stock, proper sanitation practices, proper relationship between air movement, light, temperature, and something that is very important in southern California, good quality water.

REFERENCE

Hartmann, H. T. and D. E. Kester. 1968. Plant Propagation: Principles and Practices, 2nd Edition. Prentice-Hall, Englewood Cliffs, New Jersey.

MODERATOR BRIGGS: Thank you, Ken. I know there'll be a lot of questions after a bit on that because many people are concerned about using pumice. I know we've looked at it many times.

Bob King is now going to talk on the relation of light, temperature, and humidity as it affects plant propagation. Bob, it's all yours:

THE BALANCE OF LIGHT, HUMIDITY AND TEMPERATURE AS RELATED TO CUTTING LEAF DROP

ROBERT W. KING

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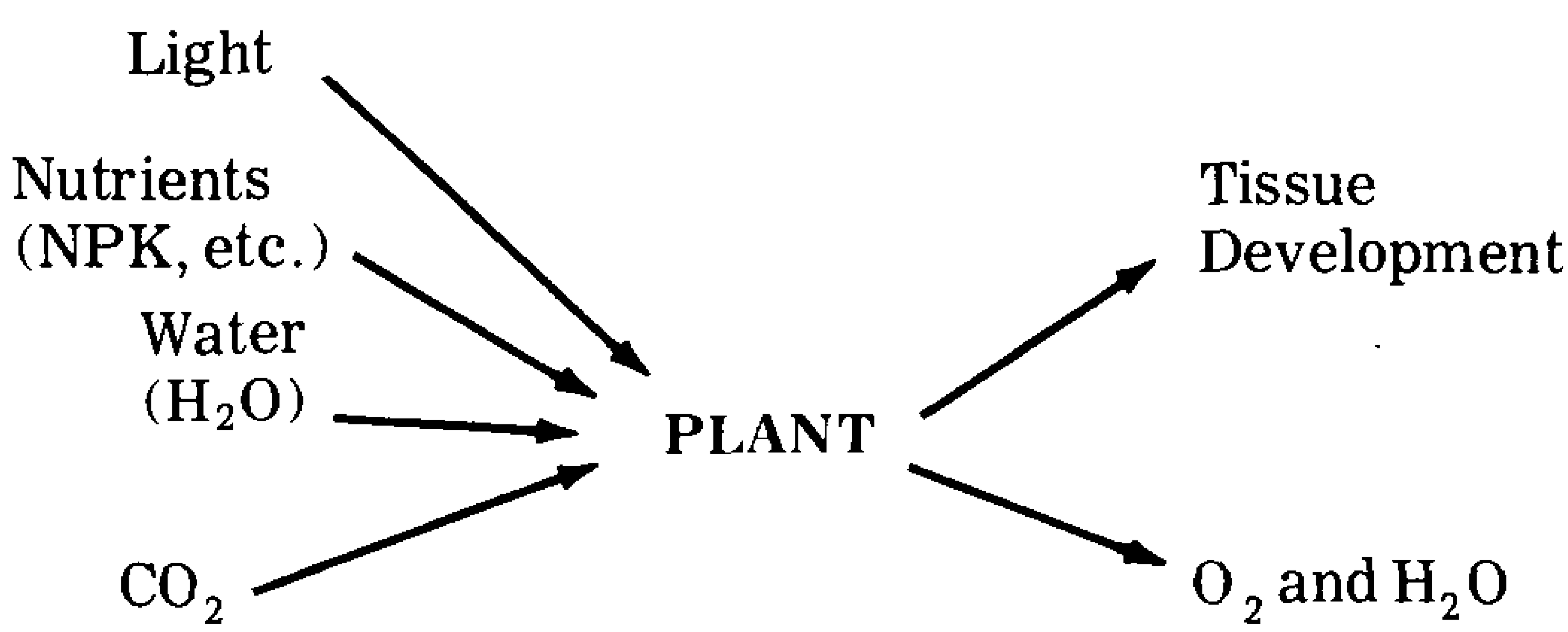
The very complex chemical mechanisms involved in plant development and growth can be summed up simply as follows:



the reactants (materials at left) entering into the plant system and being transformed into the products (materials at right).

Horticulturists have learned by experience that by increasing the amount of the reactants, the amount of products also increases. (chemists call this Le Chateliers' principle). Thus a well-watered and fertilized plant in a lighted location will grow vigorously. We know from experience, however, that there are limits to the amount we may increase these reactants. Overwatering, over fertilization, sunburn, can all result in collapse of the system (plant death). Furthermore the tolerance to increasing these reactants varies from plant to plant so that each species has its own particular optimum values. Also these reactants can only be utilized by the plant in certain ratios; fertilization without ample light and water will not increase development. It is this critical balance of the reactants—light, humidity and heat—and their relation to cutting viability that will be discussed further.

Light and Humidity. Light being an essential ingredient in plant development, the energy source for the reactions in the photosynthetic process, the practical problem for the propagator is to provide ample light without burning or drying out the cuttings. High humidity ($>90\%$) in the cuttings' atmosphere greatly reduces transpiration, as does a water film on the leaf surface; but often cuttings must be protected further by shading. In our propagation operation all cutting beds are shaded with polypropylite shade cloth. The particular cloth selected provides about 50% shade, or a maximum day light intensity of about 1,200 foot-candles.

Heat. It is general knowledge that increasing the temperature in the rooting zone of a developing cutting speeds the initiation and growth of roots. The basis for this is, of course, that Q_{10} of the chemical processes in root development must be somewhere between 2 and 3. In other words, for each 10° C that the temperature is increased, the process doubles or triples in rate. There are of course limits, and temperatures in the range 65° F to 75° F are most often selected as optimum for root initiation and growth. Practically, this is accomplished in our facilities by hot water circulating through pipes beneath the cutting beds, the flow of the water being thermostatically controlled.

The Balance. Despite our careful efforts to provide the optimum conditions of ample light and moderate heat in the rooting zone, we have found that during periods of extended cloudy weather (over two days duration) there was significant leaf drop and cutting deterioration. This condition was especially pronounced in crops of *Xylosma congestum (X. senticosa)*, *Pittosporum tobira* 'Varigata', *Ficus benjamina,* and *Ficus retusa* var. *nitida.*

The maximum daylight intensity at cutting level was measured during one such cloud-cover period and found to be only 125 foot-candles. Apparently the drop in light intensity, combined with the warmth of the bottom heat, had shifted conditions more in favor of fungal growth and cutting deterioration than plant development, fungi being Thallophytes and not requiring light for growth. The problem confronting us was how to best return the balance of heat, humidity, and light to a point more favorable to plant growth. Two solutions seemed evident.

1. To increase light intensity and thus spur plant development. This could be done by installation of artificial light sources or by removal of all shade fabric during cloudy weather but replacing it on clear days.
2. Decrease bottom heat and thus retard the growth of fungi and the rate of plant deterioration due to high respiration.

Solution No. 1 was ruled out as financially unfeasible. Artificial light (fluorescent) installation would be expensive and of doubtful benefit. Removal of the fabric cover from greenhouses and hotbeds, with subsequent replacement each time there was several days of overcast would require a great deal of labor and introduce the danger of burning the cuttings if shade was not applied promptly after clouds dissipated.

Conclusion. We then tried Solution No.2 by reducing the bottom heat, thus the temperature of the rooting zone area to 50-55° F., each time a cloud cover prevailed for more than one day. The following results were obtained as shown in Table 1.

Table 1. Effect of reduced bottom heat during cloudy weather on rooting.

	Rooting without bottom heat reduction	Rooting with bottom heat reduction	Elapsed rooting time
Pittosporium tobira 'Varigata'	58% ± 1%	88% ± 1%	49 days
Xylosma congestum (*X. senticosa*)	63 ± 1	92 ± 1	35

The ability of cuttings to retain leaves in good condition under reduced bottom heat, even through overcast periods of two weeks and longer, was most striking. Speed of root development was retarded slightly. Rooting periods averaged about 10% longer, depending upon number of overcast days occurring during cutting development.

This practice of lowering bottom heat in cloudy weather has now been adopted as standard procedure in our nursery and results have been favorable both in hotbeds and greenhouses. Graphically what we are accomplishing can be seen in Figure 1.

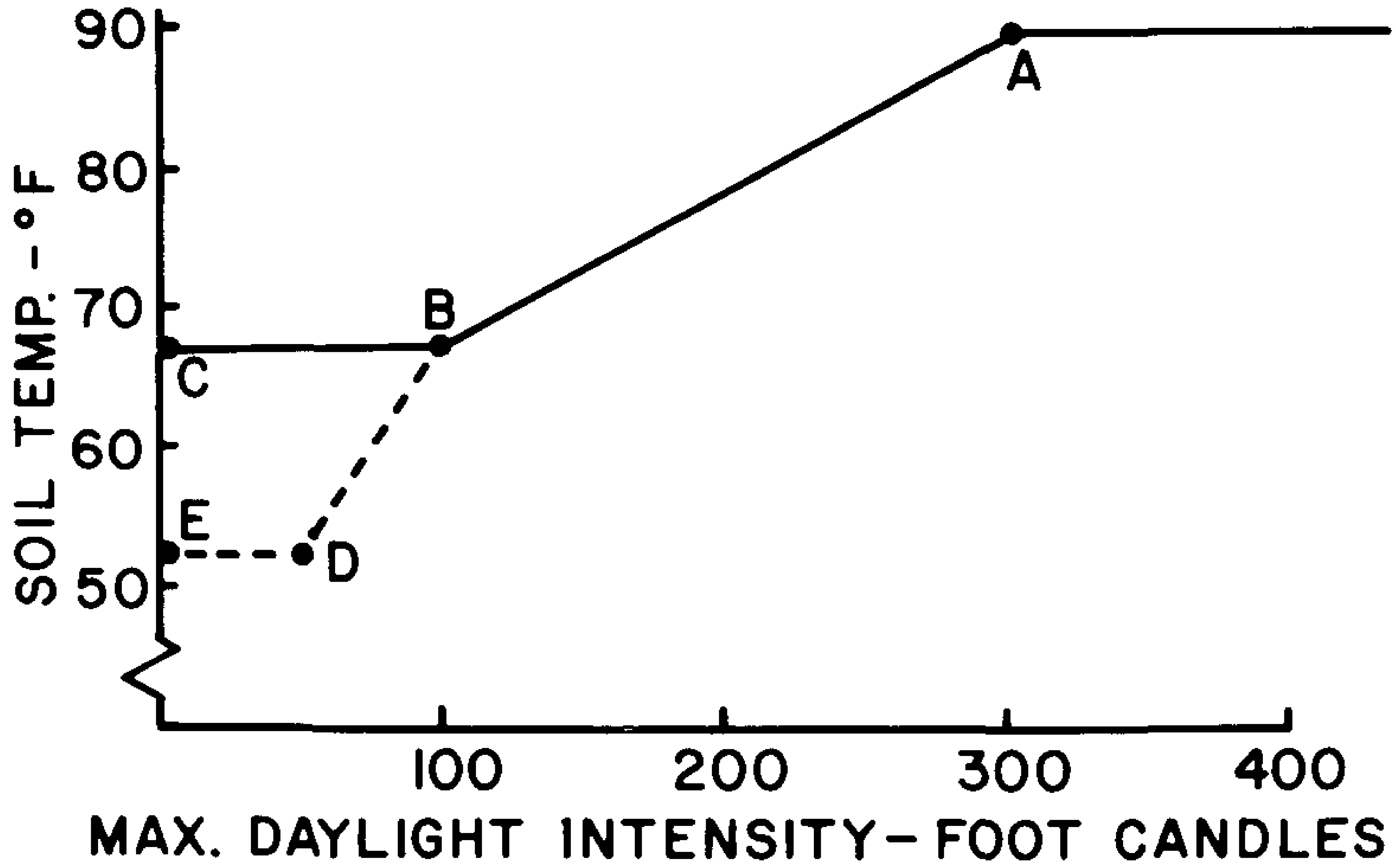


Fig. 1. Bottom heat levels as maintained according to the maximum day light intensity levels.

On clear sunny days, as light intensity drops in evening hours from point A to B, the heater goes on at 70°-65° F., maintaining plants in that temperature range throughout the night hours (B to C). On overcast days, with low light intensity, the temperature is allowed to drift lower, to the broken line B to D, and the plants are kept in this lower range (50°-55° F.) for the duration of the cloudy period.

MODERATOR BRIGGS: Thank you very much. In fact, while Bob was talking I realized that we do this and we never understood why we did it. We have some plants that root very poorly in the greenhouse under heat in the winter, but if we take them out, put them in the lath house, where it is nice and cool, they root like weeds. Maybe we've got the same problem, I'm not sure; we do have low light in the winter up in Washington.

Dick, would you introduce our last speaker?

RICHARD MAIRE: Now on our Propagation Panel we will have a talk by Richard Puffer, Farm Advisor in San Bernardino, giving information on Christmas tree propagation, developed mainly by Mr. Fred Dorman. Dick: