Irrigation efficiency in Urban and Small Farm Setting

Shital Poudyal, Ph.D

Assistant Professor and Extension Specialist

Learning objectives

- Why is irrigation needed
- Factors to consider for efficient irrigation in small farms
- Understanding water pressure for irrigation
- Optimizing irrigation system components for efficiency
- How organic matter can save water
- How can smart controller save water
- Understand distribution uniformity and plant water use

Why is irrigation/water needed ?

- Photosynthesis

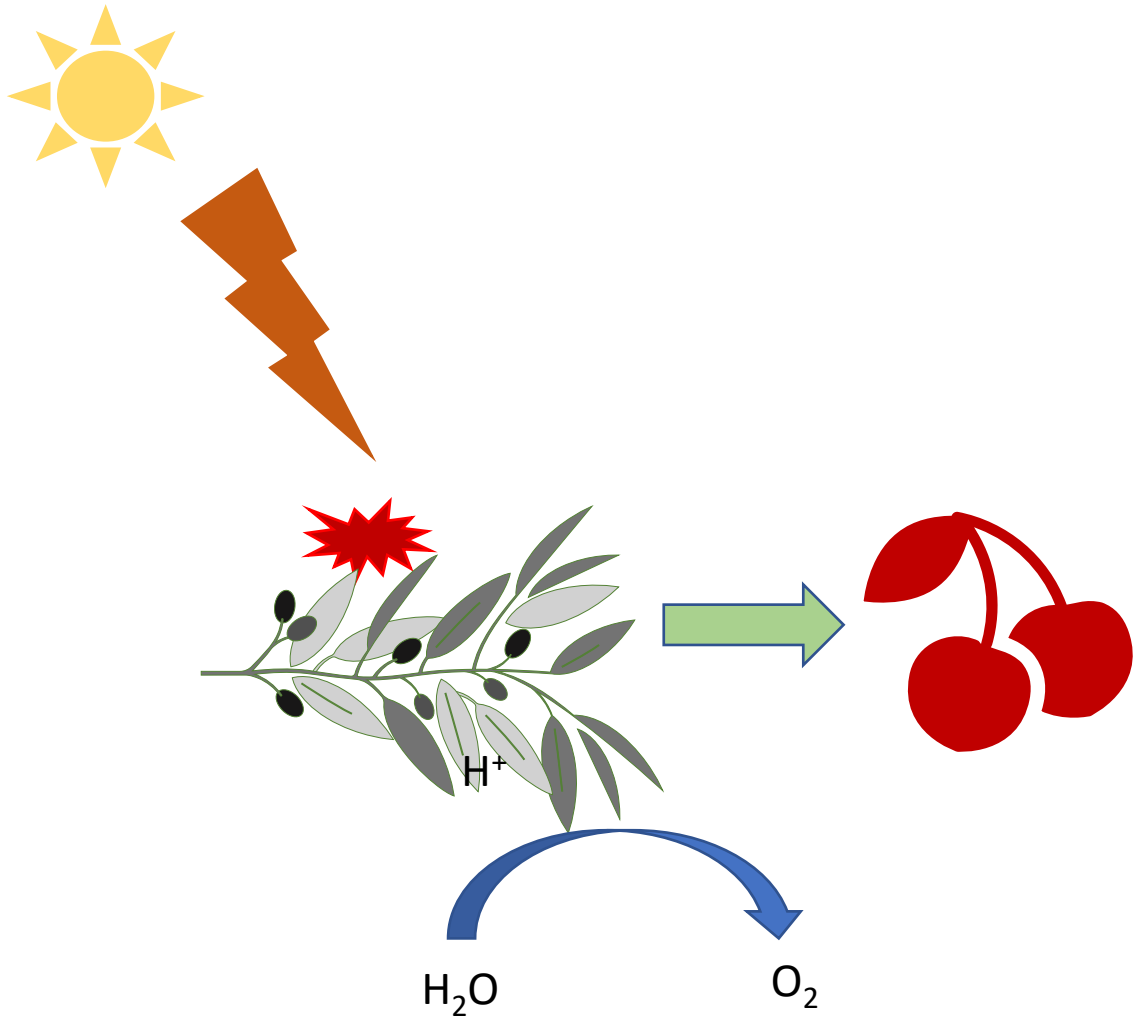
Photosynthesis

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

carbon dioxide + water → glucose + oxygen

- Nutrients and sugar movement
- Increase yield
- Cell structure (60-90% of weight of plant is water)
- Thermal stability by transpiration
- Germination of seeds

To Take up carbon plant need to transpire!



Water pressure requirements

- It is the force of water moving in a unit area
- Irrigation parts such as pipes and nozzles are usually marked with required pressure for proper functioning
- As you move further from the water source the pressure decreases
- Smaller pipes have higher pressure loss compared to larger pipes
- As you move up in the elevation the pressure decreases drastically and vice versa

  Water moving downhill from point A to point B will gain 0.433 psi per 1 foot of elevation change. Conversely, water moving uphill from point B to point A will lose 0.433 psi per 1 foot of elevation change

FRICTION LOSS CHARTS - SCHEDULE 40 PVC IPS PLASTIC PIPE

ASTM D1785 (1120, 1220) C=150 • PSI loss per 100 ft. of pipe

Nominal Size	½"		¾"		1"		1¼"		1½"		2"	
Avg. ID	0.602		0.804		1.029		1.360		1.590		2.047	
Pipe OD	0.840		1.050		1.315		1.660		1.900		2.375	
Avg. Wall	0.119		0.123		0.143		0.150		0.155		0.164	
Min. Wall	0.109		0.113		0.133		0.140		0.145		0.154	
Flow (GPM)	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss	Velocity FPS	PSI Loss
1	1.13	0.50	0.63	0.12	0.39	0.04	0.22	0.01	0.16	0.00		
2	2.25	1.82	1.26	0.44	0.77	0.13	0.44	0.03	0.32	0.02	0.19	0.00
3	3.38	3.85	1.89	0.94	1.16	0.28	0.66	0.07	0.48	0.03	0.29	0.01
4	4.50	6.55	2.52	1.60	1.54	0.48	0.88	0.12	0.65	0.06	0.39	0.02
5	5.63	9.91	3.16	2.42	1.93	0.73	1.10	0.19	0.81	0.09	0.49	0.03
6	6.75	13.89	3.79	3.40	2.31	1.02	1.32	0.26	0.97	0.12	0.58	0.04
7	7.88	18.48	4.42	4.52	2.70	1.36	1.54	0.35	1.13	0.16	0.68	0.05
8	9.01	23.66	5.05	5.79	3.08	1.74	1.76	0.45	1.29	0.21	0.78	0.06
9	10.13	29.43	5.68	7.20	3.47	2.17	1.99	0.56	1.45	0.26	0.88	0.08
10	11.26	35.77	6.31	8.75	3.85	2.63	2.21	0.68	1.61	0.32	0.97	0.09
12	13.51	50.14	7.57	12.27	4.62	3.69	2.65	0.95	1.94	0.44	1.17	0.13
14	15.76	66.71	8.84	16.32	5.39	4.91	3.09	1.26	2.26	0.59	1.36	0.17
16	18.01	85.42	10.10	20.90	6.17	6.29	3.53	1.62	2.58	0.76	1.56	0.22
18	20.26	106.24	11.36	25.99	6.94	7.82	3.97	2.01	2.90	0.94	1.75	0.28
20			12.62	31.59	7.71	9.51	4.41	2.45	3.23	1.14	1.95	0.33

Pressure check

- Static pressure
- Dynamic pressure/operating pressure

  Take at the end of the pipe with all the water running

Pressure Regulator

- At main line
- At Solenoid valve
- At each riser or head

Understand pressure requirements of nozzle

- Use pressure compensating nozzle if high pressure or whenever possible.
- What if low pressure
  - ✓ Have smaller zones
  - ✓ Have emitter and nozzle with slower flow rate.
  - ✓ Have defined flow rate nozzle and emitter through out

R-VAN14 8′ - 14′					
Nozzle	Pressure psi	Radius ft.	Flow gpm	Precip In/h ■	Precip In/h ▲
360° 	30	13	1.10	0.63	0.72
	35	13	1.12	0.64	0.74
	40	14	1.22	0.60	0.69
	45	**14**	**1.27**	**0.62**	**0.72**
	50	15	1.41	0.60	0.70
	55	15	1.45	0.62	0.72

Toro high efficiency and low flow rate nozzle

Have back flow preventer

- Have a reliable back flow preventer so you do not get sued.

Reduced pressure zone (RPZ)

Double-check valve

Nozzle selection

Nozzle type for overhead irrigation

Fixed ARC nozzles (spray nozzles):

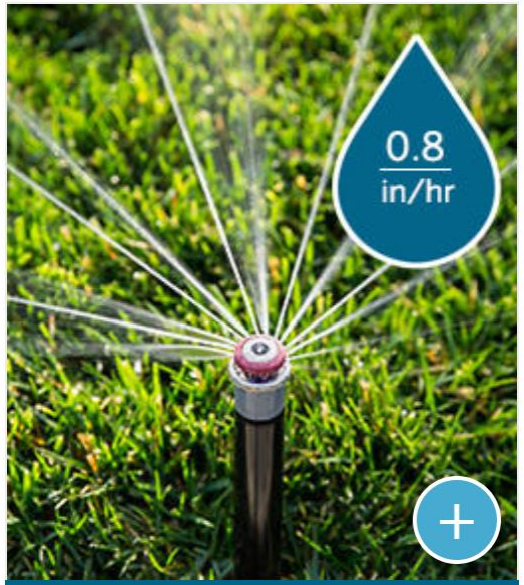
- HE-VAN Nozzle
- Precision nozzle
- Pro nozzle
- They have lower flow rate and even coverage

MPR nozzle (may be fixed or rotatory)

360° = 4 GPM

180° = 2 GPM

90° = 1 GPM



Nozzle selection

Rotatory nozzle:

Slow irrigation rate, enough time for water infiltration.

Operate at lower pressure

Suitable for slopes

Major Products						
	Rotary Nozzles	Variable ARC Sprays		Fixed ARC Sprays		
Primary Applications	R-VAN Best	HE-VAN Best	VAN Standard	U-Series Best	SQ Nozzles Standard	MPR Standard
Turfgrass	●	●	●	●	●	●
Slopes	●					
Narrow Strips					●	●
Small Areas	●	●			●	
Landscape Beds	●	●	●	●	●	●
High Efficiency	●	●		●		
High Winds	●	●		●		
High Pressure	●	●				

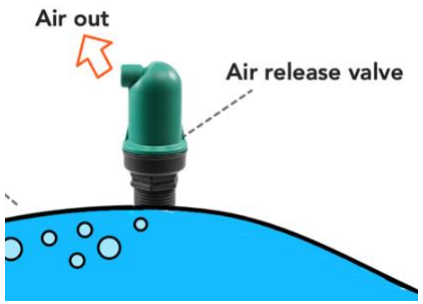
To reduce inefficiency for overhead irrigation

- Use low volume nozzles.
- Use a pressure regulator on the system if the pressure is too high or booster pumps if the pressure is too low.
- Use low-angle nozzles in windy areas.
- Irrigate during the early morning hours when winds and evaporation are typically lower.
- Space sprinkler heads to compensate for windy locations.
- Choose sprinkler heads and nozzles that provide larger water droplet sizes rather than fine sprays.

Drip Irrigation system nozzles/emitters

- Sprinkler to drip conversion kits.
- Should have filter (150 -200 mesh) and flush outlet
- Pressure Compensating Emitter Tubing
- Pressure Compensating Emitter
- Install emitter at the outlet on the spaghetti tube
- Check the pipes pressure rating and UV resistance
- Air vacuum or Relief valve

Google pressure loss on drip tubing “numerous online calculator available”



https://help.dripdepot.com/support/solutions/articles/11000064574-why-you-need-air-vent-vacuum-relief-in-your-irrigation-system

Drip Irrigation system nozzle

GENERAL GUIDELINES	TURF												SHRUB & GROUNDCOVER											
	CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL			CLAY SOIL			LOAM SOIL			SANDY SOIL			COARSE SOIL		
EMITTER FLOW	0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH			0.26 GPH			0.4 GPH			0.6 GPH			0.9 GPH		
EMITTER SPACING	18"			12"			12"			12"			18"			18"			12"			12"		
LATERAL (ROW) SPACING	18"	20"	22"	18"	20"	22"	12"	14"	16"	12"	14"	16"	18"	21"	24"	18"	21"	24"	16"	18"	20"	16"	18"	20"
BURIAL DEPTH	Bury evenly throughout the zone from 4" to 6"												On-surface or bury evenly throughout the zone to a maximum of 6"											
APPLICATION RATE (INCHES/HOUR)	0.19	0.17	0.15	0.30	0.27	0.25	0.98	0.84	0.73	1.48	1.27	1.11	0.19	0.16	0.14	0.30	0.26	0.23	0.73	0.65	0.59	1.11	0.99	0.89
TIME TO APPLY ¼" OF WATER (MINUTES)	80	89	97	50	55	61	15	18	20	10	12	13	80	93	106	50	58	66	20	23	26	13	15	17
Following these maximum spacing guidelines, emitter flow selection can be increased if desired by the designer. 0.9 GPH flow rate available for areas requiring higher infiltration rates, such as coarse sandy soils.																								

QWEL manual

Clogging of emitters

- High pH water
- No filters
- Fertigation
- High evaporation rate

Remedy

- Injection of acid
- Lot of products in market

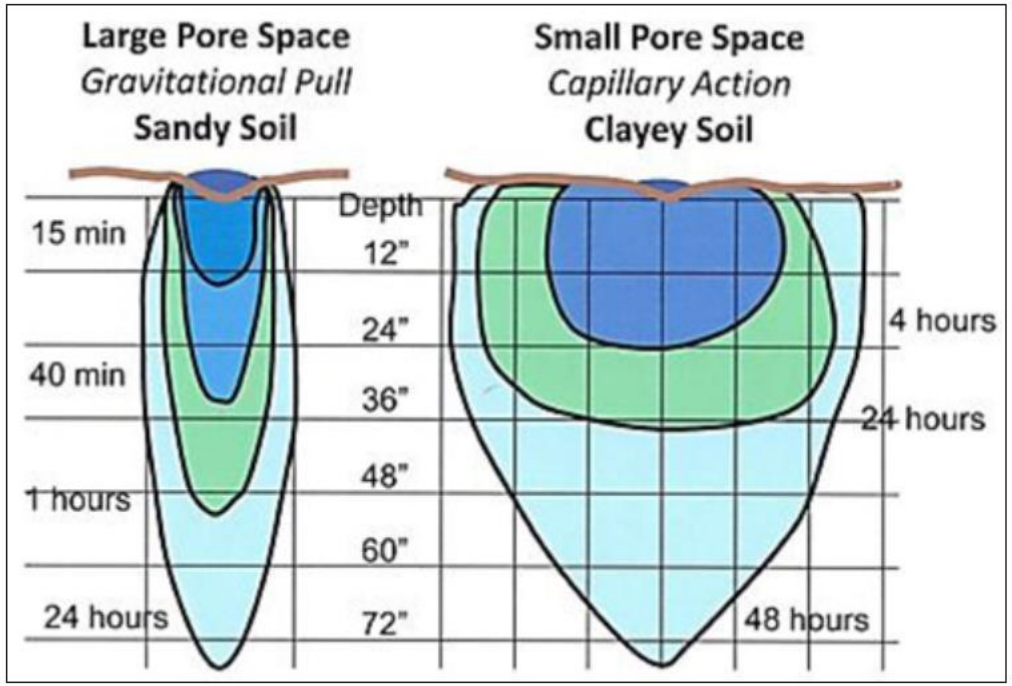
CHEMICAL WATER QUALITY FOR THE CLOGGING POTENTIAL OF DRIP IRRIGATION

Description	Clogging danger with the following concentration		
	Low	Moderate	High
pH	< 7.0	7.0 - 7.5	> 7.5
Particulate matter*	< 30	30 - 100	> 100
Total dissolved solids*	< 500	500 - 2,000	> 2,000
Ferrous*	< 0.1	0.1 - 1.5	> 1.5
Manganese*	< 0.1	0.1 - 1.5	> 1.5
Calcium*	< 40	40 - 80	> 80
Carbonate density*	< 150	150 - 300	> 300
Hydrogen Sulfide*	< 0.2	0.2 - 2.0	> 2.0
Bacteria (quantity/ml)	< 10,000	10,000 - 50,000	> 50,000

https://www.hunterindustries.com/sites/default/files/dg_plddesignguide_dom.pdf

Soil Considerations

- Top layer irrigation will not develop proper root.
- So, clay soil – low-rate long time and infrequent irrigation
- Sandy soil - More frequent and high flow and short duration
- Aeration of compacted soils and slope land



David Whiting, 2011

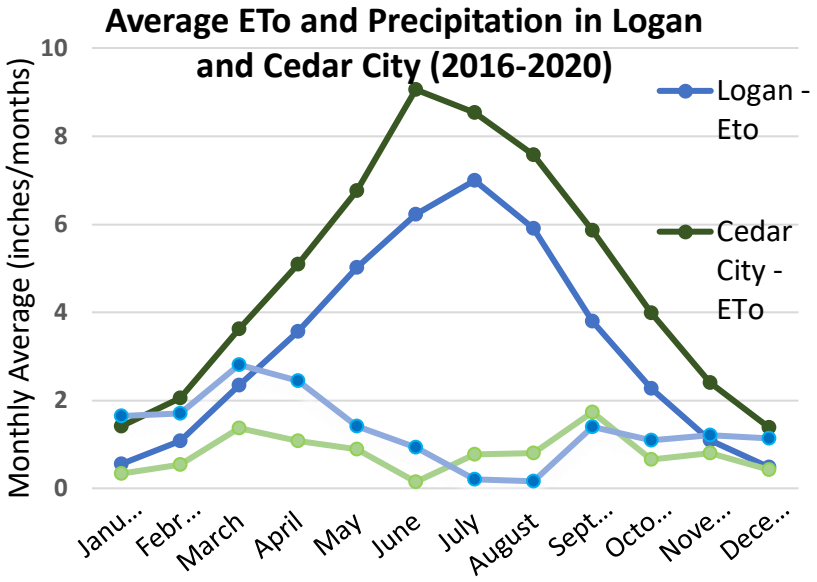
Organic matter

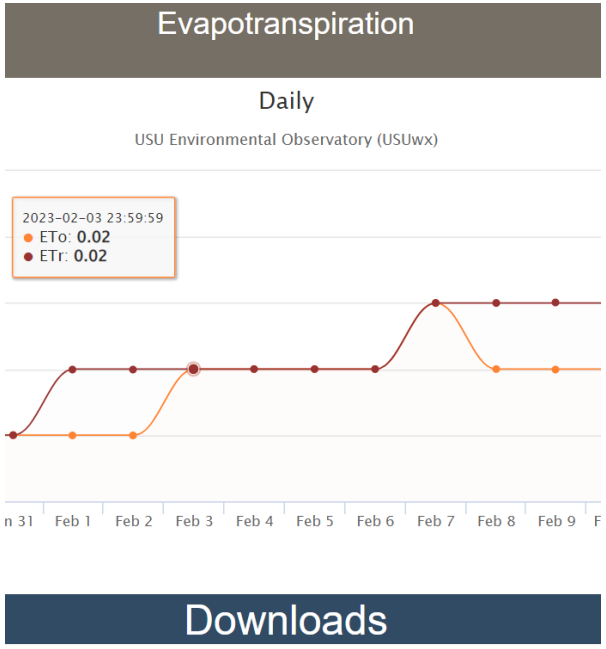
- 1% increase in soil OM can hold 16000 gallon of plant available water per acre (considering one foot storage)
- Increase OM (form something that is derived from living things) in soil
- Spread OM 8 -12 inches deep
- Inorganic matter are artificially created (perlite, vermiculite, gravel) that can increase water holding capacity
- Organic matter: increase soil aeration, water holding capacity, water infiltration, nutrient holding capacity, provide nutrients.

Weather consideration

- Evapotranspiration : The amount of water lost from the soil and plant surface.
- Need to apply water to replenish 60-100% of water lost depending on the plant type
- Look up your local weather data at:

https://climate.usu.edu/mchd/index.php

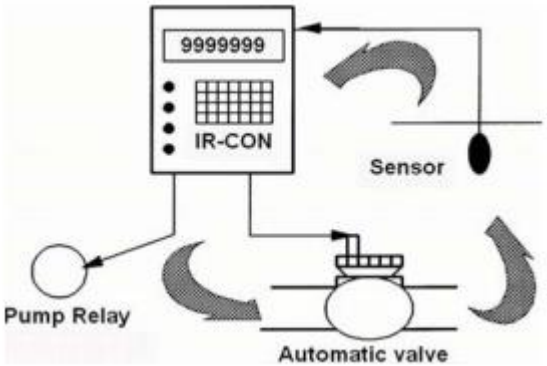




Smart Controllers

- Minimum interventions
- Like thermostat for your garden
- ET controlled and soil moisture controlled
- Irrigation decisions made based on feedback from the sensors

https://www.nytimes.com/wirecutter/reviews/best-smart-sprinkler-controller/



https://itc.tamu.edu/files/2018/05/SSAGE22.pdf

Hydrozones and leaks checking

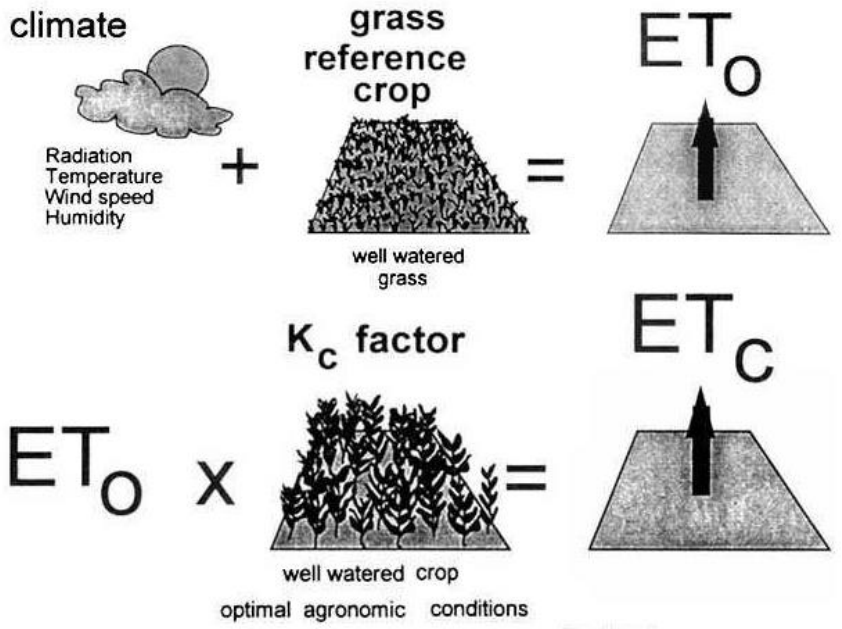
- Group plants with similar water needs together and irrigate them separately from plants with different water needs.

- Checks regularly for leaks in the systems. Leaks in subsurface and easily go unnoticed.

https://www.nytimes.com/wirecutter/reviews/best-smart-sprinkler-controller/

Plant consideration

- Most vegetable crops the Kc value would be close to 0.6 - 1.
  - For initial stage ~ 0.6-0.7
  - Actively growing and producing ~ 1
  - At final growth stages ~0.8-0.9
- https://www.fao.org/3/x0490e/x0490e0b.htm
- https://farmwest.com/climate/calculator-information/et/crop-coefficients/

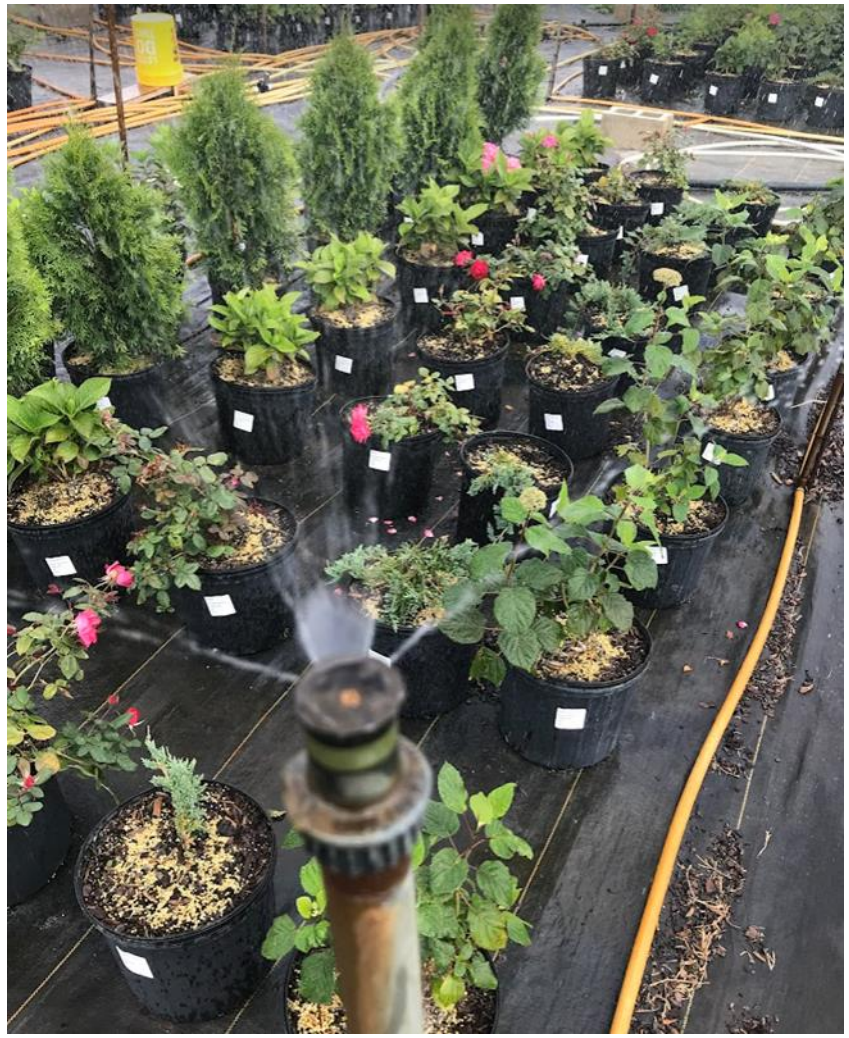


Using mulching and shade cloth

- 2- 3 inch of straw mulch any fluffy organic materials for seeds to germinate
- Growing plants in plastic mulch will lower evapotranspiration component (from bare soil and weed)
- Shade cloth can block the sunlight lowering temperature and also reducing photooxidative damage

Irrigation installation

- Create your irrigation plan
- Map irrigation area including trees, shrubs, slopes, sun, shade.
- Determine emitter head placement
  - Head to head coverage for overhead
  - Drip emitters not directly on the main root.
- Check and modify controller setting as required
- Maintain irrigation pressure (as per emitter recommendation)
- Consider cyclic irrigation
  - A 10-minute cycle can be split to two 5-minutes cycles – determined by runoff
- Sunny landscape may need double the amount of irrigation as shade landscape.



Addition water saving ideas

- Capture and reuse
- Rainwater harvesting
- Increase water travel distance.
- Curb cut

1000 sq ft root with 16 inches of rainfall will yield 10,000 gallons of water a year.

Thank you !

Extension
UtahStateUniversity

Utah State University is conducting an irrigation optimization study for small scale specialty crop growers and garden centers

If you are in Cache, Davis, Utah and nearby counties and:

- Ornamental nursery grower, garden center, cut flower producers.
- Any kind of specialty crop grower.
- Willing to switch to the smart irrigation controller full scale or on section.
- Use any kind of overhead irrigation system in your operation

Please consider participating. We will provide (free of cost):

- Replace tradition irrigation controller with a smart, evapotranspiration-based, irrigation controller for your operation, which will be for you to keep.
- Provide one on one training on using smart irrigation controller.
- Working with you on troubleshooting (if any) issues with smart controller for two growing seasons.
- With the input provided by you we will document the efficiency, water savings, ease of use and durability of each brand of SC over two growing seasons and provide it to you.

You can also use your phone to scan the QR code below for registration

Or type
tinyurl.com/irrigationcontrollers