Wheelie Green: The Development of a Mobile Unit to Produce Rooted Cuttings of *Eucalyptus* Tree Species©

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A first prototype of a mobile unit to produce rooted cuttings has been developed at CSIR NRE. The development of such a unit has two main objectives. Firstly to develop a low-tech unit in which cuttings can be rooted in infrastructure-poor conditions at nurseries based in rural areas. Such a unit needs to maintain the basic conditions conducive to the survival and rooting of the cuttings. The second objective is to develop the unit into a scientific experimental unit in which different conditions can be simulated to determine specific conditions needed to root difficult-to-root hybrid clones.

This paper reports on the progress of the development of the unit to date and the results obtained during the first rooting experiment. For this experiment hedge plants of an *Eucalyptus grandis* × *E. camaldulensis* clone were grown in the glasshouse at the University of Pretoria. Micro cuttings were placed in two media, namely a vermiculite medium and air to test for aerial rooting. The cuttings were "washed" in Benomyl (Benzidimazole) to prevent fungus infections and the cut edge was dipped in a rooting hormone, Seradix B2, before placement. Survival decreased rapidly within the first 5 days to about 54% plant survival. The first roots were observed 15 days after placement; at this stage plant survival stabilized at 44%. After 18 days the rooting percentage of the surviving plants was 6% for aerial rooting and 53% for the surviving cuttings placed in vermiculite. During this experiment the floor heating pads could not be used. However, the heat generated by the T5 Extra high output fluorescent tubes was enough to maintain an average temperature of 27 °C in the chamber. Temperatures never went below 25 °C or above 30 °C. The average relative humidity was 81%.

The results of this experiment indicate that there is sufficient potential for successful rooting of cuttings to warrant further development of this mobile propagation unit.

INTRODUCTION

Council for Scientific and Industrial Research's (CSIR) National Resources and the Environment (NRE) Tree Improvement group was tasked to develop an experimental mobile propagation unit for studying the conditions needed to stimulate root formation in difficult-to-root *Eucalyptus* hybrids. In this paper we report on the development of the first three prototypes, which will serve as the basis for the future development of a technologically advanced experimental unit.

The prototype in its current form has the potential to be used as a basic rooting environment in rural areas where the development of large infrastructures is too expensive. Not only will it be possible to root cuttings from *Eucalyptus* tree species but other tree species, e.g., *Sclerocarya birrea*, *Ximenia caffra*, *Uapaca*, *Parinari*, and *Podocarpus* sp.

DESIGN AND DEVELOPMENT

First Prototype. The original design and development of the first prototype (Fig. 1) was done by Dr. At Kruger. The unit has a metal framework with Perspex sides of which the front panel can drop down for easy access to the chamber. The size is 180 cm × 62 cm × 77 cm (L × H × D) and has the capacity for 4 × 128 seedling trays. The roof and bottom tray are made of aluminum. A single daylight fluorescent tube was attached to the centre of the roof.

The irrigation system is constructed of copper pipe extending in a T-formation in the center of the unit. In order to produce enough pressure to open the four non-drip copper fine-mist sprays, a single-phase high-pressure pump was attached to the copper pipe at the bottom of the trolley. A 20-inch hosepipe served as the water inlet and was attached to the pump. The irrigation is controlled by a timer system.

To generate heat from the bottom, four heating mats were placed within a polystyrene frame and covered with fine gravel. The temperature is thermostatically controlled.

Second Prototype. The irrigation system in the first prototype created a couple of problems. The high-pressure pump caused severe vibration of the copper pipe, which led to heat being generated and warm water being sprayed onto the plants. The vibration would also in time have led to the cracking of the copper pipe at the T connection. It was decided to replace the copper pipes with PVC pipe. The PVC pipes could be attached to the side of the chamber, creating space for an additional seedling tray (Fig. 2). This irrigation system did not need the high-pressure pump as normal tap pressure proved to be adequate enough to open the non-drip spray mist nozzles.

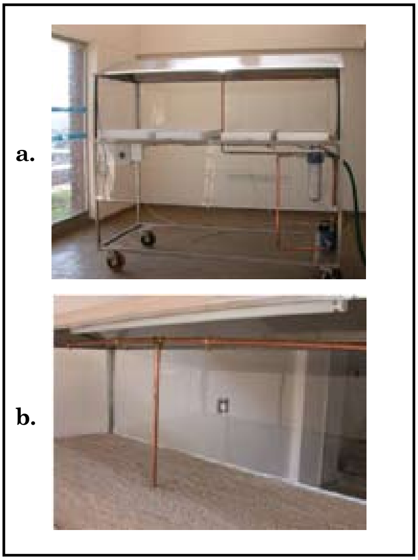

Figure 1. First prototype of Wheelie Green with high-pressure pump, copper pipe irrigation, and capacity for four seedling trays (a). Light source was a single daylight fluorescent tube (b).

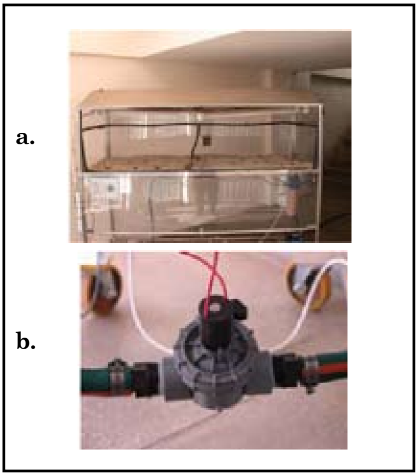

Figure 2. Wheelie Green 2 with PVC irrigation system attached to the chamber sides (a). The system has four non-drip mist spray nozzles. Normal municipal tap water pressure is adequate to open the nozzles. Irrigation is controlled by a solenoid valve on a timer (b).

The light quality (irradiance) generated by the single household fluorescent tube was not adequate to enhance photosynthesis. This tube was replaced by four T5 Plant Pro Fluorescent tubes (39W), which generates the correct light spectrum to enhance photosynthesis (Fig. 3). The tubes were attached to a wooden board suspended from the roof with two small chains. The idea was to allow for the light to be moved up and down should a change in the light energy at plant level be needed. However, this did not prove to be very successful as space was limited due to the positioning of the sprayers. They also created a safety hazard as, even though the board was painted with a water proofing layer, it started to bend after a couple of weeks under high humidity conditions in the chamber.

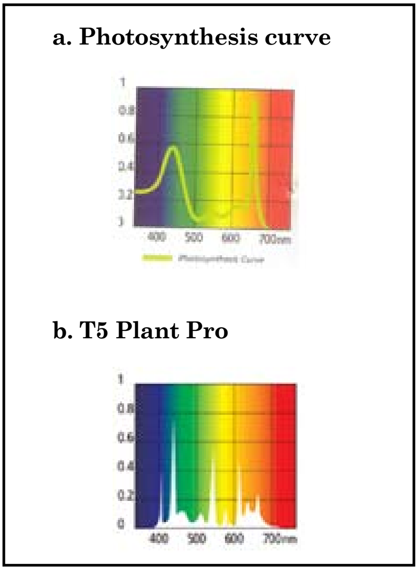

Figure 3. Wavelength produced by T5 Plant Pro Fluorescent tubes fall within the required light spectrum for photosynthesis.

Third Prototype. Only slight initial improvements were made to the second prototype. The lights were removed from the wooden board and attached to the roof (Fig. 4A). Irradiance at plant level was enough to ensure photosynthesis and it improved safety.

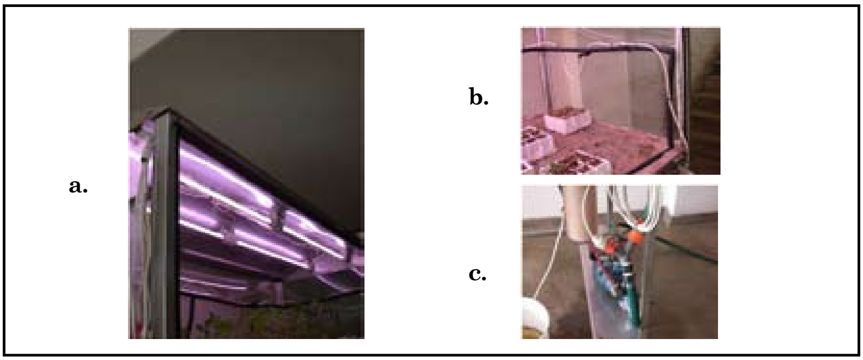

Figure 4. Prototype 3 with T5 Plant Pro Fluorescent tubes attached to the roof and a dual irrigation system.

The spray from non-drip mist nozzles from the PVC system was not fine enough. A cool mist spray system (Fig. 4B) that is commercially available was added to the PVC irrigation system. This increased the effectiveness of cooling down the chamber and a much finer spray drop was sprayed onto the plant leaves. This also created the opportunity for a dual irrigation system (Fig. 4C) with the possibility of using the PVC system for fertilization when the plants have rooted and fertilization needs to be added to the system. A future idea is to replace the existing filter system with a fertigation filter system.

ROOTING EXPERIMENT

In order to test if environmental conditions conducive to rooting can be achieved in the current prototype (No. 3), a *Eucalyptus* hybrid clone, *E. grandis* × *E. camaldulensis*, which is known to be a good rooter, was chosen for the experiment. Hedge plants of this clone were kept in nursery bags in a glasshouse at the University of Pretoria. Microcuttings were harvested from these hedge plants and placed in two rooting media:

1) Vermiculite: Generally used in nurseries.
2) Aerial: Cuttings placed in up-turned seedling trays based on a method of Mike Kruger at Top Crop Nursery in Natal.

Before the cuttings were placed they were rinsed in Benomyl (benzimidazole 500 $g \cdot kg^{-1}$) to prevent fungus infection and the tips were dipped into a root-enhancing hormone Seradix B2.

The two different rooting medium treatments were placed in a randomized block design in the Wheelie Green (Fig. 5).

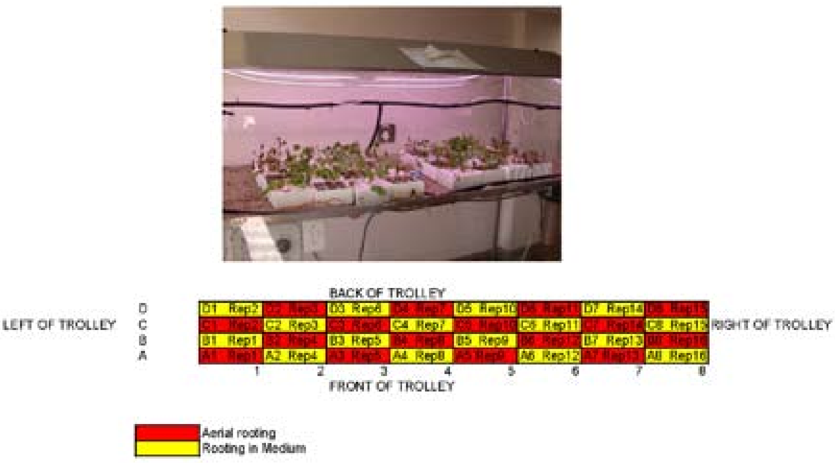

Figure 5. Experimental layout for rooting experiment.

Plant survival and rooting were monitored at weekly intervals. The temperature and relative humidity in the chamber were measured with an OakTon RH/TempLog instrument. Unfortunately due to the fact that the heating mats were not sufficiently insulated against water they had to be switched off after a week as they caused power failures. However, an average daily temperature of T = 25 °C ± 3 °C could be maintained across the experimental period. This was mainly due to heat generated by the fluorescent tubes. Irrigation was initially set for 2 h off and 60 seconds on. This was changed to 30 seconds on and 2 h off. The average relative humidity in the chamber was 81% ± 3%.

Initial plant survival dropped to around 54% within the first 5 days (Fig. 6), probably because conditions were initially too wet in the chamber. After 18 days the survival rate stabilized at 44% plant survival in both the vermiculite as well as in the aerial rooting.

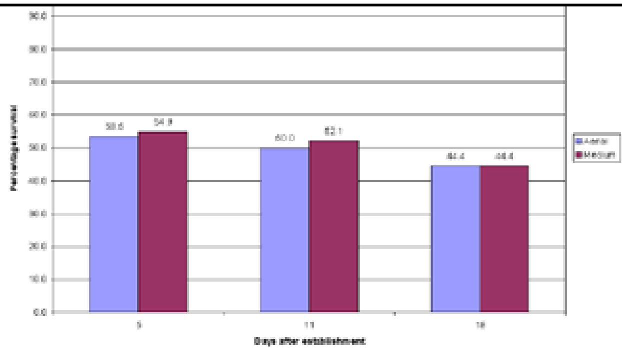

Figure 6. Survival of mini cuttings in the Wheelie Green at 5, 11, and 18 days after setting the cuttings.

Strong root development was obtained in both the vermiculite as well as in the aerial rooting (Fig. 7). However, substantially better rooting was obtained in the vermiculite (Fig. 8). Only 1.4% of the surviving cuttings rooted in the aerial medium while 30.7% rooted in the vermiculite. After 18 days only 6% of cuttings had rooted in the aerial medium while 53% had rooted in the vermiculite.

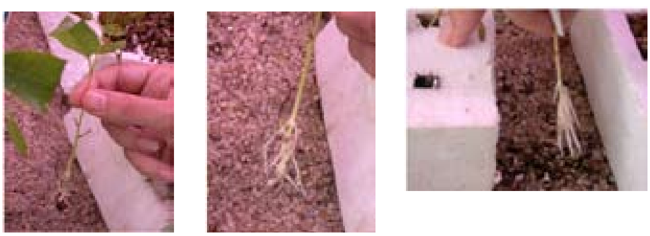

Figure 7. Strong rooting was observed in both the vermiculite and aerial rooting media.

At this stage it can be concluded that conditions suitable to enhance rooting can be obtained within the Wheelie Green. However, conditions are not conducive to aerial rooting.

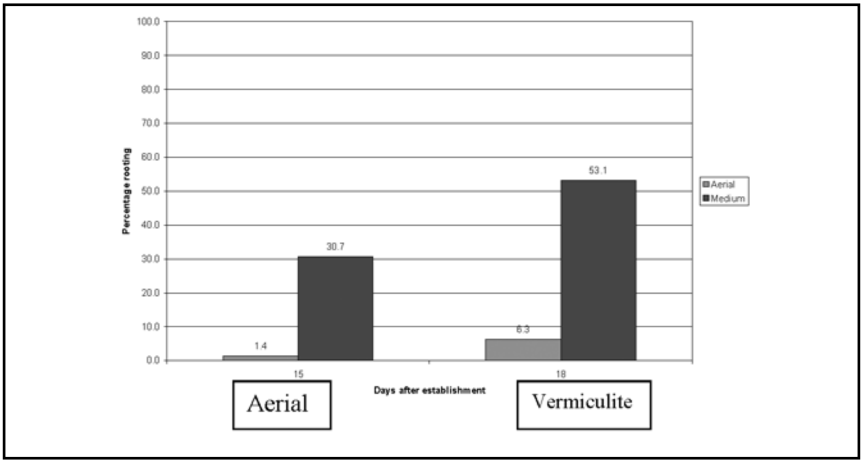

Figure 8. Percentage rooting of the surviving mini-cuttings in the vermiculite and aerial medium in the Wheelie Green.

FUTURE DEVELOPMENT

It can be concluded that at this stage we have developed the basic prototype for an experimental unit in which rooting experiments can be done. We do need to solve a couple of immediate problems, namely:

- Water and electricity problem.
  - Move heating pads to outside of chamber or replace.
- Better drainage of water from tray.
- Add fans for:
  - Better temperature control.
  - Slight air movement in chamber.

For the future upgrade to a fully controllable experimental unit we will need to obtain funding to develop a complete engineered design, which will include:

- Better insulation of the chamber.
- Addition of CO_2 system.
- Computerized control of the temperature (fans), irrigation, relative humidity, heating pads, and CO_2 system.

With the above mentioned technological improvements it will be possible to have an experimental unit in which research could be done to determine the specific conditions needed to stimulate rooting of cuttings from known difficult rooters e.g., *E. grandis* × *E. nitens* hybrids.

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