Irrigating Vegetables – Understanding when and how long to water

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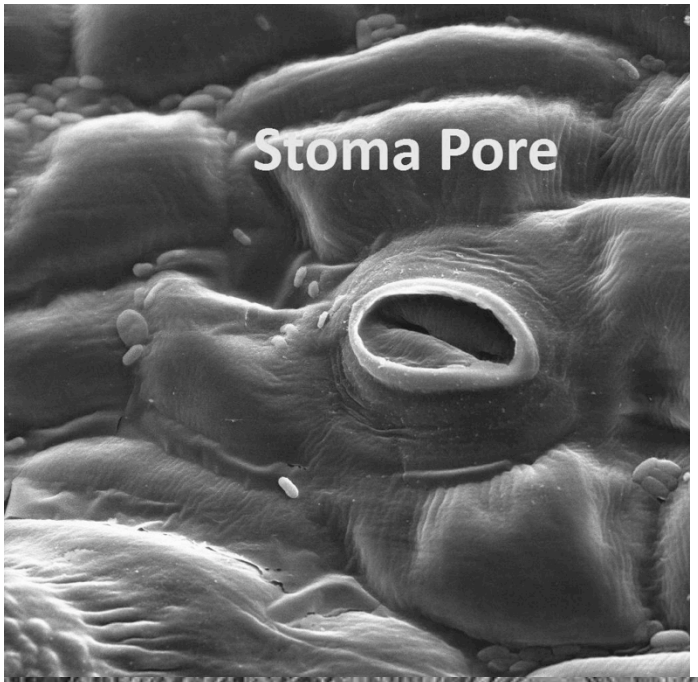
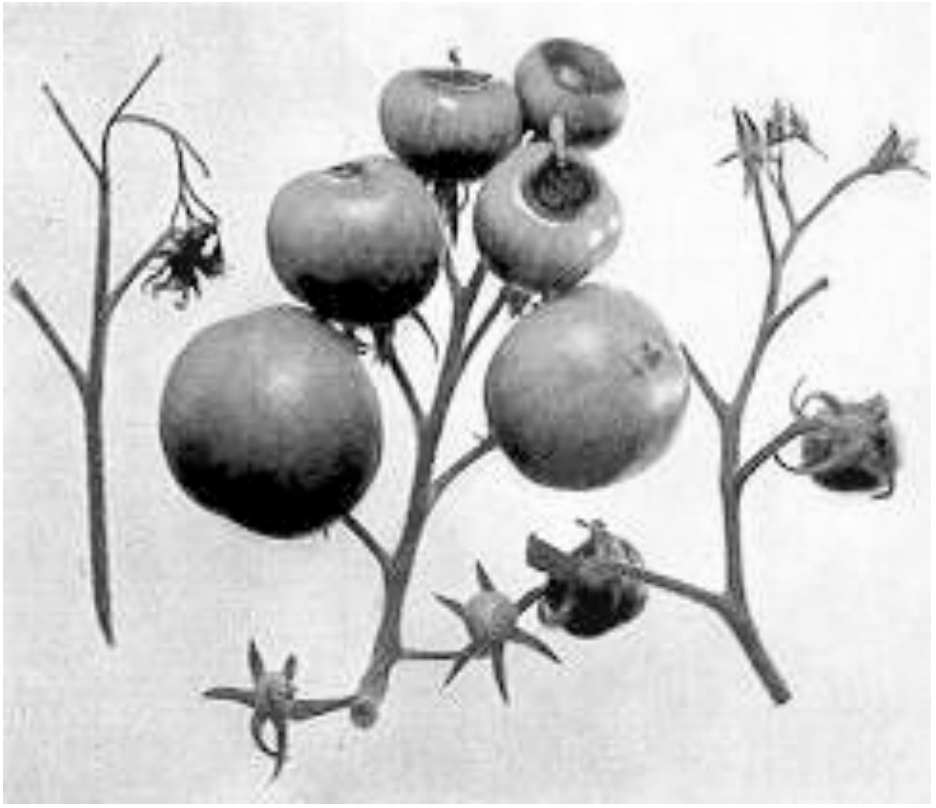
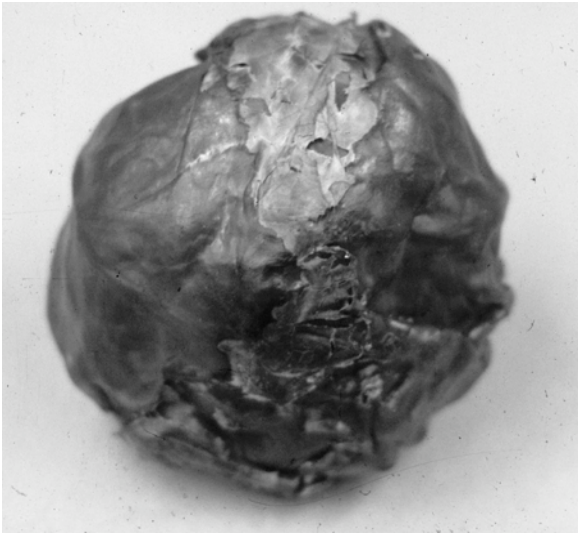


Why does drought reduce yield?

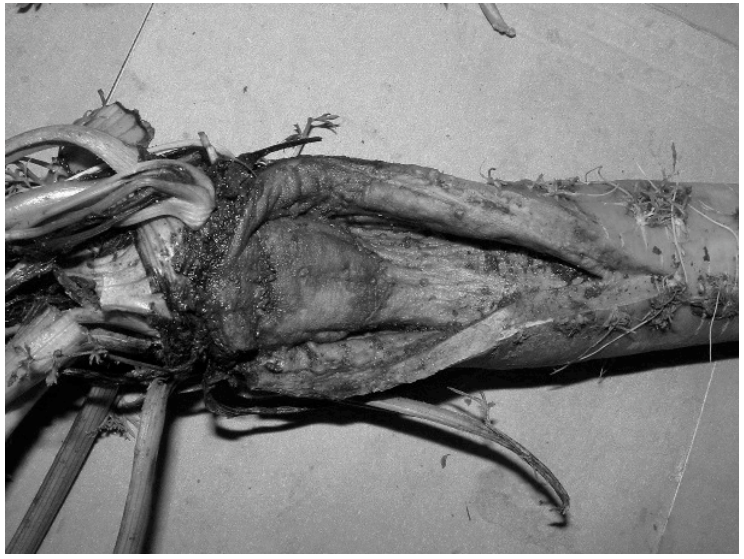
Blossom-end rot - tomato, pepper, eggplant, vine crops



Tipburn - lettuce, endive, escarole, cabbage

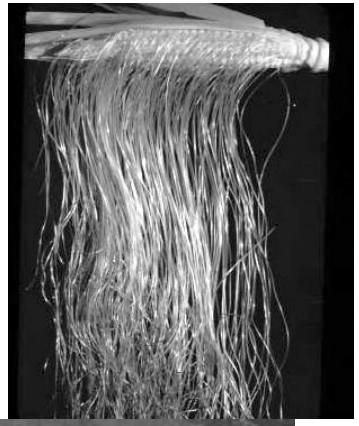


Splits and Cracks



Many Vegetable Crops

Water stress on Sweet Corn



Ear size is determined at the 4 to 10 leaf stage. Moisture stress at this time causes shorter ears

Kernel number and tip fill is determined during and shortly after pollination

Overall quality

Many Vegetable Crops

Why irrigate?

- Improved yield
- Improved quality
- More predictable harvest date

Why trickle?

- Save water
- Less leaching
- Automate
- Less weeds, foliar disease

Critical Irrigation Periods

Crop	Critical Stage for moisture stress
Asparagus	Fern growth
Beans	Flowering, Pod fill
Broccoli, Cabbage, Cauliflower	Establishment and head filling
Carrot	Establishment and root development
Cucumber, melon, pumpkin, squash	Flowering and fruit enlargement
Eggplant	Flowering and fruit development
Lettuce	Head development
Onion	Bulb enlargement
Pea	Flowering, Pod fill
Pepper	Transplanting, fruit set and development
Sweet Corn	Tassel, silk, ear fill
Tomato	Flowering, fruit set, enlargement

Trickle Irrigation

Trickle tapes vary in width, thickness and length from (1,500 to 15,000 feet)

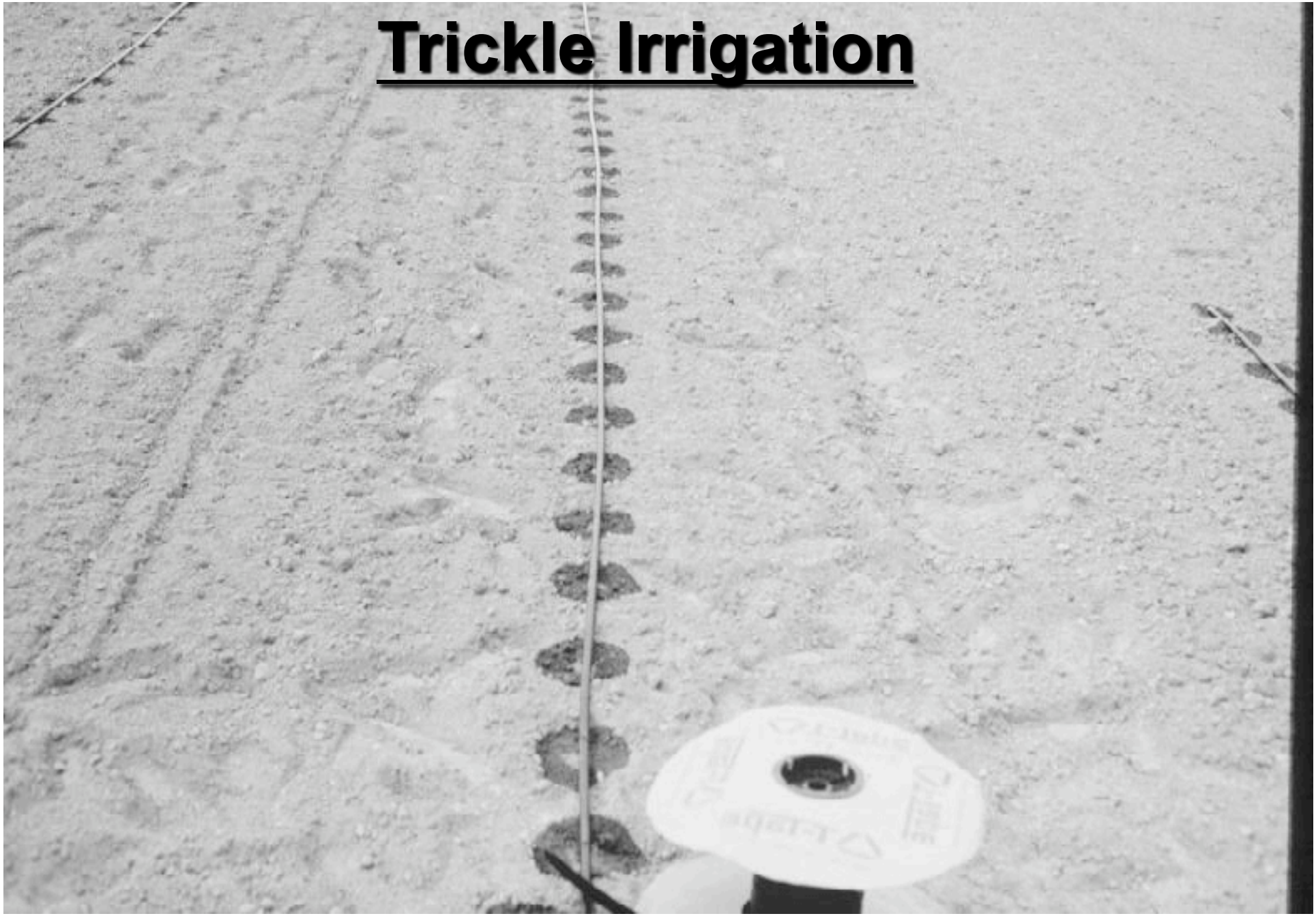
Trickle delivered with low pressure, 8-12 psi

Emitters may be spaced every 4, 8, 12, 16, 20, 24 inches

Flow rate is given as gallons/minute (gpm) per 100 feet of trickle tape

0.22 gpm/100 feet of tape on tomatoes spaced 5 feet between row = 8,712 feet of tape per acre = 19.2 gallons per minute per acre

Trickle Irrigation



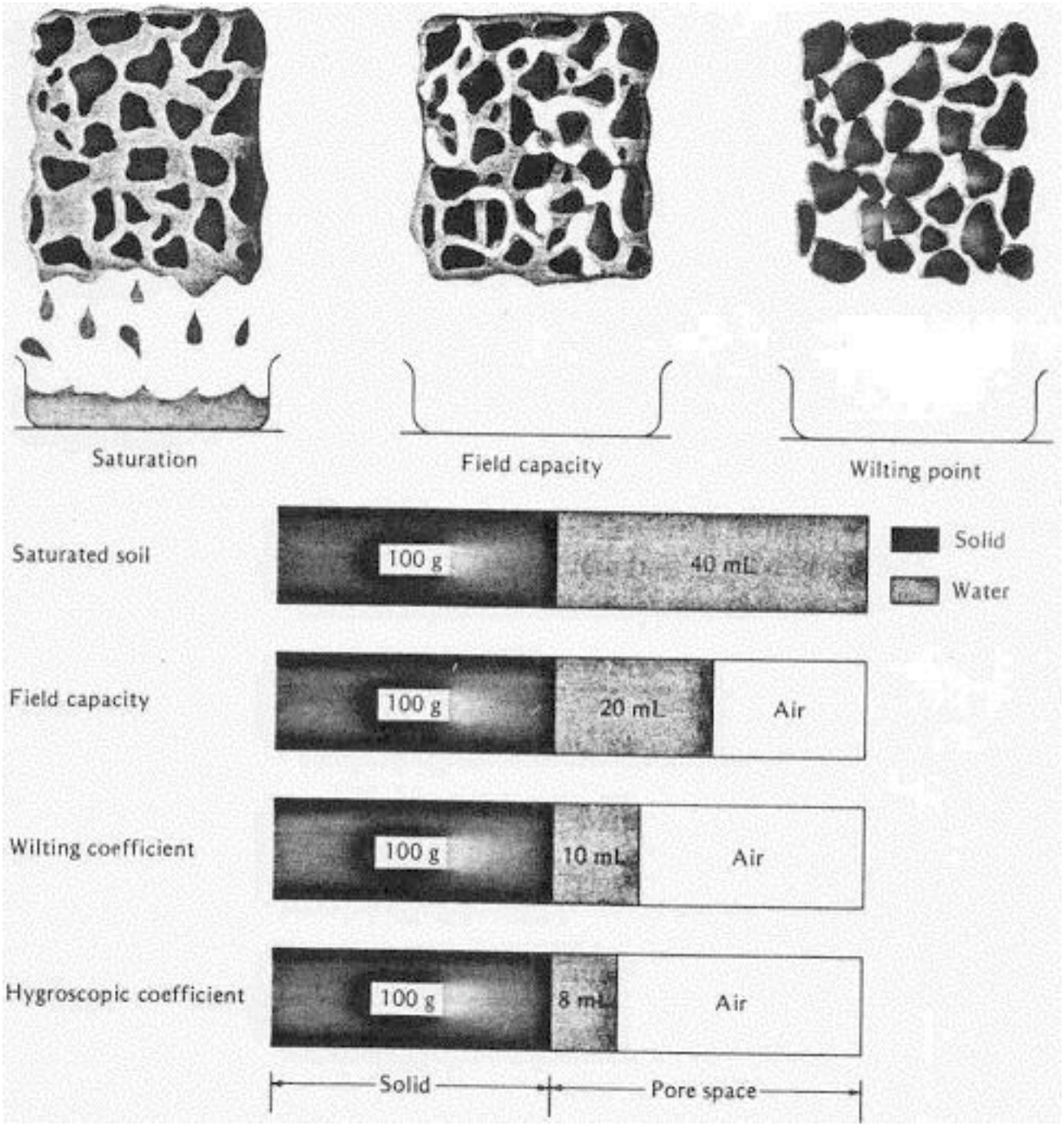
Irrigation terms

Saturated Soil = all soil pores filled with water, soil is saturated. 0-10 centibars (cb).

Field Capacity = After rain/irrigation when excess water has drained from the soil, large soil pores now filled with air, not water. 10-25 cb.

Water holding capacity = total amount of water held by the soil at field capacity, depends on soil type

Evapotranspiration (ET) – Water lost from the soil though evaporation and transpiration from the plant. Depends on time of year, % ground cover, crop rooting depth and weather.


Saturation
Field capacity
Wilting point
Saturated soil
100 g
40 mL
Solid
Water
Field capacity
100 g
20 mL
Air
Wilting coefficient
100 g
10 mL
Air
Hygroscopic coefficient
100 g
8 mL
Air
Solid
Pore space

Factors that determine when to irrigate?

- Soil water lost to evaporation and transpiration
- Soil type - Water holding capacity of soil
- Depth of crop rooting

How to monitor evaporation/ transpiration?

- Plant cues (wilting)

By the time the symptoms are seen, leaf expansion has slowed, photosynthesis is reduced, harvest date may be delayed, yield potential reduced, and defects may be induced (tipburn, blossom-end rot, cracks/splits)

How to monitor when to irrigate?

Soil Monitors

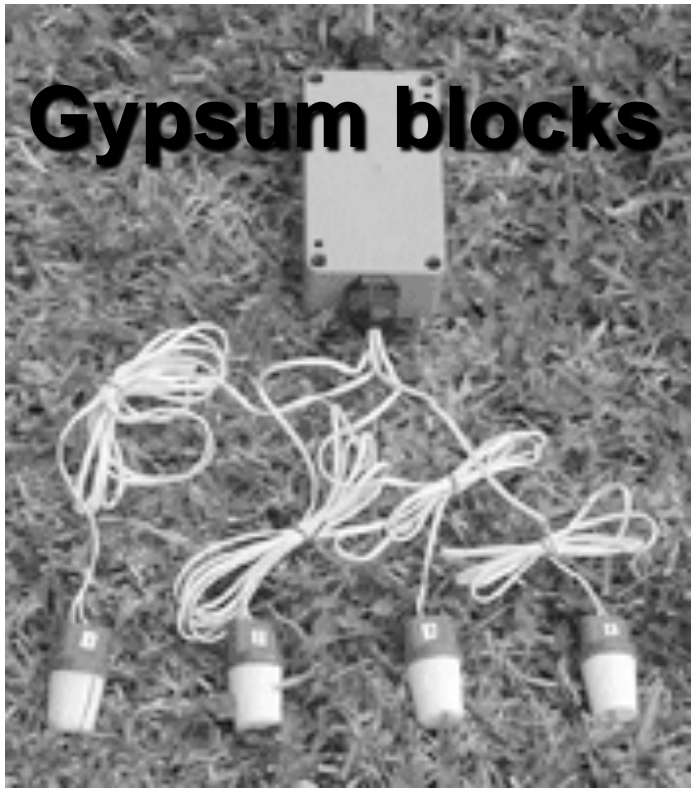
Electrical conductivity

- **Gypsum blocks**
- **Ceramic (Watermark) sensors**

Pressure gauge

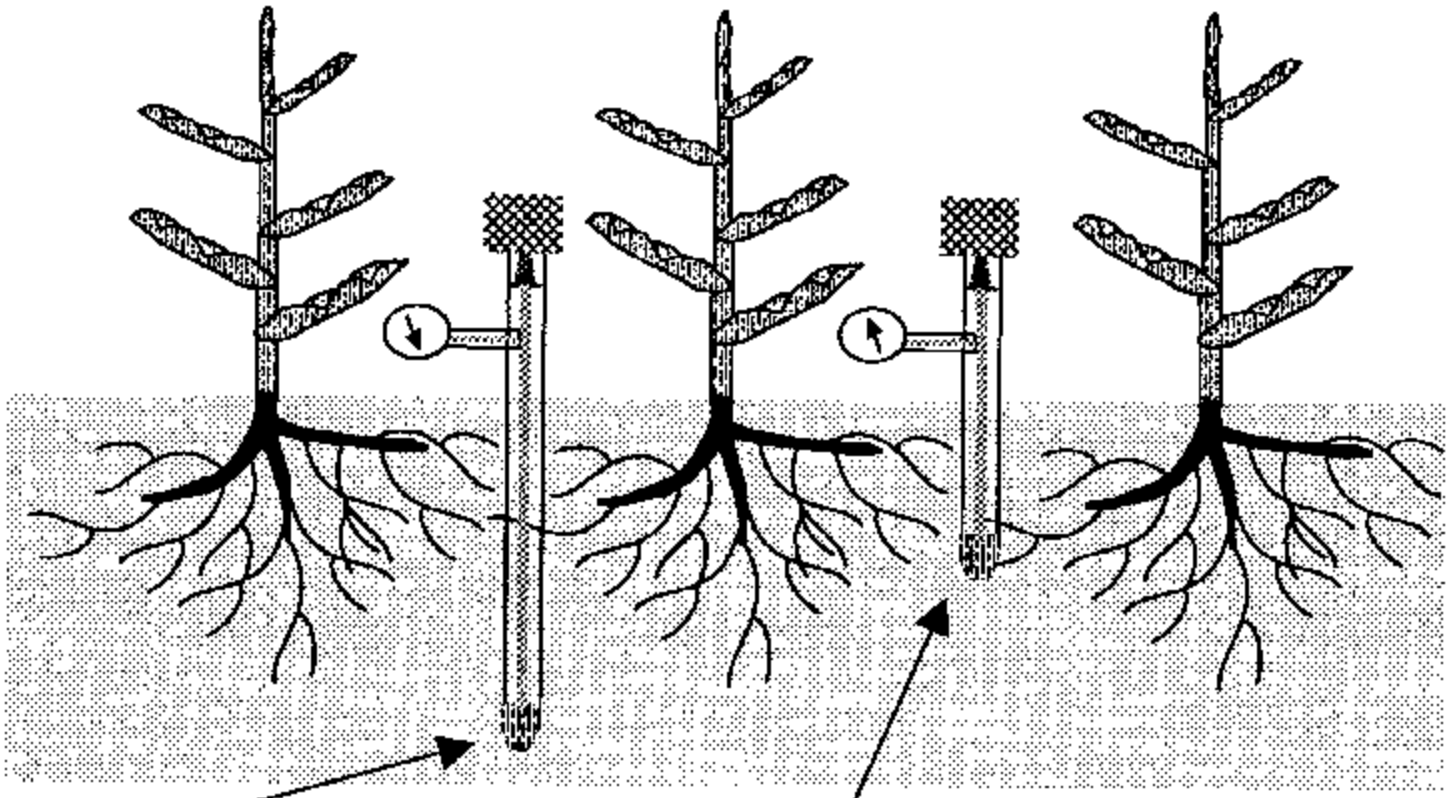
- **Tensiometers**


Tensiometer


Gypsum blocks


Watermark

Tensiometer placement – use two in same location, one shallow at 6 to 8 inches and one at bottom or root zone, 12 to 14 inches.



Tensiometer placement –

Don’t push into ground, make hole with 1 inch diameter rod

Add some water to hole

Mound soil around tensiometer to prevent a depression

Follow manufacturers directions on use

Soil Moisture readings, in centibars, for soil moisture conditions on various soil textures.		
Soil Texture	Field Capacity[1]	20% Depletion[2]
Sandy loam	5-10	10-15
Loam	10-15	22-30
Silt loam	15-20	25-35
Clay loam	25-40	40-50

[1]Soil saturated, do not irrigate

[2]20 - 25% of available water in root zone is gone, begin irrigating

Estimating your “water budget” – simple method

Based on Evapotranspiration. ET depends on the time of year, % ground cover, rooting depth, and sunshine conditions. Plastic mulch can cut ET by 50 -75%. Weedy fields can increase ET.

Vegetable crops require about 1 to 1.5 inches of rain/irrigation per week (best applied in 0.33-0.5 inch increments). Apply when 20% of water at field capacity has been lost.

One inch of water, spread across one acre of land (one acre inch) equals 27,000 gallons

Estimating evapotranspiration – one acre, no mulch, per day – assuming seasonable conditions in New York.

	Evapotranspiration (Gal/Acre/Day)	
Month	**60-79% Ground Cover**	**80 to 100% Ground Cover**
May	2,100	3,300
June	3,000	4,300
July	3,500	4,900
August	3,500	4,900
September	3,000	4,300
October	2,200	3,300

Factors that determine when to irrigate?

- Soil water lost to evaporation and transpiration
- Soil type - Water holding capacity of soil
- Depth of crop rooting
- Mulch or no mulch

Total available water of various soils at field capacity.	
Soil Class	Available water storage capacity in gallons, one foot deep
Gravelly sandy loams	27,000
Sandy loams	36,450
Gravelly loams	47,250
Loams/silt loams/silty clay loams	54,000
Organic (muck) soils	67,500

Irrigation should occur when 20-25% of available water is depleted

1 acre inch of water = 27,000 gallons

Total available water at field capacity	
Soil Class	Available water storage capacity in gallons, one foot deep
Sandy loams	36,450 gal

Sandy Loam Example

Rooting depth of 1 foot = 36,450 gallons

20% to 25% loss would be 7,300 – 9,100 gallons

We estimate we're losing 4,900 gallons per day in July, with a full canopy and no mulch

Water needed every 2 days – 9,800 gallons/0.35 inches

Total available water of various soils at field capacity.	
Soil Class	Available water storage capacity in gallons, one foot deep
Loams/silt loams	54,000

Silt Loam Example

Rooting depth of 1 foot = 54,000 gallons

20% to 25% loss would be 10,800 – 13,500 gallons

We estimate we're losing 4,900 gallons per day in July, with a full canopy and no mulch

Water needed every 3 days – 14,700 gallons

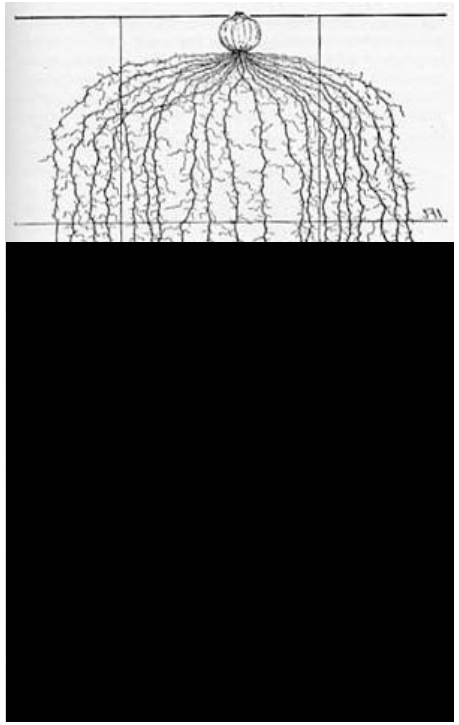
Factors that determine when to irrigate?

- Soil water lost to evaporation and transpiration
- Soil type - Water holding capacity of soil
- Depth of crop rooting
- Mulch or no mulch

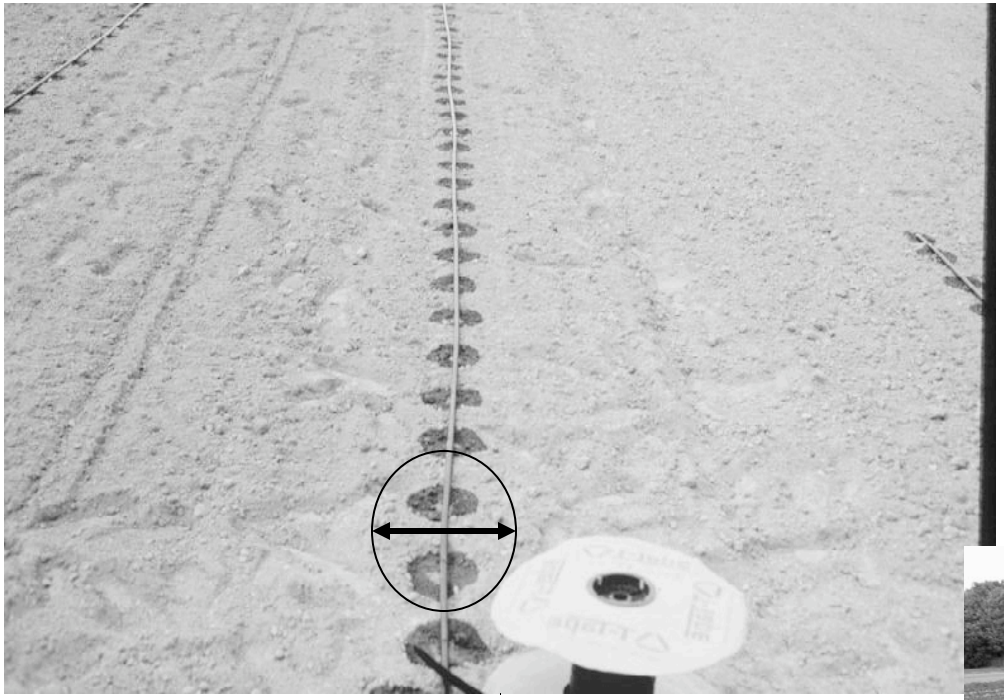
Root depth

- For most crops in plastic mulch, only 1 to 1.5 feet when transplanted, we'll assume 1 foot for our examples

- Assumes no compacted soils



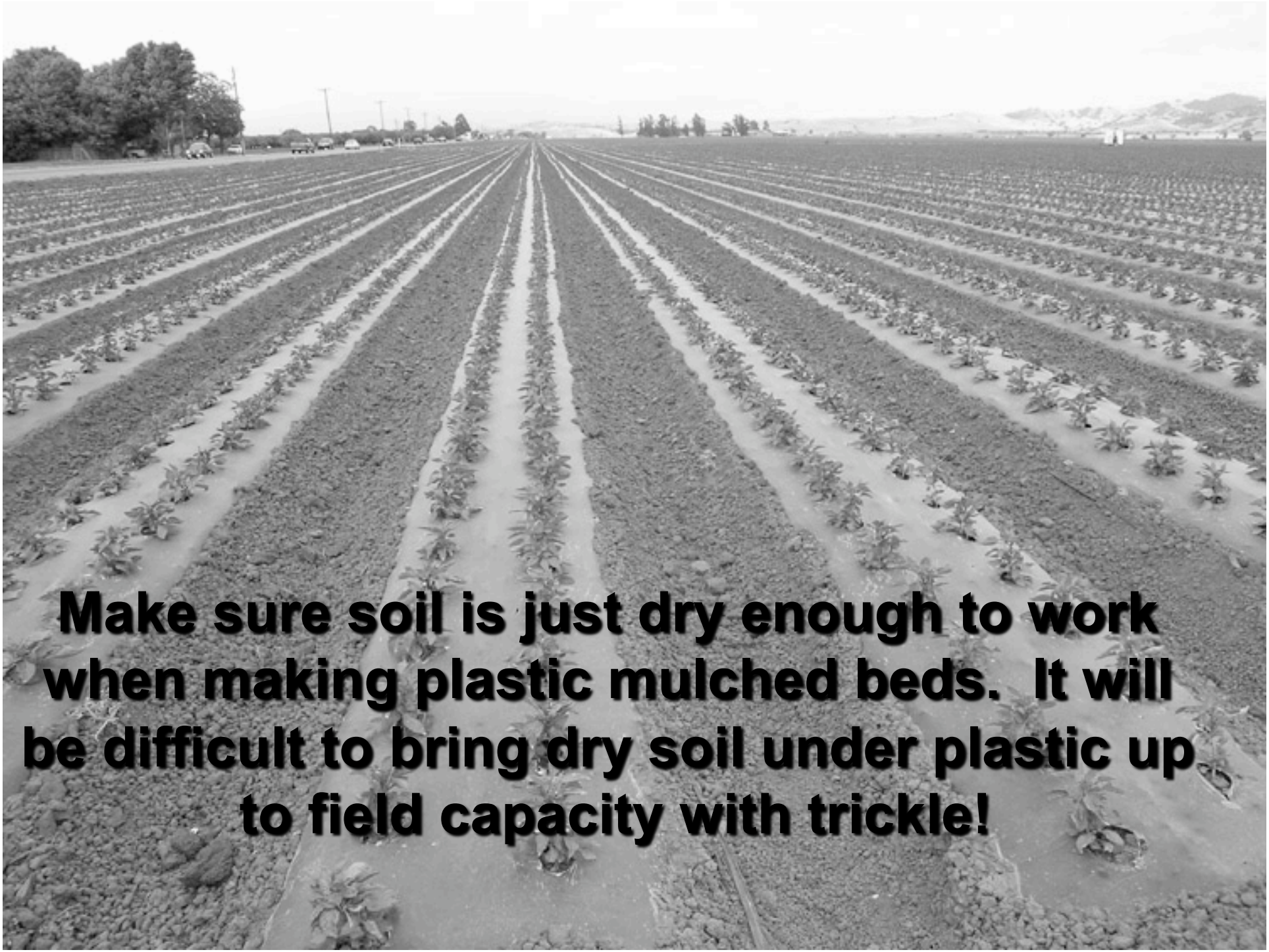
Width of Wetted Area



Assume 3 feet for plastic mulch

Best way is to check wetted area under plastic first time you irrigate


When do we water and for how long -
example with peppers
Spaced on 6 foot centers


Make sure soil is just dry enough to work when making plastic mulched beds. It will be difficult to bring dry soil under plastic up to field capacity with trickle!

Step 1 – Determine soil type and water holding capacity of soil

Sandy loam

Total available water of various soils at field capacity.	
Soil Class	Available water storage capacity in gallons, one foot deep
Gravelly sandy loams	27,000
Sandy loams	36,450
Gravelly loams	47,250
Loams/silt loams/silty clay loams	54,000
Organic (muck) soils	67,500

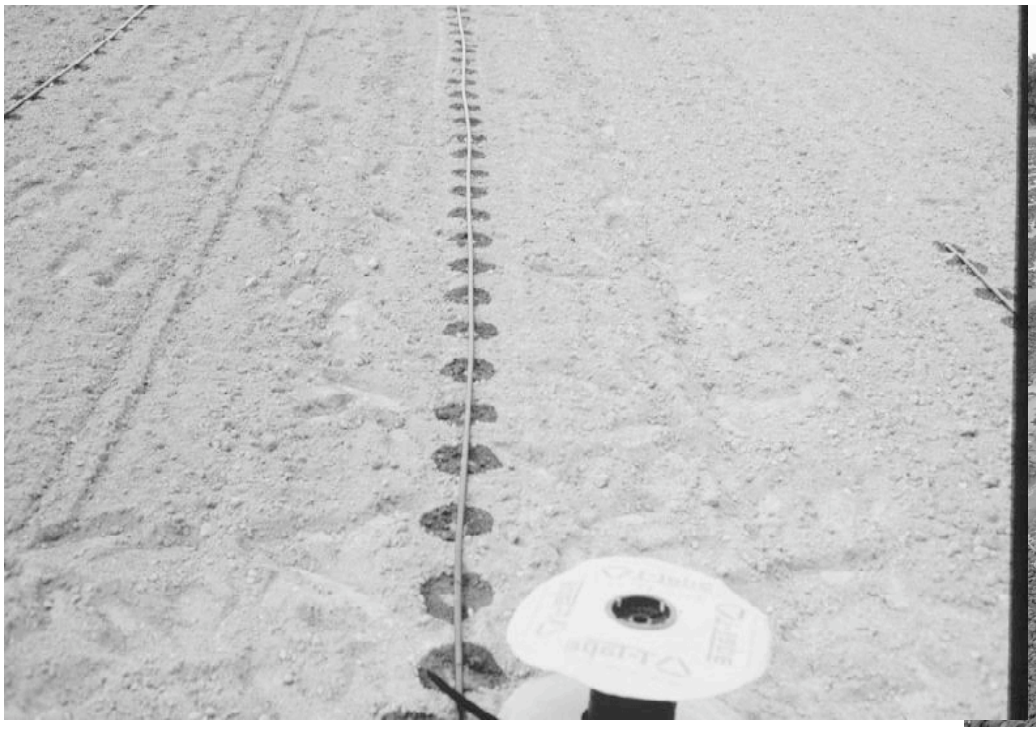
Step 2 – Determine length of plastic/trickle in field, based on one acre

43,560 divided by between row spacing (ft.)

43,560 / 6 = 7260 linear feet of mulch/trickle

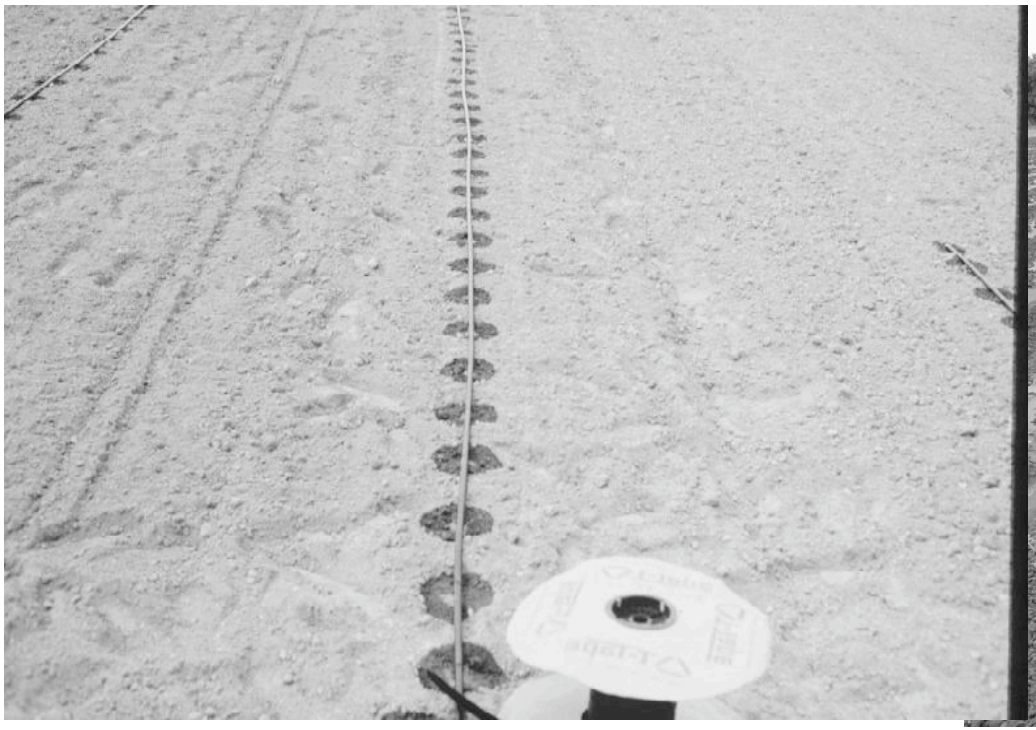
43,560 is the number of square feet in one acre

Step 3 – Determine width of wetted area under plastic



<u>3.0 feet</u>

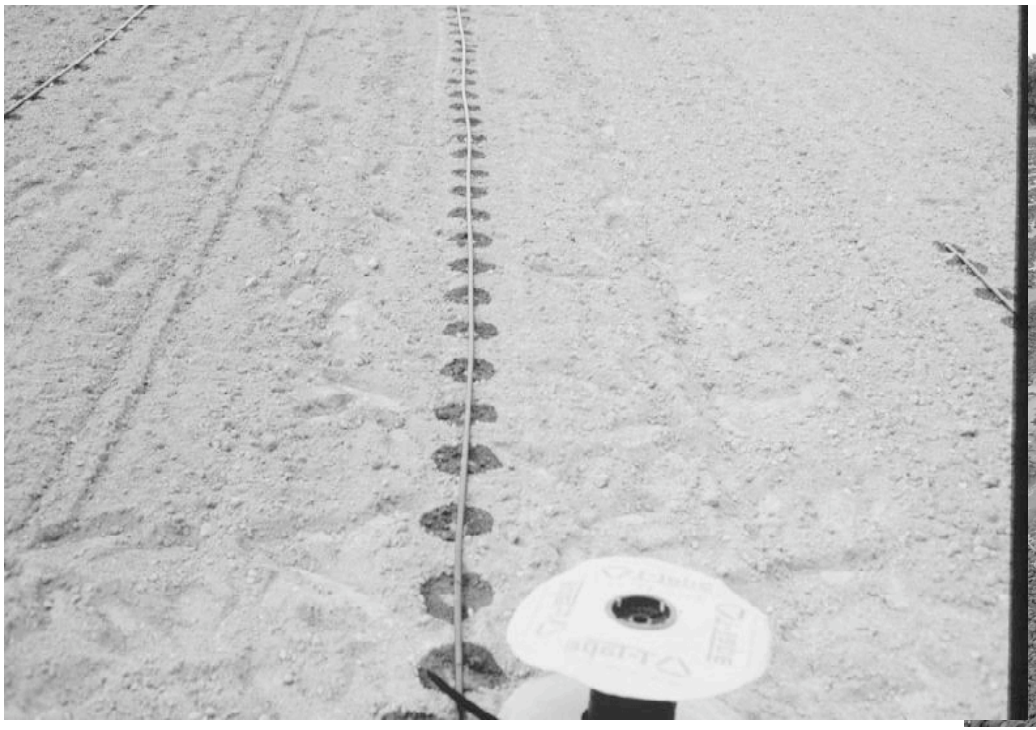
Step 4 – Calculate square feet per acre that are wetted/under mulch



Length of Mulch (7,260 ft.) x Wetted width (3 ft.) =

21,780 square feet

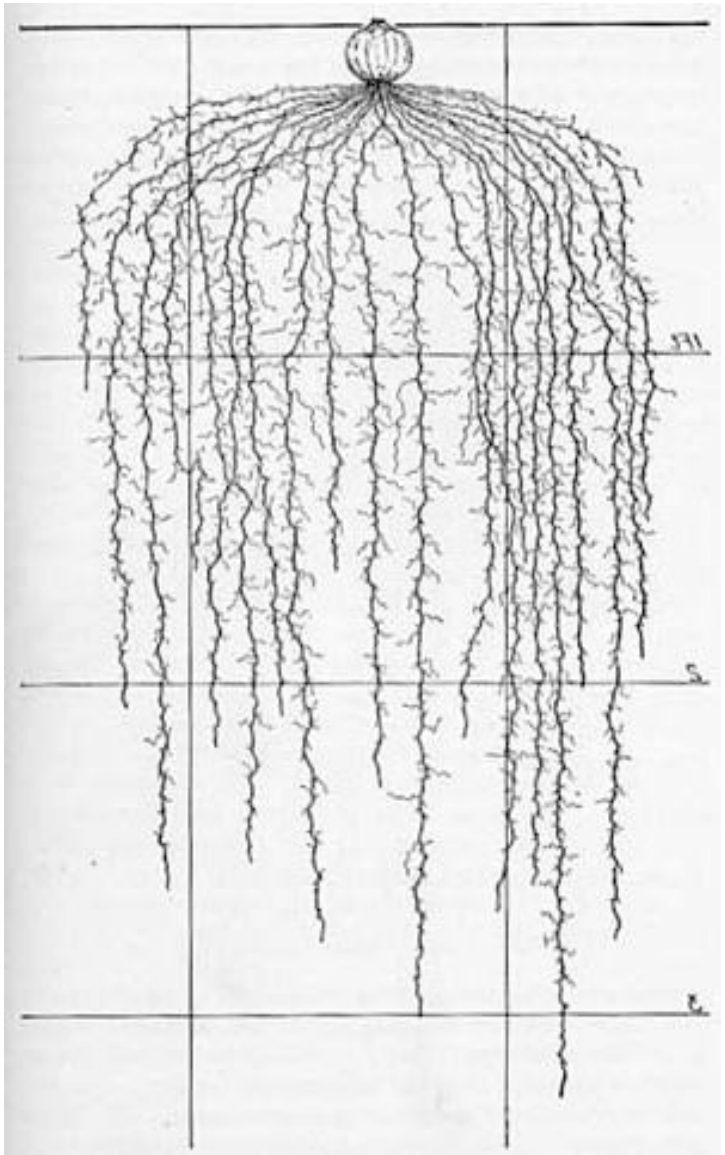
Step 5 – Calculate the % of the acre actually wetted



<u>Wet square feet (21,780)</u> divide by <u>43,560 ft. =</u>

<u>50%</u>

Step 6 – Estimate the rooting depth of crop
Let's assume <u>1 foot</u>



Step 7 – Calculate total gallons of available water at field capacity, based on soil type, depth of rooting, and width of wetted area

Total available water of various soils at field capacity.	
Soil Class	Available water storage capacity in gallons, one foot deep
Gravelly sandy loams	27,000
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Loams/silt loams/silty clay loams	54,000
Organic (muck) soils	67,500

Step 7 – Calculate total gallons of available water at field capacity, based on soil type, depth of rooting, and width of wetted area

From Table – For our sandy loam soil, 1 acre at field capacity, 1 foot deep contains = 36,450 gallons

36,450 gallons = Total held in entire acre

But

We only care about the 50% of the acre in the wetted area under plastic…
36,450 gallons x 0.50 = 18,225 gallons

Step 8 – Calculate total gallons of water lost when soil moisture is reduced 20%

18,225 gallons x 0.20 = 3,645 gallons

Is the amount we need to add to 1 acre under mulch to bring back to field capacity

Step 9 – Calculate time it takes to lose 3,645 gallons

Assumptions

We know one acre of unmulched soil will lose 4,900 gallons/day in mid-summer with full canopy

With half the field covered with mulch, that reduces field size by 50% to 2,450 Gal/day

Mulch will cut the ET loss by 50%, which cuts the water loss to 1225 Gal/Day. In 3 days we lose 3,675 gallons, about 20%.

Irrigate at least every 3 days, with 3700 gallons

Step 10 – Calculate gallons per minute (GPM) for one acre

Check flow rate of trickle tape (always rated in Gallons per minute 100 feet of length)

If we have a tape with 0.25 GPM/100 feet

We have 7260 feet of trickle tape on one acre
(43,560 ft^2 per Acre/6 ft. row spacing = 7,260)

In one minute we will use 18.15 gallons
(7260/100) x 0.25 GPM = 18.15 GPM for 1 acre

Step 11 – Calculate time system needs to run to supply 3,700 gallons

In one minute we will use 18.15 gallons

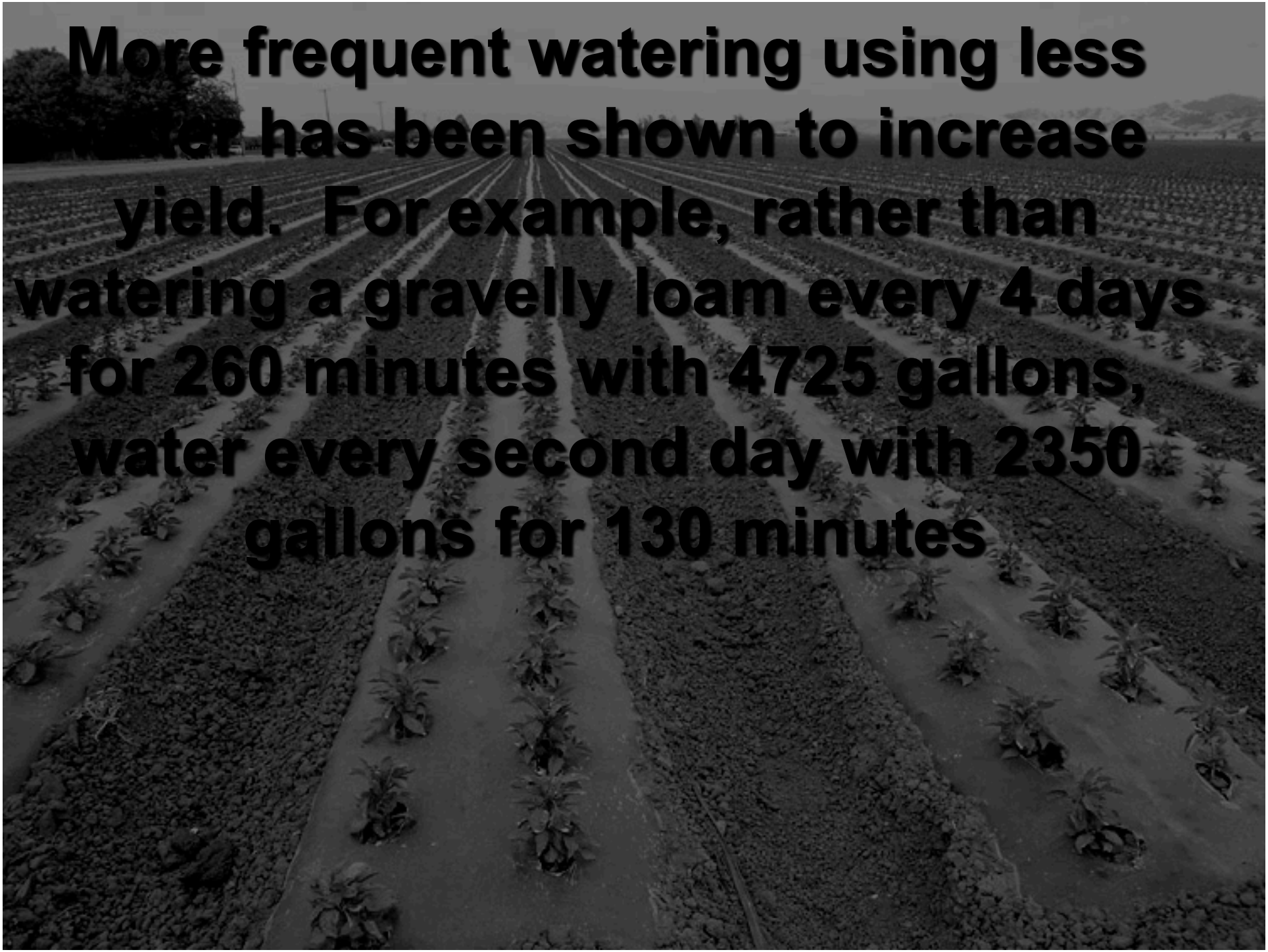
3700 Gallons divide by 18.15 GPM/Acre = 204 minutes or 3.5 hours

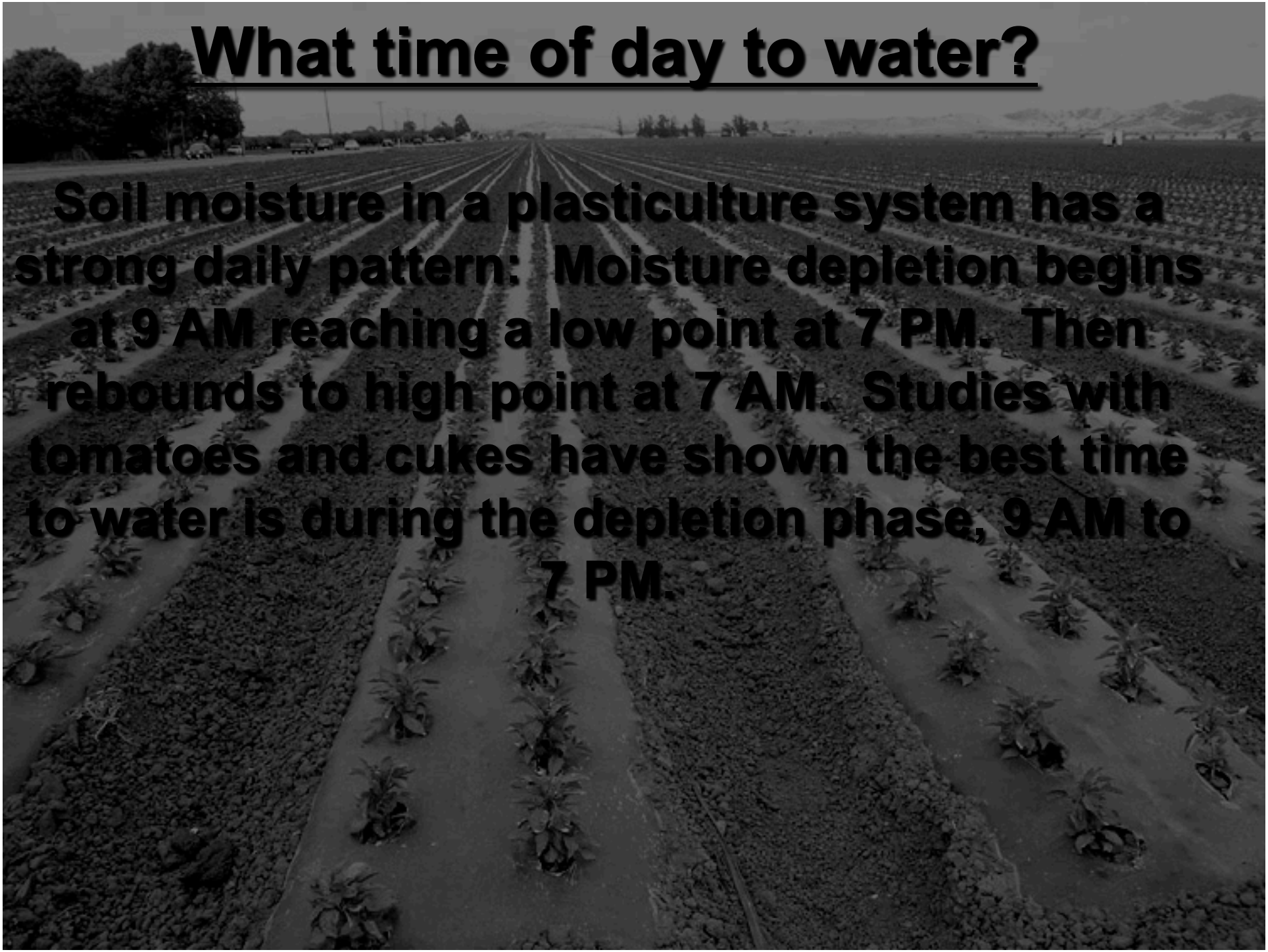
If we used a trickle tape that provided 0.5 GPM per 100 feet, we would cut time in half

For plantings on 6 foot centers during July and August. Assuming 1225 gallons lost from mulched acre each day

Soil Type	Gallons lost at 20% Field Capacity	Days between Irrigations	Irrigation Time (min)*
Gravelly sandy loams	2700	2	150
Sandy loams	3650	3	200
Gravelly loams	4725	4	260
Loams/silt loams/ silty clay loam	5400	5	300
Organic (muck) soils	6750	6	370

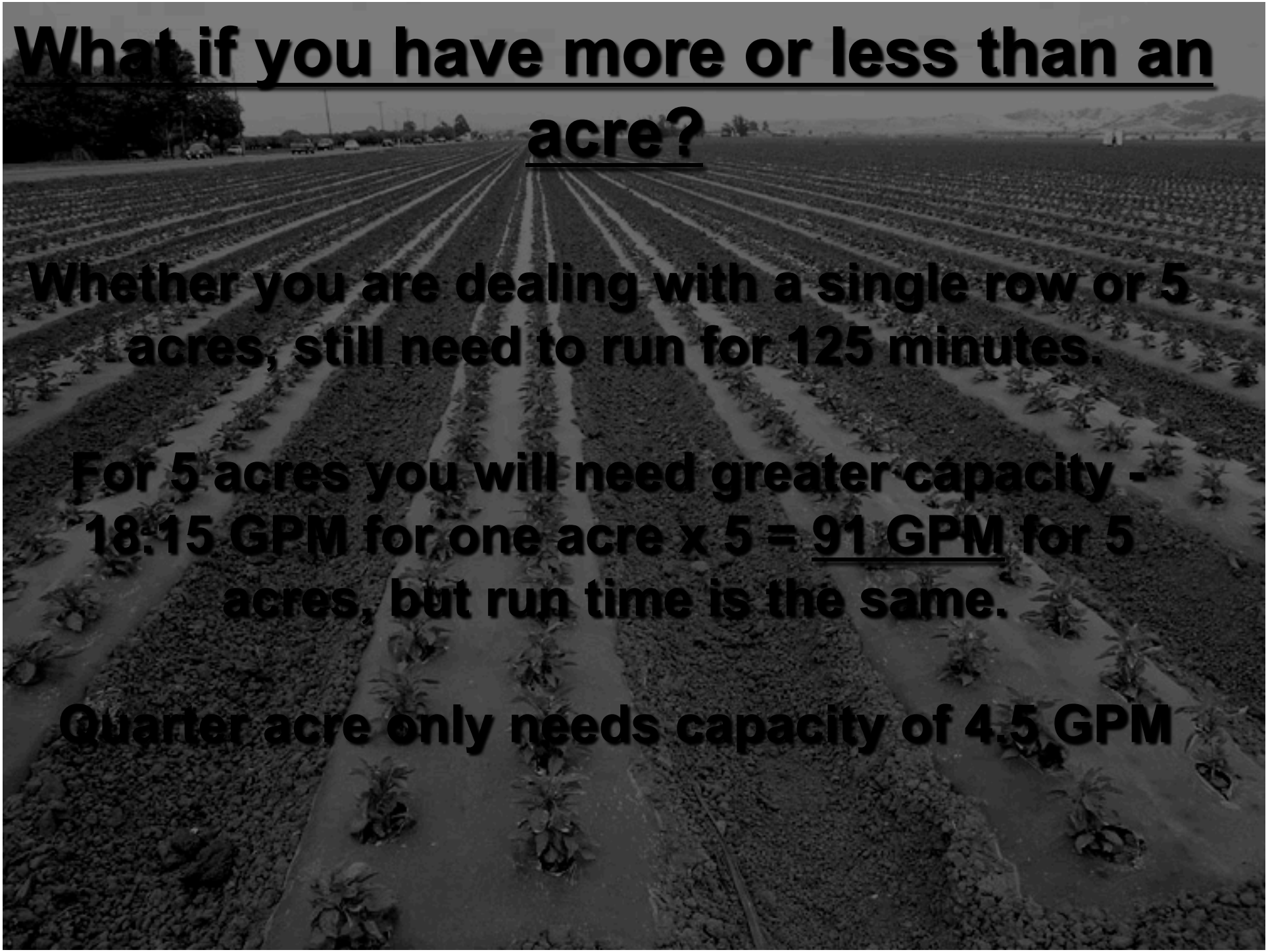
***Using 0.25 GPM/100 foot tape, delivering 18.15 GPM per Acre**


More frequent watering using less
has been shown to increase
yield. For example, rather than
watering a gravelly loam every 4 days
for 260 minutes with 4725 gallons,
water every second day with 2350
gallons for 130 minutes



What time of day to water?

Soil moisture in a plasticulture system has a strong daily pattern: Moisture depletion begins at 9 AM reaching a low point at 7 PM. Then rebounds to high point at 7 AM. Studies with tomatoes and cukes have shown the best time to water is during the depletion phase, 9 AM to 7 PM.



What if you have more or less than an acre?

Whether you are dealing with a single row or 5 acres, still need to run for 125 minutes.

For 5 acres you will need greater capacity - 18.15 GPM for one acre x 5 = 91 GPM for 5 acres, but run time is the same.

Quarter acre only needs capacity of 4.5 GPM

For plantings on 5 foot centers during July and August. Assuming 1470 gallons lost from mulched acre each day

Soil Type	Gallons lost at 20% Field Capacity	Days between Irrigations	Irrigation Time (min)*
Gravelly sandy loams	3240	2	180
Sandy loams	4380	3	240
Gravelly loams	5670	4	310
Loams/silt loams/ silty clay loam	6480	5	360
Organic (muck) soils	8100	6	350

*Using 0.25 GPM/100 foot tape, delivering 18.15 GPM per Acre

For plantings on 7 foot centers during July and August. Assuming 1050 gallons lost from mulched acre each day

Soil Type	Gallons lost at 20% Field Capacity	Days between Irrigations	Irrigation Time (min)*
Gravelly sandy loams	2320	2	130
Sandy loams	3140	3	180
Gravelly loams	4070	4	220
Loams/silt loams/ silty clay loam	4700	5	260
Organic (muck) soils	5805	6	320

*Using 0.25 GPM/100 foot tape, delivering 18.15 GPM per Acre