 1700's from the West Indies for boundary planting. Subsequently, it has been widely used as shade for coffee, pepper, cocoa and tea in the mid elevations of Sri Lanka (Gunasena, 1997; Liyanage, 1987). The advantages of *Gliricidia* as a multipurpose species are its fast growth, wide adaptability, easy establishment and tolerance to frequent lopping (Allen and Allen, 1981; Chadhokar, 1982).

Gliricidia sepium can be found in a wide range of habitats with various soil types and various rainfall conditions (Allen and Allen, 1981). It can be categorized as an aggressive pioneer species as it is distributed in various soil types ranging from pure sand to deep alluvial lake bed deposits and with the rainfall ranging from as little as 600 mm to as much as 3,500 mm, and at elevations from sea levels to 1,200 m above sea level (Cromwell *et al.*, 1996; Simons, 1996). *G. sepium* can be found in all most all major ecological zones of Sri Lanka, except in elevations over 750 m and mainly below 500 m. However, it can be grown at elevations up to 1,200 m above sea level. Poor growth and leaf fall can be observed at this region due to cold temperature. *G. sepium* is widely grown in the wet zone and the intermediate zone

areas as they are used as shade for tea, cocoa and as support for pepper vines (Gunasena, 1997; Liyanage, 1987).

Fuelwood characteristics of the wood of the *G. sepium* cannot be ever forgotten in finding a solution for energy crisis. Early culmination ability and easy coppicing nature of *G. sepium* are useful in selecting as a fuelwood species (Timyan, 1996). Other than that wood of *G. sepium* burns slowly thus, producing good embers, and gives off little smoke or sparks explaining its general acceptability. It has a good heating value (19.8 MJ/kg) with an average specific gravity of 0.5-0.6 (Withington *et al*., 1987).

Being a fuelwood tree species, easy coppicing nature of *G. sepium* provides an additional advantage. Fuelwood is obtained through the occasional lopping of branches or by completely coppicing trees to lower levels above ground (Mbuya *et al.*, 1994). Wood of *G. sepium* burns slowly, thus, producing good embers, and gives off little smoke or sparks, explaining its general acceptability. It has a good heating value (19.8 MJ/kg) with an average specific gravity of 0.5-0.6 (Withington *et al.*, 1987).

Over 90% of the population of Sri Lanka use wood energy for their domestic purposes. *G. sepium* can also be used for this, as it can be grown in homestead agroforestry systems, woodlots and farmlands (Liyanage, 1987). The lopping of branches could provide fuelwood when *G. sepium* is grown for other primary purposes such as live fences, shade and animal fodder. In places like tea factories, where wood energy is needed, woodlots could be established on underutilized lands for fuel wood production (Liyanage and Jayasundera, 1989). The spacing of plants at 1.5m × 1.5m or 2m × 2m could supply poles suitable for firewood. Fourteen provenances of *G. sepium* are available in Sri Lanka. One of them is local provenance named as Local Land Race. Other thirteen provenances are exotic provenances (Gunasena, 1997).

There is a high demand for *G. sepium* stakes but production cannot fulfill the requirement of *G. sepium* stakes as lack of best management practices about the growth of *G. sepium*. People do not know how frequently *G. sepium* should be pruned, what the most suitable height which is used to prune is and what the most suitable number of branches which should be remained is. In order to use in energy industry, the proper knowledge about the growth rate of *G. sepium* is needed. This research will focus on identification of regeneration potential of *G. sepium* and their energy values at different growth stages.

MATERIALS AND METHODS

Methodology

The study was conducted at the Agronomy Division of Coconut Research Institute (CRI), Lunuwila, Sri Lanka, situated in North Western Province of Sri Lanka, (7° 20' 37" N, 79° 51' 42" E). Study was carried out in existing Private *G. sepium* plantation at Nawagaththegama. These field experiments were established primarily for fool wood production. For this study, the field experiment was conducted in the dry zone (08° 01’ N, 80° 11’ E; 45 m from mean sea level). Agro-ecological zone of this area is DL1b (Punyawardena *et al.*, 2003). Soils belong to the great soil group of Red Brown Earth and Low HumicGlay (Mapa *et al.*, 2005). The mean annual rainfall and ambient temperature range were <900 mm and 23.8 °C - 30.4 °C, respectively. *G. sepium* trees which were planted in 2007 were used for the experiment.

Experimental Design

Two factors were evaluated in this experiment. They were height of pruning, number of branches remaining after pruning. Split-Plot Design with covariate analysis were used in this experiment to analyze the data. Basal diameter of trees was used as covariate. Two levels were associated with height of pruning, two levels were associated with number of branches remaining after pruning. This experiment was repeated in two times.

G. sepium plants were pruned up to the height of 1 m and 1.5 m. It was based on past research findings (Gunasena and Hitinayake, 1990).

Pruning heights

- 1 m (h_1)
- 1.5 m (h_2)

Two levels were associated with number of branches remaining after pruning. They were,

- Five branches remaining after pruning (b_1)
- Allow all branches to grow naturally (b_2)

Height of pruning was considered as the main plot factor to reduce the adverse effects, like shade on prevailing trees. Numbers of branches remaining after pruning were considered as the sub-sub-plot factor as higher level of precision is expected for number of branches remaining after pruning.

According to the experimental layout eight experimental units were considered as a sub-plot. Six blocks were used from private *G. sepium* plantation at Nawagaththegama for this experiment. Experiment required 192 trees to assess the biomass yield of harvested *G. sepium* stems except green portion of stems.

Collection and Analysis of Data

Six blocks were created which belonged 192 *G. sepium* trees. One block had 32 trees. Each treatments were randomized with in the block. All the *G. sepium* trees were cut according to the treatments. Existing biomass (Fresh weight and Dry weight) of stem of 192 *G. sepium* trees was measured. Existed biomass of the field were 40 tons/ha. According to the treatment combinations 96 *G. sepium* trees (Three blocks) were lopped after four months and remaining 96 *G. sepium* trees (Three blocks) were lopped after five months. Fresh weight of stems and leaves of *G. sepium* were measured separately. About 50 grams of wood samples from each tree were collected for analysis of dry weight of *G. sepium* stems.

Measuring Fresh Weight

All treatments were cut according to the treatment combinations and stem samples were separated from leaves with green portion of the stems. Weights of the fresh stem were taken as fresh weight of stem.

Analysis of Dry Weight

Dry weight of *G. sepium* wood samples was analyzed by using E 871 method which was introduced by American Society for Testing and Materials (ASTM E870-82, 2013; ASTM E871-82, 2013). Representative samples which having 50g were weighed. Sample containers were dried for 30 minutes at 103 ºC in the oven. Then, they were cooled in a desiccator to room temperature. Sample containers were weighed to the nearest 0.02g and recorded as container weight (W_c). Fifty grams of samples were placed in the containers. Containers with the samples were placed in the oven for 16 hours at 103 ºC. Containers with the samples were removed from the oven and cooled in a desiccator to room temperature. Containers with the samples were removed from the desiccator. Containers with the samples were weighed immediately to the nearest 0.01g and the weights were recorded. Containers with the samples were returned to the oven at 103 ºC for two hours. The above process was continued until the total weight change between weightings varies less than 0.2% and recorded as final weight (W_f).

Calculation:

Dry weight of 50g sample = $W_f - W_c$

Dry weight of total biomass of *G. sepium* trees were calculated by using simple mathematics as follows,

Dry weight of total biomass = $(W_f - W_c) \times$ fresh weight / 50

Analysis of Moisture Content in Gliricidia Wood

Moisture content of *G. sepium* wood samples was determined by using E 871 - 82 method which was introduced by American Society for Testing and Materials. Sample containers were dried for 30 minute at 103±1 ºC in the oven. They were cooled in a desiccator to room temperature. Weight of the container was recorded to the nearest 0.02 g was W_c. Wood sample with the weight of 50 g was placed in a container. Container with the sample was weighed to the nearest 0.01 g and recorded as initial weight, W_i. Container with the sample was placed in the oven for 16 h at 103±1 ºC. Container with the sample was removed from the oven and cooled in a desiccator to room temperature. Sample and the container was removed from the desiccator and weighed to the nearest 0.01 g and recorded as W_f. Calculation (ASTM E871-82, 2013):

Moisture % = $[(W_i - W_f)/(W_i - W_c)] \times 100$

Where:

W_c = Container weight (g)

W_i = Initial weight (g)

W_f = Final weight (g)

RESULTS AND DISCUSSION

Stem Fresh and Dry Weight of Gliricidia at Nawagaththegama when, Trees are Pruned at Several Height

According to the results which were showed in Table 1, Table 2, Figure 1 and Figure 2 *Gliricidia* trees which were pruned at 1.5 m height showed significantly high fresh and dry weight rather than trees which were pruned at 1 m height in both 4 months and 5 months. So, 1.5 m height is ideal for the pruning of *Gliricidia* trees to optimize the wood yield. Figure 3 and Figure 4 shows the growth variation of *Gliricidia* trees in several times.

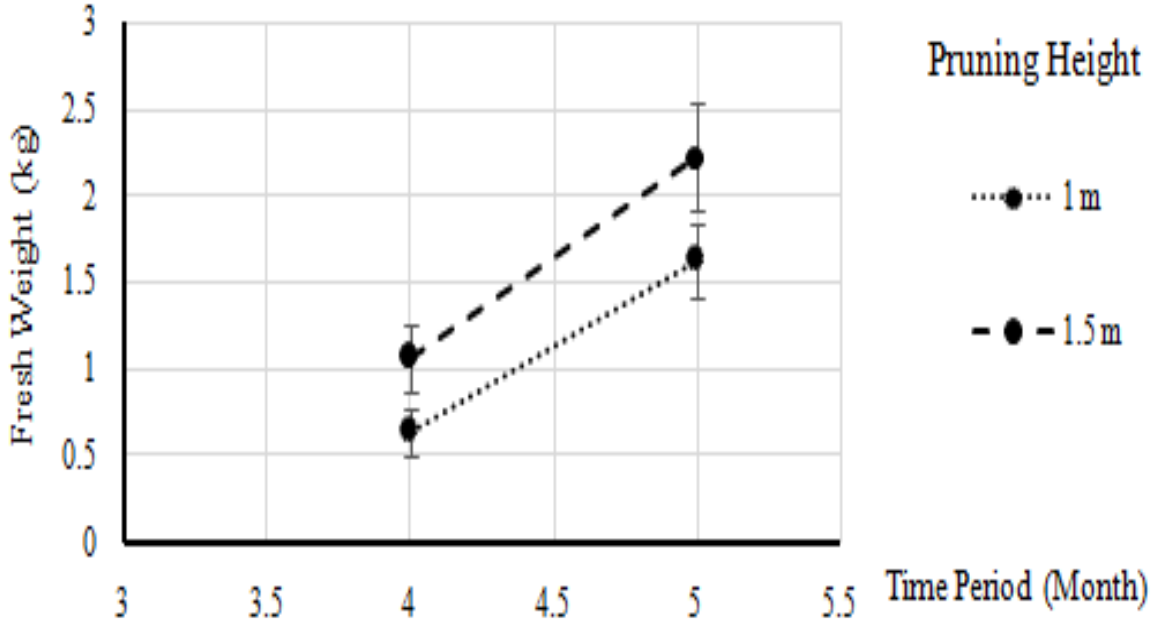

Figure 1: Stem Fresh Weight Results at Nawagaththegama

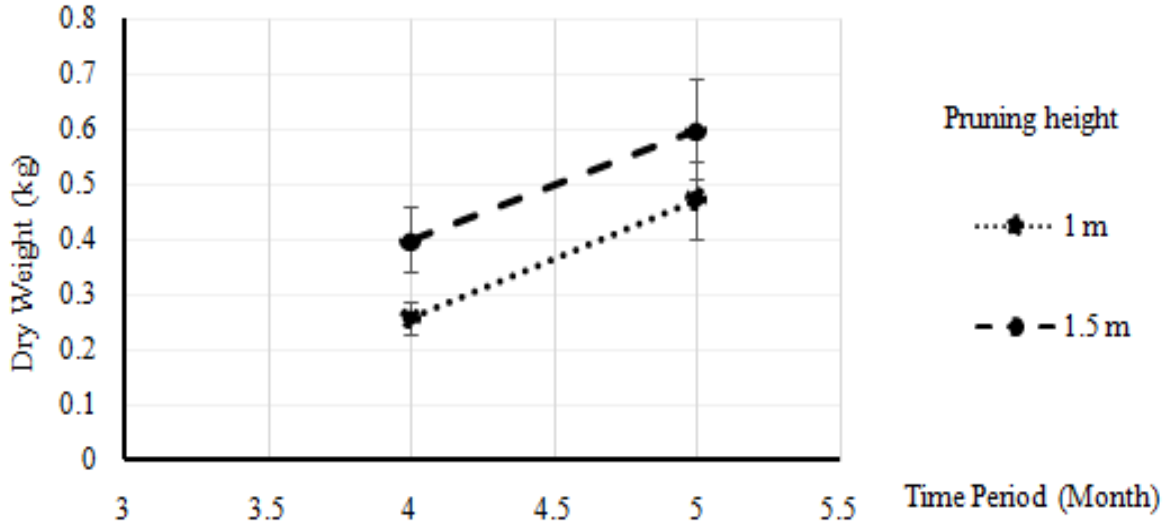

Figure 2: Stem Dry Weight Results at Nawagaththegama

Table 1: Stem Fresh Weight Results at Nawagaththegama Area

Height	4 Months	5 Months
1 m	0.64 ± 0.14^{b}	1.63 ± 0.22^{b}
1.5 m	1.07 ± 0.19^{a}	2.23 ± 0.32^{a}

Values (mean ± SD) with adjacent letter in the same column imply significant different (P<0.05)

Table 2: Stem Dry Weight Results at Nawagaththegama Area

Height	4 Months	5 Months
1 m	0.26 ± 0.03^{b}	0.47 ± 0.07^{b}
1.5 m	0.4 ± 0.06^{a}	0.6 ± 0.09^{a}

Values (mean ± SD) with adjacent letter in the same column imply significant different (P<0.05)

Stem Fresh and Dry Weight of Gliricidia at Nawagaththegama when, Trees having Several Number of Branches

According to the results which were showed in Table 3, Table 4, Figure 3 and Figure 4,*G. sepium*trees which were allowed to grow naturally showed significantly high fresh and dry weight rather than trees which were having 5 branches remained after pruning in both 4 months and 5 months. It is ideal to allow *G. sepium* trees to grow naturally for having good fuelwood yield.

Table 3: Stem Fresh Weight Results at Nawagaththegama Area

No of Branches	4 Months	5 Months
5 branches	0.98 ± 0.05^{b}	1.6 ± 0.12^{b}
Allow all branches to grow naturally	1.38 ± 0.1^{a}	1.8 ± 0.18^{a}

Values (mean ± SD) with adjacent letter in the same column imply significant different (P<0.05)

Table 4: Stem Dry Weight Results at Nawagaththegama Area

No of Branches	4 Months	5 Months
5 branches	0.26 ± 0.02^{b}	0.51 ± 0.04^{b}
Allow all branches to grow naturally	0.41 ± 0.03^{a}	0.56 ± 0.06^{a}

Values (mean ± SD) with adjacent letter in the same column imply significant different (P<0.05)

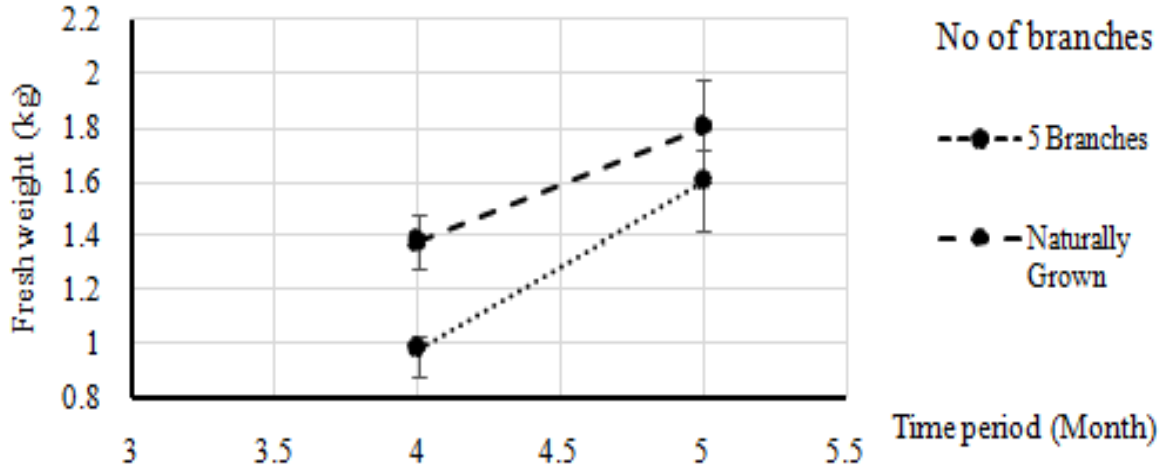

Figure 3: Stem Fresh Weight Results at Nawagaththegama

Plate 1: Two months after pruning at Nawagaththegama

Plate 2: Three months after pruning at Nawagaththegama

Plate 3: Four months after pruning at Nawagaththegama

Plate 4: Five months after pruning at Nawagaththegama

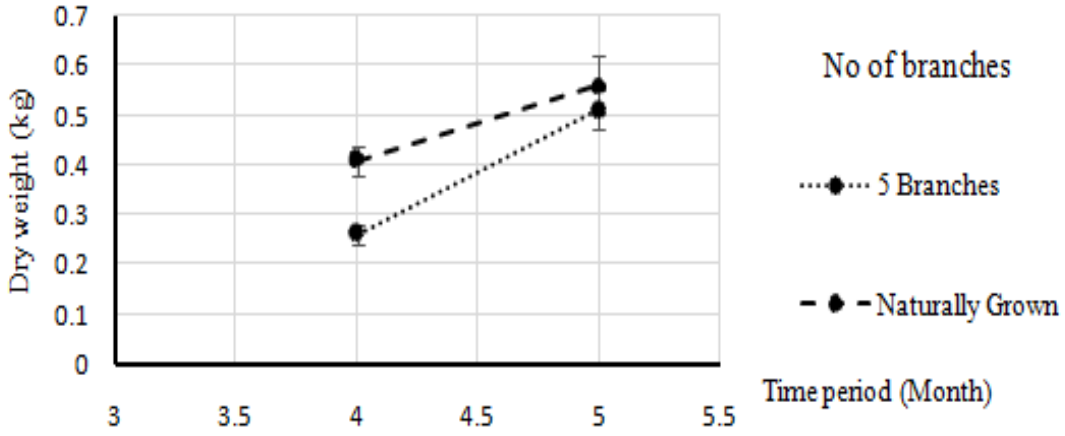

Figure 4: Stem Dry Weight Results at Nawagaththegama

Fresh Biomass Yield Variation of Local Landrace at Nawagaththegama

Fresh biomass yield of Local Landrace is varied with the time. It is shown in Table 5. When the trees are allowed for 8 years, after planting 43.5 tons/ha of yield can be obtained. Then, they were allowed for grow naturally and harvested again in 4 months after pruning. Fresh biomass yield of 6tons/ha was given by them. If the pruning is continued in 4 months intervals, it will give fresh biomass yield of 18 tons/ha/year. Some trees of the same plantation and same age (8 years) were allowed to grow naturally and harvested again in 5 months after pruning. Fresh biomass yield of 8.6 tons/ha was given by them. If the pruning is continued in 5 months intervals, it will give fresh biomass yield of 21.5 tons/ha/year.

Table 5: Fresh Biomass Yield Variation of Local Landrace with Time at Nawagaththegama

Time / Fresh Biomass Yield	8 Years after Planting	4 Month after Pruning	5 Month after Pruning
kg/plant	8.7	1.2	1.7
tons/ha	43.5	6	8.6
tons/ha/year	-	18	21.5

Conclusions and Suggestions

High biomass yield can be obtained from *Gliricidia* when, the trees are pruned at 1.5 m while allowing all branches to grow naturally. It is about 11.2 tons/ha. Regeneration potential of *Gliricidia* is high at 5 months. So, *Gliricidia* trees can be harvested in 5 month intervals. It is better, if the growth of *Gliricidia* can be measured at 6, 7, 8 months after pruning while calculating economics of keeping 4, 5, 6, 7, 8 months. Then, only it can be concluded that the most suitable time to harvest *Gliricidia*. In addition to that, it is better the heavy metal content, sulphur % of *Gliricidia* stem and fuel value index can be calculated.

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