Irrigation for vegetable production

Dr. Songsak PUTTRAWUTICHAI
Department of Irrigation Engineering
Faculty of Engineering at Kamphaeng-saen
Kasetsart University

+66 34281101
fengsspu@ku.ac.th

World Vegetable Center

Songsak PUTTRAWUTICHAI

D.Eng. (Irrigation Engineering), Kasetsart University
M.Eng. (Irrigation Engineering), Kasetsart University
B.Eng. (Irrigation Engineering), Kasetsart University

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?

6) How to apply these techniques?

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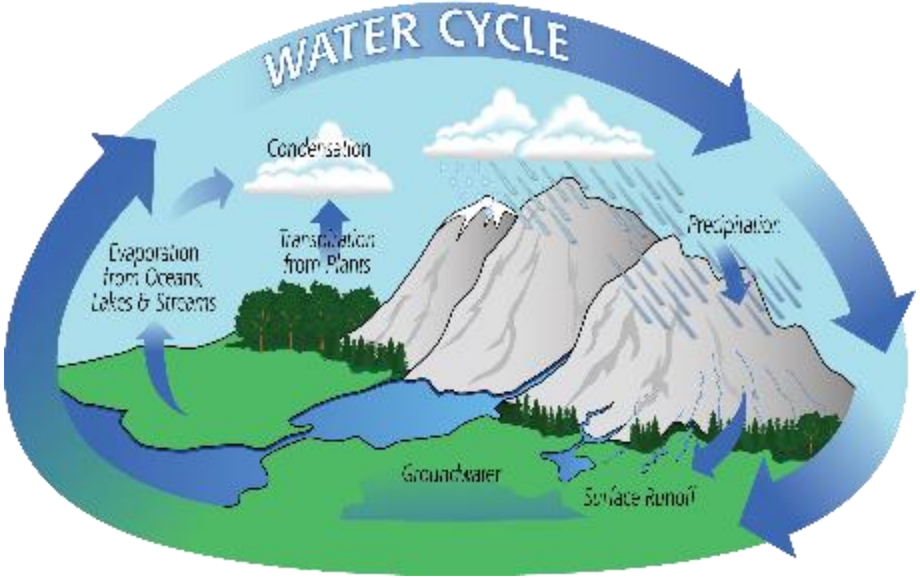
Water requirement VS. Water supply



How much water to irrigate?

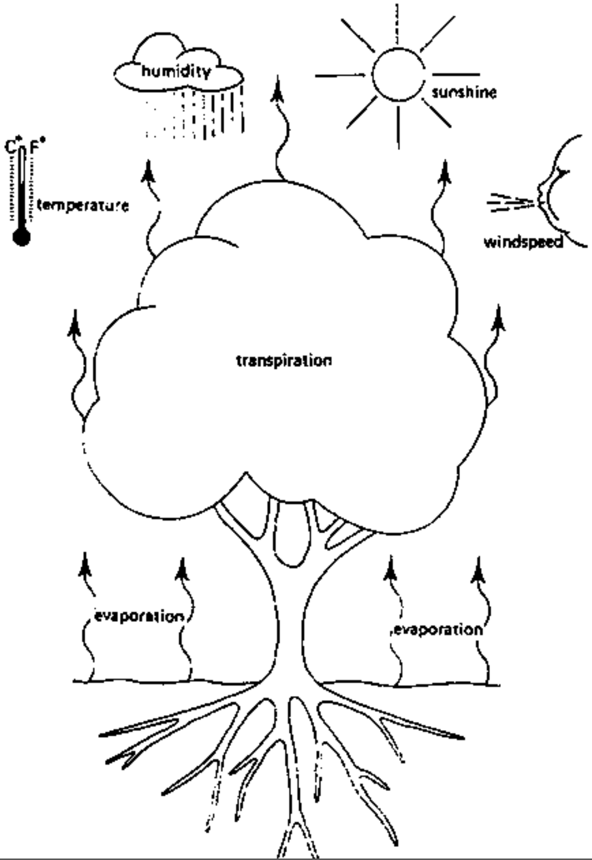
- ***What is vegetable water requirement?***

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

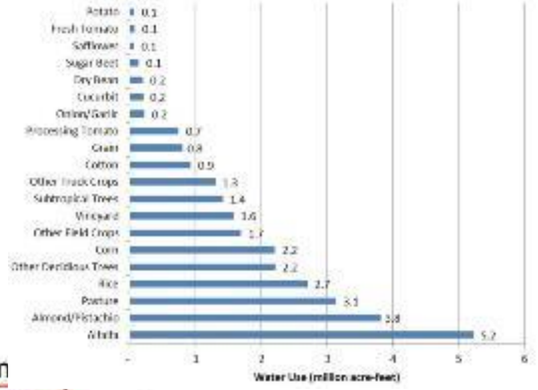
The crop water requirement

The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration

(Food and Agriculture Organization of the United Nations)

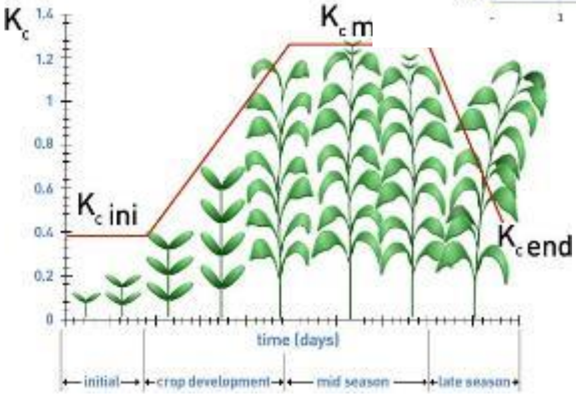


The crop water requirement mainly depends on:



- Climate
- Crop type
- Growth stage of the

Climatic Factor	Crop water need	
	High	**Low**
Temperature	hot	cool
Humidity	low (dry)	high (humid)
Windspeed	windy	little wind
Sunshine	sunny (no clouds)	cloudy (no sun)

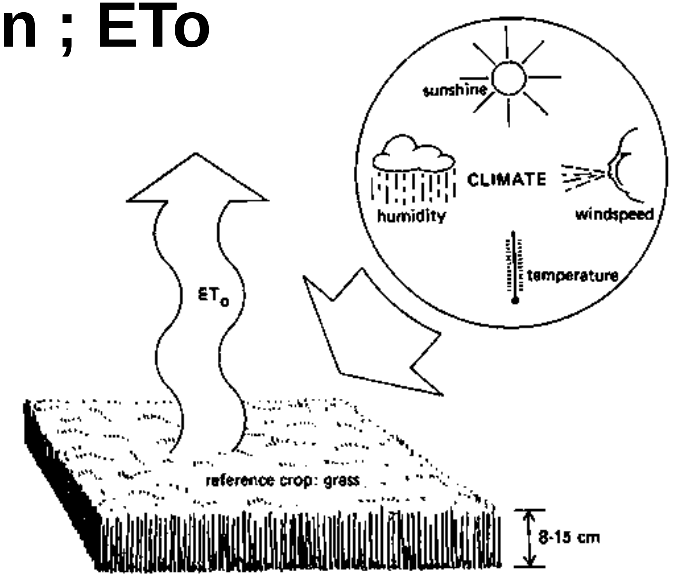


The reference crop evapotranspiration ; ETo

The **reference crop evapotranspiration** (ETo) expresses influence of climate.

The ETo is usually expressed by depth/time

Grass has been taken as the reference crop.

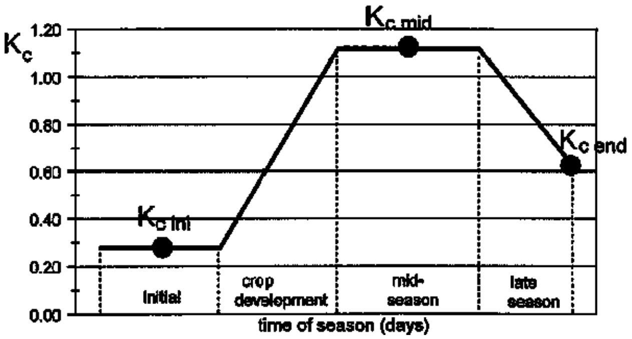


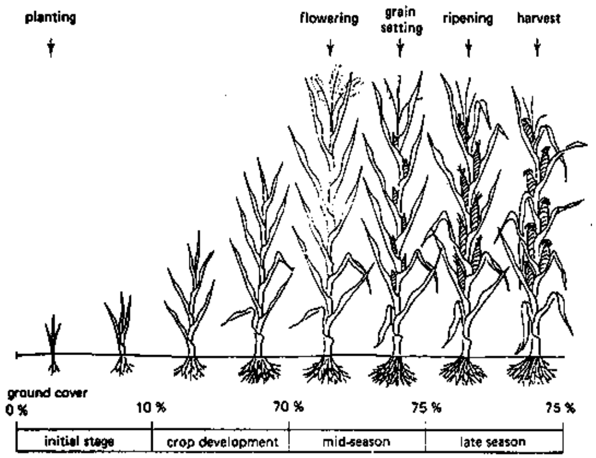
Crop coefficient; Kc

Crop coefficient; Kc is expressed the influence of the crop type and growth stage on crop water requirement

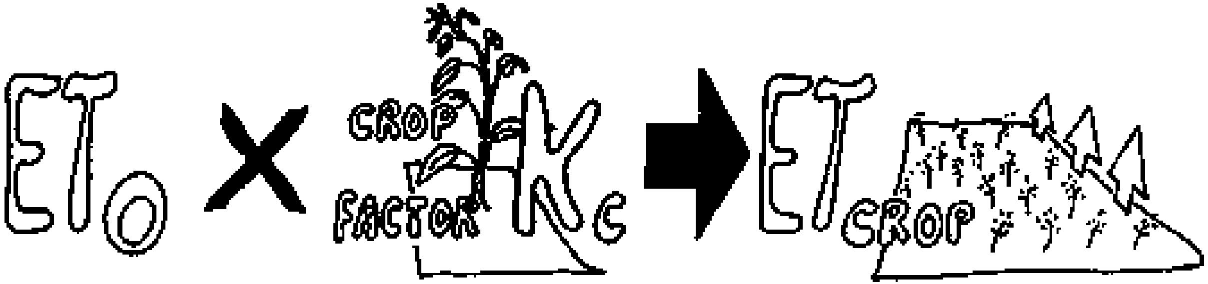
The crop coefficient, Kc, mainly depends on:

- Type of crop
- Growth stage of the crop
-





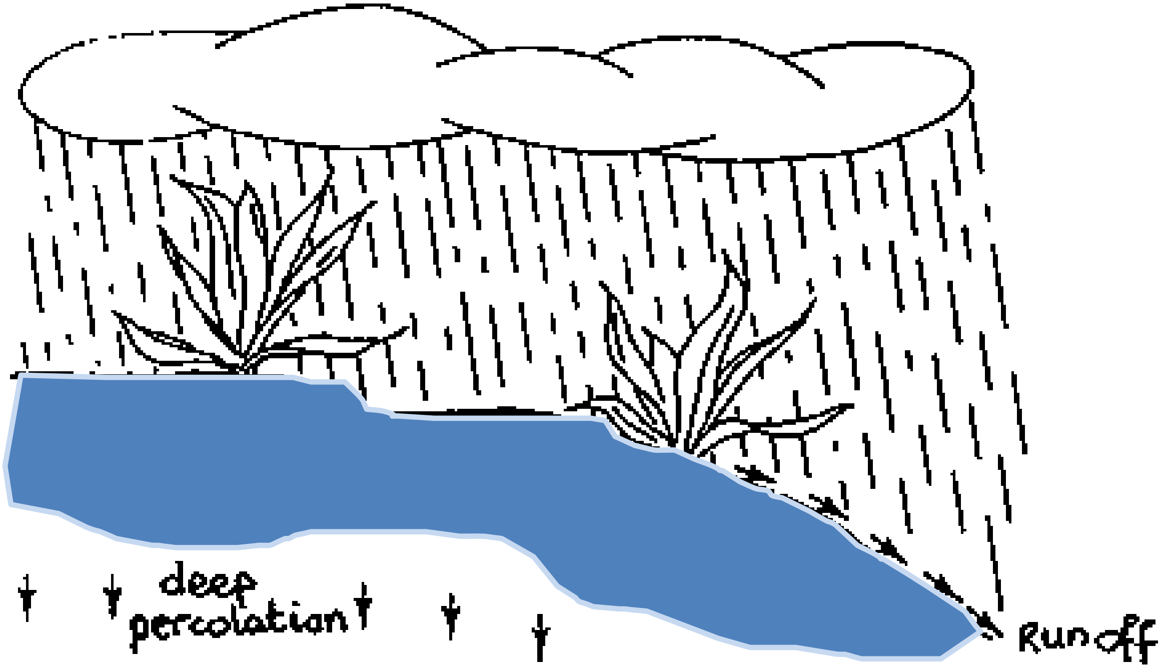
Crop Water Requirement; ETcrop



ETcrop is crop water requirement (mm)
KC is crop coefficient
ETo is reference evapotranspiration (mm)

Effective rainfall

Meaning: Effective rainfall (Pe) is the amount of precipitation that is actually added and stored in the soil, which is useful for the plants.



Amount of effective rainfall

If: Rainfall < Water requirement
Effective rainfall = All of rainfall

If: Rainfall > Water requirement
Effective rainfall = Amount of water which is stored in the soil→ To calculate

If: Rainfall >> Water requirement
Effective rainfall = Water requirement

Estimation of effective rainfall for paddy

Avg. monthly rainfall	**Effective rainfall (Ep)**	
(mm)	(mm)	%
200	200	100
250	237.5	95
300	270	90
350	292.5	83.6
400	310	77.5
450	320	77.1
500	325	65

Estimation of Effective rainfall perennial crop

$$Ep = 2.54f\,(0.329R^{0.824} - 0.116) \times 10^{0.009ET_{crop}}$$

Where: Ep = Effective rainfall in centimeter

f = $(0.532 + 0.116D + 0.009D^2 + 0.002D^3)$

D = Amount of humidity in root zone before irrigation

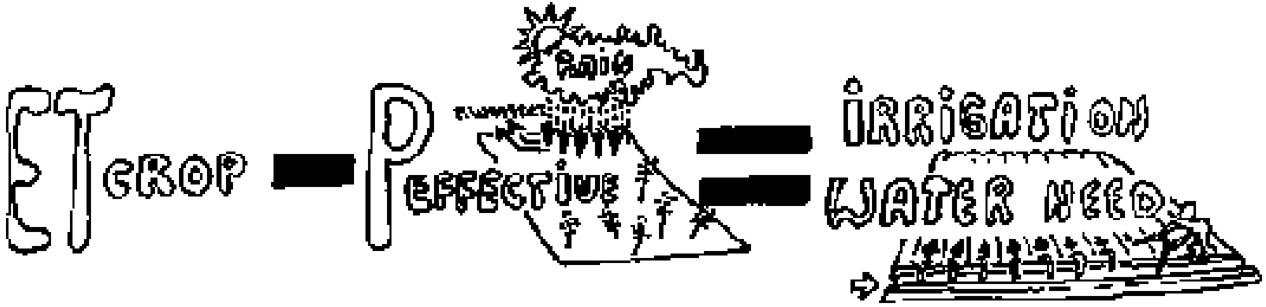
R = Avg. Monthly rainfall in centimeter

ETcrop = Crop water requirement in centimeter

Estimation of Effective rainfall for Upland crop

Avg. rainfall (mm)	Crop water requirement (ETcrop) ; mm									
	25	50	75	100	125	150	175	200	225	250
15	9	10	10	11	11	12	12	13	14	15
20	12	13	14	14	15	16	17	18	19	20
30	18	19	21	22	22	23	24	25	28	30
40	23	25	27	29	30	31	32	35	38	40
50	25	32	34	35	35	38	40	43	46	49
60		38	40	42	43	45	47	51	55	59
70		43	46	49	51	53	55	59	63	68
80		48	52	55	58	60	63	67	71	77
90		50	57	61	64	67	70	75	79	85
100			63	67	71	74	78	82	87	94
110			68	73	78	80	84	89	95	102
120			73	78	84	85	91	97	102	110
130			75	83	89	92	98	104	110	118
140				89	95	99	105	112	118	126
150				94	101	105	110	120	125	134
160				99	106	110	117	125	132	142
170				100	111	116	123	131	138	149
180					116	121	129	136	144	155
190					121	126	134	142	150	161
200					125	132	140	148	157	168
Capacity of humidity storage in soil (mm)	20	30	40	50	60	75	100	125	150	175
Factor	0.74	0.82	0.88	0.93	0.96	1	1.02	1.04	1.06	1.07

Irrigation water requirement



<u>Step 1</u>: To determine the reference crop evapotranspiration: ETo

<u>Step 2</u>: To determine the crop factors: Kc

<u>Step 3</u>: To calculate the crop water need: ETcrop = ETo × Kc

<u>Step 4</u>: To determine the effective rainfall: Pe

<u>Step 5</u>: To calculate the irrigation water requirement = ETcrop - Pe

Irrigation water requirement in irrigation area

Net Irrigation Water Requirement (NIWR) :

the quantity of water necessary for crop growth for the whole planting area

$$NIWR = \frac{\sum_{i=1}^{n} CWR_i \cdot S_i}{S}$$

where S_i is the area cultivated with the crop i in ha.

Gross Irrigation Water Requirement (GIWR) :

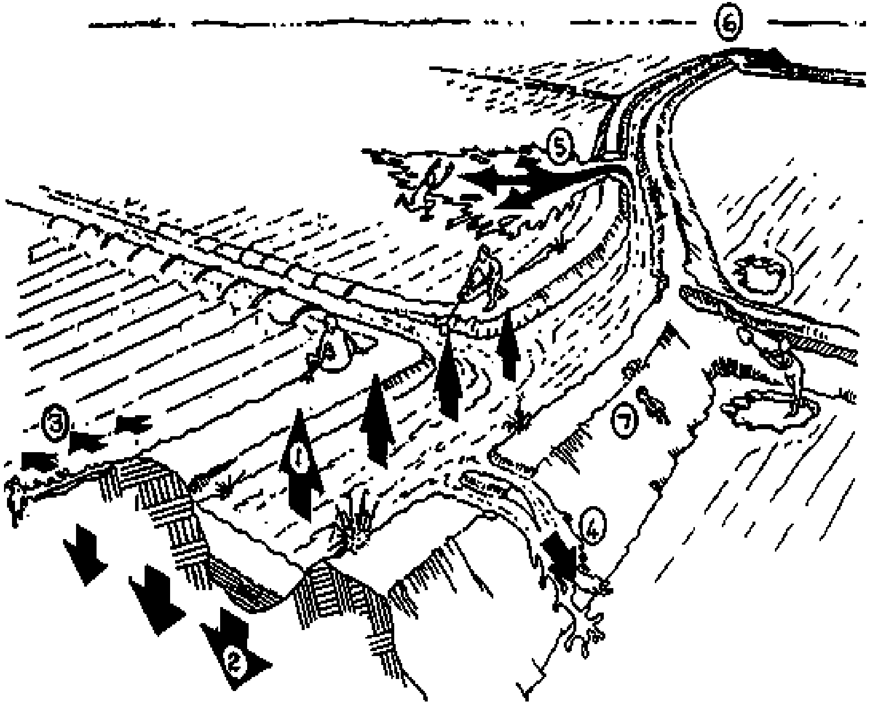
the amount of water to be extracted and applied to the irrigation scheme (includes losses).

$$GIWR = \frac{1}{E} \cdot NIWR$$

where E is the efficiency of the irrigation system.

Irrigation losses

Examples:
1. Evaporation
2. Deep percolation
3. Seepage
4. Overtopping
5. Bund breaks
6. Runoff in the drain
7. Rat holes in the canal bunds



How much water to irrigate?

- ***How to determine vegetable water requirement?***

By using class A pan,

$$ET_{crop} = K_p \times E_{pan}$$ *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 perentage**										
	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)?***

$$\mathbf{IWR_{crop} = ET_{crop} / method\ efficiency} \qquad \textit{Eq. 2}$$

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

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Completed

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4) What is efficiency of each method?

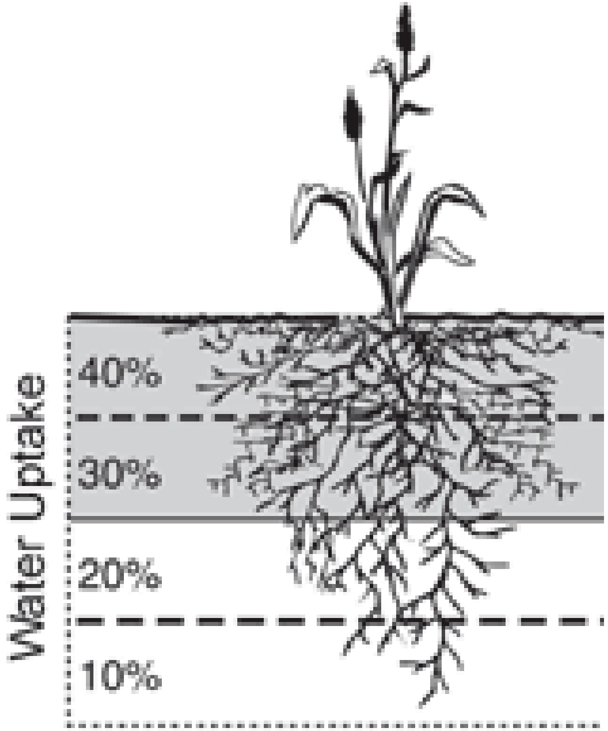
5) Where to obtain the water?

6) 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 centibars and thus can be measured by tensiometer

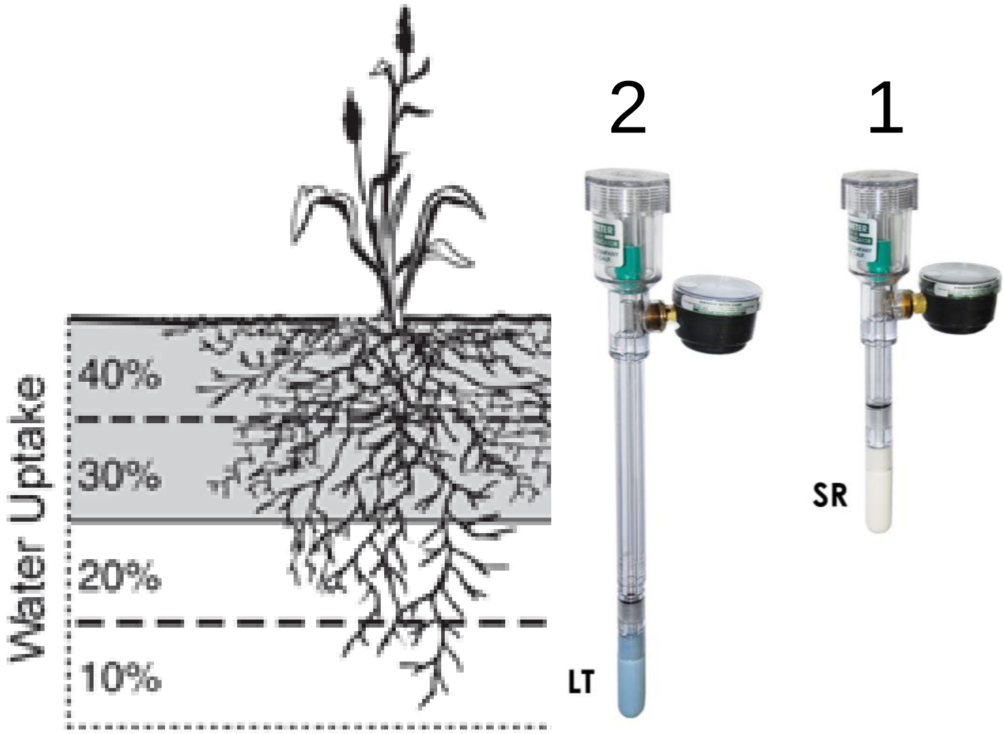
duboisag.com

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

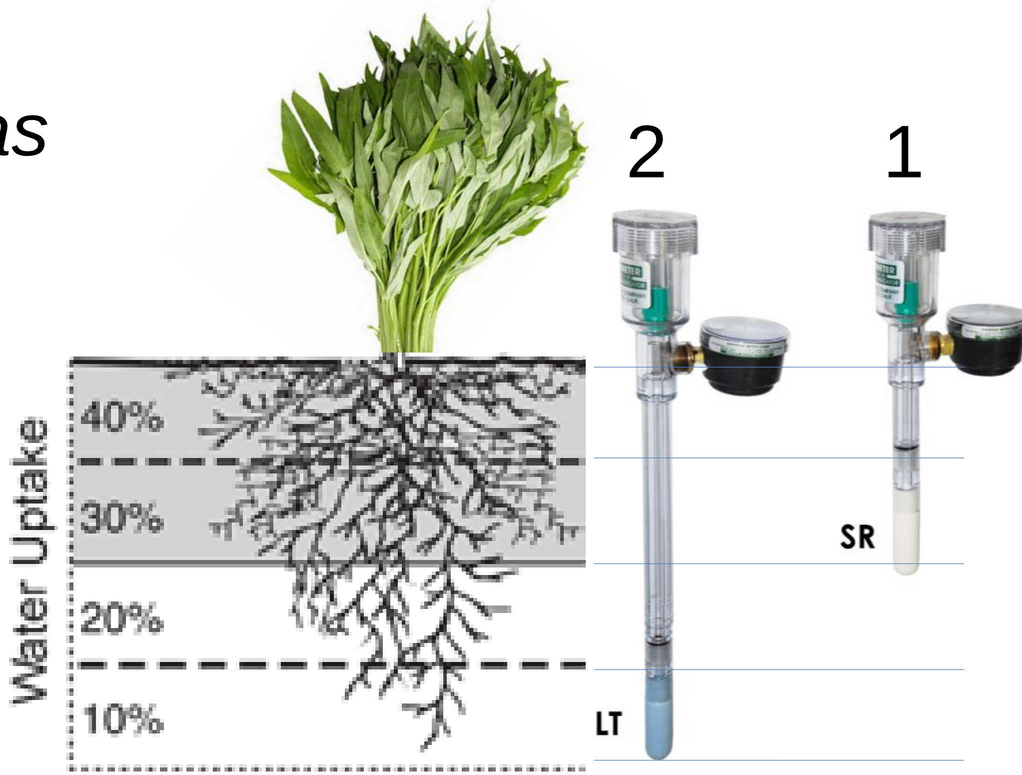


Example

Chinese morning glory has an appropriate moisture tension of 30 centibars

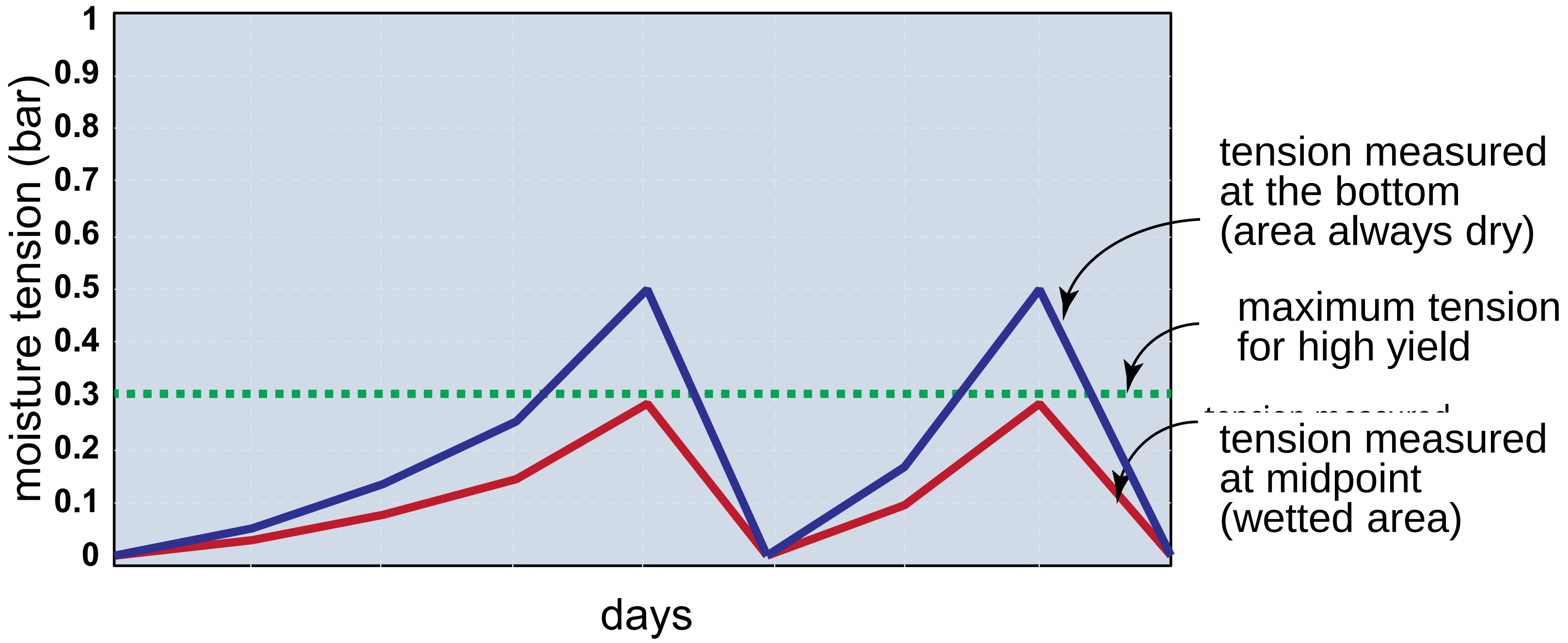
1) at 0.15 m depth

2) at 0.30 m depth



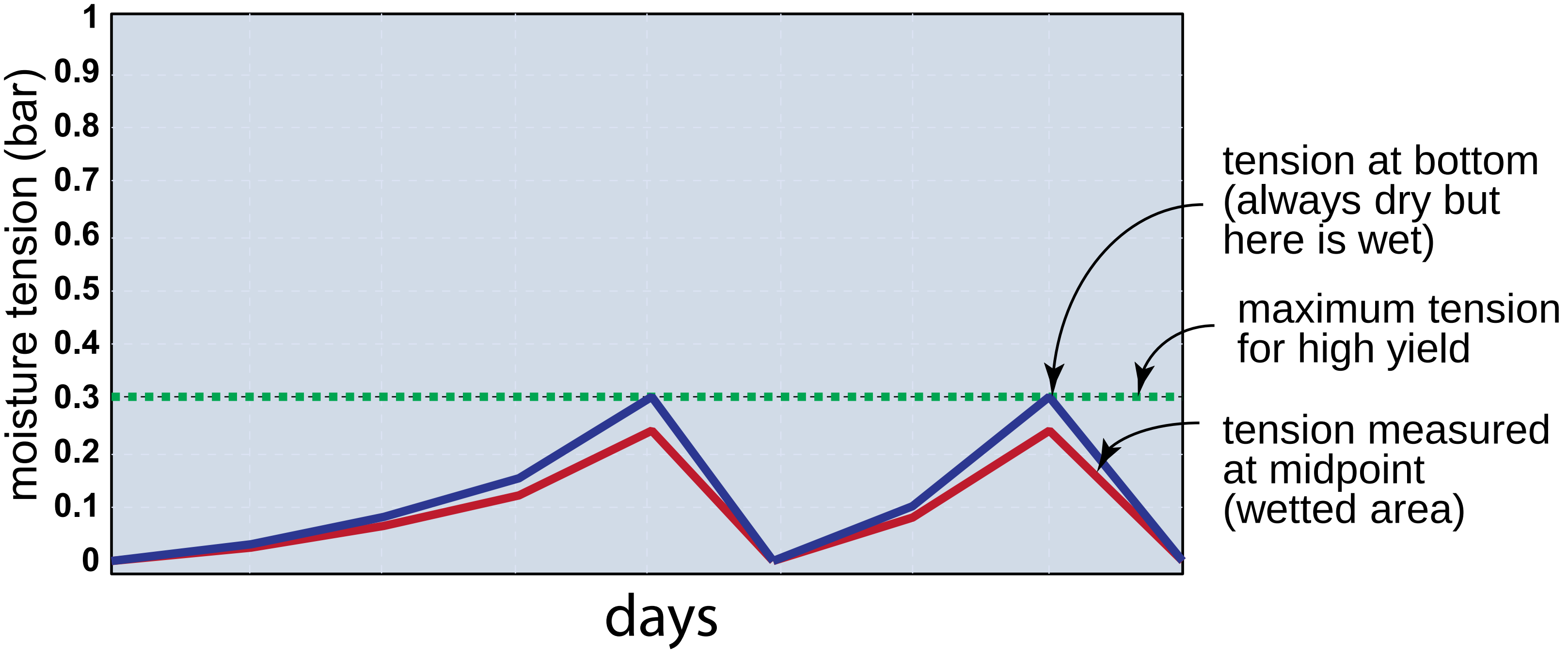
Example of data from tensiometer

Case 1: Proper irrigation



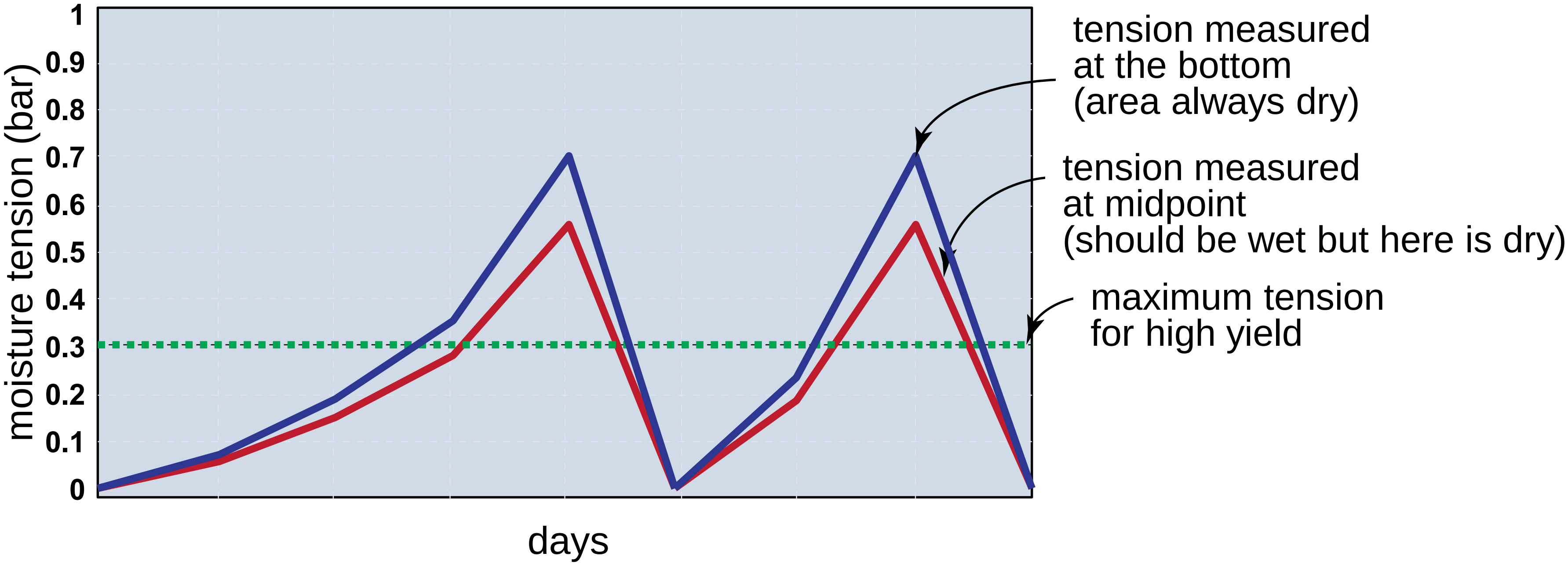
Example of data from tensiometer

Case 2: Over irrigation



Example of data from tensiometer

Case 3: Under irrigation



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Irrigation techniques will answer the following:

Completed

1) How much water to irrigate?

Completed

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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 ?

$$\text{Run Time} = \frac{IWR_{crop}}{\text{Application rate}} \qquad \textit{Eq.3}$$

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:

Completed

1) How much water to irrigate?

Completed

2) When to irrigate?

Completed

3) What is the suitable Run Time?

4) What is efficiency of each method?

5) Where to obtain the water?

6) 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

Surface Irrigation
(E_a = 50-70%)

Sprinkler Irrigation
(E_a = 70-80%)

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

- 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 course 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

Flow rate		Soil type			
		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

Border Irrigation

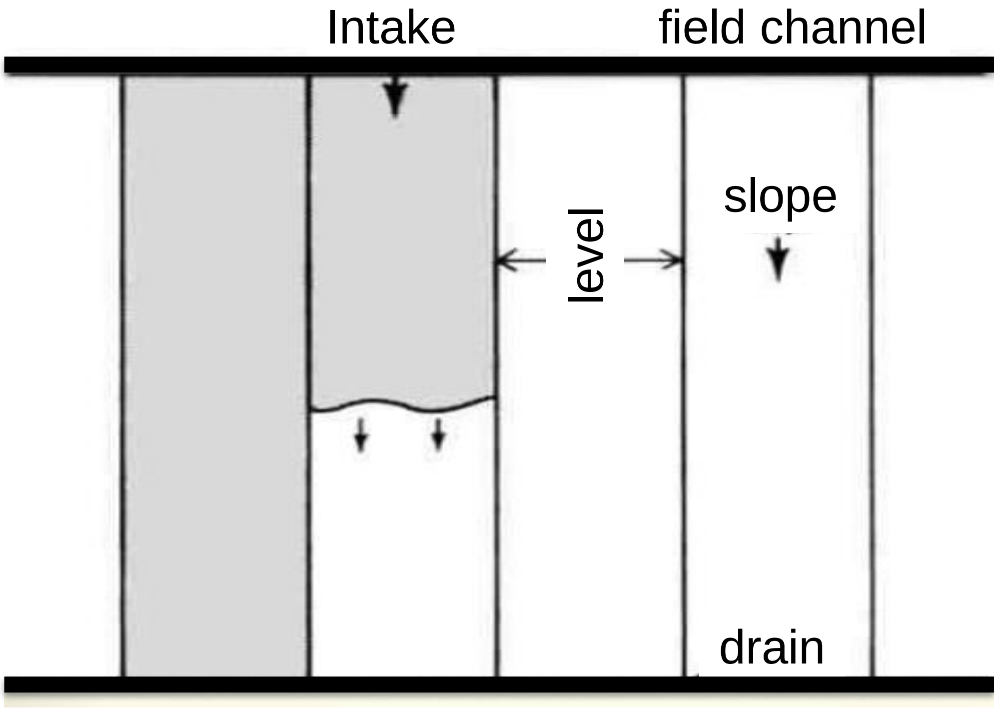
- Extended basin irrigation with sloping, long rectangular or contoured field shapes and free draining conditions at the lower end.

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	Border-strip Length
	Meters per 100 meters	Liters per second	Milli-meters	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

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

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	15.9	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	3.61	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
		5.5	5.18	38	36.0	28.8	24.0	16.0	12.0	9.0
7.5 x 5.5 PERTAT	7.5 x 5.5 PALOF	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
		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
8.5 x 5.5 PERNES	8.5 x 5.5 PAKID	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

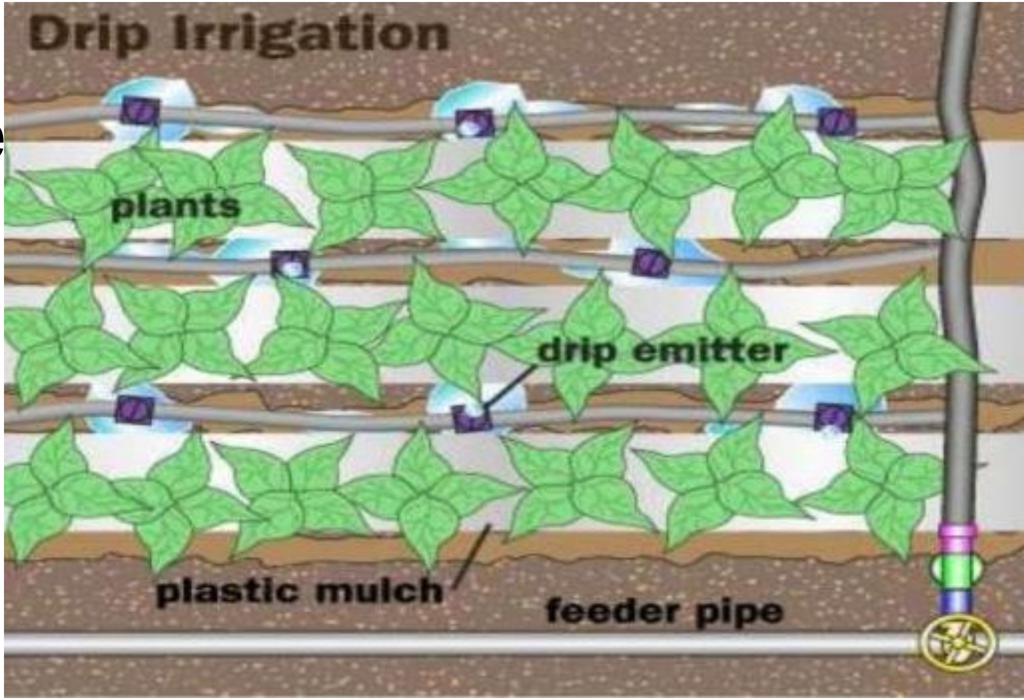
Surface Irrigation
(E_a = 50-70%)

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



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?

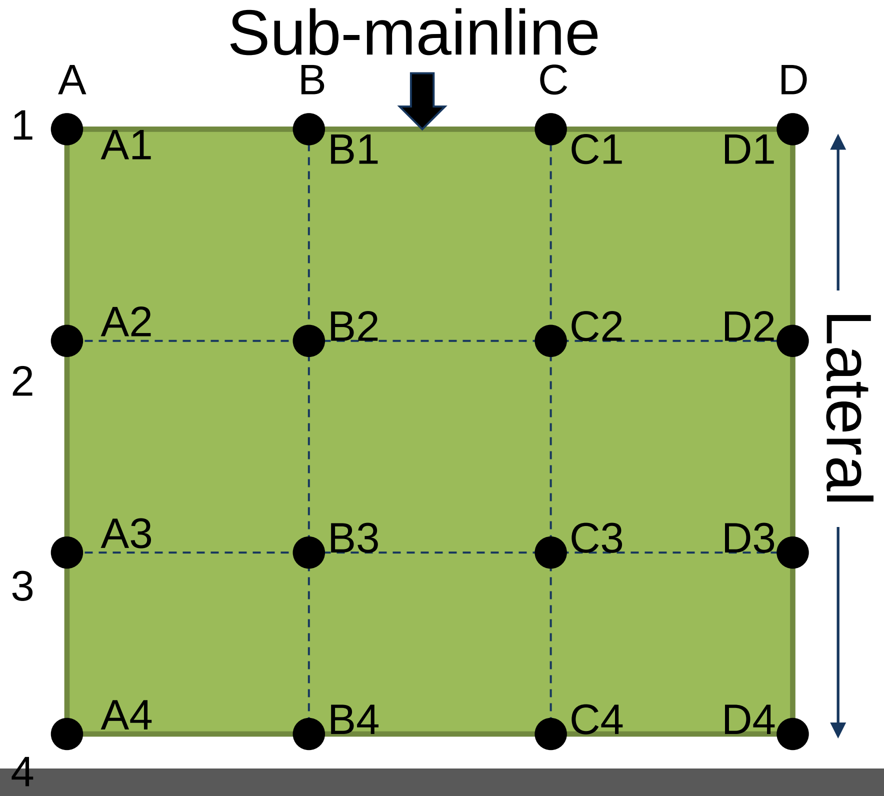
16 Chase Cans are installed. Flow rates (**Q**) are measured at each check point and used to calculate the distribution uniformity (**D_u**):

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

when

Q_n = low quarter average flow rate

Q_a = average flow rate



How to check distribution uniformity?

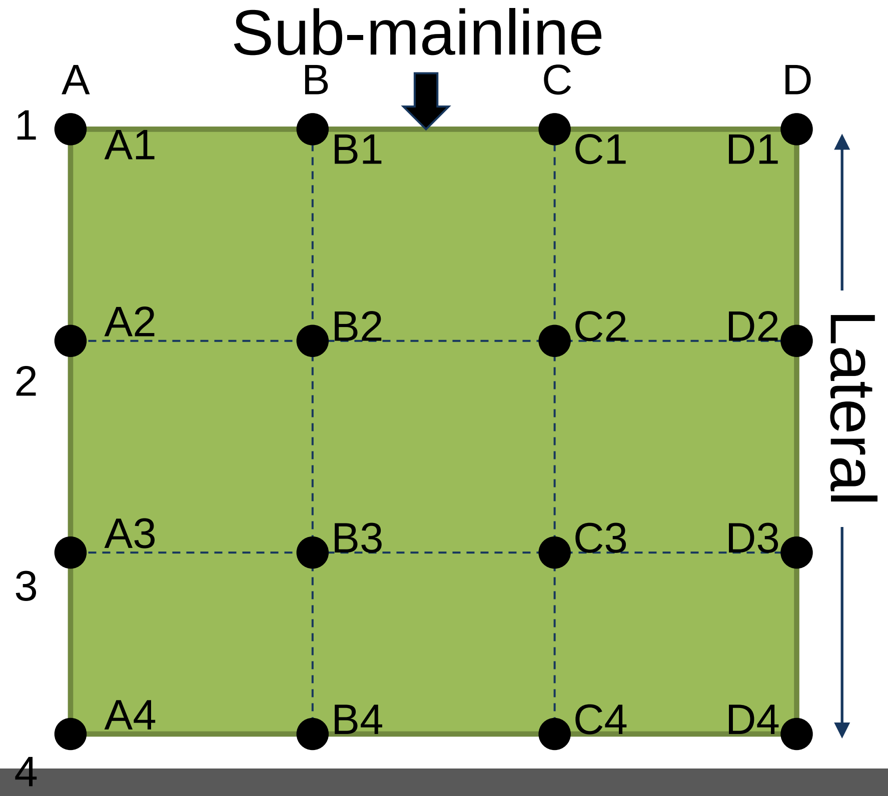
Example of data:

A1 = 1.30 L/h
A2 = 1.27 L/h
A3 = 1.26 L/h
A4 = 1.28 L/h

B1 = 1.38 L/h
B2 = 1.32 L/h
B3 = 1.36 L/h
B4 = 1.34 L/h

C1 = 0.90 L/h
C2 = 0.80 L/h
C3 = 0.80 L/h
C4 = 0.80 L/h

D1 = 0.87 L/h
D2 = 0.84 L/h
D3 = 0.84 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
Q2 = 1.36 L/h
Q3 = 1.34 L/h
Q4 = 1.32 L/h

Q5 = 1.30 L/h
Q6 = 1.28 L/h
Q7 = 1.27 L/h
Q8 = 1.26 L/h

Q8 = 0.90 L/h
Q9 = 0.87 L/h
Q10 = 0.84 L/h
Q11 = 0.84 L/h

Q12 = 0.80 L/h
Q13 = 0.80 L/h
Q14 = 0.80 L/h
Q15 = 0.74 L/h

2) Determine Q_a and Q_n

$$Q_a = (Q_1+Q_2+\ldots+Q_{16})/n$$
$$= 17.10/16$$
$$= 1.06 \text{ L/h}$$

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

$$D_u = Q_n/Q_a \times 100\%$$
$$= 0.785/1.06\text{x}100\%$$
$$= 74.05\%$$

Class objectives

Irrigation techniques will answer the following:

Completed

1) How much water to irrigate?

Completed

2) When to irrigate?

Completed

3) What is the suitable Run Time?

Completed

4) What is efficiency of each method?

5) Where to obtain the water?

6) How to apply these techniques?

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?***

Amount of Irrigation water (m^3)

= Area of Planting (m^2) x ET_{veg} (mm/day) x Growth day x Time of planting / (E_ax1,000)

Eq. 4

Example

Given an area of planting is 8,000 m^2

Evapotranspiration 6 mm/day

Growth day is 20 day with 5 times for planting

Drip irrigation method is used

Solution

$$\text{Size of pond} = \frac{8{,}000\ m^2 \times 6\ mm/day \times 20\ day \times 5\ times}{0.80 \times 1{,}000}$$

$$= 4{,}800\ m^3$$

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 planting:

$$\text{Area for service} = \frac{\text{Capacity of well pump } (m^3/hr)}{\text{Capacity of planting } (m^3/hr)} \qquad \textit{Eq.5}$$

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 m^3/hr

The Run Time is 3-h drip irrigation with 15 working hours/day

Solution

Given ET_{veg} $= 5$ mm/day

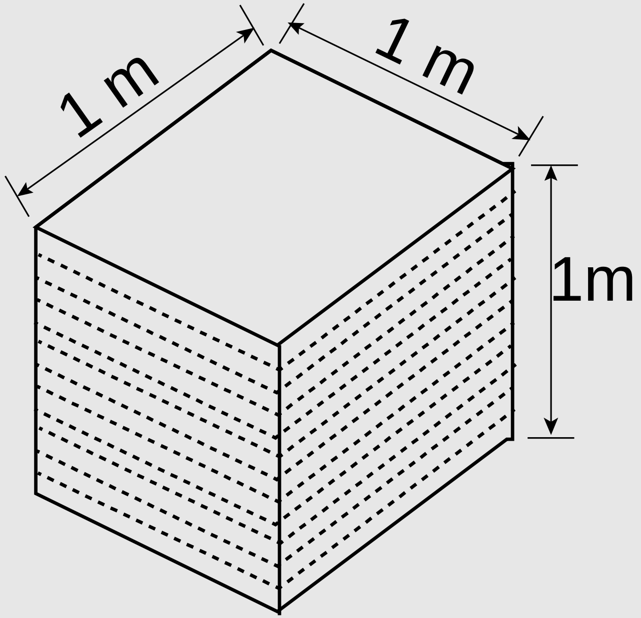
$= 5\ L/m^2/day$

1) Find IWR_{veg}

$IWR_{veg} = ET_{veg}/E_a$

$= 5/0.8$

$= 6.25\ L/m^2/day$



Volume = 1m x 1m x 1m = 1000 L

= 1m x 1m x 1000 mm

= m^2 x 1000 mm = 1000

mm = L/m^2

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/m^2/plot

and Run Time = 3 hr

$$\text{IWR/plot/hr} = 6.25/3$$

$$= 2\ \text{L/hr/m}^2$$

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

Solution (cont.)

The irrigation area service/plot

$$= 6\ m^3/hr\ /\ 0.002\ m^3/hr/m^2$$

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

Thus, the irrigation area service for the total area

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

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

Class objectives

Irrigation techniques will answer the following:

Completed

1) How much water to irrigate?

Completed

2) When to irrigate?

Completed

3) What is the suitable Run Time?

Completed

4) What is efficiency of each method?

Completed

5) Where to obtain the water?

6) How to apply these techniques?

Fundamental of irrigation

Irrigating water flows through the pipe under low pressure (20 mH_2O) 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

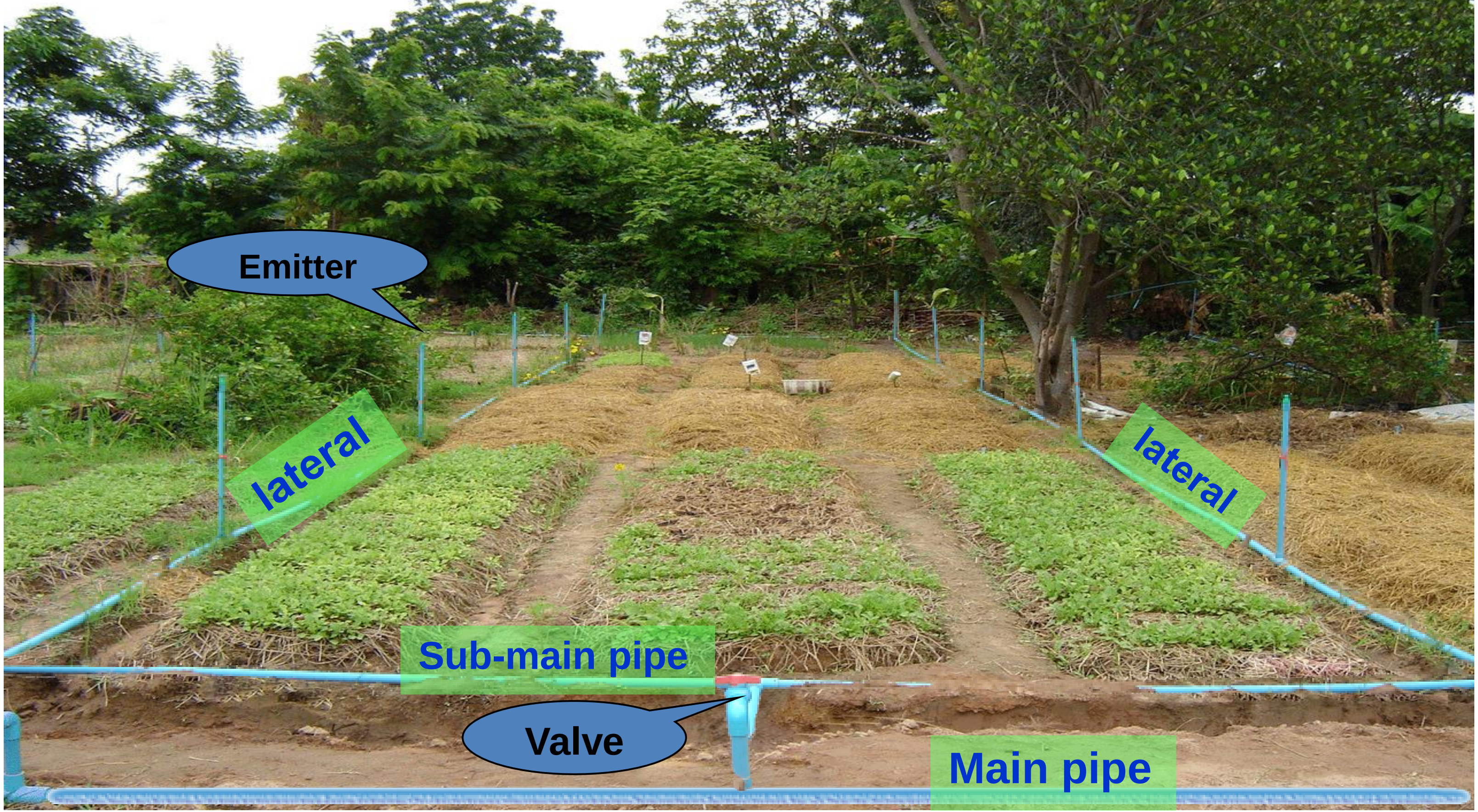
- PVC Ø ¾”	Capacity	2.80	m3/hr (2,800 litrs/hr)
- PVC Ø 1”	Capacity	5.10	m3/hr (5,100 litrs/hr)

Sub-Mainline

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

Mainline

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


Emitter
lateral
lateral
Sub-main pipe
Valve
Main pipe

How to apply micro-irrigation method to your situation?

Key: select proper components:

1) **emitters**
   (drip, spray, and micro sprinkler)
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)

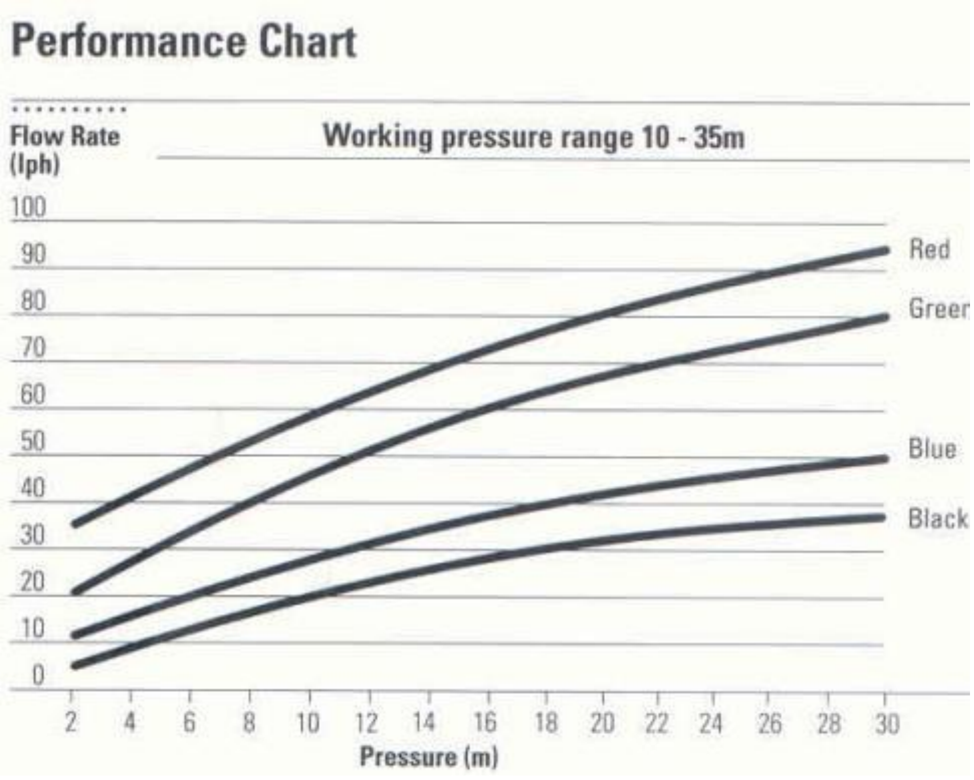
Woodpecker P. C. J. Pressure Compensating Junior Nipple Outlet (2 or 4 L/hr)

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



Emitters

- **Spray**

Table 8 **Maximum No. of Emitters per Lateral**

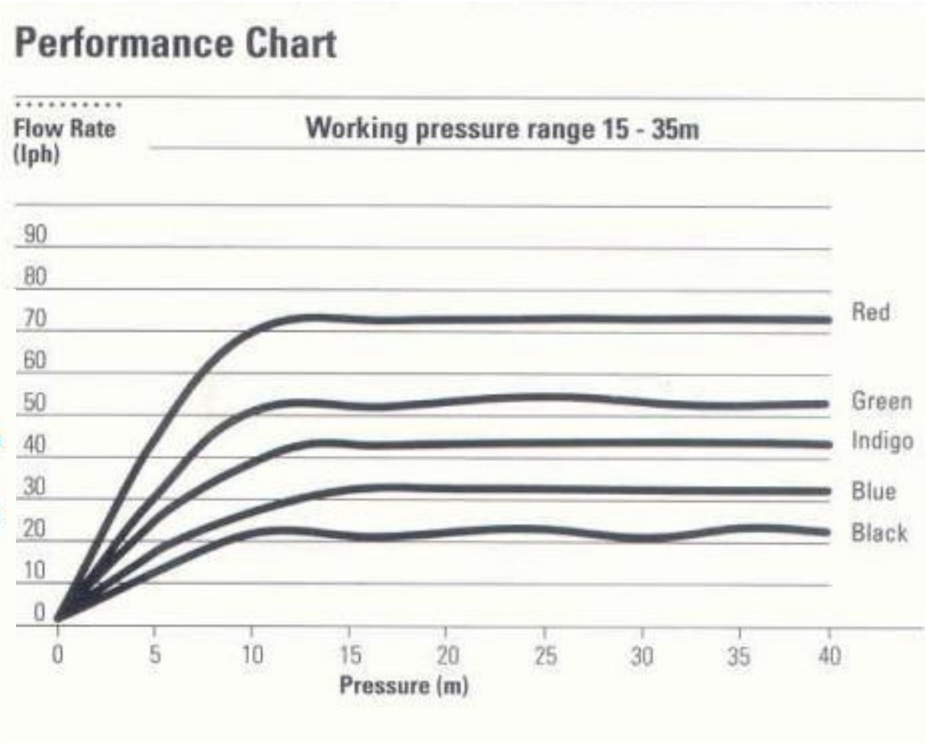
Nozzle Code (mm)	Discharge* (lph)	Wetting* Radius (m)	Pipe Diameter O.D. mm	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5
				Emitter Spacing On Lateral in m									
			16	26	24	22	21	20	19	18	18	17	16
Black	25	1.2	17.8	32	29	27	26	24	23	22	22	21	20
(0.9)			20	40	37	34	33	31	30	28	27	27	26
			16	20	19	18	17	16	15	14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

* At 1.5 atm, 25 cm high.

Emitters

- **Spray**

Water distribution pattern



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 Inlet pressure (atm)					Pipe diameter 17.8 (OD) mm Inlet pressure (atm)					Pipe diameter 20 (OD) mm 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

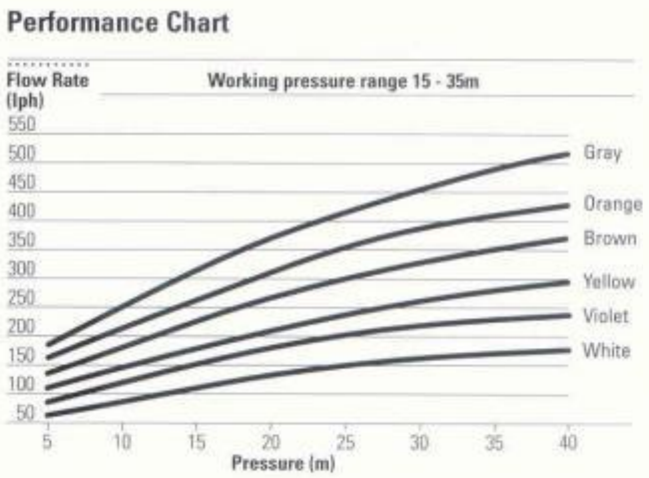


Table 10 Maximum No. of Emitters on Lateral

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

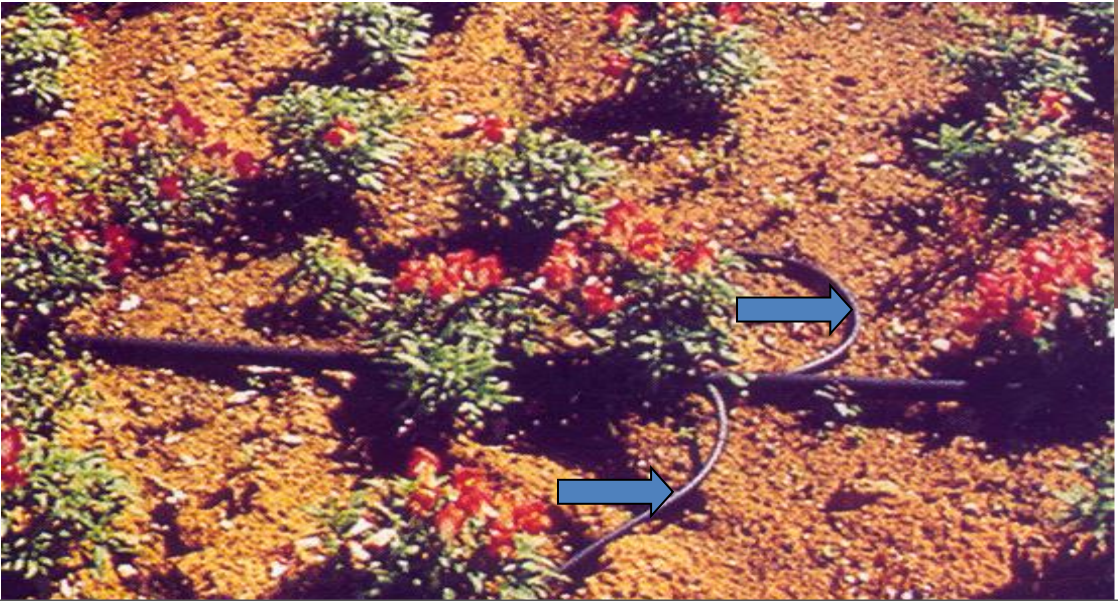
How to apply micro-irrigation method to your situation?

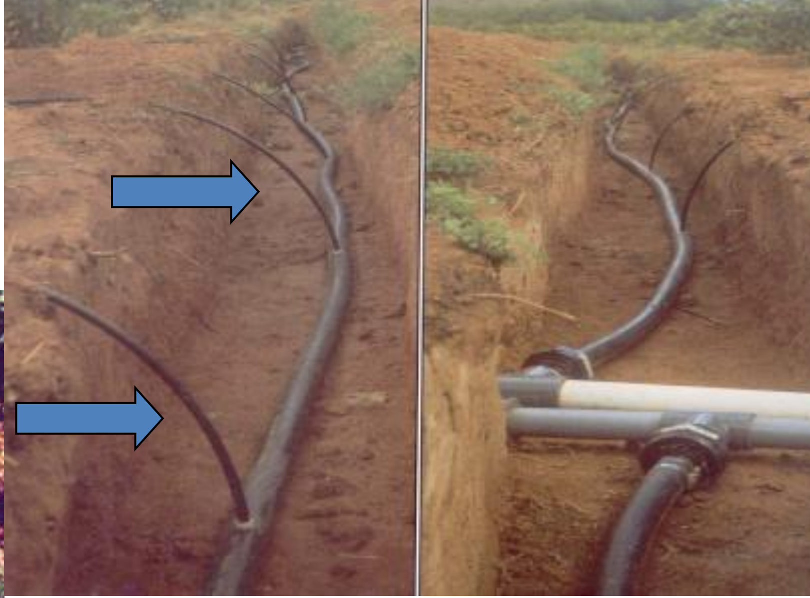
Key: select proper components:

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	diameter (mm) 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

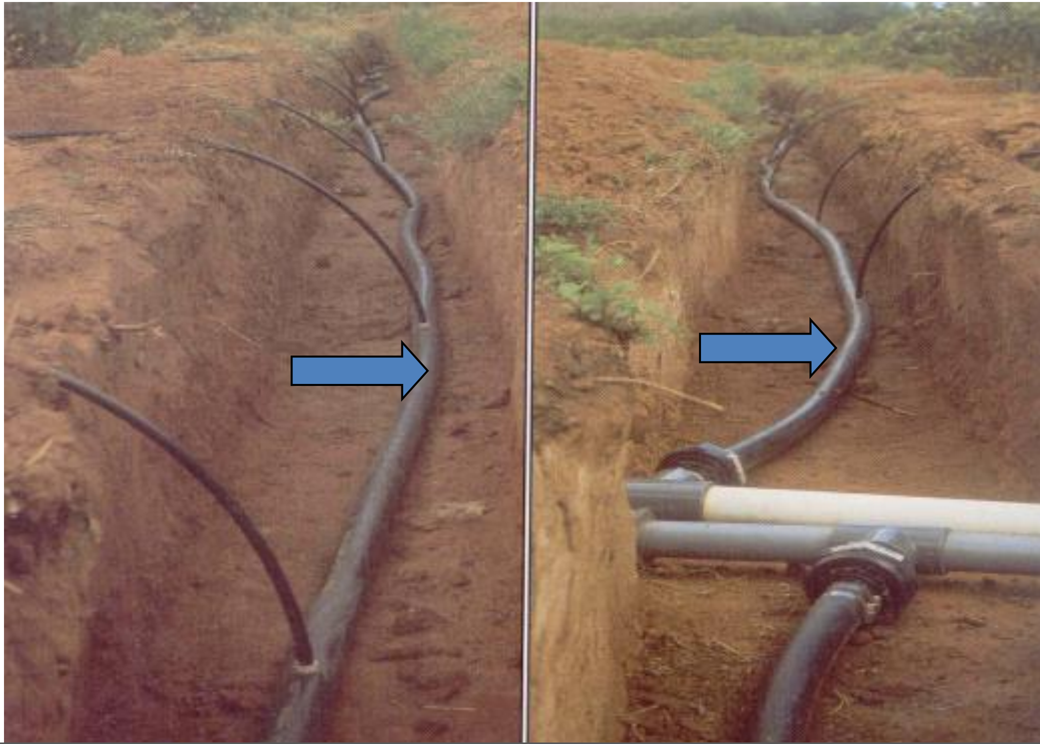
dispensing rate (L/cm) vs. pressure (m)

	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
อัตราการจ่ายน้ำ (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

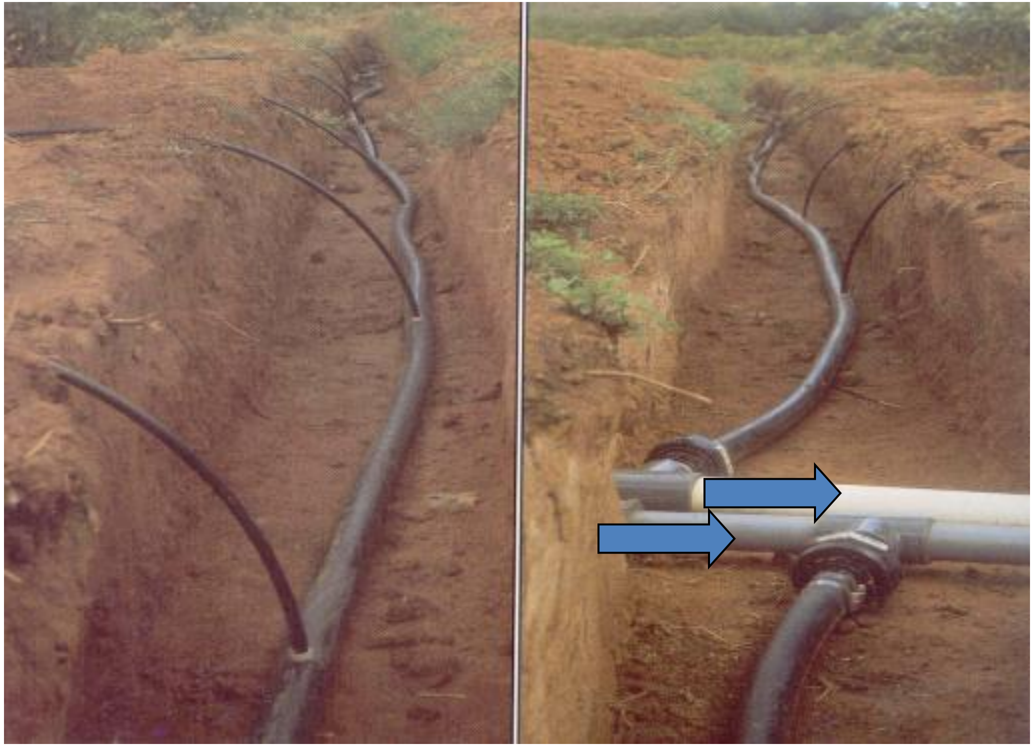


Table 13. Correlation factor depends on the number of outlets

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	16 mm		20 mm	
Q (m^3/h)	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	16 mm		20 mm	
Q (m^3/h)	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 (m^3/h)	¾ inch		1 inch		Flow rate Q (m^3/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 (m^3/h)	¾ inch		1 inch		Flow rate Q (m^3/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	12.4.3	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	2 1/2 inch		3 inch		Capzcity	4 inch		5 inch	
Q = m³/hr.	V = m/s	J = m/100 m	V = m/s	J = m/100 m	Q = m³/hr.	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**

Pump Capacity

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**

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

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

$$IWR = ET_{veg}$$ (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**

$$\text{Number of plots} = \frac{\text{Working hour/day}}{\text{Run Time}} \qquad \textit{Eq.6}$$

$$\text{Area/plot} = \frac{\text{Total area}}{\text{Number of plots}} \qquad \textit{Eq.7}$$

Design Procedures

- **Design of Pump and Motor**

$$WHP = Q \times H/273 \qquad Eq.8$$

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

where

Q = discharge (m^3/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

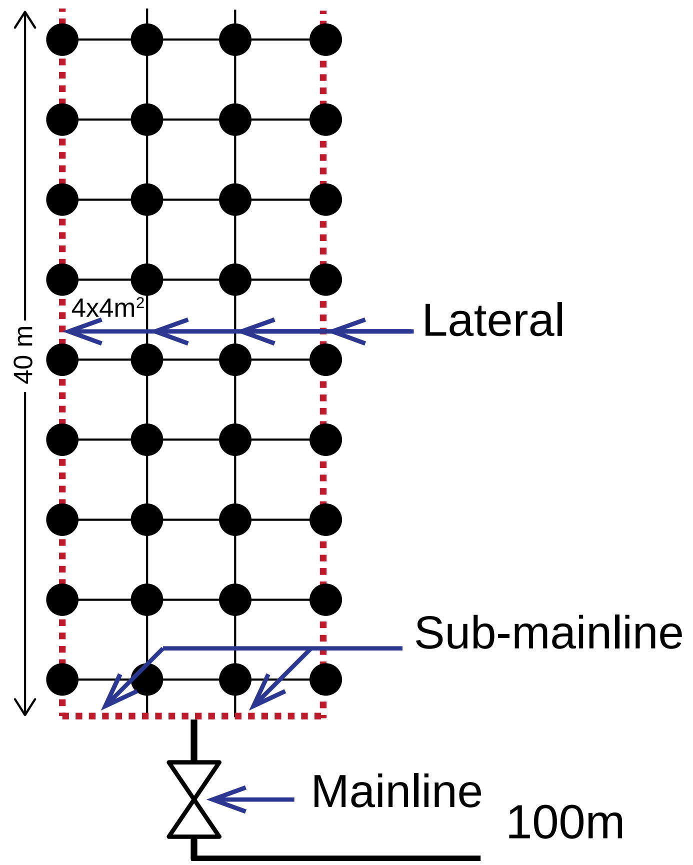
2) To select lateral pipe, we need to know

- 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 x 360 L/h = 3,600 L/h
= 3.6 m^3/h



How to select the pipe size

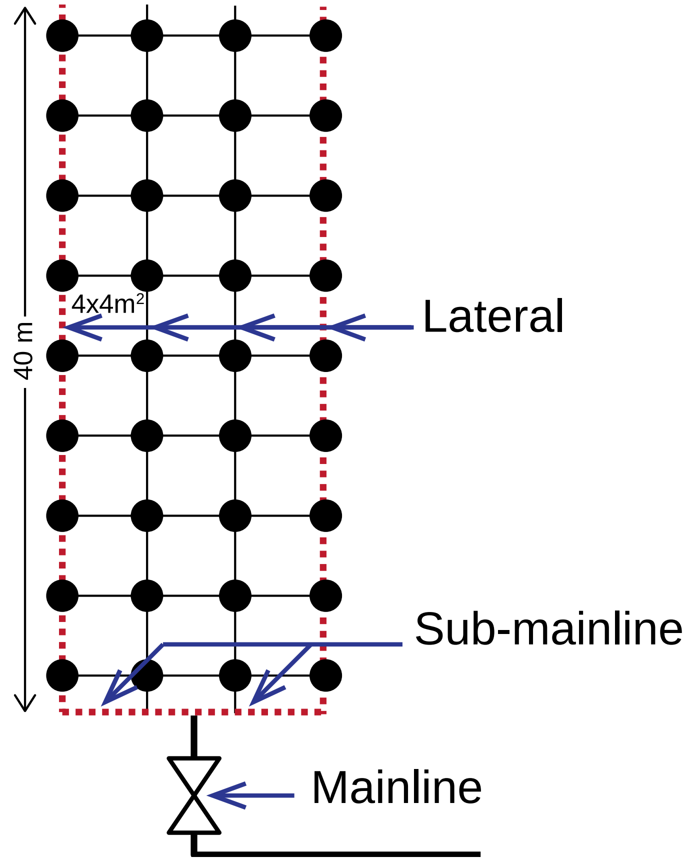
3) Based on the calculated flow rate, we can select the proper pipe size

Table 7B

Pipe Size Selection Data :

Lateral size			
- PVC ∅ ¾"	Capacity	2.80	m3/hr (2,800 litrs/hr)
- PVC ∅ 1"	Capacity	5.10	m3/hr (5,100 litrs/hr)
Sub-Mainline			
- PVC ∅ 1"	Capacity	[illegible]	m3/hr (5,100 litrs/hr)
- PVC ∅ 1½"	Capacity	[illegible]	m3/hr (11,000 litrs/hr)
- PVC ∅ 2"	Capacity	[illegible]	m3/hr (16,000 litrs/hr)
Mainline			
- PVC ∅ 1"	Capacity	[illegible]	m3/hr (3,900 litrs/hr)
- PVC ∅ 1½"	Capacity	8.00	m3/hr (8,000 litrs/hr)
- PVC ∅ 2"	Capacity	13.60	m3/hr (13,600 litrs/hr)
- PVC ∅ 2½"	Capacity	20.25	m3/hr (20,250 litrs/hr)
- PVC ∅ 3"	Capacity	27.75	m3/hr (27,750 litrs/hr)

We select this pipe because its Q is larger than 3.6 m^3/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.

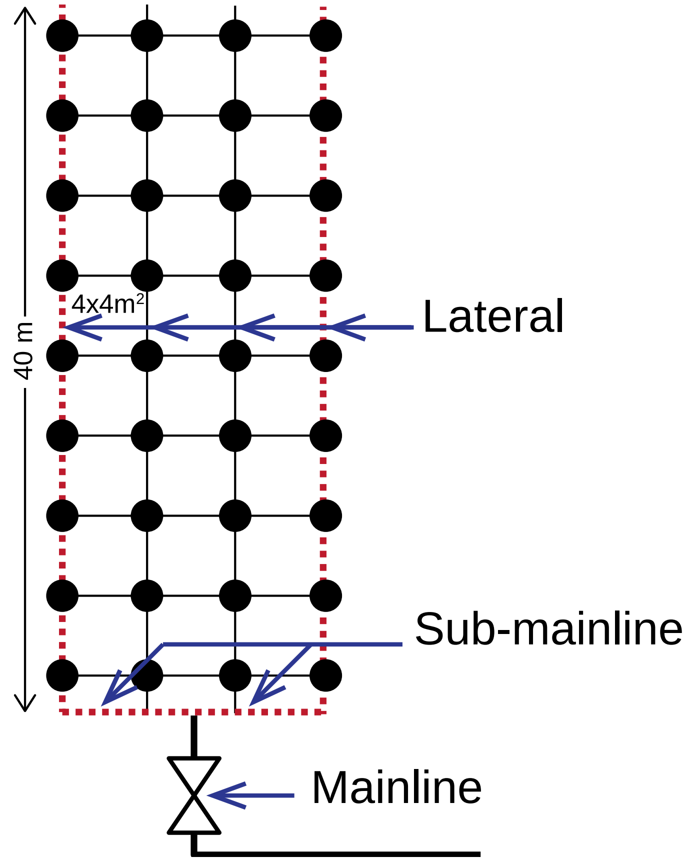
$Q_{sub\text{-}mainline}$
= number of branched lateral pipes x $Q_{lateral}$
= 2 x 3.6 = 7.2 m^3/h

Table 7B

Sub-Mainline

- PVC ∅ 1"	Capacity	5.10	m3/hr (5,100 litrs/hr)
- PVC ∅ 1½"	Capacity	11.00	m3/hr (11,000 litrs/hr)
- PVC ∅ 2"	Capacity	[illegible].00	m3/hr (16,000 litrs/hr)

We select this pipe because its
Q is larger than 7.2 m^3/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.

$Q_{mainline}$

= number of branched lateral pipes x $Q_{sub\text{-}mainline}$

= 2 x 7.2 = 14.4 m^3/h

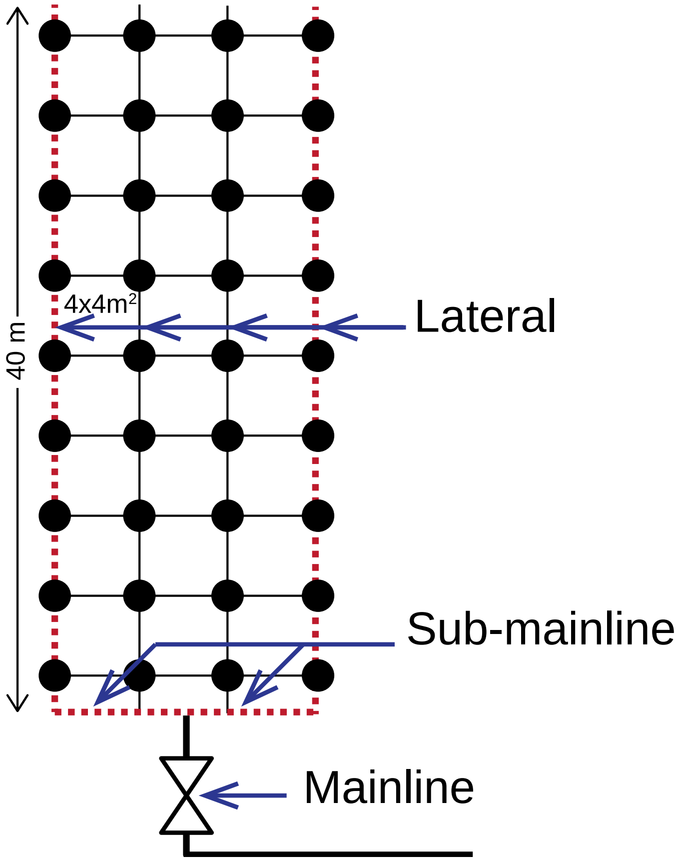


Table 7B

Mainline

- PVC ∅ 1"	Capacity	3.90	m3/hr (3,900 litrs/hr)
- PVC ∅ 1½"	Capacity	8.00	m3/hr (8,000 litrs/hr)
- PVC ∅ 2"	Capacity	13.60	m3/hr (13,600 litrs/hr)
- PVC ∅ 2½"	Capacity	20.25	m3/hr (20,250 litrs/hr)
- PVC ∅ 3"	Capacity	[illegible]7.75	m3/hr (27,750 litrs/hr)

We select this pipe because its Q is larger than 14.4 m^3/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

$$H_f = JxFxL \qquad \text{Eq.10}$$

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 m^3/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 m/100 m for a 1inch-diameter PVC pipe at a flow rate of 3.6 m^3/h

From Tables 13,

F is 0.41 for 9 outlets

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

$$= 14.4 \times \{3 + (1.34 + 0.14 + 1.995) + 5\}/273/0.4$$

$$= 1.5 \text{ HP}$$

To select a commercially-available pump:

Table 5, for Q = 16 ^{3}/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?