Spathiphyllum pollen germinated significantly better in the basic medium than in other treatments (Table 3). However, the addition of calcium and boron significantly increased germination compared to media with only 10.0% sucrose, or 10.0% sucrose plus 200 ppm magnesium or 100 ppm potassium. Germination in distilled water was significantly less than all the above treatments. Calcium and boron were the most important cations for germination of *Spathiphyllum* pollen though magnesium and potassium in the basic medium apparently helped germination.

The pH of the cultural medium has been shown to affect pollen germination of several plant species (2, 5). There was no significant difference in germination of *Spathiphyllum* pollen within the pH range of 5.0-7.0 (Table 4), whereas *Vriesea* pollen germinated equally well from pH 4.0-8.0. Germination of *Spathiphyllum* pollen was drastically reduced at pH 3.0, 8.0 and 9.0, while *Vriesea* barely germinated at pH 3.0 or 9.0. Previous work with several species (3) indicated the optimal pH for pollen growth was rather narrow with best results generally at pH 7.3 or 8.3 and poorest results at pH 5.3. *Spathiphyllum* pollen was tolerant of an acid medium but not basic. In contrast, *Vriesea* pollen was adaptable to a relatively wide range of pH.

Table 4. Effect of pH on percent germination of *Spathiphyllum* and *Vriesea* pollen in the basic medium[z,y].

Medium pH	Pollen Source: *Spathiphyllum*	Pollen Source: *Vriesea*
3.0	6.2 a	6.5 a
4.0	77.2 b	94.5 b
5.0	88.0 c	95.0 b
6.0	83.0 bc	97.2 b
7.0	88.2 c	95.2 b
8.0	1.2 a	92.8 b
9.0	2.0 a	11.2 a

[z]Medium consisted of 10% sucrose, 100 ppm H_3BO_3, 300 ppm $Ca(NO_32\cdot 4H_2O$, 200 ppm $MgSo_4\cdot 2H_2O$ and 100 ppm KNO_3.
[y]Mean separation within a column by Duncan's multiple range test, 5% level.

Results indicated that pollen from *Spathiphyllum floribundum* cv. Mauna Loa and *Vriesea Malzinei* can be germinated successfully *in vitro*. The method described in this paper can be used as an accurate indicator of pollen viability at harvest or following periods of storage. Both types of pollen are currently being used in storage studies.

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AN INITIAL EVALUATION OF DRIP IRRIGATION ON WOODY ORNAMENTALS IN CONTAINERS[1]

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Abstract. **Drip irrigation systems were compared with a sprinkler system on 4 species of woody ornamentals growing in 1-gal (ca. 3.8 liter) containers. Data included plant growth indexes, visual ratings of roots, quantities of water applied and runoff, and variation within each system in quantity of water delivered to individual plant containers. Little difference in plant growth resulted. Drip irrigation reduced water applied and runoff 75 and 90%, respectively. A problem in improving efficiency of drip systems is variation in output from one emitter to another within a system.**

Rapidly increasing demands on water supplies of south and central Florida and other areas are requiring consideration of alternatives to sprinkler irrigation. Drip systems should be considered in establishment and expansion of nurseries. Florida has approximately 15,000 acres[2] in woody ornamental production with over 90% devoted to container plants. An increase to 25,000 acres by 1985 is projected (3). Harrison (2) and Furuta (1) have found container nurseries applying between 56 and 120 inches of water per year. Assuming 1 inch of water equals 27,000 gal per acre, from 1,512,000 to 3,240,000 gal per acre are applied per year with sprinkler irrigation. Assuming 13,500 acres are in container production and sprinkler irrigated, 20 to 40 billion gal of water are applied per year in Florida container nurseries. A 50 to 75% reduction would be highly desirable, if accomplished without excessive increase in production cost. Therefore, objectives of this research were to determine: (1) Feasibility of using drip irrigation in container nurseries; (2) Quantity of water required; and (3) Quantity of waste water runoff.

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[2]For metric conversions see Table near the front of this Volume. Ed.

Materials and Methods

In 1975 Chapin Leader Tubes, Micro-drippers, and Twin-wall hose; DuPont Viaflo tubing; and Rain Bird sprinklers were installed. Each system with 3 replications was placed on separate slightly sloping nursery beds. Each replication consisted of a 100 sq ft bed enclosed within a 4-inch high frame. A collecting apron channeled runoff from each bed into a basin. Frame, bed, and apron were lined and covered with 6 ml black polyethylene groundcover. Containers of *Juniperus conferta* Parl. (juniper), *Rhododendron obtusum* (Lindl.) Planch. cv. Coral Bells (azalea), *Ilex cornuta* Lindl. & Paxt cv. Burfordii (holly), and *Ligustrum japonicum* Thunb. (ligustrum) were placed on 8-inch centers on the groundcover in 4 rows of 10 containers each per species to provide 160 containers per 100 sq ft bed. Plants were potted in Lerio 6-inch (1-gal) metal containers in May. Potting medium was a 1:1:1 by volume mixture of Canadian peat, ground pine bark, and coarse sand. Osmocote, dolomitic lime, and Perk were incorporated into the media. Granular fertilizer was added 6 months later. A residential water meter, solenoid valve, time clock, pressure reducing valves, and 200 mesh screen filter were installed on 3/4-inch laterals for each system. Water pressure approximated manufacturer suggestions, and irrigation timing depended on flow rates and visual determination of plant needs. During most of the growing season Leader Tubes and Micro-drippers were operated 15 min, Twin-wall hose and Viaflo tubing 30 min and sprinklers 60 min per day. Clocks were turned off during rainy periods and alternate days during cool weather.

Plant data included growth indexes and visual ratings of roots. Growth indexes were ht plus width (cm) of foliage divided by 2. Measurements were taken after light pruning to produce saleable plants. Root ratings were 0 to 100, where 0 = no roots visible and 100 = complete root coverage of root ball interface. Water applied by drip systems was measured by water meters and emitted directly into plant containers. To measure water applied by sprinklers, containers were removed, sprinklers were run for a specified time, and water applied to 100 sq ft bed drained into the collecting basin where it was then measured. A shield was placed over the collecting apron and basin so that water falling beyond the 100 sq ft area was diverted away. Runoff water from each system was measured similarly as it drained into the collecting basin from plant containers on the 100 sq ft bed. Also, variation in quantity of water delivered by sprinklers and individual drip emitters to empty nursery containers at selected positions on the bed was measured.

Results and Discussion

All 4 types of woody ornamental nursery plants were successfully grown in containers under each drip system. Economic feasibility, however, was not determined. Data in Tables 1 and 2 indicate that from July to November there was little, if any, difference in plant growth, regardless of irrigation system, when water was supplied in sufficient quantity for plant requirements. These data were not analyzed; however, some trends are apparent. Ligustrum were the largest plants and would be expected to have the greatest water requirement. Growth of ligustrum appeared limited under Viaflo tubing. The wetting and cooling effect of sprinklers may have been beneficial to azaleas. Quantity of water applied per irrigation in August and September was reduced 55 to 60%, regardless of type of drip system, when compared to sprinklers (Table 3). Drip systems reduced runoff 67 to 77%. Runoff from sprinklers was 74% of the water applied, and runoff from drip systems was 38 to 56% of water applied. In October, irrigation by drip systems was split into one application in the morning and another in the afternoon with a reduction in water applied in an effort to increase efficiency and effectiveness. Temperatures were cooler then. Under these conditions, quantity of water applied was reduced 71 to 74%, and runoff was reduced 86 to 93% (Table 4). Quantity of runoff from drip systems ranged from 20 to 36% of water applied.

Table 5 shows average quantity of water collected per unit of time at selected container positions in February, 1977. Except for Viaflo tubing, average quantity applied for all drip systems per container under this irrigation regime was 345 ml per day. An average of only 210 ml per container was collected from Viaflo tubing. These data were collected several months after installation, and clogging

Table 1. Growth of woody ornamental plants based on difference between growth indexes obtained in July and November, 1976.[z].

Irrigation system	Plants[y] Ligustrum	Holly	Azalea	Juniper	Average
Leader Tube	18.4	8.6	4.5	6.9	9.6
Micro-dripper	18.3	9.3	4.4	7.2	9.8
Twin-wall hose	17.5	6.4	4.3	8.6	9.2
Viaflo tubing	15.4	6.2	5.5	6.8	8.5
Sprinkler	18.8	7.2	5.9	8.0	10.0

[z]Average growth indexes in November were 46.3, 34.1, 19.8, and 25.0 for ligustrum, holly, azalea, and juniper, respectively.
[y]Data are average of 3 replications.

Table 2. Visual ratings of roots of woody ornamental plants. Roots were evaluated in February, 1977.[z]

Irrigation system	Plants[y] Ligustrum	Holly	Azalea	Juniper	Average
Leader Tuber	75.1	52.0	41.6	63.7	58.1
Micro-dripper	70.3	43.3	36.4	65.3	53.9
Twin-wall hose	75.2	41.7	33.6	66.9	54.4
Viaflo tubing	72.4	35.9	34.2	60.8	51.0
Sprinkler	74.0	47.5	38.3	67.8	57.0

[z]Rating scale: 0 to 100, where 0 = no roots visible and 100 = complete coverage of interface of root ball with normal roots.
[y]Data are average of 3 replications.

Table 3. Quantity of irrigation water applied and runoff collected per 100 sq ft of nursery container bed (including 160 1-gal containers) per irrigation in August and September, 1976.

Irrigation system	Minutes of Irrigation	Gallons of water[z] Applied	Runoff	Percent reduction by drip irrigation Applied	Runoff
Leader Tube	15	34	19	56	67
Micro-dripper	15	31	14	60	75
Twin-wall hose	30	34	13	56	77
Viaflo tubing	30	35	16	55	72
Sprinkler	60	77	57	—	—

[z]Data are average from 4 plant species, 3 replications, and 3 test dates.

Table 4. Quantity of irrigation water applied and runoff collected per 100 sq ft of nursery container bed (including 160 gal containers) per split irrigation in October, 1976.

Irrigation system	Minutes of Irrigation	Gallons of water[z] Applied	Runoff	Percent reduction by drip irrigation Applied	Runoff
Leader Tube	4 + 4	22	8	71	86
Micro-dripper	4 + 4	20	5	74	91
Twin-wall hose	10 + 10	21	6	73	89
Viaflo tubing	10 + 10	20	4	74	93
Sprinkler[y]	60	77	57	—	—

[z]Data are average from 4 plant species, 3 replications, and 2 test dates.
[y]Data on water applied and runoff from sprinklers were not obtained in October. Data from sprinklers obtained in September are used here for comparison.

Table 5. Average quantity of water collected per given unit of time at selected container positions in container bed. Data were obtained in February, 1977.

Irrigation system	Minutes of irrigation	Milliliters of water collected[z]				
		Ligustrum	Holly	Azalea	Juniper	Average
Leader Tube	8	360.5	303.8	318.4	297.1	320.0
Micro-dripper	8	351.8	314.6	320.0	321.0	326.9
Twin-wall hose	20	334.0	405.2	469.6	341.6	387.6
Viaflo tubing	20	125.2	264.0	265.2	185.6	210.0
Sprinkler	60	168.0	332.8	344.0	274.0	279.6

[z]Data are average from 4 container positions, 3 replications, and 3 test dates.

from algae and bacteria probably reduced Viaflo emission rates. The summer irrigation regime provided approximately 600 ml per container per day by each drip system. An average of 280 ml of water (Table 5) was collected at individual container positions under sprinklers. Some water was deflected from collecting containers by surrounding plant foliage. This was apparent in ligustrum. Less water entered ligustrum containers under sprinklers, yet growth was comparable to plants receiving more water under drip systems. This may indicate excessive application and leaching by drip systems and/or better distribution and wetting by sprinklers. Inefficiency in sprinkler irrigation of containers results largely from water falling between containers. Sprinklers are quite efficient where containers are spaced closely but become less efficient as containers are spaced farther apart with a greater percentage of water falling between them (1). Feasibility of drip systems vs. sprinklers appears to increase with increasing container size and distance between containers. Table 6 shows variation within systems in quantity of water delivered at selected container positions. Average variation among Leader Tubes and Micro-drippers did not exceed 26%. Average variation in Twin-wall hose and Viaflo tubing was up to 60 and 74%, respectively, and exceeded up to 46% variation under sprinklers. With such wide variation between emitters within a given system, it does not appear practical to achieve "zero runoff". Since plant roots are confined within individual containers, they are totally dependent on a single emitter supplying that container. Therefore, excess water must be applied so that all containers receive a sufficient quantity.

Table 6. Percent variation in quantity of water collected at selected containers positions.

Irrigation system	Percent Variation[z]				
	Ligustrum	Holly	Azalea	Juniper	Average
Leader Tube	20	26	22	26	24
Micro-dripper	18	24	11	11	16
Twin-wall hose	60	44	37	44	46
Viaflo tubing	34	49	25	74	46
Sprinkler	46	25	20	40	33

[z]Data are average from 3 replications and 3 test dates. Percentages are differences between greatest and least quantity of water collected at selected container positions.

Because of more variation, Twin-wall hose and Viaflo tubing appear less feasible for use on containers. Another disadvantage of Twin-wall hose is the difficulty in aligning and maintaining the unmarked and almost invisible emitter openings over containers. Alignment of Viaflo tubing is not nearly as critical; however, Viaflo must be secured over containers at frequent intervals, and because of light penetration, algae growth inside the tubing is a problem. Frequent injection of chlorine or other algacides would increase production cost and risk of injury to plants in containers. Leader Tubes and Micro-drippers have more potential for use in container nurseries. If individual emitters become clogged or damaged, they can be cleaned or replaced. Occasionally a Leader Tube may be cut by a rodent or other animal, or it can easily be knocked out of a container. Installation cost of Micro-drippers may be greater, and alignment of these emitters over containers is necessary.

To achieve maximum irrigation efficiency, more precise determination of water required to obtain maximum plant growth productivity is needed. Furuta (1) states that approximately 1 pint (473 ml) of water is required per 1 gal container per day. Similar information is needed for Florida conditions and specific nursery crops.

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