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EFFECTIVENESS OF ORGANIC POTTING MEDIA FOR RAISING MAHOGANY (*SWIETENIA MACROPHYLLA*) SEEDLINGS IN WESTERN SAMOA

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WOODS, P.V., PESETA, O. & WEBB, M.J. 1998. Effectiveness of organic potting media for raising mahogany (*Swietenia macrophylla*) seedlings in Western Samoa. The suitability of two organic potting media for raising mahogany (*Swietenia macrophylla* King) seedlings was compared with the standard operational practice of using forest soil. Several rates of addition of a slow release nursery fertiliser were added to each growth medium. Effects of treatments on nursery growth and subsequent performance in the field were assessed. Seedling heights at the end of the nursery phase (111 days) were greatest in pots with soil without added fertiliser, and in brewers waste/sawdust and coir potting media with a moderate amount of slow release fertiliser (4g l^{-1}). Both increasing and decreasing the rate of slow release fertiliser from 4g l^{-1} reduced seedling height. Ten months after planting out in the field, the trees raised in coir in the nursery were significantly greater in height, diameter and volume than trees raised in a soil medium. These results suggest that the use of organic nursery media can produce seedlings that grow significantly faster in the first year after outplanting than seedlings raised in soil. Further research is required to refine the characteristics and method of preparation of the organic media, using raw materials which are freely available in Western Samoa.

Key words: *Swietenia macrophylla* - mahogany - nursery - organic media - slow release fertiliser

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WOODS, P.V., PESETA, O. & WEBB, M.J. 1998. Keberkesanan media tabung organik untuk membesarkan anak benih mahogani (*Swietenia macrophylla*) di Samoa Barat. Kesesuaian dua media tabung organik untuk membesarkan anak benih mahogani (*Swietenia macrophylla* King) dibandingkan dengan amalan operasi piawai yang menggunakan tanah hutan. Kadar penambahan baja tapak semaian yang dibebaskan perlahan ditambah kepada setiap media pertumbuhan. Kesan rawatan terhadap pertumbuhan di tapak semaian dan prestasi berikutnya di ladang ditaksirkan. Ketinggian anak benih di peringkat akhir di tapak semaian (111 hari) didapati tertinggi dalam tabung yang mengandungi tanah tanpa baja, serta dalam tabung bahan buangan arak/habuk gergaji dan tabung sabut kelapa dengan jumlah baja yang dibebaskan perlahan adalah sederhana (4 g l^{-1}). Kedua-duanya menambah dan mengurangkan kadar baja dibebaskan perlahan daripada 4 g l^{-1} ketinggian anak benih yang dikurangkan. Selepas sepuluh bulan ditanam di ladang, pokok yang dibesarkan menggunakan cara sabut kelapa di tapak semaian mempunyai ketinggian, garis pusat dan isipadu yang baik berbanding dengan pokok yang dibesarkan menggunakan bahan tanah. Keputusan ini mengesyorkan bahawa penggunaan media tapak semaian organik dapat menghasilkan anak benih yang tumbuh lebih cepat pada tahun pertama selepas penanaman luar berbanding anak benih yang dibesarkan di dalam tanah. Penyelidikan selanjutnya diperlukan untuk mendalami ciri-ciri dan kaedah penyediaan media organik menggunakan bahan mentah yang boleh didapati dengan senang di Samoa Barat.

Introduction

Forestry Division nurseries in Western Samoa currently produce around 300 000 tree seedlings annually for use in plantations and as part of a community forestry/ extension programme. The standard practice is to raise seedlings in black polyethylene bags filled with forest top soil to which a small amount of slow release fertiliser has been added. However, seedling growth and root development in the nursery is less than ideal and the nutritional status of seedlings appears poor at the time of planting out.

One material that is widely available in some tropical regions is coconut husks and research at the ASEAN-Canada Forest Tree Seed Centre has shown that coir (chopped coconut husk) is a cost-effective potting medium for producing vigorous forest tree seedlings (Kijkar 1991).

However, for coir to be an effective medium for seedling production, it should be supplemented with fertiliser (Handreck 1992, 1993). This is consistent with other reports from the humid tropics which recommend the use of organic potting media, supplemented with nutrients (Reynolds 1973, Schroeder 1994, Webb *et al.* 1995).

In order to overcome the problems associated with the use of soil as a potting media, we conducted an experiment to (a) evaluate the rate of growth of mahogany (*Swietenia macrophylla* King) seedlings raised in two locally available organic materials, each with three rates of a slow release fertiliser, and (b) compare their responses with the current nursery practice in Western Samoa.

The rate of growth of mahogany was assessed in the nursery and subsequently in the field for selected treatments.

Methods

Nursery phase

For the nursery phase of the experiment, two organic potting media mixed at various rates with a slow release fertiliser (Nutricote; Arthur Yates & Co, Milperra, NSW, Australia) were compared with the current operational practice in Western Samoa, viz. a forest soil mixed with Magamp (Sumitomo Corp, Tokyo, Japan) slow release fertiliser (see Table 1 for details of media, fertilisers and treatments).

Table 1. Potting media and quantities of fertiliser added

Treatment code	Potting media	Fertiliser ($g\ l^{-1}$ potting media)
COIR+NIL	Coir[1]	0 g Nutricote[4]
COIR+4	Coir	4 g Nutricote
COIR+20	Coir	20 g Nutricote
BW+NIL	Brewers' waste/ sawdust[2]	0 g Nutricote
BW+4	Brewers' waste/ sawdust	4 g Nutricote
BW+20	Brewers' waste/ sawdust	20 g Nutricote
SOIL (EXP)	Ordinary forest soil[3]	2.5 g Magamp[5]

[1] Prepared by finely chopping coconut husks with a bush knife until it could be poured into pots. The medium consisted of both the fibres and the pulp from the husk.

[2] Brewers' waste (consisting mostly of spent hops and grains which remain after brewing beer; collected from Vailima Brewers Company Limited, Apia) was mixed with coarse sawdust and planer chips from a local sawmill in the ratio 50:50 by volume. This medium was left to compost, unturned, for about two months before being used.

[3] Collected from under an experimental stand of a leguminous shrub near Vailima Forestry Research Office. Soil was treated at 70 °C for 48 h before use.

[4] Nutricote Total (100 day slow release fertiliser). Formulation (%): N (13), P (5.7), K (10.8), Ca (1.3), S (4.7), Mg (1.2), Fe (0.2), Mn (0.06), Cu (0.05), B (0.02), Mo (0.02) and Zn (0.015).

[5] Magamp (7:17:5; N:P:K) is a commonly used, sparingly-soluble, fertiliser on Western Samoa.

The experiment was carried out in the Research Section greenhouse at Vailima, near Apia, Western Samoa. The greenhouse had a clear polycarbonate roof and open sides. A randomised complete block design with eight replicates of each treatment was used. Four pots per replicate plus six spare pots were prepared for each treatment, the spares being used where required to replace those pots in which no seeds germinated.

For each treatment fertiliser was weighed and mixed with 400 ml of the potting media or soil before each pot (black polyethylene; 400ml capacity; 8 cm diameter by 10 cm) was filled. Seeds, imported from Honduras and stored for three months at 4 °C, were sown directly into the pots on 28 September 1994. The pots had been watered for the three previous days to maximise wetting of the medium, and were subsequently watered manually each morning.

Stem height measurements began 44 days after sowing and continued at fortnightly intervals. Similarly, the number of seedlings which had died or exhibited dead or discoloured foliage was also recorded fortnightly. In order to minimise any block effects due to variation in light level or other environmental variable, seedlings were moved fortnightly, one block at a time, to a new position in the greenhouse. After 111 days, selected plants were used for the subsequent field trial.

Field trial

To determine the effect of different potting mixes on the growth rate of seedlings in the critical first few months after planting out, twenty seedlings with heights as similar as possible to the mean height for each treatment were selected from each of COIR+4, BW+4 and SOIL (EXP) treatments for planting out in the field. In addition, twenty other seedlings which had received the current operational application of fertiliser (0.6 g Magamp /l soil applied at the time of sowing) and raised in a nearby nursery for commercial planting (not as a part of this experiment) were included to provide a comparison with current operational practice [SOIL (OPER)].

A randomised, complete block design was used with 4 blocks, each block consisting of one planting line. Each replicate of each treatment contained 5 trees so that each line contained 20 trees. Planting lines were aligned in an east/ west direction and spaced at 5 m apart. Seedlings were planted at a spacing of 2 m along the row. The whole plot was completely cleared of competing vegetation before the trees were planted and a 2 m wide swath along each row was weeded every month. No fertilisers were applied. Treatments were allocated to positions within each row at random. The site was on a deep, well drained basaltic soil and is representative of major areas of land available for plantation forestry in Western Samoa.

Tree height (to highest bud on the stem) was measured once a month from the time of planting out (111 days after sowing in the greenhouse). Stem diameters (10 cm above ground level) were also measured with a diameter tape on every tree beginning 252 days after planting out. These parameters were used to provide an index of relative volume.

Results

Nursery phase

Germination in the brewers' waste/sawdust and forest soil treatments was complete within 19 days after sowing. In COIR treatments, germination was delayed by about two weeks compared to the rest of the trial. (Although no mortality resulted, the BW media was more prone to colonisation by what appeared to be a fungus, which required an occasional spraying with the fungicide Benlate.)

Mortality in the nursery was low in the BW and soil treatments (Table 2) and seedlings were generally healthy, although a minor abnormality in foliage colour appeared in 12 seedlings in the BW treatments (Table 2). This appeared as patches of pale green on the upper side of the fully developed foliage (blotching) and was not associated with mortality. Mortality in coir was higher and increased with increasing fertiliser supply. In the COIR+20 treatment, 50% of the seedlings died during the course of the experiment (Table 2). Seedling mortality in this treatment was usually preceded by one or two leaflets shrivelling and dying. In addition to suffering a high rate of mortality, seedlings in the COIR+20 treatment were significantly ($p<0.05$) smaller than all other treatments at the time of the first measurement 44 days after planting (Figure 1) and this difference persisted until the end of the experiment.

Table 2. Percentage (n = 32 per treatment) of mahogany seedlings which died, had one or more dead leaves or exhibited pale patches on the foliage (blotching) during the course of the nursery phase

Treatment	Mortality (%)	Dead leaves (%)	Foliage blotching (%)
COIR + NIL	9	19	0
COIR + 4	22	3	0
COIR + 20	50	37	0
BW + NIL	6	0	0
BW + 4	0	0	19
BW + 20	0	0	19
SOIL (EXP)	6	0	0

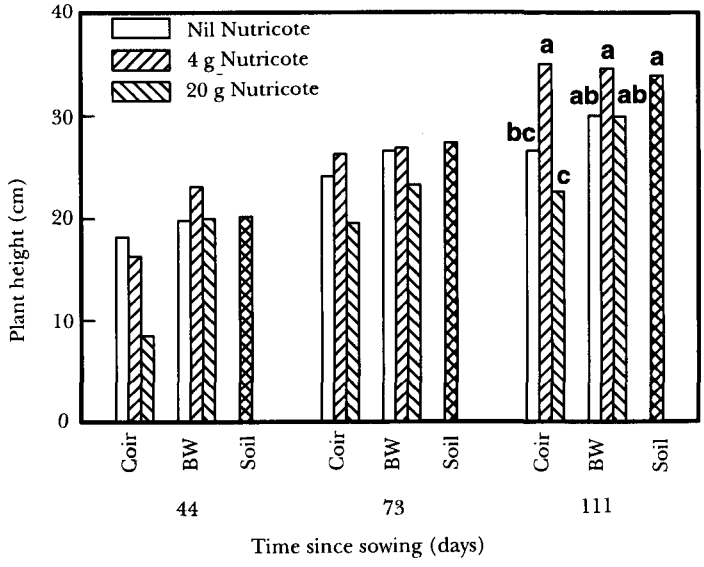

Figure 1. Height of *Swietenia macrophylla* seedlings raised with two types of organic potting mix and three rates of addition of slow release fertiliser, as well as in soil using the standard nursery practice but with a higher rate of slow release fertiliser

There were significant differences in seedling height by the end of the nursery phase of the experiment (ANOVA, $p<0.05$; see Figure 1). The treatments fell into four groups (Tukey, $p < 0.05$), the tallest seedlings being produced by the COIR+4, BW+4 and SOIL (EXP) treatments and the smallest by the COIR + 20 treatment (Figure 1), while the other three treatments were intermediate.

Field phase

There was no post planting mortality in any of the four treatments and trees were uniformly healthy. Seedlings taken from the operational nursery [SOIL (OPER)] were initially smaller than those raised as part of the nursery phase of this experiment, but this height difference soon disappeared (Figure 2). After 10 months, the only significant height difference observed (ANOVA, $p<0.05$) was between COIR+4 and SOIL(EXP) treatments, with mean heights of 2.32 m and 1.90 m respectively. Trees in the SOIL (OPER) and BW+4 treatments were intermediate, with heights of 2.09 m and 2.00 m respectively (Figure 2). In comparison to all other treatments, trees raised in coir showed a clear trend of steadily increasing height difference throughout the experiment (Figure 2).

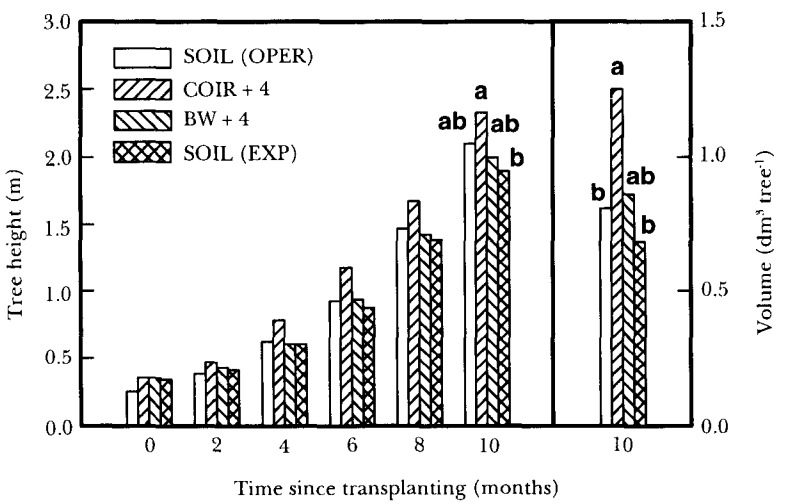

Figure 2. Height and volume of *Swietenia macrophylla* trees. Seedlings were initially raised with coir or a brewers' waste/sawdust mix with 4 g l^{-1} of Nutricote added, or in soil with Magamp added

Ten months after the seedlings were transplanted, trees raised in coir also had stem diameters which were significantly (ANOVA, $p < 0.05$) greater than for trees raised in the SOIL(EXP). Again, the two other treatments were intermediate (results not shown). Relative volume (based on an estimate of the conical volume; basal area × 0.33 × total height) of trees raised in coir was 80% greater

than that for the smallest trees [raised in the SOIL(EXP) treatment] and 50% greater than the mean for the other treatments (Figure 2).

Discussion

Nursery phase

Equally rapid tree height growth was achieved in all three potting media. The main differences were due to rates of addition of fertiliser. The addition of 4 g of slow release fertiliser per litre of potting media appeared to be the optimum rate in both the coir and brewers' waste mix, while the standard operational mix of soil plus Magamp also produced good height growth in the nursery.

In a comparable study in the Solomon Islands, similar responses were found to low rates of addition of slow release fertilisers (Webb *et al.* 1995). At a slow release fertiliser rate of only 2 g l^{-1} coir, (half the optimal rate in the current experiment) there was a 15-fold increase in dry matter production of *Cedrela odorata* seedlings compared to those which received no fertiliser. However, at higher rates there were substantial differences between the two experiments. Whilst 20 g l^{-1} caused substantial mortality of *S. macrophylla* seedlings in the current experiment, *C. odorata* was still responding positively to additions of 48 g l^{-1} (Webb *et al.* 1995).

There were several differences between these two experiments which may explain the discrepancy. In addition to the species differences, in the Solomon Islands, the coir was composted prior to use and a much higher watering regime (total of 3 - 4 h per day) as well as a slower release fertiliser formulation (combination of 5 and 9 month release time) was used. It is most likely that, in Western Samoa, the combination of lower watering regime and faster release time for the fertiliser resulted in the mortality of *S. macrophylla* through exposure to toxic levels of nutrients On the other hand, we have often observed in other experiments (unpublished) that *C. odorata* continues to respond positively at quite high rates of fertilisation and thus might be more tolerant of high nutrient concentrations in the potting media. In addition, Radjagukguk (1983) has suggested that the use of uncomposted coir can cause a high rate of seedling mortality.

The use of a properly composted coir medium with higher water holding capacity may also help overcome the delayed germination that was observed in our study with uncomposted coir. A slight water repellancy was observed in the coir for the first few weeks after the seeds were sown. This delayed germination of mahogany seeds in coir did not, however, lead to smaller seedlings at the time of out-planting. On the other hand, the current practice in Western Samoa of 'pre-germinating' mahogany seeds in plastic bags with moist peat moss brings about a very rapid germination and might be a viable option to sowing the seeds directly into pots.

Field phase

In contrast to the nursery phase of the experiment, the field growth rate of seedlings raised in coir was markedly superior to that of seedlings raised in soil or brewers' waste media. The superiority of seedlings raised in coir may have been due to differences in the root system. Other studies have found that highly porous organic potting mixtures produce good fibrous root systems which enhance the growth rate of seedlings in the field compared to those grown in a soil-based medium (e.g. Miller & Jones 1995).

Although tree height is a commonly used surrogate for production in young seedlings, it showed only a 23% increase in the field and no difference in the nursery between COIR+4 and SOIL(EXP) whereas volume showed an 80% increase between these two treatments. This suggests that volume estimates may be a more sensitive predictor of the performance of seedlings after being planted out in the field. This is consistent with observations made during the experiment which showed that the main differences between treatments were in the colour, number and size of leaves, rather than in seedling height. Indeed, all seedlings appeared to extend the main shoot very quickly immediately after germination, which implies that this process may be under genetic rather than environmental control. As this growth pattern and response to treatments have been noted in other similar experiments with mahogany and other species it strengthens our suggestion that seedling height alone is not a reliable index of the quality of nursery stock and should be supplemented by other parameters such as destructive sampling or leaf area analysis.

This experiment also demonstrates the importance of planting out experimental nursery stock under controlled conditions and monitoring growth for a reasonable length of time before making conclusions about its quality. Seedlings should be healthy and have an adequate nutritional status at the time of planting out, but this experiment demonstrates that the use of taller planting stock *per se* may not necessarily convey a long-lasting advantage in terms of tree growth.

Importantly, the use of coir as a potting media has several advantages over the use of soil. It can be produced locally, is light to carry when planting, performs equally well as other nursery media if amended with nutrients, and leads to enhanced growth rates in the field. Indeed, if the differences in height and diameter growth between trees raised in coir and those raised in other media continue with time, the use of this improved potting medium will eventually produce a substantial economic benefit.

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