Effect of Different Potting Types and Different Organic Manure Levels on Early Stages of Bamboo (*Dendrocalamus asper*) Growth inside Oil Palm Plantation in Low Country Wet Zone (WL 2a) in Sri Lanka

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ABSTRACT
Bamboos are naturally propagating both sexually and asexually from seeds and rhizomes. *Dendrocalamus asper* is one of the popular multipurpose bamboo species in Sri Lanka and lack of research conducted in the country. Therefore to recommend proper potting type, basal dressing and planting hole dimensions are timely important. The objectives of the present study were to identify effective potting type with proper pot height and suitable basal dressing at nursery stage and effective planting hole dimension at field level along with, measure the vegetative growth of *Dendrocalamus asper*. A field trial conducted at Thalgaswella estate (WL2a) in Galle district, Sri Lanka from May 2019 to March 2020. At the nursery stage seedlings were arranged in a Completely Randomized Design (CRD) with twelve replicates. At the field level plants were arranged in Randomized Completely Block Design (RCBD) with six replicates and data were statistically analyzed by using software (SAS version 9.1). According to the results, nursery with 10” height black polythene pot with sand: coir dust: compost: top soil in 2; 1; 3/4; 1/2 potting media at nursery stage and effective planting hole dimension at field level along with, measure the vegetative growth of *Dendrocalamus asper*. The results, nursery with 10” height black polythene pot with sand: coir dust: compost: top soil in 2; 1; 3/4; 1/2 potting media and at field level bamboo plants planted in 2 x 2 x 2½ feet size hole was shown the highest growth performance at 6 months after field establishment. Therefore it is recommended to use 10” height black polythene pot with the ratio of sand: coir dust: compost: top soil in 2; 1; 3/4; 1/2 potting media at nursery level. When transfer plants to field planting 2 x 2 x 2½ feet planting hole is more suitable.

Keywords: Bamboo, Nursery stage, Potting media, Plant hole.

1. INTRODUCTION

*Dendrocalamus asper*, also known as giant bamboo, or dragon bamboo (in China), is a giant tropical, dense clumping species native to Southeast Asia. Due to its common occurrence across Asia and its attractive features as well as ease of harvesting, this species has been introduced widely across Latin America and Africa. It is a sympodial or clumping bamboo that does not show lateral growth and therefore has no invasive properties. Timber bamboo has traditionally used as a building material for heavy construction due to the fact that its culms are large diameter and very straight, and its young shoots are consumed as a vegetable. *Dendrocalamus asper* is the most popular bamboo species in Asia whose shoots are used as a source of food.

Culms of *Dendrocalamus asper* are greyish green, becoming dull brown on drying. Lower nodes of young culms are covered with golden brown hairs which are the most easily distinguishing factor of the species. Young shoots are brownish black. Internode length is 25–60 cm, diameter 3.5–15 cm. The culm walls are generally very thick. Mature culms grow very straight with tapering occurring only at the upper level, and the culms show very little branching, making them easier to harvest upon maturity. This species flowers intermittently, with flowering events occurring at time intervals greater than 60 years. The seed is very fragile and seedlings have a high mortality rate requiring considerable care and controlled environments in their first few weeks of growth.

Although with a wide natural occurrence and having been introduced at small scale to many countries it has only recently been grown under a commercial setting. In 2015 Eco Planet Bamboo became the first entity globally to grow.

In oil palm industry, the oil extraction process involves the reception of fresh fruit bunches from the plantations, sterilizing and threshing of bunches to free the palm fruit, mashing the fruit and pressing out the crude palm oil. The crude oil is further treated to purify and dry it for storage and export. Large scale plants, featuring all stages required to produce palm oil to international standards, are generally handling from 3 to 60 tons of FFB/hr. The large installations have mechanical handling systems (bucket and screw conveyers, pumps and pipelines) and operate continuously, depending on the availability of FFB. Boilers, fueled by fiber and shell, produce superheated steam, used to generate electricity through turbine generators. The lower pressure steam from the turbine is used for heating purposes throughout the factory. Most processing operations are automatically controlled and routine sampling and analysis by process control laboratories ensure smooth, efficient operation.

Most of the processing factories in plantation sector of the country (tea, rubber, oil palm and coconut)
require high amount of firewood. The heat output of bamboo is impressive and it gives a good boost of temperature. Bamboo is quick growing firewood. Therefore, it might be a better replacement for conventional energy sources. Especially, since it grows so fast.

Bamboo biomass energy has great potential to be an alternative for fossil fuel. Bamboo biomass can be processed in various ways (thermal or biochemical conversion) to produce different energy products (charcoal, syngas and biofuels), which can be substitutions for existing fossil fuel products. Bamboo biomass has both advantages and drawbacks in comparison to other energy sources. It has better fuel characteristics than most biomass feed stocks and suitable for both thermal and biochemical pathways. The drawbacks of bamboo biomass include establishment, logistic and land occupation.

Industrial sector, especially in developing countries needs higher quantities of cheap energy. To supply that required energy demand, fuel wood plays a key role especially in primary and small to medium scale industries including plantation sector. Therefore plantation companies in Sri Lanka were decided to practice different solutions. One of the major solutions is to establish their own bamboo plantations as a boundary crop along the young oil palm plantation as an energy plant.

At present it is difficult to collect proper same aged planting materials for medium to large scale industrial bamboo plantations in Sri Lanka and lack of proper guidance on, suitable basal dressing and standard dimensions for planting holes were not researched in Sri Lanka.

Therefore, this study was designed to identify the proper potting type, potting height, basal dressing and size of planting hole under Sri Lankan condition.

Objectives of this research were, Identify effective potting type with proper pot height, find the suitable basal dressing at nursery stage, find the effective hole dimensions at field level and measure the vegetative growth parameters at nursery and field level of Dendrocalamus asper.

II. MATERIALS AND METHODS

A field trial is conducted at Thalgaswella estate in Galle district, low country wet zone (WL2a) in Sri Lanka from May 2019 to March 2020, to find out seed germination percentage, proper potting type, potting height, basal dressing and planting depth is conducted in two stages at early stage of bamboo nursery (Dendrocalamus asper) and later growth performance inside the oil palm plantation.

Seed coats were removed and soaked them in water about three hours. Then germination media (sand: coir dust: compost; top soil in 2; 1; 1/2; 1/2) was filled in to the trays and seeds were put in to those trays. After three weeks (twenty-one days), seedlings were transferred to the nursery.

[Compost nutritional value (C%=8.06, N%=1.12, P%=0.60, K%=0.44, Mg%=0.36)]

Two pot types were used. Those were black polythene bags (150 gauges) and transparent water bottles covers with Diyaberu (Dillenia retusa) leaves were used. Two pot heights (8” and 10”) were used. Two basal dressing ratios were used. Those were; sand: coir dust: compost; top soil in 2; 1; 1/2; 1/2 and sand: coir dust: compost; top soil in 2; 1; 3/4; 1/2. Two months old plants were transferred to the field.

Table 1: Treatments at nursery stage

| Treatment | Description |
|-----------|-------------|
| T₁        | Black polythene, 10” height, Sand:Coirdust:Compost:Topsoil in 2:1:1/2:1/2 |
| T₂        | Black polythene, 10” height, Sand:Coirdust:Compost:Topsoil in 2:1:3/4:1/2 |
| T₃        | Black polythene, 8” height, Sand:Coirdust:Compost:Topsoil in 2:1:1/2:1/2 |
| T₄        | Black polythene, 8” height, Sand:Coirdust:Compost:Topsoil in 2:1:3/4:1/2 |
| T₅        | Plastic bottle covered by Diyaberu leaves, 10” height, Sand:Coirdust:Compost:Topsoil in 2:1:1/2:1/2 |
| T₆        | Plastic bottle covered by Diyaberu leaves, 10” height, Sand:Coirdust:Compost:Topsoil ratio 2:1:3/4:1/2 |
| T₇        | Plastic bottle covered by Diyaberu leaves, 8” height, Sand:Coirdust:Compost:Topsoil ratio 2:1:1/2:1/2 |
| T₈        | Plastic bottle covered by Diyaberu leaves, 8” height, Sand:Coirdust:Compost:Topsoil ratio 2:1:3/4:1/2 |

Two planting depths such as; 2’ x 2’ x 2’ and 2’ x 2’ x 2 ½’ were used. Plant spacing was 5m x 5m. CRD design with eight treatments and twelve replicates at nursery stage and RCBD design with sixteen treatments and six replicates at field level. Plant heights, number of leaves, number of shoots were measured at two weeks intervals in the nursery and four weeks intervals at the field were measured. Statistical analyses were carried out by using software (SAS version 9.1) and Microsoft Excel 2007.
Treatments at field level

| Treatment | Potted mixture | Substrate type |
|-----------|----------------|----------------|
| T1        | P1 H1 B1 D1    | T10.5 P1 H1 B1 D2 |
| T2        | P1 H2 B1 D2    | T9.7 P1 H2 B1 D2 |
| T3        | P1 H3 B1 D3    | T9.8 P1 H3 B1 D3 |
| T4        | P1 H4 B1 D4    | T9.9 P1 H4 B1 D4 |

P1 = Black polythene bag in nursery  P2 = Plastic bottle covered by Diyaberu leaves in nursery  H1 = 10” height pot in nursery  H2 = 8” height pot in nursery  B1 = Sand:Coirdust:Compost:Topsoil in 2:1:2/1:1/2 basal dressing  B2 = Sand:Coirdust:Compost:Topsoil in 2:1:3/4:1/2 basal dressing  D1 = Planting depth is 2½ feet  D2 = Planting depth is 2 feet

III. RESULTS AND DISCUSSION

Mortality% and germination% of bamboo seeds

Mortality % of bamboo seeds were 46.48%. Due to 165 seeds were not emerged from 355 seeds. Seedlings were emerged after 10 -12 days at nursery beds. Germination % after 10th, 11th, 12th and at nursery transferred day was 34.65%, 44.51, 53.52 and 53.52 respectively.

Germination% = \( \frac{\text{No of germinated seeds}}{\text{No of seeds were planted}} \times 100 \)

Results at the nursery stage

Table 2: Estimated mean rank sum of bamboo seedlings at the nursery stage.

| Treatment | Seedlings’ height (cm) | Leaves per plant | shoots per plant |
|-----------|------------------------|------------------|------------------|
| T1        | 16.25\(^a\)            | 6.433\(^{abc}\)   | 0.35\(^a\)       |
| T2        | 16.75\(^a\)            | 6.967\(^c\)       | 0.383\(^a\)      |
| T3        | 14.8\(^a\)             | 5.8\(^a\)         | 0.15\(^a\)       |
| T4        | 15.683\(^a\)           | 6.133\(^b\)       | 0.25\(^a\)       |
| T5        | 16.05\(^a\)            | 6.2\(^{abc}\)     | 0.217\(^a\)      |
| T6        | 16.5\(^a\)             | 6.717\(^{abc}\)   | 0.317\(^a\)      |
| T7        | 14.517\(^a\)           | 5.6\(^a\)         | 0.05\(^a\)       |
| T8        | 15.167\(^a\)           | 5.867\(^a\)       | 0.083\(^a\)      |

Means represented by the same letter are not significantly different at \( P \leq 0.05 \) significant level

Table 2 shows the distribution of seedling heights among the treatments. It clearly shows that T2 is giving the highest value and there is no any significant difference among the treatments. In T2 it has been the 10” height planting black polythene bag and the potting mixture was 2:1:3/4:1/2 of sand, coir dust, compost, top soil respectively. This may be due to better moisture retention in the planting bag and easy root penetration in 10” bag. Lowest height was recorded in T7 where it was planted in a plastic bottle covered by Diyaberu leaves. It could be due to the low height (8”) and not favourable conditions inside the plastic bottle to better growth of seedlings. Still it could be seen that 10” height plastic bottle covered by Diyaberu leaves (T6) has given more reasonable height (16.5 cm) due to better height for root penetration.

Number of leaves per plant has not showing strong significant among treatments. Treatment 2 (T2) is showing the highest number of leaves per plant whilst T7 recorded the lowest leaf count per plant. When we consider the T2 and T6 both the scenarios have been received the same potting mixture with same height of planting bag and bottle respectively. Both the treatments showing higher number of leaves per plant. This could be due to the more height has facilitate better root growth of the seedling and thereby get more nutrients from the media and height of the black polythene bag with more quantity of compost fraction in potting media which enabled more moisture retention than T7 treatment. A study conducted in Costa Rica on bamboo species also reported that species responded to substrate type [Wightman et al., 2001]. Generally all the plants in black polythene (gauge 150) bags showed better growth in relation to number of leaves per plant than to that of in plastic bottles covered by Diyaberu leaves. This may be due to the fact that black polythene given a better temperature to the potting media to rapid root growth and uptake of plant nutrients.

There is no significant difference between treatments in respect to the number of shoots per plant. Same trend follows as in plant height and number of leaves per plant where T2 in showing the highest number.
of shoots per plant whilst T7 is the lowest. This could be attributed due to mainly two reasons, such as plant bag height (10”) and highest fraction (3/4) of compost in the potting media. Both these factors have provided more space to root penetration and availability of moisture to the plant respectively. This may be due to better establishment of seedlings in potting media and received proper fertilizer nutrients to plant. Fekadu et al., (2011) used different levels of compost and sand in a highland area but reported significant differences among the treatments.  

*Effect of pot type, pot height and basic fertilizer for bamboo seedlings growth at nursery stage.*

**Graph 1:** Effect of planting pot height, pot type and basic fertilizer mixture for bamboo seedlings growth at nursery stage.

Newly emerged shoots have received its highest value faster than to seedling shoot height. This may be due to better moisture and nutrient supply by the potting mixture in T2. Abera, B. et al., (2018) showed that polybag size was the factor that had the greatest effect on seedling growth, suggesting that the effects of small or medium polybag size cannot be mediated by using appropriate planting soil mixtures.

*Graph 2 - Effect of parameters of pot type, pot height and basic fertilizer for bamboo plants growth in two weeks’ time intervals at the nursery stage.*

**Graph 2:** Growth of bamboo plants with two week time intervals

(1) (2) (3)
Graph 2 (1) shows the treatment effect on number of shoots per plant with the time. After 6th week of nursery planting there is a sharp increment of number of shoots per plants in almost all the treatments. This could be due to better establishment of root system in the potting media and improved uptake of plant nutrients. The production of quality seedlings requires nutrient management, which was reported as a potential means to change morpho-functional traits of tree seedlings (Trubat et al., 2010).

Seedling height also shows increasing pattern with time (graph 2-2). Treatment 2 (T2) shows the highest value for this parameter whilst at the T7 shows the lowest. This may be due to height of the nursery bag (10") in T2 and compost fraction (3/4) in potting media against T7. After the 6th week plants representing all the treatments showed a quick increment of height. This could be attributed due to better establishment of root systems of plants and started more uptake of plant nutrients. Also this graph shows that when increasing pot height and compost ratio in potting mixture there is a better plant height gain in bamboo plants. According to findings of Dominguez-Larena et al., (2006) and Dumroese et al., (2011) better seedling performances in larger pots is due to the availability of more growing space, enabling the early development of a root system to escape drought. The production of quality seedlings requires nutrient management, which was reported as a potential means to change morpho-functional traits of tree seedlings (Trubat et al., 2010).

Results at the field

| Treatment | Height (cm) | Leaves per plant | Shoots per plant |
|-----------|-------------|------------------|------------------|
| T1        | 247.5<sup>a</sup> | 20.3<sup>abc</sup> | 8.2<sup>abc</sup> |
| T2        | 224.67<sup>bcdef</sup> | 18<sup>abcd</sup> | 5.83<sup>abc</sup> |
| T3        | 257<sup>b</sup> | 22.33<sup>c</sup> | 8.67<sup>b</sup> |
| T4        | 228.17<sup>cde</sup> | 18.33<sup>abcd</sup> | 6<sup>abc</sup> |
| T5        | 234<sup>de</sup> | 18.73<sup>abcd</sup> | 6.5<sup>abc</sup> |
| T6        | 216.34<sup>ef</sup> | 17.5<sup>a</sup> | 3.93<sup>a</sup> |
| T7        | 239<sup>g</sup> | 19.7<sup>cd</sup> | 7.33<sup>abc</sup> |
| T8        | 219.84<sup>abc</sup> | 17.83<sup>abc</sup> | 4.33<sup>a</sup> |
| T9        | 243.67<sup>b</sup> | 19.3<sup>cd</sup> | 7.83<sup>abc</sup> |
| T10       | 224.5<sup>b</sup> | 17.83<sup>abc</sup> | 5.83<sup>abc</sup> |
| T11       | 254.17<sup>c</sup> | 21.5<sup>ef</sup> | 8.33<sup>b</sup> |
| T12       | 227.17<sup>cde</sup> | 18<sup>abcd</sup> | 5.83<sup>abc</sup> |
| T13       | 233<sup>d</sup> | 18.57<sup>abcd</sup> | 6.17<sup>abc</sup> |
| T14       | 214.34<sup>+</sup> | 17.17<sup>a</sup> | 3.53<sup>a</sup> |
| T15       | 236.83<sup>+</sup> | 18.85<sup>abcd</sup> | 6.67<sup>abc</sup> |
| T16       | 219.67<sup>abc</sup> | 17.73<sup>abc</sup> | 4.19<sup>ab</sup> |

Means represented by the same letter are not significantly different at P ≤ 0.05 significant level

At the field planting table 3 shows that plant height have significant difference between treatments. Treatment 3 (T3) shows highest plant height whilst T14 recorded the lowest. This may be due to higher value of black polythene pot height (10"), higher fraction of compost in potting media (3/4) and depth of planting hole (2 ½") at the field. These factors may have helped to achieve better growth performance at the field. Bamboo is naturally a fast growing plant (Qisheng et al., 2002) and it need more nutrients and moisture for a better and rapid growth. More depth has facilitated the plant to early establishment and rapid growth in the field [Wong, 1995]. Number of leaves per plant after field planting also shows few significant differences among treatments. There is no strong relationship between treatments. The highest number of leaves per plant has received in T3 and lowest at T14. This may be due to the deeper planting hole (2 ½") in T3 has allowed plant to penetrate its’ root system effectively and rapid uptake of plant nutrients especially nitrogen to enable more vegetative growth. Treatment 3 (T3) and treatment 11 (T11) are the only two treatments which were able to record more than 20 leaves per plant. Both these treatments are having 2 ½" deep planting hole. As a rule, larger and deeper planting holes are always better and allow for easier establishment of newly planted bamboos [Wong, 1995].

There is no proper significant difference showing among treatments on number of shoots per plant after field planting. The highest number of shoots per plant was recorded in T3 whilst T14 recorded the lowest. Same pattern has fallowed T11 and T1 where the planting depth was 2 ½ feet. This factor would have promoted the easy penetration of root system and uptake more nutrients from soil and generate more number of shoots per plant.

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Graph 3: Effect of planting pot type, pot height and basic fertilizer mixture at nursery stage and planting depth at field level for bamboo plants growth at the field on plant height and number leaves per plant.

IV. CONCLUSIONS AND RECOMMENDATIONS

Seedlings were emerged after 10-12 days of sawing at nursery beds and mortality rate of Seedlings were emerged after 10-12 days of sawing at nursery beds and mortality rate of *Dendrocalamus asper* samples was 46.48%. Best pot height would be 10” and the most appropriate potting mixture is 2:1:3/4:1/2 (sand:coir dust:compost:topsoil) at nursery stage of bamboo planting. Gauge 150 black Polythene is the best material to make nursery bags for bamboo planting.

New shoot growth was faster than height increment in seedlings. At the field there was an observation that new shoots get started growing upward rapidly to get establish in the field. With the increment of compost level within the treatments it could be seen that highest level has highest seedling height, highest number of leaves and shoots than other compost levels (i.e. 3/4) and it was coupled with higher performance in black polythene pots than plastic bottles covered by *Diyabera* leaves.

Pot height has direct relationship with plant growth at initial stage and field stage. Higher the pot height (i.e. 10”) has facilitated plants to penetrate its root system quickly and establish well in nursery and field. Shoot stem diameter was higher in new shoots with more improved longer internodes length. With these results it can be concluded that planting hole depth of 2 1/2 feet is the ideal depth for planting bamboo seedlings in the field.

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