Possibility to Introduce Bamboo as an Energy Crop

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ABSTRACT

Demand for energy is increasing day by day all over the world especially for the short term renewable energy. Biomass energy has great potential to be an alternative for fossil fuel. Bamboo belongs to grass family and biomass can be processed in various ways to produce different energy products. This research focuses on comparison with bamboo and the other biomass available in Sri Lanka and possibility of vegetative propagation to plant in small to medium scale wood lots. It will work as a substitution for replace tree biomass on fuel-wood sector in future. Compare to most energy crops, bamboo biomass has better fuel characteristics. It can grow in degraded land so that it requires less care and less compete with food crops for land. However, bamboo takes comparatively lesser time to mature. First part of the results revealed that small to medium scale commercial propagation can be done through vegetative propagation. Medium with river sand and top soil 1:1 ratio showed highest germination percentage for the bamboo seed. Second part of this study reviled the characterize of energy quality attributes of bamboo species (Dendrocalamus strictus, Bambusa vulgaris, Dendrocalamus asper, Bambos bamboo, Bambosa balcoa, Dendrocalamus hookery) biomass, when compared to other raw materials of residual origin with a high potential for use in thermal energy generation processes. All the evaluated bamboo species in the energy quality characteristics are almost similar range equivalent to those of biomasses saucers traditionally used in thermal energy generation. Bambusa vulgaris had the highest calorific value among the tested bamboo species.

Keywords - Bamboo, Bio Energy, Environmental Benefits, Bamboo Propagation, Sri Lanka.

I. INTRODUCTION

Fruitwood plays a pivotal role as an energy source in rural and industrial sector in Sri Lanka (IR Palihakkara at el 2015 and Palihakkara at el 2018). In taxonomy, bamboo falls to family Poaceae (grass family), subfamily Bambusoideae which contains 1250 species. Despite of being a grass, they still have “woody stem” or culm that can reach 15-20m in height or even 40m with the largest species known Dendrocalamus giganteus (Palihakkara 2019). Bamboo is considered to be the fastest growing plant in the planet with the recorded growth of 91cm per day. The harvestable time for bamboo is about 3-5 years in comparison to 10-20 years for most softwood .It also has high biomass productivity, self-regeneration and can tolerate poor soils so that it can grow in degraded land that which makes it one of the best-known biomass resource.

Bamboo can grow well in degraded and marginal soils with low fertility and requires little fertilizer or water in comparison to other traditional sources of biomass .This implies that, even with less resource input, bamboo can thrive in severely degraded areas where other native species cannot grow (Roshanharmaet al el 2018). Further, the extensive fibrous root and rhizome systems, dense foliage, and leafy mulch of bamboo stabilize soil, control soil erosion, and retain water .The leaf litter from bamboo adds organic matter to the soil and contributes to the fertility of the degraded soil. Further, bamboo does not require high investments and, once the plantation is established, it could be managed without high maintenance.

As bamboo grows fasts and could be harvested continuously without replanting in for about 3 to 4 years, it will yield faster returns on investments, thereby attracting investors and farmers. Smallholder farmers play a cost-effective role in land restoration, and, since they are already used to bamboo cultivation, bamboo in restoration could be easily applied in Indonesia. As the availability of managed bamboo increases, households will also switch to bamboo slats that are a renewable alternative to firewood, thus bamboo will also help to reduce deforestation. Furthermore, bamboo diversifies the landscapes, providing food and habitat for numerous species of insects, birds, and Sustainability. Bamboo can be propagating through seeds, using vegetative parts or tissue culture.

There are several ways to recover energy from bamboo biomass, each process results in different products, which can be utilized in many aspects. Energy production from bamboo biomass can be classified into 2 main ways: thermo chemical conversion and biochemical conversion. In the former methods, heat is used to transform bio-matters in bamboo biomass (mostly cellulose) into various products. Biochemical conversion involves the action of microorganism to transform biomass to biogas or biofuel.
Dry bamboo biomass can be used as firewood to generate heat for cooking, boiling and warming in households and small to medium scale factories. It is a good source of energy for remote area where people cannot access electricity and is categorized as a cheap and renewable energy.

Investment in bamboo plantation for energy purposes as the ‘super-material of the 21st century’ need to increase greatly. Deforested areas could be colonized by bamboo four times faster than most native plants and trees. Villagers and land owners in rural areas should be told about the opportunities that bamboo offers; they should be incentivized to grow bamboo for Sri Lanka to become energy self-sufficient.

Bamboo is identified as a renewable energy source and cultivation of bamboo for commercial purposes in Sri Lanka is rather limited due to problems in acquiring suitable land for planting, although it has been widely recognized for excellent production of biomass globally.

Greater Focus on Sustainable Power Generation

As the conventional energy sources are on the verge of depletion, it becomes quintessential for industrial operators to turn to renewable alternatives. Bamboos produce 3x oxygen compared to other trees and its biomass is highly efficient and relatively inexpensive (100% electricity generation through renewable energy by 2050 Assessment of Sri Lanka’s Power Sector). As such, the power sector is welcoming bamboos as an energy source for power generation. This preferential shift is emerging as a safe bet for bamboo producers in the near future. Bamboo can easily compete with the most effective wood species in terms of carbon sequestration capacities. (Sritong, et al 2012)

It can play a significant role in linking climate change mitigation to sustainable economic development in the developing world. So, the Clean Development Mechanism (CDM) projects as per the Kyoto Protocol can be thought of in order to combat global warming. Bamboo biomass has relatively higher heating value than other type of biomass which means it is a good candidate for direct combustion (e.g. co-combustion in thermal power plant). The ash contain of bamboo is much less than other timber. The low moisture contain reduce the energy input to dry the biomass; hence, increase the efficiency of utilization but bamboo has a high moisture contain comparatively other wood. (Scurlock, et al 2000) The calorific value of the bamboo is fairly high and it will give high energy output in the boiler capacities. The fuel characteristic of some biomass feed stocks is provided in the table below:

II. MATERIALS AND METHODS

This research was carried out as two experiments. Propagation trial with selected bamboo species and comparison of biomass properties with available fuel wood, bamboo sources in Sri Lanka.
III. RESULTS AND DISCUSSION

**Experiment 01**

**Table 1: Seed germination % among the treatments with time**

| Treatments                              | 12 days | 15 days | 18 days |
|-----------------------------------------|---------|---------|---------|
| T1 (River sand)                         | 38.74   | 39.84   | 44.11   |
| T2 (River sand + Top soil) 1:1 ratio    | 40.98   | 44.29   | 47.91   |
| T3 (River sand + coir dust) 1:1 ratio   | 35.98   | 40.43   | 42.78   |
| T4 (Compost only)                       | 0       | 0       | 0       |
| T5 (Top soil only)                      | 30.51   | 32.44   | 30.13   |
| T6 (Coir dust only)                     | 36.22   | 35.96   | 38.64   |
| T7 (River sand + compost) 1:1 ratio     | 0       | 0       | 0       |
| F value                                 | 484.77  | 331.98  | 500.38  |
| P value                                 | <0.0001 | <0.0001 | <0.0001 |

**Figure 2: Seed germination % with the time**

Six months old bamboo seeds stored in a refrigerator (4 °C) showed highest germination percentage in 18 days treated with river sand and top soil (1:1 ratio). T4 and T7 treatments with un sterilized compost medium showed 0% seed germination. Therefore, it is better to use river sand with top soil medium for large scale bamboo seed propagation.

**Vegetative propagation**

**Table 2: Time to rooting and survival %**

| Vegetative part                        | Time duration to rooting | Survival % |
|----------------------------------------|--------------------------|------------|
| Stem cuttings (lower part of the culms)| 10 weeks                 | 45%        |
| Air layering                           | 8 weeks                  | 05%        |
| Ground layering                        | 8 weeks                  | 85%        |

Vegetative propagation was studied by using different methods and results showed ground layering gives better performance than other two types. When considering the propagation of stem cuttings, lower part of the culms gives better results than middle and upper parts (Palihakkara, I.R and Weerasinghe, C.M et al (2018). In addition to that tissue culture methods were highly used in large to medium scale propagation programs.
Figure 3: Bamboo seed survival %

Experiment 02

Table 3: Comparison of biomass properties with bamboo (Tested at ITI with sustainable energy authority and UNIDO 2019- Sri Lanka)

| Label                                      | Moisture content / % | Ash content / % (Moisture free basis) | Volatile matter / % (Moisture free basis) | Fixed carbon / % (Moisture free basis) | Gross calorific Value / kcal/kg (Moisture free basis) | Gross calorific Value / MJ/kg (Moisture free basis)² | Rank calorific value |
|--------------------------------------------|----------------------|---------------------------------------|------------------------------------------|----------------------------------------|--------------------------------------------------------|------------------------------------------------------|---------------------|
| Rubber Sawdust–Hevea brasiliensis          | 38.3                 | 1.02                                  | 81.7                                     | 17.3                                   | 3111                                                  | 13.03                                                | 30                  |
| Paddy – Husk(Oryza sativa)                 | 13.5                 | 12.4                                  | 68.4                                     | 19.2                                   | 3163                                                  | 13.24                                                | 29                  |
| Paddy - Bran                               | 27.3                 | 7.72                                  | 74.4                                     | 17.9                                   | 3513                                                  | 14.71                                                | 28                  |
| Rubber off cuts                            | 47.3                 | 4.72                                  | 76.2                                     | 19.1                                   | 3939                                                  | 16.49                                                | 27                  |
| Eucalyptus grandis- Saw dust               | 23.5                 | 0.5                                   | 77.4                                     | 22.1                                   | 4124                                                  | 17.27                                                | 26                  |
| Bagasse                                    | 39.5                 | 4.74                                  | 80.8                                     | 14.5                                   | 4171                                                  | 17.46                                                | 25                  |
| Conifers pinophyta                         | 16.3                 | 3.51                                  | 79.5                                     | 17                                     | 4179                                                  | 17.50                                                | 24                  |
| Denetrocalamus strictus                    | 49.9                 | 3.72                                  | 77.7                                     | 18.6                                   | 4364                                                  | 18.27                                                | 23                  |
| Bambusa bambus                             | 60.9                 | 3.64                                  | 76.1                                     | 20.3                                   | 4510                                                  | 18.88                                                | 22                  |
| Dendrocalamus hookerii                     | 74.6                 | 9.66                                  | 71.4                                     | 18.9                                   | 4558                                                  | 19.08                                                | 21                  |
| Bambusa balcoa(bena bamboo)                | 23.5                 | 2.12                                  | 79.2                                     | 18.7                                   | 4560                                                  | 19.09                                                | 20                  |
| Coconut –Husk Cocos nucifera               | 51.4                 | 7.34                                  | 62.2                                     | 30.5                                   | 4603                                                  | 19.27                                                | 19                  |
| Coconut Fronds                            | 71.1                 | 11.2                                  | 66.4                                     | 22.4                                   | 4651                                                  | 19.47                                                | 18                  |
| Rubber Woodchips                           | 10.6                 | 2.47                                  | 79.1                                     | 18.4                                   | 4688                                                  | 19.63                                                | 17                  |
| Tea - Removed bush mass                    | 15.9                 | 1.38                                  | 24.9                                     | 73.7                                   | 4730                                                  | 19.80                                                | 16                  |
| Dendrocalamus asper                         | 43.4                 | 1.91                                  | 76.2                                     | 21.9                                   | 4762                                                  | 19.94                                                | 15                  |
| Homestead –Giridara – abelia triflora      | 63.2                 | 1.82                                  | 72.9                                     | 25.3                                   | 4861                                                  | 20.35                                                | 14                  |
| Bamboosa vulgaris                          | 62                   | 3.55                                  | 73.1                                     | 23.4                                   | 4907                                                  | 20.54                                                | 13                  |
Table 3, investigated the bio mass characteristics of six important bamboo species viz., Dendrocalamus strictus, Bambusa vulgaris, Dendrocalamus asper, Bambosaa bamboos, Bambosa balcoa, Dendrocalamhu hookery. It is clearly shown in the characteristics of Bambusa vulgaris the most commons bamboo species in Sri Lanka has the highest calorific value which can be used for the energy purposes. In Sri Lanka many of the industries using bio mass for the boilers and heaters ex.: Tea factories, appeal and garment industry, bakeries etc. Since this B. vulgaris is freely available this species could be recommended for the bio mass energy for the industry in Sri Lanka. But there is a government policy barrier to transportation of bamboo.

|Species                        | Ash (%) | V.M (%) | Fixed C (%) | Gross Calorific Value /1 kcal/kg | Fuel Value Index |
|-------------------------------|---------|---------|-------------|----------------------------------|-----------------|
|Tea - Refused tea             | 10.3    | 5.79    | 62.7        | 4922                             | 20.61           |
|Pinus - Pinus sabiniana       | 13.4    | 0.46    | 77.9        | 4943                             | 20.70           |
|Mahogany - Swietenia macrophylla | 12.5    | 0.72    | 78.9        | 4962                             | 20.77           |
|Teak – Tectona grandis       | 11.8    | 1.59    | 79.8        | 4980                             | 20.85           |
|Thabubiarosia -              | 11.6    | 0.33    | 78.6        | 5009                             | 20.97           |
|Cinnamon–Cinnamom um zelencicum | 13.2    | 0.7     | 81.3        | 5038                             | 21.09           |
|Eucalyptus grandis           | 14.6    | 0.17    | 81.4        | 5062                             | 21.19           |
|Eucalyptus micro             | 15      | 0.02    | 81.2        | 5112                             | 21.40           |
|Rubber Wood                  | 27.1    | 0.83    | 82.4        | 5201                             | 21.78           |
|Coconut Shell                | 13.9    | 1.38    | 71.9        | 5239                             | 21.93           |
|Tea - Pruning                | 14.2    | 2.17    | 74          | 5259                             | 22.02           |
|Cyprus - Cupressus sempervirens | 12      | 0.05    | 81.9        | 5724                             | 23.97           |
of Gliricidia and from farmers in the region who grow these trees as the company's out-grower's agricultural programs.

IV. CONCLUSION

Bamboo can be identified as a short rotation renewable energy source with vegetative propagation through different plant materials and seeds in some species. Several characteristics affect the performance of biomass fuels, including the heating value, moisture content, ash content and chemical composition, particle size, and density of the fuel. These characteristics can vary noticeably from fuel to fuel and natural variations of a given fuel type. *Bamboo* *vulgaris* had the highest calorific value among the tested bamboo species and placed 13th out of 30 different fuel-wood types tested.

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