Water, Irrigation Systems and Water Use Efficiency (for Specialty Crops)

UC Urban Agriculture Workshop Series

Production Issues and Urban Farms

Pomona - July 28, 2017

Adapted from Presentations by:

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California Agriculture

- $ 45 Billion industry
- # 1 US producer of 78 Commodities
- Only US producer of 14 different commodities (99% of total or greater)

Almonds	Kiwifruit	Pomegranates
Artichokes	Olives	Rice, Sweet
Dates	Peaches, Clingstone	Ladino Clover, Seed
Figs	Pistachios	Walnuts
Grapes, Raisin	Plums, Dried	

Adapted from Doug Parker's presentation on Water Use, Reuse and Recharge.

Drought Impacts to California

- Overall decline in orchards and perennial cropping systems
- Fallow crop land
- Import feed for livestock and dairy
- Reduce cattle numbers, cull herds
- Increase wildfire danger
- Impact ecosystem health and restoration efforts
- Increased residential & urban water demand

Adapted from Doug Parker's presentation on Water Use, Reuse and Recharge.

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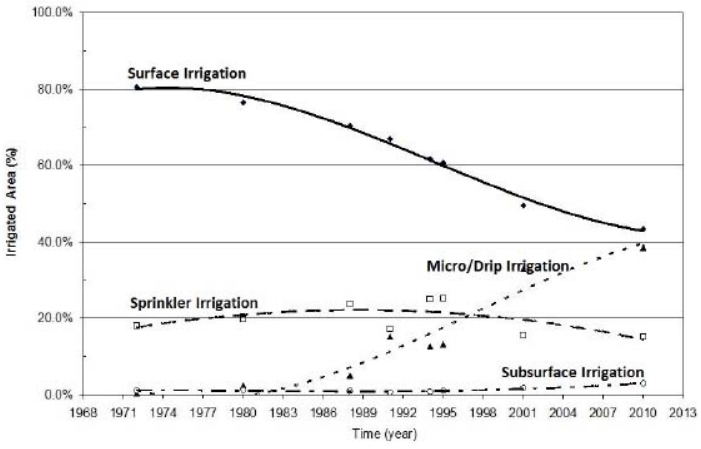
Real Impacts for California

- Switch from surface or sprinkler irrigation to micro/drip or other low volume systems
- UCCE research on water management saved water and increased product quality
- Integrated research with variety development and other on-farm management changes

Adapted from Doug Parker's presentation on Water Use, Reuse and Recharge.

Real Impacts for California



Tindula et al. (2013). Survey of Irrigation methods in California in 2010

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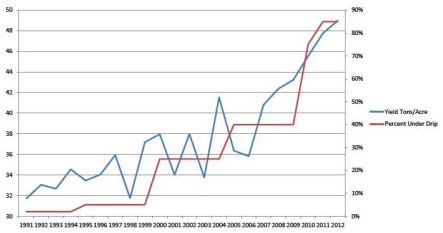
Real Impacts for California

- Tremendous efficiency gains for some crops or cropping systems
- Processing tomatoes since 1990:
  - Decreased water use
  - Increased yields
  - Reduced acreage
  - Increased production



Adapted from Doug Parker's presentation on Water Use, Reuse and Recharge.

Real Impacts for California

- 54 % increase in water use efficiency
  - Does not necessarily results in water savings
  - Return flows and percolation an issue
  - Changes in acreage significant
- Many years of irrigation efficiency research & outreach on: nut crops, tree fruits, citrus, strawberries and vegetable production
- **How is efficiency defined? Or measured?**

Adapted from Doug Parker's presentation on Water Use, Reuse and Recharge.

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Water Use Efficiency (WUE)

- Efficiency…"the ability to do something or produce something without wasting materials, time, or energy." (Merrian-Webster)
- Water use efficiency in agriculture is very complex and involves many different factors and disciplines
  - Plant physiology (transpiration efficiency)
  - Agronomy (irrigation efficiency)
  - Engineering (water application efficiency)

– (De Pascale, et.al. 2011)

Crop Water Use Efficiency (WUE)

- Defined as yield per unit of water used or the transformation efficiency of water into yield.

  WUE = Yield/Water

- Given the price of water in Southern California, perhaps we should define it in terms of the economic returns per unit of water used.

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Irrigation Water Management is Important!

- Farmers in the Southern California need to irrigate efficiently so that water use on farms does not become an issue.
- Competition for Water is high - Urban areas and other cities/states are requesting more water.
- Water cost is extremely high!

SOIL TYPE IS IMPORTANT - A soil pit is the best way to know what soil problems you may have!

CIMIS Station #78 at Cal Poly Pomona

Irrigation Systems Used in California

- Surface Irrigation
  1. Basin Irrigation
  2. Graded Border Irrigation
  3. Furrow irrigation
- Sprinkler Irrigation
  1. Solid Set Sprinklers
  2. Micro-Sprinklers
- Drip Irrigation
  1. Orchard Drip Irrigation
  2. Row Crop Drip Irrigation

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Surface Irrigation

Level Basin

Surface Irrigation Level Basin - Dates

Seven thousand acres of date palms are cultivated in the Coachella Valley. The climate is ideal for the production of fruit because of the "prolonged summer heat without rain or high humidity during the ripening period".

Surface Irrigation

Graded Border Irrigation

Surface Irrigation

Furrow Irrigation

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Sprinkler Irrigation for Salinity control

Sprinkler Irrigation

Solid Set - Carrots

Sprinkler Irrigation
Micro-Sprinklers Citrus

Drip Irrigation

Table Grapes

Drip Irrigation
bell pepper

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Drip Irrigation
Row Crops - corn

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How much water is needed

- Identify the water holding capacity of your soil and the root depth of your crop.
- Determine the daily water requirements of your plants with CIMIS evapotranspiration data.
- Determine if salinity control is necessary.
- Determine the water application rate of your irrigation system

Don't forget about salinity management

Water Meter Capacity

Meter size	Capacity in GPM (1)	Suggested acreage served (2)	Acres at 5.4 GPM/acre (3)	Acres at 8.4 GPM/ acre	Connection fees for FPUD and SCWA Combined (4)
¾ inch	16 - 24	0 - 1	3.7	2.4	$ 9,492
1 inch	40	1 - 3.5	7.4	4.8	$ 15,188
1 ½ inches	80	3.5 – 8	14.8	9.5	$ 28,476
2 inches	145	8 – 15	26.9	17.3	$ 49,358
3 inches	265	15 – 35	49.1	31.5	$ 91,124
4 inches	440	35 – 80	81.5	52.4	$ 155,168
6 inches	840	80 +	155.6	100.0	$284,760

Water Quality/Supply

- Avocado is the most sensitive tree crop to salts in water (of all the commercially grown varieties of fruits and nuts in California)
- What about the EC of water?
  - no loss in yield = EC 0.9
  - 10% loss in yield = EC 1.2
  - 25% loss in yield = EC 1.7
  - 50% loss in yield = EC 2.4
    - *From R. S. Ayers, Journal of Irrigation and Drainage, ASCE Vol. 103, June 1977*

IF WATER IS SO EXPENSIVE…WHY IRRIGATE?

WHAT IS MORE IMPORATANT… SOIL OR WATER?

Vegetables are 80 to 95% water

drip tape

- Most vegetables are shallow rooted
- For good yields and high quality, efficient irrigation is essential to the production of most vegetables

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Moisture Stress

- Fruit crops such as peppers and tomatoes can be injured by wide fluctuations in soil moisture
- Fruit may not expand to produce maximum growth size
- During fruit growth, cracking can occur

Moisture Stress Defects

Crop	Defect
Carrot	Growth cracks, misshapen roots
Sweet corn	Poor ear fill
Onion	Poor size
Lettuce	Tough small leaves

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Allowable % soil moisture loss

Field crop	% allowable depletion
Alfalfa	55
Barley	50-55
Sugarbeet	50-80 (last 8 weeks)
Cotton	50-65
Wheat	55
Corn (silage)	50-60

Allowable % soil moisture loss

Vegetable crop	% allowable depletion
Broccoli	50
Cauliflower	50
Carrot	35
Celery	20
Melon	35
Pepper	25

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What is drip irrigation?

- Low volume or trickle irrigation
- application of small amounts of water slowly and frequently
  - through emitters spaced along polyethylene tapes or tubing

Advantages of Drip 1

- Improved plant response because soil moisture is maintained at optimum level
- Increased irrigation efficiency by reducing evaporation from soil surface, reducing or eliminating runoff
- Improved chemical application, applied to the soil in areas where roots are actively growing

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Advantages of Drip 2

- Fertilizer delivery can be timed and matched to meet plant nutritional needs
- Deep percolation is lessened, chemicals are less likely to be moved past the root zone with the water
- Reduced weed growth since only a portion of the field is wetted, however weed problems continue in the wetted areas

Advantages of Drip 3

- Automation, the system can be operated any time of day or night and for any desired length of time
- Salinity is reduced in the vicinity of the emitter, salts are moved to the edges of wetted areas
- Adaptable to non level fields, on soils with low water infiltration and low water-holding capacities

Disadvantages of Drip 1

- Maintenance required, emitters can clog due to sand, organic matter, roots and chemical precipitates
- Cost: underground PVC pipe, polyethylene tubing, filters and other hardware required make drip systems among the most expensive of the irrigation systems
- Restricted root zone- water stress damage can occur if there are leaks or problems

Disadvantages of Drip 2

- Salt accumulate near the root zone and can migrate back to the root zone
- Seed germination: drip is not necessarily the best method for germinating seeds
- Drip tape disposal, after it is removed from field it must go to landfills. Recycling of drip tape is not option at this time.

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Irrigation System Planning & Design

- Each farm will have a different set of requirement because of the crop, soil type, and topography.
- Efficient irrigation systems can be developed in the planning and design stage;
- Do your homework & invest wisely, orrecting poorly designed irrigation systems is difficult.
- Inefficient irrigation systems cause drainage difficulties, salinity problems and loss of fertilizer

Key Design Decisions 1

- What field flowrate and tape discharge rates are needed
- What kind of drip tape to use
- How long to make the lateral lengths
- What kind of pump to use
- Should the tape be laid on the surface or buried
- How far apart are the emitters spaced

Key Design Decisions

2

- Will the system be used to germinate seeds or will a backup system used for that purpose
- What kind of filter system is needed
- Will fertilizer and other chemicals be injected through the system
- Get an expert to design the system

Parts of an Irrigation System

1. Pump and motor (if you have a well)
2. Water meter (if you are on district water) See Table 7 for water meter capacity
3. Reduced pressure (RP) backflow device
4. Main valve
5. Bermad valve or electrically operated valve
6. Flowmeter and pressure gauges
7. Air-vacuum relief valves
8. Injection equipment
9. Filter
10. Sub-main valves to various parts of the grove
11. Pressure regulators (usually pre-set)
12. Emitters
13. Your feet in the grove to “walk the lines”

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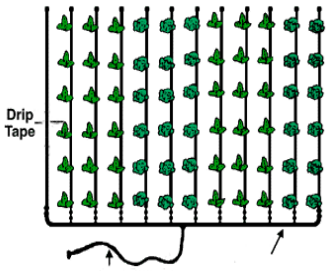
Generally a system includes:



Typical design (layout) of a drip system

- a pump
- a flowmeter
- mainlines, submains and manifolds
- drip tape lateral lines
- valves
- A filter
- injection equipment

System Components 1

- **Pumps:** the pump and motor chosen should be one that delivers the right pressure and flowrate as efficiently as possible
- **Flowmeters:** measure the volume of water moving through the system making it possible to calculate how much water is applied and how often and how long the system needs to be operated

System Components

2

- **Mainlines and submains:** A qualified drip irrigation designer will recommend the proper pipe size
- **Drip tape:** the discharge rates of the emitters of high quality tape are more uniform than the discharge rates of the emitters of lower quality tape, factors such as tape diameter, length of lateral lines are considered when the system is designed

System Components

3

- **Valves and regulators:** are used to control water flow and pressure in the drip system, want to prevent water from flowing back in to the well, maintain a constant pressure downstream and prevent soil from being pulled into the emitters
- **Emitters** may be spaced from a few inches to more than three feet apart though the usual spacing is between 12 and 18”

System Components

4

- **Filters:** the water may carry sand, suspended matter, algae and will need to be removed
- **Chemical treatment** can remove algae, fungi and bacteria and remove chemical precipitates
.
- **Flushing:** even though filters remove large sand and other particles, silt and clay will still move through and need to be flushed

System components

5

- **Injection equipment:** various types of equipment can be used to inject chemicals such as chlorine and fertilizer
- **Cost:** The initial cost of a drip irrigation system is $1000 to $1300 an acre

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Irrigation System Maintenance

- Check poly hose systems
- Flush lateral lines
- Clean filters
- Repair sprinklers/lines

Irrigation and Water Use Efficiency

AVOCADOSOURCE.COM Search Tools Site Index: <SELECT PAGE> Avocado Data

Instructions for the Irrigation Scheduling Calculator

English Español

Principles of Irrigation Select a Crop: Avocado

Kc Source: California (New Values) English Units Metric Units

Reference Evapotranspiration (ETo): in./day or period Data Source: <SELECT SOURCE>

Crop Coefficient (Kc): Get Kc for a month <SELECT>

Distribution Uniformity (DU): %

Leaching Requirement (LR): %

Method: Trees per Acre: Tree Spacing by ft.

Number of Emitters per Tree: 1

Surface area under tree canopy (ft²): (enter only when surface area covered by canopy is less than 65%)

Emitter Output (Gal/Hour):

Grove Size (acres): 1

All fields with yellow boxes must be filled out, white fields are optional.

Calculate Click on 'Calculate' after any changes are made to recompute totals.

Water per tree per day or period: gallons

Watering time per tree per day or period: hours, minutes

Total Water Requirements for Grove: gallons

Allocated Water for Grove: gallons

Shortfall: gallons

Water Efficiency Research

- California Berry Crops: Improving Water-Use Efficiency While Maintaining Crop Quality
  - 2011 to 2015
  - Blackberry, blueberry and strawberry
- Assessing the Performance, Water Efficiency and Economic Viability of Pitahaya or Dragon Fruit (Hylocereus spp.) for Commercial Production in California
  - 2012 to 2017
  - Multiple trials included in project

Pitahaya Research

- **Funded by the Thelma Hansen Trust and the UC Hansen Agricultural Research and Extension Center (2012 – 2017)**
- **Research sites in Fillmore, Irvine and Coachella**
- **Colloaborators:**
  - Jose Fernandez de Soto, UC Hansen REC
  - Cheryl Wilen, UCCE San Diego
  - Ole Becke, UC Riverside
  - Jose Aguiar, UCCE Riverside County
  - Gary Tanizaki, UCCE San Diego
  - Mary Lu Arpaia, UC Riverside

Pitahaya Festival and Research Field Day
Variety Evaluation Chart

Variety/Origin	Color Skin/Flesh	Cold Hardiness	Heat Tolerance	Avg. Wt. (grams)	Brix Score	Mkt Wt/Plant (grams)	Days to Harvest
1. Cebra (Nic.)	R/R	3.5	3.5	468	15.75	8746	46
2. Rosa (Nic.)	R/R	3.5	3.5	384	16.05	7217	45
3. Orejona (Nic.)	R/R	3.25	3.75	438	15.78	4598	45
4. Lisa (Nic.)	R/R	3.75	4	465	17.02	13319	44
5. Sin Espinas (Nic.)	P/R	2.25	2.75	393	16.5	3527	43
6. San Ignacio (Nic.)	R/R	3.75	4	552	15.6	12712	48
7. Mexicana (Mex.)	P/W	3.25	3	495	14.04	9165	40
8. Colombiana (SD-Col.)	Y/W	1	1	< 200	20.90	0	150-180
9. Valdivia Roja (Mex.)	R/R	5	4.5	250	17.9	8588	40
10. Bien Hoa Red (SD)	GR/F	1.75	1.75	360	18.9	1477	41
11. Bien Hoa White (SD)	P/W	2.5	2.5	388	11.85	7394	37
12. Delight (SD)	R/PW	3	3.5	371	18.08	14931	41
13. American Beauty (FL)	GR/F	2.75	2.5	380	18.51	5566	43
14. Haley's Comet (FL)	R/F	4.5	4.25	482	16.7	5979	38
15. Physical Graffiti (FL)	R/P	4.5	4.5	374	17.93	23429	40
16. Vietnamese Giant (FL)	PR/W	3.25	3.25	338	15.6	6511	41
17. Yellow Dragon (FL-Col.)	Y/W	1	1	< 200	21.15	0	150-180
18. Seoul Kitchen (FL)	PR/W	4	4	518	12.18	15379	41
19. Armando (Nic.)	R/R	4	4	390.5	16.11	4881	41

Why Berries and Pitahayas?

- Somewhat difficult to get into, high initial capital investment required ($10-20 K/acre)
- High profit potential, prices remain reasonably high despite increases in production
- Health trends keeps driving demand – high antioxidant activities
- High WUE despite high water use on blueberries, and unknown requirements on pitahaya, the return per unit of water very high

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Drought Management Resources

http://ciwr.ucanr.edu

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Questions??

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