7. Myhre, A.S. 1965. Chemical pre-emergence weed control in western Washington. *Proc. Int. Plant Prop. Soc.* 15:306-09.
8. Ticknor, R.L. 1966. The effect of herbicides on the rooting of juniper cuttings. *The Plant Propagator* 12(1):8.
9. Ticknor, R.L. 1972. The effect of several herbicides on propagation of four ornamentals. *Proc. Int. Plant Prop. Soc.* 22:129-31.
10. Vanderbilt, R.T. 1965. The auxin effects of some common fungicides and other chemicals. *The Plant Propagator* 11(3):6.

CAPILLARY IRRIGATION OF CONTAINER PLANTS[1]

EDWARD AUGER, CHARLES ZAFONTE and J.J. McGUIRE[2]

Abstract. Selected cultivars of rhododendrons and azaleas were grown in two container media under capillary and overhead irrigation and under five fertilizer regimes. Of the fertilizers incorporated into the container media at manufacturer's recommended rates, Osmocote 14-14-14 produced the best overall growth. The capillary system using the Chapin twin walled tubes on a sand base produced growth comparable to that obtained with conventional overhead irrigation but with only half as much water used.

Container plant production of nursery crops is of ever-increasing importance to the industry due to rising land values and labor costs in producing field grown (balled and burlapped) stock. It is important because it allows a greater efficiency of production per unit of land. Container plant production offers advantages including: extended sales and planting seasons, development of attractive sales packages, greater transportability, better control of environmental and cultural factors, and more efficient use of labor, production and sales areas (1).

Growing plants in containers, however, presents special problems of watering and fertilizing not experienced in field production. Frequent excessive overhead irrigation, besides being inefficient, can cause severe leaching of nutrients from containers (1). Therefore, the practice of subirrigation, whereby water is absorbed into containers by capillary action from a saturated substrate below, is proposed to provide a more efficient alternative irrigation system.

Subirrigation or capillary irrigation theoretically offers other advantages to the grower for increased plant growth. Capillary irrigation should reduce compaction of the growing

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[2] General Manager, Forest HIlls Nurseries, Inc.; Graduate Assistant; and Professor Plant and Soil Science, University of Rhode Island, Kingston.

media providing more pore space for better aeration of the mix. It should provide more efficient fertilizer usage by eliminating losses due to leaching. It should decrease the incidence of leafspot diseases because foliage remains dry during irrigation, and finally, by eliminating water stress at any time during the growing season there should be a resultant increase of higher quality plants.

Since water is the most important and limiting factor in the production of container grown nursery stock (2), rising municipal costs for water and recent water shortage occurrences have caused growers to reevaluate their irrigation techniques. The possibility of tremendous water losses from overhead irrigation is no longer acceptable. Furthermore, the environmental concern of lake and stream pollution by runoff water from agricultural land carrying excess plant nutrients may be reduced. Eventually, the fertilizer applied overhead which is not absorbed by plants is carried away in runoff water into lakes and streams where eutrophication may occur.

The development of twin wall trickle irrigation tubes by Chapin Watermatics, Inc. and ViaFlow, an ooze type tube manufactured by DuPont, along with various substrates, or "mats" to hold the water, on which the plant containers are placed, have provided the necessary technology and economy to make this practice feasible.

Two aspects of capillary irrigation are considered in this study. One is the comparison of growth of various rhododendron and azalea cultivars grown under conventional sprinkler irrigation with those grown via capillary irrigation. The other is a comparison of slow release fertilizers incorporated into the potting mix for use in the capillary irrigation system.

MATERIALS AND METHODS

A capillary irrigation system was installed at each of two sites: 1) Forest Hills Nurseries, Inc., Exeter Road, Slocum, R.I. and 2) The Rhode Island Agricultural Experiment Station, East Farm, Kingston, R.I. Conditions were not equal at both sites. Plants at site #1 were grown in a plastic covered greenhouse (30 × 200 ft) with one side open for ventilation. These plants were not exposed to drying winds and they received no rainfall. The plants at this site were closedly spaced so containers were touching. Plants at site #2 were uncovered, in full sun and were spaced 8-12" apart. These plants were exposed to summer rainfall.

The capillary system at both sites was installed by placing approximately 1" of sand on a continuous film of black plastic (1.5 ml). The sand was slightly less than 1" at site #2. Water was applied to this surface through twin walled Chapin trickle irrigation tubes 8 ml (4 × 24 hole spacing) placed 4 ft apart and running the entire length of the growing surface (30 × 100 ft). The tubes were connected to a 3/4″ PVC header which was connected to a 3/4″ solenoid valve and an electric clock.

Frequency of irrigation was regulated so that the sand was always saturated but no run-off occurred. At site #1 this required 30 min applications approximately 4 hours apart during the day. At site #2 it required four applications of 45 minutes each applied during the day. No water was applied at night.

Plants used in the experiments were all one year old liners of rhododendron or azaleas. Azaleas were planted in 1 gal containers and the rhododendron were planted in 2 gal or 8″ containers. Fifteen plants of each cultivar were used for each treatment. These were arranged in three replicates of five samples each.

Fertilizer Comparison Experiment. This experiment was conducted at site #1. All plants were grown in one container medium consisting of 2 parts shredded softwood bark, 1 part coarse sand and 1 part sphagnum peatmoss. Cultivars of rhododendron used were: 'Chionoides', 'English Roseum', 'Mrs. Peter den Ouden', and 'P.J.M.'. Cultivars of azaleas used were: 'Hershey's Red', and 'Mother's Day'.

The slow release fertilizers were incorporated into the medium at the manufacturer's recommended rate. They were: Osmocote 14-14-14 12 lbs/cu yd, Osmocote 18-6-12 13 lbs/cu yd, Mag Amp w/K 7-40-6 12 lbs/cu yd, and ProGrow 31-5-3 3 lbs/cu yd. An overhead irrigation application of liquid fertilizer of Peters 20-20-20 was used as a control at the rate of 200 ppm NO_3 applied twice each week.

Linear growth of plant tops was measured on July 1st and October 1st. Rootball weight and diameters were measured in late October, 1977.

Comparison of Irrigation Methods. This experiment was carried out at both sides. Plants contained only Osmocote fertilizer. Rhododendron plants were treated with Osmocote 18-6-12 (13 lbs/cu yd) and azaleas were treated with Osmocote 14-14-14 (12 lbs/cu yd) incorporated into the medium as before.

Treatments were:

1. Capillary irrigation on sand, medium with Osmocote.
2. Overhead irrigation with water, medium with Osmocote.
3. Overhead irrigation with water alternated with water and 20-20-20 at 200 ppm NO_3 (the control).

Plants used in the experiment were from two sources so two container media were used:

Medium #1 contained 2 parts shredded softwood bark, 1 part coarse sand, 1 part sphagnum peatmoss.

Medium #2 contained equal parts of sphagnum peat moss coarse, sand, and coarse perlite.

Perlite in medium #1 were *Rhododendron* 'Boule de Neige', *R.* 'Scintillation', and *R.* 'Nova Zembla'. Azaleas were: *Rhododendron* 'Firedance', *R.* 'Stewartsonian', and *R. obtusum* var. kaempferi. The plants grown in medium #2 were *Rhododendron* 'Mrs. Peter den Ouden', *R.* 'Nova Zembla', and *R.* 'English Roseum'; and the azaleas: *Rhododendron* 'Rosebud', *R.* 'Hinocrimson', and *R.* 'Kaempo'. All cultivars were represented at both sites and there were 15 plants of each cultivar in each treatment.

Linear growth was measured on July 1 and October 1, 1977. Dry weight of rootballs and rootball diameter was measured October 31, 1977. A water meter was installed at site #1. The exact volume of water used in each type of irrigation was measured. Plants were observed periodically for foliage color and general appearance.

RESULTS

The results of the fertilizer comparison experiment are summarized in Table 1. Of the slow release fertilizers tested, Osmocote 14-14-14 yielded the greatest total average increase in plant growth designated as "Fertilizer Effect". This was followed by Osmocote 18-6-12, ProGrow and Mag Amp, respectively. However, the best top growth was found with the Peters liquid fertilizer. When observing rootballs and recording their weights an interesting correlation is noted (Table 4). Osmocote 14-14-14 consistently stimulated greater root growth than any of the other treatments including the conventional overhead with Peters liquid fertilizer. The Osmocote 18-6-12 yielded about the same response as the Peters and both ProGrow and Mag Amp showed less root growth.

In the comparison of irrigation methods (Tables 2 and 3) the plants grown by the capillary watering system at site #1 did considerably better than those grown via the same system at site #2. With the rhododendron cultivars, total growth at site #1 under capillary irrigation matched that of the overhead controls (Table 2). A similar response was observed with the azalea cultivars (Table 3). The capillary irrigation system at site #2 and the overhead irrigation with slow release fertilizer incorporated, generally, were not as efficient in stimulating growth.

Of significance, however, is the efficiency of water usage. On the average, the amount of water used by capillary irrigation

Table 1. Effect of four granular slow release fertilizers on the growth of rhododendron and azalea cultivars grown in containers watered by capillary irrigation.

	Control[a] Peters 20-20-20			Osmocote[b] 14-14-14			Osmocote[b] 18-6-12			ProGrow[b] 31-5-3			MagAmp[b] 7-40-6		
	Increase in average heights in inches for 15 samples														
Rhododendron Cultivar	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.
'Chionoides'	4.5	11.5	7	4.5	9	4.5	5.5	8.5	3	5	10	5	4.5	9	4 5
'English Roseum'	7.5	17	9.5	8	18.5	10.5	7.5	13.5	6	7.5	14.5	7	6.5	13	6.5
'Mrs. Peter den Ouden'	5	9	4	5	9	4	6.5	10	3.5	4.5	7	3.5	5.5	9	3.5
'Hershey Red' azalea	3	7	4	3	5.5	2.5	3	5.5	2.5	3	5	2	3	5	3
'Mother's Day' azalea	4	8	4	4	6	2	4	6	2	4	5	1	4	5.5	1 5
'P.J.M.'	3	8.5	5.5	3	7	4	3	9	6	3	7.5	4.5	3	5.5	2.5
Fertilizer Effect[c]			34			27.5			23			22.5			20.5

[a] Liquid feed through overhead irrigation sprinklers.
[b] Applied according to manufacturer's recommendations.
[c] Sum of increase due to each treatment over all cultivars used.

Table 2. Effect of capillary irrigation on growth of rhododendron cultivars with Osmocote 18-6-12 incorporated into the potting mix.

		Capillary Site 1			Capillary Site 2			Overhead Site 2			Control Peters 20-20-20 Site 1 & 2		
Rhododendron Cultivar		July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.
'Mrs. Peter den Ouden'	a	12.5	13	0.5	13.5	14.5	1	15	17.5	2.5	13	15	2
'Nova Zembla'	a	15	19.5	4.5	15.5	19	3.5	15.5	18	2.5	15.5	21	5.5
'English Roseum'	a	15	22.5	7.5	18.5	21	2.5	17.5	19	1.5	18	19	1
'Boule de Neige'	b	9	11	2	6.5	9.5	3	9.5	9.5	---	8	10	2
'Scintillation'	b	9.5	13	3.5	6	8	2	7.5	7.5	1	7	8	1
'Nova Zembla'	b			21			15			10			21
Total				21			15			10			21

[a] 1 sand:1 peat:1 perlite mix
[b] 2 bark:1 sand:1 peat mix
[c] Sum of increases due to each treatment over all cultivars used.

at Forest Hills Nursery was 2,300 gal/week, but for an equal area and amount of plants, the overhead sprinkler irrigation required over 5,000 gal/week. Therefore, even if significant differences in plant growth were not achieved by capillary irrigation, a substantial saving of water was realized for equal plant production.

DISCUSSION

The results indicate that capillary irrigation may be feasible for container plant production. Increased water costs and recent water shortages have made it necessary to be more efficient in container plant production. Some problems connected with the system still remain to be worked out. One of the biggest appears to be fertility. Generally the plants growing with an incorporated slow release fertilizer could not compare in color to plants which received liquid applications. Some cultivars showed chlorosis more than others and in some cases it was quite severe. Possibly a periodic liquid overhead application may be necessary to maintain the quality of the plants.

Table 3. Effect of capillary irrigation on the grown of azalea cultivars with Osmocote 14-14-14 incorporated into the potting mix.

		Capillary Site 1			Capillary Site 2			Overhead Site 2			Control Peters 20-20-20 Site 1 & 2		
		Increased Average Height (in.)											
Rhododendron (Azalea) Cultivar		July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.	July 1	Oct. 1	Inc.
'Rosebud'	[a]	5	10.5	5 5	5	6.5	1.5	5	8.5	3.5	5	13	8
'Hino Crimson'	[a]	4	10.5	6.5	4	6	2	4	7.5	3.5	4	8.5	4.5
'Kaempo'	[a]	4	6	2	4	5	1	4	5	1	4	8	4
'Firedance'	[b]	3	10.5	6.5	3	7.5	4.5	3	7. 5	4.5	3	10	7
'Stewartsonian'	[b]	3	12	9	3	8	5	3	7.5	4.5	3	10	7.5
'*R. obtusatum* var. kaempferi	[b]	3	11.5	8.5	3	8	5	3	7.5	5.5	3	10.5	7.5
Irrigation Effect	[c]			38			19			21			40
Total Irrigation Effect	[d]			59			34			31			61

[a] 1 sand:1 peat:1 perlite mix.
[b] 2 bark:1 sand:1 peat mix.
[c] Sum of increases due to each treatment over all cultivars tested.
[d] Irrigation effect for azaleas plus that for rhododendrons (Table 2).

Table 4. Comparison of dry root weights of rhododendron and azalea cultivars as affected by four granular slow release fertilizers watered by capillary irrigation and Peters 20-20-20 applied by overhead irrigation.

	Overhead Irrigation	Capillary Irrigation			
	Peters 20-20-20	Osmocote 14-14-14	Osmocote 18-6-12	ProGrow 31-5-3	Mag Amp 7-40-6
Rhododendron Cultivar	Weight (grams)				
'Mrs. Peter den Ouden'	259	487	207	320	199
'Chionoides'	770	1089	780	861	119
'P.J.M.'	171	235	153	10	64
'Mother's Day' azalea	117	428	139	65	43
'Hershey Red' azalea	236	518	141	66	143

There also exists the problem of location for the capillary irrigation system. A covered or partially covered plastic house gave greater water efficiency, but whether a deeper layer of sand or close spacing of containers in the open area would increase efficiency remains to be shown. There was obviously more leaching of the medium in the unprotected site due to rain.

The frequency and duration of irrigation has to be worked out for each situation, but an essential fact remains: the containers must never be allowed to dry out since this breaks the capillary water film that allows water to be continuously drawn into the container from the saturated substrate. Along with this, it should be noted that the containers should be thoroughly watered initially to establish the capillary channels. The system should be monitored periodically to make sure it is operating properly.

The type of plant material to be grown with this capillary irrigation system should also be considered. In these experiments, rhododendron cultivars, which have a fibrous root system, were used which did not root out of the containers. Plant materials such as junipers or deciduous shrubs might not be recommended for growing on this system because they form roots more likely to grow out of the container and into the substrate.

SUMMARY

Capillary irrigation proved effective in meeting the water requirements of 1 and 2 gal container rhododendron and azalea plants. Comparable, if not increased growth was realized with capillary irrigation as opposed to conventional overhead irrigation. Since capillary irrigation required less than half the amount of water applied by overhead sprinklers, this literally translates into substantial reduction in water usage with little or no surface runoff.

LITERATURE CITED

1. Joiner, J.N., and C.A. Conover. 1967. Comparative properties of shredded pine bark and peat as soil amendments for container-grown Pittosporum at different nutrient levels. *J. Amer. Soc. Hort. Sci.* 90:447.
2. McGuire, J.J. 1972. *Growing ornamental plants in containers; a handbook* for the nurseryman. *Univ. Rhode Island, Coop. Ext. Ser. Bul. 197.*

VOICE: Did you find root growth in the bottom inch of the can?

EDDIE AUGER: No, the growth was fairly uniform throughout the can. The secret is to keep the mat damp not water logged.

JOERG LEISS: If the Osmocote is incorporated into the growing medium for the first year, how are you going to fertilize the plants the second year?

EDDIE AUGER: We will probably have to rely on overhead liquid feeding or possibly adding it to the capillary system. We won't be able to top dress because the surface of the medium stays dry which is an advantage in that it restricts the growth of weeds to a great extent.

CHARLIE PARKERSON: How soon after you added the fertilizer to your mix were the plants canned and irrigation started? Some of these materials are pretty hot.

EDDIE AUGER: These were mixed into the medium as we were canning them.

ANN MOLES: In some work done at North Carolina State University using different levels of Osmocote we found that with subirrigation the growth at half the manufacturers recommendation was far better. I was wondering what rate you used?

EDDIE AUGER: We used the manufacturer's recommendation for all the material.

MIKE DODGE: One of the problems in using mats is the buildup of algae, did you have any problem with this?

EDDIE AUGER: Algae didn't seem to be a problem and of course can to can there is little chance of it to build up.

MINIATURE ROSES BY OASIS ROOTCUBES

RICK R. ALLRED

Spring Hill Nurseries Company, Inc.
Tipp City, Ohio 45371

CUTTING PREPARATION AND STICKING

We start by taking 4 to 5 inch cuttings directly below a node using hand clippers. For convenience we use Clorox sterilized 2 gal buckets, which are used by our mail-order picking department, for collection of cuttings. While collecting cuttings, we try to keep them shaded and cooled with water to maintain turgidity. The average cutting is medium soft with six nodes and approximately 5 inches in length depending on cultivar. We find that we have a greater percentage of rooting and much less disease problems if we cut out the soft tip growth. Leaving two nodes with leaflets, we strip the rest of the cuttings and put them in bundles of 50. We have found it critical that the cuttings be cut within 1/8″ below the node, for if more of the stem is left below the node a larger percentage of cuttings are lost due to rotting off. The cuttings are dipped in a quick-dip solution of: 10 grains of IBA (K salt), 20 cc isopropyl alcohol and 1 gal water. The cuttings are now prepared to stick.

To prepare the Oasis Rootcubes, a sterilized plastic shallow flat which measures 1-1/2″ × 11″ × 21″ is filled with 1″ of potting mixture which consists of 1/2 #7030 Choice Mix, 1/4 #2