Drip Irrigation for Small Plots

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Dan Smeal
New Mexico State University
Agricultural Science Center at Farmington
What is Drip Irrigation?

• The slow, frequent application of small volumes of irrigation water to the base or root zone of plants.

• Also referred to as trickle or microirrigation.

• Not new: Modern use began in the late 1960’s to early 1970’s after the introduction of plastic pipe.
Characteristics of Drip
Low Volume & Low Pressure

- Drip flow rates generally range from **0.5 to 2.0 gallons per hour (gph)** per outlet (can exceed 20 gph).
- Operating pressures range from **2 to 6 pounds** per square inch (psi) in gravity systems up to 15 to 30 psi (high pressure systems).

- Sprinkler systems, in contrast:
  - Flow rates range from 2 to **20 gallons per minute (gpm)** per sprinkler.
  - At pressures ranging from 25 – 100 psi.
  - Large guns can have flow rates approaching 100 gpm.
Characteristics of Drip
Localized Application of Water

- Soil Wetted Area (diameter)
  - Coarse Sand: 0.5 to 1.5 feet
  - Fine Sand: 1.0 – 3.0 feet
  - Loam: 3.0 to 4.5 feet
  - Heavy Clay: 4.0 – 6.0 feet

- As opposed to sprinkler or flood where the entire soil surface is wetted.
Drip Irrigation on a Sandy Loam Soil
Characteristics of Drip
Frequent Applications Required

• Drip: Every day to every-other day in summer.
• In contrast to…
  – Sprinklers (1-3 times per week)
  – Or flood (once per week or less)
Characteristics

- Drip lines can be above ground or buried (subsurface drip or SDI).

Note: Gophers can reek havoc!
Typical Drip System Components

- **Pressure source** (gravity or pump)
- **Control valve** (to turn system on and off)
- **Check valve** (to prevent backflow into water source)
- **Fertilizer injector** (option to apply fertilizer directly into irrigation water)
- **Filter**
- **Pressure regulator** (to reduce pressure down to 30 psi or less)
- **Main line and sub-main lines/header** (to carry water to drip lines)
- **Laterals or drip lines** (distributes water to the outlets at base of plants)
- **Emitters** (outlets to plants)
- **Other:** Air vents, meters, timers, controllers, drains
Components

Valve
Backflow Preventer
Pressure Regulator
Filter
Tubing Adapter

Fertilizer Injector: downstream of the backflow but upstream of the filter

18" Minimum Between Emitters

Control Valves

MANUAL

ELECTRIC

Electric valves can be controlled by a timer or switch.

Less than $5

Up to > $100
Backflow preventers (check valves) (allows flow in only one direction)

A requirement when using domestic water!

$3.00 to $6.00
Pressure Regulators (10 – 30 psi)

Optimum operating pressure for microirrigation systems range from 10 psi for drip tape to 30 psi for microsprinklers.

- Adjustable
  - $15 to $45

- $5 to $7
Filters (Screen)

40 mesh to 200 mesh:
140-160 recommended for drip emitters, tape, etc.

$10 to $12 for ¾ and 1-inch up to nearly $80 for 2-inch
Filters (Disc)

Disc filters are better than screen filters at removing organic matter (such as algae, etc.)

$16 to over $200 depending on size
Heavy Duty, 3-inch Disk Filter

$380.00
Poly pipe for water distribution (mainlines, headers, drip laterals)

½-inch is usually sufficient for small plots (rows < 200 ft.)
Emitters

- **Button Style (1/2 – 2 gph models)** about 20 cents each
- **Flag (can be opened and cleaned) (1 - 4 gph models)** about 15 cents each
- **Adjustable (0-10 gph)** about 35 cents each

Usually inserted into ½-inch poly pipe laterals
Pressure Regulating or Compensating (PC) Emitters

These are color-coded indicating flow rate:
Red = 2 gph, Blue = 0.5 gph, Black = 1.0 gph
More PC Type Emitters

Pressure Compensating, Self Cleaning Emitter (0.5 or 1.0 gph), 31 cents to 37 cents

Pressure Compensating Emitter (1.0 to 4.0 gph), 20 cents to 25 cents
Still More PC Type Emitters

Self Cleaning; 0.5 to 2.0 gph models

About 25 cents each

0.5 to 3.3 gph models
Hole punchers and insertion tools

Less than $2

More than $25
Drip Tape (built in emitters)

Cheaper than poly with independent emitters

Fixed emitter spacing: (from 4-inch to 24-inch)
Drip Tape
(Examples of what’s available)

The greater the thickness (mil) the greater the cost but the longer it will last!

<table>
<thead>
<tr>
<th>Diameter</th>
<th>T-Tape 500</th>
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<tbody>
<tr>
<td>500 Model</td>
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<table>
<thead>
<tr>
<th>Wall Thickness</th>
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<tbody>
<tr>
<td>504</td>
<td>4 MIL</td>
<td>0.100 mm</td>
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<tr>
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<td>5 MIL</td>
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<tr>
<td>506</td>
<td>6 MIL</td>
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<td>508</td>
<td>8 MIL</td>
<td>0.200 mm</td>
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<tr>
<td>510</td>
<td>10 MIL</td>
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<tr>
<td>512</td>
<td>12 MIL</td>
<td>0.300 mm</td>
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<tr>
<td>515</td>
<td>15 MIL</td>
<td>0.375 mm</td>
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Feet per roll

<table>
<thead>
<tr>
<th>Quantity Per Reel</th>
<th>Feet</th>
<th>Meters</th>
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<tr>
<td>504</td>
<td>15,000</td>
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<td>505</td>
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<td>3,048</td>
</tr>
<tr>
<td>508</td>
<td>7,500</td>
<td>2,300</td>
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<tr>
<td>510</td>
<td>6,000</td>
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<tr>
<td>512</td>
<td>5,085</td>
<td>1,550</td>
</tr>
<tr>
<td>515</td>
<td>4,100</td>
<td>1,250</td>
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</table>

Cost of 6000 feet of 510 (12 inch spacing) about $250
About $0.04 per emitter at 12-inch spacing
## Operating Pressure

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Operating Pressure</th>
<th>Operating Pressure</th>
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<tbody>
<tr>
<td>504</td>
<td>4 to 10 psi</td>
<td>0.30 to 0.67 bar</td>
</tr>
<tr>
<td>505</td>
<td>4 to 10 psi</td>
<td>0.30 to 0.67 bar</td>
</tr>
<tr>
<td>506</td>
<td>4 to 10 psi</td>
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</tr>
<tr>
<td>508</td>
<td>4 to 10 psi</td>
<td>0.30 to 0.67 bar</td>
</tr>
<tr>
<td>510</td>
<td>4 to 15 psi</td>
<td>0.30 to 1.05 bar</td>
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<tr>
<td>512</td>
<td>4 to 15 psi</td>
<td>0.30 to 1.05 bar</td>
</tr>
<tr>
<td>515</td>
<td>4 to 15 psi</td>
<td>0.30 to 1.05 bar</td>
</tr>
</tbody>
</table>

Output of 510 (12 inch spacing): 13 gph per 100 feet @ 8 psi

= 0.13 gph per emitter
Notes on Drip Lateral Selection

- The longer the rows and the greater the flow rate (i.e. number and size of emitters), the greater should be the diameter of the drip hose:
  - For short rows (i.e. 150 feet) or low flow rates, 3/8” drip tubing should be sufficient.
  - Standard diameter for most small farm situations = ½” or 5/8 inch (rows up to 500 feet)
  - For very long rows (i.e. ¼ mile), and high flow rates, 7/8 inch tape should be used.
  - Check with manufacturer or supplier for recommendations.
Other Associated Fittings and Options
Barbed Fittings
Compression Fittings

Advantage: less friction loss
Spaghetti Tubing (Carries water from drip lateral to emitter or from emitter in lateral to base of plant)

Good for watering 2 rows with 1 lateral
Other Accessories

Holding stakes for drip lines

Fig. 8 hose end

Goof plugs
Fertilizer Injectors

Photos Courtesy of Joran Viers
NMSU CES
Bernalillo County
Flow Meters and Timers
Typical Advantages of Drip Irrigation

- **Potential** water savings over other irrigation methods.
  - Small wetted area (less evaporation)
  - No runoff (reduced soil erosion)
  - Limited deep water drainage (**with proper irrigation scheduling**)
  - Good water distribution uniformity (esp. w/ pressure compensating emitters)
  - Unaffected by wind, etc.

- Adaptable to any shape, size and slope of field.
Typical Advantages of Drip Irrigation

• Weed growth is reduced!
• High fertilizer efficiency.
  – Injected fertilizer (fertigation) is applied directly to root area and can be applied at any time and any dosage without wetting plant foliage.
  – Improved uptake of phosphorus and ammonium N from frequently wetted upper soil layer.
• Yields are typically increased.
  – Soil moisture and fertility in root zone can be maintained at optimum levels
Typical Disadvantages of Drip

• Filtration is critical
  – Emitter clogging can disrupt distribution uniformity
  – Algae growth and scale build-up (usually CaCO₃) must be controlled
• Drip tape and other components can be easily damaged by vandals, rodents, etc.
• Increased management skills required
Typical Disadvantages of Drip

- High initial costs (compared to flood).
- Water must be available on a regular basis.
  - Storage
- Potential salt build-up in arid region soils.
  - May require periodic leaching with sprinkler system
Low Pressure Gravity Drip Systems

• Some advantages over typical (higher pressure) drip systems.
The elevated water tank (reservoir) serves as a pressure regulator and fertilizer injection point. A high pressure pump is not required. Low operating costs.
Backflow prevention is usually not required.

Low-cost materials; Easy to understand, operate, and maintain.
Generally Safe; High pressure clamps, fittings, etc. not required; blow-outs usually not an issue.
Converting Head (water height above water discharge point) to Pressure

- Water height in feet (head) $\times 0.433 =$ pounds per square inch (psi)

- Inversely:
  - Water pressure (psi) $\times 2.31 =$ feet of head

- Example:
  - Water level in tank is 6 feet above drip emitter outlet (i.e. 6 foot of head).
  - Pressure = 6 $\times 0.433 = 2.6$ psi
Plastic T’s and Sleeves (Clamps)
Elevated Reservoir

Simple, Low-Cost Stand (fence posts and baling wire)
Cheap wire loops (i.e. from coat hangers) can be used to hold drip line in place when empty. WIND and EXPANSION-CONTRACTION.
Plugs at end of lateral not required: End of lateral can be folded over and held down with wire loop.

Or… the lateral can be folded at the end and a small (1”) cut piece of lateral slipped over the fold.
Some Disadvantages to the Low-Pressure (< 5 psi) Drip System

- Work is still required to lift water into elevated water tank.
Reservoir can be filled by hand, with hose, etc.
Alternate Pressure Sources

Solar or Wind-Powered Pumps
Disadvantages (continued)

• Low pressure drip tape (Netafim or T-Tape) will probably be required as plug-in emitters may not work properly at the low pressures.  
  – More research needed
• May only work above-ground (not with buried systems).
• Length of laterals may need to be shortened compared to higher pressure systems.
System Design
Design Considerations

• Area to be irrigated:
  – Number of rows
  – Row spacing and row length

• Crops:
  – Species or type
  – Number of each
Water Availability

- Potential daily volume
- Maximum flow rate
- Storage capabilities
- Pressure
Determining Flow Rate

- Water (or flow) meter.
- If the water is not metered you can determine the flow rate by timing how long it takes to fill a 5-gallon bucket.
- The rate of water flow will be important in determining how many plants you can safely irrigate during periods of peak water-use.
Irrigation Scheduling

• To effectively schedule irrigations you must know:
  – The flow rate of each emitter.
  – The crop (or plant) canopy area.
  – An estimate of the plant’s daily water-use (evapotranspiration or ET)
Determining the Crop’s Irrigation Requirement

- The equation used to estimate the irrigation requirement (IR) per plant is:
  \[ IR = \left( 0.623 \times CA \times \text{Plant Factor} \times ETr \right) \div IE \]

Where:
- \( IR \) = the irrigation requirement in gallons
- 0.623 = gallons of water required to fill 1 sq. foot 1 inch deep
- \( CA \) = plant canopy area in square feet (diameter \([D]\) squared \( \times \) 0.785)
  
  Example: if \( D = 2 \) feet, \( CA = (2 \times 2 \times 0.785) = 3.1 \) sq. ft.
- \( \text{Plant Factor} = 0.85 \) for tomatoes, chile and sweet corn (may be higher for melons, squash, cucumbers, etc.)
- \( ETr \) = reference ET (refer to chart next page or see [http://weather.nmsu.edu](http://weather.nmsu.edu) for your specific location)
- \( IE \) = irrigation efficiency (assume 90% or 0.90 for low-tech drip system)
# Average Daily ETr (inch/day) Estimates for Different NM Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>May 1-15</th>
<th>May 16-31</th>
<th>June 1-30</th>
<th>July 1-31</th>
<th>Aug 1-31</th>
<th>Sept 1-15</th>
<th>Sept 16-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmington</td>
<td>0.35</td>
<td>0.40</td>
<td>0.42</td>
<td>0.38</td>
<td>0.28</td>
<td>0.25</td>
<td>0.22</td>
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<tr>
<td>Albuquerque</td>
<td>0.37</td>
<td>0.41</td>
<td>0.44</td>
<td>0.40</td>
<td>0.29</td>
<td>0.26</td>
<td>0.23</td>
</tr>
<tr>
<td>Las Cruces</td>
<td>0.39</td>
<td>0.42</td>
<td>0.46</td>
<td>0.43</td>
<td>0.31</td>
<td>0.28</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Example

- **Formula:** $IR = \frac{(0.623 \times CA \times \text{Plant Factor} \times ETr)}{IE}$

  - **Scenario:**
    - Location – Albuquerque
    - Date: May 25 ($ETr = 0.41$ inch)
    - Chile plant (plant factor = 0.85)
    - Measured (circular) plant diameter = 1 foot
    - Estimated irrigation efficiency (IE) = 90% or 0.9

  - **Calculations:**
    - $CA = 1 \times 1 \times 0.785 = 0.785$
    - $IR = \frac{(0.623 \times 0.785 \times 0.85 \times 0.41)}{0.90} = 0.170 \div 0.90 = 0.19$ gallons (24 fluid ounces) per plant per day
Calculating Peak Daily Water Requirements for Planning & Design

- IR = \((0.623 \times CA \times \text{Plant Factor} \times ETr) \div IE\)

- Scenario:
  - Location – Albuquerque
  - Peak daily ETr = 0.44 in mid-June
  - CA = full (assuming chile is planted on 30-inch rows and plant spacing is 1 foot, full canopy = \(2.5 \times 1 = 2.5\) sq. feet.
  - Plant factor (chile) = 0.85
  - IE = 0.90

- Calculation:
  - \(IR = (0.623 \times 2.5 \times 0.85 \times 0.44) \div 0.90 = 0.65\) gallons (83 fluid ounces) per plant per day
• In this example, we find that 0.65 gallons of water per plant per day were required for maximum production of chile in the Albuquerque area.

• To determine the maximum number of chile plants that should be grown, divide your total daily water availability by 0.65 gallons.
Example

• Assume a flow rate of 10 gpm for 12 hours
  = 600 gph = 7,200 gpd
• During the peak water-use period (0.65
gal/plant/day) you could theoretically irrigate
  about 11,077 chile plants (7200/0.65).
• If storage tank is not available, choose emitters
  so the sum output from all does not exceed the
  flow rate of the available water (in this case
  600 gph).
Theoretically (at 100% IE)

- With 1 gph emitters, and an available flow rate of 600 gph, you could irrigate 600 plants at a time (600 gph/1 gph)
- Irrigation duration, to satisfy plant ET, would be 39 minutes:
  \[
  \frac{0.65 \text{ gal required for ET}}{1 \text{ gph emitter flow rate}} \times 60 = 60 \text{ minutes}
  \]
- And, you could provide 18.5 irrigation cycles during the 12 hour period (12 hours \( \times 60 \div 39 \)).
- Since you would not practically be able to apply a 0.5 irrigation cycle, the actual number of cycles would be 18.
- So maximum number of irrigable plants per day would be 10,800 (600 \( \times 18 \)) during peak ET.
Problem

• What if emitter output was 0.5 gph?
  – You could provide enough water (at 600 gph available flow rate) to irrigate 1200 plants.
  – However, the irrigation duration would have to be increased to 1 hour plus 18 minutes (0.65 ET ÷ 0.50 gph = 1.3 hours) and the irrigation cycles decreased to 9 (12 hours ÷ 1.3 hours).
  – You could still irrigate 10,800 plants (1200 x 9).
Other Design Considerations
Distribution can be easily zoned using ball valves.
• Drip laterals should be laid out down-slope (on gentle slopes) to equalize friction loss with increased head (pressure).
• On steep slopes, it's better to lay out laterals across slope.
• Prepare field to be as even as possible (i.e. try to eliminate high and low spots).
Remember

• There is an interrelationship between total flow rate (flow rate per emitter x number of emitters), maximum length of drip lateral, pressure at the head, and changes in elevation along the lateral.

• Consult the drip tape manufacturer or supplier for their recommendations.
More Irrigation Tips

• There is no need to water the same plants every day (we watered every-other day).
• You could split your garden into two sections – watering one-half at a time, for example.
• Keep in mind however, that to satisfy crop ET, you’ll need to apply 2x the water per application than you’d apply if irrigating every day.
Other Management Considerations
Fertilization

- We used dry powder, soluble Miracle Grow type products (15-30-15 or 20-20-20) and applied between 1 and 1.5 lbs. per tank about every 10 days between June 1 and mid-August.
- In addition, we applied about 1 pint of liquid N (32-0-0) per tank every-other week.
- Each tank irrigated about 460 plants.
Common Problems and Remedies

– Emitter plugging
  • Some emitters can be cleaned or replaced.
  • Add bleach periodically to control microorganism (i.e. algae) growth.
  • Add vinegar or weak acid to control calcium carbonate build-up.

– Expansion/Contraction of drip tape with temperature changes
  • Pull tape taught at end before irrigation to remove kinks.
  • Irrigate in early morning when drip line is contracted.
Gopher Damage
It’s a good idea to flush out each lateral periodically.
Other Tips

• Irrigate early in morning:
  – Drip tape will be contracted.
  – Avoid irrigating with hot water.
• Check filter and wash screen often.
• If water is dirty, pre-filter or settle out before adding to reservoir.
• Avoid using transparent or translucent drums to prevent algae growth.
Success at the Farmington Agricultural Science Center using 55 gallon plastic barrels and a low-cost system from India.
Filled with a pressurized line

Sight Gauge

Fill Line

Out to Drip System
Water level in reservoir can be maintained using a float valve.
Mains, Sub Mains, Headers

Main Control Valve
In-Line Filter (80 mesh)

100 mesh or smaller (larger number) recommended

Algae build-up a problem with clear filter
Drip System Laterals
Specifications per Plot (Tank) in the Farmington Study

- Head: 5 ft. 10 in. (2.6 psi)
- Total Irrigated Area = 2340 sq. ft.
  - Laterals per plot: 12 (spaced 36 in. apart)
  - Lateral length: 65 feet
- Emitters per lateral: 40
- Emitters per plot: 480
- Flow rate per emitter: ~ 1.2 fl. oz. per minute (0.54 gph)
- Flow rate per plot: ~ 4.5 gpm (270 gph)
Total Water Applied and Yield of Sweet Corn, Chile Peppers, and Tomatoes at Farmington
Sweet Corn (12” spacing in 36” or 34” rows):
• 35 gallons per plant (11,667 gals per 1000 sq. ft.)
• 700 ears per 1000 sq. ft. (30,492 ears per acre)

58 dozen @
$2.50/doz. =
$145.00
Chile Peppers (18” in 36” rows or 12” inch in 34” rows)

- 48 to 34 gallons per plant (10,667 to 12,014 gals/1000 sq. ft.)
- 740 to 820 lbs per 1000 sq. ft. (16.1 to 17.9 tons/acre)

20 sacks (40#)
@ $14.00/sack
= $280.00
Tomatoes (24” spacing in 34” rows)
– 36 gallons per plant (12,720 gals/1000 sq ft)
– 1,525 lbs. per 1000 sq. ft. (33.2 tons/acre)

58 lugs (26#)
@ $14.00/lug
= $800.00
Example: 83 chile plants (32 gals. per day)  
= 7 fills per day (during peak ET)
Summary: If carefully designed, managed, and maintained, low-tech, gravity-fed drip irrigation systems can be used effectively in vegetable production!
Thank You!

Contact Information:
Dan Smeal, NMSU-ASC, Farmington: 505-327-7757. e-mail: dsmeal@nmsu.edu
Website: http://farmingtonsc.nmsu.edu