Irrigation Basics for Vegetables and Small Fruits

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Natural Resource Engineering Specialists
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What We'll Cover

- The soil → soil & climate factors
- The plants → water needs
- The water → quality and quantity
- The irrigation options
  - Small-scale watering
  - Larger-scale watering

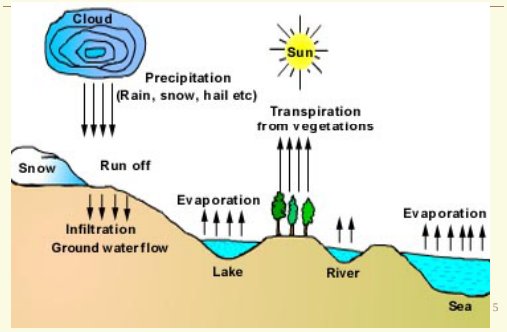
3

Use & Loss of Water

- Evaporation
- Runoff
- Transpiration
- Percolation

4

The Water Cycle



5

Soil Type

- Water moves through soil by capillary action
- Pores affect capillary action
- Good soils
  - ½ filled with water
  - ½ filled with air

6

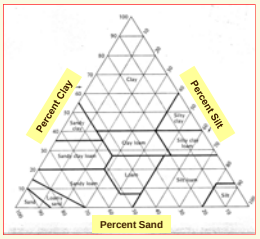
Soil & Climate Properties

- Soils store 1.5”-2.5” of water per foot of depth (check county NRCS Soil Survey)
- Intake rate = 0.3”-2.0” per hour, rest is runoff
- Available water = 75% of total water in soil
- Summer E.T. rate is 0.25” per day
- A 2-ft. deep soil holds 9-15 day supply of moisture
- SW Missouri historical weather:
  - Rainfall = 41”-42” per year
  - Evaporation = 40” per year
- Ozarks has 3-4 week summer dry spell

7

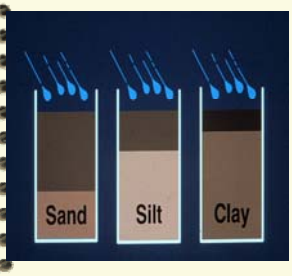
USDA Soil Texture Classes

- 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



8

Irrigation: How Frequently?



Infiltration Rate:

- Sand: 2-5 in/hr
- Silt/Loam: 1-2 in/hr
- Clay: 0.2-1 in/hr

9

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

10

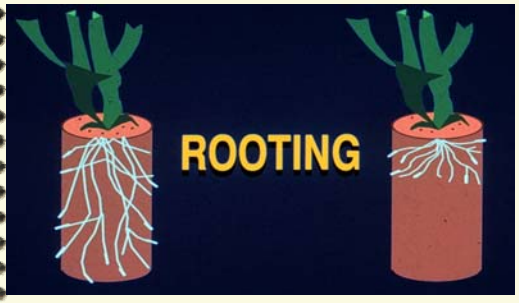
Basic Watering Facts

- 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”

11

Irrigation affects on rooting

Deep, infrequent **Shallow, frequent**



When to Water

- Rainfall less than 1" per week
  - Keep a record of rainfall received
  - Check soil moisture with long screwdriver
- It's getting bad when you see:
  - Purple-blue wilting leaves
  - Grass that leaves footprints
  - Folded or rolled leaves
- Water in early morning. Let plant leaves dry before evening to prevent diseases.
- Don't wait to see wilting before watering

13

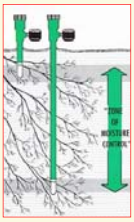
Irrigation: What time of day?

- Early morning: 4 AM to 8 AM
  - Evaporative losses minimized (no sun, calmer winds)
  - Knocks dew and guttation fluid off leaf blades and decreases leaf wetness period (compared to evening watering) all of which discourages fungal growth and infection

14

Measuring Water Needs 1

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



15

Measuring Water Needs 2

Catch cans

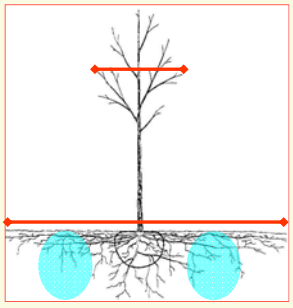
4-cycle timer

Rain gauge

16

Watering Mature Trees

- 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



The Two Major Factors in Irrigation System Planning

1. How much <u>water</u> do you need?

2. How much <u>time</u> do you have?

18

Plant Requirements

- In General
  - Gardens need 1” water /week
  - Plants vary considerably
  - Soils vary
  - Time of year makes a difference

19

Relative Water Needs of Plants

Low	Medium Low	Medium
Spinach	Peas, Green	Cabbage
Lettuce	Beans, Kale	Broccoli
Radish		Pepper

Medium High	High	Very High
Tomato	Sweet Corn,	Muskmelon
Asparagus	Vine Squash	Watermelon
		Pumpkin

20

Plant Water Requirements 3

(Estimated design rates for southwest Missouri)

Vegetable Crop (mature)	*Gallons per 100 Feet of Row per Week*
Minimum for plant survivial	100
Lettuce, spinach, onions, carrots, radishes, beets	200
Green beans, peas, kale	250
Tomatoes, cabbage, peppers, potatoes, asparagus, pole beans	300
Corn, squash, cucumbers, pumpkins, melons	400-600

21

Plant Water Requirements 1

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

Fruit Crop	Plant x Row Spacing, Ft.	Sq.Ft./ Plant	Plants/ Acre	Gal/Plant/Day Gal/Acre/Day
Apples	6 x 14	84	518	8 4144
	18 x 26	468	93	42 3906
Peaches	15 x 20	300	145	28 4060
	18 x 20	360	121	34 4114
Grapes	8 x 10	80	540	10 5440
	8 x 16	128	340	16 5440
Blueberries	4 x 12	48	908	4 3632

22

Plant Water Requirements 2

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

Fruit Crop	*Gallons per 100 Feet of Row per Day*
Strawberries	50
Raspberries & Blackberries	
With mulch	75
Without mulch	100

23

Water Source Quality

Good

Poor

- Well = check pH & hardness
- Municipal = may be expensive
- Spring or stream
- Pond water = sand filters
- Pump to tank on hill
  - Elevation dictates pressure (2.3 feet of head = 1 psi pressure)
  - Watch for tank corrosion

Water Quality Analysis

- Inorganic solids = sand, silt
- Organic solids = algae, bacteria, slime
- Dissolved solids
  - Iron & Manganese
  - Sulfates & Chlorides
  - Carbonates (calcium)
- pH
- Hardness

25

Plugging Potential of Drip Irrigation Systems

Factor	Moderate (ppm)*	Severe (ppm)*
Physical		
Suspended solids	50-100	>100
Chemical		
pH**	7.0-7.5	>7.5
Dissolved solids	500-2000	>2000
Manganese	0.1-1.5	>1.5
Iron	0.1-1.5	>1.5
Hardness***	150-300	>300
Hydrogen sulfide	0.5-2.0	>2.0

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

26

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!!

27

Pond Water Quality

- Grass filters sediment & nutrients

- Copper sulfate controls algae & slime

28

Types of Systems

- Bucket & Jug
- Sprinkler
- Furrow
- Soaker
- Drip or Trickle

29

Bucket & Jug Irrigation

- Labor-intensive
- Efficient water use
- Point-source application
- 0-2 psi system operating pressure
- Rates:
  - 2 GPH = 5/64" hole (put in bottom of bucket)
  - 5 GPH = 1/8" hole

30

Gator Bags

31

Sprinkler

- Low cost
- Fairly even
- May result in runoff
- Foliage is wet
- Water loss higher

32

Micro-Sprinkler

- Good for landscape beds
- Uses more water than soaker hose
- More evaporation
- Wide range of spray patterns
  - Spray range is 1.5-6 ft.
- Not effective for frost control

33

Sprinkler Irrigation 1

- 1.5-8.5 GPM flow rate
- 4-7 GPM water supply/acre for irrigation
- 45-60 GPM/acre for frost control from 25°F-20°F.
- 25-45 psi system operating pressure
- Equipment & labor tradeoff
- Cost = $500-$700/acre (?)

34

Sprinkler Irrigation 2

Oscillating sprinkler covers 3,500 sq.ft. rectangle

Traveling sprinkler covers 16,500 sq.ft. variable path

35

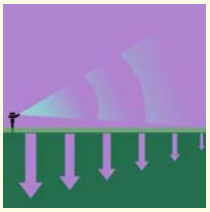
Sprinkler Irrigation 3

Whirling-head sprinkler covers 5 to 50 ft. diameter

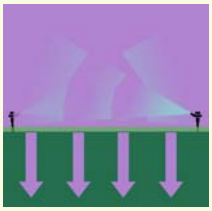
Rotary or impulse sprinkler covers partial to full circles

36

How a Sprinkler Waters



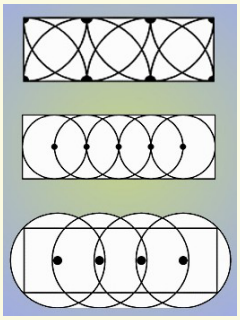
One sprinkler applies a lot of water close in and less water farther away, so watering is uneven.



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

37

Check Sprinkler Overlap



CORRECT
- High uniformity
- No waste

INCORRECT
- Poor uniformity
- Inadequate irrigation

INCORRECT
- Poor uniformity
- Wasted water

38

Furrow

- Limited because of topography
- May use more water
- Harder to control

39

Soaker Hose

- "Sweaty" hose
- Low pressure
- 1/2" - 5/8" dia.
- 0.1 - 1.0 GPH per foot (not engineered)
- Lasts 7-10 years
- Good for gardens, shrub beds
- Expensive on large areas

40

Drip Irrigation 1

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

Drip Irrigation

- More expensive
- Easy to control
- Minimizes water use
- Puts water near the plants
- Various types of systems

42

Drip Irrigation 2

- Can automatically control
- Susceptible to clogging
- Must design system to carefully match equipment to elevation
- Requires diligent management
- Cost = $900 - $1200 for 1st acre;
  $600 - $800/acre for rest

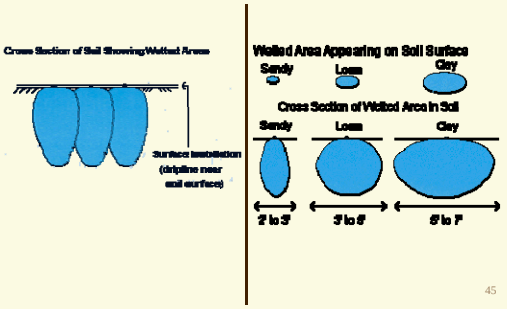
43

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

44

Wetting Patterns (Drip)



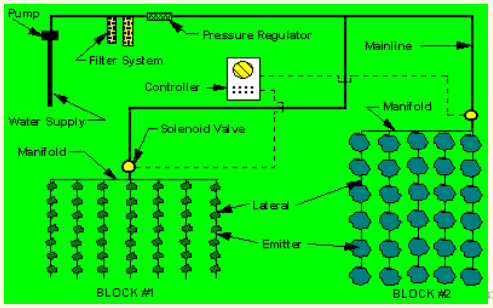
45

Design of System

- Water Supply
- Pump
- Distribution lines
- Filters
- Controls

46

Example Layout of Drip Irrigation System



47

Drip Irrigation Components 1

- Power Supply
  - Electric (Conventional or solar)
  - Gas, diesel, propane
  - Gravity
  - Ram pumps
- Pump system
  - Higher elevation = lower horsepower
  - Size to elevation & system pressure
  - Pressure tank vs. throttling valve control

48

Drip Irrigation Components 2

- Pressure Tanks
- 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

49

Pump

- Selection
  - Pumps rated by head or psi and gpm
- Determining the Amount
  - System
  - Amt. Irrigated at once

psi = pounds per square inch pressure
One psi = 2.31 ft. of head
gpm = gallons per minute

50

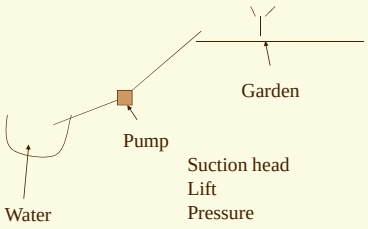
Types of Pumps

- Centrifugal
- Turbine
- Submersible
- Solar Pumps

51

Pump

Figuring the Head Requirement



52

Pressure Tanks

Larger tank

Multiple tanks

53

Filter Selection 1

- 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

54

Filter Selection 2

- 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 3

- 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

56

Drip Irrigation Components 3

- 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

57

Solenoid Valves

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

Controller

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

59

Drip Irrigation Components 4

- Controller
  - Time clock switches solenoid valves
- Mainline
  - Carry 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

Drip Irrigation Components 5

- 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 GPH "in-line" or "on-line" units
  - Pressure-compensating or not

61

Laterals & Emitters 1

- 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 & Emitters 2

- 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 3

Split water flow for low-use plants

Roll up & store laterals at end of season

64

Troubleshooting Guide

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

65

Chemical Injection 1

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

66

Chemical Injection 2

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

67

Chemical Injection 3

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

68

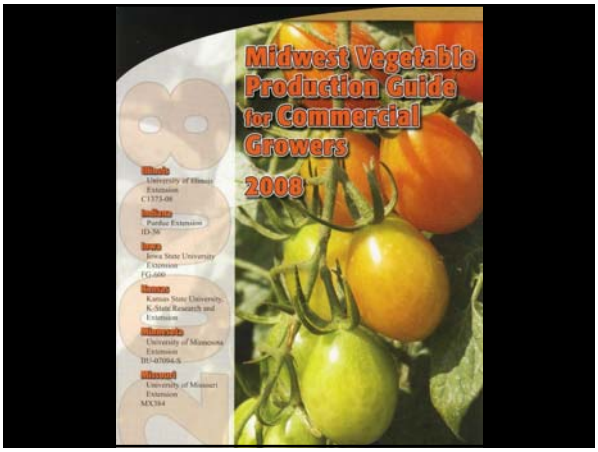


Table 4. Effective Rooting Depth of Selected Vegetables

Shallow (6-12")	Moderate (18-24")	Deep (> 36")
Beet	Cabbage, Brussels Sprouts	Asparagus
Broccoli	Cucumber	Lima Bean
Carrot	Eggplant	Pumpkin
Cauliflower	Muskmelon	Sweet Potato
Celery	Pea	Watermelon
Greens & Herbs	Potato	Squash, Winter
Onion	Snap Bean	
Pepper	Squash, Summer	
Radish	Sweet Corn	
Spinach	Tomato	

Table 5. Vegetable Crops and Growth Period Most Critical for Irrigation Requirements

Crop[1]	Most Critical Period
broccoli, cabbage, cauliflower, lettuce	head development
carrot, radish, beet, turnip	root enlargement
sweet corn	silking, tasseling, and ear development
cucumber, eggplant, pepper, melon, tomato	flowering, fruit set, and maturation
bean, pea	flowering, fruit set, and development
onion	bulb development
potato	tuber set and enlargement

[1] For transplants, transplanting and stand establishment represent a most critical period for adequate water.

Table 6. Available Water Holding Capacities for Several Soil Types

Soil Texture	Available Water Holding Capacity	
	In Inches per Inch of Soil	In Inches per Foot of Soil
Loamy fine sand	0.08-0.12	0.96-1.44
Sandy loam	0.10-0.18	1.20-2.16
Loam	0.14-0.22	1.68-2.64
Silt loam	0.18-0.23	2.16-2.76
Clay loam	0.16-0.18	1.92-2.16

Finally….

If you have further questions or would like assistance in your horticultural endeavors…

Please don't hesitate to give me a call.
Tim Baker – 660-663-3232

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72