CULTURAL CARE — INDOOR CUTTINGS

When propagating indoors we feel there is no need for an automatic mist system. Due to the changes in the environment, we manually mist all of the cuttings. Working in an enclosed greenhouse, we also have the ability to control the humidity to a certain extent. Throughout the fall and winter, we carry 70 to 100% humidity. To measure the relative humidity, we use a precision hygrometer that we monitor closely throughout the day. It aides us in determining the frequency of mist. Our bed temperatures are kept between 65 and 70°F, and our air temperature between 40 and 50°F. Our indoor cuttings are also sprayed bimonthly with fungicides. Depending on the cultivar we get root initiation in 2 to 10 weeks.

RESULTS AND COMMENTS

We, as well as everyone else, strive to get a maximum strike from what we propagate. This past year we had excellent results with the arborvitates, a take of 90%. Results with the outdoor propagated junipers were not as good. We had about 50% that rooted and 25% that just callused. We attribute the poor take to not getting the cuttings in earlier, and having to take many of the cuttings from our container stock which was high in nitrogen due to the constant liquid fertilizing. Our cuttings inside have usually yielded a good strike of 75 to 80% overall. We feel we have only made it to first base on the outside propagating technique and hope to be rounding third and heading for home in years to come.

THE HYDROSOLARIC GREENHOUSE — A NEW GROWING AND PROPAGATING ENVIRONMENT

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Abstract. A favorable growing and propagating environment was created in a hydrosolaric greenhouse This closed greenhouse was composed of a solar energy harvesting system and hydroponics Energy collected by the greenhouse air from the sun during the day was conserved in the growth solution which released the energy during the night

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The cultivation of greenhouse crops faces the challenges of increasing cost of energy and providing a suitable, economical growth medium. In many cases, especially for propagation and cultivation of young plants, high humidity in the greenhouse is important, a condition difficult to create in hot, dry climates.

Solar heating and cooling of greenhouses is still an uneconomical proposition. Even with the present price of fuel, the most advanced solar heating technology cannot heat a greenhouse cheaper than conventional methods (5).

Some hydroponic systems provide a suitable and economical growth medium. Many of these systems however, require an accurate control and any failure may cause substantial losses.

The main method to increase the humidity in dry climates is the use of mist. This method is unsatisfactory when only poor quality water is available. Salt deposition on leaves, especially of foliage plants, reduces their quality.

Maintaining a proper environment for plant growth in a "conventional greenhouse" (Fig. 1a) is achieved by wasteful technology. During the day, excess heat in the greenhouse is removed and discarded by ventilation, while expensive fuel is used to reheat the greenhouse at night. Watering and fertilizing are done by passing growth solutions through the growth medium. The excess water and fertilizers are leached out and discarded. This technology, in addition to being wasteful, contaminates the underground water with fertilizers.

The present report describes a growing system which tries to provide a suitable growing environment using more efficient technologies.

MATERIALS AND METHODS

The System and Environmental Conditions Obtained. As the name hydrosolaric ("hydro" from hydroponics, and "solaric" from solar energy) implies, 2 principles were involved in the operation of this closed greenhouse system: *first*, using solar energy harvested during the day to heat the greenhouse during the night; and *second*, growing plants hydroponically (Fig. 1b).

The hydrosolaric system was built as a closed quonset-form greenhouse, 3 m wide, 4 m high, 20 m long, and covered with a double layer of polyethylene. In order to adjust the environment for the cultivation of house plants, the entire greenhouse structure was shaded to reduce the light intensity by 50% to approximately 5000 ft-c maximum. The greenhouse floor was dug to a depth of 80 cm, and the walls of the excavated area were supported by concrete blocks. The entire area (floor and walls) was covered with black polyethylene (0.2 mm thick). The pond was

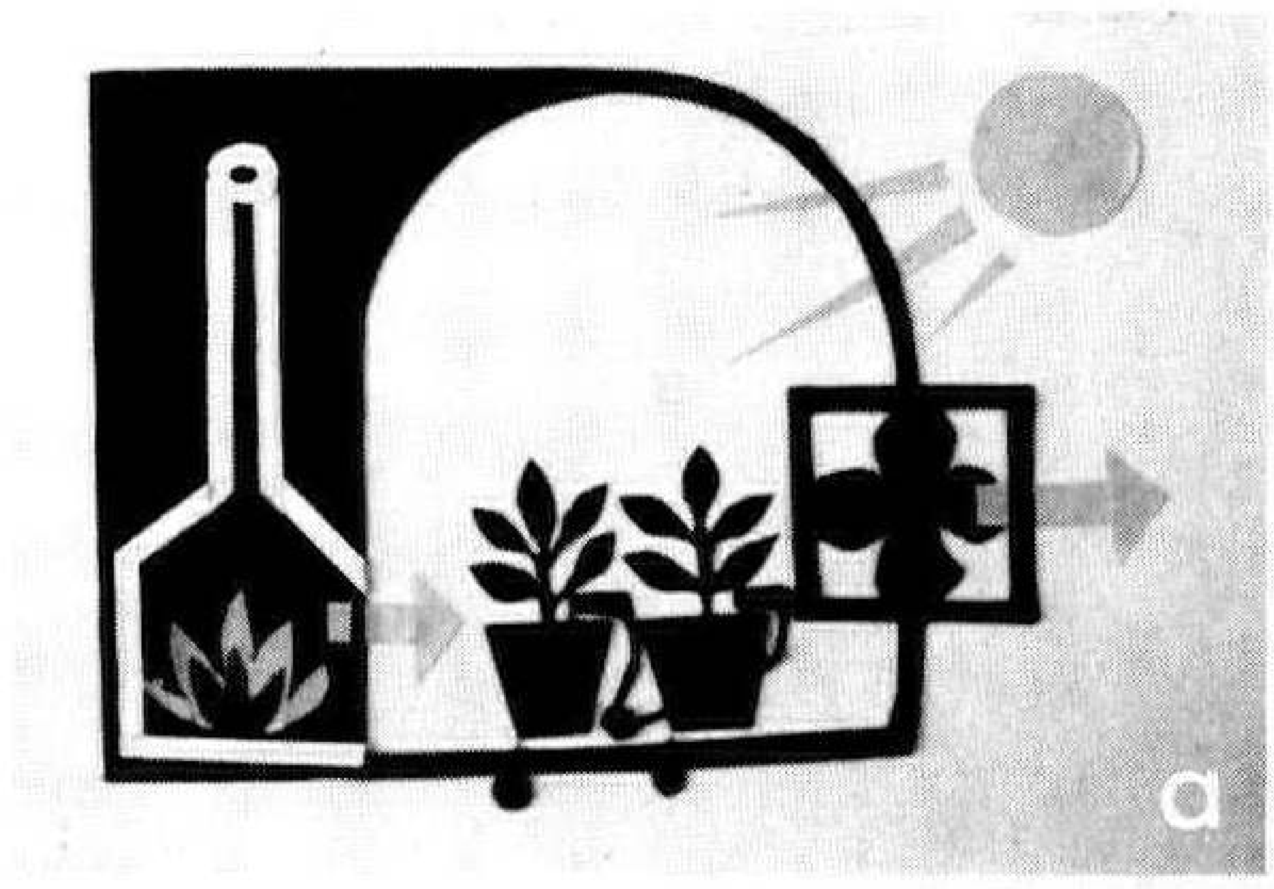

Figure 1a.
Conventional greenhouse system.

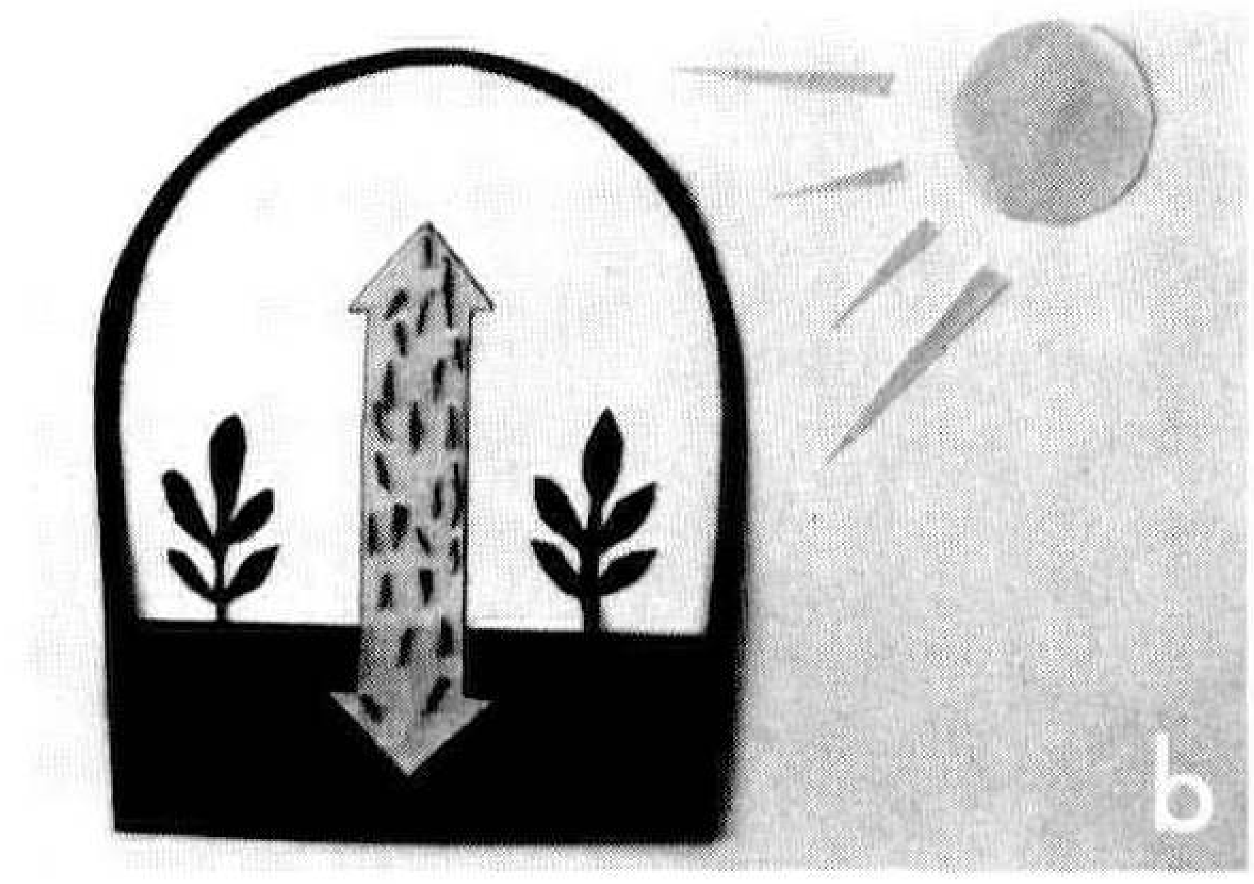

Figure 1b.
Hydrosolaric system.

filled with $38m^3$ of growth solution. The water surface was covered with styrofoam boards (10 cm thick) which floated on the water. Plastic baskets (40 cm × 28 cm × 17 cm deep) filled with *coarse volcanic gravel (Fig. 2a), were placed in holes cut through* the styrofoam boards. The floating styrofoam boards served as a path for walking between the plants, as well as a floating raft which kept the upper edge of the baskets at water level. (1,2,3,4).

The heat exchange unit was placed at the northern end of the greenhouse. In order to increase the surface exposure of the solution, it was pumped and forced through nozzles, located at the upper end of the heat exchange unit. Ventilators placed on the wall, between the heat exchange unit and the growing area, created an air circuit through the waterfall. As a result of this, two closed circuits were formed in the greenhouse: a growth solution circuit which began with the solution pumped from the southern end of the pond and then dispersed through the heat exchange unit and back to the pond; and the air circuit, with the movement of the greenhouse air through the heat exchange unit back to the greenhouse.

The close contact between the growth solution and the air moderated the greenhouse air temperature; cooling it during the day and heating it at night. The only source of heat in the hydrosolaric system was the natural sun energy. The daily amount of heat accumulated in the greenhouse was dependent on the amount of solar energy radiated into the greenhouse, on outdoor temperature, and on wind velocity — all natural, vari-

Figure 2a.
Four month old seedlings of *Philodendron bipinnatifidum* grown in hydrosolaric system: (a) plant growing in plastic basket filled with coarse volcanic gravel.

Figure 2b.
Plant after being removed from basket.

able and uncontrollable factors. To obtain optimal environment in the greenhouse at each given set of these natrual, outdoor conditions, it is necessary to distribute, wisely, the daily available energy accumulated in the greenhouse, between the air (by day and night) and the growth solution. The control of a proper distribution was achieved by the use of two thermostats: one determining the day temperature above which the pumps started to operate, thus transferring the excess heat from the air to the solution, and the other determining the night temperature below which the pump started to operate, thus transferring heat from the warm solution to the cold greenhouse air. When heat energy was limited (on cold nights and cool cloudy days), the thermostats were set for maximum 22°C and minimum 12°C, whereas when heat energy was not limited (on sunny warm days and warm nights), the thermostats were set for maximum 25°C and minimum 18°C. Setting the thermostats at too low values (22°C and 12°C) after hot days and nights caused overheating of the growth solution and thus reduced the oxygen level in it. On the other hand, setting the thermostats at too high values (25°C and 18°C), on a cloudy, cool day, and cold night exhausted the heat supply early in the night, leaving the rest of the night without any heating. On extremely hot days, a ventilating window was opened at the northern upper part of the heat exchanger, which was used as a fan and pad cooling system. Examples of the ability of the system to heat and cool the greenhouse are presented in Table 1 The hydrosolaric system maintained air temperatures of 10° to 32°C, a relative humidity that dropped below 100% for only 4 hr during mid-day, and growth solution temperatures of 13° to 25°C.

Table 1. Temperature and relative humidity (RH) in the hydrosolaric greenhouse during cold and hot days

	OUTDOOR		INDOOR		
	Air		Solution	Air	
	Temp (°C)	RH (%)	temp (°C)	temp (°C)	RH (%)
Cold — Winter	2 — 15	52	13 — 18	10 — 23	81 — 100
Hot — Spring	19 — 38	45	18 — 25	18 — 32	76 — 100

Due to the large volume of nutrient solution (0.6 m^3/m^2 growing area), once a week testing and minor adjustments were sufficient to maintain relatively stable levels of nutrient and pH.

The hydrosolaric greenhouse was completely closed all winter, which permitted the introduction of CO_2. A level of 1000 ppm CO_2 was maintained constantly in the greenhouse.

RESULTS AND DISCUSSION

Plant Performance. A broad range of plant material was examined for its suitability for the hydroponic system. *Philodendron bipinnatifidum, Ficus benjamina* and *F. lyrata, Gardenia* augusta *(syn.:G. jasminoides), Anthurium andraeanum* and *Brassaia actinophylla* grew outstandingly well. Other species, including: *Ruscus* spp., *Acacia cultriformis,* × *Fatshedera* lizei and *Eucalyptus* sp. were tried but did not react favorably to the high humidity or to the hydroponics.

The growth of species well adapted to the hydrosolaric system was unique and different from the growth of the same species in conventional greenhouses in the following ways (Fig. 2a and b):

a Rapid growth rate: In *Philodendron bipinnatifidum,* for example, after a two month acclimatization period in which growth was minimal, leaf area increased 5 times in a period of 1 month (from 200 cm^2 to 1000 cm^2 per plant).

b. Very large leaves: Very large leaves were produced in the hydro-solarically grown *Philodendron bipinnatifidum, Brassaia actinophylla* and *Ficus lyrata.*

c. May offshoots: Plants of *Philodendron bipinnatifidum* and *Anthurium andraeanum* produced many offshoots. The development of offshoots was apparently stimulated by the special environment created. The crowns of the plants were exposed, well aerated and under conditions of high relative humidity.

d. Abundance of lenticles and aerial roots: Stems of *Brassaia actinophylla, Philodendron bipinnatifidum* and *Ficus* spp. were covered with large number of relatively large lenticles. *Brassaia actinophylla* plants produced large number of aerial roots.

Some of these phenomena may have some practical implication in the propagation of these plants.

CONCLUSION

The hydrosolaric system is a closed growth system which permits CO_2 enrichment of the greenhouse, air maintaining a very high level of humidity, and a reasonable growing temperature (without artificial heating) for foliage plants during the Israeli winter.

The 2 components of the hydrosolaric system hydroponics and solar heating of the greenhouse can be separated and thus, the system can be used just to control the greenhouse air atmosphere (heating, cooling, raising humidity, and maintaining a high CO_2 level), and the plants can be grown in conventional solid media.

The hydrosolaric system supported very rapid growth of excellent quality tropical foliage plants without the need for any heating. It creates a favorable environment for growing foliage plants for the production of stock plants, and for rooting of cuttings.

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