is less moisture uptake, and (3) rupture of the seed coat and mucilage production (stock seed) are reduced. The control of certain seed-borne pathogens has been very successful and this method warrants further use.

AUTOMATIC ONE-GALLON CONTAINER IRRIGATION

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Hand watering has been the oldest and most widely used method of irrigation of container plants in wholesale nurseries. Due to the ready availability and reliability of stoop labor in the past, it was possible to proceed this way in our irrigation practices from the time of the Babylonians four thousand years ago until recently.

Today, however, we find labor is pricing itself too high for this type of work, and is not constantly available. If you will notice by the slide (SLIDE) the girl is hand watering. She does not look like she is paying much attention to her work, so therefore we are going to have spotty watering of the containers. When this happens, we are sure to get spotty plant growth. (SLIDE) Here we see the some girl turning off the water faucet. She has had to drag a heavy hose throughout the area and back to the hydrant. Notice that while she is turning the water off she is also washing three or four plants out of the containers, due to the fact that she is not paying any attention to her water hose.

Why should we automate a sprinkler system? I feel that there are three main points which should be brought into any discussion on automated sprinkler systems: One, the reliability of labor; two, proper irrigation techniques; and three, the cost of labor.

In the discussion of reliability of labor we all know what problems have arisen during the past year in the unionization of nurseries. Suppose on a day when the temperature is 110°F and you are relying on manual labor for irrigating your plants, your workers decide to go out on strike. This would be the fastest way I know to bankruptcy. Relying wholly on manual labor for irrigating plants leaves any nurseryman in an extremely vulnerable position.

Another point which we should consider in the manual irrigation of plants is that if a person becomes ill, we must either replace him or have someone else do his job. If we have someone else try to fill in for him, we are faced with the problem of people hurrying over their own watering to do other worker's jobs... thus again, we have a condition whereby the plants are receiving inadequate irrigation. In this day and age, when everyone wants a forty hour week (and recently I heard of a company in Orange County going on a thirty-five hour week)

- it becomes harder and harder for us to obtain labor that will work sixty, seventy or even eighty hours per week. When weather conditions dictate that we must water, we *must* have a reliable source of labor. We all know how hard it is to get people to work on Saturday, Sunday and holidays. However, I feel that when we are dependent on manual labor for irrigating one-gallon cans, this is a "must".

The next point is proper irrigation. Perhaps some of your people stay out all night, or they are having problems at home with the wife or girl friend . . . what happens? They come to work, and instead of concentrating on giving the plants proper irrigation, they are thinking only of their own problems. When this happens, a plant may get irrigated or it may not . . . we are at the mercy of the whims of labor . . . if they are happy, they may do a good job, but if they are not happy, we have real problems.

In our part of the country we may have a beautiful day with a temperature of about 70° F. and in two or three hours have an extremely windy condition, with a temperature of 100 to 110°F. We call this our "Santa Ana" winds. If we rely on manual labor to do our irrigation, it would be almost an impossibility to keep the plants irrigated properly. We would have to put everyone from the office and from the propagation areas in the field, give them hoses, and tell them to start watering! You can imagine the havoc this would create! It would probably be easier to take the loss from the wind than it would be to have inexperienced people irrigating the plants.

A plant, to be properly irrigated, should be irrigated when the soil reaches 50% moisture reservoir capacity. When a container such as a one-gallon can is filled with soil and is thoroughly saturated, and the excess moisture is allowed to drain away, we have a condition which we call field capacity, or that the soil has reached or is in a state of 100% moisture reservoir capacity. When this moisture reservoir capacity reaches 50%, this is when the plants should be irrigated. If the soil is irrigated before this 50% moisture reservoir capacity is reached, we will have a condition where there is lack of oxygen in the soil. This not only upsets our plants' growth, but it may also induce certain bacterial diseases which may ultimately kill our plants. In reverse, if we irrigate when the moisture reservoir capacity is extremely low, the plant may go into a wilting condition which it may never come out of, or permanent damage to the plant tissues may result. So, you see it is extremely important that the plants are irrigated at the proper time. Normally, the type of labor we are able to afford for this type of nursery work, are not adequately trained or qualified to make this type of decision.

In the irrigating of one-gallon container plants the discussion of cost always arises. We have made a fairly complete study of this factor, and have found that if we are paying our manual labor $1.35 per hour including benefits, and if they are working eight hours a day, they are able to irrigate 150,000 one-gal-

lon containers per day at a cost of 2c per can per year. Normally, however, our one-gallon containers are spaced out, and this brings the cost up to as high as 8c per can per year for irrigation. I wish to bring up the fact that in this cost figure pumps. pressure tanks, and adequate piping system have not been figured in. This is because we must already have this equipment installed before we can be in the nursery business.

Next, I would like to discuss the cost of the manual sprinkler system. In my opinion, a manual sprinkler system is a basic sprinkler system in which a Rainbird sprinkler or some other type of sprinkler is connected to our water hydrants into an existing manual system. We must have a reliable person to turn our sprinklers on and off and he must have sufficient knowledge to understand proper irrigation practices. Of course, with this type of labor we must pay higher wages than we do the people we use for manual watering. In ammortizing the cost of our sprinkler system over a ten year period and figuring in our labor, we have arrived at a cost of ½c per one-gallon can per year. This is a tremendous drop in cost in comparison to our manual watering system. However, we still are at the mercy of labor. If they are doing a good job, our plants will receive proper irrigation, but if they do not show up for work or become ill, we still have a problem on our hands.

I would next like to discuss an automatic sprinkler system. By this term I am not referring to a sprinkler system that is operated by a time-clock and comes on at a predetermined time. In my opinion an automatic sprinkler system is one which is so set up that when 50% of our soil moisture reservoir capacity has been reached, the sprinklers will automatically turn on and will automatically turn off when the proper irrigation is completed. In this type of system we must have a tensiometer, time clocks, hydraulic valves, and numerous tubing and fittings. However, after this type of equipment has been properly installed and is ammortized over a ten year period we arrive at a cost of only 9/100 of a cent per one-gallon can per year.

Here you see a man turning on a manual sprinkler system. He must be extremely conscious of when the sprinkler was turned on, so that he will not over water or under water the plants, and, as I said previously, we must have an extremely conscientious person. (SLIDE) Here you see a man turning off our manual irrigation system and getting squirted in the face. It seems the sprinkler swung around just when he was least expecting it... what happens? He either must go home to change his clothes, or stay and be miserable the rest of the day... and chances are he will have a "cold" tomorrow so that he may not return to work for two or three days. These are just a few of the factors that can affect our manual sprinkler systems. When we get into a discussion of a fully automatic sprinkler system, we must have some type of instrument that will tell us when 50% of our soil moisture capacity has been reached. We therefore must use a tensiometer. A tensiometer is an instrument

which has a porous tip, usually made of some type of porous ceramic material which allows water to flow in and out of it. This is connected to tubing which acts as a reservoir and connected to this tubing is a vacuum guage. When this instrument is inserted into the soil, water flows in or out of it according to our moisture in the soil, creating a vacuum which registers on the guage. If this instrument is placed in a saturated soil it reads zero, as there is no "pull" on the instrument. As the soil dries out through evaporation and through the root action of the plants, moisture flows out of the instrument, creating a vacuum and thus giving us a reading on the dial. Basically, you might say that this instrument acts the same way as plant's roots.

A tensiometer includes 9 porous tips, metal tubing which is connected to a vacuum guage, and glass tubing which acts as a reservoir for the instrument.

The actual instruments we are using at SELECT NURSERIES are in the root zone of the one-gallon container. A wire is connected from it to our time clock. A plastic cover over the dial on the instrument helps to keep the sun rays and excessive moisture out of the instrument.

We have numerous banks around our nursery, and the irrigation of these banks is also controlled by tensiometers. In our banks there are two tensiometers. One gives us a reading at six inches, while the other instrument gives us a reading at fourteen inches. Thus, when our banks need irrigation, it is done completely automatically. Our time clock is made by Rainbird Sprinkler Systems, and has numerous features which we find are a "must" for any type of automatic sprinkler system. This particular clock has eleven different stations which can be regulated from five minutes to one hour or more. When we irrigate, we like to do some leaching, and we found from laboratory information that the proper length of time to irrigate our one-gallon containers is 55 minutes. When the tensiometer in the field reaches 50% moisture soil capacity, the signal is relayed to this time-clock, which in turn works the hydraulic valve. The hydraulic valve is connected to a short piece of copper tubing which acts as a shock absorber. As the valve turns on, the initial surge and pressure would rupture plastic tubing if it were connected directly to the valve. However, with this short length of copper tubing, this problem does not exist. Plastic tubing in turn is connected to the copper tubing and is run completely back to our time clock. We designed our automatic system in such a way that if we ever need water in the field, we can turn a petcock on our hydraulic valves which would over-ride our tensiometers and time clock. The only time when we desire this feature is when our plants are initially canned. Our first irrigation is always done with manual labor, as we wish to give the plants a thorough soaking. However, after the initial manual irrigation, as long as the plants are in our nursery, they are never again manually irrigated.

All of our banks are automatically irrigated when 50% of the moisture capacity has been reached. Our pilot automatic watering system covers approximately 200,000 one-gallon containers and approximately 10,000 two-gallon containers. We have had this system in operation for over ten months, and have had no problems with it. So far as I know, this was the first commercial installation of a completely automatic sprinkler system in the world.

Here is a picture of some of the two-gallon cans which are automatically irrigated. Please take particular note of the extreme evenness of growth which I feel is due to the fact that the plants are receiving a very uniform amount of water, and that they are irrigated when they should be. We grow over two million one-gallon container plants per year at SELECT, and are currently making plans to convert all of our one-gallon irrigation systems over to this type of automatic sprinkler system. There is a wonderful feeling to be able to take off on a holiday or a weekend, knowing that when the plants need water, they will receive it, and at a cost far less than ever before, and at a rate of application that is even and proper for the plants.