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Original Research Paper

Use of Municipal Garbage for the Production of Quality *Swietenia macrophylla* King (Mahogany) Seedlings

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ABSTRACT

Domestic refuse and non-hazardous wastes such as commercial and institutional wastes are turning to become the major threats to the human health and environment. Municipal waste management is the most challenging issue since these wastes are dumped in open places and not being used or treated for any purpose. It has created a real threat not only to the living environment but also for the cultivation of crops as well as afforestation. The present investigation was conducted to study the influence of two weeks decayed or stored waste materials as component potting media on the growth and vigour of *Swietenia macrophylla* (mahogany) seedlings. The municipal waste, coir waste and tea wastes were mixed with sand and soil in different concentrations. At the end of the study, the growth and biomass production was higher in soil : partly decayed municipal waste in 1:1 (T2) and high quality seedlings were produce in control (soil, sand and cow dung in 1:1:1). Above ground and below ground biomass was maximum produced by soil : partly decayed municipal waste (T2) and control (T1) respectively. The physiological characters like number of leaves, specific leaf weight and chlorophyll content were highest in soil, the potting media of partly decomposed municipal waste : sand mixture (T5). Leaf weight and relative growth rate gave highest in soil : partly decayed tea waste : sand in 1:1:1 (T7). The present study revealed that potting media of partially decomposed municipal as well as tea waste in combination with soil and sand provided better performance in growth attributes. The present investigation reiterated that municipal or industrial waste will be a good alternative to the standard potting media which is widely used in the mass production of seedlings of mahogany in the nursery.

INTRODUCTION

Municipal solid waste is a heterogeneous mass of discarded waste material of industrial and commercial activities of human beings. They are normally non-flowing materials such as plastic, paper metal, glass, kitchen wastes and market wastes (Sharma 2002). Spooner (1971) has reported that solid waste comprise countless different materials like dust, food waste, packaging in the form of paper, metals, plastic, glass pieces, discarded clothing and furnishings, garden waste and hazardous and radioactive wastes. With the looming urbanization and changes in lifestyle and food habits, municipal solid waste has been proliferating rapidly and its composition keeps changing periodically. Solid waste management is the effort of removing and disposing all the unwanted material through a carefully, planned and judicious use of means. Shah (2000) reiterated the planning, financing, construction and operation of facilities for the collection, transportation, recycling and final disposition of solid waste. It is based on principles such as engineering, economics, public health, conservation, aesthetics, environmental considerations and social and ethical issues.

Swietenia mcrophylla (Family: Meliaceae) is a promising timber species, among important timber of in the round wood. It is able to tolerate a wide range of environmental conditions and is found naturally in both tropical dry and wet forest types. The economic importance of timber may due to the attractive light reddish colour and high durability. In the recent times mahogany gained a wide acceptance among the tree growers in Kerala. In Kerala, despite the favourable agroclimatic and edaphic conditions and the concomitant production potential, the forest plantations contribute marginally to meet the state wood demand (less than 25%) reported by Krishnankutty (1990). Establishing forest plantations to meet the ever-increasing demand for tree products have been a long standing tradition in the tropics (Evans 1990).

The research studies conducted elsewhere revealed that the waste materials like municipal garbage could be used for cultivation of vegetables and ornamentals particularly when supplemented with some nutrients. But information regarding the effect of these solid wastes on the growth and vigour of tree seedlings either in the nursery or in the plantation are very scanty. Scientific information on the influence of municipal garbage on growth, nutrient uptake,

biomass production, chlorophyll production and leaf growth behaviour of seedlings will be extremely useful for the production of healthy seedlings in the nursery at low cost, same time paving a way for the easy disposal of these waste materials. Hence, the present investigations were carried out in the College of Forestry, Kerala Agricultural University, Vellanikkara to study the effect of two weeks decayed or stored waste materials as component potting media on the growth and vigour of mahogany seedlings in the nursery.

MATERIALS AND METHODS

In the present investigation, the effect of two weeks decayed or stored waste materials as component potting media on the growth and vigour of *Swietenia macrophylla* (Mahogany) seedlings was conducted at College of Forestry, Kerala Agricultural University and Vellanikara during the period 2009-2012. The nursery area is located at 40m above mean sea level at 10°32'N latitude and 76°26'E longitude. The area experiences a warm and humid climate with distinct rains from south west as well as north east monsoons.

Mature mahogany seeds were collected from the Wayanad district, Kerala. The seeds/pods were brought to the college nursery and dried under partial shade. Seeds/pods were extracted for the study. Seeds were sown in standard nursery beds. Uniform vigorous seedlings were transplanted in polythene bags of 10" × 5" size filled with different treatment media and arranged in separate rows in the green house. Watering was done regularly.

Municipal waste materials were collected from the drenching site of Thrissur Corporation. Tea waste was collected from a tea factory and coir waste from a coir mill. Maximum care was taken to collect fresh wastes. The collected waste was brought to the experimental site of the college in Vellanikkara, and municipal waste chopped into small pieces kept under for curing before preparing for the potting media. The following 7 potting media were prepared by thoroughly mixing the components.

T1 - Soil : sand: cow dung (1:1:1 ratio - control treatment)
T2 - Soil : partially decayed municipal waste (1:1)
T3 - Soil : partially decayed coir waste (1:1)
T4 - Soil : partially decayed tea waste (1:1)
T5 - Soil : partially decayed municipal waste : sand (1:1:1)
T6 - Soil : partially decayed coir waste : sand (1:1:1)
T7 - Soil : partially decayed tea waste : sand (1:1:1)

The experiment was laid out in Complete Randomized Design (CRD) with three replications. A total of one thousand and fifty seedlings were kept for conducting growth studies in the nursery. The seedlings after transplanting to the polybags were kept under green house conditions. Necessary plant protection measures were also adopted.

The observations like height, girth and fresh weight of shoots were recorded at 180th day of transplanting. Representative seedlings were uprooted and the tap root length, number of lateral roots formed and root fresh weight observations were made. After finding out the fresh weights, the shoot and root portion was separated and dried in hot air oven at a temperature of 70°C ± 2°C for about 48 hours. Drying and weighing were continued till constant weights obtained.

Biovolume index, which is a non-destructive quick method to calculate the above-ground portion of the tree seedlings was calculated using the formula suggested by Hatchell (1985): Biovolume index = plant height (cm) × stem diameter (mm). Quality index which is a measure to assess the quality of seedling based on the height, stem diameter and dry biomass was also calculated using the standard formula (Hatchell 1985). Above and below ground biomass and their ratio were also calculated.

The physiological observations like number of leaves and fresh weight of leaves were taken and after oven drying, the dry weight of leaves was recorded. Drying and weighing were continued till constant weights were obtained. Representative samples were taken from each treatment and leaf area and weight of leaves per plant were recorded. The Specific Leaf Area (Kvet et al. 1971), Specific Leaf Weight (Pearce et al. 1968) and Relative Growth Rate (Williams 1946) were calculated. Leaf samples were collected from the selected plants and chlorophyll content measured by using chlorophyll meter.

The shoot portion of the plants used for destructive sampling were dried and powdered. This fine powder was used for the estimation of nitrogen, phosphorus and potassium at monthly intervals. Ammonia was distilled by KEL PLUS automatic distillation system and nitrogen was estimated (Jackson 1958). The phosphorus content was determined colourimetrically by the vanado-molybdo phosphoric yellow colour method (Jackson 1958). Potassium in the extract was determined flame photometrically using potassium filter (Jackson 1958).

Statistical analysis: Randomized complete block experimental design was used for all analyses performed in the experiment. All treatments were replicated four times. Data were analysed using SPSS (version 20.0, SPSS Institute, Chicago, IL, USA). The shoot height, collar diameter, biomass, and seedling index were statistically analysed using one-way ANOVA with LSD test for multiple comparisons (a= 0.05). The number of leaves, leaf weight, specific leaf area, specific weight, relative growth rate, chlorophyll content and nutrient content were also analysed using the same method.

RESULTS

Prominent variation was observed among various treatments with regard to height of seedlings. Treatment T7 recorded the maximum height of 48.00 cm, which was immediately followed by T5, and T2, and treatment T3 showed the lowest value (24.29cm). It indicated the influence of potting media on height and growth. Significant variation was also observed among various treatments with regard to girth of seedlings (Table 1). Treatment T7 recorded maximum girth (7.28cm) at the end of the study. Treatment T4 was on par with treatment T5. Treatment T3 recorded lowest value (5.34cm) in girth. In the case of biomass production highest value was observed in T2 followed by T1 and least in T3. The highest (8.65g) below ground biomass was obtained in T1 and lowest (1.18g) for T3. The ratio of above and below ground biomass ranged from 0.24-0.49. Root studies indicated that the length of root was maximum in T5 followed by T7 and T1. Minimum root length was recorded in T2, T3 and T4. The root length was ranged from 41.09 to 95.42 cm among various treatments studied. It was also observed that among treatments, there was a significant variation in root length at the end of the study. While considering the number of roots, T2 produced more number of roots when compared to other treatments under study. Almost similar trend was followed in T4 and T5 at the end of the study period. At the end, T1 measured minimum number of roots. The number of roots produced in this treatment was ranged from 18.99 to 21.89. Root formations at the study have no significant difference between the treatments. Root mortality was more prominent in treatments, T3 and T4. The biovolume index value ranged from 350.78-129.71 and highest for T5 and lowest for T3. Quality index ranged from 1.40-0.71 and highest value observed in T1 (Table 1).

It was observed that leaf occurrence among different treatments varied significantly (Table 2). The maximum number of leaves were recorded in treatment T5 followed by T7. The lowest number of leaves was recorded in treatment T3. The mean number of leaves produced under different treatments ranged from 12.49 to 19.38. The T7 shows the significant variation among the treatments. Leaf fresh weight was estimated among various treatments varied significantly. It indicated that treatment T7 registered maximum (18.83g) value which significantly varied from other treatment under study followed by T1 (17.73g); T4 (16.89g) and T5 (15.20g). The minimum fresh weight was noticed in T3 (4.10g) at the end of the study. Leaf dry weight was registered maximum value in T7 which significantly varied from other treatments under study. Treatment T7 showed maximum value of 12.47 g. The minimum dry weight was noticed in T3 (5.59g). Significant differences in dry weight resulted between treatments (Table 2).

The studies on Specific Leaf Area indicated that at the end of the study, T6 recorded maximum value whereas least value was represented by treatment T2 (Table 2). In the case of specific leaf weight, the maximum value was recorded in treatment T5 followed by T6 and T4 and minimum value recorded by T1 at the end of the study. Similarly, the relative growth rate was significantly different among treatments. Treatment T7 showed highest relative growth rate of 0.22 which significantly varied from other treatments under study. Minimum relative growth rate (0.11) recorded in T4, T1 and T6. It is also observed from the Table 2 that there was significant difference in chlorophyll content among various treatments under study. The chlorophyll content ranged from 30.86 to 44.23 mg/g. The maximum value was recorded in treatment T5 followed by T4 and T2. The minimum value of chlorophyll content is in the treatment T3 (30.86mg/g) of the end of the study.

Tissue nutrient content in the seedlings for different treatments, indicted that the highest N content (0.77 %) in treatment T7 at the end of study period. It is followed by T5, T1, T4 and T2 (Table 3); treatment T6 registered lowest value (0.27 %) of N content. As indicated in nitrogen content, phosphorus also registered significant variation at the end of study (Table 3). Treatment T2 showed maximum (0.46 %) concentration of phosphorus followed by T3, T5 and T4. Minimum value (0.30 %) of phosphorus recorded by T6 at the end of the study period. Potassium content of seedlings also varied among the treatments. The data furnished in Table 3 indicated that the maximum concentration (0.76 %) of potassium was recorded in T4 at the end of the study period. Treatment T1 was on par with T2 at the end of the study. Treatment T6 recorded minimum (0.42 %) concentration of potassium at the end of the study.

DISCUSSION

Disposal of solid waste has a major problem in the country, especially in Kerala as the availability of land fill sites have diminished and requirements for making landfills environmentally acceptable have driven up the costs substantially. Reuse of organic wastes in agriculture holds promise, in general, since they offer a locally available fertility resource, and their removal provides an effective and environmentally acceptable option of waste disposal. It also recycles valuable nutrients into the soil; some studies have been done on forest tree species. In this context, the present study was taken up in the College of Forestry, Kerala Agricultural University, Vellanikkara to study the effect of municipal garbage and industrial waste as a component of potting media on the growth and vigour of *Swietenia macrophylla* (ma-

hogany) seedlings in the nursery.

Partially decomposed municipal garbage and industrial waste when used as a component potting media were significantly influenced the growth of seedlings. With regards to height, maximum value was recorded by T7 (soil : partly decayed tea waste : sand) at the end of the study. Similar results were also observed in teak in a study conducted by Adersh (2001). He has reported that addition of cow dung can improve soil physical properties and also nutrient availability and this may be the probable reason for the better growth of seedlings in potting media containing cow dung. Treatment with sand and coir pith (T3) represented lowest height and girth of the seedlings at end of the study. This revealed a different response to various potting media applied. Here, maximum values were registered in both control (T1) and soil : partly decayed municipal waste in equal amount (T2). However, minimum girth was recorded in soil and partly decayed coir waste (T3). Addition of coir waste to soil proved less influence on girth and height in mahogany. Mohan et al. (1991) have reported that a combination of soil, sand and FYM in the ratio 1:1:1 increased the height and dry matter production of seedlings of *Swietenia macrophylla* and *Dalbergia latifolia*.

Fresh and dry weight of shoot showed maximum value in T5 (soil : partly decayed municipal waste : sand) and lowest values for shoot fresh weight were recorded in T3 (soil and partly decayed coir waste). Addition of sand to municipal waste has got maximum influence on fresh weight as well as dry weight. Ward et al. (1981) have noticed greater shoot weight of sugar maple seedlings when grown in green house medium. Effective utilization of available solar energy and also the availability of ample supply of nutrients especially nitrogen may be the reason for the better performance of seedlings grown in T5 (soil : partly decayed municipal waste : sand), T2 (soil : partly decayed municipal waste) and control (T1). Growth of teak was better in a medium containing black soil, sand and municipal garbage in 1:1:1 proportion (Yadav et al. 1982).

In the present study, it was seen that the overall root growth performance of the seedlings was influenced significantly by various types of potting media, as is evident from the statistical analysis of the data. Maximum root length was recorded in T5 (soil : partly decayed municipal waste : sand), while maximum root number (22) by T2 (soil : partly decayed municipal waste). Ritchie (1982) has stated that carbohydrate and growth regulators in single or in combination produced by the shoots are necessary for growth. There was a positive relationship between stored carbohydrates or photosynthates present in the stem and development of healthy root system (Davis et al. 1990). This statement is true with regard to the present study also. The treatments that were proved better with regard to the root weight performed better with regard to shoot weight also. Goswami (1990) has observed that an equal proportion of soil, sand and composted municipal garbage was found to be most effective for better rooting percentage with more root number and length in mangium seedlings. Gopikumar & Minichandran (2002) have reported that treatments containing partially decomposed municipal waste performed better compared to other treatments with regard to root growth parameters and physiological attributes in the case of *Ailanthus triphysa* seedlings.

In the present study, specific leaf area, specific leaf weight, relative growth rate, chlorophyll content, etc. were considered as important criteria for measuring the growth and vigour of the seedlings. Effect of potting media on leaf parameters indicated that maximum (19.38) number of leaves was obtained in T5 (soil : partly decayed municipal waste : sand). Similarly, minimum number of leaves was reported in T3 (soil : partly decayed coir waste). Leaf fresh weight among various treatments revealed that T7 (soil : partly decayed tea waste and sand mixture) showed highest value, and lowest value for fresh weight was noticed in T3 (soil and partly decayed coir waste). While examining the response of leaf characters to various potting media treatments, performance was proved better when sand is added along with soil and partially decomposed waste. Khalilian & Sullivan (1997) have reported that addition of composted garbage improve nutrient availability. This could be one of the reasons for better performance of the seedlings grown in potting media with decomposed garbage. In all the cases, treatment with coir waste was found unsuitable with regards to leaf number and leaf fresh weight.

Chlorophyll content in different potting media revealed that highest chlorophyll content was recorded in T5 (soil : partly decayed municipal waste : sand), and lowest values were recorded for T3 (soil and partly decayed coir waste). There was no uniform trend on the effect of treatments on the chlorophyll content of seedlings in various treatments under study. Other physiological growth attributes like specific leaf area and relative growth rate did not follow any systematic pattern with regard to difference in treatments. Similar trends were also reported by Gopikumar & Minichandran (2003) in the case of teak seedlings when solid waste was used as a component of potting media. Municipal and industrial wastes have proved good alternative to ensure the availability of good potting media in the mass production of seedlings.

As part of the experiment, effects of potting media on plant nutrients have been studied in the nursery. Maximum

Table 1: Growth parameters of *Swietenia macrophylla* seedlings under different treatments in the nursery.

Growth parameters	Treatments						
	T1	T2	T3	T4	T5	T6	T7
Height (cm)	36.98^{c}	41.61^{d}	24.29^{a}	36.61^{c}	46.77^{e}	29.59^{b}	48.00^{f}
Girth (mm)	6.69^{d}	7.40^{c}	5.34^{a}	7.07d^{c}	7.50d^{c}	5.65^{b}	7.28^{e}
Above ground biomass (g)	2.34^{c}	2.98^{d}	1.18^{a}	2.02^{c}	1.96^{b}	1.99^{b}	1.60^{b}
Below ground biomass (g)	8.65^{c}	6.09^{b}	3.65^{a}	7.81^{b}	8.09^{c}	6.77^{b}	4.18^{a}
Above : below ground biomass	0.27^{a}	0.49^{c}	0.32^{b}	0.26^{a}	0.24^{a}	0.29^{a}	0.38^{b}
Tap root length (cm)	64.28^{b}	41.09^{c}	43.96^{c}	43.51^{c}	95.42^{a}	73.02^{b}	77.41^{a}
Number of lateral roots	19^{a}	22^{a}	20^{a}	20^{a}	20^{a}	19^{a}	21^{a}
Biovolume index	247.40^{b}	307.91^{c}	129.71^{a}	258.83^{b}	350.78^{c}	167.18^{a}	349.44^{c}
Quality index	1.40^{c}	1.05^{a}	0.84^{a}	1.37^{b}	1.23^{b}	1.21^{b}	0.71^{a}

*Significant at 0.05 levels; Means with same letter as superscript are homogeneous

Table 2: Physiological parameters among different treatments of *Swietenia macrophylla* seedlings in the nursery.

Physiological parameters	Treatments						
	T1	T2	T3	T4	T5	T6	T7
Number of leaves	16.47^{d}	14.99^{b}	12.49^{a}	15.12^{b}	19.38^{f}	15.67^{c}	17.44^{e}
Leaf fresh weight (g)	17.73^{e}	13.53^{c}	4.10^{a}	16.89^{de}	15.20^{cd}	9.97^{b}	18.83^{e}
Leaf dry weight (g)	9.19^{bc}	7.64^{b}	5.59^{a}	8.44^{bc}	9.57^{c}	5.22^{a}	12.47^{d}
Specific leaf area (cm^2/g)	21.05^{b}	14.52^{a}	23.37^{bc}	22.31^{bc}	16.52^{a}	25.21^{c}	21.41^{b}
Specific leaf weight (g/cm^2)	0.17^{ab}	0.21^{bc}	0.13^{a}	0.25^{c}	0.26^{c}	0.24^{c}	0.18^{ab}
Relative growth rate ($g.g^{-1}.d^{-1}$)	0.11^{a}	0.16^{b}	0.13^{ab}	0.11^{a}	0.13^{ab}	0.11^{a}	0.22^{c}
Chlorophyll content (mg/g)	37.93^{ab}	40.36^{ab}	30.86^{a}	43.90^{b}	44.23^{b}	33.36^{a}	39.80^{ab}

*Significant at 0.05 levels; Means with same letter as superscript are homogeneous

(0.77%) content of nitrogen at the end of the study period was recorded in T7 (soil : partly decayed tea waste and sand mixture). Very low value of nitrogen content (0.27%) in the potting media has substantiated the highest nitrogen content in T4 (soil and partly decayed tea waste). In a similar potting media experiment, Adersh (2001) reported that in the case of teak and mangium seedlings, shoot growth is reported to be highly influenced by nitrogen. Gopikumar & Aravindakshan (1988) have reported that in cashew seedlings grown in sand culture, nitrogen deficiency resulted in reduced height, collar diameter and leaf area. Presence of cow dung in the T7 (soil : partly decayed tea waste and sand mixture) would have increased the nitrogen availability of the potting media by adjusting the C:N ratio of the soil. Several studies revealed that composting of garbage increases nutrient availability. Jeyabaskaran (1995) has reported that in the case of sunflower and soyabean, the content of nitrogen, phosphorus, potassium and sulphur increased with sludge application in the medium. This finding is applicable in the present study also.

Like nitrogen, in the case of phosphorus, at the end of the study period, T2 (soil : partly decayed municipal waste in equal amount) registered maximum (0.46%) value. Lowest (0.30%) value of phosphorus content was recorded by soil, partly decayed coir waste and sand. Greulach (1973) has stated that phosphorus plays an important role in various enzyme reactions that affect phosphorylation. This influences shoot growth parameters such as height, leaf area, collar girth, etc. by acting as a structural component of all constituents and other metabolically active compounds (Agarwal & Sharma 1976). Epstein (1978) has reported that phosphorus is the major controlling factor for energy release and transfer ions in all living cells and as a constituent of nucleoproteins. It is concerned with cell division also. In the present study, increased concentration of phosphorus in the seedlings grown in potting media containing decomposed garbage was due to increased availability of phosphorus in that medium.

Potassium content in the seedlings among various treatments indicated that T4 (soil and partly decayed tea waste) showed highest (0.76 %) value. Potassium activates protein synthesis and nitrogen metabolism and has a direct influence on cell division resulting in higher cell number (Greulach 1973). High concentration of potassium in plant tissues when grown in T5 (soil : partly decayed municipal waste : sand) may be due to improved available potassium due to the presence of decomposed municipal waste. Hernandez (1999) has compared the effect of fresh and

Table 3: The nutrient content of *Swietenia macrophylla* seedlings under different treatments in the nursery.

Treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T1	0.58^{e}	0.34^{ba}	0.69^{dcb}
T2	0.44^{c}	0.47^{c}	0.54^{cba}
T3	0.36^{b}	0.35^{ba}	0.52^{ba}
T4	0.54^{d}	0.37^{b}	0.76^{d}
T5	0.75^{f}	0.34^{ba}	0.46^{a}
T6	0.27^{a}	0.30^{a}	0.42^{a}
T7	0.77^{f}	0.43^{c}	0.70^{dc}

**Significant at 0.01 levels; Means with same letter as superscript are homogeneous

composted municipal garbage in addition to organic matter content when added in arid soil and found that the organic matter content was high when the soil was treated with fresh municipal garbage.

CONCLUSION

In conclusion, results of the current experiment revealed that firstly, municipal waste in potting media has no detrimental but rather stimulatory effects on emergence, growth and biomass allocation of *Swietenia macrophylla* seedlings and has thus considerable potential for substituting the high coast sand and FYM potting substrates. Secondly, physiological growth rate of mahogany seedlings can be altered by the substrate mixture used to raise seedlings. The influence of substrate may also have implications for seedling pest and disease resistance. Finally, the current results also highlight differences of potting media effects in the nutrient concentration, an aspect that has been ignored in the literature so far. Especially, the latter findings should be considered with other economically important tree species.

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