Irrigation ASSOCIATION CERTIFICATION PROGRAM

Dec. 2013

Certified Agricultural Irrigation Specialist

Length
- 1 yard = 3 feet
- 1 yard = 0.9144 meters
- 1 foot = 12 inches
- 1 foot = 0.3048 meters
- 1 inch = 0.0254 meters
- 1 inch = 2.54 centimeters
- 1 inch = 25.4 millimeters

Area
- 1 "section" = 1 sq. mile
- 1"section" = 640 acres
- 1"quarter section" = 160 acres
- 1 acre = 43,560 sq-ft
- 1 acre = 0.4047 hectares
- 1 hectare = 2.471 acres
- 1 hectare = 10,000 sq-m

Volume
- 1 cu-meter = 1,000 Liters
- 1 cu-ft = 7.48 gallons
- 1 cu-ft = 62.4 lbs. water
- 1 gallon = 3.79 Liters
- 1 gallon = 8.34 lbs. water
- 1 acre-ft = 12 acre-inch
- 1 cu-cm = 1 gram water

Depth
- 1 inch = 1 ac-in/acre
- 1 inch = 3,630 cu-ft/acre
- 1 inch = 27,152 gal/acre
- 1 mm = 10 cu-m/hectare
- 1 mm = 10,000 L/hectare

Application Rate
- 1 in/day = 18.85 gpm/acre
- 1 in/day = 0.042 cfs/acre
- 1 mm/day = 0.417 cu-m/hr/ha
- 1 mm/day = 0.116 Lps/ha

Flow Rate
- 1 Lps = 15.85 gpm
- 1 gph = 3.79 Lph
- 1 cfs = 448.8 gpm
- 1 cfs = 2 ac-ft/day (approx)
- 1 cfs = 1 ac-in/hr (approx)
- 1 cu-m/hr = 4.4 gpm

Soil Moisture
- 1 in/ft = 8.33 % by volume
- 1 mm/m = 0.1 % by vol.

Power
- 1 hp = 1 horse power
- 1 kW = 1 kiloWatt
- 1 hp = 0.746 kW

Pressure/Tension
- 1 bar = 0.987 Atmosphere
- 1 bar = 100 centibar (cb)
- 1 bar = 100 kPa
- 1 bar = 14.48 psi
- 1 psi = 6.906 kPa
- 1 psi = 2.31 feet of water

Salinity
- 1 dS/m = 1 mmho/cm
- 1 dS/m = 700 ppm
- 1 dS/m = 0.3 bars tension
- 1 dS/m = 30 cb tension
- 1 ppm = 1 part per million
- 1 ppm = 1 milligram/L

Basic Geometry

Triangle: $A = \frac{\text{base x height}}{2}$

Trapezoid: $A = \frac{(\text{base}_1 + \text{base}_2) \text{ x height}}{2}$

Circle: $A = \pi \times r^2$

General: V = depth x area

Rates, Flow Rates, Application Rates

General: $\text{rate} = \frac{\text{amount}}{\text{time}}$

$\frac{\text{in.}}{\text{hr}} = \frac{\text{flow rate (gpm) x 96.3}}{\text{area (sq ft)}}$

$\text{flow rate (cfs)} = \frac{\text{volume (ac-in.)}}{\text{time (hrs)}}$

Soil Moisture

AWHC = FC – PWP
- AWHC = available water holding capacity
- FC = field capacity
- PWP = permanent wilting point

$\%\text{ by mass} = \frac{\text{wet soil weight} - \text{oven dry weight}}{\text{oven dry weight}} \times 100$

$\%\text{ by volume} = \frac{\%\text{ by mass} \times \text{soil bulk density (gm/cm}^3)}{\text{specific weight of water (gm/cm}^3)}$

$\%\text{ by volume} = \frac{\text{volume of water in soil (cm}^3)}{\text{bulk soil volume (cm}^3)} \text{ x } 100$

Depths: Available Water; of Penetration into soil; of Irrigation Needed to Refill the Root Zone

General: depth = volume ÷ area

$\text{available water (in.)} = \text{depth of soil (in.)} \text{ x } \frac{\%\text{ moisture by volume}}{100}$

$\text{penetration (ft)} = \frac{\text{water (in.)}}{\text{soil moisture depletion (in./ft}}$

$\text{AD=depth to refill root zone (in.)} = \text{AW (in.)} \text{ x } \frac{\text{MAD (\%)}}{100}$

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Irrigation Efficiency & Uniformity

$$\text{efficiency (E) (\%)} = \frac{\text{NET}}{\text{GROSS}} \text{ x } 100 = \frac{\text{output}}{\text{input}} \text{ x } 100$$

$$\text{E (\%)} = \frac{\text{irrigation water beneficially used}}{\text{irrigation water applied}} \text{ x } 100$$

$$DU_{lq} = \frac{\text{minimum depth infiltrated}}{\text{average depth infiltrated}}$$

With perfect timing, (good management)

$$\text{E (\%)} = DU_{lq} \text{ x } 100 \text{ x } \left(1 - \frac{\text{\% losses before infiltration}}{100}\right)$$

Average depth infiltrated = Gross average depth applied x [1 - %losses before infiltration/100]

Irrigation Scheduling

$$\text{irrigation interval (days)} = \frac{\text{PAW (in.) x } \frac{\text{MAD\%}}{100}}{\text{ETc (in./day)}}$$

$$\text{AD (in.)} = \text{PAW (in.) x } \frac{\text{MAD (\%)}}{100}$$

$$\text{NET} = ET_{crop} + \text{other beneficial uses} - \text{effective rain} - \text{high water table contribution}$$

with perfect timing, no salts

$$\text{GROSS Applied} = \frac{\text{NET}}{[\text{good management efficiency}]/100}$$

$$\text{GROSS Applied} = \frac{\text{NET}}{\text{DU x (1- losses)}}$$

For Perfect Timing (of an irrigation) => minimum depth applied = NET = smd = AD

Kc = Kcb x (soil surface evaporation adjustment factor) x (moisture stress adjustment factor)

ETc = Kc x ETo [for climate based ET estimates]

$$\frac{\text{in.}}{\text{hr}} = \frac{\text{flow rate (gpm)} \times 96.3}{\text{area (sq ft)}}$$

Given: Net irrigation required

$$\text{Average Depth Infiltrated} = \frac{\text{Net (smd or min)}}{\text{DU}}$$

$$\text{Gross} = \frac{\text{Average Depth Infiltrated}}{\text{(1-losses)}}$$

$$\text{Hours} = \frac{\text{Gross (in.)} \times \text{Area (ac)} \times 43{,}560}{\text{GPM} \times 96.3}$$

Given: Hours, GPM, Area

$$\text{Gross (in.)} = \frac{\text{GPM} \times 96.3 \times \text{Hrs}}{\text{Area (sq ft)}}$$

Net (smd or min or AD) = Average Depth Infiltrated × DU

Average Depth Infiltrated = Gross (in.) × (1-losses/100)

Salinity

$$LR = \frac{ECw}{[5 \text{ x } ECe] - ECw}$$

LR = leaching requirement (fraction)
ECw = EC of irrigation water, dS/m
ECe = threshold EC for crop

$$LR = \frac{\text{irrigation depth needed for leaching (in.)}}{\text{irrigation water applied (in.)}}$$

$$\text{Gross} = \frac{\text{Net}}{\text{DU x (1- losses) x (1- LR)}}$$

$$\text{Gross} = \frac{\text{Net}}{\text{good management IE} / 100 \times (1 - \text{LR})}$$