bright sunlight Usually with the initial cover up of newspaper, which is removed, the plants go right into practically full sunlight in the greenhouse It requires a lot of cooling sometimes but we open up the greenhouse doors and that helps.

AUDREY TEASDALE: I would like to address a question to William Brokaw. What are the kiwi cultivars that you grow in southern California and which are easier to propagate by cuttings?

WILLIAM BROKAW: I don't know which are easier to root; they are all hard for us to root. I think that 'Hayward' may be easier than 'Chico Hayward'. I might make two suggestions with cultivars in southern California. One of them is if you are choosing between 'Chico Hayward' and 'Hayward', that you choose 'Hayward'. The second is that if you don't have enough chilling for 'Hayward', there are a couple of other cultivars which you might use. One is 'Bruno', which is from Australia. The fruit has an unfortunate shape, however, and some people do not like the flavor as much. It looks like a fat sausage; it is long and narrow. Another cultivar is one that was discovered as a seedling by Fred Vincent from Yorba Linda, California. This is a warm winter region and an area which had gone out with avocado root rot. This cultivar is called 'Vincent'; it fruits very well for him although the fruit is somewhat smaller than 'Hayward'. In our nursery at Saticoy, California, as well, it has fruited very well whereas all of our 'Haywards' or 'Chico Haywards' that have fruited have been from chilled budwood from the California Central Valley which has relatively cold winters.

SOLAR EFFICIENT GREENHOUSES

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With the current interest in energy conservation, the efficiency of greenhouses has come under close scrutiny. The use of double walls, ground insulation, tight doors and vents is now common practice. Several new ideas are being put to use and it seems certain that energy costs can be reduced even more. I'd like to review four areas that show great promise:

Placement and Design. A complete turnabout in thinking has occurred in the orientation and construction of greenhouses. It has been found that for maximum solar energy entry, the single-

span building should be positioned in an east-west direction. The north wall should be opaque, well-insulated and at an angle of about 60°. The south wall or roof performs best if built at an angle of 35° to 45° (1).

Heat Delivery. Space heating may soon be replaced by bench or floor heating. Don Dillon's Four Winds Nursery in Fremont, California, is one of many that have had success with the use of hot water circulated inside the bench. Whitcomb reports improved plant growth and fewer disease problems with this system, and the energy savings are substantial (4).

Heat Storage. Great strides are being made in the storage, for later use, of the heat that penetrates a greenhouse. When this is done effectively, added heating is unnecessary. If the storage medium is thought of as a sponge that pulls in and holds excess heat, it is easy to understand how this approach will also reduce the need for cooling and shading.

Air is not the best substance for heat storage. When we realize that the air inside a well-insulated and weather-stripped house is completely changed in just two hours, the limitations of air for this purpose become obvious. Soil, stone, and concrete are nearly equal in heat-storing capacity. Water retains heat five times better than these materials and has, therefore, been the first choice.

Salt hexahydrate is now coming into use and has exciting possibilities. This material changes from a solid to a liquid form at 27°C (81°F) and stores *eight* times more heat than water.

This surplus heat can be stored anywhere that does not block the solar radiation — even outside the greenhouse. I believe that the best location is directly under the benches. The natural rising of released heat passes it through the planting media in an ideal manner.

Plant Environment. A revolutionary method of propagation with the use of "ventilated high humidity" has been described by Milbocker (2,3). It sounded very promising and, because it made such good sense, I purchased the necessary equipment from the Agritech Company. In use since June, 1980, (3 months), the results have been noteworthy. Previously I used mist and had a constant battle with over-watering, drying-out and fungus problems. I am now able to take much larger cutting material and have been more successful with difficult-to-root plants. This system also meshes well with solar energy storage. The temperature of the planting medium remains slightly higher than the surrounding air and the circulating fan distributes the warmer air evenly, to assist in heat storage during daylight hours. Relative humidity of 90% to 95% is maintained at all times allowing plants to tolerate a higher temperature level. This, in turn, facili-

tates the storage of more radiant energy and reduces the need for cooling and shading.

As we learn to apply these improvements in greenhouse technology, energy conservation will be automatic. It seems that we can also expect fewer disease problems and a healthier plant as an end product.

LITERATURE CITED

1 McCullagh, James C 1978 *The Solar Greenhouse Book*, Rodale Press, Inc

2 Milbocker, Daniel C 1977 Propagation in a humid chamber *Proc Inter Plant Prop Soc* 28 455-561

3 _____ High humidity propagation promotes healthy, vigorous plant growth *American Nurseryman* May 1 15

4 Whitcomb, Carl E 1977 Self-contained solar greenhouse Oklahoma State University, Stillwater, Oklahoma

RADIANT HEATING FOR PROPAGATION AND ENERGY CONSERVATION

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I want to introduce a concept of heating that is new to the greenhouse industry, but is as old as the sun. The system is a gas fired, low intensity, infrared radiant system Infrared is proving to be an ideal method of heating greenhouse crops from propagation to finish while saving substantially on fuel consumption. The name of the system is CO-RAY-VAC and it is manufactured by Roberts-Gordon Appliance Corporation.

Infrared energy is as old as the sun and its principles have been applied for many years in heating. The cave man used it when he heated the rocks around his campfire. The sun itself is the source of infrared energy which heats the earth's surface. Infrared radiation is energy in the form of electromagnetic waves and has some similar properties to visible light waves. Light, radio waves, x-rays are all electromagnetic waves with different wave lengths and physical properties. Infrared energy travels in a straight line until it strikes and is absorbed by the object to be heated. The energy is then converted into heat that warms that object. In other words, heat is transmitted from one object to another without heating the air between the objects. The radiant heat does not directly warm the air, but the object receiving the radiation is warmed and acts as a heat exchanger to warm the air. The objects warmed by radiation then warm the air due to