

Irrigation Techniques for Vegetable Production

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Class objectives

Irrigation techniques will answer the following:



1) How much water to irrigate?



2) When to irrigate?



3) What is the suitable Run Time?



4) What is efficiency of each method?



5) Where to obtain the water?



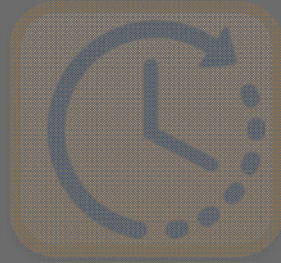
5) How to apply these techniques?

Class objectives

Irrigation techniques will answer the following:



1) How much water to irrigate?



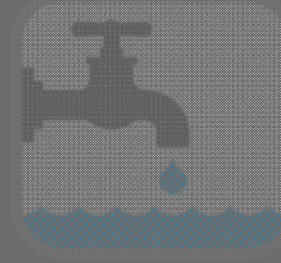
2) When to irrigate?



3) What is the suitable Run Time?



4) What is efficiency of each method?



5) Where to obtain the water?

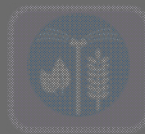


5) How to apply these techniques?

How much water to irrigate?

- ***What is vegetable water requirement?***

It is the rate of evapotranspiration (ET_{veg}) necessary to sustain optimal growth vegetable crop (mm/day)



[See video](#)

How much water to irrigate?

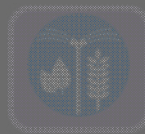
- *How to determine vegetable water requirement?*

By using class A pan,

$$ET_{veg} = K_p \times E_{pan} \quad Eq. 1$$

where K_p = Pan crop coefficient, **Table 1**

E_{pan} = Evaporation rate (mm/day), **Table 2**



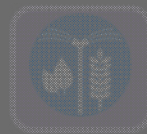
How much water to irrigate?

Table 1 | Pan crop coefficients from Class-A Pan

Vegetable	Kp as Growth rate percentage										
	0	10	20	30	40	50	60	70	80	90	100
Long root depth	0.20	0.20	0.25	0.35	0.50	0.65	0.70	0.60	0.45	0.35	0.20
Shallow root depth	0.10	0.20	0.40	0.50	0.60	0.60	0.60	0.55	0.45	0.35	0.3

Table 2 | Evaporation Rate (mm/day)

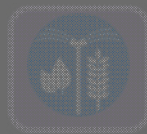
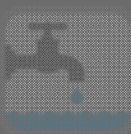
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ep.	3.3	4.5	6.4	8.0	6.5	6.3	5.0	6.0	4.5	4.8	5.0	5.0



Example:

Determine water requirement of Chinese morning glory given it is planted in March with a growth rate of 20 days to harvest.

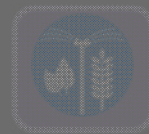
The calculated water requirement of morning glory water is shown in **Table 3**.



Example:

Table 3. Water requirement for Chinese morning glory

Growth day	0	2	4	6	8	10	12	14	16	18	20
% Growth	0	10	20	30	40	50	60	70	80	90	100
Kp	0.20	0.20	0.25	0.35	0.50	0.65	0.70	0.60	0.45	0.35	0.20
Ep (mm/day)	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40
Etcrop (mm/day)	1.28	1.28	1.60	2.24	3.20	4.16	4.48	3.84	2.88	2.24	1.28



How much water to irrigate?

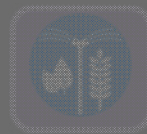
- *How to determine Irrigation Water Requirement (IWR)?*

$$IWR_{veg} = ET_{veg} / \text{method efficiency}$$

Eq. 2

Each irrigation method has varied efficiency:

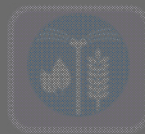
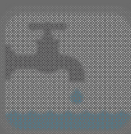
- Surface 50-70%
- Sprinkler 70-80%
- Micro-Irrigation 80-95%



Example: IWR for each irrigation method

Table 4. Irrigation Water Requirement

Growth day	0	2	4	6	8	10	12	14	16	18	20
% Growth	0	10	20	30	40	50	60	70	80	90	100
Kp	0.20	0.20	0.25	0.35	0.50	0.65	0.70	0.60	0.45	0.35	0.20
Ep (mm/day)	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40	6.40
Etcrop (mm/day)	1.28	1.28	1.60	2.24	3.20	4.16	4.48	3.84	2.88	2.24	1.28
IWR (mm/day)											
- Surface 55%	2.33	2.33	2.91	4.07	5.82	7.56	8.15	6.98	5.24	4.07	2.33
- Sprinkler 75%	1.71	1.71	2.13	2.99	4.27	5.55	5.97	5.12	3.84	2.99	1.71
- Micro 80%	1.60	1.60	2.00	2.80	4.00	5.20	5.60	4.80	3.60	2.80	1.60



[See video](#)

Class objectives

Irrigation techniques will answer the following:



1) How much water to irrigate?



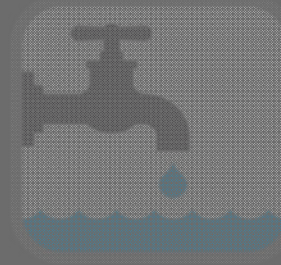
2) When to irrigate?



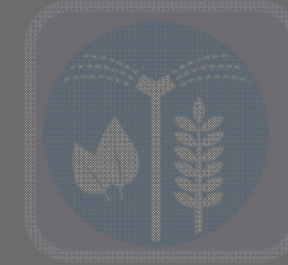
3) What is the suitable Run Time?



4) What is efficiency of each method?



5) Where to obtain the water?

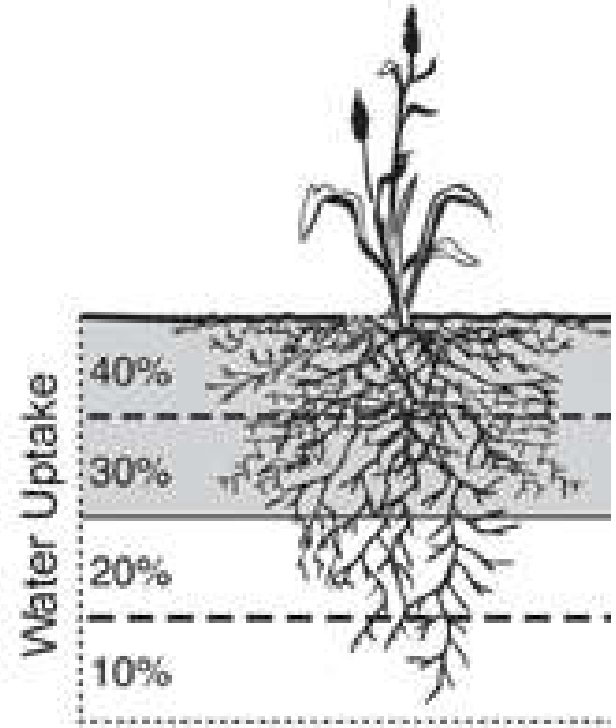


5) How to apply these techniques?

When to irrigate your vegetables?

A commonly-used indicator for when to irrigate is the moisture depletion in soil

As a vegetable grows, it uses up the water with in the soil profile of its root zone



When to irrigate your vegetables?

Practically, the moisture of soil is related to the matric potential.

For high yield crop production, the matric potential is 30 centibar and thus can be measured by tensiometer



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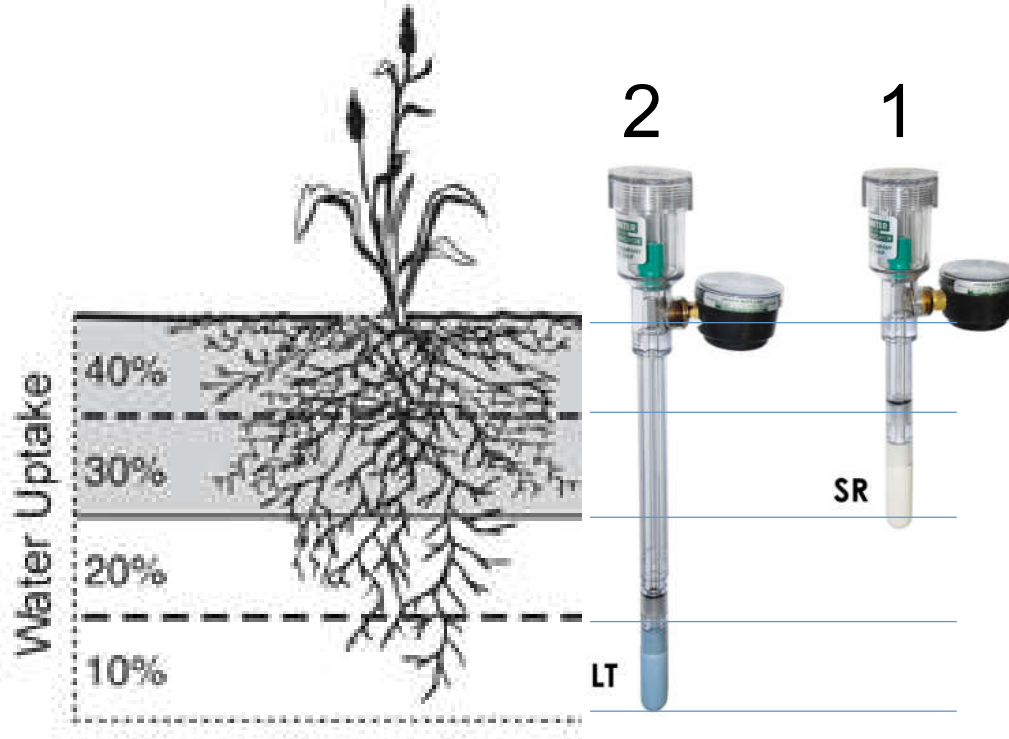


[See video](#)

Determine irrigation interval

Two tensiometers must be installed:

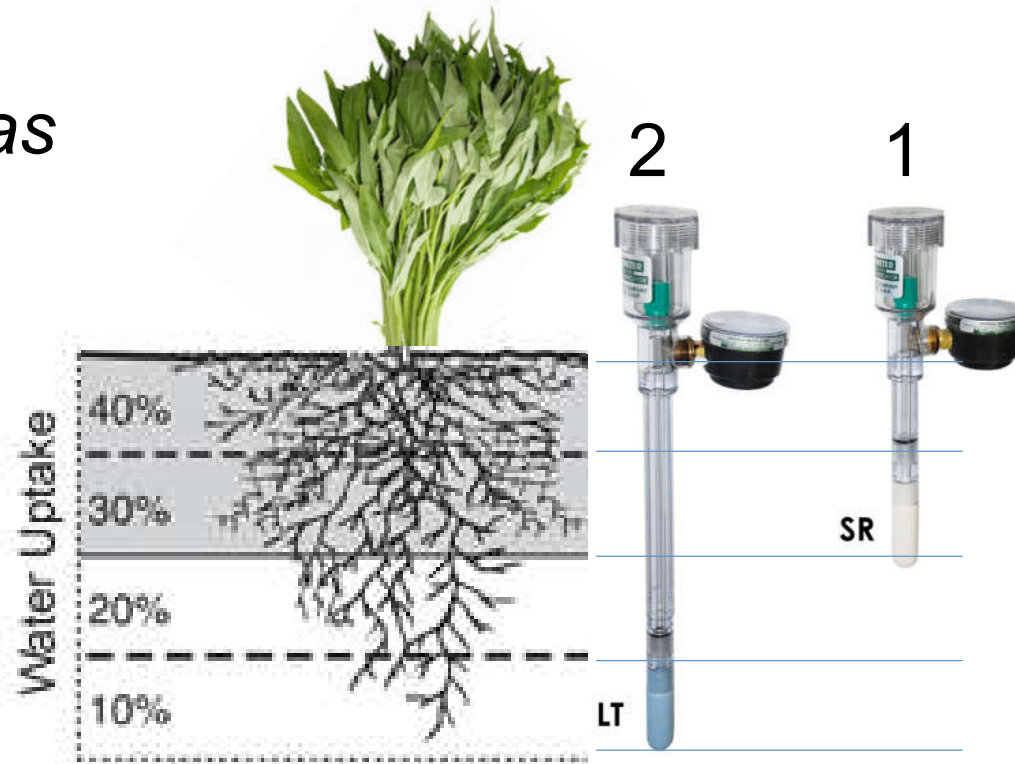
- 1) at midpoints of the main root depth where irrigation is always wet
- 2) at the bottom of the root depth



Example

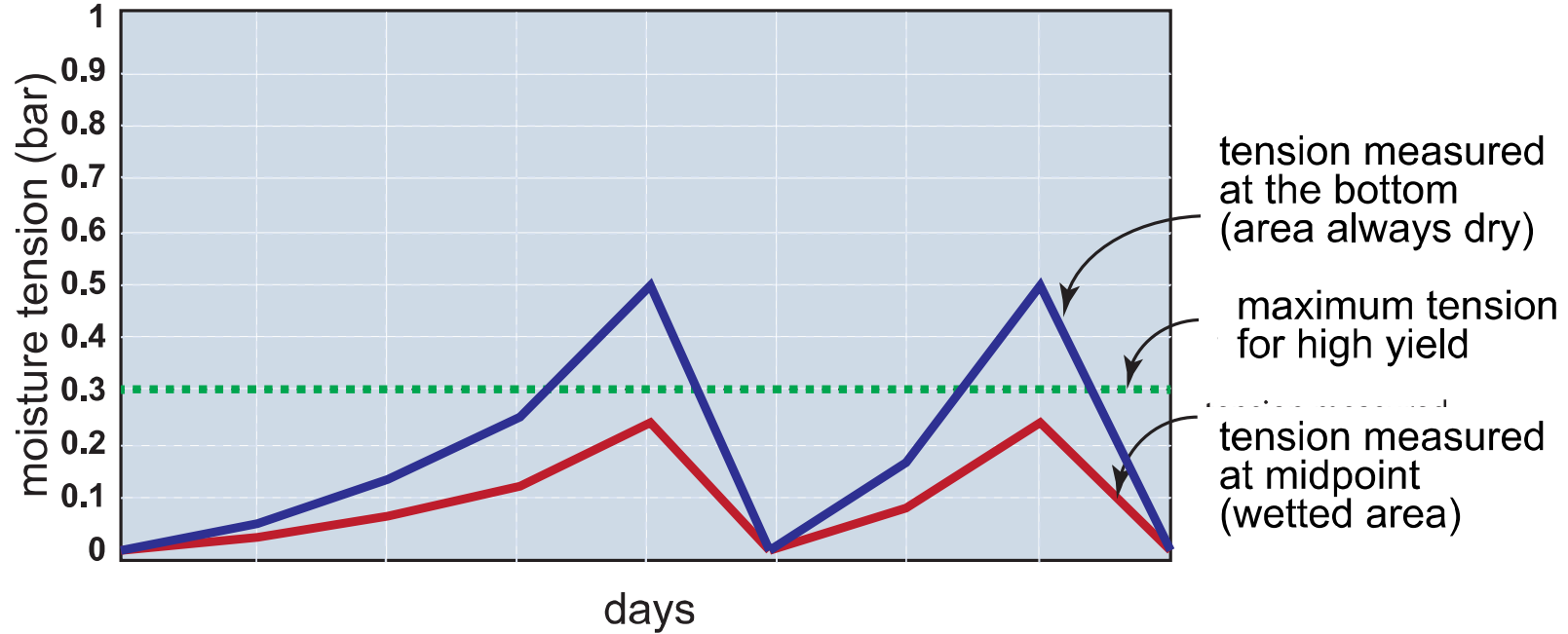
Chinese morning glory has an appropriate moisture tension of 30 centibars

- 1) at 0.15m depth
- 2) at 0.30m depth



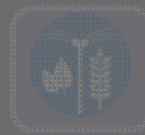
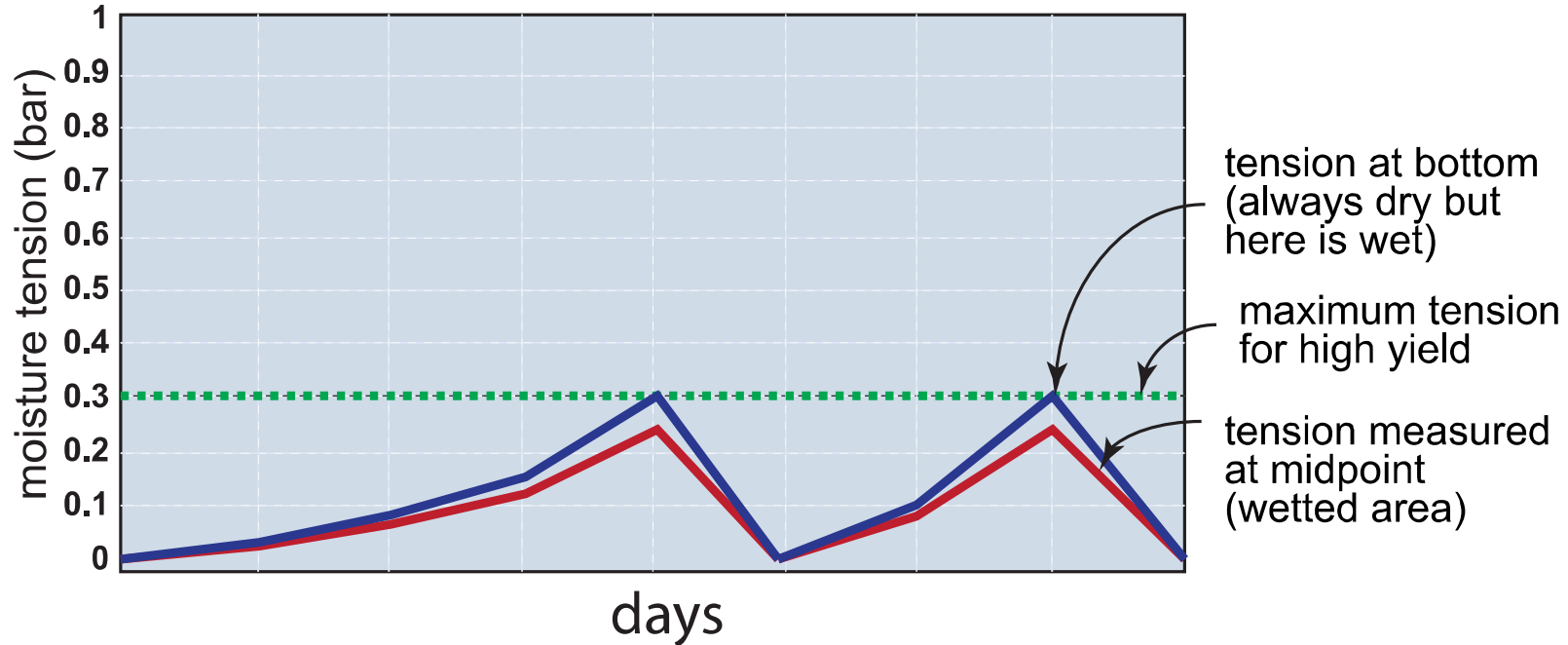
Example of data from tensiometer

Case 1: Proper irrigation



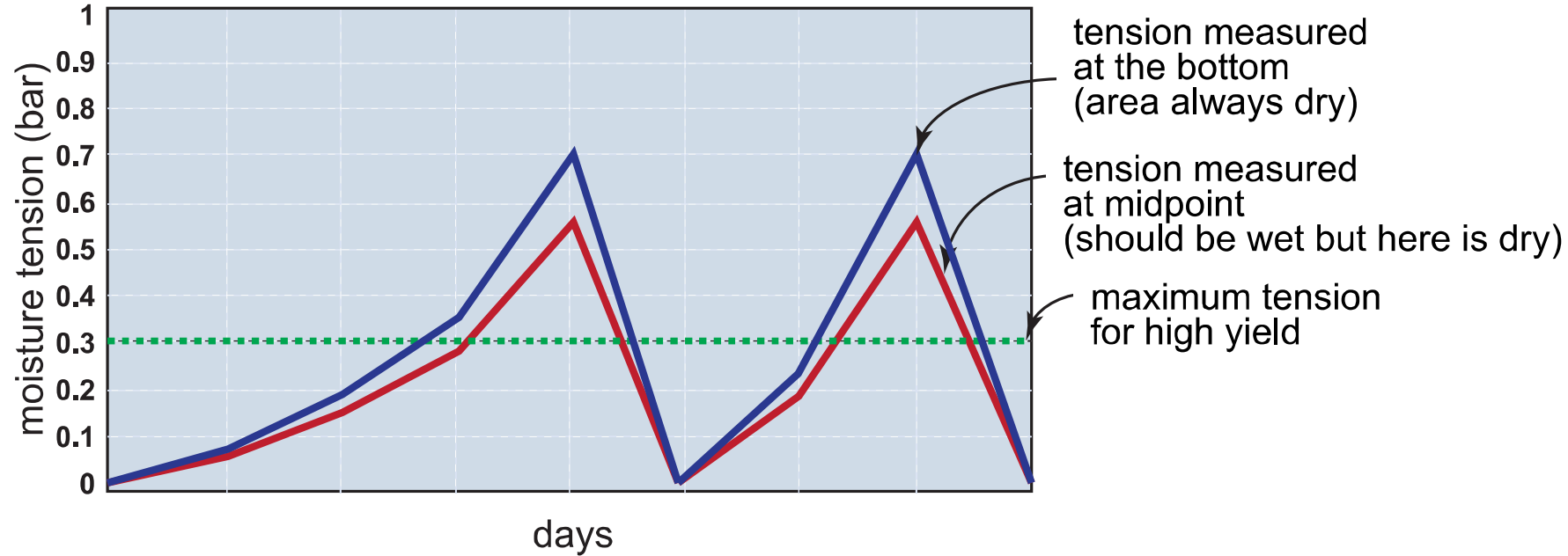
Example of data from tensiometer

Case 2: Over irrigation



Example of data from tensiometer

Case 3: Under irrigation



Class objectives

Irrigation techniques will answer the following:



Completed

1) How much water to irrigate?



Completed

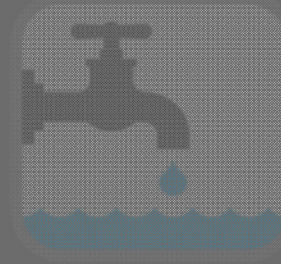
2) When to irrigate?



3) What is the suitable Run Time?



4) What is efficiency of each method?



5) Where to obtain the water?



5) How to apply these techniques?

What is the appropriate Run Time?

Run Time:

the time duration between the start and the stop of a valve.

Knowing an accurate Run Time will save cost, labor and energy.



What is the appropriate Run Time?

$$\text{Run Time} = \frac{\text{IWR}_{\text{veg}}}{\text{Application rate}} \quad \text{Eq.3}$$

For sprinkler,

Application rate = precipitate rate (mm/hr)/area of coverage

For micro-irrigation,

Application rate = number of emitters in the area x rate of emitter



Class objectives

Irrigation techniques will answer the following:



1) How much water to irrigate?



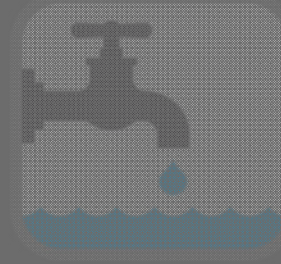
2) When to irrigate?



3) What is the suitable Run Time?



4) What is efficiency of each method?



5) Where to obtain the water?



5) How to apply these techniques?

What is the efficiency (E_a)?



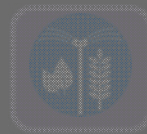
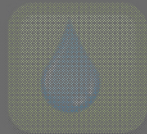
Surface Irrigation
($E_a = 50-70\%$)



Sprinkler Irrigation
($E_a = 70-80\%$)



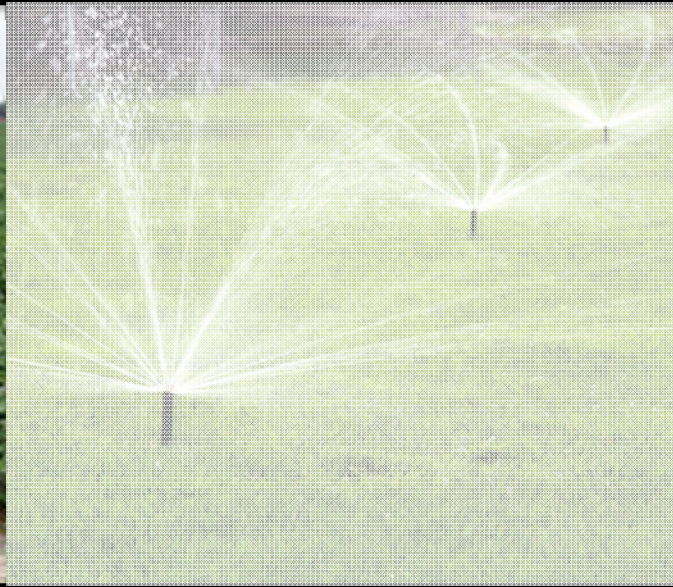
Micro-Irrigation
($E_a = 80-95\%$)



Surface Irrigation



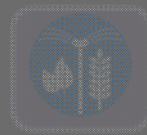
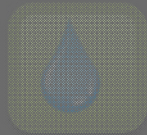
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($E_a = 50-70\%$)



Sprinkler Irrigation
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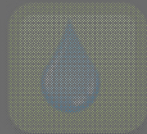


Micro-Irrigation
($E_a = 80-95\%$)



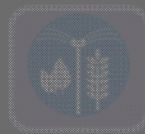
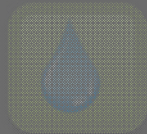
Surface Irrigation

- Most commonly-used method
- Water is applied and distributed over the soil surface by gravity
- ***Examples of surface irrigation***
 - Basin irrigation
 - Border irrigation
 - Furrow irrigation



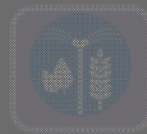
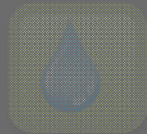
Surface Irrigation

- ***Basin Irrigation***
- ***Border Irrigation***
- ***Furrow Irrigation***



Surface Irrigation

- ***Basin Irrigation***
- *Border Irrigation*
- *Furrow Irrigation*



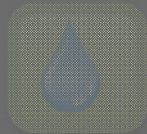
Surface Irrigation

Basin Irrigation

- Most commonly used surface irrigation in small fields
- Undirected flow of water is provided onto the field and prevented from runoff by an encompassing dyke



Example of Basin Irrigation



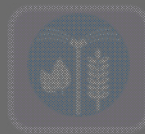
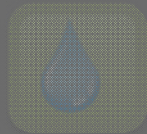
Surface Irrigation

Basin Irrigation

- Suitable crops for basin irrigation are those able to stand in wet conditions for >24 hr



Rice in the field irrigated by basin method



Surface Irrigation

Basin Irrigation

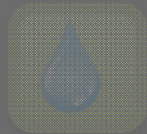
On flat land, only minimal leveling is required to obtain basin levels

Loamy soils are preferred to avoid water-logging

Note that coarse sands are not recommended due to a high percolation loss



Loamy soil for basin irrigation



Design for Basin Irrigation

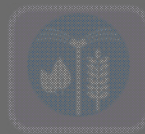
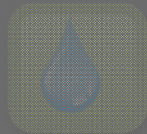
Table 5 Suggested basin areas for different soil types and rates of water flow. (Taken from Booher, 1974.)

A. Area in hectares		Soil type			
Flow rate		Sand	Sandy loam	Clay loam	Clay
Liters per second	Cubic meters per hour	Hectares			
30	108	0.02	0.06	0.12	0.2
60	216	0.04	0.12	0.24	0.4
90	324	0.06	0.18	0.36	0.6
120	432	0.08	0.24	0.48	0.8
150	540	0.10	0.30	0.60	1.0
180	648	0.12	0.36	0.72	1.2
210	756	0.14	0.42	0.84	1.4
240	864	0.16	0.48	0.96	1.6
270	972	0.18	0.54	1.08	1.8
300	1080	0.20	0.60	1.20	2.0



Surface Irrigation

- *Basin Irrigation*
- ***Border Irrigation***
- *Furrow Irrigation*



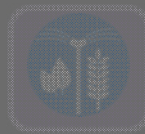
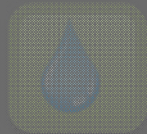
Surface Irrigation

Border Irrigation

- Extended basin irrigation with sloping, long rectangular or contoured field shapes and free draining conditions at the lower end.



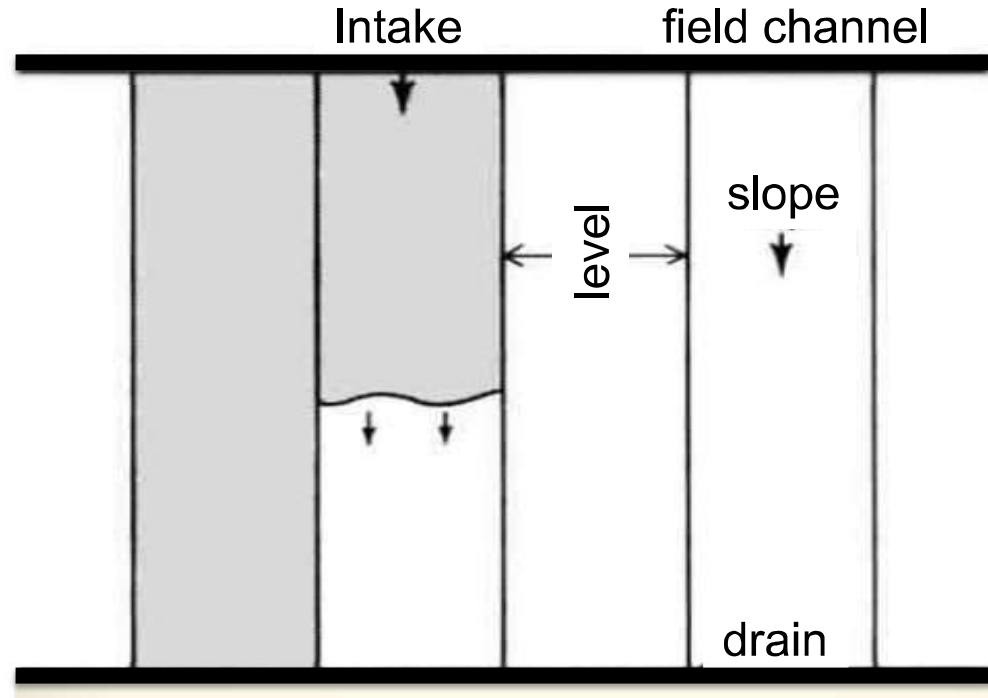
Example of Border Irrigation



Surface Irrigation

Border Irrigation

- In a typical border irrigation, a field is divided into sloping borders.
- Water is applied to each border from the field head ditch from the upper to the lower end.

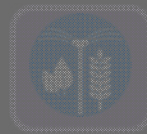
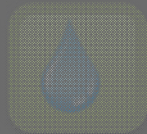


Design of Border Irrigation

Table 6A Suggested standards for the design of border-strips for shallow-rooted crops.
(Taken from Booher, 1974.)

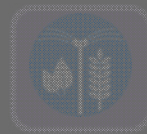
A. Metric units

Soil profile	Percent of slope	Unit flow per meter of strip width	Average depth of water applied	Border-strip	
				Width	Length
	Meters per 100 meters	Liters per second	Milli-meters	Meters	
CLAY LOAM	0.15–0.6	6–8	50–100	5–18	90–180
0.6 meter deep over permeable subsoil	0.6–1.5	4–6	50–100	5–6	99–180
	1.5–4.0	2–4	50–100	5–6	90
CLAY	0.15–0.6	3–4	100–150	5–18	180–300
0.6 meter deep over permeable subsoil	0.6–1.5	2–3	100–150	5–6	180–300
	1.5–4.0	1–2	100–150	5–6	180
LOAM	1.0–4.0	1–4	25–75	5–6	90–300
0.15 to 0.45 meter deep over hardpan					



Surface Irrigation

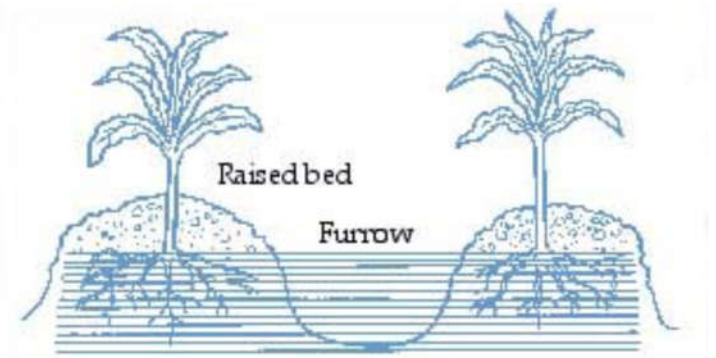
- *Basin Irrigation*
- *Border Irrigation*
- ***Furrow Irrigation***



Surface Irrigation

Furrow Irrigation

- Flow is channeled along the primary direction of the field using furrows



Example of Furrow Irrigation

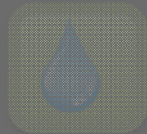


Design for Furrow Irrigation

Table 6B Suggested maximum lengths of cultivated furrows for different soils, slopes, and depths of water to be applied. (Taken from Booher, 1974.)

A. Lengths in meters; depths in centimeters

Furrow slope	Average depth of water applied (centimeters)											
	7.5	15	22.5	30	5	10	15	20	5	7.5	10	12.5
	Clays				Loams				Sands			
Percent					 Meters							
0.05	300	400	400	400	120	270	400	400	60	90	150	190
0.1	340	440	470	500	180	340	440	470	90	120	190	220
0.2	370	470	530	620	220	370	470	530	120	190	250	300
0.3	400	500	620	800	280	400	500	600	150	220	280	400
0.5	400	500	560	750	280	370	470	530	120	190	250	300
1.0	280	400	500	600	250	300	370	470	90	150	220	250
1.5	250	340	430	500	220	280	340	400	80	120	190	220
2.0	220	270	340	400	180	250	300	340	60	90	150	190



Sprinkler Irrigation



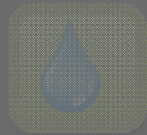
Surface Irrigation
($E_a = 50-70\%$)



Sprinkler Irrigation
($E_a = 70-80\%$)



Micro-Irrigation
($E_a = 80-95\%$)

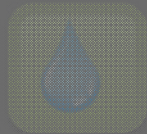


Sprinkler Irrigation

- Similar to natural rainfall
- Water distributed through the pipes is sprayed into the air through sprinklers



Examples of Sprinkler Irrigation



[See video](#)

Sprinkler Irrigation



NAAN 344/90 MAJOR SIZE
General Purpose Sprinkler.
With two nozzles, larger
discharges and precipitations.
Spoon hammer drive, thrust
spring and protector sleeve,
stainless steel axle.
Weight: 770 g



NAAN 344/92 MAJOR SIZE
General Purpose Sprinkler.
Brass hammer, wedge
drive, thrust spring and
protector sleeve, stainless
steel axle. Weight: 730 g

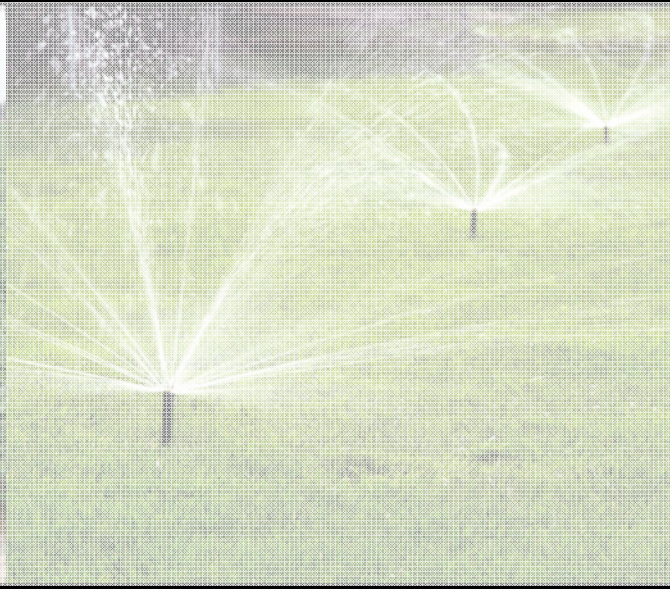
Nozzle Size in mm, CODE		Pressure in atm.	Discharge in m ³ /h.	Diameter Coverage in m.	Precipitation in mm/h for Covered Area Spacing in metres					
344/90	344/92				12 x 12	12 x 15	12 x 18	18 x 18	18 x 24	24 x 24
4.8 x 4.8 PERSIL	4.8 x 4.8 PAGOD	3.0	2.86	29	19.9	16.9	13.2			
		3.5	3.08	30	21.4	17.1	14.3			
		4.0	3.29	31	22.8	18.3	15.2			
		4.5	3.48	32	24.2	19.4	16.1			
		5.0	3.64	32	25.3	20.2	16.9			
5.5 x 4.8 PERLOD	5.5 x 4.8 PATIN	3.0	3.30	32	22.9	18.4	15.3	10.2		
		3.5	3.59	33	24.9	20.0	16.6	11.1		
		4.0	3.84	34	26.7	21.4	17.8	11.9		
		4.5	4.04	35	28.0	22.5	18.7	12.5		
		5.0	4.25	35	29.5	23.6	19.7	13.1		
6.3 x 4.8 PERGIN	6.3 x 4.8 PARAC	3.0	3.85	34	26.7	21.4	17.8	11.9	8.9	
		3.5	4.16	35	28.9	23.1	19.3	12.9	9.6	
		4.0	4.47	36	31.0	24.9	20.7	13.8	10.3	
		4.5	4.71	37	32.7	26.2	21.8	14.6	10.9	8.2
		5.0	4.94	37	34.3	27.5	22.9	15.3	11.4	8.6
7.5 x 5.5 PERTAT	7.5 x 5.5 PALOF	5.5	5.18	38	36.0	28.8	24.0	16.0	12.0	9.0
		3.0	5.28	36			24.5	16.3	12.2	9.2
		3.5	5.68	37			26.3	17.6	13.1	9.9
		4.0	6.05	39			28.0	18.7	14.0	10.5
		4.5	6.38	40			29.5	19.7	14.7	11.1
8.5 x 5.5 PERNES	8.5 x 5.5 PAKID	5.0	6.74	41			31.2	20.8	15.6	11.7
		5.5	7.06	41			32.7	21.8	16.3	12.3
		3.0	6.16	38			28.5	19.0	14.3	10.7
		3.5	6.66	39			30.8	20.6	15.4	11.6
		4.0	7.11	40			32.9	22.0	16.4	12.4
		4.5	7.52	41			34.8	23.2	17.4	13.1
		5.0	7.77	42			36.0	24.0	18.0	13.5
		5.5	8.13	42			37.7	25.1	18.8	14.1



Micro (or Drip) Irrigation



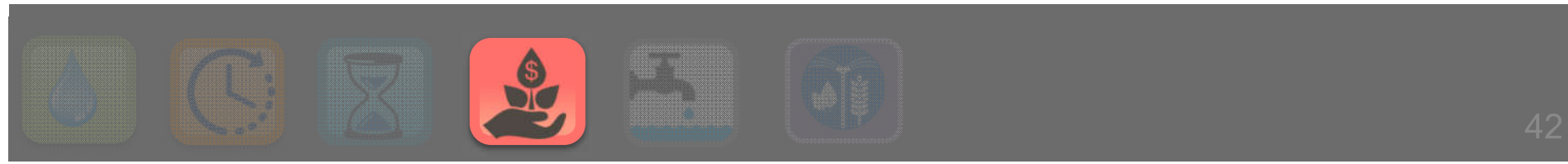
Surface Irrigation
($E_a = 50-70\%$)



Sprinkler Irrigation
($E_a = 70-80\%$)

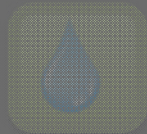
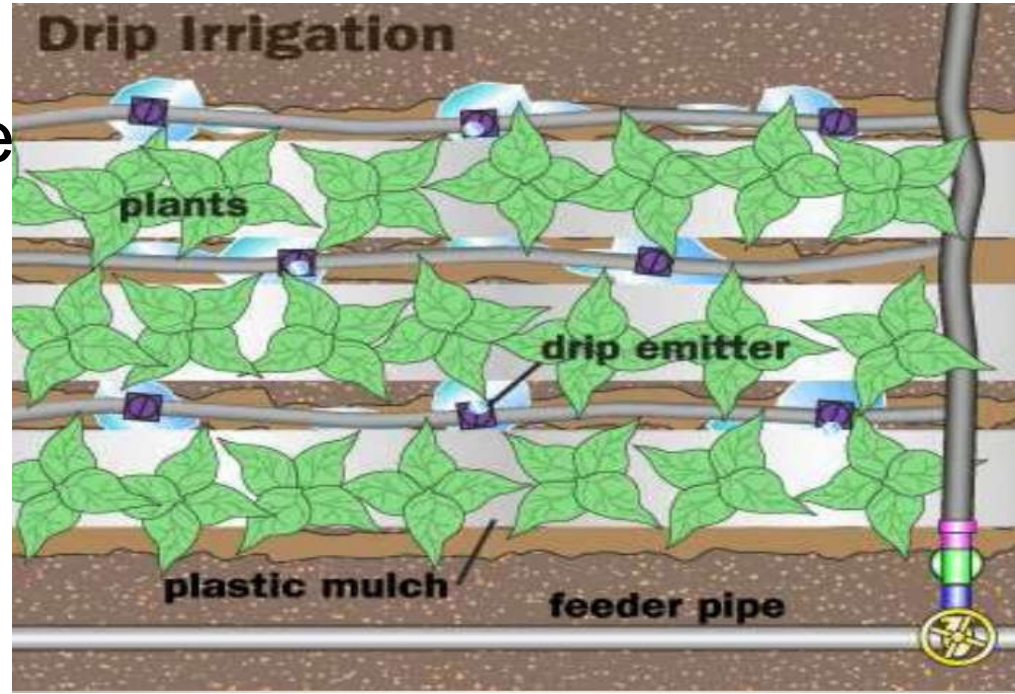


Micro-Irrigation
($E_a = 80-95\%$)



Micro Irrigation

- Water is dripped onto the soil slowly (2-20 L/hr) from a network of small diameter pipes called emitters
- Only root zones receive water



[See video](#)

Which irrigation method to use?

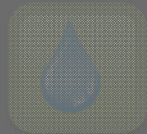
Soil type	Compatible methods
Loamy	All
Clay	All
Sandy	Sprinkler or drip only

Aside from soil type, we need to consider crop types, available resources (technologies, labors, and budgets)



How to check distribution uniformity?

As the field is being irrigated, the water distribution in the plot can be checked using “Catch Can Irrigation test”



How to check distribution uniformity?

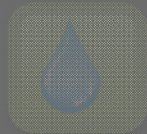
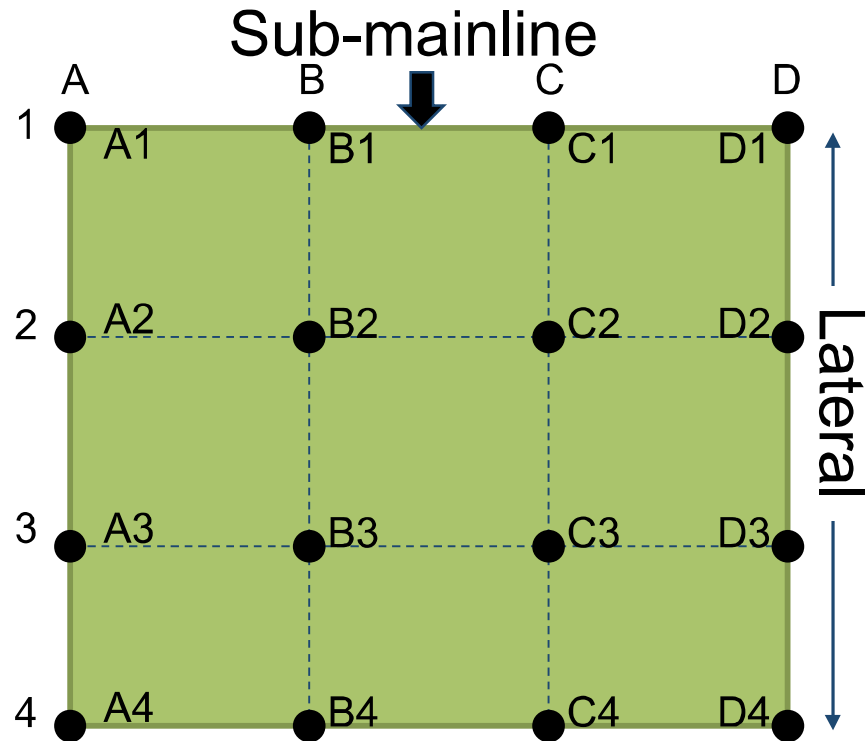
16 Chase Cans are installed. Flow rates (Q) are measured at each check point and used to calculate the distribution uniformity (D_u):

$$D_u = \frac{Q_n}{Q_a} \times 100\%$$

when

Q_n = low quarter average flow rate

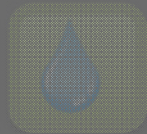
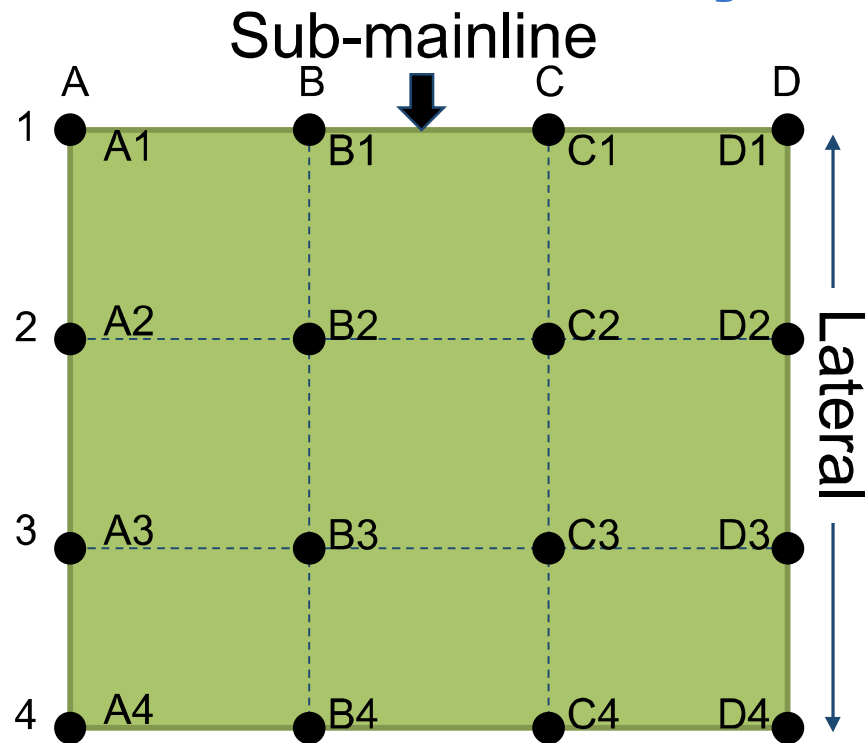
Q_a = average flow rate



How to check distribution uniformity?

Example of data:

A1 = 1.30 L/h	C1 = 0.90 L/h
A2 = 1.27 L/h	C2 = 0.80 L/h
A3 = 1.26 L/h	C3 = 0.80 L/h
A4 = 1.28 L/h	C4 = 0.80 L/h
B1 = 1.38 L/h	D1 = 0.87 L/h
B2 = 1.32 L/h	D2 = 0.84 L/h
B3 = 1.36 L/h	D3 = 0.84 L/h
B4 = 1.34 L/h	D4 = 0.74 L/h



How to check distribution uniformity?

Solution

1) Rank the flow rates from max to min

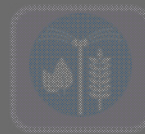
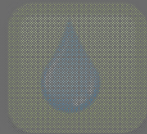
Q1 = 1.38 L/h	Q8 = 0.90 L/h
Q2 = 1.36 L/h	Q9 = 0.87 L/h
Q3 = 1.34 L/h	Q10 = 0.84 L/h
Q4 = 1.32 L/h	Q11 = 0.84 L/h
Q5 = 1.30 L/h	Q12 = 0.80 L/h
Q6 = 1.28 L/h	Q13 = 0.80 L/h
Q7 = 1.27 L/h	Q14 = 0.80 L/h
Q8 = 1.26 L/h	Q15 = 0.74 L/h

2) Determine Q_a and Q_n

$$\begin{aligned}Q_a &= (Q_1 + Q_2 + \dots + Q_{16})/n \\&= 17.10/16 \\&= 1.06 \text{ L/h}\end{aligned}$$

$$\begin{aligned}Q_n &= Q_{13} + Q_{14} + Q_{15} + Q_{16} \\&= (0.80 + 0.80 + 0.80 + 0.74)/4 \\&= 0.785 \text{ L/h}\end{aligned}$$

$$\begin{aligned}D_n &= Q_n / Q_a \times 100\% \\&= 0.785 / 1.06 \times 100\% \\&= 74.05\%\end{aligned}$$



Class objectives

Irrigation techniques will answer the following:



1) How much water to irrigate?



2) When to irrigate?



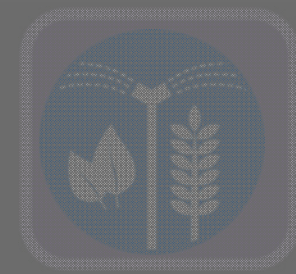
3) What is the suitable Run Time?



4) What is efficiency of each method?



5) Where to obtain the water?



5) How to apply these techniques?

Where to obtain water for irrigation?

- Surface Irrigation
- Ground Water



Where to obtain water for irrigation?

- Surface Irrigation
- Ground Water



Where to obtain water for irrigation?

- ***What is the sizing of the pond/ reservoir for vegetable production?***

Surface water is from rainfall at the lowest of the farmland.

The pond or reservoir can be constructed to the size equivalent to vegetable requirement



Where to obtain water for irrigation?

- *What is the sizing of the pond/ reservoir for vegetable production?*

$$\begin{aligned} &\text{Amount of Irrigation water (m}^3\text{)} \\ &= \text{Area of Planting (m}^2\text{)} \times \text{ET}_{\text{veg}} \text{ (mm/day)} \times \\ &\quad \text{Growth day} \times \text{Time of planting} / (\text{E}_a \times 1,000) \end{aligned}$$

Eq. 4



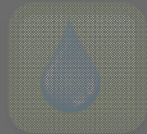
Example

Given an area of planting is $8,000 \text{ m}^2$, evapotranspiration 6 mm/day . Growth day is 20 day with 5 times for planting. Drip irrigation method is used.



Solution

$$\begin{aligned}\text{Size of pond} &= \frac{8,000 \text{ m}^2 \times 6 \text{ mm/day} \times 20 \text{ day} \times 5 \text{ times}}{0.80 \times 1,000} \\ &= 4,800 \text{ m}^3\end{aligned}$$



Where to obtain water for irrigation?

- Surface Irrigation
- Ground Water



Where to obtain water for irrigation?

- Ground Water

From secondary data, the level and capacity of the ground water in the well can be obtained.

The capacity of ground water can be used to design the size of planning:

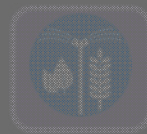
$$\text{Area for service} = \frac{\text{Capacity of well pump (m}^3\text{/hr)}}{\text{Capacity of planting (m}^3\text{/hr)}}$$

Eq.5



Example

Find the area for irrigation service for morning glory of which evapotranspiration is 5 mm/day, given the capacity of all pump is 6 m³/hr. The Run Time is 3-h drip irrigation with 15 working hours/day.

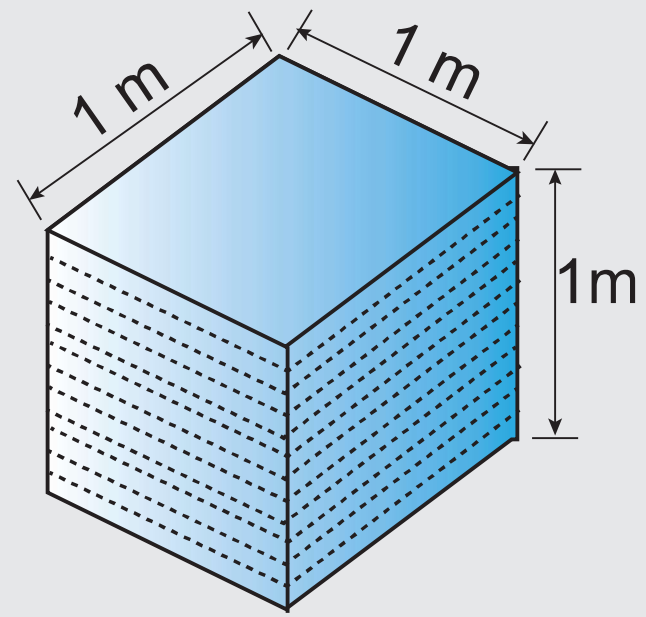


Solution

$$\begin{aligned}\text{Given } ET_{\text{veg}} &= 5 \text{ mm/day} \\ &= 5 \text{ L/m}^2/\text{day}\end{aligned}$$

1) Find IWR_{veg}

$$\begin{aligned}IWR_{\text{veg}} &= ET_{\text{veg}}/E_a \\ &= 5/0.8 \\ &= 6.25 \text{ L/m}^2/\text{day}\end{aligned}$$



$$\begin{aligned}\text{Volume} &= 1\text{m} \times 1\text{m} \times 1\text{m} = 1000 \text{ L} \\ &= 1\text{m} \times 1\text{m} \times 1000 \text{ mm} \\ &= \text{m}^2 \times 1000 \text{ mm} = 1000 \\ &\text{mm} = \text{L/m}^2\end{aligned}$$



Solution (cont.)

2) Find the number of plots

Given

Working hour = 15 hr/day

Run Time = 3 hr

Thus, the number of plots = $15/3$
= 5 plots



Solution (cont.)

2) Find the number of plots

Given

Working hour = 15 hr/day

Run Time = 3 hr

Thus, the number of plots = $15/3$
= 5 plots



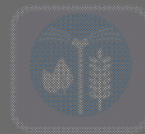
Solution (cont.)

3) Find IWR/ plot

From 1), IWR = 6.25 liter/m²/plot

and Run Time = 3 hr

$$\begin{aligned}\text{IWR/plot/hr} &= 6.25/3 \\ &= 2 \text{ L/hr/m}^2 \\ &= 0.002 \text{ m}^3/\text{hr/m}^2\end{aligned}$$



Solution (cont.)

The irrigation area service/plot

$$= 6 \text{ m}^3/\text{hr} / 0.002 \text{ m}^3/\text{hr}/\text{m}^2$$

$$= 3,000 \text{ m}^2$$

Thus, the irrigation area service for the total area

$$= 3,000 \text{ m}^2 \times 5 \text{ plots}$$

$$= 15,000 \text{ m}^3$$



Class objectives

Irrigation techniques will answer the following:



1) How much water to irrigate?



2) When to irrigate?



3) What is the suitable Run Time?



4) What is efficiency of each method?



5) Where to obtain the water?



5) How to apply these techniques?

Fundamental of irrigation

Irrigating water flows through the pipe under low pressure (20 mH₂O) and through the emitter at an adjustable, suitable flow rate to the soil



How to apply micro-irrigation method to your situation?

Key: select proper components:

- 1) emitters**
- 2) pipes (riser, lateral, sub-mainline, main line)**
- 3) pump**

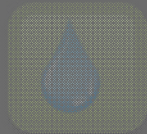


Table 7A

Emitter Selection Data :

Diameter of coverage (m) ; to select suitable of canopies see figure I.

Pressure head (m) ; to select Pressure head of Pump.

Discharge (Liter/hr.) ; to determine runtime schedule.

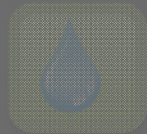


Table 7B

Pipe Size Selection Data :

Lateral size

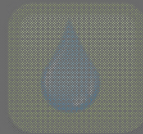
- PVC Ø ¾"	Capacity	2.80	m3/hr (2,800 litres/hr)
- PVC Ø 1"	Capacity	5.10	m3/hr (5,100 litres/hr)

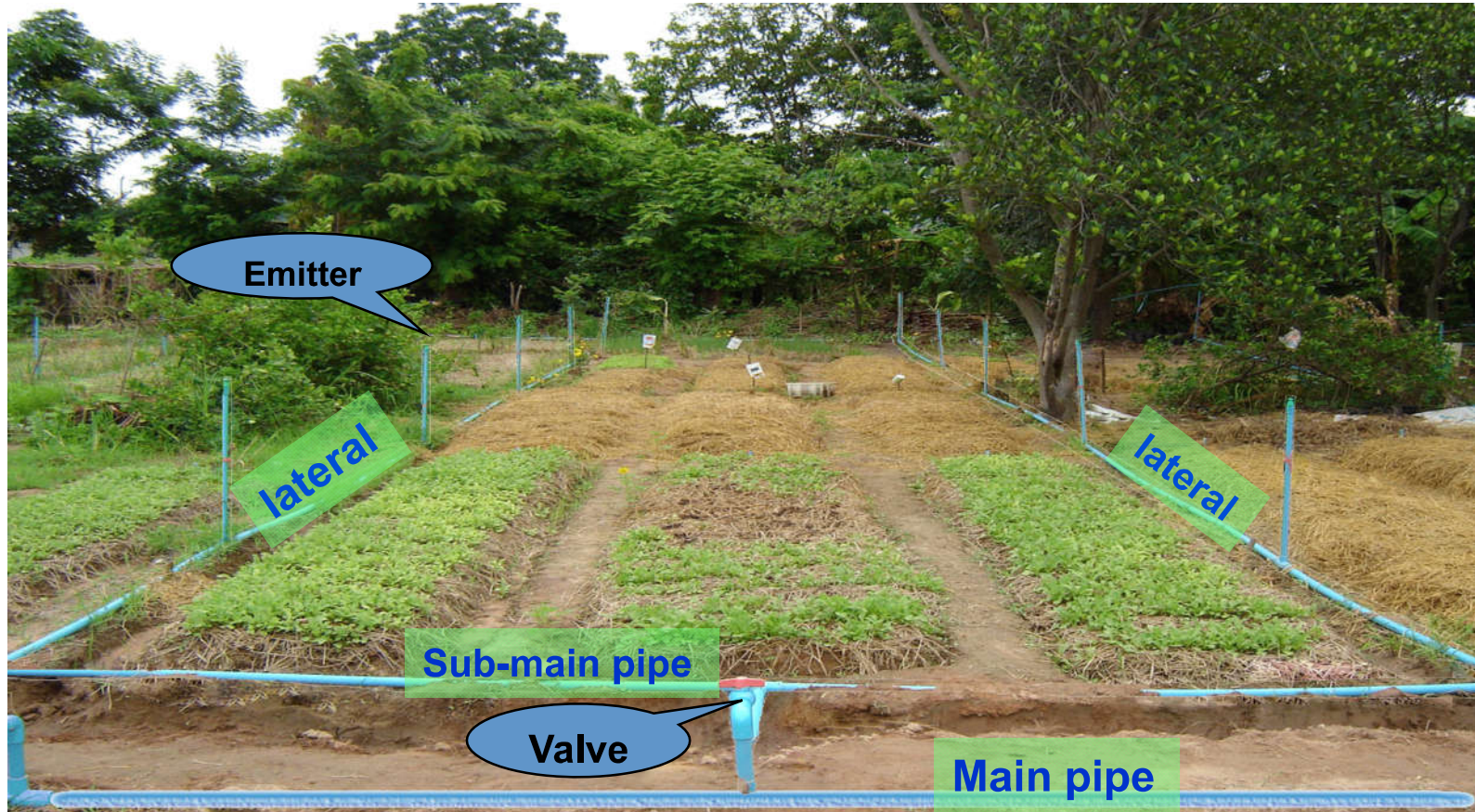
Sub-Mainline

- PVC Ø 1"	Capacity	5.10	m3/hr (5,100 litres/hr)
- PVC Ø 1½"	Capacity	11.00	m3/hr (11,000 litres/hr)
- PVC Ø 2"	Capacity	16.00	m3/hr (16,000 litres/hr)

Mainline

- PVC Ø 1"	Capacity	3.90	m3/hr (3,900 litres/hr)
- PVC Ø 1½"	Capacity	8.00	m3/hr (8,000 litres/hr)
- PVC Ø 2"	Capacity	13.60	m3/hr (13,600 litres/hr)
- PVC Ø 2½"	Capacity	20.25	m3/hr (20,250 litres/hr)
- PVC Ø 3"	Capacity	27.75	m3/hr (27,750 litres/hr)





How to apply micro-irrigation method to your situation?

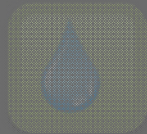
Key: select proper components:

1) emitters

(drip, spray, and microsprinkler)

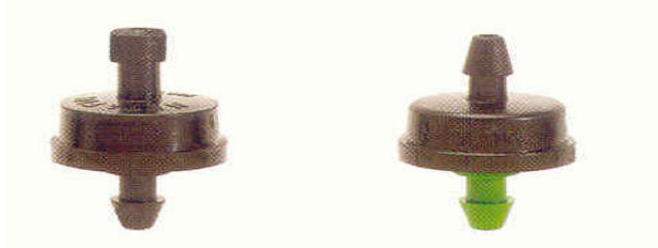
2) pipes

3) pump capacity



Emitters

- Drip



**Woodpecker
Nipple Outlet**
(1,2,4, or 8 L/hr)

**Woodpecker
Barbed Outlet**
(1,2,4, or 8 L/hr)



**Woodpecker P. C. J.
Pressure Compensating Junior
Nipple Outlet** (2 or 4 L/hr)

**Woodpecker P. C. J.
Pressure Compensating Junior
Barbed Outlet** (2 or 4 L/hr)

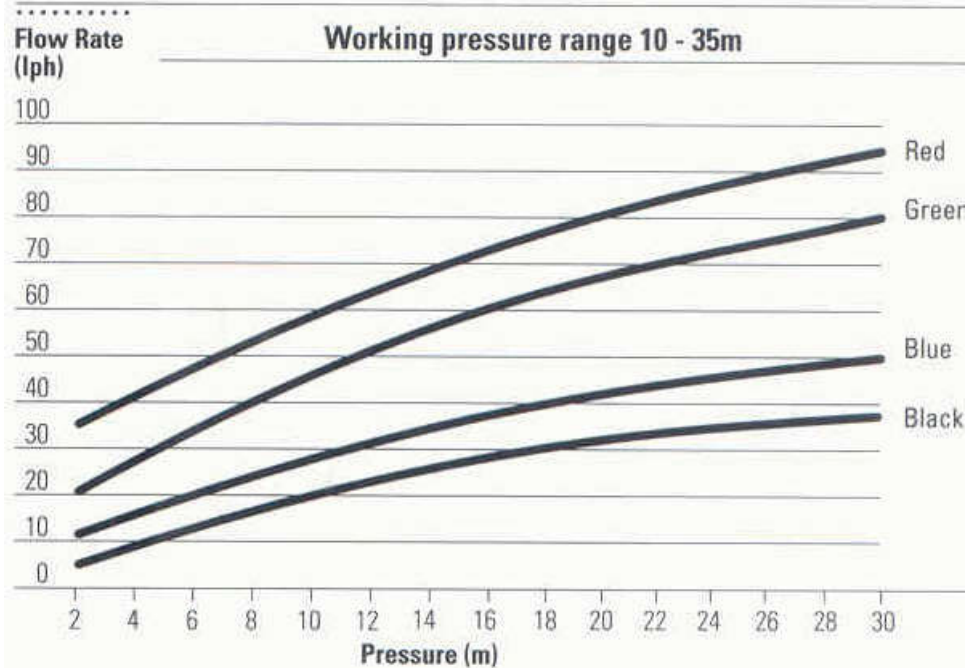
Emitters

- **Spray**

Need to know radius of wetted area, flow rate, and working pressure



Performance Chart



Emitters

- Spray



Table 8 Maximum No. of Emitters per Lateral

Nozzle Code (mm)	Discharge* (lph)	Wetting* Radius (m)	Pipe Diameter	Emitter Spacing On Lateral in m										
			O.D. mm	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	
Black (0.9)	25	1.2	16	26	24	22	21	20	19	18	18	17	16	
			17.8	32	29	27	26	24	23	22	22	21	20	
			20	40	37	34	33	31	30	28	27	27	26	
Blue (1.3)	34	1.6	16	20	19	18	17	16	15	14	14	13	13	
			17.8	25	23	21	20	19	18	18	17	16	16	
			20	32	29	27	26	25	23	23	22	21	20	
Green (1.7)	55	1.8	16	15	14	13	12	12	11	11	10	10	10	
			17.8	19	17	16	15	14	14	13	13	12	12	
			20	24	22	21	19	18	18	17	16	16	15	
Red (2.0)	70	2.1	16	14	13	12	11	11	10	10	10	9	9	
			17.8	18	16	15	14	13	13	12	12	11	11	
			20	22	21	19	18	17	16	16	15	15	14	

* At 1.5 atm, 25 cm high.

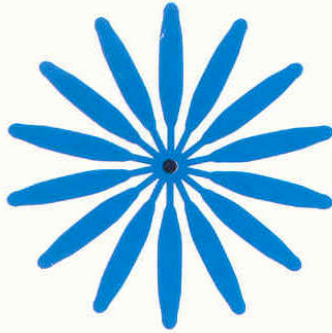


Emitters

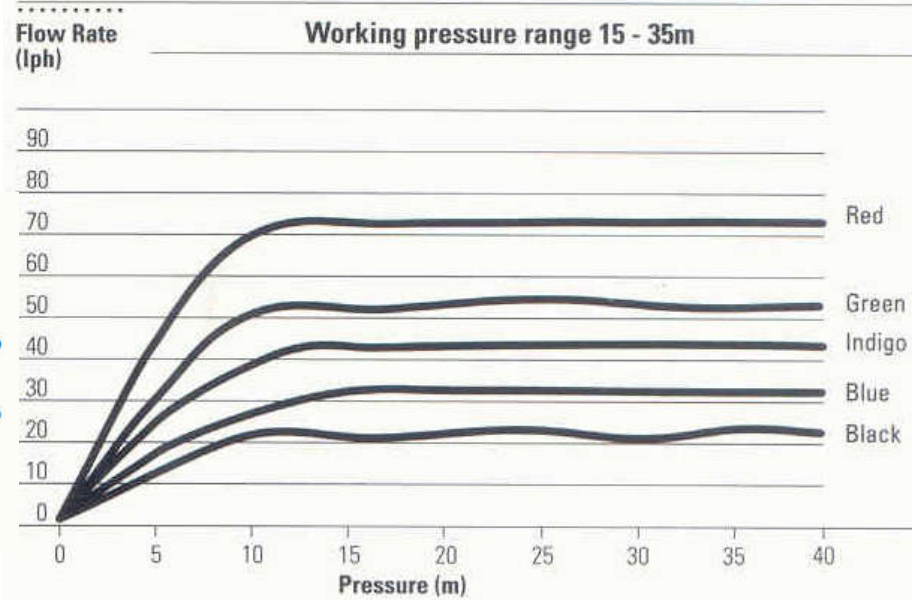
- **Spray**



Water distribution pattern



Performance Chart



Emitters

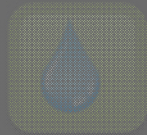
Spray



Table 9 Maximum No. of Emitters per Lateral

Nozzle Code (mm)	Discharge (lph)	Wetting Radius* (m)	Emitter Spacing (m)	Pipe diameter 16 (OD) mm					Pipe diameter 17.8 (OD) mm					Pipe diameter 20 (OD) mm				
				Inlet pressure (atm)					Inlet pressure (atm)					Inlet pressure (atm)				
				1.6	2.0	2.4	2.8	3.5	1.6	2.0	2.4	2.8	3.5	1.6	2.0	2.4	2.8	3.5
Black (0.8)	20	1.80	3	17	31	38	44	46	21	37	46	53	56	26	47	58	67	70
			4	15	28	34	39	41	19	34	42	48	50	24	43	53	60	63
			5	14	26	32	36	38	17	31	38	44	46	22	39	49	56	58
			6	13	24	30	34	36	16	29	36	41	43	20	37	45	52	55
Blue (1.0)	30	2.10	3	13	24	30	34	39	16	29	36	41	48	20	36	45	52	60
			4	12	21	27	30	36	15	26	32	37	43	18	33	41	47	54
			5	11	20	25	28	33	13	24	30	34	40	17	30	38	43	50
			6	10	19	23	26	31	13	22	28	32	37	16	28	35	40	47
Dark Blue (1.1)	41	2.60	3	11	20	24	28	32	13	24	29	34	39	17	30	37	42	50
			4	10	18	22	25	29	12	21	26	30	35	15	27	33	38	45
			5	9	16	20	23	27	11	20	24	28	33	14	25	31	35	41
			6	8	15	19	22	25	10	18	23	26	30	13	23	29	33	38
Green (1.2)	53	2.80	3	9	17	21	23	25	11	20	25	28	30	14	25	31	36	38
			4	8	15	19	21	22	10	18	22	26	27	13	23	28	32	34
			5	8	14	17	20	21	9	17	21	24	25	12	21	26	30	31
			6	7	13	16	18	19	9	16	19	22	23	11	20	24	28	29
Red (1.4)	70	3.00	3	8	14	17	20	23	9	17	21	24	28	12	21	26	30	35
			4	7	13	16	18	21	8	15	19	21	25	11	19	24	27	32
			5	6	12	14	16	19	8	14	17	20	23	10	18	22	25	29
			6	6	11	13	15	18	7	13	16	19	22	9	17	20	23	27

* At 25 cm high



Emitters

- Micro-sprinklers**

Need to know radius of wetted area, flow rate, and working pressure



Performance Chart

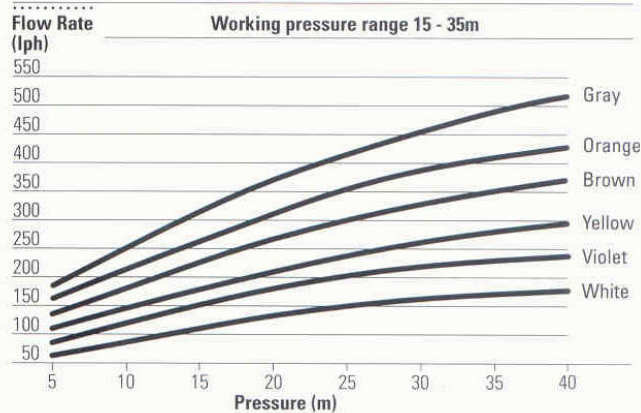


Table 10

Maximum No. of Emitters on Lateral

Nozzle Code (mm)	Discharge* (lph)	Wetting* Radius (m)	Lateral Pipe Diameter O.D. mm	Emitter Spacing on lateral in m						
				4	5	6	7	8	9	10
				Number of sprinklers						
White (1.6)	135	7.25	20	11	10	9	9	8	8	8
			25	16	15	14	13	13	12	12
			32	26	24	22	21	20	19	18
			40	44	40	38	36	34	32	31
Violet (1.8)	170	7.25	20	9	9	8	7	7	7	6
			25	14	13	12	11	11	10	10
			32	22	20	19	18	17	16	16
			40	38	35	32	31	29	28	27
Yellow (2.0)	210	7.25	20	8	7	7	6	6	6	6
			25	12	11	10	10	9	9	8
			32	19	18	17	16	15	14	14
			40	33	30	28	27	25	24	23
Brown (2.2)	260	7.25	20	7	6	6	6	5	5	5
			25	11	10	9	9	8	8	7
			32	17	16	14	14	13	12	12
			40	29	27	25	23	22	21	20
Orange (2.4)	305	7.25	20	6	6	5	5	5	4	4
			25	9	9	8	8	7	7	7
			32	15	14	13	12	11	11	11
			40	26	24	22	21	20	19	18
Gray (2.6)	367	7.0	20	5	4	4	4	3	3	3
			25	7	7	6	6	5	5	5
			32	12	11	10	9	9	8	8
			40	20	10	17	16	15	15	14

* At 2.0 atm on 70 cm Rod



Our invention: IRRE1 an all-in-one emitter

KU Department of Irrigation Engineering developed “IRRE1” an all-in-one emitter.

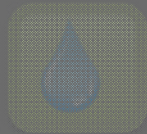
The flow rate (Q) and diameter coverage of our emitter are adjustable.



IRRE: Performance Table

Table 11

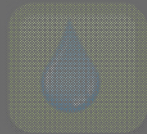
Working pressure (m)	Emitters Adjusting (Round)	Flow rate (L/ hr)	Wetting Radius (m)	Spacing (mxm)	Uniformity of Coefficient (Cu %)	Precipitation Rate (mm/hr)
5	2	360	3.0	4.0 x 4.0	89.63	22.50
5	3	480	3.5	4.0 x 4.0	78.74	33.00
10	2	520	3.5	4.0 X 4.0	90.44	32.50
10	3	660	4.0	4.0 X 4.0	81.20	41.25
15	2	430	3.5	4.0 X 4.0	80.00	26.88
15	3	640	4.0	4.0 X 4.0	85.37	40.00



How to apply micro-irrigation method to your situation?

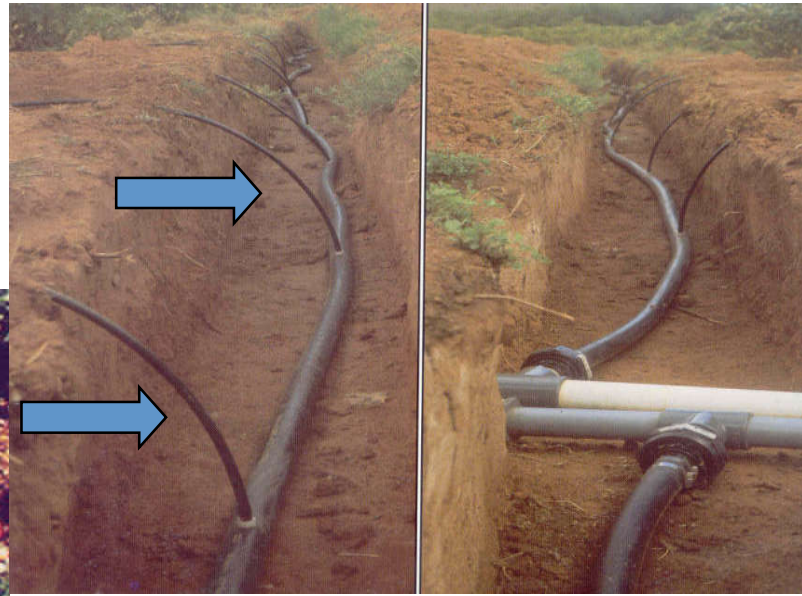
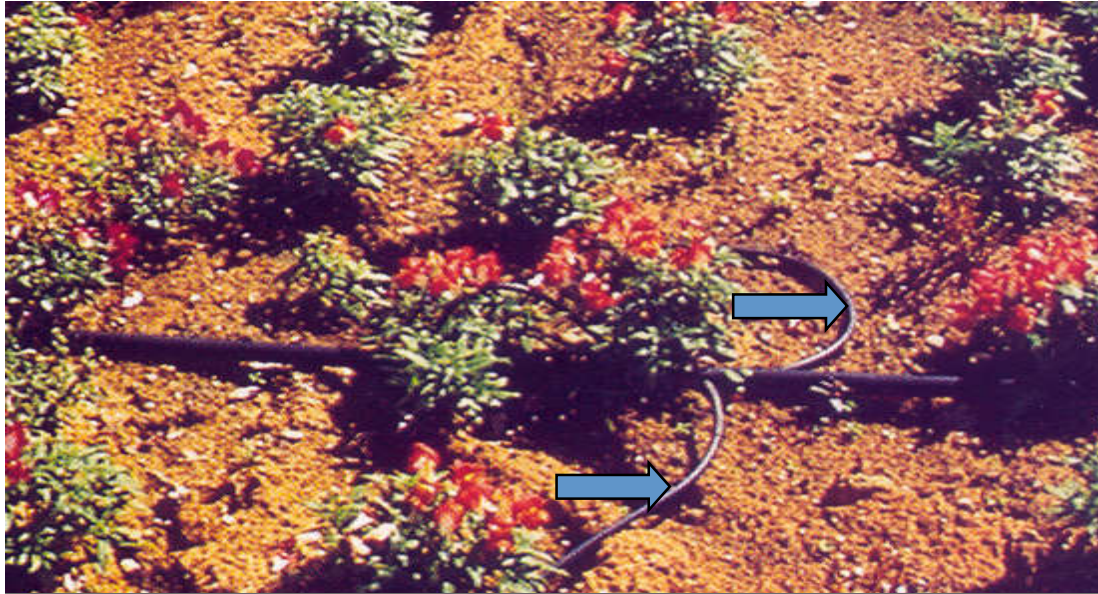
Key: select proper components:

- 1) emitters
- 2) pipes**
- 3) pump capacity



Pipes

- Lateral pipes



- PE
- PVC



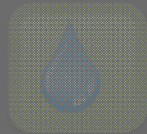
TYPHOON

Table 12

	wall thickness (mm)	dispensing rate (L/cm)		maximum pressure (m)	diameter (mm) inner outer	
TYPHOON 10	0.25	1.65	2.60	7.0	16.0	16.5
TYPHOON 13	0.33	1.75	2.70	8.5	15.9	16.5
TYPHOON 16	0.40	1.75	2.70	10.0	15.7	16.5
TYPHOON 20	0.50	1.75	2.75	14.0	15.5	16.5
TYPHOON 25	0.64	1.75	2.75	18.0	15.4	16.7
TYPHOON 35	0.90	2.00	3.00	25.0	15.2	17.0
SUPER TYPHOON 100	0.25	1.60	2.50	10.0	16.0	16.5
SUPER TYPHOON 125	0.32	1.65	2.60	14.0	15.9	16.5
PYTHON 100	0.25	1.55	-	9.0	20.8	21.2
PYTHON 135	0.34	1.55	-	12.0	20.8	21.5

dispensing rate (L/cm) vs. pressure (m)

	TYPHOON 10		TYPHOON 13, 16, 20		TYPHOON 25		TYPHOON 35		TYPHOON Super 100		TYPHOON Super 125		PYTHON 100 135
5 m	1.18	1.87	1.26	1.92	1.26	1.97	1.43	2.15	1.15	1.81	1.18	1.97	1.09
10 m	1.65	2.60	1.75	2.70	1.75	2.75	2.00	3.00	1.60	2.50	1.65	2.60	1.55
15 m	2.00	3.14	2.13	3.26	2.13	3.33	2.42	3.61	1.94	3.04	2.00	3.14	1.87
20 m	2.30	3.60	2.44	3.75	2.44	3.83	2.76	4.13	2.23	3.47	2.30	3.60	2.18
อัตราจ่ายน้ำ (ลิตร/ชม.)	1.65	2.60	1.75	2.70	1.75	2.75	2.00	3.00	1.60	2.50	1.65	2.60	1.55



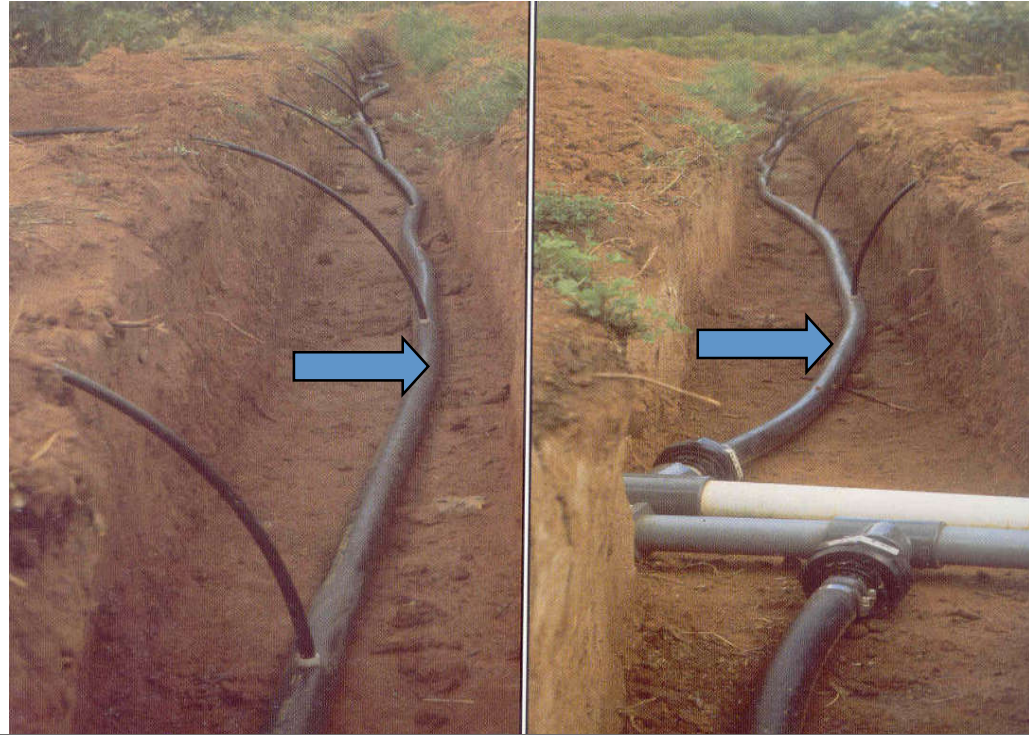
Pipes

- Sub-mainline or manifold

PE

HDPE

PVC



Pipes

- Mainline

HDPE

Rigid PVC

Asbestos Cement

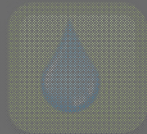
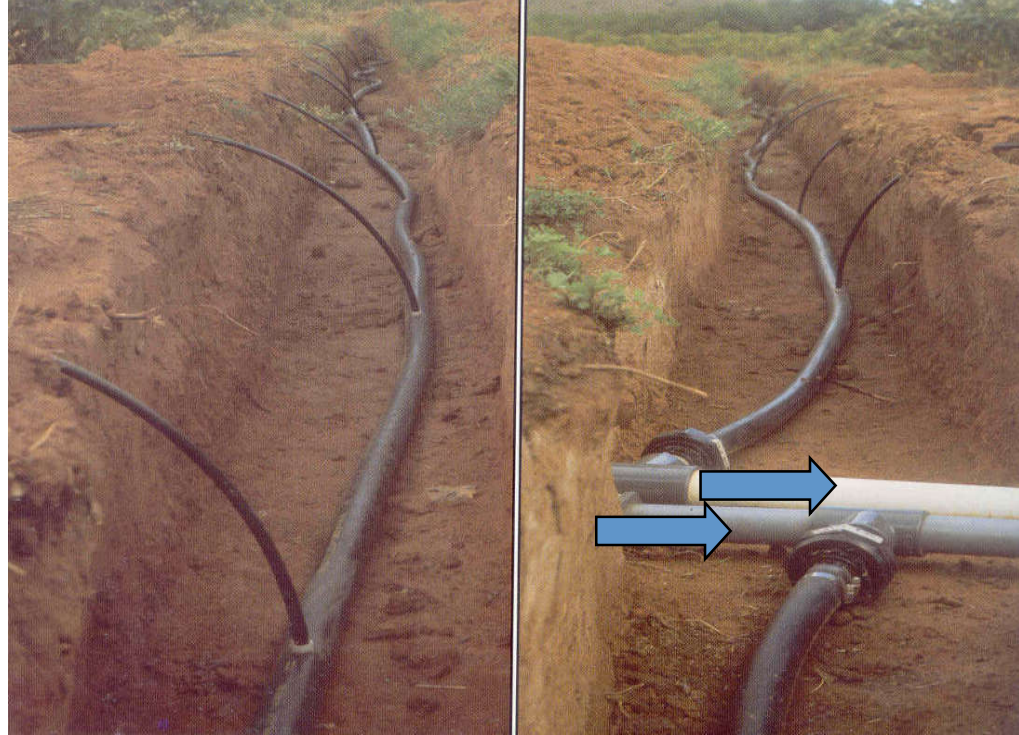


Table 13. Correlation factor depends on the number of outlets

Number of outlets		F	Number of outlets		F
1		1.00	8-9		0.41
2		0.64	10-11		0.40
3		0.54	12-15		0.39
4		0.49	16-20		0.38
5		0.46	21-30		0.37
6		0.44	31-70		0.36
7		0.43	>70		0.36

Table 14 Size and friction loss of LDPE pipe class 2.5

Flow rate Q (m ³ /h)	16 mm		20 mm	
	V (m/s)	J (m/100m)	V (m/s)	J (m/100m)
0.25	0.48	2.769	0.29	0.834
0.29	0.56	3.645	0.34	1.098
0.33	0.63	4.631	0.39	1.394
0.37	0.71	5.724	0.43	1.724
0.41	0.78	6.922	0.48	2.084
0.45	0.86	8.225	0.53	2.477
0.49	0.94	9.630	0.57	2.900
0.53	1.01	11.136	0.62	3.353
0.57	1.09	12.742	0.67	3.837
0.61	1.17	14.448	0.71	4.351
0.65	1.24	16.251	0.76	4.894
0.69	1.32	18.152	0.81	5.466
0.73	1.40	20.148	0.85	6.067
0.77	1.47	22.241	0.90	6.697
0.81	1.55	24.428	0.95	7.356
0.85	1.63	26.708	0.99	8.043
0.89	1.70	29.083	1.04	8.758
0.93	1.78	31.550	1.09	9.501
0.97	1.86	34.109	1.10	10.271

Table 14 (cont.) Size and friction loss of LDPE pipe class 2.5

Flow rate Q (m ³ /h)	16 mm		20 mm	
	V (m/s)	J (m/100m)	V (m/s)	J (m/100m)
1.05	2.01	39.501	1.23	11.895
1.09	2.09	42.333	1.27	12.748
1.13	2.16	45.255	1.32	13.628
1.17	2.24	48.266	1.37	14.534
1.21			1.41	15.468
1.25			1.46	16.428
1.29			1.51	17.415
1.33			1.56	18.429
1.37			1.60	19.468
1.41			1.65	20.534
1.45			1.70	21.626
1.49			1.74	22.744
1.53			1.79	23.887
1.57			1.84	25.057
1.61			1.88	26.252
1.65			1.93	27.473
1.69			1.98	28.719
1.73			2.02	29.990
1.77			2.07	31.287
1.81			2.12	32.609
1.85			2.16	33.956

Table 15 Size and fraction loss of PVC pipe class 8.5

Flow rate Q (m³/h)	¾ inch		1 inch		Flow rate Q (m³/h)	1 ½ inch		2 inch	
	V (m/s)	J (m/100m)	V (m/s)	J (m/100m)		V (m/s)	J (m/100m)	V (m/s)	J (m/100m)
1.20	0.88	4859	0.47	1.073	4.25	0.80	1.847	0.51	0.626
1.30	0.95	5635	0.51	1.244	4.50	0.85	2.053	0.54	0.695
1.40	1.02	6.464	0.55	1.427	4.75	0.89	2.269	0.57	0.769
1.50	1.10	7.345	0.59	1.621	5.00	0.94	2.495	0.6	0.845
1.60	1.17	8.278	0.63	1.827	5.25	0.99	2.731	0.63	0.925
1.70	1.24	9.262	0.67	2.044	5.50	1.03	2.977	0.66	1.008
1.80	1.32	10.296	0.71	2.273	5.75	1.08	3.232	0.69	1.095
1.90	1.39	11.8	0.75	2.512	6.00	1.13	3.497	0.72	1.185
2.00	1.46	12.514	0.79	2.762	6.25	1.17	3.772	0.75	1.278
2.10	1.54	13.698	0.83	3.024	6.50	1.22	4.056	0.78	1.374
2.20	1.61	14.93	0.87	3.296	6.75	1.27	4.350	0.81	1.474
2.30	1.68	16.211	0.9	3.578	7.00	1.32	4.653	0.84	1.576
2.40	1.76	17.541	0.94	3.872	7.25	1.36	4.966	0.87	1.682
2.50	1.83	18.918	0.98	4.176	7.50	1.41	5.287	0.90	1.791
2.60	1.90	20.343	1.02	4.491	7.75	1.46	5.618	0.93	1.903
2.70	1.97	21.816	1.06	4.816	8.00	1.50	5.959	0.96	2.019
2.80	2.05	23.336	1.10	5.151	8.25	1.55	6.308	0.99	2.137
2.90	2.12	24.903	1.14	5.497	8.50	1.60	6.667	1.02	2.258
3.00	2.19	26.517	1.18	5.853	8.75	1.64	7.034	1.05	2.383
3.10	2.27	28.144	1.22	6.220	9.00	1.69	7.411	1.08	2.511

Table 15 (cont.) Size and fraction loss of PVC pipe class 8.5

Flow rate Q (m³/h)	¾ inch		1 inch		Flow rate Q (m³/h)	1 ½ inch		2 inch	
	V (m/s)	J (m/100m)	V (m/s)	J (m/100m)		V (m/s)	J (m/100m)	V (m/s)	J (m/100m)
3.20	2.34	29.883	1.26	6.597	9.25	1.74	7.797	1.11	2.641
3.30	2.41	31.636	1.30	6.983	9.50	1.79	8.192	1.14	2.775
3.40	2.49	33.434	1.34	7.380	9.75	1.83	8.595	1.17	2.912
3.50			1.38	7.787	10.00	1.88	9.008	1.21	3.052
3.60			1.42	8.204	10.25	1.93	9.429	1.24	3.194
3.70			1.46	8.631	10.50	1.97	9.860	1.27	3.340
3.80			1.49	9.068	10.75	2.02	10.299	1.3	3.489
3.90			1.53	9.515	11.00	2.07	10.747	1.33	3.641
4.00			1.57	9.972	11.25	2.11	11.204	1.36	3.795
4.10			1.61	1.439	11.5	2.16	11.669	1.39	3.953
4.20			1.65	10.915	11.75	2.21	12.143	1.42	4.114
4.30			1.69	11.401	12.00	2.26	12.626	1.45	4.277
4.40			1.73	11.897	12.25	2.30	13.117	1.48	4.444
4.50			1.77	12.43	12.50	2.35	13.618	1.51	4.613
4.60			1.81	12.918	13.00	2.44	14.643	1.57	4.961
4.70			1.85	13.443	13.50	2.54	15.704	1.63	5.320
4.80			1.89	13.978	14.00			1.69	5.691
4.90			1.93	14.522	14.50			1.75	6.073
5.00			1.97	15.075	15.00			1.81	6.466
5.10			2.01	15.639	15.50			1.87	6.871
5.20			2.05	16.211	16.00			1.93	7.287
5.20			2.05	16.211	16.00			1.93	7.287

Table 15 (cont.) Size and fraction loss of PVC pipe class 8.5

Capacity Q = m³/hr.	2 1/2 inch		3 inch		Capzcity Q = m³/hr.	4 inch		5 inch	
	V = m/s	J = m/100 m	V = m/s	J = m/100 m		V = m/s	J = m/100 m	V = m/s	J = m/100 m
10.50	0.78	1.030	0.57	0.478	24.00	0.79	0.658	0.53	0.242
11.25	0.84	1.171	0.61	0.543	26.00	0.86	0.763	0.57	0.281
12.00	0.89	1.320	0.65	0.612	28.0	0.92	0.875	0.61	0.322
12.75	0.95	1.476	0.69	0.684	30.00	0.99	0.995	0.66	0.366
13.50	1.00	1.641	0.73	0.761	31.50	1.04	1.089	0.69	0.401
14.25	1.06	1.814	0.77	0.841	33.00	1.09	1.187	0.72	0.437
15.00	1.12	1.995	0.81	0.925	34.50	1.14	1.288	0.75	0.474
15.75	1.17	2.184	0.85	1.012	36.00	1.19	1.394	0.79	0.513
16.50	1.23	2.380	0.89	1.103	37.50	1.24	1.504	0.82	0.553
17.25	1.28	2.584	0.94	1.198	39.00	1.29	1.617	0.85	0.595
18.00	1.34	2.796	0.98	1.296	40.50	1.34	1.734	0.89	0.638
18.75	1.39	3.016	1.02	1.398	42.00	1.39	1.855	0.92	0.683
19.50	1.45	3.243	1.06	1.503	43.50	1.43	1.979	0.95	0.728
20.25	1.51	3.478	1.10	1.612	45.00	1.48	2.107	0.98	0.776
21.00	1.56	3.720	1.14	1.724	46.50	1.53	2.239	1.02	0.824
21.75	1.62	3.970	1.18	1.840	48.00	1.58	2.375	1.05	0.874
22.50	1.67	4.227	1.22	1.959	49.50	1.63	2.514	1.08	0.925
23.25	1.73	4.492	1.26	2.082	51.00	1.68	2.657	1.12	0.978

How to apply micro-irrigation method to your situation?

Key: select proper components:

- 1) emitters
- 2) pipes
- 3) pump capacity**



Pipes



vegetableclimate.com

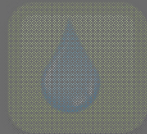
Table 16. Data for selecting pump size

Type	Motor		Capacity - m³/H or L/min											
			0	8	10	12	14	16	18	20	25	30	35	40
			0	133	167	200	233	267	300	333	417	500	583	667
WR	HP	Kw	Tot. head in m											
40-125 C	2	1.5	18.5	18.5	18.3	18.1	17.8	17.5	17.1	16.6	14.8	12.5	9.4	
40-125 B	3	2.2	22.0		22.0	22.0	21.8	21.5	21.2	20.8	19.4	17.5	14.8	
40-125 A	4	3	26.5		26.5	26.3	26.1	25.8	25.4	25.0	23.7	22.0	19.8	17.2
40-160 C	4	3	31.8		31.2	30.8	30.4	29.8	29.2	28.6	26.6	24.1	21.2	
40-160 B	5.5	4	36.4			35.6	35.2	34.7	34.3	33.6	31.8	29.4	26.5	23.2
40-160 A	7.5	5.5	39.4			39.2	39.0	38.6	38.2	37.6	35.9	33.8	31.1	28.1
40-200 C	5.5	4	45.0			43.5	43.0	42.2	41.3	40.8	38.0	33.7	28.0	
40-200 B	7.5	5.5	48.2			47.0	46.5	45.7	45.1	44.5	42.1	39.0	34.5	
40-200 A	10	7.5	57.5			56.0	55.5	55.0	54.5	54.0	51.6	49.0	45.1	40.0
40-250 C	12.5	9	69.0			66.5	65.0	64.0	62.5	61.5	57.5	52.0	45.0	
40-250 B	15	11	76.0			72.5	71.0	70.0	69.0	67.5	64.0	59.0	53.0	45.0
40-250 A	20	15	92.0			89.0	88.0	86.5	85.5	84.7	82.2	79.0	75.0	70.0

HP e Kw Potenza nominale motore - HP and Kw nominal motor power - CV et Kw puissance nominale moteur

Design Procedures

- Identify the location of water supply
- Identify number of plot
- Calculate of the number of emitters in a plot, and determine capacity of system
- Layout: lateral, sub-main line, main line
- Calculate total dynamic head loss
- Use capacity of system and total dynamic loss to select pump size



Design Procedures

- Find maximum consumptive use

$$ET_{veg} = 0.8 \times E_p \quad (\text{mm/day})$$

$$ET_{tree} = 0.5 \times D^2 \times E_p \quad (\text{L/plant/day})$$

$$IWR = ET_{veg} \quad (\text{L/plant/day})$$



Design Procedures

- **Calculate Run Time**

$$\text{Run Time} = \frac{\text{IWR}}{\text{Flow rate of emitters}}$$



Design Procedures

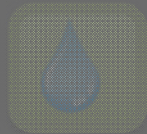
- **Number of plot/zones**

$$\text{Number of plots} = \frac{\text{Working hour/day}}{\text{Run Time}}$$

Eq.6

$$\text{Area/plot} = \frac{\text{Total area}}{\text{Number of plots}}$$

Eq.7



Design Procedures

- **Design of Pump and Motor**

$$\text{WHP} = Q \times H / 273 \quad \text{Eq.8}$$

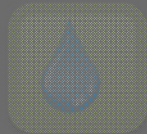
$$\text{BHP} = \text{WHP} / \text{Pump Efficiency} \quad \text{Eq.9}$$

where

Q = discharge (m³/hr)

H = total dynamic head loss

= static head loss + friction loss from pipe + working pressure



How to select the pipe size

- To select a proper pipe size, we must know
 - 1) Radius of wetted area
 - 2) Flow rate
 - 3) Working pressure

These parameters define the proper pipe size in Table 7A-C.



How to select the pipe size

1) Select emitters

From Table 11,

Working pressure (m)	Emitters Adjusting (Round)	Flow rate (L/hr)	Wetting Radius (m)	Spacing (mxm)	Uniformity of Coefficient (Cu %)	Precipitation Rate (mm/hr)
5	2	360	3.0	4.0 x 4.0	89.63	22.50
5	3	480	3.5	4.0 x 4.0	78.74	33.00
10	2	520	3.5	4.0 X 4.0	90.44	32.50
10	3	660	4.0	4.0 X 4.0	81.20	41.25
15	2	430	3.5	4.0 X 4.0	80.00	26.88
15	3	640	4.0	4.0 X 4.0	85.37	40.00



How to select the pipe size

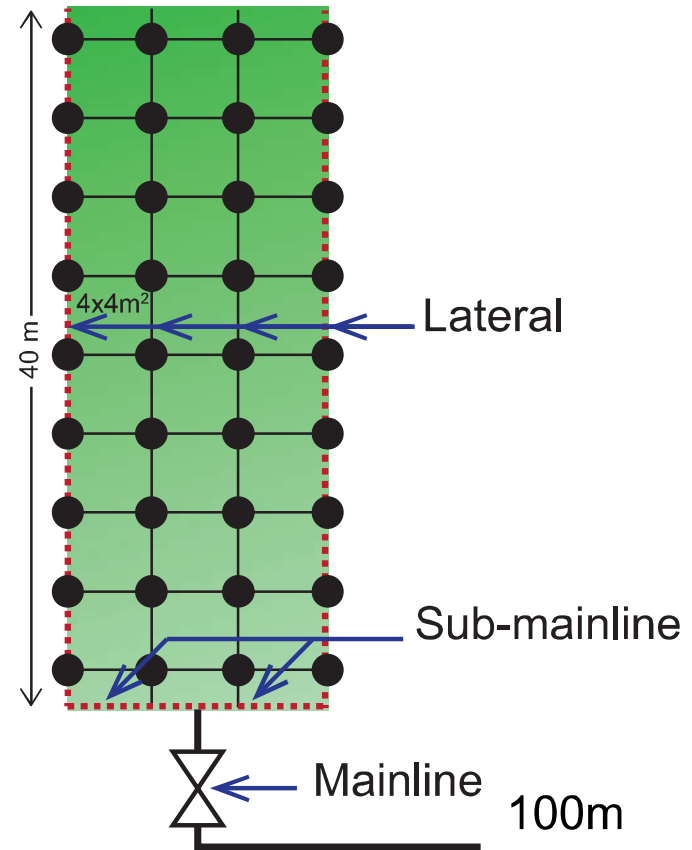
2) To select lateral pipe, we need to know

- flow rate
- number of emitters

Example

Here we have 10 emitters with a flow rate of 360 L/h.

Thus, lateral flow rate (Q_{lateral})
= number of emitters x flow rate
= $10 \times 360 \text{ L/h} = 3,600 \text{ L/h}$
= $3.6 \text{ m}^3/\text{h}$



How to select the pipe size

3) Based on the calculated flow rate, we can select the proper pipe size

Table 7B

Pipe Size Selection Data :

Lateral size

- PVC Ø ¾"	Capacity	2.80	m ³ /hr (2,800 litres/hr)
- PVC Ø 1"	Capacity	5.10	m ³ /hr (5,100 litres/hr)

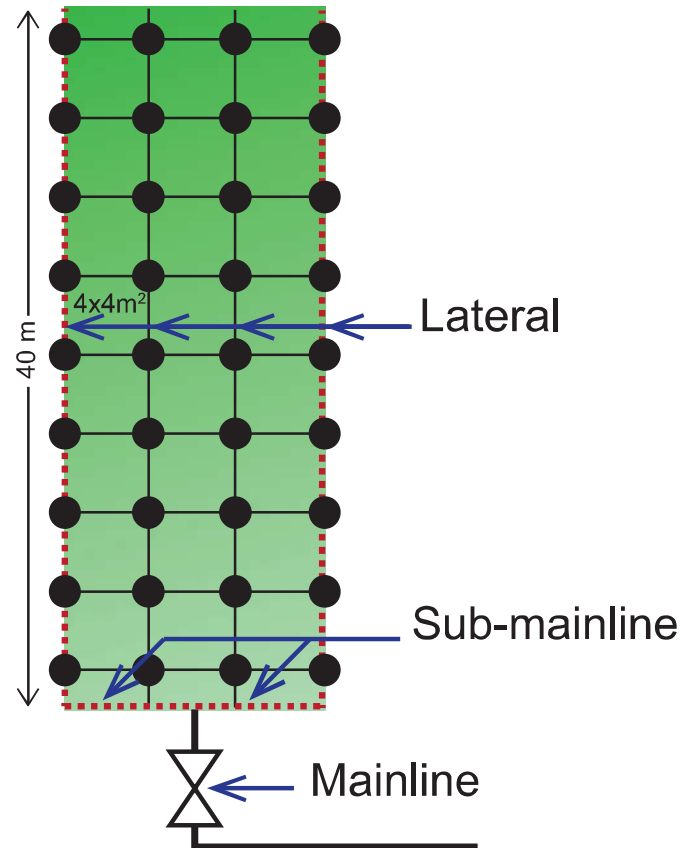
Sub-Mainline

- PVC Ø 1"	Capacity	5.10	m ³ /hr (5,100 litres/hr)
- PVC Ø 1½"	Capacity	11.00	m ³ /hr (11,000 litres/hr)
- PVC Ø 2"	Capacity	16.00	m ³ /hr (16,000 litres/hr)

Mainline

- PVC Ø 1"	Capacity	3.90	m ³ /hr (3,900 litres/hr)
- PVC Ø 1½"	Capacity	8.00	m ³ /hr (8,000 litres/hr)
- PVC Ø 2"	Capacity	13.60	m ³ /hr (13,600 litres/hr)
- PVC Ø 2½"	Capacity	20.25	m ³ /hr (20,250 litres/hr)
- PVC Ø 3"	Capacity	27.75	m ³ /hr (27,750 litres/hr)

We select this pipe because its Q is larger than 3.6 m³/h



How to select the pipe size

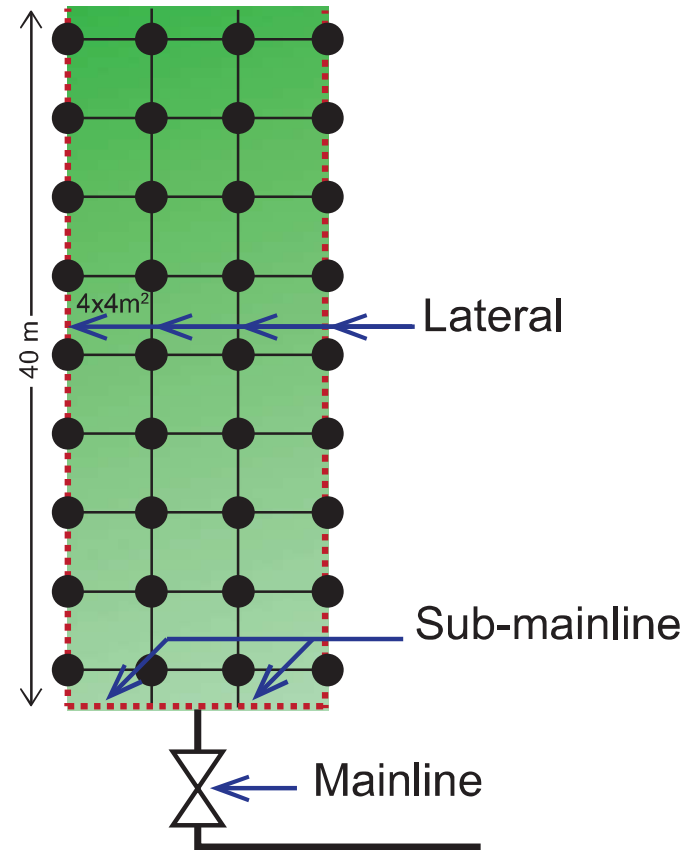
3) To select sub-mainline pipe, we need to know its flow rate, which equals to the combined flow rate of its branched lateral pipes.

$$\begin{aligned} Q_{\text{sub-mainline}} &= \text{number of branched lateral pipes} \times Q_{\text{lateral}} \\ &= 2 \times 3.6 = 7.2 \text{ m}^3/\text{h} \end{aligned}$$

Table 7B

Sub-Mainline			
- PVC Ø 1"	Capacity	5.10	m ³ /hr (5,100 litres/hr)
- PVC Ø 1½"	Capacity	11.00	m ³ /hr (11,000 litres/hr)
- PVC Ø 2"	Capacity	16.00	m ³ /hr (16,000 litres/hr)

We select this pipe because its Q is larger than $7.2 \text{ m}^3/\text{h}$



How to select the pipe size

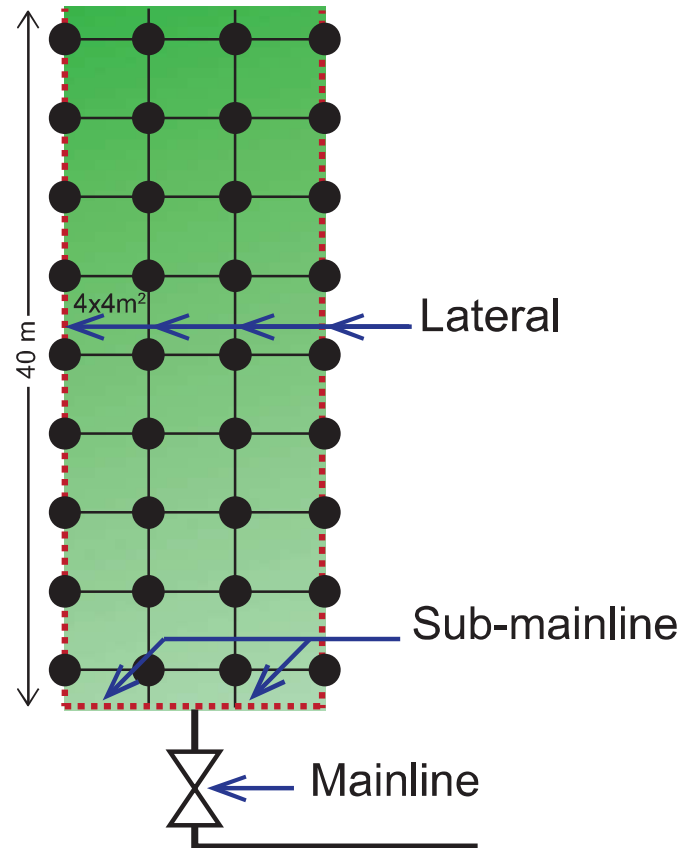
3) To select the mainline pipe, we need to know its flow rate, which equals to the combined flow rate of its branched sub-mainline pipes.

$$Q_{\text{mainline}} = \text{number of branched lateral pipes} \times Q_{\text{sub-mainline}} \\ = 2 \times 7.2 = 14.4 \text{ m}^3/\text{h}$$

Table 7B

Mainline			
- PVC Ø 1"	Capacity	3.90	m ³ /hr (3,900 litres/hr)
- PVC Ø 1½"	Capacity	8.00	m ³ /hr (8,000 litres/hr)
- PVC Ø 2"	Capacity	13.60	m ³ /hr (13,600 litres/hr)
- PVC Ø 2½"	Capacity	20.25	m ³ /hr (20,250 litres/hr)
- PVC Ø 3"	Capacity	27.75	m ³ /hr (27,750 litres/hr)

We select this pipe because its Q is larger than 14.4 m³/h



How to select the pump

3) To select the pump, we need to know the friction loss in lateral, sub-mainline, and mainline pipes

$$H_f = J \times F \times L \quad Eq. 10$$

where H_f = friction loss in pipes (m)
 J = friction loss (m/100m, **Tables 14-15**)
 F = correlation factor (**Table 13**)



How to select the pump

Previously, we selected the lateral pipes of 1inch diameter with a flow rate of $3.6 \text{ m}^3/\text{h}$. Along its length of 40 m, 9 emitters are installed.

The friction loss in the lateral pipes can be calculated:

From Table 15,

J is $8.20 \text{ m}/100 \text{ m}$ for a 1inch-diameter PVC pipe at a flow rate of $3.6 \text{ m}^3/\text{h}$

From Tables 13,

F is 0.41 for 9 outlets

Thus, $H_{f, \text{lateral}} = 8.20/100 \times 0.41 \times 40 = 1.34 \text{ m}$

For sub-mainline and mainline pipes, we can calculate their friction loss similarly (*the answers are 0.14 and 1.995 m, respectively*)



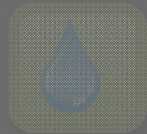
How to select the pump

From Eq. 9, BHP

$$\begin{aligned} &= 14.4 \times \{3 + (1.34 + 0.14 + 1.995) + 5\} / 273 / 0.4 \\ &= 1.5 \text{ HP} \end{aligned}$$

To select a commercially-available pump:

Table 5, for $Q = 16 \text{ }^3/\text{h}$ and total head = 17.5,
the proper model of pump is WR 40-125C (2 HP)



I hope that you now...



1) Know how much water to irrigate



2) Know when to irrigate



3) Know the suitable Run Time



4) Know the efficiency of each method



5) Know where to obtain the water



5) Know how to apply these techniques?

THANK YOU
for your attention

QUESTIONS?