Drip/Micro Irrigation: An Overview

Drip and Micro Sprinkler Irrigation Meeting

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Center for Irrigation Technology...

- Irrigation Equipment Laboratory Testing
- Applied Research
- Analytical Studies and Special Projects
- Education

A part of:

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- 100+ seminars across state
- 16,000+ pump efficiency tests
- 834 installed pump retrofit projects
- $2,611,000 in incentives paid
- 43,592,000 kWh saved in 1st year after retrofit

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Today’s discussion...

Drip/Micro Irrigation Systems

- Physical Characteristics
- Operating Characteristics
- Advantages
- Disadvantages
- Scheduling Irrigations
This is Micro-Spray Irrigation...
Physical Characteristics...

Water is delivered:
- Through an extensive system of above and below ground pipe
- To a specific point or area of the field
- For emission through specialized devices
- Pressure varies depending on terrain but emission devices operate 10-20 psi
- Requires some type of filtration
Emission Devices...

- **Point Source - standard emitters**
  - .5 - 2 gph per outlet
  - Can be integrated into the tubing during manufacturing process (inline) or installed in the field (online)
  - One or more emitters per plant
    - Spaced along drip hose at repeating spacing
  - Water spreads from a central point at the surface resulting in “onion” of wetted root zone
  - Double line drip is common in areas with sustained winds, instead of sprays (no wind drift and spray loss)
Point Source Emitters...
**Emission Devices...**

- **Line Source – drip tape/row crop drip**
  - Closely spaced emitters
  - Integrated within piping material during manufacturing
    - Flat tape
    - Round heavy wall tubing
  - Intended to produce a wetted strip of soil down the row
    - Process tomatoes, other vegetables
    - Cotton
Row Crop Drip...
**Emission Devices...**

**Jets/ Foggers/ Micro-Sprinklers**
- Water sprayed over larger surface area but generally not intended to overlap patterns
- Flow rates from 2-15 gph
- Used:
  - where more wetted root zone is desired
  - with a light soil that will not spread water (possibly economic tradeoff between multiple point sources or single sprayer)
  - Generally easier to check for correct operation than drip
  - Can provide limited frost protection
Spray Devices...

Jets

Micro Sprinklers

Foggers

Center for Irrigation Technology
Operating Characteristics...

- Evaporation losses generally low but can be quite high with jets due to combination of high frequency irrigation and substantial wetted surface area vs drip.

- Infiltration during an irrigation is due to application rate and set time assuming that the application rate is less than the soil’s infiltration rate at all times during the irrigation (infiltration decreases over time).

- Usually maintain low soil moisture depletions. High soil moisture levels lead to optimum growing environment and high yields for crops (e.g., daily irrigation events during peak ET).
Operating Characteristics…

- Requires extensive filtration and usually chemical additives to keep system clean (continual or periodic)

- Requires a stable (flow rate) and flexible (timing) water supply
  - Engineered system for specific flow rate
  - Usually irrigating frequently - thus, need a flexible water supply
  - Set times can vary throughout the season - thus, need a flexible water supply
Advantages...

- Very good for fertigation as precise control of application and placement is characteristic of system
- Doesn't wet the crop - less disease problems
- Good on streaked or variable soils (as long as Application Rate < Infiltration Rate)
Advantages...

- May be necessary in rolling terrain

- Consistently high soil moisture is good for use with salty water although micro irrigation does not get you out of the salt problem (salts still need to be managed in soil profile)

- Typically no or limited wind problems (even with jets and mini-sprinklers, since there is no overlap to worry about - watch evaporation and extreme and constant winds)
Advantages...

- Good control of total application (turn pump on, turn it off, known Application Rate)
- Total labor costs can be higher or lower depending on maintenance but usually lower
- Given good design and maintenance, fairly easy to get good DU / IE (Common solution to limited water supply and/or flow rate situations if the crop value will support the cost of the system)
Advantages...

- Relatively easy to measure DU
- DU = device uniformity x field pressure uniformity (Pressure compensating devices can overcome changes in PSI)
- Device
  - Do not mix and match emission devices (flow rate)
  - No partial or completed plugged emitters!
- Pressure - It is critical to maintain design pressure and flow conditions in the field (check pump performance and filters)
Disadvantages...

- Usually most expensive system option
- Maintenance (failure to maintain usually means system failure)
- Restricted root zone (not all soil volume wetted) - can put crop at risk quickly if there is a system failure or break in water supply
- Irrigation management is critical
Disadvantages...

- Rodent/insect damage can be a problem
- Requires informed (proactive) management for maintenance and irrigation scheduling
- Frequent field checking and pressure/flow measurement is recommended
Economics of Design/Operation...

- **Capital Costs vs. Operating Costs** - know the total lifetime costs of ownership.

- **Reduced capital cost may result in higher operating costs** (selecting first cost option or low bidder):
  - Lower distribution uniformity - more water to buy and apply
  - Higher energy costs
Economics of Design / Operation...

- Vineyard with 2 inch net water requirements
- 3% evaporation losses
- Water at $75/AF at pump
- Electricity at $.12/kWh (melled energy and demand costs)
- Low cost system with 83% DU and 194 kWh/AF (45 psi @ 55% pumping efficiency)
- Higher cost system with 90% DU and 163 kWh/AF (38 psi @ 55% pumping efficiency)
Economics of Design / Operation...

- **Lower capital cost system**
  - 22 inches / .83 = 26.5 gross applied
  - 26.5 / .97 = 27.3 gross with evap losses
  - Cost per acre-foot = $75 + .12 \times 194 = $98.28/AF
  - COST PER ACRE/YR = $223.59

- **Higher capital cost system**
  - 22 inches / .90 = 24.4 gross applied
  - 25.3 / .97 = 25.2 gross with evaporation losses
  - Cost per acre-foot = $75 + .12 \times 163 = $94.56/AF
  - COST PER ACRE/YR = $198.58
Scheduling Irrigations...

- Expensive system is intended to save water, fertilizer, labor, and/or increase yield/quality

- Important to take full advantage of the system capabilities for crop production

- Drip/Micro is inherently uniform (assuming good design/maintenance) - NOT necessarily efficient
Management Strategy...

- Decide WHEN to irrigate - but drip/micro is generally a high frequency system since intent is to maintain optimum soil moisture

- Determine **HOW MUCH** and **WHEN** to apply

- React to soil/plant moisture measurements
Soil moisture devices...
HOW MUCH to apply (length of set)...

- Know the application rate per plant in GPH
- Know the area per plant in Square Feet
- Know crop water use (ETc) since last irrigation
- Have an estimate of overall Irrigation Efficiency - DU, adjust for leaks, scheduling errors (check periodically to verify)
Calculating The Gross Depth of Water to Apply

- Gross = NET / IRR-EFF

Where:
  - Gross = gross water application required
  - Net = water required by the crop
  - IRR-EFF = irrigation efficiency as a decimal (0-1.0)

Note: This is based on individual field irrigation efficiency
Calculating The Gross Depth of Water to Apply

- Set the **NET DEPTH OF WATER REQUIRED** = 2.1 in

IRRIGATION EFFICIENCY = 70%
Calculating The Gross Depth of Water to Apply

- Set the NET DEPTH OF WATER REQUIRED = 2.1 in
  IRRIGATION EFFICIENCY = 70%

- Read GROSS DEPTH OF WATER TO APPLY at the arrow (3 inches).
Set the **GROSS DEPTH OF WATER TO APPLY** = .5 in

**GALLONS PER HOUR PER TREE/VINE** = 8 gph
Set the GROSS DEPTH OF WATER TO APPLY = .5 in
GALLONS PER HOUR PER TREE/VINE = 8 gph

Read the REQUIRED HOURS OF PUMP OPERATION
PER SET (14 hours) above the AREA PER TREE/VINE =
360 sq ft per tree/vine
Set the GROSS DEPTH OF WATER TO APPLY = .5 in GALLONS PER MINUTE PER 100’ of TAPE = .33 gpm/100’
Set the GROSS DEPTH OF WATER TO APPLY = .5 in
GALLONS PER MINUTE PER 100’ of TAPE = .33 gpm/ 100’

Read the REQUIRED HOURS OF PUMP OPERATION PER SET (5.25 hours/set) above the DRIP TAPE SPACING = 40 inches
Purchasing a Drip/Micro Irrigation System
A. System design philosophy

a) Common local practices
b) Economic limitations
c) Land and water limiting
d) Land tenure (lease/rent/own)
e) Service requirements (parts/warranty)
f) Tax implications
B. System design options

a) Direct copy of neighbors
   ✓ Good with the bad

b) Grower design
   ✓ May lack full appreciation of economics

c) Dealer design
   ✓ Practical design

d) Consultant design
   ✓ Permits competitive bidding
C. Background information

- Crops - present and future
- Water supply - quantity/quality
- Soils - texture/structure
- Terrain - slope
- Climate - ETo, wind, temperature
- Hydrogeology - water table, drainage
- Fertilization practices - injection, backflow
- Cultural practices
- Pest problems
- Theft and vandalism
D. System Installation

- Grower
  - a) Broad technical capabilities required
  - b) May use available farm labor
  - c) Lower efficiency

- Dealer
  - a) Single responsible party
  - b) Crews (subs) experienced in working together
  - c) Dealer reputation is important
H. Comparing bids

➢ Key items of comparison

Design tolerance. What is the uniformity of water delivered in the field.

✓ Typically all these being even, higher efficiency will cost more than low efficiency. You may end up paying less for a non-uniform system. Many times the life cycle cost of a system is higher.

Total Dynamic Head (TDH). What is the horsepower required to operated the system.

✓ This relates to the size of motor or engine required to satisfy the system hydraulics. Usually, a system with a higher TDH requirement will be the system most costly to operate.
H. Comparing bids

- **Key items of comparison (con’t)**

  Are the application rates and duration of irrigation times similar?

  ✓ Are the application rates less or equal to the infiltration rate of the soil. If not, run-off will occur. Does the irrigation duration during peak ETo allow for catch-up and down time? If not, you run the risk of water deficit.
I. Verifying Performance

➢ Does the system perform as stated?

Hopefully your contract identified an “Emission Uniformity” to be verified in by a field audit at system start-up

✔ Emission Uniformity calculation can be applied to an entire drip system, a system sub-unit, or an individual lateral. When data is collected in a newly installed system, it represents the effects of both the manufacturing variability and pressure differences (elevation changes and/or piping losses) within the drip system. In older systems, flow rates can also be affected by emitter clogging.
I. Verifying Performance

- **Emission Uniformity (EU)**
  
  EU measures the uniformity of flow rates from emitters.

  EU is calculated according to the formula:

  \[ EU = 100 \left( \frac{L}{Q_{ave}} \right) \]

  where

  - **EU** is Emission Uniformity (%)
  - **L** is the average flow rate in the Low Quarter
  - **Q_{ave}** is the average flow rate for the sample
I. Verifying Performance

- EU rating per ASAE EP458 Dec 93 (withdrawn)

Field evaluation of Micro-irrigation systems

<table>
<thead>
<tr>
<th>Acceptability</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>100-94</td>
</tr>
<tr>
<td>Good</td>
<td>87-81</td>
</tr>
<tr>
<td>Fair</td>
<td>75-68</td>
</tr>
<tr>
<td>Poor</td>
<td>62-56</td>
</tr>
<tr>
<td>Unacceptable</td>
<td>&lt; 50</td>
</tr>
</tbody>
</table>
J. Conclusions

- Setting the conditions of your irrigation system
  a) Decide how you want to purchase your irrigation system
  b) Be sure competing bids meet the needs of crop/practices
  c) Be sure you are comparing “apples to apples”
  d) Specify system performance in the contract and verify with field measurements at system “start-up”
Questions???

Thank You !