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A light-intensity controlled, mist system with water and power backup for rooting cuttings of agroforestry species

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Abstract Rooting of cuttings is an important part of many components of agroforestry and horticultural research. A technique for rooting cuttings in which the frequency between misting is controlled by environmental sensors is reported here. In developing countries variability in water pressure (or lack thereof) and voltage levels for mist systems often greatly comprises research involved with rooting of cuttings. These problems were overcome with an electrical system comprised of a permanently charged truck battery with a DC mist controller and a high pressure pump. An 800 l ground level storage tank with float valve provided a water reservoir. This system was capable of operating a 2.2 m by 2.2 m, high-pressure, mist bench for about 8 h completely independent of water and electricity. As an added advantage, the mist frequency was proportional to light intensity (and air temperature), thus avoiding over watering.

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Introduction

The long generation time necessary to breed true to type tree species from seed and the possibility to directly propagate rare genetic recombinations asexually by rooting of cuttings, has lead to increased interest in rooting of cutting techniques for woody plants for agroforestry and horticulture. Great advances have been made in the rooting of difficult hardwoods such as eucalyptus (Marques et al. 1999) and conifers (Brinker et al. 2004). An urgent need in developing countries is to solve problems related to unreliability of water and electricity (absolute cuts in addition to variability in voltage and water pressure) in mist propagation systems.

Since our first report on rooting *Prosopis* cuttings in 1981 (Felker and Clark 1981) we have evaluated numerous hormone treatments and environmental conditions and have found that for the more difficult to root *Prosopis* species, such as *P. alba*, a mist system is preferred. This is partially attributable to the high light requirement of *P. alba* for rooting (>200 μmol m^{-2} s^{-1}) (Klass et al. 1984) that is difficult to obtain in transparent enclosures without causing overheating. We recently published a paper (Felker et al.

2005) with the method reported here in which 80% of one year old *P. alba* cuttings rooted when 40°C air temperatures occurred for 21 of the 28 days of the experiment and when one day reached 50°C. Using this mist system, *P. pallida* (which is very closely related to *P. juliflora*) proved much easier to root than *P. alba* (virtually 100% rooting in 14 days) (Felker unpub obs 2003).

While various types of rooting environments are possible, high-pressure mist (>6 MPa) with a fine fog provides more complete coverage of unrooted cuttings than low pressure systems with larger droplets. Due to the better coverage, less water is required than for lower pressure systems which may lead to less ''water logging'' and development of fungal pathogens. In systems whose mist frequency is controlled by a fixed time clock, it is necessary to adjust the time clocks to wet the leaf surfaces in the middle of the day when the evaporative demand is greatest, and to accept the fact that over watering occurs in the early morning or on days with less evaporative demand. In commercial rooting of cuttings environments, that do not have extensive control of the environment, there can be large diurnal and day to day variability in evaporative demand. Thus it is advantageous to continually adjust the mist frequency to match environmental parameters.

For desert tree species such as *Prosopis* that have high temperature (ca. 35°C) and light intensity requirements to root cuttings, breaks in the water or electrical supply necessary to maintain a layer of water on the cuttings for a little as one hour, may cause total mortality to the unrooted cuttings. Since trials normally last about 4 weeks and since only about five trials can be conducted per year in the spring, summer and early fall, such a cut in the misting may result in a loss of 25% of a year's research. Even when total breaks in the water supply do not occur, pressure drops to the mist heads from competing uses (other areas of the greenhouse) may result in inadequate moisture being maintained on the mist surface area normally covered. For these reasons it is critical to provide backup systems to ensure maintenance of water supply, water pressure and electricity to control the mist system.

A previous report of a solar powered mist system that functioned well in Haiti (Wojtusik et al. 1994) had access to a reliable source of constant pressure water and used the rate of evaporation from a mechanical leaf to control the misting. However this leaf occasionally became stuck and winds sometimes caused the leaf to dislodge from the housing. In search for a non-mechanical method to track evaporative demand, a system was evaluated in which the frequency between mists was proportional to the light intensity. This system was found to be more reliable than the mechanical system. At night this system goes into a clock type mode in which the frequency of misting can be scheduled at a variety of time intervals to keep cuttings moist during dry nights. To overcome the problem of low light intensities at the end of hot summer days when the evaporative demand is still very high, this system has an optional thermostat modifier which can be used to increase the mist frequencies.

Materials and methods

The schematic for the backup system for auxiliary water and electricity is shown in Fig. 1. A Solar 3B-12 V DC (capable of misting three independent systems) with a 12 V DC input option and a thermostat option (www.davisengineering.com) was used to adjust the frequency and duration of the misting. This unit measured the solar intensity and accumulated solar intensity units that were continuously compared to a solar repeat unit selected by the propagator. When the accumulated solar units matched the repeat interval, a 12 V DC output was sent to a relay (www.davisengineering.com) which activated a 12 V DC pump. This DC pump (FLOJET model 2100-959-12 Morgan, Irvine, Calif www.flojet.com) had a 7.0 amp draw and provided 6.8 l (26 l max) of water at 4.8 MPa pressure. A 120 mesh filter was located on the inlet side of the pump to prevent particles from clogging the small (0.75 mm) orifices of the mist nozzles. The pump withdrew water from an 800 l storage tank (at ground level) fitted with a float valve and sent pressurized water through a high pressure hose (thick walled 6 MPa drip irrigation tubing) to the

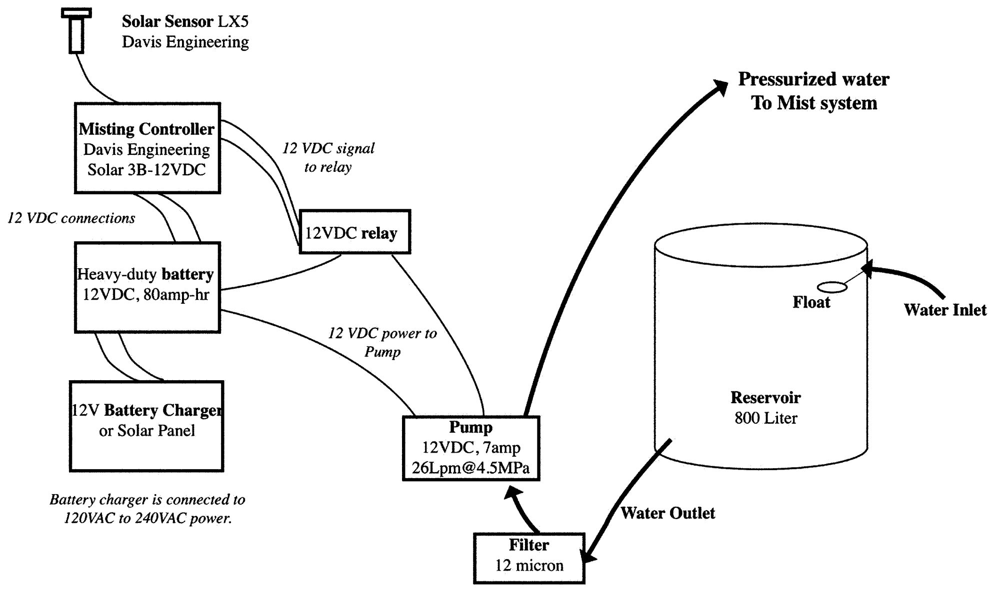

Fig. 1 Schematic diagram for a light intensity controlled, high-pressure mist system with DC backup power for rooting cuttings

Dramm Misty Mist High Pressure nozzles (www.agaupply.com) that each had an output of 0.45 l per minute at 5.1 MPa. These nozzles were spaced 1.1 m apart in both directions 1 m above the misting bench. For a 2.2 m by 2.2 m mist bench, nine nozzles were used with the no-drip high riser option available from the manufacturer. This is a higher nozzle density than the manufacturer recommends but was found necessary to provide a pattern without gaps. In mid-summer in Argentina when greenhouse temperatures were 38–42°C, the Solar 3B settings were; Solar mode (as opposed to time clock), repeat interval = 6 solar units, 28 s on, ¼ hour night repeat, normal days, and 100°F (38°C) for thermostat. In the middle of the day with about 600 μmole light intensity, this unit provided misting about every 3.5 min while in the early morning it provided misting every 12–14 min. The long time of 28 s on was due to the long time to refill the lines between pump activations. Only about 7 s full misting was necessary to wet the cuttings. It would be helpful to install a check valve between the nozzles and the pump to prevent the need from continually refilling the line between mists.

This system employed a 25 amp-13.8 voltage output charger that maintained an 80 amp h, 12 V truck battery fully charged. This charger was locally used to maintain batteries supplying current to radios in taxis. The 12 V DC battery provided power to both the Solar 3B unit and to the DC pump via the relay. On several occasions the fully charged battery powered this system for half a day without problem. At a duty cycle of 28 s on every 3 min (worst case scenario), and a 7 amp draw, a new 80 amp h battery should theoretically provide power for about 80 h.

At a water consumption of 0.45 l per minute per nozzle, operating 28 s every 3 min and 9 nozzles per mist bench (38 l per hour), the 800 l water reservoir would provide water for 21 h. We have added agrochemicals (fungicides, fertilizers etc) to this reservoir to be in constant contact with the cuttings.

These high misting rates necessary to keep the leaves moist at 38°C air temperatures, decreased root zone temperatures. As one of the most important factors in rooting *Prosopis* is a root temperature in the 33°C range, this self-adjusting mist system was used in conjunction with a 200 l hot water tank, circulating pump and a 6 mm o.d. serpentine of copper tubing (embedded in a low density charcoal matrix covered with plastic) on the mist bench to increase the root temperature

(We have recently switched to less expensive aluminum tubing). This system provided an approximate 6°C increase in root temperature to about 33°C (even when air temperatures were 38°C) and was one of the most important factors identified thus far in stimulating rooting of cuttings in this difficult to root species (Felker et al. 2005).

Results and discussion

This system was used approximately 8 months of the year (spring, summer and fall) for 3 years without a problem until in the third year, the battery, battery charger and DC pump had to be replaced.

In summary the system described here was used for 3 years without a break in the misting that previously was fraught with breaks in the water and electrical supply. This system provided a mist frequency proportional to evaporative demand, and thus had less of a tendency to over or under water cuttings as occurs when a fixed time clock is used. Due to the DC pump, a uniform mist distribution occurred due to a constant water pressure.

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