PROPAGATION IN A HUMID CHAMBER

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A humid environment around cuttings is an essential requirement of propagation to prevent wilting. Humidity of air increases when exposed to warmer wet surfaces. The moist surfaces of leaves and the propagation medium serve to humidify the surrounding air during cool cloudy weather but are inadequate under hot, windy or sunny conditions. The amount of evaporative surface can be greatly increased by dispersing water droplets in the air. The surface of each droplet becomes an evaporative surface while air-borne or after impingement on another surface. The evaporative surface is greatest when the droplets are sufficiently small to remain air-borne and hence are defined as fog. The use of fog to maintain high relative humidity was tried and reported by Stoutemyer in 1942 (1). The heat accumulating in the enclosed humid atmosphere during midsummer led to shading which, in turn, led to the use of non-solar lighting (2). The consequential stagnant environment encouraged fungal growth resulting in an unpopular conception of high humidity propagation and it was nearly forgotten until 3 years ago. At that time, the concept was conceived of using supplemental humidification to cool as well as humidify through controlled ventilation.

MATERIALS AND METHODS

Cooling as well as humidifying the air around cuttings requires an exchange of air within the humid chamber. Humidifying without cooling involves the suspension of sufficient moisture in the air to restore 100% relative humidity (RH) as solar radiation heats and expands the air but the small amount of evaporation required to restore the humidity is insufficient for cooling the air. Increasing evaporation enough for cooling requires taking in ambient air which has a lower RH. During humidification of this ambient air, evaporation lowers its temperature sufficiently so that it can withstand solar heating without becoming too hot for cuttings. By suspending additional fog in the air, it remains at 100% RH during solar heating and expansion of the air as in a non-cooled high humidity chamber. The hot air is exhausted while taking in ambient air which helps to remove heat that otherwise would accumulate until dissipated more slowly through the walls of the enclosure. The rate of air flow must not exceed the humidification capacity of the fog generating units and this capacity must be adequate to maintain suitably low temperatures during the hottest weather anticipated throughout propagation.

Two types of fog generators were used, the centrifugal humidifier and the syphon nozzle*. The centrifugal humidifier was installed to draw ambient air through the humidifier and exhaust it intermixed with fog at the level of the cuttings. The heated fog rose and was forced through a vent at the highest point in the enclosure. This type of humidification and ventilation system was used in a 2.4 × 3.6 m quonset with a height of 2 m. The syphon nozzles were installed just above the cuttings to encourage air circulation among the cuttings. The above enclosure and two enclosed ground beds (of 0.6 m and 1.2 m width) were also operated with syphon nozzles. The quonset was vented with a thermostatically controlled fan. The wider of the two bed enclosures was vented with a 2 cm opening along the entire length of each side of the enclosure at 0.6 m height. The narrower bed enclosure was vented through a 15% shade cloth covering the end farthest from two terminally positioned nozzles. Syphon nozzles were also placed in front of a continuously operating intake fan which mixed the air with fog at the ratio of 30 ppm water v/v. The freshly humidified air was directed across the cuttings in the previously described quonset enclosure and the hot air was vented at the roof gable. Fogging equipment was operated only during daylight hours and was installed to distribute between 5 and 10 liters of water as fog per 10 m^2 of propagation area. The enclosed beds were not shaded except the larger one by a building and several tall trees during the late afternoon. the quonset was located in a fiberglass greenhouse transmitting 50% light and later removed and covered by 80% shading over the upper 50% of its periphery.

The temperature was measured in the quonset by a Honeywell multipoint temperature recorder and checked daily with a mercury thermometer. The humidity was measured with a sling psychrometer. At least 25 cuttings were propagated of 30 species either for determining their ability to root under this system or to acquire plants for other research. Performance of the ventilated high humidity chamber for propagation was measured in terms of temperature control and ability to propagate cuttings.

RESULTS

Droplet size and their distribution was found to be important to successful propagation with this system. Large droplets

* Delevan manufacturing Co. 811 Fourth St. West Des Moines Iowa 50265. The low pressure (15PSI), low volume (0.3 gal/hr) nozzle was used but should not be interpreted that other nozzles of similar specifications could not be used.

maintained the humidity below 100%. Whenever visible fog was suspended in the air, the humidity was measured to be 100%. Circulation of the cooler humidified air among the cuttings was necessary to prevent the humidity among the cuttings from dropping below 100% and scorching the foliage. The best circulation was maintained by mixing the fog with the incoming air stream. The force of the fog leaving the syphon nozzles was sufficient if the nozzles were carefully positioned to distribute the fog equally over the cuttings and the vents were adequate for removing the hot air without allowing excess cross ventilation from exterior wind currents.

Measurements of the temperature within the enclosures showed that temperatures above 46°C caused leaf scorch. The temperature was maintained below 38°C in each enclosure except on extremely hot humid days which did not seem to adversely affect the rooting of most cuttings. The ambient air temperature during the 2 weeks following Aug. 29 ranged between 20 and 35°C. The temperature of the propagation medium and the humidified air in the quonset enclosure are shown in Figure 1. Fluctuations of the temperature from the line of least squares is the consequence of variations in the daily humidity. The temperature of the propagation medium was warmer than the humidified air indicating that the propagation medium is the site of solar heat conversion. Circulation of the cooler humid air carried this heat into the current of exhausted air.

Root initiation of cuttings occurred within 2 to 4 weeks for most species and cuttings that were slower to root remained in good condition for much longer periods of time (Table 1). Additional shoot growth and the maintenance of healthy erected positioned leaves without the loss of natural luster was common among cuttings. Decline of cuttings followed any deterioration in operation of the system that resulted in low humidity or high temperature stress. Cuttings that were permitted to wilt or were stored for prolonged periods of time in preparation for propagation also declined rapidly. Larger cuttings than are customarily rooted under mist were easily rooted and when transplanted, adjusted rapidly to the natural environment.

DISCUSSION

The former view that humidified enclosures do not work well during mid-summer for propagation is no longer valid. The temperature within such enclosures can be controlled at acceptable and even beneficial levels through controlled ventilation. The temperature in non-ventilated sun exposed enclosures is always higher than the ambient air temperature and can reach 46°C during mid-summer. With ventilation and humidification the temperature can be reduced to lower and safer levels

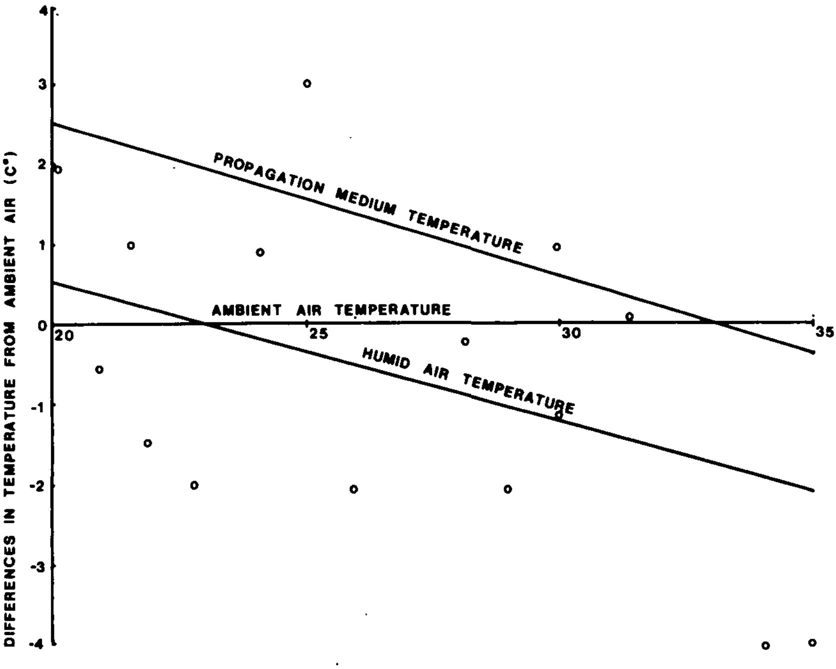

Figure 1. Temperatures of the propagation medium and enclosed air in relation to ambient air temperatures. Lines determined by the least squares method with deviation of individual temperatures being primarily due to differences in ambient air relative humidity.

Table 1. Percent rooting of cuttings under high humidity conditions.

Name	Percent Rooting	Name	Percent Rooting
Arundo donax	70	*Juniperus horizontalis* 'Wiltonii'	70
Betula nigra	100	*Juniperus procumbens* 'Nana'	43
Buxus sempervirens	100	*Lagerstroemia indica*	64
Camellia japonica	80	*Ligustrum lucidum*	100
Carissa grandiflora	90	*Malpighia coccigera*	95
Catharanthus roseus (syn. *Vinca rosea*)	60	*Pieris japonica*	73
Cotoneaster dammeri	83	*Potentilla fruitcosa*	90
Euphorbia pulcherrima	--*	*Prunus tomentosa*	--
Gordonia lasianthus	100	*Pyracantha coccinea*	87
Hydrangea macrophylla	100	*Pyrus calleryana*	60
Hypericum × 'Hidcote'	95	*Rhododendron* cultivars	--
Ilex aquifolium, 'Aureo-marginata'	--	*Salix matsudana* 'Tortuosa'	100
Ilex cornuta 'Burfordi'	--	*Taxus cuspidata*	--
Ilex crenata 'Helleri'	90	*Viburnum tinus*	75
Ilex × *attenuata* 'Foster No. 2'	90	*Vitis rotundifolia*	90

* Percent rooting not recorded.

for propagation. The capacity to cool is greatest during sunny days when heating and air expansion is greatest and greatly reduced when solar heating is reduced by cloudy weather. This moderating effect is most evident on the propagation medium which as a consequence, remains for extended durations within the temperature range considered beneficial for stimulating early root initiation of cuttings. The temperature factor which was formerly considered to be a disadvantage of this system has become beneficial in the ventilated high humidity propagation system.

The moderating effect of this system is also due to the interaction of naturally occurring factors and evaporative cooling. During the night hours, the air cools to the dew point (100% RH). As the air expands with rising temperatures of the early daylight hours, the humidity drops. If the temperature remains cool with its associated high level of humidity, evaporative cooling remains relatively inefficient and the temperature within the enclosure rises from solar radiation converted to heat. As the temperature rises. ambient air humidity drops and the greater capacity for evaporative cooling more efficiently removes the heat produces within the enclosure. Unlike misting, evaporative cooling in the enclosure does not reduce the temperature at the surface of the leaf or the propagation medium below that of the surrounding air. Therefore, the effects of bottom heating occur as a consequence of this type of cooling.

Night time dew point humidity was also used advantageously. While the fogging units were not operating, the air became stagnant in the enclosure and similar to Stoutemeyers system, water mold, *Pythium* sp., invaded the cuttings. This invasion was first controlled by weekly applications of fungicides such as daconyl, captan and benomyl but was later controlled more efficiently with ventilation. Opening the enclosure at sunset had no detrimental effect except on windy nights and effectively controlled the water mold. On the unit with forced air intake, the fan was operated continuously with equal results but without the need for windy night vigilance. While Stoutemeyer associated fungal problems with low light intensities and shading, our experiences indicate that they are due to inadequate ventilation and shading is an efficient means of assisting in temperature control during mid-summer.

This system of propagation has been used successfully in a variety of structures. Humidified enclosures have functioned within a greenhouse or fully exposed to the weather with success. While the experimental enclosures covered 10 m^2 or less in area, they varied in shape from a tunnel-like covering for a narrow bed to a nearly square quonset. The methods of ventilation were also varied. Its installation on a larger scale should also be successful if humidification and ventilation equipment is proportionately increased but this has not been done yet. In all installations, as with mist, successful operation is dependent on adequate and reliable equipment.

Propagation under this system produces a high quality rooted cutting. The roots are initiated and grown in a propagation medium that receives and looses very little water during propagation. While typical propagation media made from vermiculite, sand, peat and perlite were used in much of this research, growing media were also used which contained large proportions of field soil, leaf mold and well composted sawdust. The propagation medium appeared to be much less important to the success of rooting than has been observed for mist. In an extreme situation, individual cuttings developed root systems that thoroughly permeated 6 to 8 liters of medium before removal from the enclosure.

Because cuttings decline in vigor very slowly (unsuccessfully rooted cuttings have been maintained for 9 months before discarding), the leaves of large leafed cuttings were not trimmed and cutting sizes were increased from the customary 8 to 15 cm to 16 to 30 cm to obtain more mature foliage on rapidly growing new shoots of stock plants. When rooted, these cuttings quickly recovered from transplanting and continued vigorous growth. As with mist, cuttings of some species and cultivars were difficult or impossible to root under this system. The range of plants propagated easily under this system is expected to include most but not all plants now propagated under mist and a portion of those plants known to be difficult to root under mist including many of those which are native to dry climates.

In addition to propagation of cuttings, the ventilated high humidity system may be used for other purposes. It has been used successfully to maintain plants in a turgid condition that were field bare rooted during late summer and transplanted to containers. The recovered plants as well as rooted camellia cuttings were free of mineral deposits common from mist and were salable without developing new foliage. It should work equally well for B&B stock. It has been used with very good success for annealing both dormant and non-dormant grafts and for germination of seeds including fern spores. It also has the potential of providing the specific environment for adjusting tissue culture explants to natural conditions.

Three years of research has greatly improved the almost completely abandoned high humidity system of propagation for summer propagation. While it appears to have promise as a valuable addition to nurseries, it needs considerable research to validate these findings in other areas with different weather conditions and to adapt equipment for large scale commercial operation.

LITERATURE CITED

1. Stoutemyer, V.T. 1942. Humidification and the rooting of greenwood cuttings of difficult plants. *Proc. Amer. Soc. Hort. Sci.* 40:301-304.
2. Stoutemyer, V.T. 1946. Rooting and germinating seeds under fluorescent and cold cathode lighting. *Proc. Amer. Soc. Hort. Sci.* 48:309-325.

BRIAN HOWARD: Would you envision cooling the water to be an advantage before it goes into the chamber?

DAN MILBOCKER: I doubt there would be an advantage to cooling it; in fact, there may be an advantage to heating it, because the cooler the water, the more energy it takes to make a fog droplet.

PROPAGATION OF *ARALIA ELATA* 'VARIEGATA'

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The white variegated form of the Japanese angelica tree, a plant of the genus Araliacea to which belong *Hedera* and *Acanthopanax*, is a most exotic looking plant that thrives under difficulties that would tax most other plants. City conditions, sun, shade, or drought prove no obstacle.

We obtained our first two plants from a Belgian nursery approximately twelve years ago. The price at that time was $7.50. When we lost one of the two, the cost per plant was well over $20.00. However, during the second season of growth, large double compound leaves more than one inch long, edged on each of the more than 150 leaflets with a creamy white, was worth any price.

PROPAGATION

After a thorough search of the literature, suggestions for root cuttings, grafting on established understocks or seeding were found. Since the plant was not on its own roots, root cuttings were out. Seeding showed that only green plants germinated; that left grafting. This was tried but proved unsuccessful because of a gumlike substance that seemed to prevent healing. Another problem arose because of the fact that scion material was between 3 and 4 cm thick and understocks of such propor-