



Sprinkler Irrigation - Preliminary Design

Sprinkler and Micro irrigation Systems

Soil Water

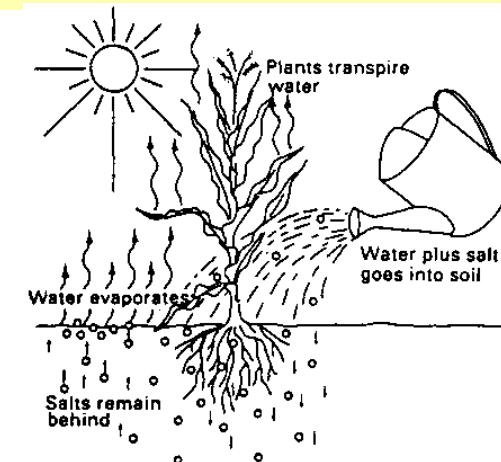
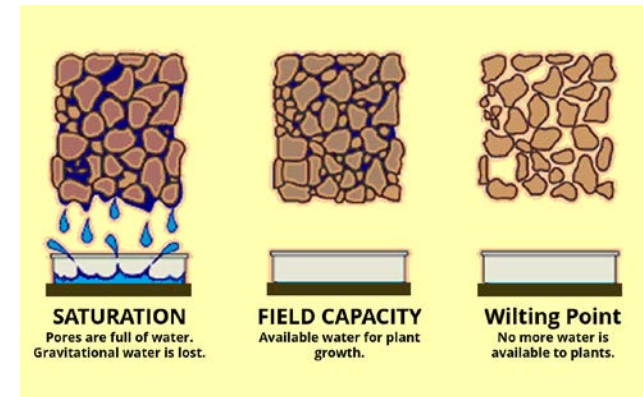
Water Holding Capacity

- Soils of various texture have varying abilities to retain water.
- Apart from leaching requirement, any irrigation beyond field capacity is an economic loss.

Range in available water-holding capacity of soils of different texture

Soil texture	Water-holding capacity	
	Range mm/m	Average mm/m
1. Very coarse texture—very coarse sands	33 to 62	42
2. Coarse texture—coarse sands, fine sands, and loamy sands	62 to 104	83
3. Moderately coarse texture—sandy loams	104 to 145	125
4. Medium texture—very fine sandy loams, loams, and silt loams	125 to 192	167
5. Moderately fine texture—clay loams, silty clay loams, and sandy clay loams	145 to 208	183
6. Fine texture—sandy clays, silty clays, and clays	133 to 208	192
7. Peats and mucks	167 to 250	208

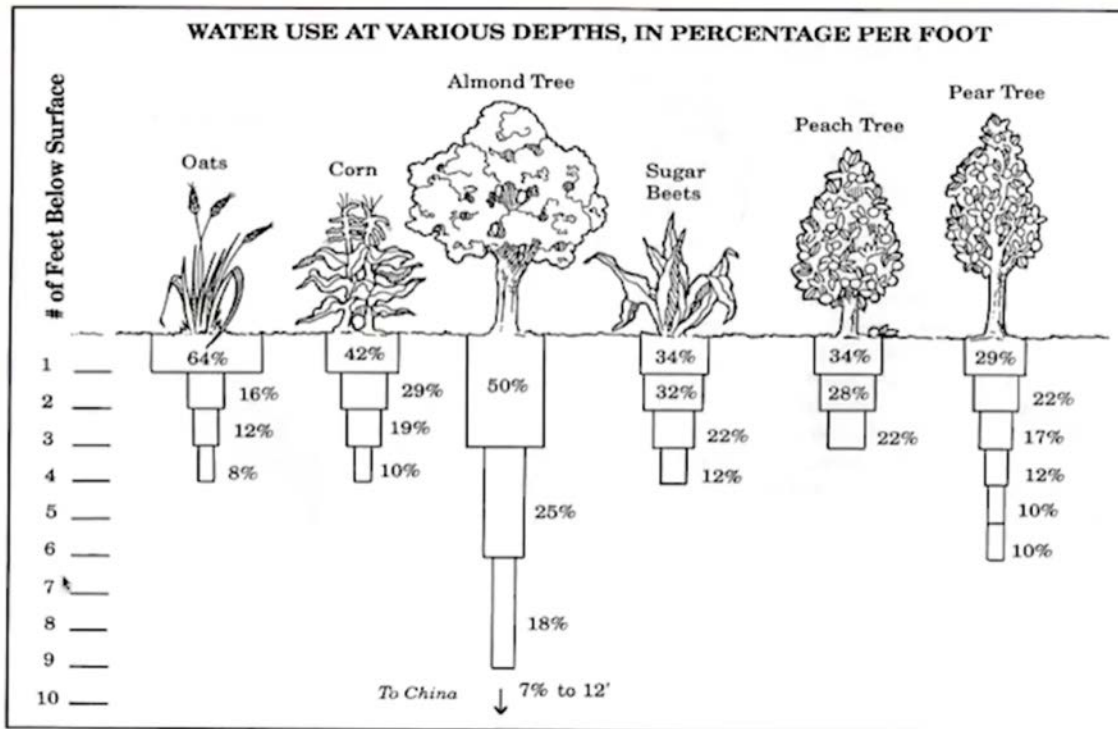
NOTE: 1 mm/m = 0.012 in./ft.



Soil Water

Root Depth

- The soil water available for plant is sum of available WHCs of all horizons occupied by plant roots.



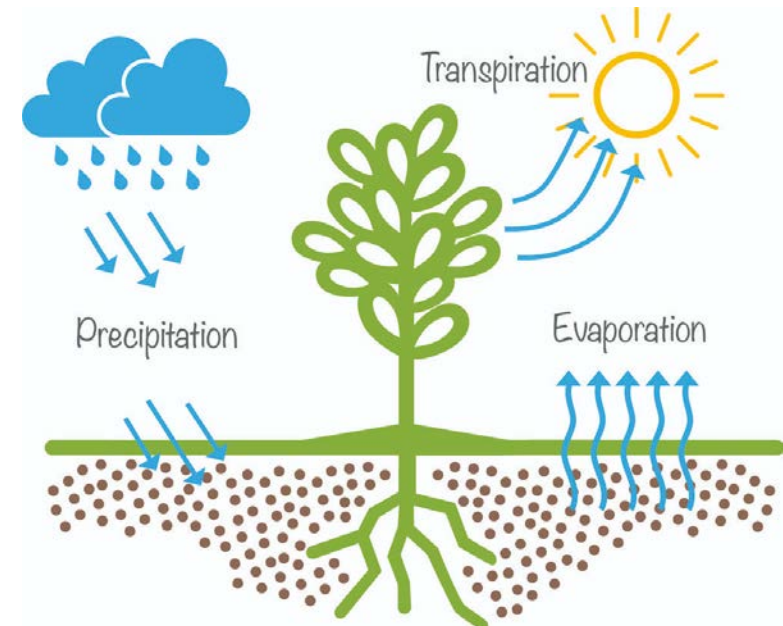
- ❖ The actual depth of rooting of various crops are affected by soil conditions.
- ❖ Therefore, actual depth at any site should be checked.
- ❖ Where local data isn't available and there are no root restrictions, data from other sources of standard reference can be used.

Consumptive Use and Design

- To address the design capacity of an irrigation system, the data on consumptive use is important.
- The rate of water use during peak consumptive use should be the basis of determining rate for designing system capacity.

Typical peak daily and seasonal crop water requirements in different climates

Crop	Type of climate and water requirements, mm									
	Cool		Moderate		Hot		High desert		Low desert	
	Daily	Seas	Daily	Seas	Daily	Seas	Daily	Seas	Daily	Seas
Alfalfa	5.1	635	6.4	762	7.6	914	8.9	1016	10.2	1219
Pasture	4.6	508	5.6	610	6.6	711	7.6	762	8.9	914
Grain	3.8	381	5.1	457	5.8	508	6.6	533	5.8 ¹	508 ¹
Beets	4.6	584	5.8	635	6.9	711	8.1	732	9.1	914
Beans	4.6	330	5.1	381	6.1	457	7.1	508	7.6	559
Corn	5.1	508	6.4	559	7.6	610	8.9	660	10.2	762
Cotton	-	-	6.4	559	7.6	660	-	-	10.2	813
Peas	4.6	305	4.8	330	5.1	356	5.6	356	5.1 ²	356 ²
Tomatoes	4.6	457	5.1	508	5.6	559	6.4	610	7.1	660
Potatoes	4.6	406	5.8	457	6.9	553	8.1	584	6.9 ²	533 ²
Truck vegetables	4.1	305	4.6	356	5.1	406	5.6	457	6.3 ²	508 ²
Melons	4.1	381	4.6	406	5.1	457	5.6	508	6.4 ²	559 ²
Strawberries	4.6	457	5.1	508	5.6	559	6.1	610	6.6	660
Citrus	4.1	508	4.6	559	5.1	660	-	-	5.6	711
Citrus (w/cover)	5.1	635	5.6	711	6.4	813	-	-	6.9	889
Dec orchard	3.8	483	4.8	533	5.8	584	6.6	635	7.6	762
Dec orchard (w/cover)	5.1	635	6.4	711	7.6	813	8.9	914	10.2	1016
Vineyards	3.6	356	4.1	406	4.8	457	5.6	508	6.4	610



Soil Moisture Management

- As a general rule of thumb, the soil moisture deficit should not fall below 50% (i.e., Management Allowable Deficit (MAD) = 50%).
- The depth and duration of irrigation is constant throughout the growing period.
- However, the frequency of application changes as the rate of water use changes in the growing period.

Guide for selecting management-allowed deficit, MAD, values for various crops

MAD, %	Crop and root depth
25-40	Shallow-rooted, high-value fruit and vegetable crops
40-50	Orchards,* vineyards, berries and medium-rooted row crops
50	Forage crops, grain crops, and deep-rooted row crops

*Some fresh fruit orchards require lower MAD values during fruit finishing for sizing.

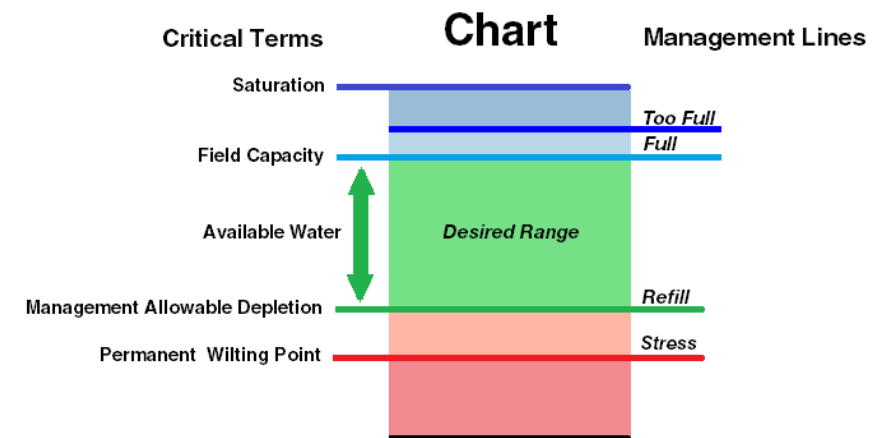
Soil Moisture Management

Irrigation Depth

- The maximum net depth of water per irrigation (d_x) = maximum allowable depletion of soil water between irrigations.

$$d_x = \frac{\text{MAD}}{100} W_a Z$$

- d_x = maximum net depth of water to be applied per irrigation (mm).
- MAD = management allowed deficit (in %)
- W_a = available WHC of soil (mm/m).
- Z = effective root zone depth (mm).



Soil Moisture Management

Irrigation Interval

- The irrigation interval, i.e., the time elapsed between beginning of two successive irrigations, is determined by:

$$f' = \frac{d_n}{U_d}$$

- f' = irrigation interval or frequency (days)
- d_n = net depth of water application per irrigation, to meet the consumptive use requirements (mm)
- U_d = average daily crop water requirement, or use rate, during the peak use month (mm/day).

Soil Moisture Management

Leaching Requirement

- All irrigation water contain some dissolved salts, that are pushed downward by sprinkling and rainfall.
- *Application of more water than the plant consume, **push (or leach)** most of the salts below root zone.*
- The leaching requirement can be determined as:

$$LR = \frac{EC_w}{5EC_e - EC_w}$$

- LR = leaching requirement ratio
- EC_w = electrical conductivity of irrigation water, (dS/m)
- EC_e = electrical conductivity of saturation extract of soil root zone for an appropriate yield reduction($\approx 10\%$) (dS/m)

Soil Moisture Management

Leaching Requirement

- *When $LR \leq 0.1$, the annual deep percolation losses, will be sufficient to provide necessary leaching.*

$$d = \frac{d_n}{E_a / 100}$$

- *When $LR > 0.1$, water in addition to consumptive use should be applied.*

$$d = \frac{0.9d_n}{(1.0 - LR) E_a / 100}$$

- d = gross depth of irrigation application (mm)
- E_a = application efficiency (%)

System Capacity Requirement

- The required capacity of sprinkler system depends on
 - the size of the area irrigated
 - the gross depth of water applied at each irrigation and
 - the net operating time allowed to apply this depth

$$Q_s = K \frac{Ad}{fT}$$

- Q_s = system discharge capacity (lps)
- K = conversion constant (2.78 for metric units)
- A = design area (ha)
- d = gross depth of application (mm)
- f = operating time allowed for completion of one irrigation (days)
- T = average actual operating time per day (hr/day)

Intake and Optimum Application Rate

The rate at which water should be applied depends on the following

- Infiltration characteristics of soil, the field slope and the crop cover
- The minimum application rate that will produce a uniform sprinkler distribution pattern and satisfactory efficiency under prevalent wind and evaporative demand conditions;
- The coordination of the lateral moves for periodic move system with other operation on the farm

Q. How surface sealing is occurred in case of impact problem and what are the problems related with it ?

Intake and Optimum Application Rate

Suggested maximum sprinkler application rates for average soil, slope, and tilth

Soil texture and profile	Slope			
	0-5%	5-8%	8-12%	12-16%
	Maximum application rate			
	mm/hr (in. /hr)	mm/hr (in. /hr)	mm/hr (in. /hr)	mm/hr (in. /hr)
Coarse sandy soil to 1.8 m (6 ft)	50 (2.0)	38 (1.5)	25 (1.0)	13 (0.50)
Coarse sandy soils over more compact soils	38 (1.5)	25 (1.0)	19 (0.75)	10 (0.40)
Light sandy loams to 1.8 m (6 ft)	25 (1.0)	20 (0.80)	15 (0.60)	10 (0.40)
Light sandy loams over more compact soils	19 (0.75)	13 (0.50)	10 (0.40)	8 (0.30)
Silt loams to 1.8 m (6 ft)	13 (0.50)	10 (0.40)	8 (0.30)	5 (0.20)
Silt loams over more compact soils	8 (0.30)	6 (0.25)	4 (0.15)	2.5 (0.10)
Heavy textured clays or clay loams	4 (0.40)	2.5 (0.10)	2 (0.08)	1.5 (0.06)

This table can be suggested for maximum application rate for periodic move system.

Average Application Rate from Sprinkler

$$I = \frac{Kq}{S_e \times S_l}$$

I = average application rate (mm/hr)

K = Conversion factor (60)

q = Sprinkler discharge (lpm)

S_e = Sprinkler spacing along laterals (m)

S_l = Sprinkler spacing along mains (m)

!!!-Thank you-!!!

