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Comparative growth performance of *Leucaena leucocephala* seedlings raised in nursery bed, polybag and root trainers

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Abstract— **Growth of *Leucaena leucocephala* seedlings grown in polybag, nursery bed and root trainers was investigated with an aim to select suitable container for quality seedlings for large scale plantation programs. Seed germination and seedling growth were assessed for shoot length, root length, collar diameter, fresh weight, dry matter production, leaf number and number of nodules of the seedlings. Vigor index, quality index, imbibition period, energy period and root shoot ratio were also calculated for each treatment. Germination percentage was found better in nursery bed. Seedlings raised in polybags of 23 x 15 cm size revealed best performance in respect to germination and other growth parameters. However, root-shoot ratio was higher in root trainer in comparison to other treatments. Polybag size of 23 x 15 cm was found suitable in the nursery for quality seedling production of *Leucaena leucocephala* .**

INTRODUCTION

To mitigate demand supply gap between forest product demand and supply in forestry sector, Bangladesh Forest Department introduced *Leucaena leucocephala* in August 1977 from the Philippines [1]. *Leucaena* probably offers the widest assortment of uses compared to all tropical legumes. Through its many varieties, *Leucaena* can produce nutritious forage, firewood, timber, and rich organic fertilizer. The wood, leaves, twigs have a medicinal value as well as tannin [2]. It's diverse uses in regenerating tropical hill slopes and providing windbreaks, firebreaks, shade and ornamentation. *Leucaena* is relatively resistant to the pests and diseases. More over in mixed cropping it is reported that Bananas may do better in the shade of *Leucaena* [3]. Wood specific gravity of *Leucaena leucocephala* is about 0.50-0.70 [4]. Leucaena wood has the potential to become a major source for pulp and paper, round wood and construction materials [5]. In some cases, the wood of *Leucaena leucocephala* is used for light furniture, handles of agricultural tools [6]. The cylindrical type of bole is also used for Posts, poles, rafts [2]. Plants are used in some countries for shade for black pepper, coffee, cocoa, quinine, and vanilla and for hedges [3]. Fuel wood calorific value of this species is about 4200-4600 [4]. This species is browsed by cattle, goats [4]. In Bangladesh it was reported that the leaves, twigs and fruits are excellent fodder for domestic animals [2], [6]-[8]. The powdered form of seeds is used as poultry feed [7]. Young pods and seeds are cooked and eaten with rice [9]. In recent, British-American Tobacco Company Ltd. utilizes the wood chips of Ipil-Ipil for the substitute of Tobacco. So it is more economic as well as to conserve human health. Due to its multipurpose utility and wide range of ecological amplitudes (especially suitable to Bangladesh Environment) the species is recommended for roadside as well as khetland other than forest land [8]. The species has potentiality in newly formed islands and coastal areas of the country where immediate plantations are essential for stability of soils and protect the country from unexpected flood and other natural calamities.

However, the success of a plantation program largely depends on prompt, germination of seeds, growth parameters and even on the containers in which seeds are sown. Seedling raising at the nursery stage is a very important aspect of the program. The nursery technology should be in such a way that it will produce good quality and handsome quantity of seedlings within a reasonable period of time. Moreover, the technology should be cost effective. Containers used for growing tree seedlings have passed through a number of evolutionary shapes and designs over time. Any type of receptacle which can be used to contain the medium, seed and later, the seedling is called container. Different kinds of containers i.e, earthen pots and tubes, palmyrah and bamboo baskets, seed boxes, leaf, cups or 'doras', tin trays, manure bricks and even cylindrical rolls of moss were used in the past [10]. Most of these containers, however, do not possess the chief requirements of lightness and cheapness. They were, therefore, gradually replaced by light weight, durable, easy to transport, cheap and resistant polythene bags. Polythene bags are available in different volumes. No proper information is available as to which size and what type of container should be used to obtain optimum growth of the seedlings. Present investigation was made to find the suitable size of the container to obtain optimum growth of *L. leucocephala* seedlings in the nursery.

MATERIALS AND METHODS

The study was conducted in the nursery of the Institute of Forestry and Environmental Sciences, Chittagong University Campus during the month of April-September. Forest top soil was mixed with decomposed cow dung in a ratio of 3:1. A total of 120 poly bags and root-trainers were filled with the sieved potting media. Three types of containers with the same potting media, were used to compare the *Leucaena leuccephala* seedling growth are: T_0 : Root-trainer; T_1 : Poly bag of size 23×15 cm (9×6 inch); T_2 : Poly bag of size 12×15 cm (5×6 inch) and T_3 : Traditional nursery bed (100 cm x 125 cm). (Note: The specific type of Spencer-Lamaire Root-Trainer was used. The root-trainer was Fleet 'B' block of four cells each 350 cc pot space with 20 cm depth. Ten blocks (40 cells) fit into a plastic fleet holder (also called basket or tray), size 40 cm long×26 cm wide×13 cm height. 0.06 mm thick, white and transparent polybags and Nursery bed of 5 m length and 1.25 m. wide was used). A randomized complete block design with four replicates was used in the study. *A. procera* seeds were sown in the subplots of the nursery bed directly and covered with thin layer of sand and soil. Adequate care and maintenance were taken from the time of seed sowing up to the harvesting of seedlings.

The effects of seed sowing in different containers were assessed periodically through counting germination and initial growth performance of the seedlings. At the age of four months, five dominant seedlings from each treatment were randomly selected and uprooted very carefully to estimate the seedling biomass. The seedlings were measured for shoot length, collar diameter, root length and total oven dry weight (leaf, shoot and root components). Leaf, shoot, root and nodules were oven dried at 70^{O}C for 48 hours until the constant weight is obtained. The germination and growth data were analyzed statistically by using computer software package SPSS for determining the morphological growth variation. Germination energy was calculated using the formula of [11]. Vigor Index was calculated according to [12]. The Quality Index (QI) of the seedlings was computed as developed by [13].

RESULTS AND DISCUSSION

Seed germination

Leucaena leuccephala attained 100% germination within 8 days energy period in T_3 treatment followed by T_0 (Germ. 59%, EP 11 days), T_2 (Germ. 55%, EP 3 days) and T_1 (Germ. 34%, EP 7 days) treatment. T_0 treatment (root trainers) took longer time (energy period 11 days) and germination percent (59%) was high in comparison to other containers (Table 1).

Table 1. Effect of different containers on germination imbibition, germination period of *Leucaena leucocephala* seeds.

Treatments	Germination %	Imbibition (days)	Germinations Period	Energy period (days)
T0	59.0 b*	4	15	11
T1	34.0 c	6	13	7
T2	55.0 b	5	8	3
T3	100.0 a	5	13	8

* Means followed by the same letter (s) are not significantly different at p<0.05, Duncan's Multiple Range Test (DMRT).

The effect of different containers on mean daily germination percent was highest (Figure 1) at the 8th day after sowing in T_2 treatment. The cumulative germination percent for treatment T_3 rises sharply from the 4th to 12th days and remains constant upto 24th day. The cumulative germination percent remains highest for T_3 treatment followed by T_0, T_1 and T_2 treatments (Figure.2).

Growth performance of the seedlings

Table 2 presents the comparative morphological information recorded in different treatments. The mean total length of the seedlings was highest in T_1 (95.7 cm) followed by T_0, T_3 and T_2 treatments. Considering the collar diameter of the seedlings, T_1 has highest collar diameter (8.4 mm) followed by T_0 and is significantly different from T_3 and T_2 . However, the mean number of leaves was same (11) in T_0, T_1 and T_3 and not significantly different from T_2 (10).

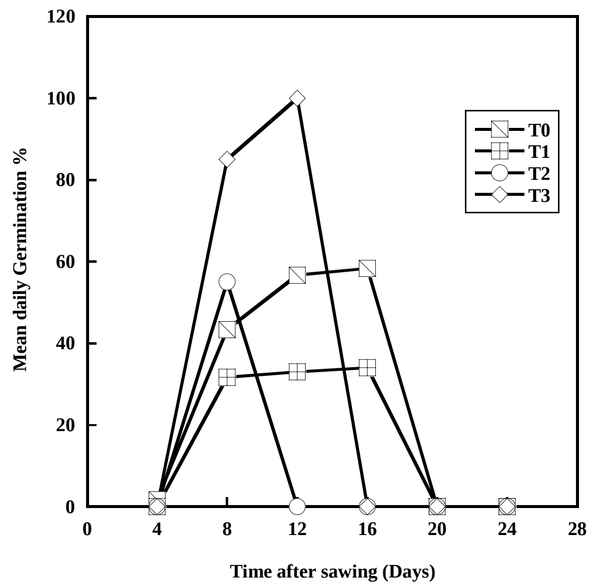

Fig. 1. Effect of different containers on mean daily germination percent of *Leucaena leucocephala* seeds.

As shown in Table 3. Mean shoot dry weight (g) was highest in T_1 and significantly different from T_0, T_3 and T_2. Root dry weight (g) of the seedlings was highest for T_1 and significantly different from other three treatments. Same trend was also found for Leaf dry weight (g). Considering the seedling dry weight, T_1 attained the highest biomass followed by $T_{0,}$ T_2 and T_3. Considering the vigor index, T_3 attained the highest value followed by T_0. The lowest vigor index was found for T_2, and T_1. But, T_1 attained the maximum seedlings quality index followed by T_0 and significantly different from T_2 and T_3. The high root/shoot ratio was observed in T_2 followed by T_0, T_1 and T_3 treatments.

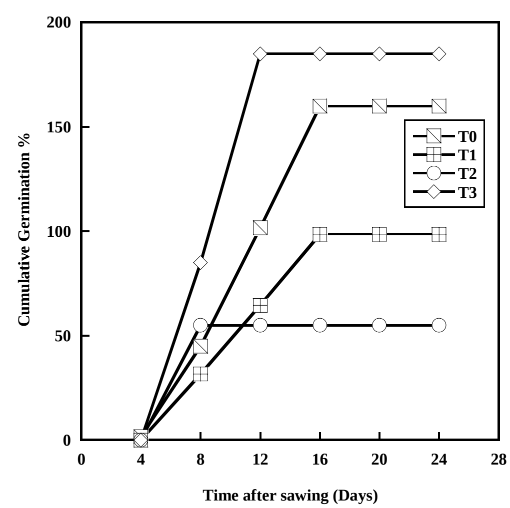

Fig. 2. Effect of different containers on cumulative germination percent of *Leucaena leucocephala* seeds.

Table2. Comparative morphological study at 4 months aged *Leucaena leucocephala* seedlings in different containers (under nursery conditions).

Treatment	Length(cm) Shoot	Root	Total	Collar dia (mm)	Vigor Index	Leaf no.
T0	73.0ab*	35.7b	108.7ab	5.1ab	6407.b	11.0 b
T1	95.7a	47.0a	142.3a	8.4a	4838.b	11.0 b
T2	62.7b	25.0b	87.7b	4.5b	4838.0c	10.0 b
T3	71.3ab	33.3ab	104.7ab	4.83b	10460a	11.0 b

* Means followed by the same letter (s) are not significantly different at $p<0.05$, Duncan's Multiple Range Test (DMRT).

Table 3. Comparative study of dry weight, quality index (QI), root/shoot ratio (R/S) of at 4 month aged *Leucaena leucocephala* seedlings in different containers (under nursery conditions).

Treatment	Oven-dry weight (gm) Shoot	Root	Leaf	Total	(QI)	R/S
T0	8.3b	5.56b	5.97b	19.83b	1.25	0.67 ns
T1	18.5a	12.28a	16.3a	47.08a	3.65	0.66 ns
T2	3.81b	3.29b	3.87b	10.97c	0.73	0.86 ns
T3	4.88b	1.83b	3.41b	10.12c	0.58	0.38 ns

* Means followed by the same letter (s) are not significantly different at $p<0.05$, Duncan's Multiple Range Test (DMRT).

Comparative nodulation behavior is shown in Table 4. Maximum 50 nodules were recorded in T_1 and the number of nodules recorded in T_3, T_2 and T_0 were significantly lower than T_1. Highest fresh and dry weight of nodules was recorded T_1 followed by T_2. Nodule dry weight was significantly higher in T_1 and T_2 compared to T_0 and T_3. In the present study, the seedling morphometric parameters were superior in 23×15 cm (9×6 inch) polybags (Table 4).

Table 4. Comparative nodulation study at 4 month aged *Leucaena leucocephala* seedlings in different containers (under nursery conditions).

Treatment	Nodule Number	Fresh Wt. (gm)	Dry Wt. (gm)
T0	8.0d*	0.14c	0.07b
T1	50.0a	0.41a	0.16a
T2	19.0c	0.25b	0.09b
T3	38.0b	0.24b	0.06b

* Means followed by the same letter (s) are not significantly different at $p<0.05$, Duncan's Multiple Range Test (DMRT).

Significant differences were observed for all the growth parameters among containers, root-trainers and seedlings grown in nursery bed. It is revealed that the size of the container has clear influence on all the characters, e. g. size, root length, shoot height, shoot collar diameter, number of leaves, number of nodules, root and shoot fresh weights, root and shoot dry weights, and quality index, vigor index, root/shoot ratios throughout the growth period of the seedlings. The increased root lengths of container grown seedlings perform better on adverse sites than do bare root seedlings [14] and they survive better under drought conditions [15]. Milks *et al.* [16] reported that plants growing in small containers have growth problems due to poor aeration or low water holding capacity of the growing medium. Aeration porosity is considered to be the most important physical property of any growing medium [17]. The container of 9 x 6 inch size recorded superiority over 5 x 6 inch size polythene containers and then nursery bed and the seedlings grown in the root trainer for the above growth parameters of the seedlings. The seedlings raised in root trainers have shown poor performance for height, collar diameter, number of nodules and the biomass parameters for *A. procera* in comparison to other treatments. This may be due to the limited space available to the root system in root trainers [18]. Seedlings can better be compared on the basis of quality parameters, rather than on actual values on height or collar diameter. Seedling quality specifications have traditionally been based on certain morphological characters such as root/shoot ratio and some other root features [19]-[22]. The root /shoot ratio indicates the higher amount of root production which is also a pre-requisite for seedling establishment through anchorage and more absorption of nutrients [23]. Poor nodulation was observed in seedlings raised in root trainers. However, root trainer raised seedlings registered the maximum values on root/shoot ratio among the treatments. Higher values on root/shoot ratio were observed in seedlings raised on polybags in comparison to seedlings raised on nursery beds. Several Researchers found suitable container size for particular species such as 30×20 cm for *Cocoa* [24], 30×15 cm for *Santalum albam* [25], 26×12.6 cm for *Azadirachta indica* [26] and 25×15 cm for *Albizia lebbeck* [27]. However, the treatments when compared on the basis of seedling quality parameters in different containers, 23×15 cm size (9×6 inch) container is the best in order to obtain vigorous seedlings capable of surviving under stress nursery condition.

Growth performance of seedlings increased with the increase of polybag sizes in comparison to nursery bed and root trainers. Longer containers have significant influence on the survival, height and nodule formation under nursery conditions. The present study has provided information that differences in seedlings growth were significant throughout the treatments. The seedlings raised in root trainers showed poor performance in comparison to other treatments.

For quality seedlings, polybags of T_1 treatment (23×15 cm size, or 9×6 inch) produce the best seedlings followed by T_2 (12×15 cm or 5×6 inch), T_3 (nursery bed) and T_0 (root trainer) treatment. T_1 treatment may be recommended to raise the quality seedlings for large scale plantations in short time due to its lower cost involvement. However, for successful afforestation and reforestation programs and maximum survival of seedlings in the field, the bigger size poly bags as well as the quality seedlings are essential in field planting. So, after keeping cost factors in consideration polybags of bigger sizes (23×15 cm size =

9×6 inch) may be preferred for raising large and vigor seedlings.

CONCLUSION

Based on the results of the present experiment, it may be recommended that polybags of 23 x 15 cm in size may be used in order to obtain vigorous *Leucaena leucocephala* seedlings capable of surviving in plantation area for quality seedling production programs.

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