Drip system design

The distances between the emitters along and between the laterals must be adapted to crop water requirements

These distances should be based on the hydraulic properties of the soil and the discharge rate of the emitters.

The width and depth of the wetted soil volume to emitter discharge and saturated hydraulic conductivity of the soil.

$$d = 1.32z^{0.35}(q/K_s)^{0.33} = 1.32(zq/K_s)^{1/3}$$

d = The maximal diameter of the wetted volume

z = The depth of wetting

q = The emitter discharge

K_s = The saturated hydraulic conductivity

Problem:

Determine emitter spacing discharge combinations for non-overlapping wetted soil volumes considering various rooting depths in sandy and loamy soils.

Solution:

1. Reasonable values for the saturated hydraulic conductivities are: K_s = 10 and 1 cm/h for the sandy and loamy soils respectively.

2. Select a reasonable range of emitter discharge rates and rooting depths and calculate d.

Emitter spacing (cm) for sandy soil with K_s = 10 cm/h

Z_{root} (cm)	Q (l/h)				
	1	2	4	8	12
30	19.0	24.0	30.2	38.1	43.6
60	24.0	30.2	38.1	48.0	54.9
90	27.5	34.6	43.6	54.9	62.9
120	30.2	38.1	48.0	60.4	69.2

Emitter spacing (cm) for loamy soil with K_s = 1 cm/h

Z_{root} (cm)	Q (l/h)				
	1	2	4	8	12
30	41.0	51.7	65.1	82.0	93.9
60	51.7	65.1	82.0	103.4	118.3
90	59.2	74.5	93.9	118.3	135.4
120	65.1	82.0	103.4	130.2	149.1

The basic idea is the selection of the wetted soil volume needed for sustaining the crop's seasonal peak water use (*PWU* cm/day) between consecutive irrigations.

This volume is calculated for a given preferred irrigation interval, *PI* (day), soil water holding capacity *WHC* (the difference between field capacity θ_{fc}, and wilting point θ_{wp}), and management allowed deficit, *MAD* (expressed as a decimal fraction).

$$V_w = (PWU*PI/WHC*MAD)*DL*d = V_w^{*}*d$$

V_w – The wetted soil volume

DL – The spacing between drip lines

d – The emitter spacing

V_w^* – Lumps all the parameters required for Vw calculation except d

Assumption

The wetted volume is approximated by a semi-ellipsoid whose volume is given by:

$$V = \pi * z * d^2 / 6$$

WHC = 0.15 cm^3cm^{-3}, MAD = 0.3 and PWU = 0.5-0.7 cm/day

$$Vw = 13.5 * PI * DL * d(cm)$$

$$q = (6K_s*d*Vw)/2.3*z*\pi = (0.83K_s*Vw_**d^2)/z^2$$

Emitter discharge as a function of soil K_s, and wetted volume shape (d and z)

Where $Vw_* = 13.5 * PI *DL$

For a given row spacing, or drip line spacing DL, and preferred irrigation interval PI, compute Vw_*

Example: DL=100cm, and PI=3 days, yields Vw_* = 4050 cm^2

Select d values for which to compute the wetted volume V_w, and several possible z values

Example: assuming d = 100cm, V_w = 405000cm3,

and $z = 6V/\pi d^2 = 77.3$ cm

Finally, select the q that best satisfies the assumed shape and the required wetted soil volume

Example: assume Ks = 1 cm/h,

$q = 0.83*1*4050*(100/77.3)^2 = 5626\ cm^3/h$

Emitter spacing and discharge for a wetted strip

A wetted strip may be created by means of line source such as soaking tube or a drip-tape with virtually continuous outlets. Another possibility is to use a drip line with "discrete" emitters whose discharge and spacing would results in an overlap of saturated radii of water entry ponds.

Emitter spacing and discharge for a wetted strip

The ultimate saturated radius that develops around a surface emitter is given by:

$$r_s = \{(4/\alpha^2*\pi^2) + (q/\pi*Ks) - (2/\alpha*\pi)\}^{1/2}$$

The lateral extant of the saturated strip for the continuous (drip) line source x_s

$$x_s = ½*\{(q_L/K_s) - (3/4\alpha)\}$$

q_L is the line source discharge per unit length [L^2/T]

The minimum linear discharge rate for a positive X_s, and the onset of a saturated strip is $q>3K_s/(4\alpha)$

For long application times, using smaller emitter spacing and smaller spacing between line sources may result in runoff.

$$d = 1.7z^{a}(q/K_s)^{b}$$

Where the exponent **a** ranging between 0.75 and 0.85, and **b** between –0.15 and –0.25

A reasonable approximation would be:

$$d = 1.7z^{0.8}(q/K_s)^{-0.2}$$

Example: Design on surface wet strip using discrete emitters

Problem: Determine emitter spacing for various discharge combinations for a wet surface strip on a soil with K_s=0.84cm h^{-1} and α = 0.025 cm^{-1}.

Solution: Select several emitter discharge rates and calculate r, for each q using equation

$$r_s = \{(4/\alpha^2 * \pi^2) + (q/\pi * Ks) - (2/\alpha * \pi)\}^{1/2}$$

Emitter discharge (l/h)	1	2	3	4	8	12
Saturated radius (cm)	6.6	12.0	16.8	21.0	35.2	46.6
Emitter spacing (cm)	13.2	24.0	33.6	42.0	70.4	93.2

Example: Minimum spacing between adjacent line sources (to attain a completely wet soil surface)

Problem: Determine spacing between line sources to attain a completely wet soil surface for a range of discharge combinations for a soil with K_s=0.84cm h^{-1} and α = 0.025 cm^{-1}.

Solution: Select a range of line discharge rates and calculate x_s, for each q_L using equation

$$x_s = ½*\{(q_L/K_s) – (3/4\alpha)\}$$

Line discharge (l/h/m)	1	2	3	4	8	12
Spacing between adjacent line sources (cm)	N/A*	N/A	5.7	17.6	65.2	112.8

* The minimum line discharge for the onset of a saturated strip for this soil is $q>3K_s/(4\alpha)$ = 2.52 l/h/m.

Example: Minimum spacing between adjacent line sources for non-overlapping wetted volumes

Problem: Determine spacing between line sources for a range of (linear) discharge-root depth combinations in soils with K_s=1 and 10 cm h^{-1} (loamy and sandy soils). Maintain non-overlapping wetted soil volumes.

Solution: Select a reasonable range of emitter discharge rates and rooting depths and calculate d for the line sources using equation

$$d = 1.7z^{0.8}(q/K_s)^{-0.2}$$

Note that the discharge is per unit length

Spacing between adjacent line sources (cm) for non-overlapping wetted volumes in a loamy soil with K_s = 1cm/h

Z_{root} (cm)	Q (l/h)				
	1	2	4	8	12
30	40.9	47.0	54.0	62.1	67.3
60	71.3	81.9	94.1	108.0	117.2
90	98.6	113.3	130.1	149.4	162.1
120	124.1	142.6	163.8	188.1	204.0

Spacing between adjacent line sources (cm) for non-overlapping wetted volumes in a sandy soil with K_s = 10 cm/h

Z_{root} (cm)	Q (l/h)				
	1	2	4	8	12
30	25.8	29.7	34.1	39.2	42.5
60	45.0	51.7	59.3	68.2	73.9
90	62.2	71.5	82.1	94.3	102.3
120	78.3	89.9	103.3	118.7	128.7