Hands-On Irrigation Training for Nursery Growers

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During the past year, Dr. Richard Evans has conducted several workshops for nursery growers throughout California that have focused on improving irrigation efficiency for plants in containers. California nurseries are trying to comply with strict regulations regarding runoff and pollution from their properties. Re-examining and optimizing their irrigation practices are actions growers can readily take to fulfill regulatory obligations while maintaining plant quality. This series of workshops was funded by the Kee Kitayama Research Foundation. Following are excerpts from the educational materials used by Dr. Evans at his workshops.

Why is Irrigation Efficiency Important?

Achieving high irrigation efficiency can be time-consuming, but its importance is increasing throughout California. The most direct reason is the increasing cost of water as consumers fight for this limited resource. Another reason is concern about water pollution. Federal, state, and regional government entities may demand that nurseries reduce or eliminate the introduction of pollutants into water leaving the property. The most important pollutants from nurseries are pesticides, sediments, nitrogen, and phosphorus. Nurseries that irrigate efficiently will have less runoff, and therefore less of a potential problem to manage.

What Factors Affect Irrigation Efficiency?

Irrigation efficiency is affected by how much water is applied relative to crop needs, how uniformly water is applied among the crop plants, and how much leaching is needed to manage water quality problems.

How Much Water Do Plants Need?

Growers can control some aspects of irrigation efficiency. For example, growers determine the amount of water applied at each irrigation. Clearly, this amount should be enough to replace what the plant has transpired since the previous irrigation. However, most growers do not know how much water their crops use. Table 1 presents average daily water use values for some ornamental crops. Note that none of them uses more than a pint of water per day under normal conditions.

A grower can estimate plant water use by measuring the change in weight of a pot containing the crop plant between irrigations. For our purposes, it is most convenient to use a scale that records in grams (one gram of water is the same as one milliliter). For pot plant growers, this is easy to do. For crops in the ground, an estimate of water use can be made by growing some plants in pots. It is best to use a potting mix rather than the field soil—water use will not be affected. For accurate results, sink an empty pot into the ground next to the field-grown crop, and nest the potted plants inside those pots. To measure water use, irrigate the plants, wait an hour or more until drainage stops, then weigh the pot. Weigh the pot again the next day before irrigating. The difference in weight represents the amount of water used. It is best to weigh several pots distributed throughout the growing area, if possible.

Table 1. Average Daily Water Use for Selected Ornamental Crops

Crop	Water use (mL per day)	oz. per day
Hydrangea (1 gallon, outdoor)	340	11
Holly (1 gallon, outdoor)	140	5
Rhododendron (1 gallon, outdoor)	200	7
Greenhouse rose (for cut flowers)	400	14
Chrysanthemum (6-inch)	240	8

How is Irrigation Uniformity Measured?

Most irrigation systems are imperfect. Some sprinklers or emitters put out more water than average, and others apply less than average. Some plants will receive more water than others at each irrigation. To meet the needs of plants that receive less than average amounts of water, growers must supply excessive amounts to other plants. Measuring irrigation uniformity gives growers two important pieces of information. First, it provides a measure of how good the system is. In many cases, there are simple steps that can be taken to increase uniformity (for instance, using better nozzles, repairing leaks, and eliminating sources of large pressure drops). Second, the measured irrigation uniformity gives growers a way to decide exactly how much water to apply.

Dr. Richard Evans presents a hands-on irrigation training workshop to growers gathered at Weidners' Gardens in Encinitas, CA.

There are several methods for evaluating irrigation uniformity. The simplest method is the low-quarter distribution uniformity. To measure it, follow these steps:

1. Place catch cans in a grid throughout an irrigation block.

2. Irrigate for a known amount of time that results in partial filling of the cans.

3. Measure the amount of water in the cans. The volume of water can be measured with a scale similar to the one used to measure plant water use. Another method is to measure the height of water, if all of

Table 2. Common Constituents of California Waters

Cations Element	Symbol		Anions Element	Ion	Symbol
		major			
Calcium	Ca^{2+}		Chlorine	Chloride	Cl^-
Magnesium	Mg^{2+}		Sulfur	Sulfate	SO_4^{2-}
Sodium	Na^+		Carbon	Bicarbonate	HCO_3^-
			Carbon	Carbonate	CO_3^{2-}
		minor			
Potassium	K^+		Phosphorus	Phosphate	HPO_4^{2-}
			Nitrogen	Nitrate	NO_3^-
			Fluorine	Fluoride	F^-
			Boron	Borate	$B(OH)_3$
			Silicon	Silicate	$Si(OH)_4$

the cans have the same dimensions and vertical walls.

4. Make a table listing the cans and the amount of water in them.

5. Calculate the average amount of water in the cans by adding up the total amount, then dividing by the number of cans.

6. Calculate the average amount of water in the lowest quarter of the cans (for example, the lowest 5 cans if the total number of cans is 20).

7. Divide the average for the low quarter by the overall average to get the value of distribution uniformity.

If you know the volume applied in a known amount of time, then you can calculate the rate of application. For example, if you catch 60 mL in 30 seconds, the application rate is 120 mL/minute.

What Determines Water Quality?

For agriculture, the salts in water are the main determinants of water quality. Water picks up salts from the geologic materials it comes in contact with. There are several common constituents of water in California, depending on the geologic materials through which the water passes (Table 2). In reports from laboratories, these constituents are usually reported in either milligrams per liter (mg/L) or milliequivalents per liter (meq/L). An older unit, parts per million (ppm), is nearly equivalent to mg/L.

Why is Water Quality Important?

1. Salt accumulation in soil or container media can decrease yield and crop quality.

Most irrigation water, especially from wells, contains dissolved salts. Plants take up some of these salts when they take up water, but most accumulate in the root zone. Over time, the accumulated salts reduce the amount of water available to plants. A high amount of dissolved salts reduces yield and crop quality.

The salinity of a water is usually measured by its electrical conductivity (EC). It used to be reported as millimhos per centimeter (mmho/cm), but now the common unit is decisiemens per meter (dS/m). The values are the same for both units. The EC is related to total dissolved solids (TDS):

EC X 640 = TDS (in mg/L)

Irrigation water with an EC greater than 1.5 dS/m is regarded as having a high salinity hazard.

2. Soil pH is affected by water quality.

Bicarbonate in irrigation water results in a gradual increase in soil pH to undesirable levels. This is a greater problem on permanent or long-cycle crops than it is on bedding plants and most potted flowering crops. If the bicarbonate concentration is between 2-4 meq/L, the soil pH can be managed by increasing the use of ammoniacal fertilizers. If the bicarbonate concentration exceeds 4 meq/L, it may be necessary to acidify the water. This should be done through consultation with a laboratory familiar with acid injection.

3. Some constituents of water are toxic to plants if present at high concentrations.

Boron, chloride, and sodium are the most important problems for California ornamental crop producers.

Boron. Boron is toxic to plants at low concentrations. Some crops are sensitive to water boron concentrations as low as 0.5 mg/L. It is absorbed by roots and transported to the leaves, where it accumulates along the leaf margins. Sensitive crops develop marginal leaf burn.

Chloride. After being taken up by plant roots, chloride ions move through the plant and accumulate in the leaves. Some crops tolerate chloride, but others (especially roses, camellias, azaleas, and rhododendrons) develop marginal burning or leaf drop. Overhead irrigation with water high in chloride (greater than 3 meq/L) results in foliar uptake, which can also cause leaf scorch or leaf drop.

Sodium. Plants irrigated with water high in sodium may develop symptoms similar to those from chloride.

4. Some constituents of water are major plant nutrients.

Irrigation water can be a significant source of three elements that plants require in large amounts: calcium, magnesium, and sulfur. Some well waters contain enough nitrogen to be a significant fertilizer source. The contribution of irrigation water to crop nutrition should be considered when deciding on fertilizers and rates of addition.

How is Water Quality Managed?

Water treatment (e.g., reverse osmosis or deionization) is expensive, but effective leaching can reduce the hazard from marginal water quality by preventing excessive accumulation of salts in the root zone. Leaching is best achieved on ornamental crops by applying the proper *leaching frac-*

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Table 3. Recommended leaching fractions.

EC Applied (dS/m)	EC Leached (dS/m) 3	6	9	12
0.50	0.17	0.08	0.06	0.04
0.75	0.26	0.12	0.09	0.06
1.00	0.33	0.17	0.11	0.08
1.25	0.43	0.20	0.15	0.10
1.50	0.50	0.25	0.17	0.12
1.75	0.60	0.28	0.21	0.14
2.00	0.67	0.33	0.22	0.17
2.25	0.77	0.36	0.27	0.18
2.50	0.83	0.42	0.28	0.21
3.00	1.00	0.50	0.33	0.25
5.00		0.83	0.56	0.42

Workshop participants check irrigation uniformity using the can test.

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tion. This is the ratio of the volume of water leached (for example, the water that runs out of the bottom of a pot) to the volume of water applied (for example, the total amount of water applied to a pot). The proper leaching fraction depends on the salinity of the irrigation water (including fertilizer, in a liquid feed program) and the salinity sensitivity of the crop. In Table 3, EC Applied is the salinity of the irrigation water and EC Leached is the desired value in the water that has passed through the root zone. For most ornamental crops, EC Leached should be between 6-9 dS/m.

Applying the selected leaching fraction requires application of the information known about crop water use and irrigation distribution uniformity. Table 4 gives the volume of irrigation water needed for several amounts of plant water use and several leaching fractions. The values for leaching fraction and water use can be rounded off to conform to the table values. For example, a pot mum that used 240 mL of water should be irrigated with about 313 mL of water if the EC Applied is 2 dS/m and the desired leachate EC is 9 dS/m (the leaching fraction is about 0.22).

The values in Table 4 do not take into consideration the distribution uniformity. To correct for that, the values in the table must be divided by the distribution uniformity value. For example, if the distribution uniformity is 0.8, the mum in the example above would require 390 mL.

Using the average application rate of the irrigation system (calculated during the test of distribution uniformity), the duration of each irrigation cycle can be calculated. Again using the pot mum example, the 390 mL needed could be applied in just over 3 minutes if the system applies water at 120 mL per minute.

Pot plant growers can monitor leaching fraction and leachate EC by catching leachate from a few pots periodically. Measure the volume of leachate and either measure or calculate the volume of irrigation water applied. The ratio of leachate volume to total volume applied is the actual leaching fraction.

How Often Should Plants Be Irrigated?

The maximum amount of time between irrigations is determined by the amount of easily available water. This amount can be determined easily for potted crops. Irrigate some plants thoroughly and wait for drainage to stop. Weigh the pots, and withhold irrigation until the plants show the first signs of wilting. Weigh the pots again. Subtract this weight from the weight just after irrigation. The difference (in grams) is equal to the volume of water (in milliliters) that is available to plants. This is sort of like the “gas tank” of water the plants can use. The normal recommendation is to irrigate when about half of this volume has been used by the plant. For example, if a pot holds 500 mL of easily available water, then irrigation should be scheduled when about half of that, or 250 mL, has been used by the plant. The pot mums we discussed above used 240 mL per day, so a daily irrigation would be just right. GP

Table 4. Volume of water (in mL) to apply to achieve desired leaching fraction.

Leaching fraction	Plant water use (mL)										
	50	**75**	**100**	**125**	**150**	**175**	**200**	**250**	**300**	**350**	**400**
0.075	54	81	108	135	162	189	216	270	324	378	432
0.100	56	83	111	139	167	194	222	278	333	389	444
0.125	57	86	114	143	171	200	229	286	343	400	457
0.150	59	88	118	147	176	206	235	294	353	412	471
0.175	61	91	121	152	182	212	242	303	364	424	485
0.200	63	94	125	156	188	219	250	313	375	438	500
0.225	65	97	129	161	194	226	258	323	387	452	516
0.250	67	100	133	167	200	233	267	333	400	467	533
0.275	69	103	138	172	207	241	276	345	414	483	552
0.300	71	107	143	179	214	250	286	357	429	500	571
0.400	83	125	167	208	250	292	333	417	500	583	667
0.500	100	150	200	250	300	350	400	500	600	700	800