It is inevitable that more restrictions on run-off water will be forthcoming and it is only a matter of time when many nurserymen will be approached in this regard.

MODERATOR TOKUJI FURUTA: I have the pleasure of introducing the last speaker, who happens to be myself. So we will just turn the slides on and get started.

IRRIGATION OF ORNAMENTALS

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Present day concern for our environment has had many profitable benefits for the environmental horticultural community. Plants of all types are used indoors and out-of-doors, not as mere decoration or objet d'art, but as a subject to create moods within *our surroundings, moods to soothe and refresh our inner self.*

Present day concern for our environment has necessitated that we examine our ways as producers. Degradation of the environment in the name of profit or growth is no longer acceptable. Utilization of all resources in an inefficient manner is not acceptable. Painful though the process may be, it is necessary to adapt to the present day real world. As some have stated, we, who are the prime providers of better environments through the use of living plants, certainly should not contribute towards the degradation of that same environment.

Efficient and effective use of water for the production of container-grown ornamental plants is a many-faceted opportunity. Some claim that to replenish the water withdrawn from the soil, all that is needed is to uniformly spread the water over the area where the plants are growing, and to do this with the least cost of capital investment and labor. This disregards efficient use of resources. This disregards possible degradation of the environment. The situation is complex, and is subject to many constraints.

Let us examine some of the facets of efficient and effective use. To be efficient, one must distribute water to the plants with the least waste of water, labor and capital — all considered together. To be effective, one must apply the water on a schedule and in the amount necessary to maintain desirable plant growth. To be efficient, the water must be applied only inside many containers. Efficient and effective use of water then requires the need

to consider aspects other than the mere spreading of water, because these influence or limit the opportunities and options available.

I like to consider water, fertilizer and soil mixture as a subsystem of the system for production of environmental horticultural plants in containers. Not only from the viewpoint of affecting plant growth, but from the viewpoint of engineering and capital management, we have found time and again the necessity of considering these factors together.

Consider, for example, how fertilization methods and material limit the options open for irrigation systems. Fertilizer placed on the soil surface must dissolve in water before the nutrient elements percolate to where they are absorbed. The irrigation system, therefore, must apply water so that the fertilizer is dissolved. You might sprinkle water over the entire soil surface — systems such as overhead or spray nozzles, or must apply water rapidly to flood the surface — manual hose, or large diameter spaghetti tubing. Irrigation systems such as drip irrigation, where water infiltrates as soon as it drips onto the soil surface are not used because water will not spread on the surface and the fertilizer will not be dissolved.

EFFICIENT AND EFFECTIVE USE OF WATER

Efficient and effective uses requiré that water be placed where the plants can utilize it at intervals before the reservoir is depleted, and in the amount needed to bring the reservoir to capacity and to control salinity within the soil. Many factors must be considered — how much is needed, when it's needed, how the water should be distributed, what capital and labor resources are involved, and what legal, ethical and environmental factors must be considered. And from the point of view of the businessman, how does all this affect optimum profit.

Applying water directly into the container increased greatly the efficiency of water use. Under overhead irrigation, 82 percent of the water ran off. Under the same climatic conditions, only 20 percent of the water ran off when drip irrigation was used.

HOW TO GET WATER INTO THE CONTAINER?

Simple, you may answer to the question — how to get water into the container? Either you let water drop uniformly over a bed of containers and each container receives enough water — or you subirrigate the whole — or you pipe water to each container. We must understand the advantages and limitations of each approach (Table 4).

Overhead sprinkler irrigation is the most commonly-used procedure. It is simple to maintain and operate, relatively inexpensive

to install, and with properly installed and maintained controller, has a low demand for labor. On the other hand, it is inefficient in the use of water. Most of the inefficiency is due to placement of containers. Most of the sprinkled water falls between containers and runs off.

Subirrigation of plants seems to have limited application in nursery production and is used primarily in greenhouses. It requires a level area where water may be retained, and a soil with excellent capillary conductivity of water. Some modes of operation are wasteful of water.

Piping water to each container has low labor requirements and is simple to operate. There is efficiency in the use of water — only the water needed for growth and maintaining balance of salts is used. These systems require an elaborate system of tubes and pipes. Depending on the discharge rate of each tube, controllers and control systems may be rather elaborate. Thus installation may be more expensive than overhead sprinklers. Some modification of other cultural practices may be required. Essentially three types of systems are usable:

Spray, where a spray nozzle is on the end of each tube to spray the water over the surface. Application rates are high — up to one quart per minute.

Trickle, where water is discharged in a stream to one spot. The tube may be weighted — or small deflectors may be used. Application rates are high — as high as the spray systems.

Drip, where the water is discharged in one spot in a very slow rate — a pint to a quart per hour.

WETTING THE ENTIRE SOIL MASS

The thoroughness of wetting all the soil in a container was found to depend on how the water was applied and the rate of application.

When very slow application rates — as with drip irrigation — were used, the soil was thoroughly wetted with the possible exception of the top portion located on the side away from the emitter. The water moved through the soil by capillarity with little flowing through non-capillary pores.

When fast application of water was used — as with trickle irrigation — the soil ball was poorly wetted with the water essentially moistening a column of soil under the point of application and along the bottom. Often the wet area was a cone-shaped area. Water moved primarily through the non-capillary pores.

Spraying the water over the surface resulted in thorough wetting of the soil mass. Again the water moved downward through the non-capillary pores. Thorough wetting was achieved by

spreading the water before infiltration occurred. Flooding the surface achieved the same result.

DRIP IRRIGATION AND ROOT DISTRIBUTION

Under drip irrigation, more roots were found in the center of the ball than under other methods of irrigation. This may be due partly to the distribution of salts in the root zone. Under drip irrigation the center of the ball had less salts than the sides or bottom. Under overhead irrigation, salt concentration increased from the top to the bottom of the soil ball. The root distribution of plants under overhead irrigation was an increasing amount from top to bottom.

HOW MUCH WATER WAS NEEDED?

Ideally we replace the water used daily. Evapotranspiration — the loss of water from the soil by evaporation and transpiration — is dependent upon weather, plant species and plant size. Evapotranspiration was correlated to the profile of the plant. During a period of two years, we found with *Eucalyptus globulus* that the volume of water used varied from 0.14 to 0.37 quarts per day per one gallon container, depending upon plant size and weather.

SUMMARY

Many irrigation systems are usable for containers. Our experiments have shown marked difference in the amount of water wasted. Overhead irrigation wasted the most, drip irrigation wasted the least amount. Systems are available to keep waste to a minimum — no more than that needed to maintain favorable salt balance in the soil.

Where fertilizer was injected into the irrigation water, the waste of fertilizer was directly correlated to waste of water.

Procedures where water and fertilizer may be used efficiently also result in minimum degradation of the environment.

Table 1. Characteristics of irrigation systems for containers.

Name of System	Application Rate	Water Movement in the Soil	Characteristic of System
Overhead	To 1'' per hr. depending on design — 1'' per hour equals 27,180 gals. per acre	Saturated and unsaturated	Water sprayed over surface from fixed nozzles.
Trickle	Fast	Saturated	Tube to each container discharging water to one spot.

Table 1. (cont.)

Drip	Slow, to 1 gal. per emitter per hour. Best to stay below 1 qt.	Unsaturated	Emitter discharging water slowly to one spot. Tube to each pot.
Spray	Fast, 15 gal. per hour per nozzle	Saturated	Nozzle or device at end of tube. Spray water over soil within container.
Subirrigation	Slow. Rate depends on capillarity of soil	Unsaturated	Water placed under container. Water rises in soil by capillary action.

Table 2. Soil characteristic influences on irrigation system.

Soil Characteristics			
Rate of Infiltration	Capillary Conductivity	Application Rate of Water	Irrigation Systems to Use
Less than 1 inch per hr.	Good	Slow	Drip Overhead Subirrigation Manual
	Poor	Slow	Overhead Manual
1 to 10 inches per hr.	Good	Slow	Trickle Drip Overhead Manual Subirrigation
		Fast	Trickle Spray Overhead Manual
	Poor	Fast	Overhead Spray Manual
Over 10 inches per hr.	Good	Slow	Drip Overhead Subirrigation
		Fast	Spray Overhead Manual
	Poor	Fast	Manual Overhead Spray

Table 3. Methods of fertilization and irrigation systems for each procedure.

Fertilization Procedure	Irrigation System[1]
Liquid - constant	— all
- periodic	— all
Incorporation in soil mix	— all
Surface application — dry	— not for subirrigation
	— not for drip irrigation
	— not for trickle where infiltration rapid and no surface flow occurs

[1]See Table 1 for information on irrigation systems.

Table 4. Advantages and disadvantages of systems of applying water.

Class	Type	Reqmt. for Labor	Capital Invest-ment	Mgmt. Com-petence Needed	Labor Skill Needed	Water Use Effic.	Notes
Overhead	Manual	High	Low	Low	High	Poor	Runoff excessive
	Sprinkler	Low	Med.	Med.	Low	Poor	Runoff excessive
Individual container	Manual	High	Low	Low	High	Poor	Runoff excessive
	Trickle	Low	High	High	Low	Fair	Poor wetting of soil mass
	Drip	Low	High	High	Low	Exc.	Filters needed
	Spray	Low	High	High	Low	Exc. to *Good*	
Sub-irrigation	Subirri-gation	Low to med.	Med. to high	Med.	Low	Poor	Set-up difficult outdoors
	Capillary bench	Low to med.	Med.	Med.	Low	Fair	Hard to set up outdoors

Friday Afternoon, September 6, 1974

VICE-PRESIDENT BATCHELLER: Our final panel for the program will be chaired by our able Farm Advisor from Los Angeles County, Richard Maire. Richard, will you get the program started?

MODERATOR RICHARD MAIRE: The first speaker that we have is Fred Dorman, a former Agricultural Extension man with the University of California. He was County Director in San Bernardino County, California, for many years but retired a few years ago. He couldn't retire and not keep his finger into some area of growing, so he got interested in the Christmas tree business. Because of the problems of Monterey pine and the fact that the Monterey pine is the best Christmas tree species for Southern California, as far as getting fast growth and a good tree, this is the tree that we are growing. Since we had problems, Fred proceeded to do some experiments of his own in selecting trees from seed sources from New Zealand. He is here to present information on how he went about this over the last few years; he was very ably helped by his wife, Mae, and I think she is going to help him on the presentation today. So, Fred and Mae Dorman from Highland Holiday Trees: