Spotting Problems Early with Irrigation System Efficiency Assessments

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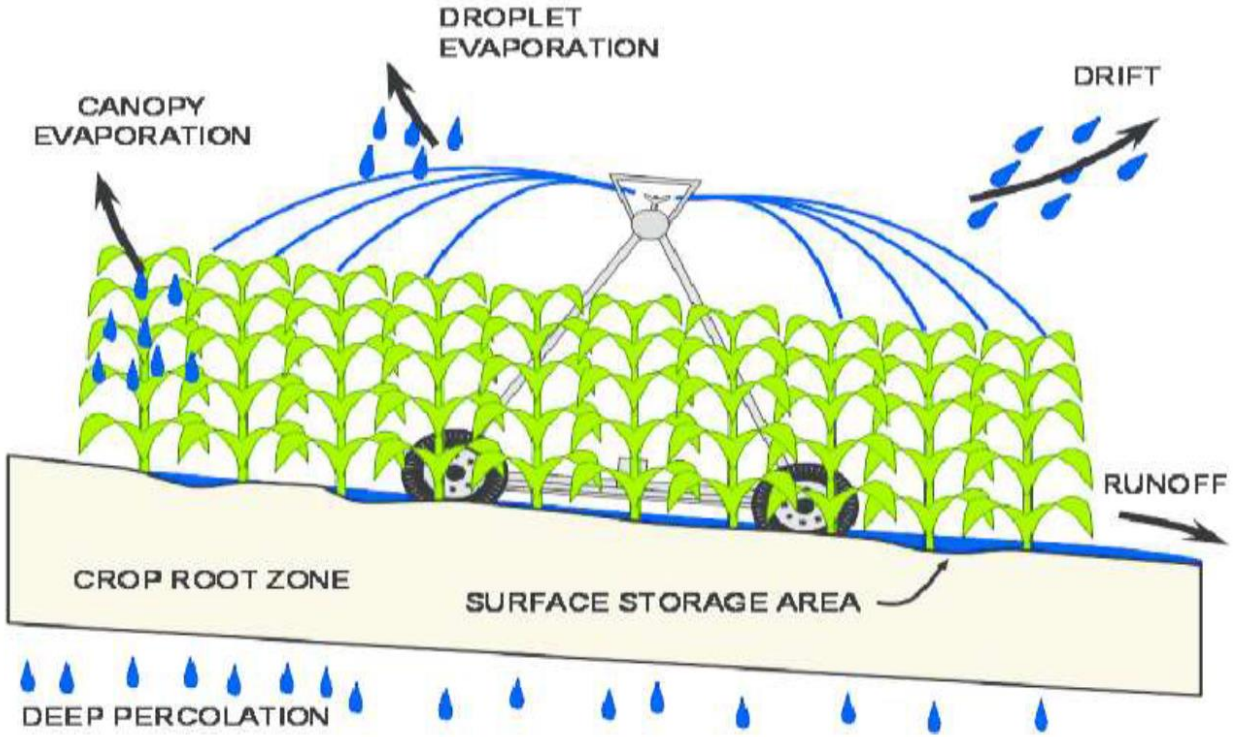
USDA
United States Department of Agriculture

National Institute of Food and Agriculture

System Efficiency Assessment

Irrigation efficiency:

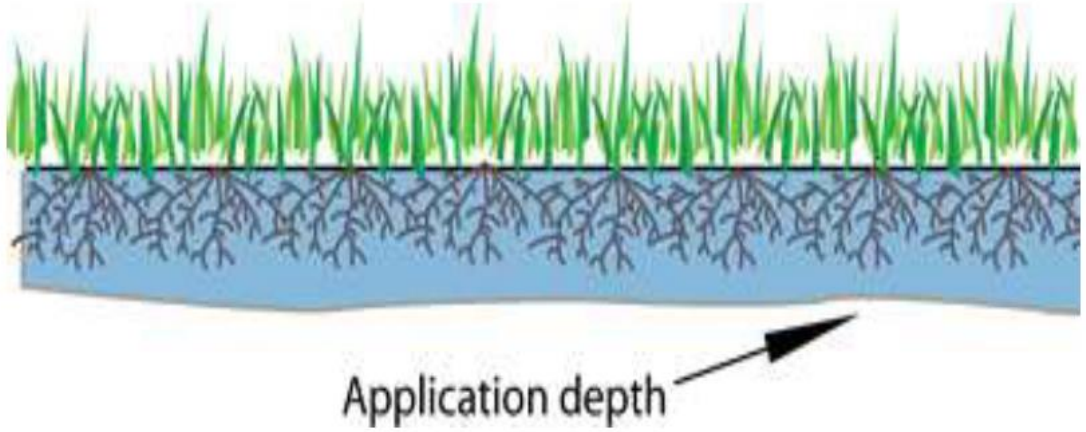
the ratio of the amount of water consumed by the plant to the amount of water supplied by irrigation



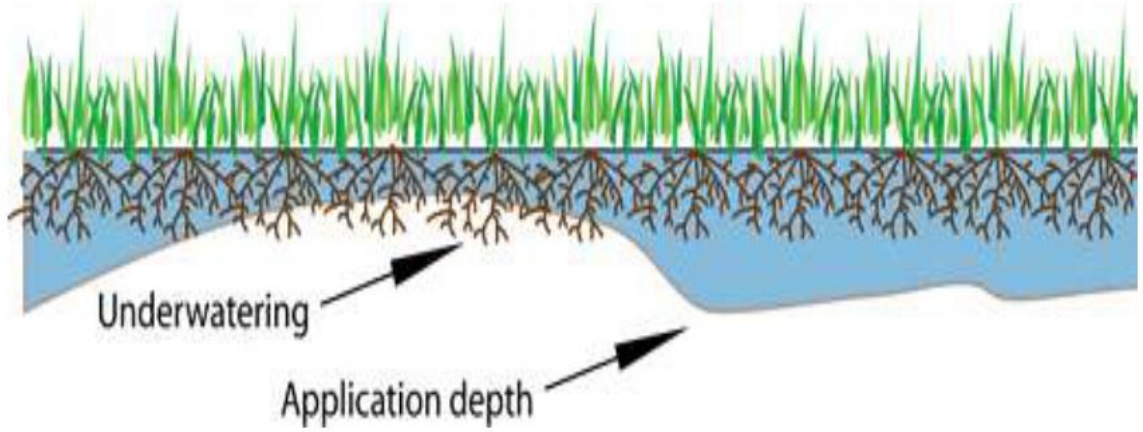
(Source: Addink, J. W., et al. "Design and operation of sprinkler systems." Design and operation of sprinkler systems.)

System Efficiency Assessments

Irrigation Uniformity: measurement of how equally irrigation is being applied to different areas of the field



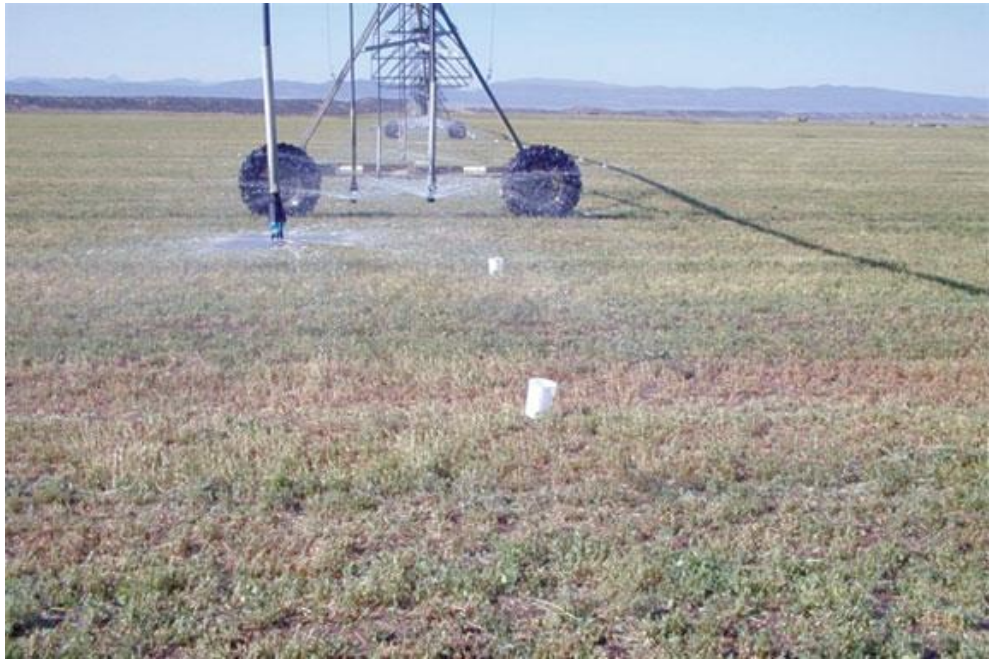
Good DU



Poor DU

System Efficiency Assessments

Tests and inspections that tell you how efficient and uniform your irrigation is.



sprinkler - Excel

File | Home | Insert | Page Layout | Formulas | Data | Review | View | ACROBAT | Tell me what you want to do...

Paste | Calibri | 11 | Wrap Text | General | Merge & Center | Conditional Formatting

Clipboard | Font | Alignment | Number

A1 | Collectors

	A	B	C	D	E	F	G	H	I	J
1	Collectors			Row A	*Spacing*					
2				***Vi***	***Di***	***Si***	***ViSi***	***Vi-VbarP***	***Si|Vi-VbarP|***	
3			**1**	30	2	2	60	14.06	28.12	**1**
4	**A_count**	22	**2**	31	2.5	4.5	139.5	13.06	58.78	**2**
5	**B_count**	22	**3**	32	2.5	7	224	12.06	84.43	**3**
6	**Total Collectors**	44	**4**	33	2.5	9.5	313.5	11.06	105.09	**4**
7			**5**	34	2.5	12	408	10.06	120.74	**5**
8			**6**	35	2.5	14.5	507.5	9.06	131.40	**6**
9	***∑Si***	1243	**7**	36	2.5	17	612	8.06	137.05	**7**
10	***∑ViSi***	54769	**8**	37	2.5	19.5	721.5	7.06	137.71	**8**
11	***∑VbarP***	44.06	**9**	38	2.5	22	836	6.06	133.36	**9**
12	***∑Si|Vi-VbarP|***	5462.48	**10**	39	2.5	24.5	955.5	5.06	124.02	**10**
13			**11**	40	2.5	27	1080	4.06	109.67	**11**
14	**CU_H**	90.0%	**12**	41	2.5	29.5	1209.5	3.06	90.33	**12**
15			**13**	42	2.5	32	1344	2.06	65.98	**13**
16			**14**	43	2.5	34.5	1483.5	1.06	36.64	**14**
17	Enter Can Vi's		**15**	44	2.5	37	1628	0.06	2.29	**15**
18	in Shaded area		**16**	45	2.5	39.5	1777.5	0.94	37.05	**16**
19			**17**	46	2.5	42	1932	1.94	81.40	**17**
20			**18**	47	2.5	44.5	2091.5	2.94	130.74	**18**

Why do an assessment – impact to crops

Under-watered

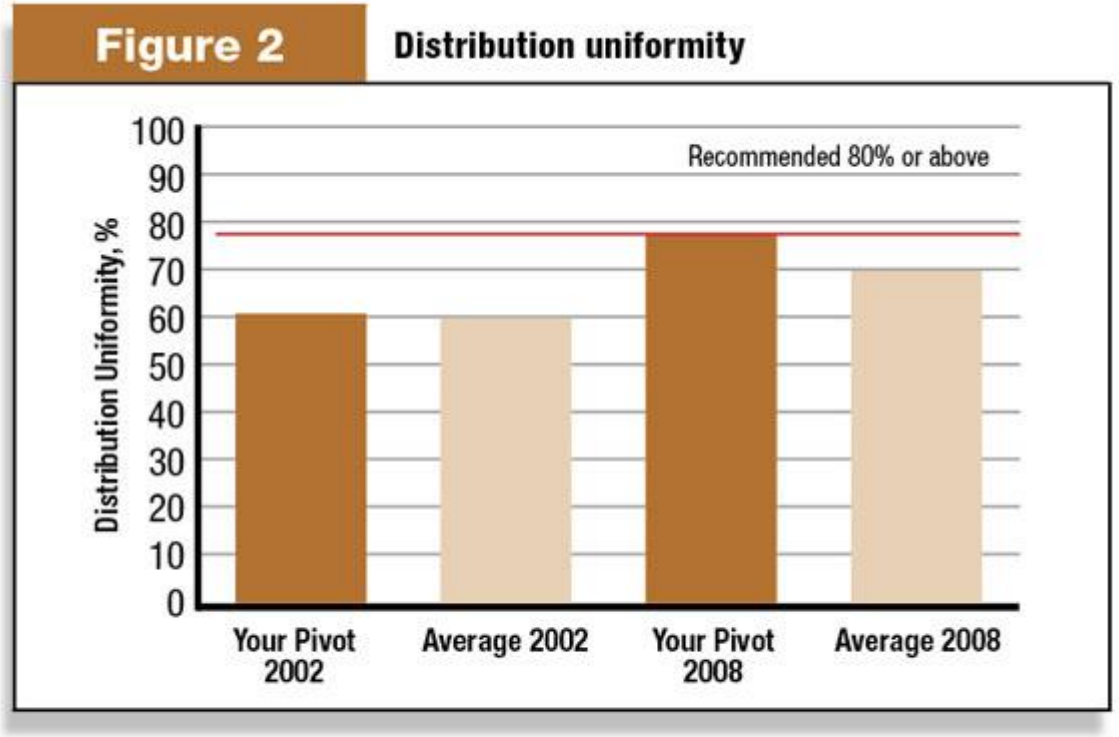
Over-watered

Cotton Root Rot symptoms in a field of carrots.
Courtesy Tom Isakeit, TAEX, Weslaco, 1996.

Images: Janice Person; Texas Agri-life extension

Why do an assessment – excess costs

- Uniformity (2002): 61%
- Uniformity (2008): 70%
- Savings: $1745 per pivot



A representation of one producer's printout of the distribution uniformity from 2002 to 2008.

Why do an assessment – excess costs

	System 1	System 2
Acreage	160	160
Irrigation efficiency	60%	80%
Crop water requirements (inches)	10	10
Water needed (inches)	17	13
Water needed (acre-inches)	2700	2000
Pumping costs (diesel: $11/AI)	$ 29,300	$ 22,000
Pumping costs (electric: $7/AI)	$ 18,700	$ 14,000

Savings:
$4,400 to $7,300

Why do an assessment – system maintenance

Images: Ted Harm (topcropmanager.com);

Irrigation efficiency assessments

- Goals:
  - Know how much water is being lost (efficiency)
  - Know how evenly water is being applied (uniformity)
  - Identify strategies to improve efficiency and/or uniformity
- Range of approaches
  - Operational inspection (pressure, flow, catch)
  - Calculations (spreadsheet tools)

Overhead assessments – checking pressure

- Pitot tube (0-60 or 0-100 psi)
- Insert end of pitot tube into sprinkler jet about 1/16” away from nozzle
- Note down reading on gauge
- Difference between sprinklers should be under 20%
- Should be consistent with design

Images: John Ignosh; University of Maryland

Overhead assessments – checking flow

- Put hose over the operating sprinkler nozzle
- Direct water from the sprinkler into the 5-gallon bucket
- Measure the time to fill
- Convert the volume and time into the sprinkler flow rate in gallons per minute (GPM)

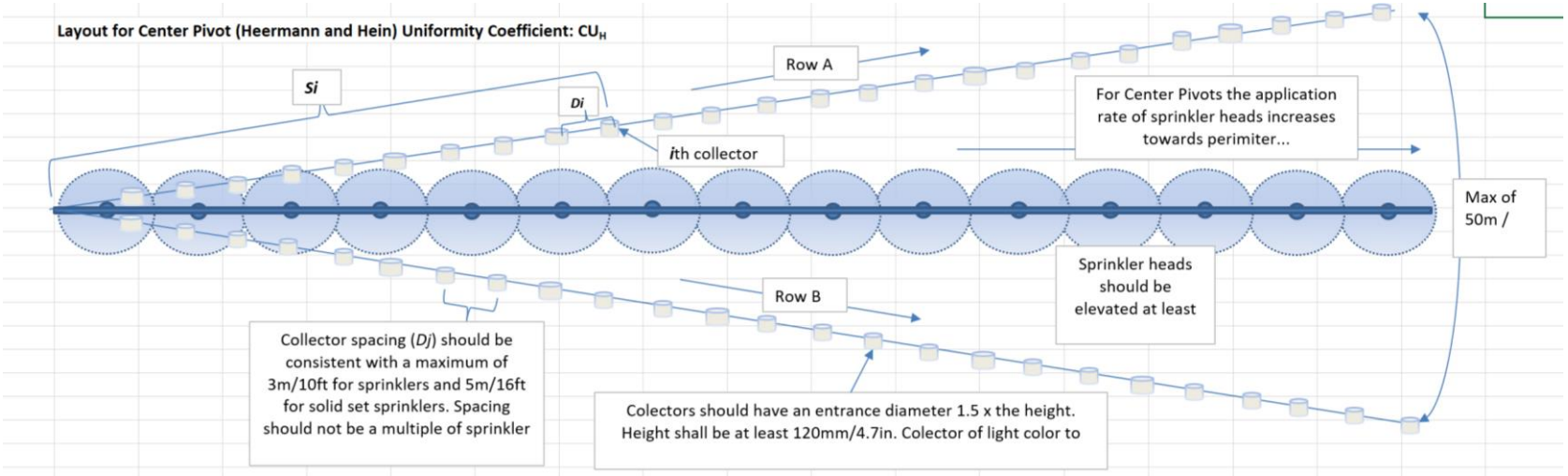
$$GPM = \frac{60\ x\ Container\ volume\ (gallons)}{Fill\ time\ (seconds)}$$

- Differences should be less than 10%

Images: John Ignosh; University of Maryland

Overhead irrigation assessments – catch cans

- Set out cans at uniform spacing
  - < 10 ft for pivot/lateral
  - Not a multiple of sprinklers
  - < 5 ft for solid set
- Set out uniform catch cans



Images: Kansas State University; John Ignosh

Overhead irrigation assessments – catch cans

WSU Othello

Average catch (in)	**0.42**
Distribution Uniformity	**88%**

S	Can ID	mL	in	S	Can ID	mL	in	S	Can ID	mL	in	S	Can ID	mL	in	S	Can ID	mL	in
0	1	x		0	31	x		0	61	x		0	91	x		0	121	x	
0	2	x		0	32	x		0	62	x		0	92	x		0	122	x	
0	3	x		0	33	x		0	63	x		0	93	x		0	123	x	
0	4	x		0	34	x		0	64	x		0	94	x		0	124	x	
0	5	x		0	35	x		0	65	x		0	95	x		0	125	x	
0	6	150	0.36	0	36	x		0	66	x		0	96	x		0	126	x	
0	7	200	0.48	0	37	x		0	67	x		0	97	x		0	127	x	
0	8	154	0.37	0	38	x		0	68	x		0	98	x		0	128	x	
0	9	200	0.48	0	39	x		0	69	x		0	99	x		0	129	x	
0	10	185	0.44	0	40	x		0	70	x		0	100	x		0	130	x	
0	11	179	0.43	0	41	x		0	71	x		0	101	x		0	131	x	
0	12	160	0.38	0	42	x		0	72	x		0	102	x		0	132	x	
0	13	192	0.46	0	43	x		0	73	x		0	103	x		0	133	x	
0	14	189	0.45	0	44	x		0	74	x		0	104	x		0	134	x	
0	15	173	0.41	0	45	x		0	75	x		0	105	x		0	135	x	
0	16	165	0.39	0	46	x		0	76	x		0	106	x		0	136	x	
0	17	x		0	47	x		0	77	x		0	107	x		0	137	x	
0	18	x		0	48	x		0	78	x		0	108	x		0	138	x	
0	19	x		0	49	x		0	79	x		0	109	x		0	139	x	

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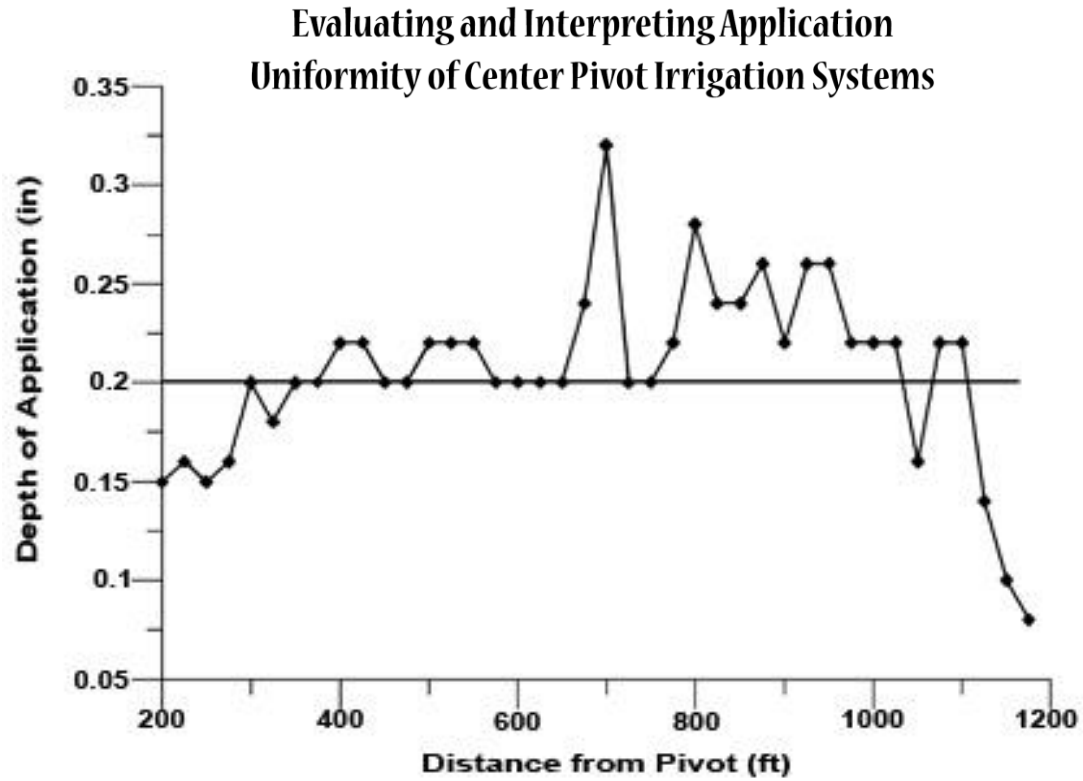

Images: University of Georgia Cooperative Extension; Washington Irrigation System Efficiency Program

Drip irrigation assessments

- Same idea – check pressure, flow, and uniformity
- What parts of system are exposed?
- Pressure –
  - Need 0-30 psi gauge
  - Punch hole and replug
- Flow – place containers under individual emitters

Drip irrigation assessments – line flushing

- Place nylon mesh over end of line
- Dirt, sediment
- Organic material
- Colored material
  - Reddish – iron bacteria
  - White – lime

Improving efficiency – big gun

- Changing travel speed
- Changing lane spacing
- Changing nozzle type, size, and pressure
- Change irrigation time – eliminate wind effect

Images: Moneim Mohamad

Improving efficiency – solid set

- Reduce number of sprinklers (needs to match pumping capacity)
  - Too many means pressure too low – poor uniformity, damage soil/crops
- Consistent nozzle type
- Replace nozzles that are broken or worn
- Check for plugging, clean pluggled sprinklers

Improving efficiency – pivots and laterals

- Clean plugged or clogged nozzles
- Inadequate system pressure
  - Check pump
  - Pump and sprinkler design should be consistent
- Pressure regulators for elevation differences
- Replace worn out nozzles

Improving efficiency - drip

- Pressure regulation/compensation
- Check water quality
- Maintain filtration/treatment system
  - Check water quality
  - Backflush as specified
- Flush lines monthly

Additional Resources

- Washington State University Uniformity Evaluation Forms and Spreadsheets: Traveling gun, hand-move, and drip: https://www.aeei.bse.vt.edu/?page_id=396

- University of Georgia Center Pivot evaluations: http://extension.uga.edu/publications/detail.html?number=C911

- Evaluation and maintenance of drip systems: http://micromaintain.ucanr.edu/

Thank you!

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