Irrigation Systems for Horticulture Crops

by
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for
Southern Illinois Commercial Vegetable School
Mt. Vernon, IL
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1. How much water do you need?
2. How much time do you have?

Plants are 80-95% Water

- Water shortages early in crop development = delayed maturity & reduced yields
- Water shortages later in the growing season = quality often reduced, even if yields not hurt
- Short periods of 2-3 days of stress can hurt marketable yield
- Irrigation increases size & weight of individual fruit & helps prevent defects like toughness, strong flavor, poor tipfill & podfill, cracking, blossom-end rot and misshapen fruit

If you take care of your soil, the soil will take care of your plants.

- Plant available water depends on:
  - Soil structure & texture
  - Water infiltration rate
  - Soil organic matter
  - Soil type
  - Plant rooting depth

USDA Soil Texture Classes

- Particle size
  - Sand = 2.0-0.05 mm
  - Silt = 0.05-0.002 mm
  - Clay = <0.002 mm

- Characteristics
  - Sand adds porosity
  - Silt adds body to the soil
  - Clay adds chemical & physical properties

Determining Soil Texture

- By feel
  - Gritty, smooth, sticky

- Using the jar method
  - Fill a 1-quart jar 1/4 full of soil
  - Fill the jar with water to 1/3 full
  - Add 1 teaspoon of dishwashing detergent
  - Shake very well to suspend soil
  - Place on a flat surface and allow soil to settle for 2 days
  - Measure % thickness of each layer relative to all
Checking Soil Drainage

- Perched water table
- Fragipan on upland soils
- Standing water after a rain

Benefits of Using Compost

- Improves drainage & aeration of heavy clay soils
- Increases moisture-holding ability of sandy soils
- Increases earthworm & soil microbial activity that benefit plant growth
- Improves soil structure & makes it easier to work
- Contains nutrients needed for plant growth

Irrigation Definitions

- **Saturation**: When all soil pore space is filled with water
- **Field capacity**: When a soil is sufficiently wet, its capillary forces can hold no more water
  - Soil M.C. varies with soil texture, ranging from 15-45% by volume
- **Permanent wilting point**: Soil moisture content at which plants can no longer get water from the soil and will wilt and die
  - Soil M.C. ranges from 5-25% by volume
- **Plant available water**: The portion of the soil water that can be taken up by plants; ranges by crop from 25-75% of the water holding capacity of the soil

Evapotranspiration (ET)

- **Rate of water loss changes as plant grows and sets fruit**
- **Peak water use is during bloom, fruit set and ripening**
- **Factors that affect ET**
  - **Season**
  - Temperature, wind, relative humidity
  - Type of crop or vegetation cover
  - Soil moisture content
  - Mulches and ground covers

Illinois Average Annual Precipitation 1971-2000

- **1971 - 2000 Annual Precipitation (inches)**

Table 6. Effective Rooting Depth of Selected Vegetables

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Root Depth</th>
<th>Root Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean</td>
<td>30-60</td>
<td>Shallow</td>
</tr>
<tr>
<td>Cabbage</td>
<td>50-90</td>
<td>Deep</td>
</tr>
<tr>
<td>Corn</td>
<td>30-60</td>
<td>Shallow</td>
</tr>
<tr>
<td>Potato</td>
<td>60-90</td>
<td>Deep</td>
</tr>
<tr>
<td>Watermelon</td>
<td>60-90</td>
<td>Deep</td>
</tr>
</tbody>
</table>

Most of the active root system for water uptake may be between 6’-12’.
**Evapotranspiration (ET)**

- Missouri – Annual ET is 60-70% of precip.
- Maximum daily ET can exceed 0.25”

**Soil & Climate Properties**

- Soils store 1.5”-2.5” of water per foot of depth (check county NRCS Soil Survey)*
- Intake rate ≤ 0.2”-2.0” per hour, rest is runoff
- Plant Available Water ** = % of soil water between field capacity & permanent wilting point = ranges by crop from 25% to 75%
- Summer E.T. rate can be 0.25” per day – Can be as high as 0.50” per day with low humidity & high temperature with wind

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**Available Water Holding Capacity for Several Soil Types**

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Available Water Holding Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loamy fine sand</td>
<td>0.08-0.12 0.96-1.44</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>0.10-0.18 1.20-2.16</td>
</tr>
<tr>
<td>Loam</td>
<td>0.14-0.22 1.68-2.64</td>
</tr>
<tr>
<td>Silt loam</td>
<td>0.18-0.23 2.16-2.76</td>
</tr>
<tr>
<td>Clay loam</td>
<td>0.16-0.18 1.92-2.16</td>
</tr>
</tbody>
</table>

**Is a Rain Barrel Enough?**

- 1” of rain from a 1,600 sq. ft. house roof = 1,000 gallons
- Elevation dictates pressure
  - 2.3 feet of head = 1 psi pressure

**Low-Budget Options?**

- What is your time worth?
- What is your mechanical expertise?

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References:

* www.nrcs.usda.gov/wps/portal/nrcs/soilsurvey/soils/survey/state/
* websoilsurvey.nrcs.usda.gov/app/
* www.ces.ncsu.edu/depts/hort/hil/hil-33-e.html

Available Water Holding Capacity for Several Soil Types

Reference: Midwest Vegetable Production Guide for Commercial Growers

http://www.btny.purdue.edu/pubs/id/id-56/

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Basic Watering Facts

- Plants need 1”-1.5” of water per week
  - 624-935 gallons (83-125 cu.ft.) per 1,000 sq.ft.
- Can survive drought on half that rate
- Deep infrequent waterings are better than several light waterings
- Deeper roots require less supplemental irrigation
- Taller plants have deeper roots
  - Lowers tendency to wilt
  - Shades soil surface
  - Controls weeds by competition
  - Makes water “go farther”

Watering Mature Trees and Shrubs

- Most roots in top 12” of soil
- Root spread up to 4X tree crown spread
  - Varies by tree species
- Saturate 20% of root zone
  - 12” deep

How Much Water for Trees?

- Gallons needed for 1” water per week = Diameter x Diameter ÷ 2
- Example #1: 6 ft. x 6 ft. = 18 gal./wk.
- Example #2: 20 ft. x 20 ft. = 200 gal./wk.

Watering Trees

- “Gender bender” to improve uniformity of water flow
- Soaker hose around drip line of tree

Plant Water Requirements

<table>
<thead>
<tr>
<th>Vegetable Crop (mature)</th>
<th>Gallons per 100 Feet of Row per Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum for plant survival</td>
<td>100</td>
</tr>
<tr>
<td>Lettuce, spinach, onions, carrots, radishes, beets</td>
<td>200</td>
</tr>
<tr>
<td>Green beans, peas, kale</td>
<td>250</td>
</tr>
<tr>
<td>Tomatoes, cabbage, peppers, potatoes, asparagus, pole beans</td>
<td>300</td>
</tr>
<tr>
<td>Corn, squash, cucumbers, pumpkins, melons</td>
<td>400-600</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fruit Crop</th>
<th>Gallons per 100 Feet of Row per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries</td>
<td>50</td>
</tr>
<tr>
<td>Raspberries &amp; Blackberries</td>
<td>75</td>
</tr>
<tr>
<td>Without mulch</td>
<td>100</td>
</tr>
<tr>
<td>With mulch</td>
<td>75</td>
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</tbody>
</table>

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Plant Water Requirements

(Design rates for southeast Missouri assuming no effective rainfall for >60 days.)

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<tr>
<th>Fruit Crop</th>
<th>Plant x Row Spacing, Ft</th>
<th>Sq Ft/Plant</th>
<th>Plants/Acre</th>
<th>Gal/Plant/Day</th>
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<td>4144</td>
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<tr>
<td></td>
<td>18 x 26</td>
<td>468</td>
<td>93</td>
<td>42</td>
<td>3606</td>
</tr>
<tr>
<td>Peaches</td>
<td>15 x 20</td>
<td>300</td>
<td>145</td>
<td>28</td>
<td>4090</td>
</tr>
<tr>
<td></td>
<td>18 x 20</td>
<td>360</td>
<td>121</td>
<td>34</td>
<td>4114</td>
</tr>
<tr>
<td>Grapes</td>
<td>8 x 10</td>
<td>80</td>
<td>540</td>
<td>10</td>
<td>5440</td>
</tr>
<tr>
<td></td>
<td>8 x 16</td>
<td>128</td>
<td>340</td>
<td>16</td>
<td>5440</td>
</tr>
<tr>
<td>Blueberries</td>
<td>4 x 12</td>
<td>48</td>
<td>908</td>
<td>4</td>
<td>3632</td>
</tr>
</tbody>
</table>

Scheduling Irrigation

1. Appearance of plants - wilt
2. "Feel" method - handful of soil
3. Screwdriver method - force into soil
4. Calendar method - daily, 3rd day
5. "Checkbook" method
   - Tally total rainfall + irrigation against daily water use of plants
6. Tensiometers
   - Read scale of 0 (wet) to 100 (dry)
7. Moisture resistance blocks
   - Buried at depths in soil, check with meter

Sprinkler Irrigation

1. 1.5-8.5 GPM flow rate
2. 5-7 GPM water supply/acre for irrigation
3. 45-60 GPM/acre for frost control from 25°F-20°F.
4. 25-45 psi system operating pressure
5. Equipment & labor tradeoff
6. Cost = $800 - $1,000/acre

Overhead Irrigation Use

1. Apply water at rate to avoid puddling and runoff
2. Water early morning (4 a.m. to 8 a.m.)
   - Less evaporation loss (no sun, calmer winds)
   - Knocks dew and guttation fluid off leaf blades
   - Lets plant leaves dry before evening to discourage fungal growth and infection

How a Sprinkler Waters

One sprinkler applies a lot of water close in and less water farther away, so watering is uneven.

When sprinklers are set so that patterns overlap, the entire area gets an even amount of water.

Check Sprinkler Overlap

CORRECT
- High uniformity
- No waste

INCORRECT
- Poor uniformity
- Inadequate irrigation

INCORRECT
- Poor uniformity
- Wasted water
Drip Irrigation

- Also known as:
  - Trickle irrigation
  - Micro-irrigation
  - Low-volume irrigation

Drip Irrigation 2

- 0.5-2.0 GPH flow rate per emitter
- 2-5 GPM/acre for water supply
- Point use gives less runoff, less evaporation, easier weed control, saves 30%-50% water
- Low pressure of 6-20 psi means smaller pumps & pipes
- Can fertilize through system
- Do field work while irrigating

Drip Irrigation 3

- Can automatically control
- Susceptible to clogging
- Must design system to carefully match equipment to elevation
- 2.3 feet of head = 1 psi pressure
- Requires diligent management
- Cost = $1,200 - $1,500 for 1st acre; $900 - $1,100/acre for rest

Wetting Patterns (Drip)

Water Source Quality

- Good
  - Well = check pH & hardness
  - Municipal = may be expensive
  - Spring = may not be dependable
  - River or stream = depends on runoff
  - Lake or pond water = sand filters
  - Pump to tank on hill = limited use

- Poor
  - Well = check pH & hardness
  - Municipal = may be expensive
  - Spring = may not be dependable
  - River or stream = depends on runoff
  - Lake or pond water = sand filters
  - Pump to tank on hill = limited use
**Water Quality Analysis**

- Inorganic solids = sand, silt
- Organic solids = algae, bacteria, slime
- Dissolved solids (<500 ppm)
  - Iron & Manganese
  - Sulfates & Chlorides
  - Carbonates (calcium)
- pH (5.8-6.8 preferred)
- Hardness (<150 ppm)
- E. coli bacteria

**Plugging Potential of Drip Irrigation Systems**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Moderate (ppm)*</th>
<th>Severe (ppm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended solids</td>
<td>50-100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Chemical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH**</td>
<td>7.0-7.5</td>
<td>&gt;7.5</td>
</tr>
<tr>
<td>Dissolved solids</td>
<td>500-2000</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.1-1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Iron</td>
<td>0.1-1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>Hardness***</td>
<td>150-300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>0.5-2.0</td>
<td>&gt;2.0</td>
</tr>
</tbody>
</table>

* ppm = mg/L  ** pH is unitless  *** Hardness: ppm = gpg x 17

**Good Agricultural Practices - Irrigation Water**

- Pathogens that contaminate the surface of produce are difficult to remove
- Irrigation water can be a vehicle for foodborne pathogens
  - E. coli 0157:H7 in spinach
  - Salmonella in peppers
- GAPs program looks at food safety practices
  - Irrigation water quality
  - Manure management
  - Worker hygiene
  - Harvesting, transportation & storage practices

**Using Ponds for Irrigation**

- Pond 8’ deep, 100’ dia. holds 280,000 gallons of water.
- One-half of water volume is usable for irrigation. Rest is seepage & evaporation.
- 20 GPM demand for 20 hrs/day uses 24,000 gal/day.
- Pond holds about 6-day water supply.
- Water is least available when most needed!!

**Pond Water Quality**

- Grass filters sediment & nutrients
- Copper sulfate controls algae & slime
- No overhead irrigation on vegetables or fruits

**Estimating Water Quantity**

- Household water demand
  - GPM = Total count of toilets, sinks, tubs, hose bibs, etc. in home
- Excess is available for irrigation
  - Contact pump installer for capacity data
- Is pressure tank large enough?
  - Stay within cycle limits of pump, OR
  - Run the pump continuously
### Home Water Flow Rates

<table>
<thead>
<tr>
<th>Number of Bathrooms in Home</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedrooms</td>
<td>Flow Rate (Gallons Per Minute)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>--</td>
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<tr>
<td>4</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
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<tr>
<td>5</td>
<td>--</td>
<td>13</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>6</td>
<td>--</td>
<td>--</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

Source: [http://extension.missouri.edu/p/G1801](http://extension.missouri.edu/p/G1801)

### Pump Cycling Rate, Max.

<table>
<thead>
<tr>
<th>Horsepower Rating</th>
<th>Cycles/ Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25 to 2.0</td>
<td>20</td>
</tr>
<tr>
<td>3 to 5</td>
<td>15</td>
</tr>
<tr>
<td>7.5, 10, 15</td>
<td>10</td>
</tr>
</tbody>
</table>

### Pressure Tank Selection

<table>
<thead>
<tr>
<th>Average Pressure, psi*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Size, gallons</td>
</tr>
<tr>
<td>Pumping Capacity, GPM</td>
</tr>
<tr>
<td>42</td>
</tr>
<tr>
<td>82</td>
</tr>
<tr>
<td>144</td>
</tr>
<tr>
<td>220</td>
</tr>
<tr>
<td>315</td>
</tr>
</tbody>
</table>

* Cut-in pressure + 10 psi = Avg. Pressure = Cut-out pressure - 10 psi

### Pressure Tanks

- Larger tank
- OR
- Multiple tanks
- Variable-speed pump controller

### Example Layout of Drip Irrigation System

- Power Supply
  - Electric = 1st choice
  - Gas, diesel, propane = 2nd choice
  - Gravity = ram pumps
- Pump system
  - Higher elevation = lower horsepower
  - Size to elevation & system pressure
  - Pressure tank vs. throttling valve control
**Drip Irrigation Components**

- Check valve(s)
  - Stop backflow into water source
  - Critical if fertigating
- Filter system
  - 150-200 mesh screen
  - Manual or automatic backflushing
  - If you can see particles, the system can plug

**Filter Selection**

- Cartridge filter
  - Best with well water on very small systems
  - Made of paper or spun fiber
  - Disposable or washable
  - Install in pairs to avoid service downtime
  - Clean when pressure loss exceeds 5-7 psi

**Filter Selection**

- Screen filter
  - 150-200 mesh, 3/4” to 6” dia.
  - Slotted PVC, perf. or mesh stainless steel or nylon mesh
  - Manual or automatic flush
- Disc filter
  - Stack of grooved wafers
  - Provides more filter area than screen of same size
  - Cannot handle sand well

**Filter Selection**

- Sand media
  - 14” to 48” diameter
  - Use swimming pool filter for smaller systems
  - Use pairs of canisters for larger systems
  - #16 silica sand = 150-200 mesh screen
  - Work best at < 20 GPM flow per square foot of media
  - Follow with screen filters
  - Backflush to clean

**Drip Irrigation Components**

- Pressure regulation
  - Depends on field slope & pipe layout
  - In-line regulators
  - Pressure tank(s) = match to pump cycle rate to avoid pump burnout
- Solenoid valves
  - Low-voltage water control valves
  - Mount above ground for easy service

**Solenoid Valves**

- Low-voltage water control valves
- Mount above ground for easy service
Drip Irrigation Components

- **Controller**
  - Time clock switches solenoid valves

- **Mainline**
  - Carries water to each irrigation block
  - Buried 1.5” - 3” dia. PVC pipe

- **Manifolds**
  - Meter water from mainlines to laterals
  - Buried 3/4” - 2” PVC or PE pipes

- **Emitters**
  - Deliver water to the plants
  - 0.5 – 2.0 GPH “in-line” or “on-line” units
  - Pressure-compensating or not

Controller

- Protect controllers from weather & pests
- Use proper wiring (Type UF or USE)

Laterals & Emitters

- **Operating pressure in laterals**
  - Thin-wall “tape” = 4-8 psi
  - Non-P.C. emitters = 8-15 psi
  - P.C. emitters = 10-60 psi
- Max. pressure variation in plant block = 20 psi (+/- 10 psi)

- **Laterals**
  - Carry water down rows to the plants
  - Surface or buried 3/8” - 3/4” PE pipe
  - Thin-wall “tape” for close-growing crops

- **Emitters**
  - Deliver water to the plants
  - 0.5 – 2.0 GPH “in-line” or “on-line” units
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Laterals & Emitters 1

- Extend laterals 10-20 ft. past row end to serve as debris trap

- Use air relief valve at high point of each plant block to stop shutoff suction

Laterals & Emitters 2

- Split water flow for low-use plants

- Roll up & store laterals at end of season

Laterals & Emitters 3
Home Garden Drip Irrigation

Design Considerations 1
- Water supply capacity
- Source of power
- Hours of operation per day
- Field size, shape & elevation
  - 2.31 feet elevation change = 1 psi pressure change
  - Design for +/- 10% or less flow variation
- Plant spacing
- Row spacing

Planning Your System 1
- Make a field plan
  - Show field size, shape, elevation contours
  - Show distance to water source, electricity
  - Note soil type, climate, air drainage
  - Example: Two acres grapes
    a. 290' x 300' field, 4.0% slope across rows, 2.3% along row
    b. 37 plants per row 8' o.c., 28 rows 10' o.c.,
    c. Irrigate up to 20 hrs./day

Sample Field Plan 1
- Emitter selection & location
- Clogging control - air relief valve
- Burial and draining
  - Frostline depth = 24" - 30"
  - Flush with air
- Pipe protection
- under roadways
- Animal damage
- Expansion

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Slope Measurement by Elevation Change

Two types of instruments
- Builder’s level and measuring rod
- Line level + string + tape measure + stake

Slope in % = (vertical / horizontal) x 100

Slope Measurement by Direct Reading

Two types of instruments
- Clinometer (Abney level)
- “Smart” level (electronic)

Plant Water Requirements

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<td>Blueberries</td>
<td>4 x 12</td>
<td>48</td>
<td>908</td>
<td>4</td>
<td>3632</td>
</tr>
</tbody>
</table>

Planning Your System 2

7. Calculate minimum pumping capacity needed & compare to water source

\[ \text{GPD} = \text{Gallon/plant/day x # of plants} \]

Example: Two acres 8’ x 10’ grapes
10 GPD x 1,080 plants = 10,800 gal.
per 20 hr. day = 540 GPH
= 9.0 GPM

Planning Your System 3

7. Calculate area irrigated at once
- # of plants = Well capacity / GPH appl. rate
- Allow for home water demand
- Balance well cap. to row length & block size
- Example: 3 BR, 1 1/2 bath home & 19 GPM well
  a. Home needs 10 GPM, so field gets 9 GPM
  b. (9 GPM well cap. x 60 min/hr) + 1 GPH/plant = 540 plants
  c. 540 plants / 37 plants/row ≈ 14 rows at once
  d. 28 total rows / 14 rows/block = 2 blocks
  e. 2 blocks x 10 GPD/plant = 1 GPH/em. = 20 hrs.

Example of Pumping Head Calculations

<table>
<thead>
<tr>
<th></th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation from water source to high point, feet</td>
<td>200.00</td>
</tr>
<tr>
<td>Pipe friction loss (400 ft. pipe x 1 psi/100’ x 2.31 ft./psi)</td>
<td>9.24</td>
</tr>
<tr>
<td>Misc. friction loss of elbows, risers, valves, etc.</td>
<td>6.25</td>
</tr>
<tr>
<td>(convert to equiv. length of straight pipe)</td>
<td></td>
</tr>
<tr>
<td>Discharge pressure (15 psi x 2.31 ft./psi)</td>
<td>34.65</td>
</tr>
<tr>
<td><strong>Total head in feet</strong></td>
<td><strong>250.14</strong></td>
</tr>
</tbody>
</table>
Pump Curve Example

Friction Loss Design
- Size piping for 1 psi or less pressure loss per 100 feet
  - Pipe diameter x 2
  - 4X flow rate
- Pipe friction may replace pressure regulators on downhill runs
- Vary flowrate no more than 20% (+/- 10%) within each block of plants
- Manifolds attached to mainline...
  - at center if < 3% slope
  - at high point if 3+% slope

Plastic Pipe Friction Loss

<table>
<thead>
<tr>
<th>Pipe Diameter, inches</th>
<th>0.75&quot;</th>
<th>1&quot;</th>
<th>1.5&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPM</td>
<td>PSI Loss per 100 ft. of pipe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>2.8</td>
<td>0.8</td>
<td>0.1</td>
<td>--</td>
</tr>
<tr>
<td>10</td>
<td>11.3</td>
<td>3.0</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>15</td>
<td>21.6</td>
<td>6.4</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>20</td>
<td>37.8</td>
<td>10.9</td>
<td>1.3</td>
<td>0.4</td>
</tr>
<tr>
<td>25</td>
<td>--</td>
<td>16.7</td>
<td>1.9</td>
<td>0.6</td>
</tr>
<tr>
<td>30</td>
<td>--</td>
<td>--</td>
<td>2.7</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Sample Field Plan

| Block #1 |
| 0 psi |
| 5 psi |
| 300 ft. @ 2.3% slope |

| Block #2 |
| 5 psi |
| 280 ft. @ 4.0% slope |
| 8 psi |

Troubleshooting Guide

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reddish-brown slime or particles near emitters</td>
<td>Bacteria feeding on iron</td>
</tr>
<tr>
<td>White stringy masses of slime near emitters</td>
<td>Bacteria feeding on sulfur</td>
</tr>
<tr>
<td>Green or slimy matter in surface water</td>
<td>Algae or fungi</td>
</tr>
<tr>
<td>White film on tape or around emitters</td>
<td>Calcium salts or carbonates</td>
</tr>
<tr>
<td>Presence of silt or clay</td>
<td>Inadequate filtration</td>
</tr>
</tbody>
</table>

Chemical Injection
- Kill bacteria & slime
  - Chlorine needs “contact time”
  - Powdered HTH can plug emitters
Chemical Injection 2

- Control pH with acid
  - Help acidify soil for plants (blueberries)
  - Dissolve Mn, Fe, Ca precipitates
  - Make chemicals work better

Chemical Injection 3

- Apply fertilizer
  - Be sure it’s 100% water-soluble
  - Always inject it two elbows before the filter for good mixing
  - Use backflow preventer

Irrigation Resources on the Web

- Irrigation System Planning & Management Links
  extension.missouri.edu/webster/irrigation/
- USDA NRCS Web Soil Survey
  websollsurvey.sc.egov.usda.gov/App/

Questions??

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Program Complaint Information
To file a program complaint you may contact any of the following:
University of Missouri
- MU Extension AA/EO Office
  109 F. Whitten Hall, Columbia, MO 65211
- MU Human Resources Office
  130 Hinkle Bldg, Columbia, MO 65211
USDA
- Office of Civil Rights, Director
  Room 326-W, Whitten Building
  14th and Independence Ave., SW
  Washington, DC 20250-9410

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