NC Farm School Summit 2015
Horticulture Track 2 – Vegetable Irrigation

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Uniform water supply throughout the growing season is critical to maximize vegetable yield and quality. Shortages in supply may cause uneven stand, transplant stress, delay maturity, and ultimately reduce yield.

Benefits of irrigation system: Stimulate germination, improved stand establishment, increased yield, a reliable product supply, increase fruit size

Critical irrigation timing is crop dependent: Fruiting vegetables typically during flowering, non-fruiting during vegetable development (swelling).

Sources: Ponds, streams, well, municipal.

Food safety risk associated with source: From lower risk to higher risk (treated municipal waters, covered well water, open ponds and streams. Test water to be aware of risk. For more information on water quality and testing see: freshproducesafety.ces.ncsu.edu.

System types: Depends on soil type, field configuration, crop, cultural practices, costs

a. **Solid Set** ($900-1,400/A):
    i. Pros: Low labor requirements, Adaptable to irregular fields, Moderate pressure requirements
    ii. Cons: High initial cost, Not suitable for tall canopies

b. **Travelling Gun** ($400-500/A):
    i. Pros: Can be used for tall crops, Moderate/Good Uniformity, Portable
    ii. Cons: High Pressure requirements, Not for irregularly shaped fields, Drop impact on tender crops

c. **Center Pivot/Linear Move** ($275-500/A):
    i. Pros: Moderate initial costs, Low pressure, Tall canopies, Good uniformity, Low labor requirement
    ii. Cons: Poorly adaptable to irregular or small fields, Not suitable for variable topography, Field free of obstructions

d. **Hand Move Sprinklers** ($175-275/A):
    i. Pros: Cheap initial investment, Moderate pressure required
    ii. Cons: High labor requirement, Not for tall canopies, Not for large areas

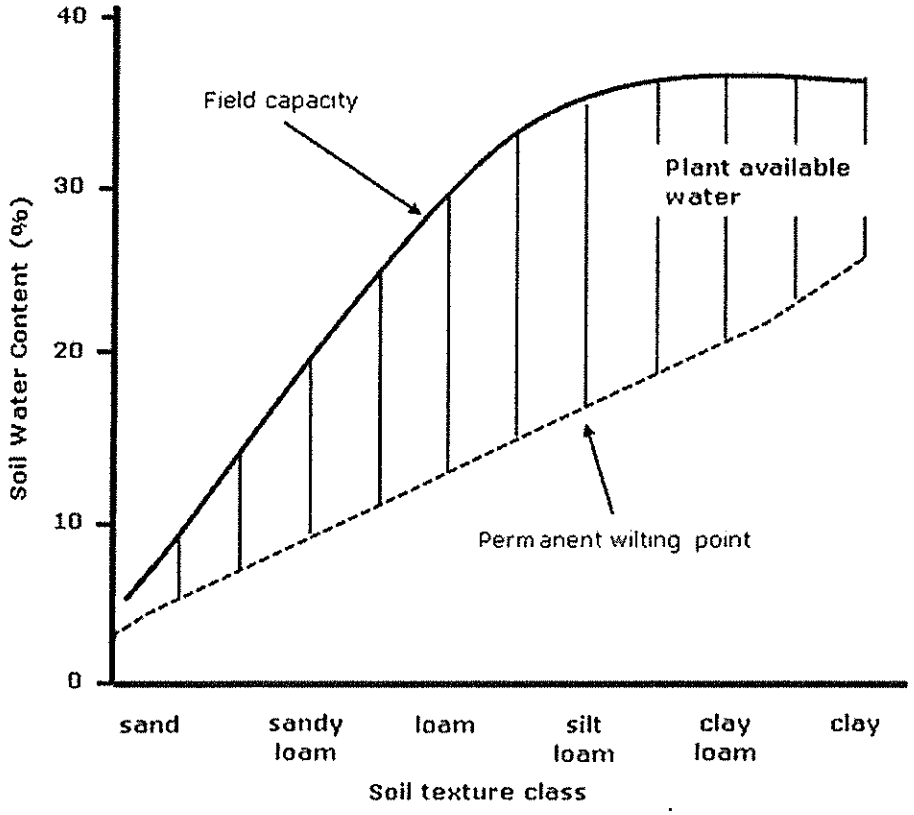
e. **Drip Systems** ($750-1,500/A):
    i. Pros: Good uniformity, High efficiency
    ii. Cons: Expense
        1. Drip System Components: Headworks (media or disk filters)
        2. Pressure Regulators
        3. Lay Flat Delivery

Volume: Most crops need 1-1.5 inches per week, accounting for rainfall, crop, and temperature.

Cautions:
Don't delay irrigation
Under irrigating due to low system capacity
Avoid crop damage with large droplets
Avoid areas of ponding
Avoid soil compaction
Fresh produce safety

Managing Water: You cannot control what you do not measure.

1. Water Holding Capacity – Amount/Volume of water in pore spaces (soil texture and structure), Stay in upper range of this curve to avoid plant stress.
2. Plant Available Water (Field Capacity-Wilting Point) is ½ of the amount at field capacity



http://www.nature.com/scitable/content/generalized-relationship-between-soil-texture-classes-and-59719652

3. Finer textures hold more water than coarser textures (Clay vs Sand)
    a. Rule of Thumb for Soil Texture
        i. 0.4 inch per hour for sandy soils
        ii. 0.3 inch per hour for loamy soils
        iii. 0.2 inch per hour for clay soils
    b. Course soils and shallow rooted crops – Frequent, shallow irrigations
    c. Heavy and deep rooted crops – Infrequent, deep irrigations

Gauging Soil Moisture: Various methods available

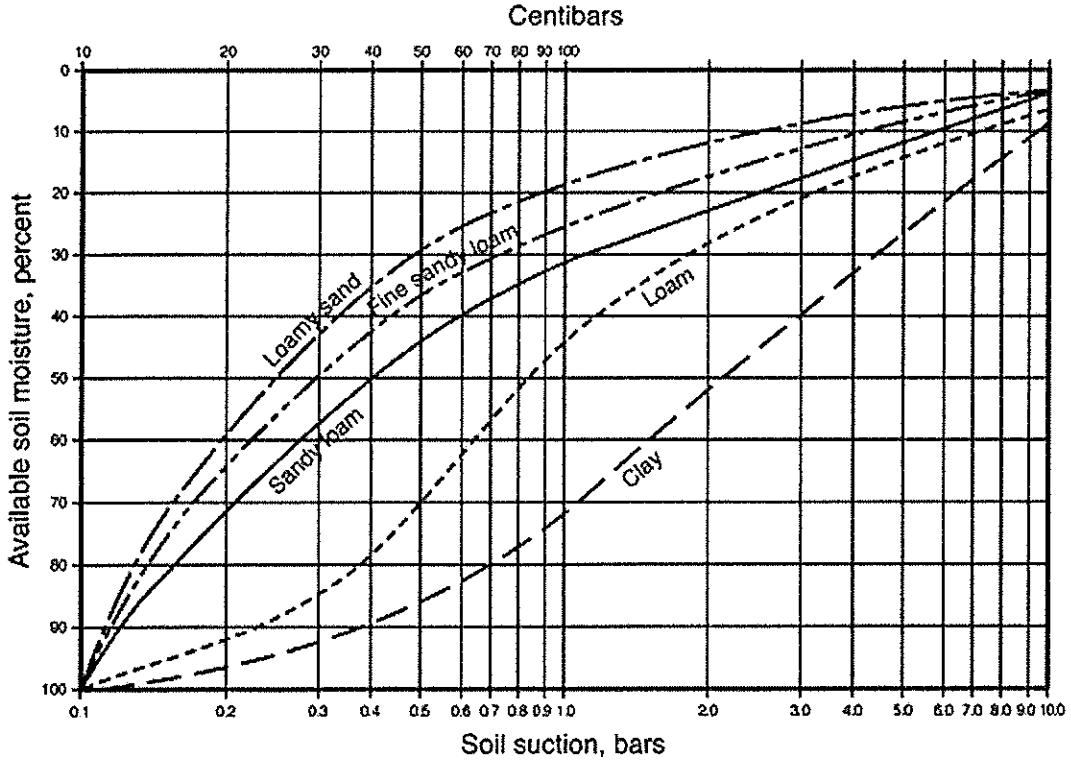
1. "Feel Method" – Subjective, relative to field characteristics (See Table Below)

Moisture level	Sands and Sandy loams	Loams, Clay loams and Clays
Above field capacity	On squeezing, free water oozes from the ball of soil.	Soil very sticky and sloppy. When squeezed is oozes water.
Field capacity (100% available) water	No free water appears on the soil when the ball is squeezed, but wet outline of ball is left on the hand.	Soil sticky. No free water appears on soil when ball is squeezed, but wet outline of ball is left on hand. Possible to roll long thin rods (2mm in diameter) between finger and thumb.
75% available water	Slightly coherent. Will form a weak ball under pressure but breaks easily.	Soil coherent. Soil has a slick feeling and ribbons easily. Will not roll into long thin rods 2mm in diameter.
50% available water	Appears dryish. Forms a ball under pressure, but it seldom holds together.	Soil coherent. Forms ball under pressure. Will just ribbon then pressed between finger and thumb.
25% available water	Appears dry. Will not ball under pressure.	Somewhat crumbly but will form a ball under pressure. Will not ribbon between finger and thumb.
Permanent wilting point	Soil is dry, loose, and flows through fingers.	Crumbly, powdery, Small lumps break into powder. Will not ball under pressure.

http://www.foodforest.com.au/fact-sheets/property-design/irrigation/

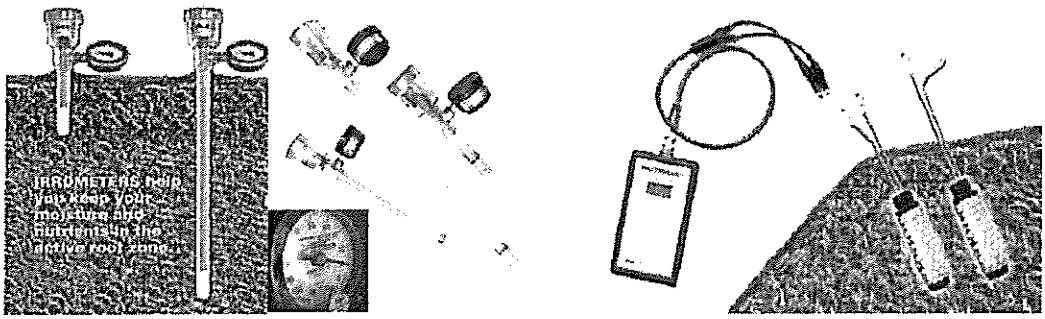
2. Soil Suction Measurement: Less subjective, based on plant/soil properties
    a. Tensiometer – Soil-water suction, easy to use, suitable for medium to course soils (0-0.8 bars)
    b. Ex. Guidelines for various soils when to irrigate
        i. Sand, loamy sand 0.2-0.4 bar
        ii. Sandy loam, loam, silt loam 0.4-0.6 bar
        iii. Clay loam, clay 0.5-10 bar

From: https:/njaes.rutgers.edu/drought/pdfs/vegetableirrigationbmp.pdf



Adapted (with permission) from the *BC Trickle Irrigation Manual*, BC Ministry of Agriculture and Food, Irrigation Industry Association of British Columbia (T.W. Van der Gulik)
Note: 1 kpa = 1 centibar; 100 centibars = 1 bar

3. Electrical Resistance – Gypsum blocks, up to -15 bars



Pictured above: Soil moisture measurement devices A-B) Tensiometers, C) Electrical resistance

Useful Reference Table: Below you will find a useful table for several vegetable crops, highlighting irrigation needs, critical soil moisture period, and drought tolerance and rooting depth.

	Preferred Minimum Soil Moisture								
Crop	Bars	ASM (1)	Amount/Inches in "X" Days	Irrigation Critical Moisture Period	Preferred Irrigation Method (2)	Drought Tolerance(3)	Rooting Depth (4)	Defects Caused by Water Deficit	Comments
Asparagus	-.70	40%	1/20	Crown set and transplanting	a,b	H	D	Shriveling	Will withstand most drought
Beans, dry	-.45	50%	1/7	Flowering	a	M	M	Poor pod fill and small beans	No irrigation after pods begin to dry
Beans, lima	-.45	50%	1/7	Flowering	a,b	L-M	D	Poor pod fill and small beans	Cooling irrigation can increase yield
Beans, pole	-.34	60%	1/5	Flowering	a	L-M	M	Poor pod fill and pithy pods	Steady moisture supply is necessary during flowering
Beans, snap	-.45	50	1/7	Flowering	a	L-M	M	Poor pod fill and pithy pods	Irrigation prior to flowering has little benefit
Beans, soy (edible)	-.70	40%	1/14	Flowering	a,b	M	M	Poor pod fill	Irrigation prior to flowering has little benefit
Beet	-2.00	20%	1/14	Root expansion	a,b	M	M	Growth cracks	
Broccoli	-.25	70%	1/5	Head development	a,b,c	L	S	Strong flavor	
Brussels sprout	-.25	70%	1/5	Sprout formation	a,b,c	M	S	Poor sprout production	

Cabbage	-.34	60%	1/10	Head development	a,b	M-H	S	Growth cracks	
Cantaloupe	-.34	60%	1/10	Flowering and fruit development	a,b	M	S-M		
Carrot	-.45	50%	1/21	Seed germination and root expansion	a,b	M-H	S-M	Growth cracks, misshapen roots	Avoid droughts during root expansion
Cauliflower	-.34	60%	1/5	Head development	a,b,c	L	S	Ricey curd, buttoning	
Celery	-.25	70%	1/5	Continuous	a,b,c,d	L	S	Small petioles	Moisture deficit can stop growth irreversibly
Chinese cabbage	-.25	70%	1/5	Continuous	a,c	L	S	Tough leaves	
Collards	-.45	50%	1/14	Continuous	a,b,c	M	S	Tough leaves	
Corn, sweet	-.45	50%	1/14	Silking	a,b	M-H	S	Poor ear fill	Irrigation prior to silking has little value
Cucumber, pickles	-.45	50%	1/7	Flowering and fruiting	a,b,c	L	S-M	Pointed and cracked fruit	Moisture deficit can drastically reduce yield and quality
Cucumber, slicer	-.45	50%	1/7	Flowering and fruiting	a,b,c	L	S-M	Pointed and cracked fruit	Moisture deficit can drastically reduce yield and quality
Eggplant	-.45	50%	1/7	Flowering and fruiting	a,b,c	M	M	Blossom-end rot, misshapen fruit	

Greens (turnip, mustard, kale)	-.25	70%	1/7	Continuous	a,b	L	M	Tough leaves	Good continuous moisture essential to good yields
Leek	-.25	70%	1/5	Continuous	a,b	L-M	S	Thin scale formation	
Lettuce (head, Bibb, leaf, cos)	-.34	60%	1/7	Head expansion	a,b		D	Tough small leaves	
New Zealand Spinach	-.25	70%	1/5	Continuous	a,b,d	L	S	Tough leaves, poor production	Irrigate to keep growth continuous and rapid
Okra	-.70	40%	1/14	Flowering	a,c	M-H	D	Tough pods	Irrigation can reduce yield
Onion	-.25	70%	1/7	Bulbing and bulb expansion	a,b	L	S	Poor size	
Parsnip	-.70	40%	1/14	Root expansion	a,b	H	D		
Peas, Garden (English)	-.70	40%	1/7	Flowering	a	L	M	Poor pod fill	
Peppers	-.45	50%	1/7	Transplanting flower up to1/2" fruit	a,b,c	M	M	Shriveled pods, blossom-end rot	Irrigate for increased pod size and yield
Potato, Irish	-.35	70%	1/7	After flowering	a,b	M	S	Second growth and misshapen roots	Irrigate only during extreme drought during root development
Pumpkin	-.70	40%	1/14	Fruiting	a,b	M	D	Blossom-end rot	
Radish	-.25	70%	1/5	Continuous	a	L	S	Pithy roots	Keep soil moisture levels high to promote rapid growth

Rhubarb	-2.00	20%	1/21	Leaf emergence	a,b	M	D	Pithy stems	
Rutabagas	-.45	50%	1/14	Root expansion	a,b	M	M	Tough roots	
Southernpeas	-.70	40%	1/14	Flowering and pod swelling	a,b	M	M	Poor pod fill	Plants will recover from drought but yield is reduced
Squash, summer	-.25	70%	1/5	Fruit sizing	a,c	L	M	Pointed and misshapen fruit	Fruit sizing. Irrigation can double or triple yields
Squash, winter	-.70	40%	1/10	Fruit sizing	a,b	M	D		
Sweetpotato	-2.00	20%	1/21	Fruit and last 40 days	a,b	H	D	Small and misshapen roots	
Tomato, staked	-.45	50%	1/5	Fruit expansion	a,c	M	D	Blossom and root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
Tomato, ground	-.45	50%	1/7	Fruit expansion	a,b	M	D	Blossom and root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
Tomato, processing	-.45	50%	1/7	Fruit expansion	a,b	M	D	Blossom and root growth cracks	Continuous water supply helps avoid blossom-end rot and increase fruit size
Turnip	-.45	50%	1/10	Root expansion	a,b	M	M	Woody roots	

Watermelon	-2.00	40%	1/21	Fruit expansion	a,b,c	M-H	D	Blossom end rot	This crop can withstand extreme drought, but there will be some yield reduction

(1)ASM (Available Soil Moisture). Percentage of soil water between field capacity (-0.1 bar) and permanent wilting point (-15 bars).
(2)Irrigation method: a = Sprinkler, b = Big Gun, c = Trickle (drip), d = Flood
(3)Drought tolerance : L = low, needs frequent irrigation; M = moderate, needs irrigation in most years; H = high, seldom needs irrigation.
(4)Depth of rooting, of most roots: S = shallow, 12 to 18 inches; M = moderate, 18 to 24 inches; D = deep, 24 inches plus.

ANR-1169, Reprinted November 2000. J.K. Kemble, *Extension Horticulturist,* Associate Professor, Department of Horticulture, Auburn University; **D.C. Sanders,** *Extension Horticultural Specialist,*Professor, Department of Horticultural Science, North Carolina State University.