down the stem. These were then taken as a cutting with a heel and they rooted very well indeed.

JIM KELLEY: That should work; I don't believe you can take the cuttings of this plant too soft.

MIST NOZZLES

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Prior to the development of mist propagation, the turgidity of cuttings in the rooting bench was maintained by manual syringing and shading. Hand syringing during hot weather requires a considerable amount of time especially for the first few days to acclimate the cuttings to their new situation without roots. The use of shade during the acclimation period or during the entire rooting period helped to reduce the transpiration rate but also increased rooting time as a result of light reduction. Early studies involved the use of various systems of supplying water to the cuttings such as centrifugal humidifiers, atomizing, deflector and whirling nozzles to alleviate the hand labor. The advent of mist propagation not only greatly alleviated the need for manual syringing but also permitted cuttings to be acclimated without the need for shading.

Although it is important to maintain the turgidity of the cuttings, excess mist can cause problems by reducing the medium temperature and/or leaching nutrients from the foliage. For maximum effectiveness, uniform water distribution over the cutting bench area is desired. This would allow the on cycle to be kept to a minimum which would conserve water, prevent leaching of nutrients from the foliage and avoid a reduction in medium temperature. Ideally this would require a square pattern spray nozzle with uniform water distribution over the area covered. Mist nozzles, however, spray a circular pattern which requires overlapping of the pattern at some locations and thereby gives non-uniform wetting of the area.

MIST PROPAGATION NOZZLES

The two basic types of nozzles used in mist propagation systems are the oil-burner type, which has a whirling action and deflection nozzles where a small stream of water hits a flat surface. The whirling nozzles use smaller orifices and some-

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what higher pressures to develop small droplets. The total water flow rate is generally less than for deflection nozzles. The deflection nozzles, since they have larger orifices, are less inclined to plug with fine sand or dirt particles.

The nozzles may be placed on vertical risers from a supply pipe located in the bed or they may be placed in a line suspended above the beds. The riser system nearly doubles the piping cost because of the extra pipe needed for the risers but it avoids dripping from the nozzles when the system is turned off and the pipe does not interfere with the water distribution pattern. With the overhead line system care is needed to keep the line level since water tends to drain out of the lowest nozzle due to gravity. When this occurs several nozzles may not be operating efficiently because air which has entered the line must first be forced out and the water pressure built up in the line to restore efficient operation at the nozzle. One advantage of the overhead system in addition to lower pipe cost is that it can be more readily disconnected and moved to a new location after a bed of cuttings are rooted.

EXPERIMENTAL TESTS

Ten nozzles were tested using the manufacturers recommended nozzle spacing and water pressure. Several of these nozzles were also tested at pressures other than that recommended to determine the effect of water line pressure on these nozzles. The nozzle types tested and their description is given in Table 1.

The tests were conducted on a 4 ft wide bed. The nozzles were connected to a water line suspended 18" above the test bed. Two nozzles were used in each test. Round containers approximately 4 inches in diameter and 3 inches deep were placed side by side on the entire bench area. The mist system was activated for 5 to 10 min and the water collected in each container was weighed. The total weight was determined and an average weight per cup was calculated. The percent that the weight in each cup deviated from the average was then computed. Two sets of data were taken for each type of nozzle. The number of cups within plus or minus 20% of the average, plus or minus 50%, plus and minus 80% and greater or less than 80% were counted. The percentage of cups within each of these ranges was then determined. The water flow rate was also determined by collecting the total water discharged by a nozzle during a 5 or 10 min interval.

To provide an overall index of a nozzle's discharge uniformity, the percentage of cups in the ± 20% range was assigned a value of 4, those in the ± 50% range 3, ± 80% range 2, and greater or less than 80% range 1. The percentage value in each range was multiplied by the assigned value. These values were then summed and divided by 400 to obtain a "Uniformity Index" value. A value of 1 would indicate a water distribution where no cups had more or less than 20% of the average amount of water per cup.

RESULTS OF EXPERIMENTAL TESTS

The results of the experimental tests are given in Table 2. As indicated by the "Uniformity Index", nozzle #5, which is a deflection type nozzle, when operated at 40 psi provided the best uniformity. With this nozzle none of the bed had a water distribution which deviated by as much as ± 80% of the average. In fact, 88.2% of the bed had a uniformity of distribution within ± 20% of the average. The second best nozzle was one of the whirling types (No. 8) operated at 60 psi. For this nozzle 68.2% of the area had a uniformity within ± 20% of the average.

As a group the whirling type nozzles were better than the deflection type nozzles. This was true regardless of the pressure at which they were operated. The average uniformity index number for this type nozzle was 0.83 with a low value of 0.78 and a high value of 0.89. For the deflection nozzles the average index number when considering only the data for the pressures recommended by the manufacturers was 0.80 and for all deflection nozzle data it was 0.77. The range of uniformity index numbers for the deflection nozzles was 0.57 to 0.96 when considering all data and 0.70 to 0.96 when only considering the data which was consistent with the manufacturer's recommendations.

Since excess leaf wetting was not considered to be as serious as the lack of wetting, nozzles which tended to have significant regions of low water application would be particularly poor. A comparison of nozzles from this viewpoint could be made by summing the percentage of bed area where the water distribution was −80% or less than −80% of the average. Considering only the data for nozzles tested with 18.9 to 21.8% of the total area having water distribution low ranges. Nozzle #5 was the best in this respect with only 0.9% of the total area falling in these ranges.

For those nozzles having a relatively high percentage of the area over-wetted (high values in the +80% and > +80% ranges), a check of the data was made to determine the location of the high values. If it was between the two nozzles, spreading the nozzles further apart to reduce overlap might have merit. The data indicated that this was the case for nozzle #3 operated at 60 psi, nozzle #4 operated at 40 and 60 psi, nozzle #5 operated at 60 psi, and nozzle #7 operated at 40 and 60 psi.

As would be expected the discharge rate increased as the pressure increased and as the orifice size was increased. Considering the deflection type nozzles tested, the discharge at 40 psi varied from 4.18 to 15.34 gal/hr. The discharge of the whirling type at 40 psi varied from 3.46 to 7.70 gal/hr. Though the whirling type were generally somewhat lower in discharge than the deflection type, deflection type nozzles with discharge rates comparable to the whirling type are available. The low discharge deflection nozzle; however, gave the poorest overall uniformity and the highest discharge nozzle gave the best uniformity.

Table 1. Nozzle identification and description.

Nozzle Number	Trade Name	Orifice or Gap Setting	Spacing feet
1.	National Fog-Mist	Anvil at 0.10″	4
2.	Brighton Flora-Mist	Orifice 0.020	3
3.	Brighton Flora-Mist	Orifice 0.031	3
4.	Brighton Flora-Mist	Orifice 0.040	3
5.	Brighton Flora-Mist	Orifice 0.040	4
** 6.	IBG, Mist Propagation	62A, 0.012 slots	3
** 7.	IBG, Mist Propagation	63A, 0.018 slots	3
** 8.	IBG, Mist Propagation	64A, 0.020 slots	3.5
9.	National "Mister 100"	Orifice 0.040	3
10.	Brighton Mister Green	Orifice 0.040	*

* Spacing was 3′ @ 20 psi, 4′ @ 40 psi, and 5′ @ 60 psi.
** Whirling type nozzles; all other nozzles were the deflection type.

Table 2. Uniformity of water distribution from selected mist propagation nozzles.

Nozzle	Pressure psi	Flow rate Gal/hr	±20%	±50%	±80%	≶±80%	Uniformity Index
1	20	4.46	43.3	9.5	2.7	3.6	0.77
				19.1	18.2	3.6	
	40	6.12	19.5	13.2	5.9	13.2	0.57*
				9.5	17.8	20.9	
	60	7.78	29.1	20.9	5.0	4.1	0.68*
				9.5	20.0	11.4	
2	20	2.88	26.1	15.0	7.2	11.7	0.64*
				14.4	12.8	12.8	
	40	4.18	31.1	18.3	10.0	6.1	0.71
				13.4	21.1		
	60	5.11	28.4	17.2	8.3	7.8	0.69*
				12.2	23.3	2.8	
3	20	7.63	32.3	28.3	8.3	1.7	0.75*
				11.7	14.4	3.3	
	40	10.73	53.9	12.2	5.6	3.3	0.82
				11.1	13.9		
	60	12.31	63.4	12.2	3.9	3.3	0.88*
				15.0	2.2		

Table 2. (Continued)

Nozzle	Pressure psi	Flow rate Gal/hr	±20%	±50%	±80%	≤±80%	Uniformity Index
4	20	11.81	45.0	8.9	2.2	5.0	0.78*
				25.0	8.9	5.0	
	40	15.34	52.2	10.0	4.4	6.1	0.83
				23.3	3.9		
	60	17.50	35.6	13.3	7.8	5.0	0.79*
				36.1	2.2		
5	40	15.34	88.2	2.7	0.5		0.96
				7.7	0.9		
	60	17.50	52.1	7.1	5.0	1.2	0.82*
				27.5	2.1		
6	25	2.74	42.7	16.7	7.8	1.1	0.78
				25.0	6.7		
	40	3.46	52.2	18.4	3.3	1.1	0.84
				13.9	10.0	1.1	
	60	4.25	41.7	25.0	4.4	2.2	0.79
				11.1	13.9	1.7	
7	25	6.19	40.6	7.3	4.4	4.4	0.81
				39.4	3.9		
	40	7.70	51.1	20.0	2.8	4.5	0.84
				18.3	3.3		
	60	9.65	42.2	8.9	8.9	4.4	0.79
				26.1	8.9	0.6	
8	25	6.12	50.9	14.1	3.6	1.4	0.83
				19.1	10.0	0.9	
	40	7.63	62.3	13.2	2.3	1.8	0.87
				14.1	5.9	0.4	
	60	9.36	68.2	13.2	1.4	2.3	0.89
				7.7	7.2		
9	25	11.66	28.3	15.0	5.0	10.6	0.70
				22.2	17.8	1.1	
	40	14.11	31.1	15.0	8.3	7.8	0.72*
				20.0	17.8		
	60	16.49	45.6	14.4	5.6	3.9	0.81*
				24.4	6.1		
10	20	10.51	33.4	16.7	6.7	5.0	0.75
				24.4	13.3	0.5	
	40	15.19	56.3	5.4	2.9	7.9	0.83
				21.7	5.4	0.4	
	60	19.01	67.0	5.3	5.0	7.7	0.85
				9.7	4.0	1.3	

* Nozzles operated at pressures higher or lower than recommended by the manufacturer.

PETE VERMEULEN: We use a nozzle which you call Flora-mist and in testing them with cups as you have done, we find that the deflectors gradually wear out and give us too much water in certain areas. We buy the deflectors separately and replace them periodically. I also recall that Harvey Templeton plated the deflectors with a hard metal and this negated the wear from the constant force of the water against it.

LEN STOLTZ: How do some of you growers set the anvil height on nozzles which have an adjustable anvil?

DAVE BARKER: I use feeler-gauge but I don't recall what the setting is.

VOICE: After the mist system turns off, there will be a droplet of water hanging from the anvil; I turn the anvil down until the surface tension just releases the droplet.

VOICE: We adjust the anvil up and down to get the largest, continuous sheet of water before it begins to break into droplets, but we also use higher pressures than recommended.