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RESIDUAL STRENGTH OF HESSIAN CLOTH USED IN TREE TRANSPLANTATION

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Transplanting large trees has become an important component of landscaping in urban areas, as well as in projects such as the Kuala Lumpur International Airport (KLIA) and the Kuala Lumpur City Centre project (KLCC). When planted together with herbaceous plants and other understorey species, these trees help create the ambience of a forest environment. In development projects where large, mature trees cannot be incorporated into the overall design of the project or where they become an obstruction to construction, the trees may be transplanted to other sites in efforts to preserve them, for example in the construction of the Kuala Lumpur Light Rail Transit system.

The process of transplanting big trees is a complicated one involving many steps and stages; a manual detailing the various steps is presently being prepared by the Forest Research Institute Malaysia (FRIM). One step involves wrapping the root ball with Hessian cloth (made from jute fibre) before the tree is lifted out of the ground for transportation to the planting hole with the root ball still encased in the Hessian cloth. This cloth remains on the root ball during transplantation for stability and moisture retention.

This preliminary laboratory-scale study was carried out to investigate the rate of decay of the Hessian cloth when used to encase a root ball and to see whether the wrapping prevented root growth and development.

Seedlings of 1-y-old *Hopea odorata* raised in polybags measuring 18 × 9 cm were used. Seedlings were excavated from their polybags, excess soil was removed and the root ball with its attached soil wrapped in pieces of Hessian cloth measuring approximately 20 × 30 cm. The wrapping was secured by tying it around the stem of the plant at soil level. The seedlings were then transplanted into polybags measuring 20 × 30 cm and the bags filled with a soil-sand mixture composed of three parts forest top soil to one part sand. In the other treatment, the soil-sand mixture was wrapped in pieces of Hessian cloth of the same size, then buried in the soil-sand mix contained in polybags of the same size as above. Each treatment was replicated three times. At each sampling period of 2, 4, 8, 12 and 16 weeks after experimental set-up, the wrapping was removed from around the root ball or from the soil, brushed clean of adhering soil particles and stored in plastic bags to prevent loss of moisture. The bags were then stored in a non-frost freezer until measurements for loss of strength could be carried out. The loss of strength of the cloth was determined by measurement of maximum tensile load using the Shimadzu Materials Testing Machine (Shimadzu Corporation, Kyoto, Japan).

Before the strength test was conducted, the width of each piece of cloth was measured to the nearest millimeter. Each piece was then folded in half along its length three times to form a corrugated sheet and the folded sheet of cloth placed in the grips of the machine so that the axis of tensile force was parallel to the length of the cloth. This was to ensure that the tensile force was spread evenly along the width of the cloth. Maximum tensile load in kilogram force required to snap the corrugated sheet was recorded. The load per width value was determined by dividing the maximum tensile load (kgf) by the width (mm). The load per width values of control pieces of cloth of similar dimensions as those used above, but which had not been buried in the soil, were also determined. These measurements served as the basis for comparison of strength loss.

Tension measurements showed that the strength of the Hessian cloth decreased as the duration of burial in the soil increased, regardless of whether the cloth was wrapped around a root ball or not (Figures 1a and 1b). However, at each sampling period the loss of strength was higher when the cloth was wrapped around a root ball (Tables 1a and 1b). The residual strength of the cloth approached zero at the sixteenth week in both cases.

The trend of the curves for average load per width versus the number of weeks of burial in the soil suggested the fitting of a polynomial relationship to the data. A polynomial regression by the least squares estimator technique was employed and the fitted models are as follows:

For Hessian cloth buried without a root ball:

$$Y = 0.71996 - 0.17226X + 0.01422X^2 - 0.00039X^3$$
$$R^2 = 1.00$$

For Hessian cloth buried with a root ball:

$$Y = 0.70514 - 0.19079X + 0.01765X^2 - 0.00053X^3$$
$$R^2 = 1.00$$

where Y = load per width (kgf mm^{-1})

X = duration of burial (number of weeks)

The graphs for average load per width versus number of weeks of burial in the soil with the polynomial models superimposed are shown in Figures 1a and 1b. The value for the unburied cloth is the first point on the graph; this corresponds to zero number of weeks. The trend on the graph shows a smooth reduction from the value of the control to almost zero at the sixteenth week. By fitting the models the percentage of strength reduction of the cloth could be quantitatively predicted (Tables 1a and 1b).

At least until the eighth week the strength loss was generally slightly higher in the cloth which was used to encase the root ball compared to when plant roots were absent (Table 1a and 1b). This could have been due to the pressure exerted on the soil ball and surrounding cloth by the growth of the roots. Roots also produce root exudates which are known to have a stimulating effect on the growth of bacteria and other soil microorganisms which may enhance the rate of decomposition of organic materials such as the Hessian cloth (Hale *et al.* 1978). From the eighth week onwards the presence or absence of roots did not have a significant effect on the loss of strength of the cloth. By the sixteenth week, the biological, biochemical and chemical activities in the soil had reduced the strength of the fibres which make up the cloth material to nil. This was also evident from the fact that the growing roots could easily penetrate the cloth.

Throughout the duration of the experiment, the plants whose roots were encased in the cloth grew normally. When the plants were sampled in the twelfth week, actively growing roots were observed to have grown out of the cloth into the surrounding soil. These roots appeared normal and were not deformed in any way and the cloth did not hinder the growth and development of new roots. This was due to the coarse weave of the cloth material that allows roots to penetrate easily (Kuhns 1997). Kuhns (1997) in his study noted that untreated burlap made from coarse hemp or jute fibres decayed very quickly and had no

Table 1. Third degree polynomial regression and percentage strength reduction of Hessian cloth when buried

a) wrapped around a root ball

Batch no.	Number of weeks	Avg. load per width length (kgf mm^{-1})	Polynomial regression model $Y=0.70514-0.19079X+0.01765X^2-0.00053X^3$	Strength ratio compared to control (Predicted model)	% strength reduction
1*	0	0.712	0.70514	1.00	0
2	2	0.385	0.38992	0.55	45
3	4	0.173	0.19043	0.27	73
4	8	0.069	0.03697	0.06	95
5	12	0.021	0.04114	0.06	94
6	16	0.009	0	0.00	100

b) without a root ball

Batch no.	Number of weeks	Avg. load per width length (kgf mm^{-1})	Polynomial regression model $Y=0.71996-0.17226X+0.01422X^2-0.00039X^3$	Strength ratio compared to control (Predicted model)	% strength reduction
1*	0	0.712	0.71996	1.00	0
2	2	0.451	0.42922	0.60	40
3	4	0.217	0.23355	0.32	68
4	8	0.054	0.05254	0.07	93
5	12	0.031	0.02718	0.04	96
6	16	0.01	0.00771	0.01	99

effect on root egress into the soil. By 90 days after planting he found that roots of 2-y-old Norway maple (*Acer platanoides*) were starting to emerge from the original root ball. In another study with yew (*Taxus* x *media* 'Densiformis'), Maynard and Johnson (1997) found that the number of roots growing out of unmulched, untreated burlap increased sharply from 8 to 16 weeks after planting.

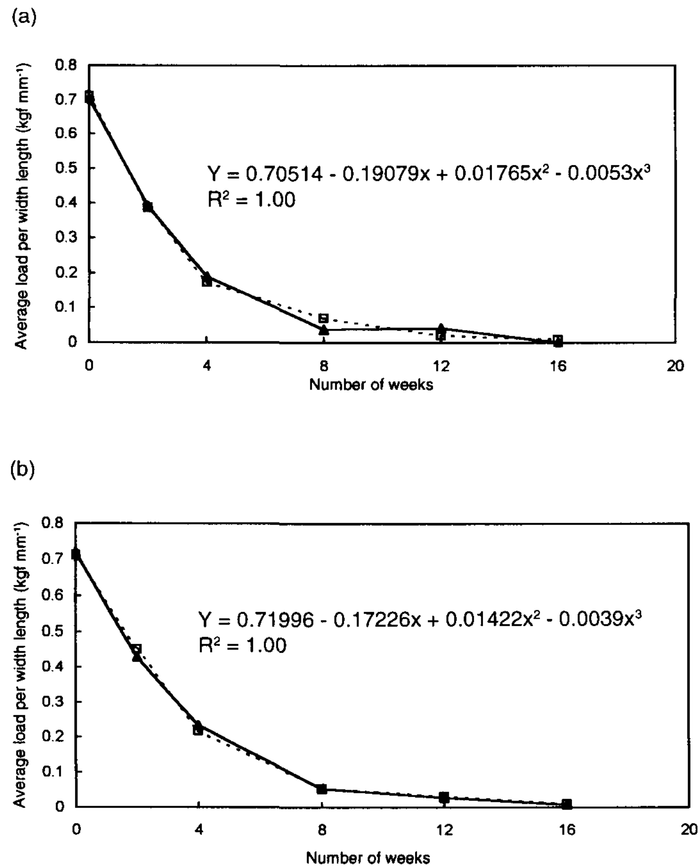

Figure 1. Reduction in tensile strength of buried Hessian cloth a) with a root ball, and b) without a root ball over a period of 16 weeks (▲ 3rd degree polynomial regression, ❐ before regression)

The fitted models can be used to predict the strength reduction of the buried cloth. The coefficients of X are dependent on the type of soil, the moisture content of the soil, the chemical constituents of the soil and the biological activity inherent to that type of soil (Gray & Williams 1971). In the case of the cloth used to encase the root ball, the coefficients may also be dependent on the type of plant and its root system as root texture, branching and the rate of root expansion differ from species to species. Thus the rate of strength loss will differ depending on soil type and tree type.

This experiment showed that although the wrapping material was still recognisable after 16 weeks, it had lost all its tensile strength. However, a study by Kuhns (1997) showed that at 90 days after planting, a single layer of untreated natural burlap (made from coarse hemp or jute fibres) had decayed to the point where it had many holes and much of it was completely gone.

Little documentation of the rate of burlap decay could be found in the literature, though an assumption is usually made that it is 'biodegradable' and will decay quickly once in contact with the soil (Harris 1992). In contrast to natural burlap, treated burlap or burlap made from synthetic fibres does not decay readily and may last many years in the soil. Kuhns (1997) found that although roots may grow through the treated burlap, they could be damaged or constricted, and recommended that treated or synthetic burlap be removed from root balls at planting time. Further studies need to be carried out to obtain more deterministic values of the coefficients in the fitted models for different types of soil and trees. Nevertheless the two models proposed above can be used to obtain an estimate of the strength reduction of Hessian cloth used to encase root balls for tree transplantation. Such information would be useful to predict how long Hessian cloth could be kept wrapped around root balls before they loose a critical amount of tensile strength that would prevent the moving of the tree to a new site.

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