Engineering Logbook

Senior Capstone - Portland State University

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Monday, 4 January 2016

1 Irrigation Policy - Research Summary

Water balancing method of irrigation scheduling appears suitable for computational methods and requires no field work.[1]
Water balancing accounting is performed by calculating how much water leaves the soil and how much water is absorbed by the soil. Moisture can leave the soil through the following mechanisms:

- Evapotranspiration (E_{tc}):

    1. Moisture leaves the soil to the surrounding air.

    2. Water is absorbed by the plants.

- Surface Runoff (SRO): Runoff occurs when irrigation or rainwater is applied at a rate faster than the soil can absorb.

- Deep Percolation (DP): Drainage of water away from the root zone

Water enters the soil through the precipitaion, irrigation, or upwelling. (P, Irr, U)
If these terms can be estimated, a water deficit can be calulated by:

$$D = E_{tc} - P - Irr - U + SRO + DP \qquad ^{[2]}$$

The goal of our device will be to restore water lost from the soil by irrigating the correct amount so as to correct the water deficit. We can simplify the equation above by assuming the SRO and DP terms to be negligible. This requires the delivery of water via irrigation to not exceed the rate of uptake by the soil. The application rate will be determined outside of this system. U will be assumed to be negligible as well. Irrigation will be set equal to the deficit, leaving the resulting equation:

$$Irr = D = E_{tc} - P$$

This approach will require a method to estimate E_{tc} and precipitation. Can we skip a day if precipitation is detected? Can we detect precipitation using sensors for determining evapotranspiration? Humidity perhaps?

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[1] CSUE Fact Sheet No. 4708
[2] CSUE Fact Sheet No. 4707

Monday, 6 January 2016

1 E_{tc} Estimations

$$E_{tc} = E_{to} * K_c * K_s \qquad [1]$$

Where E_{to} is a reference evaportranspiration rate, K_c is the crop specific coefficient, and K_s is the crop stress coefficient. This equation will be simplified by setting both coefficients equal to 1, resulting:

$$E_{tc} = E_{to}$$

E_{to} is usually determined by following the Penman-Montieth method.[2] Since this method requires many environmental variables, it is not suitable for our application. Instead, a reduced set method such as Hardgreaves(HARG)[3] will be used. HARG:

$$E_{to_H} = HC * R_a * (T_{max} - T_{min})^{HE} * (\frac{T_{max} + T_{min}}{2} + HT)$$

HC, HE, and HT are all constants that can be calibrated. The Hardgreaves method requires only ambient air temperature and calendar day since R_a can be supplied from meteorological data given date and latitude. At this point we can determine Irrigation (Irr) needed with the following:

- Calendar Day (Requires Table of R_a stored in memory)

- Maximum/Minimum Ambient Temperature (Daily?)

- Precipitaion (Sensing Pad?, Humidity?)

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[1] CSUE Fact Sheet No. 4707

[2] FAO Irrigation and Drainage Paper 56

[3] Hardgreaves and Other Reduced-Set Methods for Calculating Evapotranspiration

Sources