College of Agriculture Engineering Sciences

Soil and Water Department

3rd stage Irrigation System

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Lecture (5) 2023-2024

Calculate the Volume of Water Applied to Crop

In this lecture calculate the crop water need (ET crop). This water can be supplied to the crops in various ways:

- **by rainfall**
- **by irrigation**
- **by a combination of irrigation and rainfall**

When we calculate the irrigation water, we have 3 (three) cases:

1. If sufficient rain fall :IN = 0
2. If no rainfall at all :IN = ET crop
3. If partly irrigation, partly rainfall :IN = ET crop-pe

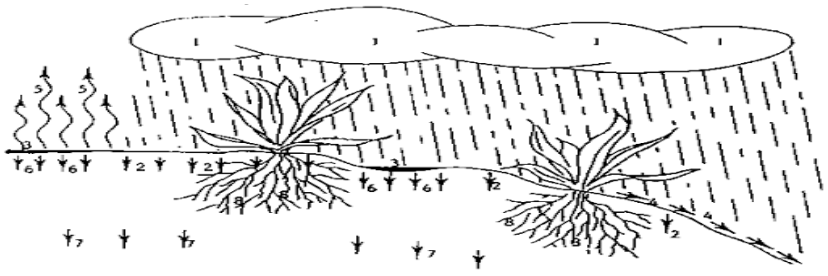
Determination of the Effective Rainfall:

For general information on rainfall: the amount, the intensity and the distribution,

When rain water (1) in figure, some of it infiltrates into the soil (2), some stagnates on the surface (3), while some of runoff (4).

When the rainfall stops, some of the water stagnating on the surface (3) evaporates to the atmosphere (5), while the rest slowly infiltrates into the soil (6).

From all the water that infiltrates into the soil ((2) and (6)), some percolates below the root zone (7), while the rest remains stored in the root zone (8).



For the purpose of this manual, only 2 simple formulae are provided to estimate the fraction of the total rainfall which is used effectively. These formulae can be applied in areas with a maximum slope of 4-5%:

$$\boldsymbol{Pe = 0.8\,P - 25} \quad \text{IF P} > 75\text{mm/month}$$

$$\boldsymbol{Pe = 0.6\,P - 10} \quad \text{IF P} < 75\text{mm/month}$$

P = rainfall or precipitation (mm/month)

Pe = effective rainfall or effective precipitation (mm/month)

NOTE: Pe is always equal to or larger than zero; never negative

Example (1)

Calculate the effective rainfall for the following monthly rainfall figures: P = 35, 90,116, 5, 260, 75 mm

Calculation of the irrigation water needs

Step 1: Determine the reference crop evapotranspiration (Eto) by The Blaney-Criddle method:

$ETo = P(8.13 + 0.46t)$

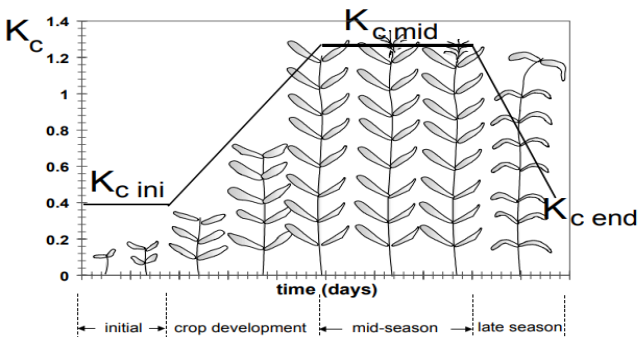
When

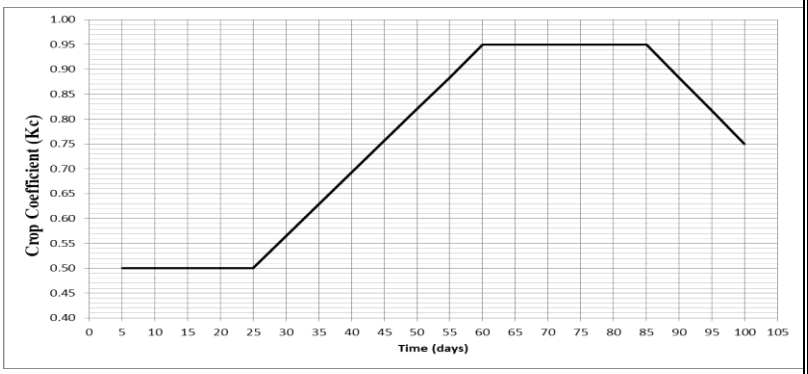
ETo = crop evapotranspiration (mm/month) $\quad \frac{\boldsymbol{ETo}}{\boldsymbol{30}}$ (mm/day)

P = atmospheric pressure

t = average air temperature (°C)

<u>Step 2</u>: Determine the crop factors: Kc





Lengths of crop development stages* for various planting periods and climatic regions (days)

Crop	Init. (L_{ini})	Dev. (L_{dev})	Mid (L_{mid})	Late (L_{late})	Total	Plant Date	Region
a. Small Vegetables							
Broccoli	35	45	40	15	135	Sept	Calif. Desert, USA
Cabbage	40	60	50	15	165	Sept	Calif. Desert, USA
Carrots	20	30	50/30	20	100	Oct/Jan	Arid climate
	30	40	60	20	150	Feb/Mar	Mediterranean
	30	50	90	30	200	Oct	Calif. Desert, USA
Cauliflower	35	50	40	15	140	Sept	Calif. Desert, USA
Celery	25	40	95	20	180	Oct	(Semi)Arid
	25	40	45	15	125	April	Mediterranean
	30	55	105	20	210	Jan	(Semi)Arid
Crucifers[1]	20	30	20	10	80	April	Mediterranean
	25	35	25	10	95	February	Mediterranean
	30	35	90	40	195	Oct/Nov	Mediterranean
Lettuce	20	30	15	10	75	April	Mediterranean
	30	40	25	10	105	Nov/Jan	Mediterranean
	25	35	30	10	100	Oct/Nov	Arid Region
	35	50	45	10	140	Feb	Mediterranean
Onion (dry)	15	25	70	40	150	April	Mediterranean
	20	35	110	45	210	Oct; Jan.	Arid Region; Calif.
Onion (green)	25	30	10	5	70	April/May	Mediterranean
	20	45	20	10	95	October	Arid Region
	30	55	55	40	180	March	Calif., USA
Onion (seed)	20	45	165	45	275	Sept	Calif. Desert, USA
Spinach	20	20	15/25	5	60/70	Apr; Sep/Oct	Mediterranean
	20	30	40	10	100	November	Arid Region
Radish	5	10	15	5	35	Mar/Apr	Medit.; Europe
	10	10	15	5	40	Winter	Arid Region
b. Vegetables – Solanum Family *(Solanaceae)*							
Egg plant	30	40	40	20	130\14	October	Arid Region
	30	45	40	25	0	May/June	Mediterranean
Sweet peppers	25/30	35	40	20	125	April/June	Europe and Medit.
(bell)	30	40	110	30	210	October	Arid Region
Tomato	30	40	40	25	135	January	Arid Region
	35	40	50	30	155	Apr/May	Calif., USA
	25	40	60	30	155	Jan	Calif. Desert, USA
	35	45	70	30	180	Oct/Nov	Arid Region
	30	40	45	30	145	April/May	Mediterranean
c. Vegetables - Cucumber Family *(Cucurbitaceae)*							
Cantaloupe	30	45	35	10	120	Jan	Calif., USA
	10	60	25	25	120	Aug	Calif., USA
Cucumber	20	30	40	15	105	June/Aug	Arid Region
	25	35	50	20	130	Nov; Feb	Arid Region
Pumpkin,	20	30	30	20	100	Mar, Aug	Mediterranean
Winter squash	25	35	35	25	120	June	Europe
Squash,	25	35	25	15	100	Apr; Dec.	Medit.; Arid Reg.
Zucchini	20	30	25	15	90	May/June	Medit.; Europe

Crop	$K_{c\ ini}$[1]	$K_{c\ mid}$	$K_{c\ end}$	Maximum Crop Height (h) (m)
a. Small Vegetables	**0.7**	**1.05**	**0.95**	
Broccoli		1.05	0.95	0.3
Brussel Sprouts		1.05	0.95	0.4
Cabbage		1.05	0.95	0.4
Carrots		1.05	0.95	0.3
Cauliflower		1.05	0.95	0.4
Celery		1.05	1.00	0.6
Garlic		1.00	0.70	0.3
Lettuce		1.00	0.95	0.3
Onions - dry		1.05	0.75	0.4
- green		1.00	1.00	0.3
- seed		1.05	0.80	0.5
Spinach		1.00	0.95	0.3
Radish		0.90	0.85	0.3
b. Vegetables – Solanum Family (*Solanaceae*)	**0.6**	**1.15**	**0.80**	
Egg Plant		1.05	0.90	0.8
Sweet Peppers (bell)		1.05[2]	0.90	0.7
Tomato		1.15[2]	0.70-0.90	0.6
c. Vegetables – Cucumber Family (*Cucurbitaceae*)	**0.5**	**1.00**	**0.80**	
Cantaloupe	0.5	0.85	0.60	0.3
Cucumber – Fresh Market	0.6	1.00[2]	0.75	0.3
– Machine harvest	0.5	1.00	0.90	0.3
Pumpkin, Winter Squash		1.00	0.80	0.4
Squash, Zucchini		0.95	0.75	0.3
Sweet Melons		1.05	0.75	0.4
Watermelon	0.4	1.00	0.75	0.4
d. Roots and Tubers	**0.5**	**1.10**	**0.95**	
Beets, table		1.05	0.95	0.4
Cassava – year 1	0.3	0.80[3]	0.30	1.0
– year 2	0.3	1.10	0.50	1.5
Parsnip	0.5	1.05	0.95	0.4
Potato		1.15	0.75[4]	0.6
Sweet Potato		1.15	0.65	0.4
Turnip (and Rutabaga)		1.10	0.95	0.6
Sugar Beet	0.35	1.20	0.70[5]	0.5

Step 3: Calculate the crop water need ETc:

$$\mathbf{ETc = ETo \times Kc} \text{ (mm/days)}$$

When:

ETc = crop water need (mm/days)

ETo = crop evapotranspiration (mm)

Kc = crop factor

Step 4: Determine the effective rainfall: Pe

Step 5: Calculate the irrigation water need:

$$\mathbf{IN = ET\ crop - Pe}$$

Step 6: Calculate the area we want to irrigate

Calculate the area depending on the shape we want to wet such as circle, rectangular, square and etc….. Most wet shape is the circle and

$$\textbf{area of a circle} = \pi r^2\ (cm^2)$$

Step 7: Calculate the volume of water we must be add to the plants :

$$\mathbf{Volume\ water = ETc \times Area/1000\ (liter)}$$

Example (1)

Calculate the volume of water we need to add for the squash plant at Juley for 3 days when the average temperature is equal to 37℃ and atmospheric pressure is 9.8 Also, Kc= 0.87 if you know the diameter of wetting is equal 60 cm.